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An engaging nuisance: Weka, flipping and farmers.

A thesis submitted in partial fulfillment of the requirement for the Degree of

Doctor of Philosophy

at

Lincoln University

By

Scott Freeman

------------------------------------------------------
Lincoln University

2012
Abstract

Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of
Doctor of Philosophy.

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by Scott Freeman

The interaction between society and the environment has become a significant topic of study in recent decades due to the suggested impacts humans are now having on their local, and the global environment (Clayton & Radcliffe, 1996; Naveh, 1995). In New Zealand, one such impact is the changes agricultural development has had, and is having, on the country’s indigenous ecosystems. In the Cape Foulwind area, near Westport on the northern west coast of the South Island, such development has been rapid in the last decade. This development, using a land development technique called flipping, has turned significant areas of rough pasture and scrub into pure exotic pasture grasses. Land development on private land at Cape Foulwind peninsula is reducing the habitat, and potentially impacting on the population of an endangered, flightless, indigenous rail, the western weka (Gallirallus australis australis).

The first part of the study involved developing an individual based model (IBM) to evaluate the impacts of land development on the western weka population on the Cape Foulwind peninsula. The second part of the research implemented a qualitative investigation of the significance to landowners of western weka. It investigated the importance of this relationship and its impact, if any, on landowners’ land use practices. In doing this the study used, and also explored the usefulness, and limitations of, fuzzy cognitive maps (FCMs) in social science research. FCMs are digraphs that are used to map and model participants’ understandings of physical, causal connections. Qualitative in-depth interviews are used in parallel with FCMs to explore these interactions further. These methods are used to meet a primary aim of the research; to develop a socio-ecological system (SES) model to help understand the ongoing interactions of people and weka. The contemporary systems-based, Resilience Theory (Gunderson & Holling, 2002), is used as a way to understand and analyse the notion of socio-ecological systems.

Philosophically this research is based in developments within Continental phenomenological and post-structuralist thought. It follows this tradition through Martin Heidegger, Maurice Merleau-
Ponty to the neo-realism of Giles Deleuze and relates this to systems theory. The notion that people are foremost embodied, affective and immersed in the world that is in an ongoing process of unfolding, is central these approaches, and is in contrast with people being understood primarily as either objective observers or subjective interpreters. Consequently, the focus of this research is on people’s relationships with weka. This is based in their embodied practices and everyday activities and interactions, and the networks and epistemologies that ensue from these relations, rather than the values they assign to weka.

The ecological fieldwork and IBM shows the weka population is being impacted by land development, along with a number of other pressures. The study finds embodied interaction with weka as central to the participants’ relationships with them. These relationships are found to be affectively based and complex. Weka are active agents in these relationships and their behaviour impinges on the networks of significance of the Cape Foulwind peninsula, influencing it in both positive and negative ways. A normative understanding lies with these relationships and at the basis of the desirability of outcomes within a Resilience Theory approach to managing the SES. The research suggests that Resilience Theory needs to more fully account for these relationships in its analysis of SESs. This in turn impacts on the role of governance in SESs.

**Key words**

Western Weka (*Gallirallus australis australis*)  
Land development

Phenomenology  
Systems theory  
Resilience Theory

Post-structuralism  
Affect  
Embodied cognition

Immanence  
Cape Foulwind  
Fuzzy cognitive maps

Wild animals  
Individual based modelling  
Private land

Sense of place  
Conservation  
Local knowledge

Ecology  
Endangered species  
Ontology
Acknowledgments

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This thesis was written at my home by Gillows Dam on the Cape Foulwind peninsula.
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<tr>
<td>ABM</td>
<td>Agent based model</td>
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<tr>
<td>ANT</td>
<td>Actor Network Theory</td>
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<td>CAS</td>
<td>Complex adaptive systems</td>
</tr>
<tr>
<td>CID</td>
<td>Cognitive interpretation diagram</td>
</tr>
<tr>
<td>CST</td>
<td>Critical systems thinking</td>
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<tr>
<td>DOC</td>
<td>Department of Conservation</td>
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<tr>
<td>DST</td>
<td>Dynamical systems theory</td>
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<td>FCM</td>
<td>Fuzzy cognitive maps</td>
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<tr>
<td>GST</td>
<td>General systems theory</td>
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<tr>
<td>IBE</td>
<td>Individual based ecology</td>
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<td>IBM</td>
<td>Individual based modelling</td>
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<tr>
<td>LCDBII</td>
<td>New Zealand land cover database version II</td>
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<tr>
<td>LEK</td>
<td>Local ecological knowledge</td>
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<tr>
<td>MAS</td>
<td>Multi-agent simulations</td>
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<tr>
<td>OOP</td>
<td>Object orientated programming</td>
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<tr>
<td>POM</td>
<td>Pattern orientated modelling</td>
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<tr>
<td>RT</td>
<td>Resilience theory</td>
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<tr>
<td>SES</td>
<td>Socio-ecological system</td>
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<tr>
<td>SSM</td>
<td>Soft systems methodology</td>
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<tr>
<td>TEK</td>
<td>Traditional ecological knowledge</td>
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1 Introduction

At first sight, and disregarding its name, you might not recognise Gillows Dam as the outcome of human endeavour. A closer inspection - say a circumnavigation of the small Africa shaped lake - would reveal the curved line of a stony embankment along its eastern edge. Even buried under a mass of gorse and manuka this embankment may give itself away as the work of miners. The dam’s inhabitants too might suggest, in a more indirect way, the hand of humans: mallard and grey ducks, black swans, a pair of harrier hawks and swallows, mix with spur winged plovers and black back gulls; These in turn, with putangitangi, weka and pukeko, matuku, matata, kawaupaka and kotuku. In summer, swarms of midges and dragonflies fill the air while cattle wade through the dam’s swampy surrounds of spagnum, patches of raupo and flax. It is these inhabitants, along with more secretive ones not to be seen, that make up the contemporary ecology of Gillows Dam. A cosmopolitan mix of the indigenous, the native and the exotic. I have developed an affection for this ecology, this assorted mix of species, all trying to inhabit a place not quite home; not for the new arrivals, or the inhabitants of millennia.

1.1 Conservation and private land

The interaction between society and the environment has become a significant topic of study in recent decades due to the suggested impacts humans are now having on their local, and global, environment (Clayton & Radcliffe, 1996; Naveh, 1995). In New Zealand, one such impact is the changes agricultural development has had, and is having, on the country’s indigenous ecosystems. Today, agricultural land dominates much (58% according to MacLeod et al., 2008) of the New Zealand landscape and only one third of New Zealand’s pre-human forest cover still exists (Cocklin & Doorman, 1994). Most of these remaining indigenous ecosystems are protected as public conservation lands which take in approximately 30% of New Zealand’s total land area. However, less than 20% of land below 500 metres is protected in these public lands (Norton, 2000). This means many of the rich coastal lowland habitats important for native species, and the areas of highest biodiversity in pre-human New Zealand, have been lost or severely reduced (Jay, 2005). Habitat loss is one of a number of causes associated with the extinction of almost one half of the country’s non-marine birds since human habitation began approximately 800 years ago. Some 87% of these species are endemic (Wilson, 2004).

By far the majority of these lowlands is not only agricultural land but also privately owned. By implication many of New Zealand’s most biologically diverse remaining habitats lie on private land. MacLeod et al. (2008) argue that, compared to indigenous habitats, birds in agro-ecosystems have not received a great deal of conservation attention. They suggest that both endemic and native birds
may significantly contribute to the social and ecological resilience of agricultural landscapes. The tension between the development and conservation of the country’s privately owned agricultural landscapes is an over arching theme of this research.

Farina (2003) suggests that this tension has been addressed by different cultures in two main ways. Conservation in New Zealand over the past 100 years, in common with other new world countries, falls under what he calls the ‘empty world’ vision. In this approach large areas of the landscape are put aside where human intrusion is minimized. Central to this development is the separation of the landscape into public conservation and private productive lands. The ‘empty world’ approach, according to Farina (2003), implies that humans are not part of the natural world but it exists independently and is to be preserved separate and un-impacted by human activities. The complement to this is that conservation is not required on productive land. In contrast, Farina (2003) outlines a ‘full world’ vision that characterises many indigenous and long established cultures. In this approach nature and human activities are physically integrated in the landscape. In addition, there is an implicit understanding that humans are interconnected with the natural world and its processes and there is a reciprocal interaction between the two.

Problems with the ‘empty world’ approach are highlighted by global climate changes that are now generally agreed to be at least partially caused by human activities (Flannery, 2005). These kinds of large-scale changes tend to undermine the usefulness or reality of the notion of a pristine or natural world not impacted by humans (McKibben, 1990). However, the interconnections implied by global climate change also expose the need for conservation to take place in all landscapes and not just landscapes set aside for this purpose. Some argue that the separation between humans and nature implicit in the ‘empty world’ approach corresponds with dualisms bound up in western thought (humans/nature, mind/body). These dualisms have been challenged, in particular, by developments in post-structural thought (Head, 2000).

In order to understand and investigate the links between this global interconnectedness and what occurs in local settings, and also develop an approach to address these dualisms, this Chapter will first give an outline of the notion of socio-ecological systems. Second, it will briefly highlight some relevant points of the Continental philosophical approach that is to be used in the study, and then provide some details of the local study site. Finally, it sets out the chapter structure of the thesis as a whole.

1.2 Socio-ecological systems

This research is both theoretically broad, and empirically focused. It is transdisciplinary and utilizes and combines ecology, philosophy, phenomenology and psychology with systems theory. Its aim is to develop a socio-ecological system model of the interactions between people and a wild
animal conceptualised in a systemic manner. The study concerns the status of western weka
*Gallirallus australis australis*, an endangered, flightless indigenous rail, in the agriculturally
dominated landscape at Cape Foulwind, on the West Coast of the South Island of New Zealand,
under the intensification of agriculture. Agricultural practices are considered in light of local people’s
relationships with weka.

The notion of ‘sustainability’ is used as a guiding and normative concept for social-ecological
analysis. Within a socio-ecological framework, sustainability is a long term goal that includes a fair
distribution of resources between present and future generations, and a use of natural resources
that lie within the ability of ecological support systems (PCE, 2002). As an example of its influence,
New Zealand’s core environmental management legislation, the Resource Management Act 1991,
emphasises sustainable development.

There have been a number of developments and refinements of the sustainability concept
and the use of systems theories in conceptualizing socio-ecological systems. For example, the
‘resilience’ framework emerged in the 1960s and 1970s when ecologists such as C.S. Holling
illustrated that natural systems showed multiple stability domains and the relationship of these
domains to disturbance events and changes at multiple temporal and spatial scales (Folke, 2006).
This framework was subsequently expanded to incorporate social systems (Folke, 2006). Within the
resilience framework Gunderson et al. (2002a) define sustainability as “the capacity to create, test,
and maintain adaptive capability” (p. 76). Indeed, this approach focuses on the adaptive ability of
social systems to respond to feedback from the environment while, at the same time, the natural
environment evolves in response. In this sense, people and ecosystems evolve together (co-
evolution) (Berkes & Folke, 1998). Methodologically, the resilience conceptual framework has
involved developing mathematical models based on empirical observations (Folke, 2006).

The need to examine both ecosystem dynamics and social dynamics and the complexity and
heterogeneity of both parts has led to the application of the concept of complex adaptive systems
(CAS). This is a development of systems theory which can itself be considered as a metatheory which
allows the linking of disciplines, and their associated formal quantitative and descriptive qualitative
methods (Naveh, 1995). Extending CAS to the social sciences has had to take account of human
agency (Gunderson & Holling, 2002; Stepp et al., 2003; Checkland, 1981). In this study, a soft systems
approach involving fuzzy cognitive maps (FCM) is used to represent the social system, and an
individual based modelling (IBM) approach is adopted for ecological aspects. Chapters 9 and 10 set
out the use of these methods.
On the northern leg of your exploration of Gillows Dam, and if the day is clear, looking across the dam to the south you would see the Paparoa Range, its lower slopes heavily forested, its granite tops often cloud covered: the flat topped Bucklands, the pyramidal Kelvin, the rounded Fleming, and the jagged Einstein taper off the south. This range looms over my life - physically outside my window, but also in my imagination. It is magnified by childhood holidays spent hard-up against the ranges’ western flanks on a relative’s farm. Not that I ventured into them at that time. I didn’t need to, their presence; forest, granite peaks, August snow storms, was palpable and enough for my young life.

* * *

1.3 Continental philosophy
The study is framed within Continental phenomenological and post-structuralist thought. It follows the phenomenological tradition through Martin Heidegger (1892-1976), Maurice Merleau-Ponty (1908-1961) to the neo-realism of Giles Deleuze (1925-1995) and relates this to systems science and systems thinking. The notion that people are foremost embodied, affective and immersed in the world that is in an ongoing process of unfolding, is central to these approaches, and contrasts with depictions of people as either objective observers or subjective interpreters. This focus on embodiment also involves consideration of recent developments in cognitive science on embodied cognition. Furthermore, some recent scholars (e.g., Ingold, 2000) have developed the phenomenological approach towards a fundamentally interactive and embodied account of place, with its emphasis on emotional connections.

This research examines people’s embodied everyday interactions with weka and networks that ensue from these relations. It does this by using, and exploring the usefulness and limitations of FCMs (and their neural network modelling) for understanding these everyday relationships with weka. FCMs are based on understandings of physical causal connections and the study explores claims (Özesmi, 1999) that FCMs represent lay persons’ perceptions, desires, or emotional aspects of their environmental relationships. Qualitative in-depth interviews are used in parallel with FCMs to explore the link of the emotional and causal and consider this in relation to phenomenological notions of sense of place.

1.4 Western weka and landowners
The study was undertaken within the mixed pastoral landscape of Cape Foulwind peninsula on the northwest of the South Island, New Zealand. The Cape Foulwind peninsula itself covers
approximately 15,000 hectares\(^1\) of mostly privately owned farmland. Approximately 85% of the land on Cape Foulwind is used for agricultural production. Up until around 10 years ago agricultural activities on this relatively flat peninsula consisted of predominantly low intensity sheep, deer and dry stock grazing on rough pasture. The landscape was characterized by poorly drained mixed areas of pākihi\(^2\), scrub and gorse covered pasture. The development of humping and hollowing and land flipping techniques\(^3\), that increase pasture quality though mixing soil layers and improving drainage, has allowed dairy farm development and the creation of productive farmland covered in almost pure exotic pasture grasses. Resource consents under the Resource Management Act 1991 have been issued by the West Coast Regional Council to allow up to 50% (c.7500 hectares) of the Cape Foulwind peninsula to be worked into developed pasture land by 2030. Approximately 3000 ha of land has already been developed. These farm development initiatives are good examples of the productivist approach in New Zealand agriculture (Jay, 2005; Egoz et al., 2001) and of the rapid change of habitat that can occur from farm development practices.

Western weka is one of four forms of weka that were once widespread throughout New Zealand. Western weka are classified as threatened and ‘at risk’ (Miskelly et al., 2008). The north west of the South Island is one of the strongholds of the surviving population (Marchant & Higgins, 1993). Within this area weka have adapted more successfully than many other indigenous bird species to farmland ecosystems. As a result, western weka are common in the Cape Foulwind area and are seen frequently around houses, on farmland and on the roadsides. Weka are known for their inquisitiveness and ‘feistiness’ and are an indigenous species that live close to humans (Soper, 1980).

The first part of the study involves developing an individual based model (IBM) to model the

---

\(^1\) The Cape Foulwind peninsula area is referred to as ‘Cape Foulwind’ in this study.

\(^2\) Pākihi is a general term used to describe generally flat areas of ground containing leached gley acidic (mean pH 4.5) podzol soils that have a base mineral deficiency. An impervious iron pan exists in the B soil horizon meaning drainage is poor (McPherson, 1978). Ross et al. (2000, p.3) describe pākihi as a type of wetland “which may be natural or induced through logging and burning and now carries ferns (mainly tangle fern, *Gleichenia dicarpa*), restiads (wire-rush, *Empodisma minus*), sedges (*Baumea** spp.), rushes (*Juncus** spp.) and mosses (*Sphagnum** spp.), with scattered manuka (*Leptospermum scoparium*).” Pākihi is a Maori word having several meanings. The ones that apply here are ‘bad land’, ‘infertile country’, ‘open country’ and ‘place where fern root has been dug’ (Ross, 2006) as it supports only poor vegetation. It is often mispronounced as ‘parkee’ dating from the gold rush days (Macdonald, 1973).

\(^3\) Two main methods have been developed to improve the quality of pākihi soils. The first method involves many of the deeper silty or humus-clogged soils with poor internal drainage within the soil. These soils are usually humped and hollowed, which entails the construction of long mounds with hollows in between, to improve surface runoff. This is not common at Cape Foulwind (Ross, 2006). The second method is flipping. This involves mixing the top 2 – 3 metres of surface material using hydraulic excavators to improve subsoil drainage (MAF, 2006). It is used on relatively shallow soils with underlying iron or humus cemented gravels or sands, which are known as iron pans. The iron pans inhibit drainage and flipping is used to break them up and mix the gravel/sand and soils layers (Ross, 2006).
impacts of land development on the weka population on the Cape Foulwind peninsula. The
second part of the research involves a qualitative investigation of the significance to landholders of
western weka. It investigates the importance of this relationship and its impact, if any, on
landowners’ land use practices. This reflects Norton’s (2000) suggestion that conservationists need
to develop more knowledge of ecosystems on private land, and also ways of working with land
owners. This in turn will guide policy initiatives that will better integrate conservation onto private
land rather than separate them.

It is in this context that the study takes its management or intervention strategy for the
socio-ecological system. Doran (2001) discusses a range of such strategies in relation to who is
involved. They range from being dominated by formal agencies and scientific knowledge to ones
focused on community management based on local knowledge. This research focuses on the latter
but also asks whether “intervention” is necessary or, alternatively, whether or not the SES in relation
to conserving weka is adaptive at present. Modelling the SES also allows consideration of
management options (i.e., experimentation with different strategies).

1.5 Chapter structure

Chapter 2 develops the theoretical grounding for the study. It explores the Continental
phenomenological and post-phenomenological tradition. The overall aim of the chapter is to give a
philosophical basis for developing an understanding of the interactive relationships held between
people and weka. It will also act as a basis for the research methodology, and the application of the
primary methods used in the research (FCM and IBM).

Chapter 3 discusses systems theory. The analysis and modelling undertaken in this study uses
a systems framework and systems-related tools (FCMs and IBM). The contemporary systems based
‘Resilience Theory’ is used as a way to conceptualise and understand socio-ecological systems and
aspects of it are used to develop an integrated conceptual and methodological framework.

Chapters 4 and 5 consider how cognition and affect (or emotion), respectively, can be
understood in a manner consistent with the philosophical approach taken. In cognitive science this is
an embodied and situated cognition which has been recently developed as an alternative to
cognitivism. In relation to emotion, biologically determinist approaches are rejected for a more
cognitive based understanding of emotion that integrates the cognitive and affective. Chapter 6
draws the foregoing discussions together under the notions of dwelling and place. This involves a
development of Heidegger’s notion of dwelling that also includes embodiment, so that people are
considered immersed in practical and material place. This understanding also includes networks that
link these practical concerns beyond the specific locale. These practical concerns are bound up with affect.

Chapter 7 gives an overview of weka ecology. Chapter 8 outlines the study’s central methodological approach. Chapters 9 and 10 supply backgrounds to FCMs and IBMs, and Chapters 11 and 12 set out the results of the interviews, FCMs, and IBM. Chapter 13 discusses the weka ecology results. Chapter 14 uses the results to discuss the application of Resilience theory to Cape Foulwind SES. Finally, Chapter 15 presents an overall discussion and conclusion.

This chapter structure reflects the objectives of the study. In very general terms these are to:

1) Provide an account of the interactions between people and weka within an socio-ecological systems framework; 2) Incorporate a post-structural philosophical understanding into the socio-ecological systems framework; 3) Develop IBM and FCM models of the interactions; 3) Provide recommendations based on the account and models developed under objectives 1), 2) and 3).

* * *

There are few human visitors to the dam. In winter duck shooters create confusion with their decoys and inane duck callers, and havoc with their guns. Thankfully they are intermittent visitors: State farmers work the land on the south side of the swamp during the summer months; A digger clatters clumsily and dumbly across the pākihi lea by a dog and a man; A neighbour collects waterlogged stumps for his aquarium; And twice now, and at a distance, what looked like a young man with a beard and backpack appeared, striding out towards the mountains.

* * *
2 Phenomenology and Relationality

2.0 Introduction

The aim of this chapter is to develop a philosophical framework for the rest of the study. This is based on phenomenological and post-structuralist developments within Continental philosophy. This introduction gives an overview of these developments.

Over the past three decades there has been a debate between cultural relativists or anti-realists and realist philosophers of science over the validity of the truths proposed in the natural sciences. Realist arguments relate to a position that comprehends nature as a given and that it is best described through the methods of natural science (Lease & Soule, 1995). By contrast, post-structuralism, environmental history and philosophy of science have recently emphasised a supposed mediational effect of social practices in our understanding of Nature (Norris, 1997). They argue that reality as discovered within the natural sciences is, at least in part, a linguistic construction and suggest that understandings of nature are dominated by cultural prejudices (Lease & Soule, 1995).

Much of the relativist shift can be linked to the suspicion of modernist foundational, epistemological or metaphysical frameworks promoted by Continental philosophers such as Martin Heidegger, Maurice Merleau-Ponty and Gilles Deleuze. For them the aim of philosophy should in general be to gain an understanding of the interplay of thought, action, affect, practices, materiality and so on, in the everyday, and the lifeworld while being wary of simplifying foundationalism (Schrag, 1986). Heidegger, Merleau-Ponty and Deleuze are, strictly speaking, post-structuralists, rather than post-modernists, and so temper their ontological relativism through the notion of immanence. Their central concerns can be loosely listed as: the importance of language, the disorder of logos (reason), the inability of language to capture the world, the relationality of the world, the existence of otherness, and the temporal nature of life (Dillon, 2000). This loose list does not capture the distinctive differences in these thinkers and the tensions between them (Mullarkey, 2006). These differences can in part be attributed to developments within the tradition itself and also within each contributor’s thought.

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4 There are a number of varieties of relativism. Epistemological relativists posit a separate autonomous world operating independently of human concerns and understandings. This approach recognises, however, that human cultural groups or individuals may have different understandings of this reality (Smith, 2001). Some commentators suggest that Western science may be the best way to understand this reality, (e.g. Bhaskar), while others do not (Shepard, 2008). Ontological relativists argue that the mediational effect of culture and language means that any prior reality is inaccessible and so the notion is meaningless. However, rather than denying the existence of a separate reality they tend to suspend claims about the ontological nature of reality and concentrate on various discourses about it. Realist philosophers often criticise the latter, while many would agree with the former (Smith, 2001).
Of particular significance in this literature are recent developments in the philosophies of dispersion and immanence (e.g., Deleuze, Henry)(Crotty, 1998; Mullarkey, 2006). Importantly, these involve rejecting the earlier phenomenological tradition of transcendence (e.g., of consciousness, Being). This development is centered around French philosophy where, over the past 15 years, phenomenology has been either sidelined through interest, for example, in Deleuze’s work, or, following the later work of Heidegger, has become theological in focus and hence little resembles the earlier Husserlian tradition (Mullarkey, 2006).

In addition, Continental philosophy has taken a naturalistic turn engaging with bio-science and also with embodiment. Mullarkey (2006) suggests its earlier lack of engagement with such things as culture’s relationship with biology can be in part attributed to Heidegger’s anti-scientism and phenomenology’s transcendental approach. By contrast, Merleau-Ponty’s phenomenology engaged directly with the sciences and embodiment. This has been further developed by Francisco Varela (Maturana & Varela, 1987; Varela et al., 1991; Thompson, 2007).

Philosophies of immanence contain the problem of how to gain a separation to allow critique of our own individual and social practices and cultural understandings (Mullarkey, 2006). In modernity such a distance has been achieved through positing an underlying reality that is accessible via objectivist science and the epistemological subject, and philosophically through the proposed existence of transcendent entities. Philosophies of immanence questioning of these foundations creates a tension between reflexivity (the transcendental) and immanence (Mullarkey, 2006). This tension is unable to be easily resolved, consequently the social sciences have tended to take up the reflexive side as the ‘linguistic turn’ in philosophical theorizing (Palmas, 2008), while the immanent side was largely disregarded. The resulting instability has produced, for want of a better term, ‘dead geographies’ (Thrift, 2001). In other words, ontological relativism, in its extreme form, created unanimated material worlds completely mediated by the social and cultural, while the implications of the immanent side were ignored. This is not to deny the vital role of reflexivity which allows for a separation for the creation of the Other, and assessment of our practices. In addition, it is the openness admitted by the reflexive instability of postmodern thought that gives scope to allow a movement beyond itself, and potentially also beyond phenomenology in which many of its roots lie (Mullarkey, 2006). The two threads of reflexivity and immanence, along with a concern for everyday practices allow for a movement towards a further position; embodied practice.

Over the past ten years this movement has occurred and is sometimes called the ‘performative turn’ or a ‘new materialism’ (Palmas, 2008). The main overlapping threads to this have

---

5 This is possibly linked to the complex of approaches in social science which has had an interpretivist (constructivist) positivist split, epitomised by Weber’s and Durkheim’s contrasting approaches to social science, for some 150 years (Checkland, 1981).
been described as “...a reconsideration and reworking of vitalism. Another is a growing interest in the intermingling of human and material [...] Still another is a revival of systems thinking” (Thrift, 2006, cited in Palmas, 2008, p. 1. emphasis added). These interests align closely with Deleuze’s thought which is vitalist, materialist and has been linked closely with open systems thinking (Palmas, 2008; Delenda, 2002).

This Chapter focuses on these developments in the Continental philosophy tradition. It also engages with more recent developments in non-representational theory. Non-representation theory is a hybrid of phenomenology and various other threads of post-structuralist thought (Wylie, 2007). McCormack (2005 cited in Popke, 2009, p. 82) describes it as, first, valorising “those processes that operate before ... conscious, reflective thought ... [and] second, it insists on the necessity of not prioritising representations as the primary epistemological vehicles through which knowledge is extracted from the world.” However, as already noted, there are tensions between these positions which will be central to this Chapter’s discussion. Ultimately a phenomenological hybrid approach is supported because phenomenology, via its philosophical basis and methodology, has as its primary interest people’s subjective everyday experiences and relationships and the ways of knowing that arise from this, while a materialist ontology grounds this in the natural world.

This chapter will initially briefly outline phenomenology generally and then consider the philosophy of Martin Heidegger. Heidegger’s philosophy is central to all subsequent developments in 20th century continental philosophy (Dreyfus, 1991) as well as in place studies (Wylie, 2007) and some recent developments in cognitive science (Wheeler, 2005). First, from his early work in *Being and Time* (1997), it will discuss the practical and everyday absorption of being-in-the-world (ready-at-hand) and the secondary ability to consider the world in an abstract and scientific manner (present-at-hand). Second, it will cover this in relation to poetic dwelling (contemplation) developed in his latter phenomenology that goes hand in hand with his critique of Western metaphysics. Both of these aspects of his philosophy have been used by later scholars in developing theories of place (e.g., Seamon, 1982; Ingold, 2000).

Following this discussion of Heidegger will be an overview of Merleau-Ponty’s phenomenology. His thinking begins from our embodiment highlighting the primacy of our carnal existence (Hass, 2008). This concern for materiality is then taken up through Deleuze’s philosophy in regards to our embodiment. Delueze’s eschews phenomenology by promoting a distinctly non-subjective account of the world based on non-personal forces and affects. This somewhat chaotic world is linked in Deleuze (and Guattari’s) later work to dynamical systems theory. Their fundamental materiality allows an empirical link with the sciences, particularly non-linear science (DeLanda, 2002).
These threads are brought together to meet the overall aim of this Chapter, that is to give a philosophical basis for developing an understanding of the interactive relationships held between people and weka. It will also act as a basis for the research methodology, and the application of the primary methods used in the research (FCM and IBM).

2.1 Phenomenology

The philosophy of phenomenology appeared during the early 20th century in Germany. It was developed by Edmund Husserl (1859-1938) who elaborated Franz Brentano’s (1838-1917) ‘descriptive psychology’. Driving his development of phenomenology was Husserl’s concern that the objective truths of logic, mathematics, etc. needed to be re-grounded in the everyday acts of human consciousness. He argued that it is from the world as an experience of living that the world, as an object we know, is derived. Husserl was interested in establishing the true identity of phenomena as they are presented to consciousness through a method that uses subjective experiences as its starting point (Schroeder, 2005). A basic structure of Brentano’s account was intentionality and this became central to Husserl’s phenomenology (Dowling, 2007). Intentionality, as the basic structure of individual consciousness, asserts that we are never just conscious but always conscious of something. This creates a counterpoint to individual consciousness - the ‘other’ or ‘alterity’ (Thompson, 2007). Consequently, consciousness is central to phenomenology, despite being difficult to define. Humans are certainly conscious, as are all sentient beings. Humans are also self-conscious or self-aware, that gives the ability to inspect and re-evaluate mentally what they are aware of (Reber, 1985). This is the key lever of the phenomenological method. There are a range of conscious mental states including sensations, moods, emotions, propositional thought and self-awareness that make up consciousness. Phenomenology highlights the distinctive first person nature of consciousness. It is considered to be ‘as it is’ (i.e., only known by the subject) and therefore irreducible to an objective ontology (Honderich, 1995).

Because of these first person concerns phenomenology, as a philosophical method, has been criticised for being both irrational and subjectivistic (Hass, 2008). Hass (2008) argues firmly against both of these concerns. First, phenomenology is not the use of deduction or induction, but is a form of argumentation. This form is one of ‘showing’. It uses descriptive and evocative language to guide others towards seeing something within our lived experiences. Phenomenology can be criticised but, like any other form of reasoning, this needs to be done within its own terms or standards.

Indeed, phenomenology is not a philosophy of idealism, but involves a constructivist epistemology. Constructivism considers that meaning in reality is constructed through ongoing human interactions with the world. It is this ongoing construction of meaning that emphasises an
open nature to reality that involves a continuous unfolding of meaning through new experiences. This suggests that reality can be interpreted in many different ways and, taken to an extreme, that there may be no true interpretation. However, due to the relational nature of interaction, not just any interpretation can be made. Constraints are placed on how it can be usefully interpreted via our embodiment (perceptions), language and tradition (Crotty, 1998).

Phenomenology remains an influential and active tradition in contemporary disciplines such as human geography (Wylie, 2007), cognitive science (Gallagher, 2005) and environmental philosophy (Foltz & Frodeman, 2004), to name several relevant to this study. This is in part due to its diversity, as the meaning of phenomena (i.e., how things appear) is interpreted by various phenomenologists in a number of ways. Schroeder (2005) suggests there are two main divisions within phenomenology, as theorized and applied. The first is known as ‘transcendental phenomenology’. This is phenomenology as developed by Husserl. It can be broadly described as the investigation of ‘essences’ of things through a method that attempts to ‘bracket out’ certain levels of consciousness. Although all phenomenologists attempt to reveal common features of experience, the second thread – which could be broadly called non-transcendental - questions transcendental phenomenology’s method and, instead, has as its basis the complexity of everyday experience. Non-transcendental phenomenology has several divisions. These include a purely descriptive approach (i.e., understanding the world as it is described through the experiences of individuals and deriving common features from this). Much contemporary social science investigation within the tradition uses this approach (Auburn & Barnes, 2006). The other main approaches are hermeneutic phenomenology (e.g., Heidegger, Merleau-Ponty), and existential phenomenology (e.g., Satre, 1943) (Schroeder, 2005).

Of the subsequent philosophers who have adopted and developed the early phenomenology of Husserl, arguably the most influential and relevant for this research are Heidegger, whose primary concern was ontology, and Merleau-Ponty who developed a phenomenology of embodiment. The following sections consider in more detail the phenomenologies of Heidegger and Merleau-Ponty.

2.2 Being-in-the-world
2.2.1 Introduction

Heidegger’s phenomenology revolves around the phenomenological theme of presence and absence in particular relation to Being. For Heidegger ontology is the study of Being. Heidegger considers ‘standing in wonder of Being’, that anything exists at all, as the genesis of philosophical thinking (Cupitt, 1998). Heidegger asks what the nature of Being might be and the relationship beings
might hold with it. Here beings (seiendes) are entities, such as physical objects, numbers, thoughts (the ontic), while Being (sein) is existence itself (the ontological). Sein or Being is the permanent reality which endures and remains and finally disposes us to the meaning of beings (seiendes) or appearances (Kluback & Wilde, 1956).

His book *Being and Time* (1927), written early in his career, involved the development of a fundamental ontology through an analysis of the human condition and its relationship with Being. For Heidegger, for something to be requires it to manifest itself via the human Dasein. Dasein (‘being there’) is the basic human disposition whereby ‘Being’ and then ‘beings’ can be encountered. However, because of his realisation of the implied anthropocentrism and subjectivism in *Being and Time* (1927) his later thought was developed around insights of previous (pre-Socratic) thinkers toward Being. It avoided a further development of his analysis of Dasein (Zimmerman, 2003) although his latter thinking always involved developments on his early insights (Schroeder, 2005).

In this section the background for the development of two threads in theoretical development will be discussed. One relates to the selective use of Heidegger’s philosophy from Division I of *Being & Time* (1927) by some proponents of embodied cognitive science in order to articulate the philosophical foundations of a non-Cartesian cognitive science (Clark, 1997; Dreyfus, 1991; Wheeler, 2005) (Chapter 4). This allows a grounding for the idea of local knowledge and the use of dynamical systems theory in cognitive science. The second relates to the broader use of his concept of dwelling in studies of place (Seamon, 1982; Ingold, 2000) (Chapter 6). This will ultimately be in order to develop ideas of how landowners at Cape Foulwind might be understood to relate physically, emotionally and cognitively to that place and aspects of it. This relates to the environment generally and also to ethical and emotional responses, along with the use of FCMs and socio-ecological systems. Finally, questions remain regarding Heidegger’s philosophy particularly regarding biology, essences, embodiment and its compatibility with science. These will be briefly considered in the sections that follow some more detail of Heidegger’s thought.

### 2.2.2 Dasein

For Heidegger humans are unique as they are the ones who ask the question: What is Being? Raising this question or concern supposes that we first have a preliminary understanding of Being. In addition, Dasein must itself be a product of Being as the meaning of Being is itself shown through Dasein’s concern (Lawson, 1985). Heidegger calls this the ‘pre-ontological’. The pre-ontological always remains inaccessible as a pre-meaningfulness and absence. This is because Being is not an entity or something that adheres to entities as an obvious property (Inwood, 1997). It is the very closeness of Being that impinges upon our ability to be able to grasp it. As such, it is what is most
distant - ontologically farthest. We can point towards this understanding but not explicitly describe it, as we dwell in it (Dreyfus, 1991). Consequently, attempts to reveal Being are hermeneutic, always from within it and always incomplete.

For Heidegger, this questioning reveals that humans have no definite essence (i.e., no pure presence as objects to ourselves or to each other). He is concerned that the Western philosophical tradition has understood humans as objects, and hence they have become understood as individualised egos or transcendental knowers (Dreyfus, 1991). Implicit in this is that it is mental content (cognition) that gives intelligibility to the world. Heidegger is suggesting that there is a more fundamental relation that is presupposed by this position. This is the world we are born into; one we exist in and do not construct mentally, and which remains as a background that is never explicit. Our ‘being’ (like Being), is both something we already know, but we take for granted, so do not know. Consequently, it is not necessary to propose a mental entity called meaning to account for our acts towards the world (intentionally) as we already know the world (Kearney, 1986).

*Dasein* is ‘in-the-world’ not because it occupies space with other entities but because it continuously engages with other entities within their context. This practical in-the-world engagement creates a ‘world’ rather than a collection of known entities (Inwood, 1997). When practically engaged people are interconnected to their world they are not able to be skeptical about it - as it merely is (Schroeder, 2005). Heidegger proposes that people’s most basic relationship with the world is through *practical everyday activity*. It is through this ‘ready-at-hand’ relation that they implicitly understand Being. Heidegger’s goal is to make this taken-for-granted understanding more explicit. People do not grasp this because they have a mistaken understanding of this relationship and so of their own being. This misunderstanding is based on relating to everything as entities or things (Schroeder, 2005).

Because *Dasein* is not a pure psychological subject and is embedded in a practical world of significances the implication is that *Dasein* is embodied, however Heidegger rarely mentions the body. This is probably because when the body is described in biological terms (e.g., as a product of evolution) it becomes present-at-hand; an object. From Heidegger’s perspective we do not primarily become aware of ourselves or each other as extended bodies (i.e., as organisms) but as human beings engaged in our practical projects. So the body becomes an implicit background and unless something is wrong with it (e.g., we are unwell or we hurt ourselves) it remains inconspicuous (Inwood, 1997). Embodiment, according to Inwood (1997) is a necessary but not a primary element of *Dasein*. In contrast, Merleau-Ponty’s phenomenology explicitly focuses on our embodiment; our carnal immersion in the world. His position is outlined in Section 2.3.
2.2.3 Late Heidegger, Being, and science

If *Being &Time* was an attempt to re-open the question of Being via the human subject in a time dominated by positivism, Heidegger’s later philosophy was concerned with the oblivion of Being in a time of expanding technology. This meant he turned to the history of Being, or how it had been rethought in Western philosophy. However, in common with his early thought this change was still aimed at reawakening encounters with Being (Pattison, 2000). During this development of Heidegger’s thought the ‘clearing’ (i.e., the openness in which Being can appear in its self-manifestation (presencing)) is moved from *Dasein’s* reciprocating, temporal, and interpretative activity to an ‘unveiling’ and a focus in the role of language (*logos*) and contemplation (thinking) (Zimmerman, 2003).

As already alluded to, this shift centrally involved Heidegger’s deconstruction the understanding of Being in Western metaphysics (Foltz, 1995). It entailed recollecting the understanding of Being held by the early Greeks that emphasises being’s hiddenness and self-emergence (Foltz, 1995). This elusiveness plays on the core phenomenological theme of presence and absence. It involves ‘waiting’, as Being is given and not merely demanded or extracted. The withdrawnness or reticence associated with other early Greeks’ understanding of Being means it cannot be described, explained or even thought. So Being itself is always un-thought. Consequently, retrieving the unthinkable being in its withdrawal in entities does not involve calculable thinking that plans and investigates. Thinking can only ever be a response to Being in its self-withdrawal as a poetic (Foltz, 1995). It is because Being is what is covered up that phenomenology becomes paradoxical, as it seeks to uncover that which is hidden, but to do so would mean that it is no longer hidden. Indeed, an unhidden Being is no longer Being (Lawson, 1985).

This poetic uncovering can be understood as a temporal and historical event that is an outpouring of continuing emergence, of which the source can never be seen. This has parallels with Deleuze’s notions of becoming and the role of the actual and the virtual (see Section 2.4). For Heidegger the subtleties of temporality, of Being, unconcealing, and unfolding are all related and framed within language; *logos*. *Logos* is a gathering together that allows entities to be perceived, and so spoken of (Foltz, 1995). *Logos* interconnects Being to the world, the matrix of meaningfulness, which both is and allows language. The world is the meaningful region in which we dwell that is gathered in *logos* (Foltz, 1995). Heidegger argues that the realisation of this occlusion or withdrawal is itself obscured by metaphysics (Foltz, 1995) and consequently can become dominated by other types of interactions with the world (Steiner, 1978). This involves the critical side of his deconstruction of Western metaphysics, one that highlights the limitations of nature as an object; nature as present-at-hand. According to Heidegger the conceptual idea as pure presence is the
feature of Western metaphysics. It is in Plato’s thought that this metaphysics matures and then becomes central to much subsequent Western philosophy (Foltz, 1995). For Plato, the being of an entity lies in its idea or pure rational form (Foltz, 1995). These forms are what grant the visible entity its “constancy, identity and intelligibility” (Foltz, 1995, p. 70). The locus of truth is shifted from the unconcealment of things to the correctness of thought by the apprehender. This leads first, to the subordination of Being to the knowing subject, and second, to the beforehand character of the idea as an *a priori* (Foltz, 1995).

Plato’s metaphysics along with other early Greek metaphysics was appropriated by the Romans and became productionist. In this understanding an entity’s being lies in its ability to be actualized or produced. Metaphysics then focuses on the ultimate ground in the production of beings. A self-producing God became the ultimate ground (Zimmerman, 2003). The emphasis on external causes, according to Heidegger, denatures nature by removing any potentiality from nature itself. This metaphysics of the middle ages prepares the way for modern science through Descartes’ philosophy in which certainty comes initially from human self-certainty. Here, the subject is the absolute ground of truth so entities become objects for the subject. As such they can best be explained, and consequently fixed, as constantly present to subjectivity and mathematically calculable. Presence becomes pre-organised by reason (Foltz, 1995).

Science sets up how nature is to be known by revealing it through a predefined mathematical model. This forces nature to reveal itself as components (objects) in a causal molecular network (Foltz, 1995). Scientists must know numbers as an ‘idea’ before they can count things. This is a way of understanding that involves methods and quantitative analysis, in short, proofs to which aspects of nature must conform before they can be considered as an actuality (Foltz, 1995). This is not to deny that science is a *way* of revealing nature with its own truth, but according to Heidegger it acts to conceal “the fullness of the coming to presence of nature” (Foltz, 1995, p. 79).

Criticisms of Heidegger’s thought have come from within the Continental tradition itself. For example, Jacques Derrida (1930-2004), although accepting Heidegger’s appraisal of Western philosophy as embodying a metaphysics of presence, does not agree with the epochal nature of Heidegger’s understanding and suggests that there never was a single all encompassing metaphysics, but a plurality (Bernasconi, 2004). Derrida had a very broad view of what constituted metaphysics. He did not consider it just a philosophical endeavour concerned with such things as the ultimate nature of reality (ontology) or how we may know it (epistemology). Rather he considered it to relate to the notions embodied in everyday thought, language and experience that enable us to make sense of the world (Norris, 2004). This understanding of metaphysics is consistent with Heidegger’s overall
philosophy to the extent that it highlights our everyday interactions and our ultimate inability to step outside this.

Such a metaphysical plurality is implied by a previous empirical study where I found people in regular contact (i.e., practical and embodied) with the natural world still have understandings of a poetical disclosure of Being, however they may conceive this (e.g., ‘the uncontrolled’, ‘wilderness’, ‘wild animals’) (Freeman, 2002).

2.2.4 Dwelling

As already discussed, for Heidegger, the question of Being is not metaphysical (i.e., as abstract questions: What is the world? What can we know?) rather it is a question of how we dwell. As developed through his later philosophy, dwelling can be understood as a more holistic and poetically based understanding of the more practical being-in-the-world (Wylie, 2007).

In his essay *Building Dwelling Thinking* Heidegger approaches dwelling etymologically. Dwelling comes from the Old Saxon *wuon*, the Gothic *wunian*, and is related to the German *bauen*, which is to build - to remain or stay in a place. *Wunian*, suggests how remaining is to be experienced; this is "to be at peace, to be brought to peace, to remain in peace." (Heidegger, 1978a, p. 351). The word for peace, *Friede*, means the free, and indicates preserved from harm and danger. So to free means to spare and preserve, “that safeguards each thing in its essence” (Heidegger, 1978a, p. 351). The problem of the nature of essences is discussed in Section 2.6.1. Through this process Heidegger traces dwelling to; *living in one’s home, in freedom and peace which leads us to spare and preserve that place*. This homeliness implies that dwelling invokes geographical boundaries of place. It also suggests a letting be that grants leeway for things to disclose themselves and endure. It involves placing limits on our needs to control and organize. However, it should be noted that this does not deny use, but a use without domination. Such a situation is characterised by the term, *techne*. *Techne*, along with *phusis*, is a kind of *poiesis* (poetic). *Techne* involves the bringing forth of something out of itself by the craftsman or artist, as they respond to the possibilities lying in the thing itself. This involves primarily a recognition or sympathy with the thing that is gained through the experience of interacting with it (Foltz, 1995).

Significantly, Heidegger asserts that to dwell (*wohen*) is the way humans are on the earth, as dwelling is the very basis of being-in-the-world. Human being lies in our ability to cultivate and safeguard the earth (Farrell Krell, 1978). But humans always dwell imperfectly. Indeed it is Heidegger’s claim that we have largely forgotten how to dwell. Modernity, through technology, has made us homeless and in this we do not know we are in such a situation (Hay, 2002).
The loss of our ability to dwell is related to a loss of our ability to think. Put simply, thinking is that which contemplates the meaning of things (Foltz, 1995). Heidegger is referring to meditative thinking (poetic) rather than a calculative thinking. Meditative thinking relates to Being or the horizon or field in which beings lie, including ourselves. It is both a proactive and passive concernful relation to Being in its continual flow and outpouring (Foltz, 1995). The loss from use of the original meaning of words (logos) that express these relations, along with lack of meditative thought, means that people become homeless and fail to dwell (Heidegger, 1978).

2.2.5 Heidegger’s limitations

Dwelling became the cornerstone of the Heidegger’s latter thought (Pattison, 2000). Contemporary human geography is a discipline where Heidegger’s notion of dwelling had been taken up as a way of understanding the concept of place (Wylie, 2007). However, there have been concerns over its overly fixed nature that privileges the local. According to Massey (2005 cited in McHugh, 2007), this sets up an opposition between place, as the everyday reality of a harmonious home, and space as universal, abstract and alienating. Further, it has been associated with Romanticism, valuing the rural over the urban and the pre-modern over the modern (Wylie, 2007). In doing this it does not recognize dispersal and interconnections of place into the flows of the wider world. As a response there has been a move towards a more dynamic recognition of place highlighting broader interconnections and relations (topologies), and of movement and becoming. This relational approach has tended either to appeal to ontology’s such as Deleuze’s based on relationality and difference, or, in contrast, take up a cultural geography based on the values that people, as subjects and of cultures, impose upon the world (McHugh, 2007; Wylie, 2007; Wylie & Rose, 2006).

This tension between closeness and distance exists throughout Heidegger’s thought. It lies in the notion that what is closest to us is overlooked, and between the closeness of the everyday ontic (embodied) world and the distance of the ontological. Zimmerman (2003) suggests that Heidegger never managed to adequately reconcile the ontic development and ontological self-manifesting of beings. This in turn led to an overemphasis on the ontological that tended to override concern for

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6 Meditative thinking can involve two aspects. First, an ascetic meditation where the incessant flow of thoughts is halted in order to get beyond them, so as to transgress the cultural and linguistic meaningful reality. This is a waiting whose nature is derived from a reference beyond the human (Anderson, 1966). As such, meditation is always a gift, rather than a subjective expectation (Anderson, 1966). As Karl Jaspers suggests, we only ever get scattered glimpses of that ‘background’ of our existence from which all emerges, as grace or awe perhaps. Mostly, it just overwhelms us and can only be approached or ‘sensed’ in the everyday (Wahl, 1965). Second, as already discussed, Heidegger proposes that the world becomes present to us through language (logos), it is a gift that brings things to presence. The poetic, as language, opens a world as a meaningful matrix; a space to dwell.

7 Both Heidegger’s and relational approaches share the same non-representational base (Wylie, 2007).
entities’ ontic characteristics (Pattison, 2000). Concernfulness or care for the embodied world does have a role in Being & Time. Indeed, Daseins’ primary relationship with the world is practical and concerned, in that Dasein does not first know the world, but cares for its place in it (Solomon, 1984). Caring resolves in part from moods which give a basic orientation to the world (Guigon, 2003). In contrast, in Heidegger’s later philosophy the role of affect was downplayed, along with his criticism of Western metaphysics and science (Engelland, 2008) (see Section 2.5 for further discussion of affect in Heidegger’s thought).

Heidegger’s lack of recognition of embodiment is exposed in how animals are understood in his thought. Peters & Irwin (2002) argue that in Heidegger’s later thought humans are implied as being superior because only they are capable of poetic insights; it is only humans who dwell. While in his earlier thought animals’ behaviour cannot be considered meaningful as they do not possess any culturally derived spheres of significance. Animals are absorbed unreflectively in their environments. It is only adult humans who are fully initiated into these cultural worlds.

Heidegger’s thought set out in Being & Time, his criticism of Western metaphysics and the associated notion of dwelling, underpins the work of other thinkers in the Continental philosophical tradition. Their developments, in part based on Heidegger’s thought, can be used to address and develop the apparent gaps in Heidegger’s philosophy, in particular in regard to privileging the local, embodiment, affectivity, and the role of science. Addressing these gaps allows the development of links between affect, cognition, systems theory, place and local knowledge, and so in turn for developing a post-structuralist based understanding of the interaction of people, place and weka at Cape Foulwind.

2.3 Embodiment

Merleau-Ponty’s phenomenology focuses on embodiment. The body, for Merleau-Ponty is not one thing among other things but has a special status. It is a required condition through which the world can exist. It is also a permanent condition, unlike other objects which come in and out of experience. It is also not normally entirely visible or able to be independently touched so is cannot be fully objectified. One’s body then always holds both subjective and objective elements, it both sees and is seen, it both feels and is felt. This unique dynamic creates a boundary that other objects do not cross. The body has a wholeness that does not just include its spatial aspects but affective ones as well (Hass, 2008).

Merleau-Ponty understands the body as a way of belonging in the world. This belonging is fundamentally expressed in our perceptual gestures and speech (Kearney, 1986). Along with Heidegger, Merleau-Ponty suggests there is no ‘inner’ person, humans are first and foremost in the
world; we only know ourselves in the historical intersubjective world of our incarnate existence with others. We are linked to others by a common embodiment, (and significantly with animals too) as well as through language. Merleau-Ponty proposes that language draws us into mutual experiences so our relationships are not then characterized as subject and object. This is not, however, a proposal that the self consumes the other. Rather, a separation remains, as individual ‘lived bodies’, our experiences ultimately remain distinct (Hass, 2008).

For Merleau-Ponty consciousness and the world overlap. This is what he called the lived body (Kearney, 1986). The lived body is both a physical structure, and lived experientially as a subject (i.e., made of the biological and the personal) (Varela et al., 1991). This is not a dualism but a relation in which the personal is enabled by the biological, while the personal situates the biological. This dynamic is central to Merleau-Ponty’s understanding of our embodied lives (Hass, 2008). The lived body actively engages with the world by anticipating future stimulations. This is not cognitive anticipation but a directedness devolved from the facticity of our corporal existence itself and the possibilities it holds. As a body–consciousness it has the ability to pursue those possibilities not just in thinking but in doing. This is not to deny cognition but to see it as primarily embedded in an embodied and situated existence (see Chapter 4) (Hass, 2008).

The implication is that the human intellect is an elaboration of the deep creativity already existing in immediate bodily perception (Holden, 2001). Indeed, for Merleau-Ponty all theories come out of, and are sustained by, the structures of the perceptual world (Abram, 1996). Theories are not otherworldly (Platonism), innate (Cartesianism), a priori (Kantian), or a straight mechanical impression on the blank mind (empiricism) (Kearney, 1986). This is not naïve realism in the sense that a lack of the use of representations means that we know the world just as it is. Merleau-Ponty agrees that the brain and central nervous system make significant contributions to perception. He sees perception as a synergy between the perceiver (living body) and the perceived (the transcendent world of things) and the field in which they lie. The point of their interrelations is called experience. This could be described as perceptual realism and highlights that experience “is a continual opening to and immersion in a natural world that is not oneself” (Hass, 2008, p. 53).

Since, for Merleau-Ponty, perception always takes place within the larger context of the experiential world as a lived spatial and temporal realm. He also believes it is unable to be reduced to a purely causal field amenable to scientific explanation. This is not to suggest that what science discloses of this causal field is not real. It is rather that scientific explanation makes up a certain perspective that is always partial. This is because it requires breaking phenomena up into their constituent parts so the wider context (i.e., field) that they lie within is largely ignored (Hass, 2008). In addition, this process always involves making a choice about how this dissection will be
undertaken. In doing so it ignores other possible ways of dissecting, or perspectives on, the phenomena. This means that perception cannot be exhausted by analysis or explanation (Hass, 2008). Consequently, Hass (2008) argues that neurological explanations do not cover everything about perception and that a phenomenological account will still be required.

Merleau-Ponty’s thought shows how phenomenology can be developed to highlight embodiment. Merleau-Ponty’s concern, in common with Heidegger, is our situated everyday experience. In this manner Merleau-Ponty’s lived body has much in common with Dasein and his development of this structure is accepted. Furthermore, Merleau-Ponty develops these insights further in his later work towards a fundamental ontology that has some parallels with Heideggers’ later thought. This is discussed in the following section.

2.3.1 ‘Flesh’

Merleau-Ponty develops these insights further in his later work towards a fundamental ontology. This change comes partially from the influence of Heidegger’s later work and requires more expressive forms of language to attempt to show it. In doing this he develops the concepts of the ‘flesh’, écart and reversibility to show this ontology of the perceptual world (the visible). He also relates this to the invisible world of ideality and language (Hass, 2008).

What Merleau-Ponty hopes to elucidate in his investigation of the visible is our world of perceptual faith. In other words, the very perceptual world we exist in which lies beyond or below belief; our and the world’s plain thereness. In this way he is not trying to reveal cognitive attributes of perception or belief. This creates the problem, like Heidegger’s difficulty of expressing Being, of theorising this paradoxical web in which we are both in and out (Hass, 2008). Écart is the term he develops to describe the movement in living perception between the ‘I’ who perceives enveloping those things I perceive, while at the same time they envelop me (Hass, 2008).

Merleau-Ponty argues that we should not try to resolve these paradoxes of the lived perceptual world into oppositions. Logically they are fuzzy, being neither entirely one nor the other. Attempting to resolve them merely deforms them and so never captures them. Écart shows the opening in which relation lies within separation. As such, écart is an immanent notion; it reveals a breach in the folding over of the seer within the seen and seen within the seer, which allows them to occur. The folding over or overlapping of living bodies with the perceptual world itself Merleau-Ponty calls reversibility (or sometimes chiasm or intertwining). Reversibility goes hand in hand with écart being two aspects of the same condition and describes the backward-forward flow or exchange in perceptual interaction linking what is thoroughly different (Hass, 2008).
Hass (2008) suggests that Merleau-Ponty’s development of écart as a relation that lies within separation, is an understanding of difference that has been influential in subsequent developments in Continental philosophy. For example, it arises in Derrida’s difference, which also highlights the roles of spacing and relation within spatial and temporal movements. However, their philosophical styles are quite different. Derrida develops Heidegger’s deconstructive approach, while Merleau-Ponty utilized Heidegger’s more expressive ontological method. Given Heidegger’s use of both approaches (i.e., his deconstruction of Western metaphysics in tandem with his poetic reminiscence of Being) there appears to be no reason that both approaches cannot be continued to be used together (Hass, 2008).

Just as important for this study is the link between Deleuze and Merleau-Ponty. This link is exposed in Merleau-Ponty’s development of the flesh. The flesh is used by Merleau-Ponty in a number of ways. First, as the carnality or physicality of the world, which is best described as the term ‘matter’. Second, as ‘reversibility’, as discussed above. Third, as a facet of Being, where flesh is a component of experience sitting with matter and idea. In the first instance this latter definition appears to have some relation to Heidegger’s notion of Being. However, when overlapped with the others as the carnal, reversible folded over world of écart, Hass (2008) suggests the flesh is closer to Deleuze’s ideas on multiplicity (see Section 2.4). Merleau-Ponty’s flesh includes the multidimensionality, immanent flowing variation, and the linking and de-linking of heterogeneous elements central to Deleuze’s multiplicities. Both are attempting to think and refashion thought beyond dualism and pure identity (Flynn, 2008). There are, however, differences between their positions. The most significant one appears to relate to Merleau-Ponty’ notion of reversibility, as Deleuze’s multiplicities include radical disruptions and breaks that undermine the more stable folding reversibilities in Merleau-Ponty’s thought (Hass, 2008). Deleuze’s philosophy is discussed in the following section.

2.4 Relation and phenomenology

Giles Deleuze is a central figure in the mid-late 20th century Continental philosophical tradition. His thought is nuanced and difficult due to his frequent use of allusions, neologisms and his wide ranging subject matter. This is in part, in common with Heidegger, due to his intent to unsettle his readers and force them to rethink their presuppositions (Smith & Protevi, 2008). In addition, his thought evolved through his career and although it basic focus never changed it was expressed in different ways in his different works. This development is consistent with his philosophy itself. The two books he authored in conjunction with Felix Guattari, Anti-Oedipus (1983) and A Thousand Plateaus (1987), are of interest to this study as they engage with the minor non-linear sciences of
systems theory and associated self-organisation (DeLanda, 2002). Deleuze’s thought more generally is relevant to this study as it allows an alternative approach to immanence from phenomenology. This discussion will briefly set out his philosophy, in particular, its relation to phenomenology.

The primary concern that drives Deleuze’s thought is that some Western philosophy (i.e., Platonism) proposes that reality is made up of fully formed objects containing an essence (transcendent forms) that makes up their identity (DeLanda, 2002). Deleuze was concerned first, that these approaches produced a priori unified objects (objects here being physical, mental or conceptual) and, second, that it did not fully account for their genesis, only their condition. (Smith & Protevi, 2008). Deleuze’s proposal is that the genesis of objects is through difference (i.e., that identity is a derivative of difference and not an a priori) or what DeLanda (2002) calls ‘dynamical processes’. Difference for Deleuze involves the ‘ground’ for material possibilities in contrast to Derrida who was concerned with difference in regards to the ‘ground’ for conceptual possibilities (Linck, 2008).

This ground for Deleuze is a pre-objective, pre-individualized immanent plane which he calls the ‘virtual’. The virtual consists of ‘constructing’ processes “that assembles ‘raw matter’ into entities with more or less consistent identities/properties [called the actual].” (Palmas, 2008, p. 9). The virtual is a plane of pure difference and a power that contains no transcendental objects or essences. The transformation from virtual to actual is ongoing; they are not separate ontological realms but processes of becoming and flux. The virtual is not a potential that then has existence added to it to become real-ised. The virtual as is fully real as an undifferentiated condition (a multiplicity) actualized in real experience (Schroeder, 2005). The emergence of forms from immanent processes links with the natural scientific concepts of morphogenesis (Palmas, 2008).

Multiplicity is the term used throughout Deleuze’s work to replace the notion of essence, or the commonalities of natural kinds of things (e.g., species). Multiplicities as the potential, or states of possibility, lying in the differentiated virtual can be expressed as an orderliness in actual objects and events (assemblages). In particular, it relates to their genesis or morphogenesis through common and immanent material processes. Deleuze utilises the resources of mathematics, differential geometry and dynamical systems theory to develop the notion of multiplicities (DeLanda, 2002). The details, particularly in relation to systems theory, are discussed in Chapter 3. It is in this respect, along with his materialism, that Deleuze reconnects post-structural thought with the sciences.

Deleuze calls his ultimately materialist ontology, a transcendental empiricism (Smith & Protevi, 2008). The transcendental in transcendental empiricism needs to be separated from the transcendent. Transcendence is an exteriority, something lying on the outside giving a metaphysical foundation for knowledge and being (e.g., God, Being, Nature, Truth or the subject). Deleuze calls
these ‘planes of transcendence’ when they are used to explain and justify all life. Deleuze, in questioning transcendent foundations also saw the positive side. This being that the development of such foundations exposed a creative side of thought itself. Deleuze, however, suggests these creativities lie within a ‘plane of immanence’. This involves folding over within the world that creates immanent outsides but no true exterior. The production of foundations lie within these foldings, so always remain immanent (Colebrook, 2002).

Deleuze’s philosophy radicalizes phenomenology. He “proposes a radically non-subjectivist account where the existence of vital non-personal and non-human affects, forces and singularities supersede rather than supplement being-in-the-world and dwelling” (Wylie 2007, p. 202). In this non-subjectivist account he further develops Heidegger’s critique of Western metaphysics. Deleuze’s empirical position is based on the givenness of experience itself and the formation of the subject from that experience. Through experience we develop ideas that extend experience. This is embodied because it is sensory and involves an elaboration through ideas into a self and a causal world. In his critique of phenomenology, Deleuze asserts that phenomenological appearances presuppose only a human world, when there is a proliferation of experiences (e.g., other organic life). This proliferation of experiences arises from the virtual and is actualized as experiencers (Colebrook, 2002).

In his later work Deleuze represents this ontology as an empirical hypothesis through the model of the rhizome (Deleuze & Guattari, 1987). Rhizomes are processes of growth where branching occurs in an endless divaricating manner. There is no primary trunk, branching can occur anywhere, independently in multiple directions, and unpredictably. There is no hierarchy or single goal, as rhizomes respond to multiple external stimuli, growing towards them, away from them, or around them. They cannot be integrated into a larger whole and there is no beginning or end to their interchangeable parts (Schroeder, 2005). The rhizome is then an actual (empirical) reflection and manifestation of the virtual. For Deleuze the ‘power’ that drives this rhizomatic proliferation is the affect of desire. The role of affect in Deleuzes’, and other Continental philosophers’ thought, is briefly discussed in the next section.

### 2.5 Affect in Heidegger, Merleau-Ponty, Henry and Deleuze

Affectivity is a general term covering a number of felt psychological phenomena. These include; emotions, which are externally observable behavior related to feelings about something; Moods, which are low level enduring feelings, sometimes objectless, which colour or tone our disposition; Passion, which is an intensified mood about an object; and, feelings as subjective, internal bodily events (Cataldi, 2008).
This section considers affectivity in relation to a number of thinkers. This will set a background to the discussion of emotion in Chapter 5 and its relation with cognition. This is important for this study because affect is an important element in notions of dwelling, place and local knowledge.

A fundamental element of being-in-the-world in Heidegger’s early thought was care, of which the affective category of mood was central. For Heidegger, our moods express our basic attunement to the world. This is a reflection of both our situation at any particular time and also articulates our throwness in an already existing culture and history. We are never without moods and even a disinterested attitude carries with it a particular mood. Moods are not considered just as subjective overlays onto things but as a qualities of being-in-the-world and so lie before any separation between subject and object, and consequently have a role in disclosing the meaningfulness of the world. They do this first by revealing the fact of our raw existence. Second, they also reveal the wholeness of the context of our existence. Third, they give meaningfulness to things through orientating us towards the world in certain ways (Guignon, 2003). Heidegger’s interest in affect, through the use of moods, in his earlier work tends to become watered down in later developments. The general notion of an expectant and reticent human waiting for the giving of Being still, however, has a significant affective ambience or tonality.

Another phenomenologist, Michel Henry (1922-2002), espouses a much more radical affectively based philosophy. It is an immanent phenomenology where phenomena and life are grasped only through affect. Indeed, phenomenology itself is affective (i.e., it investigates how we feel about things). The only subject of his philosophy is the living subjectivity, which is to say the real everyday material life of living individuals. Henry’s focus is not on what it is to be (i.e., Dasein) but what it is like to be. Life is thoroughly affective and only refers to itself, rather than to Being-in-the-world. This sidesteps Heideggers’ later work also, rather than ‘waiting upon’ Being we now always feel it in the everyday; The warm sun, the touch of a hand. For Henry Life surpasses Being. Life is a continual arising from within itself. Consciousness and cognition extend out secondarily from affect. Henry’s position is that all cognition is affective, “‘rationality’ is simply an honorific term for certain dominating and socially reinforced affects.” (Mullarkey, 2006, p. 67).

This produces a problem of normativity and so in the roles of description and prescription. This is a central problem for phenomenology generally as the phenomenological method is both strongly descriptive, with some approaches to it also involving a normative or critical aspect (Schroeder, 2005). In Henry’s thought this tension is partially resolved. Description is not undertaken as an observer (i.e., via a conscious pole (subject)) but from being immanent within the world. Description is reconstituted away from a descriptive metaphysics. It is description that always
changes the world through its immanence. Every affective interpretation changes the world; it transforms it but not through judgment. For Henry, every affectively derived thought that ‘lets be’ transforms the world as much as active thought that attempts to judge. The individual ultimately ebbs and flows with the complexity of Life and affect; There is no position of ultimate judgment; Judgment is swallowed back up into the everyday which is a transformation of metaphysics and world beyond judgment. Ultimate reality lies in this flux not in moments of revelation or authenticity (Mullarkey, 2006). Henry is useful for bringing affect as central to phenomenology, an aspect, like Merleau-Ponty’s embodiment, that Heidegger’s phenomenology does not address centrally.

Merleau-Ponty’s understanding of affect was developed through his career. Initially, it was considered as part of the structure of behaviour, this was developed into being part of the lived body, and finally into an element of the carnal associated with écart and reversibility (Cataldi, 2008). With his emphasis on the fundamental notion of our immersed, living, embodiment, Merleau-Ponty does not see emotional experience as just a belief or a physiological response. This is because the lived body always underlies purely cognitive or physiological acts. Here emotions are manifest as part of the living conscious body arising at the junction of the biological and personal. It is because of this that they have such a rich overwhelming nature (Cataldi, 2008).

Affect is intertwined with the whole synaesthetic perceptual body. In common with Heidegger and Henry, affects for Merleau-Ponty are what we live rather than know, and so we are always in an affective state of some sort. They are part of our embodied relations to the world. In this intertwining or folding over; in the overlap between individuals; in the overlap of sensible with the carnal, affects are sometimes diffuse, not always clearly defined. These semi-discernible affects Merleau-Ponty calls carnal meanings. They reflect our very basic carnality. For Merleau-Ponty we do not possess affects, rather they possess us (Cataldi, 2008). This encompassing nature has some parallels with Henry’s ontology of affect. Henry, however, always starts from affect while Merleau-Ponty starts from our perceptual embodiment in the world. Affect in Merleau-Ponty is part of the flesh of the world but it is not the very basis of Merleau-Ponty’s ontology. Also the conceptual has a role that is not just secondary and derivative as it is in Henry. Rather, it is, along with affect, part of the carnate lived body. Affect and cognition are not separable (Cataldi, 2008).

Affect is more central to Deleuze’s thought than to Heidegger’s and Merleau-Ponty’s. Affects are not personal feelings or perceptions but pre-personal powers that are separated from bodies that experience them (Colebrook, 2002). In this sense, affect may be understood as that through which the subject and object arise and become possible, hence although affect includes human emotions it is not reducible to them (Wylie, 2007). These pre-personal powers are linked with conceptual singularities; elements that organize and make connections but are not ‘thought-like’
concepts but are pre-personal feelings and, perhaps foremost, have the power to disturb synthesis. For example, Deleuze claims the presentation of affect in art is an important way opinion is disrupted, or new experiences developed through singularities disordering everyday connections (Colebrook, 2002).

For Deleuze (and Guattari) the most important affect is desire. Although a disruptive role for affect is highlighted above, desire is considered the power of connection. Desire creates relations between entities called desiring-machines. These relations are transient and interactive and can operate separately from their originating bodies. Parts of a person’s body interact with and contribute too many desiring-machines in a complex manner connecting it with other bodies. Deleuze suggests desiring-machines, because they actualize bodies, are the proper components of study for the psychological and the social (Schroeder, 2005). The power in desire is not understood as repressive but expansive, it expands desire and, hence, the connections that augment life. Social wholes channel desire to produce regular interests as collective forms of desire (Colebrook, 2002).

Common to all these thinkers is the immanence of affect. The role of affect in Heidegger’s philosophy is heightened by the other theorists. This development of Heidegger’s understanding is accepted, and throughout the rest of the study the importance of affect is highlighted. As will be seen in Section 2.6.3, this will be broadly a hybridisation of Deleuze’s desire and Merleau-Ponty’s more reticence understanding of affect. This revolves around the issue of immanence and transcendence.

2.6 Immanence and transcendence

The preceding sections set out various responses, and possible alternative paths, to some of the limitations in Heidegger’s thought. These, in particular, relate to embodiment, affect and naturalism. Heidegger’s phenomenological thought is complex as are the phenomenology of Merleau-Ponty and the post-phenomenology of Deleuze. This makes the task of reconciling, or bringing together these alternative paths towards an affective, embodied, naturalistic dwelling a fraught one. As Dillon (2000) notes, the longer the list of relations the more difficult it becomes to keep thinkers under the same label due to their influences and developments. Certainly, common to all of them is that thought is constitutive rather and representational. Their focus is on developing thought in the world rather than about it.

Following this line of immanent non-representational thinking, Dillon (2000) argues that the difference between thinkers is not necessarily best developed through directly comparing their

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8 A body can be anything that is ‘actualised’. For example, an idea, a mind, a biological entity, a collectively etc (Mullarkey, 2006).
definitions but rather through what ethos or form of life they embody. Ethos is a concern for ethics; of how we should live. It does not have its origin in calculative thought (and so pre-ordered by morality), and its associated concern for epistemology, but in ontology. It is a question of how we are in the world (epitomized by Heidegger’s notion of dwelling). Ethics is contingent on relations of the personal, natural and social which vary in space and time. Thinkers of immanence are always ethical thinkers. In general, Heidegger and Henry posit a reticent ethos, while Deleuze’s and Merleau-Ponty’s thought is more proactive and engaging. However, because I am not primarily addressing ethics in this study, rather the potential role of their thought in systems theory and the associated FCM and IBM methods of this research, I have attempted to set out the some of the differences in their approaches. Key to this is the role of immanence and transcendence and its challenge to phenomenology. This is highlighted in the following sections.

2.6.1 Immanence

As already noted, common to all these thinkers are that subjects are immanent in the world. This raises the problem of immanence and transcendence in relation to phenomenology. This has already been touched on in the discussion of both Henry’s and Deleuze’s immanent philosophies. Henry considers phenomenology a reflexive affect of Life, while Deleuze considers the experiencing subject and so phenomenology as catholic, and where experience precedes the subject. This is important because it relates to what phenomenology’s limits are. For example, whether it is descriptive or essential, as well as the problem of its genesis. These concerns are discussed further in the rest of this section.

According to Deleuze, in recent philosophy transcendence and immanence have been inverted; immanence is now primary and in phenomenology a transcendent element is found and spread everywhere as subjectivity as a way to escape its solipsism (Lawlor, 1998). Consequently, a residue of transcendence is left as the subject, to which phenomena are considered to be purely given. So while phenomenology’s concern is our immersion in the world (our immanence), Deleuze considers that the givenness of the subject (or consciousness) undermines this. Immanence forces phenomenology to turn upon itself. Indeed, when applied to phenomenology itself, as a mode of consciousness (a phenomenology of phenomenology), a regression develops that resists phenomenology’s definition (Llewelyn, 2003). It is a tension that lies in the notion that phenomenology posits an element of absence in the presencing of phenomena, including consciousness itself. Because of this, essences (as transcendent elements) are unknowable to the phenomenological consciousness.
Heidegger was aware of the problem of the subject’s pure presence to itself as an object. Consequently, he considered the subject as a hermeneutic retrieval and reminiscence where the subject along with Being is an unveiling and becoming always containing an absence (Schrag, 1986). Following Heidegger and Merleau-Ponty, some recent phenomenologists (e.g., Sallis, 1986; Llewelyn, 2003) have also attempted to address this problem of immanence.

Table 2.1 gives an overview of the relationships between the various theorists’ thought. Heidegger, Merleau-Ponty, Sallis (1986) and Llewelyn (2003) are suggesting similar understandings expressed in different ways. They are implying the role of phenomenology is to attempt to reveal ‘essences’ within the limitations and knowing produced by our immersion. Essences in phenomenology and consequently phenomenology itself, are both concrete and contingent. Concrete in that they are known but cannot be fully explicated; Contingent because they lie in the absence generated by a horizon.

These positions all involve a ‘de-centreing’ of the subject. Schrag (1986), in his pragmatist-influenced development of Continental philosophy, proposes such a de-centred subject based in praxis (action, expression and communication), which he argues precedes any ontological account of existence or the subject. Schrag’s (1986) subject is not primarily one made up beliefs and applying meaning to the world but exists in the flow of the everyday as a speaker and actor. Schrag (1986) concentrates on the phenomenological structure of presence and absence where temporality is seen to be the core element undermining presence as change. Schrag (1986) is still proposing an identity (self as presence) which he calls a “responding centre” (p. 149) over which change occurs. The de-centred subject for Schrag (1986) is temporal, embodied and multiplicious. Consciousness does not possess itself. It arises in the “hermeneutic flow of culture in which the subject is embedded” (p. 167), rather than through Deleuze’s ontological multiplicities.

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9 In phenomenology, absence always exists as a background within which things can appear, but does not appear itself. This background or horizon is at one level the emergent infinite sum of the profiles of all things (i.e., their essences). To make the horizon present would rob the world of its character and the ability of things to come to presence as they would be overwhelmed and so indiscernible (Sallis, 1986). Sallis (1986) suggests - following Merleau-Ponty - that the horizon is already known by us through our essential physical immersion in the world. Phenomenology then involves a ‘reflexive adherence’ to things and a ‘reticent discerning’ of the background horizon. Our immanence and pre-knowing requires that it is through the world that the thing is then given back to itself (as a subject), as mediation with itself, of self through world; a type of reflective recovery (Sallis, 1986). From another perspective, Llewelyn (2003) suggests that because phenomenology can be considered a descriptive science its findings need not be essences understood as final ‘truths’, but could be considered more flexibly as an aggregation of features that produces the thing in question. Phenomenology as a concept can itself be considered as such an aggregation with various approaches in the tradition emphasizing different groupings. This produces a paradox in the concept of phenomenology and highlights that essences as aggregations can include contradictory aspects. Llewelyn (2003) argues that this sort of conceptual openness only undermines logic if it is considered as requiring formal oppositions. An example of the sort of logic that allows these essential aggregations is fuzzy logic (see Chapter 10).
Although Heidegger’s position lacks Deleuze’s materiality both are developing and stretching phenomenology, and possible parallels can be seen Heidegger’s concern for Being identified as an unveiling and becoming rather than a pure presence, and Deleuze’s concern with difference rather than identity. The difference between them is that for Heidegger Being stands ‘outside’ and gives to the physical world (although it always remains hidden), so he is not an ontological monist. Deleuze’s ontological monism suggests everything is physical process, everything is to exist within the physical world; there is no ‘outside’. However, there can still be inside/outside dichotomies within this (e.g., representations, emergent properties), but these would have to be finally all constituted of the same stuff (i.e., as matter) (Mullarkey, 2006).

Table 2.1 Overview of the relationships between the various theorists’ thought in regard to immanence and transcendence.

<table>
<thead>
<tr>
<th>Immanence</th>
<th>Transcendence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deleuze</td>
<td>Relation (difference)</td>
</tr>
<tr>
<td>Phenomenology</td>
<td>Absence</td>
</tr>
<tr>
<td>Heidegger</td>
<td>Hermeneutic retrieval - Unveiling</td>
</tr>
<tr>
<td>Merleau-Ponty</td>
<td>Lived body - Ecart</td>
</tr>
<tr>
<td>Sallis (1986)</td>
<td>Reticent discerning – Reflexive adherence</td>
</tr>
<tr>
<td>Llewelyn (2003)</td>
<td>Fuzzy aggregations</td>
</tr>
</tbody>
</table>

Both Henry and Deleuze are concerned with processes and how immanence relates to change. For Deleuze this relates to material flows and for Henry how Life flows affectively. However, for Deleuze these actual flows or processes require a virtual background that specifies them. For him actual molar realities are underlain by a plane of pure immanence (see Section 2.4). This is not the case for Henry whose affective processes are conditioned by themselves. Each philosopher regards his own immanent projections as the actual and the other’s as a virtual illusionary transcendence (Mullarkey, 2006).

This highlights the difficulty for philosophies of immanence in critiquing other positions, as by their own definition there is no outside to do this from. The same concern has been expressed about post-modern thought generally (Lawson, 1985). Indeed, it is not even clear that they can state there is no outside, no transcendence, without using the certainty associated with the outside or transcendence. Accordingly, immanence creates a number of problems. First is the problem of discourse, or how we are to describe or talk about immanence. Second is the problem of the instability of infinite regression (e.g., the reflexivity created within language through its ability to talk
about itself) (Mullarkey, 2006). Finally, it creates problems of creating consistent epistemologies and ethical positions.

2.6.3 The non-relational

Because of the problems of immanence in post-structuralism, according to Lawlor (1998) there has been a renewed interest in the subject and, consequently, phenomenology. In addition, is the influence of Levinas’s ethical requirement for an Other (Lawlor, 1998). The thought of Levinas focuses on the otherness of the Other, of a radical non-relationality between self and the Other. Levinas critiqued phenomenology's emphasis on subjective experiential understanding of the world which according to him appropriates others into a reflection of our selves so denying the other (Hass, 2008). Arguably, this problem arises more significantly in Deleuze’s thought. This is because rhizomatic interconnections break down the Other, as the self and Other connect and re-connect.

In this respect, some recent commentators see an inadequacy in pure materialist relational ontologies (e.g., Deleuze). Sallis (1986) and Llewelyns’ (2003) phenomenological approaches allow a way to conceptualize post-structural insights in phenomenological terms. Another response, aimed at addressing the role of affect, is Harrison’s (2007) notion of the non-relational. Harrison (2007) argues for a non-relational beyond the relational. He suggests that in the development of biophilosophy, materialist ontologies and the concentration on the relational, the fissure relating to withdrawal, absence and distance has been overrun or lost. This fissure, according to Harrison (2007), is the non-relational. It lies in the gap between relations, in the separation that enables desire, care and creativity. In Deleuze’s thought the relational or difference disrupts any closure in identity (DeLanda, 2002), so too the non-relational resists the full closure of the relational. Indeed, it is the very openness of the relational that affirms the non-relational as it disrupts pure and static relation, while also setting the relational in motion (Harrison, 2007). For Harrison (2007) the non-relational is a negativity because he understands the relational as a positive philosophy highlighting processes of creativity, desire, energy and networks. He argues that this positivity only gains significance against tragedy, from which it is inseparable. He suggests some types of affect cannot be spoken or said (e.g., suffering) and this exposes the non-relational.

Harrison (2007) questions Deleuze’s impersonality through a non-relationality (absence) embedded in relation that arises as personal affects. The non-relational reclaims the subject, a reticent passive subject where affects arise unbidden. For Dillon (2000) the ethical claim of post-structural thought lies in this non-relational being ‘held-toward-another’ (i.e., in relation with them but not consuming or consumed), along with its inability to be anticipated or calculated. So the other exists with the relational. These aspects (affects) are not able to be themeised in corporeal existence,
so non-relationality lies with relationality as the Other and affect in a passive subject. This has commonalities with the phenomenological approach outlined in Section 2.6.1 that de-centres, but does not entirely lose, the subject. This in turn allows for an Other, without appropriating it.

This is a return to an affective and embodied subject, but a de-centred one, as affects arise unbidden in our bodies as a reticent poetic. Heideggers’ poetic is broadened out to embodiment and affect and not just language. In the broader sense, Meleau-Ponty’s thought is poetic as our body expresses the world as that is fundamentally how we are in it. Dillon (2000) includes Deleuze’s thought under the poetic. However, Deleuze is not poetic in Heidegger’s manner of seeking “to have being ‘show itself’ through our own way of being, or through a preparation that we might make for being’s own self-showing” (Linck, 2008, p. 522). Deleuze’s method involves an engagement with the physical sciences which divulge ways of being that become channels for developing a metaphysics (concepts) to explain them (Linck, 2008). Deleuze materializes Heidegger’s notion of the poetic.

This combination of the relational and non-relational reinforces Heidegger’s dwelling as place as it now becomes embodied and affective. Being still contains relation and pre-personal elements but is always impinged on by affects of the non-relational ‘unground’, which we wait on but not just cognitively. The power of life to connect (relation) lies as an essential counterpoint to this passivity. There is an ongoing disclosure not just a Heideggerian reminiscence but one that happens anyway to everyone in the everyday. Such ‘waiting’ is fundamentally affective. Following Merleau-Ponty and Deleuze the actual (ontic) world is not a degenerate one, scientific understanding is important and is not just a covering up but complementary to the phenomenological.

2.6.4 Conclusion

The position developed in this chapter focuses on concerns over the implications of transcendental structures and the role of immanence in addressing this. In summary, this involves, centrally, a consideration of Heidegger’s thought, including its weaknesses and how they may be addressed. In this respect, it uses Heidegger’s insights into dasein (practical everyday world) and development of dwelling (including his critique of Western metaphysics). Drawing on their commonalities, it incorporates with this Merleau-Pontys’ notion of embodiment and Deleuze’s critique and development of phenomenology, to gather together a materially based, embodied, affective notion of dwelling that invokes a de-centred subject (agent) based in the everyday. The retention of a de-centred subject allows for a measure of ‘transcendence’ be it through embodiment (Merleau-Ponty), affect (Harrison, 2007), or practical everyday activities (Heidegger). This avoids

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Merleau-Ponty’s later ontology of the perceptual world supports the non-relational lying with relationality in ecart’s fuzzy gap in perception between relation and separation.
falling into a purely descriptive phenomenological approach. In this constructivist account the subject is immersed (immanent) in-the-world, and a production of it - as embodied practice.

This is supported in some recent approaches in human geography that use a style of “writing that recognizes both the phenomenological understanding of self as embodied and in-the-world and post-structuralist understandings of selfhood as contingent, fractured, multiple and culturally constituted” (Wylie, 2007, p. 214). This is explored through the non- or pre-subjective affects of Deleuze. This includes a notion of a charged background of affective capacities and tensions acting as a catalyst for physical actions, as well as signaling the non-rational or more than rational. This denotes the shifting mood, tenor or colour of situation and places.

Crucially, these ideas will be used in the rest of the study as the basis for interpreting the relationship between people and weka. In Chapters 4 and 5 these ideas will be expanded and built upon as they applied to cognitive science and emotion. In Chapter 6 the commonalities between this approach and Ingolds’ (2000) thought on place and local knowledge is outlined. Before this, Chapter 3 will relate the position developed to complexity science and, in particular, systems theory. Systems based theoretical approaches respect the ontic development of entities and their self-organising properties. They also allow for the emergence and autonomy of an organism as a whole (embodied, affective) (Kauffman, 1995; Thompson, 2007). Systems theory will also be considered in relation to Deleuze’s ontology with which it has much in common.
3 Systems

3.1 Introduction

This chapter integrates and links the philosophical position developed in Chapter 2 with systems theory. This is undertaken on the premise that systems approaches highlight a notion of immanence – that subjectivities are immersed in either hierarchies of systems or networks. Systems theory supplies a way to approach and model such an understanding.

In the first two main sections (Sections 3.2 and 3.3) of this chapter I give a brief background and historical overview of the systems approach. I then discuss the development of systems thought and its relation with systems science. The two are often separated by differing epistemologies and ontologies in line with the traditional separation between the natural and social sciences. An integrative approach is proposed. In the following section I discuss the relation of Deleuze’s ontology of neo-realism in relation to systems following Delanda (2002). In the next two sections I discuss the important systems science ideas of self-organisation, dissipation and complex adaptive systems as they relate to ecology. Before moving onto socio-ecological systems, the problems of conceptualising the social within systems thought is explored with reference to Structuration theory, Actor Network Theory (ANT), and Deleuze’s thought. Finally, socio-ecological systems are discussed with particular reference to Resilience Theory.

This discussion flows into the following three chapters on cognitive science, emotion and place. In these chapters the use of systems concepts is a way to consolidate these subjects and draw them into the overarching idea of a socio-ecological model using FCMs and an IBM that are used in this study.

3.2 Science and systems

In general, science is an approach toward acquiring and accumulating knowledge; it assumes natural phenomena are characterized by order and seeks to discover and explain that order (Checkland, 1981). This is achieved through the use of a reductive approach, sometimes called Newtonian science which assumes an underlying order expressed as pre-formed bodies that interact mechanistically and causally (Dillon, 2000). In association with this the two other central attributes in the practice of science are reliability and refutability. The second, according to Karl Popper (1902-1994), is what sets science apart from pseudo-science (Crotty, 1998).

Although Mullarkey (2006) argues there are naturalistic threads in phenomenology - particularly in Merleau-Ponty’s and also in Deleuze’s post-phenomenological philosophy - as has
been discussed in Chapter 2, Continental philosophers have criticized certain aspects of the scientific approach. The open-ended philosophies of Heidegger (Wheeler, 2005), Merleau-Ponty (Hass, 2008) and Deleuze (Colebrook, 2002) question the tenets of objective knowledge as being ahistorical, value-neutral and cross-cultural. Questions about the scientific method have also arisen from within natural science itself. These developments suggested, first, that scientists, in the act of observing, affect what they are observing (e.g., Heisenberg’s (1901-76) uncertainty principle). Second, is the assertion that scientists are actively constructing scientific knowledge within the limitations of current conceptions of reality, rather than discovering the given laws of nature (Crotty, 1998). Indeed, Thomas Kuhn’s (1922-96) work on the development of science suggests that even when faced with conflicting evidence scientists tend to continue using established theories11 (Kuhn, 1962). Paul Feyerabend (1924-94) extends this idea further, suggesting that an anarchic character is necessary for the advancement of scientific knowledge. Chaos and opportunism are the most important functions of scientific theorising. Under this premise science should be encouraging the development of alternative theories (counter-induction), for example, from religion, philosophy, and other cultures (Crotty, 1998).

Arguably, these issues are in part created within science by the realization12 of the complex and interwoven nature of reality (Francois, 2006). In order to cope with this complexity, science has been broken down into a number of hierarchically ordered disciplines concentrating on certain aspects of the world, each one using the elements of the level below as a foundation to build upon (Checkland, 1981). There are fundamental continuities between levels in organizational processes and structures. However, due to functional, physical and behavioural differences at different levels, and along with increasing complexity at higher levels, each discipline has developed various epistemologies and methodologies. The increased complexity at higher levels increases variability and reduces predictability along with a decreased ability to undertake replicable experimentation (Clayton & Radcliffe, 1996).

The problems created for science by complexity have stimulated the development of the sciences of complexity. This challenges the reductionist approach of Newtonian science by proposing phenomena that are fundamentally relational and contingent and consequently highly complex. Relations between them are not mechanistically causal but involve a new type of causality that is probable and not deterministic. Developments in the bio-sciences show a range of ways of how

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11 Some disciplines may not fit into this model of development. Indeed, a characteristic of the social sciences throughout much of the 20th century has been one of largely irreconcilable, multiple, and competing paradigms (Therborn, 1994).

12 These issues could be seen as a result of the developing realisation of the complex and interwoven nature of reality and are also part of the cause of this understanding.
relating might occur (e.g., infection, mutation, symbiosis) (Dillon, 2000). Complexity science attempts to order relations between phenomena and addresses behaviour that is neither random, nor ordered and predictable, but lies in between (Thompson, 2007).

This post-positivist science is made up of fields such as cybernetics, chaos theory, systems theories (e.g., dynamical systems theory, complex adaptive systems), and non-linear mathematics. Significantly, they re-conceptualise the nature of complexity as much as develop new methods to model such interactions. Consequently, at its more radical, complexity science reconsiders the metaphysics underlying science (Capra, 1996). Continental thought is important to this reconceptualisation as, directly related to complexity, it understands relationality as the key feature of all phenomena (Dillon, 2000).

Ecology is a science that has been at the forefront of a turn away from a reductionist and mechanistic mode to a more holistic or organic model, particularly with the use of systems theories. This is because a reductionist approach when applied to ecological processes produces empirically underdetermined theories (Schrader-Frechette, 2001). However, the extent of this shift is still in dispute and some commentators, such as Kidner (1999), suggest a mechanistic view is still dominant in the biological sciences, including ecology. Others, however, suggest that complexity concepts are beginning to be extensively adopted (Dillon, 2000).

Another issue is the extent that complexity science (and systems theory in particular) is intended to supplement reductionist science rather than replace it. Checkland (1981) suggests it does and in two ways: First, it addresses the problem of complexity by conceiving reality as an interacting hierarchy of wholes. This involves invoking a set of principles which attempt to encapsulate non-reducible properties associated with certain levels of complexity as wholes, and the interaction between these wholes at various scales. Second, it attempts to act as “a unifying analytical and explanatory framework throughout the hierarchy of nature” (Clayton and Radcliffe, 1996, p. 17), and so act as a set of concepts that can unify knowledge across disciplines (Thompson Klein, 2004). As such, systems, or a systems approach, can be considered a meta-discipline or a transdisciplinary theory (Francois, 2006).

Transdisciplinarity involves the recognition of the need for a new common mode of knowledge that bridges the social sciences, humanities and natural sciences (Capra, 1996). The very realisation of complexity impinges on the notion of transdisciplinarity itself, so that “[t]ransdisciplinarity requires deconstruction, which accepts that an object can pertain to different levels of reality, with attendant contradictions, paradoxes, and conflicts.” (Thompson Klein, 2004, p. 524). This position also calls for a broader multidimensional understanding within the disciplines themselves. Consequently, Francois (2006) questions whether a transdisciplinary theory could fully develop.
However, along with Thompson Klein (2004), he promotes the potential of systematics with its understanding of multidimensional wholes to take on the role.

3.3 Systems overview

As noted above, a general systemic approach involves a shift from a concern with the reductive analysis of parts to that of the contextual framework of the whole. It is also a shift from a primary concern for parts as objects and their constitution, to that of their relations and connections. This in turn produces a focus on the communication of information\textsuperscript{13} between the parts. Wholes are considered to arise from the organising interrelations and processes of parts while parts can only be understood in the context of the whole (Capra, 1996). Indeed, quantum physics suggests that there are no parts but rather parts are “patterns in an inseparable web of relationships.” (Capra, 1996. p, 37). Wholes are considered to have emergent properties that cannot be explained through analysis of its parts (Clayton & Radcliffe, 1996).

There is a large range of contemporary approaches (methodologies and theories) to systems thought. The most significant separation is between systems science which has broadly ontological concerns (i.e., the world as a system), and systems thinking which has broadly epistemological concerns (i.e., knowing the world in systematic terms) (Reynolds, 2008). This distinction was first made by Checkland (1981) and still remains contentious in the systems community (Cabrera et al., 2008). The former has its roots mostly in the natural sciences and so is concerned primarily with natural systems, the latter in the social sciences and so is focused on social systems. There is considerable overlap between the two, with attempts to apply objectively based systems science to the social (e.g., Eidelson, 1997; Abel & Stepp, 2003) and subjectively based systems thinking to the natural (Checkland, 1981). The rest of this Section discusses developments between the two with a particular focus on systems thinking. It considers how these developments might be linked with the philosophical position developed in Chapter 2.

3.3.1 First wave

Midgley (2007) breaks the development of systems thought into three waves or movements. The first wave developed in the 1940-50s with the development of general systems theory, cybernetics and complexity theory. These developments of systems science pulled together ideas from the first half of the 20\textsuperscript{th} century through the concerns of some biologists, gestalt

\textsuperscript{13} Communication is the transfer of information. Information is something which reduces uncertainty. Feedback is the transfer of the type of information associated with causal connections (Clayton & Radcliffe, 1996).
psychologists and the scientists from within the new discipline of ecology. They, in turn, were preceded by such thinkers as Goethe, who saw “form as a pattern of relationships within an organised whole” (Capra, 1996, p. 21).

A significant figure in the growth of systems science was Ludwig von Bertalanffy who developed general systems theory (GST). He was a biologist who stressed the difference between the physical and biological sciences. This disparity was between, on the one hand, forces and associated reversible paths, and on the other hand, change and development. He utilised the second law of thermodynamics to develop the latter. Its notion of entropy introduced irreversible process; however, it did not address the ‘negative entropy’ or developing order seen in living systems. Consequently, he developed the idea of open systems in contrast to the closed entropic systems described by the second law of thermodynamics. These are systems that have a continuous flux of energy and matter through them that maintains them. In contrast to closed systems that settle into a thermal equilibrium, open systems exist far from equilibrium in a semi-steady state of dynamic balance and flow (Capra, 1996). Bertalanffy’s GST is a general theory intended to cover all phenomena which were understood to share common features able to be described systematically (Midgely, 2007).

Bertalanffy (1969) notes a number of approaches and developments both useful to and supportive of general systems theory. They include: mathematical models, cybernetics, game theory, computer models and graph theory. The latter is the basis of Fuzzy Cognitive Maps, which are a type of digraph. “Graph theory, especially the theory of directed graphs (digraphs), elaborates relational structures by representing them in topological space.” (Bertalanffy, 1969, p. 21). Digraphs are related to another system approach called Compartment theory, which models the interaction between subsystems through various boundary conditions. It is worth stressing here that along with network theory, graph theory can be seen to utilise both systems and topological or relational approaches (Bertalanffy, 1969). Consequently, fuzzy cognitive maps are made up of networks of relations between nodes and also utilise feedback, attractors and emergent property concepts of systems thinking (see Chapter 10).

GST understands wholes to be organised in a hierarchical manner (e.g., cells, tissues, organs, organisms) (Midgely, 2007). Hierarchy theory proposes that the emergent properties at one level of a hierarchy are constrained by the higher level it exists within (Warren, 2005). However, according to Capra (1996) such hierarchies should not be considered as having top down control, but as networks (or holarchies) that interact with each other in a mutually causal manner. In this vein, Thompson (2007) proposes a dynamic co-emergence where wholes arise from the parts and parts from the wholes. This dynamic still involves organisational constraints between levels that allow or force
emergent properties by imposing new functional relationships. Constraints, in living systems, that are too strong will make the system static while constraints that are too weak will not foster the emergent characteristics. This variability in constraints suggests hierarchies are not necessarily clearly defined and so a number of alternative descriptions could be developed for them. For example, an alternative description of the lower level characterised by its emergent properties rather than its detailed dynamics could be used. Such hierarchical constraints are related to living system’s ability to recreate themselves and adapt to their environment (Checkland, 1981). In systems investigations consideration of both the system’s sub-systems and its environment (i.e., one level above and below in the hierarchy) are considered important to develop understanding of the system of concern’s processes (Midgley, 2007).

In parallel with Bertalanffy’s development of a general systems theory were those of the closed systems of cybernetics which were primarily focused on feedback (both negative and positive) mechanisms, and the associated circular causality and self-regulation (i.e., communication and control (Capra, 1996). This was further developed by Maturana & Varela (1987) in their theory of second order cybernetic organisational closure (autopoiesis) (see Section 3.4.2). At the same time the initial conceptualisations of complexity science arose. This was closely associated with systems theories and the complex interactions (e.g., circular causality) associated with even simple systems (Midgley, 2007). The complex relations, suggested by complexity theory, questions the tidy hierarchical structure posited by systems theory and can even make conceptualising the situation in hierarchical terms unhelpful. Rather, a conceptualisation in terms of networks may be more appropriate (Midgley, 2007). Networks have become increasingly used in ecology and the social sciences (e.g., Actor-Network-Theory) to represent all levels of reality (e.g., organisms as networks of cells, society as networks of actors). Reality becomes a hierarchy of networks, or networks within networks (Capra, 1996).

### 3.3.2 Second wave

An insight to come out of first wave systems science generally was the recognition of the embeddedness of the observer itself within networks of relations and so, philosophically a move toward immanence. This has two significant outcomes. First, it questions the existence of a stable subject as an epistemological knower (although this does not appear to be addressed well in many systems science or systems thinking approaches). Second, it invokes contingency in our knowledge of reality including how systems and their boundaries might be understood and viewed. There is a range of ways that systems can be conceived associated with the delineation of their spatial and temporal scales and the form and complexity of their interactions (Clayton & Radcliffe, 1996).
This insight instigated Midgley’s (2007) second wave of systems development known as systems thinking. This wave occurred in the 1970s and 1980s and developed from criticisms of the first wave of systems science. These included a concern with the first wave’s tendency to treat system conceptualisations as models of reality, along with a focus on normative conceptualisation of system goals (i.e., system’s primary goals involving continued survival), rather than as aids to understanding. Relatedly, another concern in their application to the social world involved conceptualising individuals not as agents with their own goals, but understanding them as being controlled by system structures. Indeed, Jackson (2001) notes this period of ‘hard’ systems thought to be “dominated by positivism and functionalism” (p. 235). In this respect the second wave is a swing towards individualism and social constructivism and so a concern with “interior realities” (Floyd, 2008, p. 138).

There is a metaphysical tension between the two approaches. Systems science, according to Midgley (2008), presumes a realist ontology proposing that “‘systems’ are real-world phenomena, and that our knowledge of them reflects this reality, albeit imperfectly.” (p. 319). Systems thinking, by contrast, is concerned with the way individuals are able to systematically conceptualise the natural and, in particular, the social world within which they exist and also create. Such understandings are considered to arise subjectively through experience and inter-subjectively through language and so is “about how human beings construct social realities” (Midgley, 2007, p. 17), in this case in a systematic way. According to Midgley (2007) this is not idealism but a position that rejects the existence of some ultimate proof of the nature of reality.

The second wave focuses on the analysis of complex social problems (Jackson, 2001) and involves transitions towards pluralism and taking wider views (Reynolds, 2008). For example, soft systems methodology (SSM) (Checkland, 1981), is primarily interested in systems thinking as a process of enquiry rather than as systems as models of the world (Floyd, 2008). In doing so, it has a normative aspect that is focused on the ‘improvement’ of given social situations14. This means, according to Churchman (1970 cited in Midgley, 2007), such assessments require ongoing reconsideration of system boundaries as changing boundaries can modify what is desirable. This in turn reconceptualises where wholes might lie. This often involves increasing the range of relevant knowledge and of participants (or knowledge holders) involved, and in doing so questions the importance of the central expert. This approach becomes more network and local knowledge

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14 Systems thinking has been primarily applied to ascertaining and linking stakeholder perspectives in action research and interventions (e.g., Checkland, 1981).
orientated, although it restricts the range of actors to human individuals\(^\text{15}\). This approach also recognises that the researcher is always a participant in the system they are considering (Floyd, 2008).

Checkland (1981) defines the social reality implicit in SSM (and in particular human activity systems\(^\text{16}\)) as “...the ever changing outcome of the social process in which human beings, the product of their genetic inheritance and previous experiences, continually negotiate and renegotiate with others their perceptions and interpretations of the world outside themselves” (p. 284). It is the last few words that are telling, and I suggest could be replaced with ‘.....and understandings of the world they exist within’. Checkland’s (1981) position tends towards a social constructionist approach rather than a constructivist one congruent with the philosophical position set out in Chapter 2. This is not to deny differing perspectives but it is the origin of these perspectives that needs to be further considered.

### 3.3.3 Third wave

The third wave of systems development occurred from the 1980s to the present time (Midgley, 2007). This criticised the second wave for reasons other than the one noted above, which the third wave retained. Rather, it involved the tension that the separation between the first (systems science) and second waves (systems thinking) created for systems thought as a whole. Consequently, a complementary approach between the two was proposed in the guise of methodological pluralism (Midgley, 2007). In addition to this was disquiet over the second wave’s lack of ability to address power relations between participant relations, or within society as a whole. This was influenced by critical theorists such as Habermas (Jackson, 2001). It included concerns that the second wave did not include a theory of society.

These emancipatory concerns were developed further as critical systems heuristics (Ulrich, 1983). This involves methodologies to deal with issues in relation to the amount of information that is required to enable practical outcomes, while addressing how normative judgements are made by various participants in defining relevant boundaries (boundary critique). These boundary concerns

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\(^{15}\) When considered from a systems science perspective, systems thinking is a second-order feedback or a second order cybernetics, (i.e., cognitive systems observing systems, and also observing itself as a system). These lie in contrast to first-order feedback associated with hard systems which are engineered systems where the structure of the system is known and its investigation is concerned with feedback and control (Ison et al., 1997). In second-order systems the structure of the system is not known so its objectives and consequently its control processes cannot be clearly defined. This adds another layer of feedback that includes the definition of the system itself (Ison et al., 1997).

\(^{16}\) Human activity systems are best considered as social systems or social realities. They are one system type in the SSM typology that includes five types. The others being natural, designed physical, designed abstract systems, and transcendental systems (Checkland, 1981).
are central to the emancipatory practice of third wave approaches (e.g., Jackson, 2001; Reynolds, 2008; Midgley, 2007).

Attempts to straddle both systems science and systems thinking, through a methodological pluralism, came in two forms. For Midgley (2008) pluralism is “not dependent on aligning methodologies and methods with philosophical categories” (Midgley, 2008, p.319). This is because Midgely (2007, 2008) sees methods as a flexible set of tools to be used as each unique, and potentially multi-layered, situation demands. It is practical, ultimately normative, and open to ongoing theoretical developments. However, as Jackson (2001) notes, unrestrained use of methodologies without being clear about their philosophical foundations means conclusions may be confused and inconsistent.

An alternative methodological pluralism was promoted by some practitioners as a fixed set of approaches to use in certain circumstances. These were based on, for example, Habermas’s theory of human interests: the technical, the practical and the emancipatory (Jackson, 2001; Reynolds, 2008). Critical systems thinking (CST) is one such approach and its theorists, such as Jackson (2001), promote the use of multiple paradigms (i.e., functionalist, interpretative, radical). This is a “sophisticated form of pluralism” (p. 238) where methodologies from the various paradigms are used co-jointly. Indeed, Jackson (2001) sees the paradigm diversity as essential, which in turn requires a clear understanding of the paradigms. He stresses that their philosophical bases may be incompatible so that they interact through a “‘reflective conversation’” (p. 240). In this situation a question remains as to what paradigm researchers themselves think they exist within. Jackson (2001) sees the benefits of pluralism in systems thinking as promoting its further development, and giving the ability to apply the best methods to a range of circumstances. The set of approaches in critical systems thinking theory is based on a consideration of both system type (i.e., simple to complex) and relationships between participants (i.e., unitary, pluralist, coercive).

This weka study is complex and pluralist at the human level but complex and coercive at the broader level. Critical systems thinking only considers emancipation for human participants and not for non-humans. There has been criticism of Habermas’s thought in this respect (Eckersley, 1990 cited in Hay, 2002). At first glance weka, as non-human participants, have a lack of power (certainly at the local level) and lie in a marginalised position, although to some extent they may be represented by human participants. This can be developed further if considered in a network rather than a hierarchical fashion. Actor-Network-Theory (see Section 3.5.3) develops this approach by proposing an integration of the social and the natural.

To address some of the problems of philosophical consistency in pluralistic third wave approaches, Cabrera et al. (2008) endeavour to develop a general theory for systems thinking
through amalgamating universal patterns they found within a survey of systems thinking. In Cabrera et al.’s (2008) proposal, systems thinking becomes wedded to the concepts of systems science. This move is rejected by some commentators (e.g., Renolds, 2008), as confusing the map with the territory, as they wish to retain a strict separation between ‘reality’ and our systemic interpretations (worldviews) of it. Cabrera et al. (2008) implies their theory is the nature of thought and so is the territory. I suggest both of these views can be questioned and this lies in the fourth wave.

3.3.4 A fourth wave

Floyd (2008) applies a developmental element to systems thinking. He highlights the ongoing development of the cognitive understanding of reality as a system, within individuals. Floyd (2008) attempts to move past the perceptual subjectivism (worldviews) central to much systems thinking. This is done through proposing that adult individuals in their understanding of systems thought develop through a number of stages from a simpler understanding of reality as being able to be objectively fully described, and existing as, hard systems, to systems being perceptions of individuals; to reality as an “undifferentiated phenomenological continuum” (Cook-Greuter cited in Floyd, 2008, p. 148). Here systems thinking as both a way of understanding, and an understanding of their own embeddedness in such understandings. The latter stages are able to encapsulate the early stages and, I suggest, tend to become less systematic and more post-structural in theme. The stages also move from initially being an ontology (realist) to an epistemology (idealist), finally to become both epistemology and ontology.

An objection could be raised with this approach that the stages themselves become worldviews of sorts, but this is to miss the point. Floyd’s (2008) reflexive systematic understanding itself is proposed from a position of immanence. He claims that there are foremost, perspectives and not perceptions. Perceptions always presuppose an existing entity that holds a perspective. On this view perceptions are a dualist hangover but perspectives explicate immanence (i.e., we are immanent in the world prior to dualist perceptions, as developed in Chapter 2). Perspectives highlight this immanence and basic meaningfulness. Everyday sense making is a perspective not a perception. This means first person or third person perceptions are derivative. Perspectives are an emphasis on sentience “for which feelings, awareness, perceptions and consciousness ‘are always already perspectives’” (Floyd, 2008, p. 147). This is in contrast to reality being made up of systems, webs, information, matter and so on. Floyd’s (2008) position is that in their immanence sentient subjects can become aware and develop clearer understandings.

Floyd’s (2008) position does not presume that systems thinking is able to be undertaken by all individuals to the same extent. He is proposing a pluralistic systems methodology that respects
multiple perspectives, recognising that systems thought itself will differ for different individuals. This pluralism offers a consistent philosophical framework based in immanence. He proposes exploring a range of methods which address both technical and communicative and emancipatory aspects of systems.

This study takes such a methodological pluralistic approach. This is not a meta-methodological position but an amalgamation of several of many possible methodologies. It uses individual based modelling based in systems science, along with some quantitatively based field work with weka. It also uses fuzzy cognitive maps which lie in the interface between systems science (i.e., neural networks) and systems thinking and its concern with subjective understandings. FCMs and IBMs are both based in complex adaptive systems and can also be considered to have a common philosophical basis. FCMs by their very nature arrange individual understandings into a systematic format. They could be treated as purely subjective constructions, but will be considered as perspectives that are immersed in the social and material world.

This contrasts with approaches that assume a subject and object separation and attempt to amalgamate them after the fact (e.g., Kay et al.’s (1999) approach to the integration of systems science and systems thinking in a more conventional manner). Such approaches use an individual-based participatory framework to ascertain the desired outcomes, and systems science to understand what the feasible outcomes are. They then reconcile these into a vision for the situation. These pluralist approaches take up underlying separate philosophical positions reflecting the second wave systems thinking criticism of systems science (i.e., a combination of moderate realism and idealism). As Floyd’s (2008) perspectives suggest, in their different ways, these pluralistic approaches miss both the important insights of new developments in complexity and systems science, and the implied immanence in all systems thought.

New systems based theoretical approaches respect the ontic development of entities and their self-organising properties. They also allow for the emergence and autonomy of an organism as a whole (embodied, affective) (Kauffman, 1995; Thompson, 2007). New system science offers a way to conceptualise cognition and subjectivity, rather than taking subjectivity for granted as systems thinking tends to do, as well as recognition of the importance of subjectivity. As set out in Chapter 2 it incorporates the de-centred subject of post-structuralism, but still an embodied self, an ‘identity’ - which engages, perceives, experiences. This more subtle position suggests there are material tendencies in the world, which because of our immanence in such tendencies, is part of our everyday practices (social and embodied) and can be understood through a systems account.

The following section will firstly give an overview of Deleuze’s post-structuralist thought in relation to new systems science. The sections following this will discuss the new systems science
notions of self-organisation, dissipative structures and other concepts that underlie complex adaptive systems. This gives a background for the use of Resilience Theory.

3.4 New systems science

3.4.1 Deleuze, systems and neorealism

Deleuze's philosophy has been considerably influenced by complexity science. This in turn has been subsequently elucidated by contemporary theorists such as Massumi (2002), DeLanda (2002) and (Fuchs, 2003). Fuchs (2003) suggests Deleuze's linking of the natural sciences with complexity theory gives Deleuze's philosophy the foundation and scope to move past the separation between the natural sciences, social sciences and the humanities. In this Section I will briefly discuss Deleuze's neo-realist ontology, particularly in how it has been developed by DeLanda (2002) in relation to systems theoretical approaches. This will expand on the overview of Deleuze's ontology in Section 2.4.3, in relation to multiplicities, intensities, the virtual, and the actual.

Multiplicities refer to the “the structure of spaces of possibility” (DeLanda, 2002, p. 10) and describe the recurring patterns shown in morphogenetic processes associated with movement from the virtual to the actual (see Section 2.4). Multiplicities are closely related to the mathematical idea of manifolds, which are abstract multidimensional surfaces defined by differential equations. Importantly, they are defined relative to themselves (i.e., without reference to an external (transcendent) axis). Manifolds can be associated with physical processes through dynamical systems theory (DST), where they are used to represent (model) properties of physical systems. This is done through modelling each way a system is able to change as a dimension (degrees of freedom) and relating these through differential calculus. At each point in time the system's current status is defined as a point on the manifold. The entire range of points the system can move to is called its state space and the system's trajectory, derived from vector fields of its instantaneous movements, can be traced through its state space over time. This trajectory can show reoccurring patterns which represent the system's typical behaviour. Because it is typical behaviour dynamical systems models are considered as qualitative (Thompson, 2007).

Unlike essences which are distinctive, multiplicities have fuzzy boundaries meshing together to form a continuous space. It is this continuum of multiplicities that differentiates into three dimensional space of physical objects. This occurs because space in multiplicities is not just a set of points (i.e., metric space) but it contains regions of proximity where distances are not fixed. This is topological (or non-metric) space. Non-metric space contains more symmetry (i.e., less
differentiation) than metric space as it can be stretched and deformed into other shapes like manifolds can.

Multiplicities are also divergent in nature as they proliferate with the breakdown of prior symmetries. These transformations relate to a hierarchy of symmetry breaking transitions that result in an increase in differentiation (i.e., from a relational field to more discrete physical entities). These gradually specify the multiplicity through bifurcations occurring in state space. These are disturbances that reveal critical points or thresholds in the system state. When they occur they break the prior symmetry of the system (e.g., from one attractor to another or to a periodic attractor, or to a chaotic attractor) (DeLanda, 2002).

Attractors or singularities are points that trajectories with reoccurring patterns tend towards. Equilibrium systems tend toward and settle at single attractors while non-equilibrium systems develop new attractor sets through phase transitions (Capra, 1996). Because singularities show a global pattern of the behaviour of the system they are considered by Varela et al. (1991) to be an emergent property. If attractors operate only when the system is within certain bounds they are known as basins of attraction. There are also closed loop attractors, which operate periodically (DeLanda, 2002).

Even though singularities (attractors) are never fully actualised (i.e., they are never part of the system’s actual state, the system only moves around them as ‘virtual’ focal points), Deleuze considers singularities to be fully real, influencing the vector fields. The singularities are part of the virtual. Multiplicities themselves, as a nested collection of vector fields made up of singularities and symmetry changing bifurcations, are also part of the virtual. The number of attractors in a system depends upon whether it is linear or non-linear. Non-linear systems have multiple attractors (i.e., non-linear equations have multiple answers) (DeLanda, 2002).

Deleuze’s thought offers a process based metaphysics for systems theory, particularly for complex open systems. This is fundamentally historical and shows the genesis of actual phenomena in parallel, and interacting with, a virtual realm (DeLanda, 2002). Care needs to be taken when discussing systems theory, which is always only of the process of development in the actualised world. Deleuze’s thought is also concerned with the actual process of the constitution of entities and their subsequent change, where it can be difficult to tease the unity of virtual and actual apart. Indeed, because unity in Deleuze’s thought is always relational this cannot really be achieved. Such relating is an active and ongoing process, of both the virtual and actual, of differentiating or individuating phenomena while still in relation. Individual phenomena are not stable identities but in a process of becoming in relation to themselves and others. Relation also combines and mingles phenomena in unique ways to produce new forms. In this process with each interaction phenomena
themselves are always transformed within relationality’s productive flow. This relationality is applied to all phenomena, organic and inorganic alike, breaking down the separation between how they are conceived (Dillon, 2000).

Interestingly, Dillon (2000) relates relationality directly to autopoiesis (self-organisation) (see Section 3.4.2) even though Deleuze’s thought appears to down play the importance of boundaries (and wholes) central to autopoietic theories and also phenomenologically derived systems approaches, to which self-organisation is central (e.g., Kay et al., 1999; Thompson, 2007; Varela et al., 1991). In addition, autopoiesis only relates to living systems while Deleuze’s thought does not differentiate between organic and non-organic systems. Dillon (2000) goes on to stress the importance of novel events (surprises, gaps, breaks) involving dispersion, invasion, etc., where complex feedbacks within and throughout open systems break down notions of boundaries. This tension can be addressed by considering how the unfolding of multiplicities and the bifurcation of attractors can change the way entities emerge into the actual. There can be both a hierarchical and also a mesh-like (network) development of entity structures.

According to Dillon (2000) Deleuze’s ontology has incorporated in it a strong metaphor for understanding systems approaches. Deleuze’s ontology is compatible with complexity science based new systems (Delanda, 2002; Palmas, 2008) and so also offers an ontology for systems based socio-ecological developments. The following section discusses further features of complexity science.

3.4.2 CAS, self-organisation and dissipative structures

Further development of Bertalanffy’s (1969) open systems was undertaken in the 1970s by Prigogine. He related far from equilibrium semi-steady states to the notions of self-organisation and dissipative structures (Capra, 1996). Applying this to chemical and physical systems, Prigogine depicted self-organisation “as the spontaneous emergence of order out of chaos in thermodynamical systems.” (Fuchs, 2003, p. 2). Self-organisation is the emergence of a pattern in an open system without its specification coming from the outside environment (Eidelson, 1997). Self-organising systems became known as complex adaptive systems (CAS). CAS is a subset of complex dynamical systems that have the ability to self-modify and so preserve some features including the ability to adapt further under changing environmental conditions (Fuchs, 2003). Examples of CAS include cells, individuals and ecosystems.

Self-organisation is an emergent property of CAS. There is no unified theory for emergence although it is found in all types of phenomena. For example, attractors are considered to be emergent phenomena (Varela et al., 1991). Often ideas of emergence suggest only the parts specify the emergent whole. As already mentioned, Thompson (2007) argues for the idea of a dynamic co-
emergence\textsuperscript{17}, sometimes called circular causality where the parts co-emerge with the whole in a circular and complementary specifying manner\textsuperscript{18}. As noted self-organising systems emerge as internally controlled organisations which are known as complex autonomous systems. This is in contrast to heteronymous systems whose organisation are defined by external input and output interactions (Thompson, 2007). Autonomous systems are defined by their organisation including certain common processes. These generic processes establish the interactions with the environment, recursively require each other for their existence, and comprise the system’s unity. The cell, through its recursively constituted metabolic network and membrane, epitomizes such a system (Thompson, 2007). Within the biochemical realm (or life), from the cell to the whole organism, this type of autonomous system - that is self-producing and creative of its own material boundary or membrane - is what Maturana & Varela (1987) call an autopoietically organised system. Although for Maturana & Varela (1987) all living systems are autopoietic systems not all autonomous systems are living systems. What distinguishes living autonomous systems from non-living ones are that they also reproduce, develop, evolve and adapt (Capra, 1996).

The autonomy of a living system is a property of the organizational whole of the system itself. The recursive processes and dynamics that characterize autonomous systems as a unity means they are described as organizationally closed. However, they are also considered to be structurally coupled to other systems (its environment) without which they would not exist. This embodies a recursive link between the systems so they co-evolve together, which causes state changes within the system that creates further self-organised events (Thompson, 2007). Maturana & Varela (1987) recognise structure/organisation distinction in autopoietic systems. A system’s structure is the physical components that implement its organization and can be of various forms. Structure makes up the organism’s niche (Maturana & Varela, 1987). Structure involves the concern about the physical constitution of things (i.e., substance), while organisation’s concern is the form or pattern. A system’s organization is the interrelations required for a system’s existence. System organisations are common to particular classes of systems (e.g., cell, human brain) while structural couplings (embodiment) are particular to different beings. These are both complementary concerns, but because of their nature understandings of them are quite different. Structure (substance) is able to be measured and quantified through reductionist methods, while organisation (pattern) requires mapping relationships and is qualitative by nature (Capra, 1996). This is another way to link system

\textsuperscript{17} Dynamic co-emergence follows an enative approach to mind (see Section 4.3.3). The enative approach is one that highlights the development of cognition as a practically arising through interaction (Varela et al., 1991).

\textsuperscript{18} Another approach to address the existence of emergent properties is vitalism. Vitalists (e.g., Sheldrake) suggest a power or force (e.g., non-physical morphogenetic fields) create the emergent properties of wholes (Capra, 1996).
science with systems thinking. Fuzzy cognitive maps are a good example of the mapping of relationships.

Through their structural coupling CASs are always exchanging matter and energy with their environments (Thompson, 2007). This is because as far from equilibrium open systems they have a constant flow of matter and energy through them. As such living systems are considered thermodynamically to be dissipative structures that dissipate energy to maintain their order at far from equilibrium states (Kay et al., 1999). However, when complex adaptive systems are displaced past a certain critical point from equilibrium the system uses, or dissipates, the excess energy by (re-)self-organising and maintaining a new structure using the energy and available resources (i.e., information and materials) (Kay et al., 1999). These transition points (thresholds or bifurcation points) enable them to reorganise in complex ways so to dissipate still more energy and matter (Capra, 1996). This is the spontaneous production of new complexities or self-organisation (Kauffman, 1995).

Self-organising dissipative structures will be produced whenever there is enough surplus energy to support them. The development of new a structure gives the framework for new processes to emerge (Kay et al., 1999). It is at the bifurcation points that the dynamic instabilities of a CAS are greatest. Some proponents have suggested that CAS evolve towards these unstable points lying between order and disorder (edge of chaos) through a principle called self-organised criticality (Eidelson, 1997). However, Levin (2005) suggests that self-organised criticality does not produce the modularity and heterogeneity critical to natural systems. Regardless, the points of bifurcation or phase transition points are considered by some investigators (e.g., Langton, and is also central to

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19 Information is “defined as factors embedded within the system that constrain and guide self-organisation.” (Kay et al. 1999, p. 723). This can be considered a process that reduces uncertainty.

20 In an autocatalytic process the structures formed feedback to capture and dissipate further energy (Abel & Stepp, 2003). This process can keep continuing in a series of discrete steps if more energy is input into the system that is amplified by these positive feedback loops (Capra, 1996). In this morphogenetic process the system makes increasingly more efficient use of the resources though building more complex and robust structures. These new structures move the systems further from equilibrium and increase their energy dissipation, complexity and non-linearity (Capra, 1996). Life processes increase the efficiency of energy use and human cultural processes do so even more (Abel, 1998).

21 Due to the numerous interactions involved in the behaviour of complex dynamic systems their states can be dependent on very small changes in initial conditions. They may show a range of general responses that are classified in four ways. The first are frozen or fixed systems, the second are periodic systems that cycle through a repetitive pattern, the third are chaotic systems whose behaviours are unpredictable, the fourth are systems on the ‘edge of chaos’, these systems lie in dynamic tension between systems two and three. They are dynamic systems but also show stable states. CAS (e.g., living entities) are these types of systems (Clayton & Radcliffe, 1996).
Deleuze’s ontology) to be where CAS have most information exchange and are most adaptive. CAS often linger near these points where they are most flexible (e.g., the human brain) (Eidelson, 1997).

### 3.4.3 CAS and ecosystems

This section expands on previously discussed self-organisation and dissipative structure aspects of CAS through the application of CAS theory to ecosystems.

Although some general rules about how ecosystems evolve over time have been developed, relating in particular to calculating material and energy flows and measures of interconnectivity of populations, there is the lack of an accepted theoretical framework for understanding ecosystem processes based on first principles. This is because of the complexity produced by “complex assemblages of interacting organisms embedded in an abiotic environment” (Hartvigsen et al., 1998, p. 427). This complexity occurs due to the large number of variables, weak and strong (clear and diffuse) interactions, multiple levels of positive and negative feedback, large spatial and temporal variability, non-linear interactions, emergence of new structures, and the occurrence of essentially random catastrophic events (Schneider & Kay, 1994). This makes it difficult to predict future states of ecosystems, either undisturbed or facing disturbance (Schneider & Kay, 1994).

System theory’s concern for process means that it has been widely used in ecology. Indeed, the very term ‘ecosystem’ would suggest that ecosystems have always been thought of as systems of some sort. Early use of systems theory represented aspects of ecosystems as feedback regulated aggregated stocks and flows. It focused on homeostasis, self-regulation, climax communities and negative feedback as their essential properties (Gunderson & Holling, 2002). These models did not, however, account for processes of adaptation (Hartvigsen et al., 1998). More recently, ecosystems have been considered CASs which recognises their complexity and the role of adaptation.

As outlined above, CASs exist in multiple scaled (spatial and temporal) nested hierarchies with interaction taking place across and between with hierarchical levels creating complex, non-linear, non-equilibrium interactions\(^2\). The adaptable and evolutionary nature of CAS instigates the emergence of the important systemic property of novelty and its associated uncertainty. Indeed, the essential nature of CAS is the “ongoing process of creating novelty, selection and adaptation.” (Rammel et al., 2007, p. 10). This means there is ongoing directional change in CASs (i.e., cycles are never repeated in quite the same way) (Abel & Stepp, 2003).

There is, however, a dynamic tension between adaptive transitions in CAS and existing structural formations. This is because the varying components require the existing configuration of

\(^2\) However, self-organised dissipative structures tend to create concentrations or lumps in temporal and spatial scales (Abel & Stepp, 2003). These are often seen in the natural world (e.g., body size) (Sendzimir et al., 2003). This suggests that there may be discontinuity’s across scales to some extent (Abel & Stepp, 2003).
interrelations to allow co-operative change, while the system as a whole requires such links to be adaptive with regards to its environment. Any change in a component affects both the other components and the greater system and may or may not improve its adaptability. This is a cascade effect and emphasises the importance of feedback mechanisms within and between hierarchies. This interplay or co-evolution places constraints on the evolution of the system (Rammel et al., 2007).

CAS can give insights on how large scale patterns emerge from smaller scale interactions, and potentially how large scale changes effect smaller scales. Understanding cross scale interactions are, according to Hartvigsen et al. (1998), a considerable challenge that CAS can help meet. “Analysing CAS means to incorporate variability, adaptations, uncertainty and non-linearity while heading for improved understanding of how co-evolutionary processes and dynamic patterns emerge and interact across hierarchical levels and across different spatial, temporal and social scales.” (Rammel et al., 2007, p. 10)\(^23\). Such analysis can be considered in a co-evolutionary manner occurring between the social and ecological components of socio-ecological systems. This notion is considered and developed in the remaining Sections in this chapter.

3.5 Social systems

The use of the systems approach in sociology was largely rejected through the 1950-60s critique of what Wadsworth (2008, p. 154) describes as “linear, status quo-preserving, objectivist, determinist, predictive, structural-functional” systems thought. In parallel with developments in systems thinking, this coincided with an increased interest in interpretivist approaches to sociological theorizing and associated methodologies (i.e., qualitative, descriptive, interpretive). These “heralded the whole new era of cultural studies, fluidity of identity, change complexity, diversity, poststructuralism...” (p. 154), that arose in part from cultural changes that occurred in the 1960s and 1970s (e.g., protest movements and cultural diversity). This disturbed the status quo and forced a focus on social change in sociology, that had an emphasis on agency and freedom, and therefore personal responsibility. This had two threads: The first one being the advent of personal autonomy, mass consumerism, freedom of choice, celebrity, and the ascendency of the individual’s wants and desires. The second one being emancipatory in nature, e.g., feminism, environmentalism, post-colonialism, multiculturalism, etc. (Wadsworth, 2008).

\(^{23}\) The use of agent-based simulation models allows these processes to be included in ecosystem modelling. The weka IBM developed in this study does not attempt to model genetic variation among weka but concentrates on environmental and behavioural heterogeneity.
However, according to Wadsworth (2008) the lack of success of establishing any foundation for emancipatory critique in this increasingly theoretically and methodologically complex social world has meant a renewed interest in structure. In the 1980s this often came in the form of an economic rationalism but this lacked the elements required to address the complexity of environmental problems, inequality, etc. The new systems theory based on complexity thought allows for such a development and endorses the concern with agency in the interpretivist approaches but tempers the excess with underlying patterns and constraints of self-organisation, dissipative structures, attractors, etc.

As noted in Section 3.3.3, parallel developments occurred within systems thought itself through the first and second waves (Midgely, 2007). However, the emancipatory aspects have not necessarily been take up through overt use of recent developments in system science but more commonly through Habermas’s thought (i.e., CST). Likewise, new systems theory has not been taken up substantially by sociologists (Wadsworth, 2008). This is due, according to Eidelson (1997), to a lack of a unified theory for complex systems, confusion over concepts and definitions and, as discussed, a methodological individualism in sociology. However, attempts are ongoing and the following is a general discussion of this from the perspective of socio-ecological theory development. It explores the commonalities and tensions between agency-structure theories and network theories and systems.

3.5.1 Complex adaptive systems and social theory

The social domain is seen by many socio-ecological theorists to involve the same basic systemic properties as natural systems (Kay et al., 1999; Rammel et al., 2007). Walker et al. (2006) propose that the “fundamental ideas of scale, relative rate of change, and thresholds apply to social and ecological systems as well as socio-ecological systems, although, of course, the specific dynamics may be infinitely varied among such systems.” (p. 6). They consequently suggest that they can both be dealt with under a common conceptual framework. One high profile theorist in this respect is Niklas Luhmann (Luhmann, 1984; Moeller, 2006).

In contrast, other commentators propose that the functioning of natural ecosystems and human ecosystems have different properties (Gunderson & Holling, 2002; Stepp et al., 2003; Edielson, 1997; Doak & Karadimitriou, 2007) and so require different theoretical and methodological approaches, (i.e., the form of interaction between their system elements are conceived of differently). This has been traditionally reflected in the differing approaches of the natural sciences and social sciences to their subjects. Natural scientists focus on furthering an objective understanding the natural world, social science has a normative aspect in “both explaining and
improving the world(s) we create” (Eidelson, 1997, p. 63). In Stepp et al’s (2003) framework this
difference appears in the role taken by the symbolic and the agency of human individuals. Symbolic
human belief systems, are the “collective and shared epistemologies that influence and mediate
human behaviour” (Stepp et al., 2003, p. 15) that are central to allowing adaptation, while individual
agency is considered to have a central role to play in the ongoing evolution of systems through
affecting change (Abel & Stepp, 2003). As Gunderson & Folke (2005 p. 22) understand it in their
approach to CAS, “[a]daptability in a resilience framework implies the capacity not only to respond
within the social domain but also to shape ecosystem dynamics and change it in an informed way.”
These approaches highlight a normative agency in social systems.

According to Frazer (2003) the present challenge for social–ecological research and
management is to find ways to integrate data from social and natural systems in ways that consider
the differences between them, and allow for the interactive complexity within, and between them.
However, the integration of these social domain differences has not generally been clearly
developed. Scoones (1999 cited in Abel & Stepp, 2003) suggests that the social sciences have not yet
assimilated complex systems theory into their theories, and rather tend to take an equilibrium view
of natural processes. This can perhaps be seen in the difficulties faced by some SES theorists (e.g.,
Gunderson & Holling, 1995) in attempting to find useful social theories to match the robustness of
their ecological models, and the tendency to use small scaled organizational theories. So although
Abel (1998) stresses the need to coordinate with more general theories or frameworks of social
processes these may not be available. For example, Warren (2005) notes that many socio-ecological
system frameworks tend to ignore the role of human agency by modelling only to the local level
rather than the individual micro level. For example, in discussing the resilience approach Berkes &
Folke (1998) note that “[t]he level of analysis is not the individual or household but the social group”
(p. 16).

Indeed, according to Giddens (1984) what a systems theoretical approach to the social is
lacking are theories of agency and the subject. Giddens’ (1984) developed Structuation theory to
address this gap. Structuation theory also attempts to address the opposing problem of interpretivist
approaches lacking a theory of social structure and associated constraints on individualism. “The
methodological individualists are wrong in so far as they claim that social categories can be reduced
to descriptions in terms of individual predicates” (Giddens, 1984, p. 220). Consequently, Westley et

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24 Gunderson et al. (2002b) compare three types of social theory. These being successional (i.e. a gradual
growth to a stable plateau), revolutionary (i.e., a two stage cycle of a long period of gradual change followed by
a short period of transformation), and a four phase cycle in common with Resilience theory (i.e., phases of
growth, stability, collapse, and renewal). The latter is similar to a number of micro (and so simplified) economic
and social theories that have been developed.
al. (2002) utilized Gidden’s Structuration theory to integrate these aspects for Resilience theory (see Section 2.5.2 for further discussion).

As an alternative, Lockie (2007) suggests applying some of the more recent developments in environmental social theory (e.g., Deliberation Theory, Actor-Network-Theory) to the socio-ecological domain. This is to avoid some of the human-nature dualism that exists in traditional social theory, be it realist or constructionist. Indeed, the network metaphor has come to the forefront in recent sociological theory. This has occurred in several ways. The first is the idea of social capital. This is focused on the use of social groups or networks for procuring social outcomes. The second is an understanding of contemporary Western society as becoming more interconnected and organised as a network. In this ‘network society’ new forms of organisation and identity have arisen. The third are theories that use networks as a metaphor to understand the social world as a whole (e.g., Actor-Network-Theory) (Lockie, 2007). Both Structuration theory and network theories are discussed in relation to systems in the following sections.

3.5.2 Structuration theory

Structuration theory understands the existence, persistence and change of societies as a process occurring over space and time. In this process social structure is produced (emerges) through agents recursively recreating structures during their knowledgeable activities while at the same time being embedded in the structures (Brooks et al., 2008). It emphasises a positive empowering as well as a constraint of actors in this process (Warren, 2005). In doing this the dualism between structure and agency is replaced by relation. The focus of relation is on process rather than on the individual actor or the society as a whole (Falkheimer, 2007). The three social structures recognized by Giddens are signification, legitimation and domination. The structure of signification enables communication between agents (language) and holds stocks of knowledge (Scheffer et al., 2002). Legitimation concerns individual social rights and obligations, and domination involves authorising others’ behaviours and allocating material resources. An individual’s motivated activities involve the linking of these structures together in psychological and external interactions so that they recreate and incrementally change society (as an emergent property). This recreation and change of social structures involves an individual reflexive process of monitoring themselves and other’s activities (Brooks et al., 2008). These three facets of social structures can be seen at both the macro and micro levels. At the macro level (e.g., law) change is slow, while at the micro level (e.g., personal interactions) change is rapid (Scheffer et al., 2002).

Westley et al. (2002) elaborate on Gidden’s structure of signification, in particular, for systems-based Resilience Theory. Westley et al. (2002) argue that it is the interpretative schemes
associated with the symbolic that involve and give meaning to human activities. This allows social systems to abstract from local environments (i.e., from space and time). In addition, the symbolic gives rise to reflexivity which gives increased ability for response and adaptation and so a capacity to switch behaviour types quickly. This symbolic abstraction and reflexivity allows for purposiveness and assessing consequences.

There is a risk, here, of over emphasizing the symbolic toward a social constructionist position, i.e., “Human beings...collectively invent and reinvent a meaningful order around them and then act in accordance with that invented world, as if it were real” (Westley et al., 2002, p. 108). The broadly immanent materialist embodied account proposed so far in this study also questions such a position. This does not consider the reality to be a social invention, but something we are both immersed in and construct through a process of ongoing interaction that reverberates with meaning.

This is not to deny a role for the symbolic and its ability to allow exploration, i.e., as embodying an expanded type of self-organisation that does not exist in non-human systems so giving the capacity for reflexivity and planning. The reflexivity is important but again this needs to be grounded in the experiential (Freeman, 2002) (i.e., not just linguistic but in the affective and physical too). The abstraction from space and time can be thought of as being associated with changes in heterogeneous topological material networks rather than purely associated with abstract symbolic purely human systems (e.g., a change in relations of a place (locale) may involve technological developments such as transport, or changes in the status of species which then link to symbolic changes). So the ability to change social organisational patterns quickly (which entail or produce material/physical actions as structural changes) can be seen to have more to do with communication than the symbolic. For Maturana & Varela (1987) the symbolic acts as a type of communication, which in turn is linked closely with structure.

This creates a problem for Structuration theory, because its structures are not materialized, giving it a weak theory of structure (Murdoch, 1998). In addition, it is unable to account for how breaks or rapid changes occur in structures (although this is not consistent with Westley et al.’s (2002) use of the theory above) (Brooks et al., 2008). Also, Structuration theory does not give agency to the non-human (Brooks et al., 2008). To address these concerns Brooks et al. (2008) attempt to hybridize Structuration theory with Actor-Network-Theory (ANT) (Latour, 2005), which allows for an approach that includes non-human actors, and breaks and rapid changes. It does, however, eschew structures. Before discussing this hybridsation I will give a brief overview of ANT.
3.5.3 Actor-Network Theory

Actor-Network-Theory (ANT) has three key theoretical proposals. First, it includes a symmetry - or human and non-human equivalence - in its understanding of the social (i.e., that the non-human materially impacts on the social). Second, that the theoretical categories conventionally used to describe the social (e.g., class, space etc.) do not explain it. Rather, it is the process of the development of groups or networks that need to be explained. Third, that the role of social science is to explore the way the social is drawn together through institutions and concepts (including scientific ones) (Latour, 2005). Accordingly, ANT is not a social theory in a classical sense in that it acts as a framework for analysis (e.g., functionalism, interpretivism). It is thoroughly empirical and descriptive and is interested in the way things are connected, but eschews underlying propositions about how and why such connections arise (Lockie, 2007).

In ANT humans are not thought of as agents, but along with all objects considered as actants in networks\(^{25}\) (Latour, 2005). Symmetry is critical to ANT as this mixing of human activities and non-human objects gives networks their durability and stability, while their materiality allows them to become in some way ‘structural’. Networks are never neutral but their materials carry with them the work of others (human and non-human) to contribute to the assembled network across space and time. The assemblage both modifies and is modified by each contributing actant developing into new, unique and complex relations. As such the actants are interdependent (Murdoch, 1998).

ANT enquires into how these actants become enrolled and then intertwined into complex groups of inter-relations in space and time. These networks are considered to be gathered together as complex folded topologies of space-time (Murdoch, 1998). In other words, spaces do not consist of just local and global scales but are primarily networks of relations which may include the close and the distant. These relations are developed through practical activities of actors, and grounded in networks. However, Murdoch (1998) notes that these networks of relations can and do mark out spatial scales depending on the priorities for, and ability to, organize elements into differentiated spatial units.

Each network enrolls or attracts together actants, which have their own space-time, into new arrangements reflecting both the actant’s existing properties and the new relations established. In this process of translation actors are displaced and transformed to align more closely with the

\(^{25}\) ANT considers actants as human and non-human actors suggesting that there is no difference in the ability of technology, humans, animals, or other non-humans to act. Actants take the shape that they do by virtue of their relations with one another within the networks they constitute, and nothing lies outside these networks (Latour, 2004). By contrast, human agency is based on the capacity for human beings to make choices and to impose those choices on the world (i.e., as a causal power). ‘Natural forces’ are not considered to have such ability. How humans come to make those choices, through transcendental notions of free will or other processes, is an unresolved issue (Honderrich, 1995).
network itself (Murdoch, 1998). Enrolment is considered to be activated by a central actor or actors. This is because for actors to do things requires the co-opting or co-operation of heterogeneous others into a network of stable relations. If the network is successful it will take on the properties of the actor which will stabilise and consolidate it for a time. Actor-networks consist of both individuals and collectives (Murdoch, 1998). As an example, ANT considers scientific practices to involve translation. They are an attempt to encapsulate (record, calculate and represent) the activities of actors over a variety of locations and centralise them as a form of knowledge to allow their manipulation. This may not always be successful and it may be resisted by the actors. In this translation process the practices of science activate and take in actors and networks (Lockie, 2007).

The idea of social structure is not taken up by ANT. This is firstly because the fluid, changing and unstable nature of networks in ANT leave little scope for the creation of stable social structures. Second, ANT’s flat ontology does not give any causal capacity or explanatory significance to structures. For Latour (2005) ANT is a sociology of associations, of distributed changing power relations, rather than one of central and stable set of ties (structures) that dominates human behaviour. Although Edler-Vass (2008) notes at times Latour does allow for the potential existence of structure, overtly recognizing the structure is always deferred in the ongoing movement of networks.

The symmetry in ANT has been criticised as it is claimed that human agency, because of the reflection and intentionality allowed by human consciousness and the use of language, is different from other forms of agency (Lockie, 2004). However, Lockie (2004) notes that ANT does not characterise agency and power as properties of individuals but “as the outcomes of interactions within a network.” (Lockie, 2004, p. 35). In other words, it is the property of relationships. However, as mentioned above, a single actor instigates (translates) and maintains the networks in the first instance. This actor has to continuously impose their ‘will’ for the network to remain stable until it reaches a point where it becomes undifferentiated and completely aligned with the actor’s interests (Brooks et al., 2008).

To address the tension between the existence of an a priori actor and power lying in interactions, Brooks et al. (2008) suggest that Structuration theory in conjunction with ANT allows for the centering of the individual through the development of self-organising autopoietic networks, so actants are emergent from networks and also constrained by them. This links ANT with complex adaptive systems - as noted above this agency is not based in the ‘symbolic’ but in communication

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26 Elder-Vass (2008) notes that there may be issues of translation between French and English that over emphasises the symmetry suggested by ANT.
and also ANT’s relationship based networks. Brooks et al. (2008) propose a hybrid theory they call StructurANTion theory. In this theory non-humans (they refer to technology in particular) have an ability to (re)create the structurated system in which they exist, although in a more limited form than humans. In other words, they have the ability to respond but have no intentionality. Non-human animals such as weka could be considered to be closer to human agents as they possess the ability for unique responses to situations.

3.5.4 Hybrid theories

There are, however, significant tensions in such hybridising. The structure agency debate, which Structuration theory attempts to tackle, is for Latour not to be addressed through a dialectic like Structuration theory. Rather the structure agency debate is a non-existent theoretical dichotomy that highlights difficulties, but should be addressed through tracing links and networks rather than simplifying anticipatory frameworks (Latour, 2005). In this respect it is not clear that ANT and Structuration theory are entirely compatible. Latour (2005, p. 155) states “...no structuralist explanation. The two [ANT and structuralism] are completely incompatible. Either you have actors who realize potentialities and are thus not actors at all, or you describe actors who are rendering virtualities actual (this is Deleuze’s parlance by the way)...”. However, Brooks et al. (2008) are primarily interested in the actor based reflexive process (an autopoietic based reflexivity) offered by Structuration theory (as are Westley et al., 2002) as a way to allow networks to be maintained over time when faced by disturbances without an ongoing central organising actor as proposed by ANT. Actors are able to reflexively draw on the modalities of structure to allow this to occur.

Murdoch’s (1998) development of ANT is also helpful here. According to Murdoch (1998) there are two basic types of networks. There are ones which are fully co-opted (i.e., where elements are fully allied and the network stabilized in line with the central actor) which he calls ‘prescriptive networks’. The second are networks under negotiation where the links between elements are not fully established and are unstable and fluid (topological). This distinction, and Murdoch (1998) stresses it is only an analytical device, allows scope within ANT to consider fluidity and instability in networks; where elements are both aligned and not aligned. This creates a tension between regularity and multiplicity in networks. Murdoch (1998) applies flux and fluidity in networks to the ability of subjects to re-negotiate their role and extent of co-opting into networks. Subjects may be assemblages but their ability for negotiation (intentionality) implies the existence of some form of emergent stable subject within certain networks. This reflexive actor (rather than ANTs more inflexible actor) does not just instigate and dominate networks but responds and re-negotiates both
their role and the network, so the network becomes more recursive and adaptive, and so more
**systemic in nature** – i.e., it could be conceptualized as involving structures of sorts.

**ANTS** symmetry in actors, as well as its descriptive material focus that allows networks to
become more firmly established, along with breaks and changes in networks, and the interest in
heterogeneity and the unique and individual, has support from Deleuze’s thought.27 “Deleuze [and
Guattari] do not deny that human subjects can initiate novel and creative action in the world.
However, they refuse to mystify this creativity as something essentially human and therefore non-
natural.” (Bonta & Protevi cited Palmas, 2008, p. 23). In addition, as has already been stressed, is the
association of Deleuze’s thought with systems theory where it supports ideas of emergence and self-
organisation (Gangle, 2007). It allows for stratification but sees agency, like **ANT**, to exist at all levels.

Agency in Deleuze’s thought tends to be limited to far-from-equilibrium crisis points which
can precipitate shifts in the system to different attractor/s. This is why functionalist accounts of the
social based on equilibrium systems tend to deny agency (Palmas, 2008). This is consistent with
Resilience Theory which also suggests there are more sensitive points for actors to trigger change
(Gunderson & Holling, 2002) and also suggests a way to link ANT to Structuration theory and systems
thought. This introduces the idea that there are cycles in network formation. Cycles can be seen in
**ANT** where the process of network building is considered to be in four main stages: problemisation,
interest, enrolment and mobilisation. This is the development of networks from initial identification
of the problem to a stable network (Doak & Karadimitriou, 2007). It does not, however, address the
dynamic ongoing nature of such networks. Murdoch’s (1998) notion of networks under negotiation,
however, allows more fluidity in **ANT** networks.

The hub in this discussion are the parallels between systems theory and networks. Doak &
Karadimitriou (2007) attempt to amalgamate insights from network theories with those from
complexity theory. They suggest that the ideas of networks and complex systems have been used in
social science for a considerable time and that some merging of the approaches should be occurring.
They propose that network theories fundamentally focus on interacting components and so **CASs** can
be analysed as networks. The self-organising properties of **CASs** can also be applied to networks
which have shown to behave like self-organising complex systems (Kauffman, 1995). Doak &
Karadimitriou (2007) suggest there has been further emphasis on the contingent and fuzzy nature of
networks signalling a more dynamic understanding of them in line with **CAS**. Similarly, **ANT** can be
helpful in considering systems as it allows the tracing of networks across space and time and does
not impose a hierarchical framework or limits on these. In addition, Deleuze’s thought can be
considered a system (DeLanda, 2002) and network mix (e.g., rhizomes). Putting these together

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27 Latour (2005) at one time was interested in calling **ANT** “actant-rhizomeontology” (p.9).
means the social could be considered to “emerge from a network of communications among individuals”...aris[ing] from a complex, highly non-linear dynamic” and is reproduced through the actions of individuals who at the same time are constrained by it (Capra, 2002, p. 75 cited in Doak & Karadimitriou, 2007). This clearly links networks and systems with Structuration theory.

To summarise this section, it has shown potential connections between ANT, systems theory, Structuration theory and Deleuze’s thought. A systems based autopoietic actor consistent with Deleuze and Structuration theory is proposed, that draws on network ‘structures’ to exist and adapt, and that is most effective at certain points. It suggests an enlarged view of systems as more fuzzy and networked, and networks as having points of consolidation and cycles as having some systemic properties.

3.5.5 CAS, networks and social-theory

The foregoing Sections discuss connections between new systems and post-structural thought in relation to social theory. This discussion has considered how social theory has been utilised in social-ecological theory based on systems science. The discussion is necessarily brief and is unable to fully cover the complexity of the approaches, if this were even possible given the dynamic nature of concepts implicit in this approach. However, the discussion has revealed a set of positions containing both commonalities and tensions. When considered from a broadly post-structuralist or network understanding this is not unexpected and also legitimate. Deleuze’s thought, like ANT, focuses on learning to think of things in more relational terms (Lockie, 2004).

In conclusion, a possible hybrid social theory that is based on Structuration theory, ANT, and Deleuze’s philosophy has been discussed. It extends Structuration theory beyond its use in Resilience theory by Westley et al. (2002) to what is primarily a blend of systems and networks. This hybrid social theory includes the following elements: (1) Responsive human actants within networks; (2) Fully embedded human actors; (3) Networks containing diffuse structures; (4) A material basis to social systems; (5) Flexibility in system hierarchies and boundaries; (6) Cycles in networks; (6) Breaks and rapid changes; (7) and an actor symmetry.

This expands the attempt to establish a subject in Chapter 2 as affective, embodied, material (biological) and poetic. It extends the conceptualisation of the social in socio-ecological theory and, more specifically, Resilience theory. It gives a position that includes the individual rather than just the group, it moves away from both structural-functional social systems theory and purely interpretivist based accounts. It extends Structuration theory to being materialised, more dynamic, networked and cyclic and so more closely aligns it with systems science understandings. Agency is given to the non-human (e.g., weka, the material landscape), as well as more flexible hierarchical levels and
boundaries, and a broader view on knowledge (as not just being subjectively or objectively derived). Furthermore, networks question a strict adaptive cycle framework (see Section 3.5.3), while systems approaches allow simplification of complex networks for analysis. The methodological approach this position implies is the use of interpretive, qualitative and pluralistic methods but with the recognition that positions are not just subjectively based so it involves tracing networks, fluid structures and agencies (hybrids).

The last sections of this chapter provide an overview of Resilience theory; a CAS based socio-ecological theory. Resilience theory is used as a basis for the analysis of the socio-ecological situation at Cape Foulwind in regards to weka and land development.

### 3.6 Resilience Framework

A CAS based framework for understanding ecosystems was originally put forward by C.S. Holling in 1973 (Peeples et al., 2006). This development came out of studies of ecosystems that included human interaction rather than purely natural ecosystems (Gunderson & Folke, 2005). This model has become known as Resilience Theory (RT) and has been usefully applied as a framework for understanding socio-ecological systems (Andries et al., 2006). Within this theory resilience is understood as “the ability of an adaptive system to undergo change and reorganisation while maintaining its fundamental functions, processes and structures.” (Peeples et al., 2006, p. 23).

Crucially, this re-organisational capacity is dependent on the self-organizing and adaptive capacities of CAS (Folke, 2006) (see Section 3.4.3). This is in contrast to the other widely used definition of resilience - the ability of a system to return to its equilibrium state after disturbance.

RT is best described as a framework rather than a theory as it acts as a guiding approach for understanding the interaction of SESs (Andries et al., 2006). RT does not profess to provide a theoretically based explanation of why change occurs (Peeples et al., 2006; Andries et al., 2006). This is because of SESs extremely high complexity and non-linearity, which means experiments are not able to be controlled or verified (Andries et al., 2006). Because of this, much RT research into SES has been undertaken on a phenomenological or descriptive case study basis and has then relied on continual comparison of these case studies to gain general insights about the nature of SES. As such, it is a powerful tool for categorizing patterns and making insights into the nature of SESs (Andries et al., 2006). Andries et al. (2006) suggest that developing the RT framework theory further is a key research direction in RT research.

RT is a framework that attempts to describe the processes through which adaptive systems can be fundamentally transformed as well as providing a framework for how adaptive systems are structured and organised (Peeples et al., 2006). RT postulates that there are a number of potentially
stable states (attractor basins) that a complex socio-ecological system can settle into. These stable states themselves move through an adaptive cycle of succession, exploitation, conservation, crisis and reorganisation (See Figure 2.1) (Kay et al., 1999). In total, SESs are considered to be made up of a range of spatially and temporally nested systems moving through this cycle. The larger systems tend to move more slowly through the adaptive cycle and provide stability to the system as a whole while smaller, faster moving systems create ongoing change and novelty (Gunderson & Holling, 2002). Because of this RT, postulates that SESs incorporate both stability and change (Peeples et al., 2006).

When considering the impacts of human action on natural systems RT does not just undertake an analysis that emphasizes the social sphere, i.e., if society is well organised it can adapt to changes and also manage the natural world in sustainable way. Rather, RT takes into account the ability of the ecosystems to adapt which may then create thresholds (bifurcations) in the resilience of the entire socio-ecological system (i.e., the social and natural co-evolving) (Folke, 2006).

There are two main concepts central to RT. These are those of the adaptive cycle and thresholds. They are complementary but neither requires the other. The following sections discuss these concepts.

3.6.1 The adaptive cycle

As has been mentioned, the four phase adaptive cycle is the key and basic conceptual model for RT. The four phases (see Figure 3.1) are made up of:

1. Growth (r phase). Dominated by opportunist actors or species (r species) that use all available resources and exploit all niches. Components are weakly connected.

2. Conservation (K phase). Dominated by competitive and long lived actors or species that displace the opportunists. It is characterised by increasing rigidity (i.e., highly interconnected components) and susceptibility to disturbance (i.e., less resilient).

3. Release ($\Omega$ phase). This follows a disturbance event that exceeds the system’s resilience. Closely bound resources and natural and social capital are released as the system’s structure is lost. These become a source for reorganisation.

4. Reorganisation ($\alpha$ phase). This is a stage of creative renewal where actors and species re-sort themselves in potentially novel ways. This generally leads back to the growth stage.

These cycles are propelled by processes of accumulation and sporadic events and are generally conceptualized as following each other in the order listed above, although this does not have to be the case (Folke, 2006). The part of the loop containing the r and K phases and characterized by accumulation, stability and conservation is sometimes called the fore loop, while
the $\Omega$ and $\alpha$ phases, characterized by uncertainty, novelty and experimentation, is the back loop. The adaptive cycle lies in contrast to the traditional three phase succession model where ecosystems are depicted as moving, following disturbance, through a set of stages towards a final climax community (Gunderson & Holling, 2002). The use of this earlier model has meant that conventional resource management has concentrated on approaches that assume ecosystems are inherently near equilibrium and resource flows should be controlled (command and control). The $\Omega$ and $\alpha$ phases have mostly not been considered. These phases emphasize that disturbance and rapid change and renewal are as important to the systems as much as slow change and development (Folke, 2006).

The additional reorganisational stage included in RT posits that the resulting successional path, following from release, will not necessarily follow the preceding one as resources are reorganized in potentially novel ways (i.e., to a different attractor). As such, RT recognises that there are potentially a number of stable equilibrium states or ‘climax communities’ into which a system can reorganize itself following disturbance. These disturbances can be either external events or internal events within the system (Peeples et al., 2006). Because the reorganisational phase is crucial to what trajectory the system will take it is considered a site of opportunity to influence the development of the system.

![Figure 3.1](image_url) The Resilience theory adaptive cycle (from Peeples et al., 2006).

Other important features of the adaptive cycle include connectedness and resource potential. The horizontal axis in Figure 3.1 relates to the connectedness of the system. This is the strength of relationship between various system elements and as they increase it is thought that the system becomes less resilient (Peeples et al., 2006). However, an assessment by Andries et al. (2006)
suggests that there is no clear relationship between connectivity and resilience and suggests that there may be increased links during the reorganization part of the cycle rather than the conservation phase.

The vertical axis of Figure 3.1 shows the suggested changes in the variability in potential of resources (capital) for either use (high in reorganisation phase) or transformation (high in conservation phase). These resources include biomass or social capital (Peeples et al., 2006).

A further development in RT is the concept of panarchy. This explicitly links interaction across temporal and spatial scales. Panarchy is conceptualized as a nested set of systems each moving through the adaptive cycle. Each layer operates at its own speed and is embedded within larger scales operating at slower speeds, while incorporating smaller, faster systems (Gunderson & Holling, 2002).

With its emphasis on the interaction between scale, investigations undertaken using RT attend to several scales. Walker & Salt (2006) suggest SES trajectories are governed by only a small number of variables. If there were many more the SES would be very unstable. Consequently, as one of heuristics for SES Walker et al. (2006) suggest that “[c]ritical changes in socio-ecological systems are determined by a small set of three to five key variables” (p.4). This would suggest that deciphering these key variables is an important part of understanding interactions within a SES28.

The multi-scaled interactions of panarchies relates to what is called ‘general resilience’. This is the general capacity of a SES to absorb shocks. There are three factors, according to Walker & Salt (2006), associated with this resilience. The first is diversity. This is the number of institutions, species, etc. in a SES. Some aspects of diversity (e.g., particular species) may only become important during periods of recovery from disturbance, or they may be important for connections at different scales. It is the functional group and the variability of response within them across scales that is most important for diversity rather than the total number of species (Folke, 2006). Higher diversity creates more options to absorb shocks.

The second is modularity, which relates to how closely systems are linked. In highly linked systems shocks move quickly through them, while in more modular systems individual modules can keep functioning when shocks to the system occur. The third is the tightness of feedbacks. This relates to how strongly and quickly change in one part of a system is felt in another. Another type of resilience is called ‘specified resilience’. This is optimizing resilience in a particular interaction (i.e., managing for specific variable and specific disturbances (e.g., weka and land development)).

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28 The variables at Cape Foulwind in relation to weka are developed and discussed in Chapter 14.
3.6.2 Regime shifts, Thresholds and Cascades

Resilience in RT is considered as the ability to absorb disturbance without creating a change in the key processes and feedbacks of the system. Should this occur the system is considered to have reached a threshold and a consequent movement of its state space from one attractor basin to another (Walker & Salt, 2006). This is a shift into another state with a different set of internal controls and structure. This is called a ‘regime shift’. It is not clear that regime shifts are always a move to a more efficient and complex dissipative structure (see Section 3.4.2). A regime shift involves a loss of resilience as a system’s functions and structures are reorganized (Kinzig et al., 2006). Regime shifts may or may not occur as part of the adaptive cycle (i.e., a system may reach a threshold during a disturbance event and then reorganize into a different regime (i.e., a different attractor), or reorganize back into the same general r and K adaptive phases (Walker & Salt, 2006)). The transition between regime shifts can be clear and defined or it may be gradual (Kinzig et al., 2006). The distance from a threshold that marks a regime shift is a measure of Resilience (i.e., the lesser the distance the smaller the resilience). This distance changes over time and can depend on either internal changes to the system or external disturbances (Walker & Salt, 2006).

Kinzig et al. (2006) note that the location and potential for crossing thresholds are impacted upon by factors in other scales in the panarchy. This means thresholds can interact and potentially create cascades of regime shifts throughout the panarchy. This can lead to very resilient outcomes but not necessarily desirable ones. They can also occur across domains (i.e., social, ecological). The dynamics of thresholds or interacting regime shifts are consequently complex and no general model for how they work has yet been produced (Kinzig et al., 2006). In particular, thresholds may be reached at fast, smaller cycles which then cascade down forcing thresholds to be reached at slower larger cycles. The smaller, faster scale thresholds act as sources of novelty while the slower, larger cycles tend to act as memory (e.g., as long term cultural knowledge or seed banks in the soil) to provide the context and sources for renewal (Walker & Salt, 2006). Consequently, small scale (temporal and spatial) systems are understood as a source of adaptation (learning) while larger scales are understood as sources of stability (Kinzig et al., 2006).

Regime shifts can be marked and contain an element of hysteresis (i.e., irreversibility), or be a smoother transition. As mentioned, the position of these thresholds is not static and depends on the state of other parts of the system. Kinzig et al. (2006) propose developing a general model of threshold interaction in socio-ecological systems, that emphasises the cascading effects. It assumes that the social and ecological can both be addressed in a common theoretical framework. This is at odds with RT generally which implies different frameworks for each (Gunderson & Holling, 2002; 29)

Distance refers to the closeness of the state space to the edge of the attractor basin.
Stepp et al., 2003). However, lacking any other frameworks, Kinzig et al.’s (2006) is a useful start in trying to conceptualize cascading interactions. Kinzig et al. (2006) note that the socio-cultural thresholds are often overlooked in analysis, and also that all regional SES are affected by extra-regional effects, including global forces (e.g., commodity prices, technological developments). Knowing which internal regime shifts are most susceptible to outside forces can help clarify which thresholds are likely to be breached first.

### 3.6.3 Learning and management

Brock et al. (2002) describe three types of human learning associated with panarchies that correspond with three types of change; incremental (fore-loop phases), abrupt (back loop phases) and transforming (cross scale reorganization). The first type - incremental change - is associated with learning involving simple first order feedback and incremental knowledge development. The second - abrupt change - involves dynamics that undermine the standard schema of the situation and its associated policies. Learning involved in these situations is a second order feedback loop where the underlying understanding is questioned then redeveloped. The third type - transformational - involves several levels in the panarchy. Learning in these situations moves beyond just developing new schema, it involves new paradigmatic structures (Brock et al., 2002). The success of this learning is key to a SES reinventing itself into a different kind of system. It involves socio-ecological memory, as well as the social part of the system or network, for example, being tolerant of and open to failure (Anderies et al., 2006)

Rammel et al. (2007) note that case studies show that retaining socio-ecological memory, integrating different types of knowledge, and giving scope for self-organisation to occur, are important for both retaining diversity and so for adaptive change. In regards to different ways of knowing, Holling et al. (2002) tentatively link the adaptive cycle with a range of systems including individuals. At the individual level they suggest that the r phase is primarily to do with sensation, the K phase with thinking, the Ω phase with intuition, and significantly they link α phase with feeling. The α phase or reorganisation phase is understood in RT as the most crucial phase in the cycle as it is most sensitive to small changes that set up the ongoing development of the system. They do not develop this idea any further, but, it is founded in the notion that time is experienced in different ways. This pivotal role suggests that affect (emotion) may be central to ecological memory. In addition, affect may also be important for the diversity and novelty central to the reorganization phase. The relationship between cognition and embodiment, and cognition and affect is discussed further in the chapters that follow. This is based on a systems understanding, and so allows the possibility of a revised understanding of the nature of the individual in RT.
Understood as a panarchy, systems at various scales are moving through the adaptive cycle and so surprise and unpredictability occur. As mentioned, this means learning needs to be more than just incremental. Because of this, adaptive management performs better than approaches that focus on set outcomes. Adaptive management recognises the lack of certainty in purely scientific approaches and uses an iterative and flexible approach to management problems (Andries et al., 2006).

Adaptive management is based on the understanding of sustainability as the capability to maintain adaptive capacity through testing of alternative paths (Gunderson & Holling, 2002). Because of the experimental aspect, adaptive management involves developing hypotheses about the way SESs will respond. As such RT’s role in management is not in developing predictive outputs for management options but in “focusing attention on particular system attributes that play important roles in the dynamics of SESs and attempting to develop principles to guide interventions in SESs to improve their long-term performance” (Andries et al., 2006, p. 2). Implementing adaptive management involves developing models of how SESs will behave under various management options. This can reveal assumptions and refine questions. A second phase is the implementation and testing of modelled management options. However, this is not often carried out due to the costs and risks of implementation (Andries et al., 2006). This study involves the development of models (FCM and IBM) in an attempt to ascertain how the SES involving weka at Cape Foulwind might be best approached.

RT has a strong systems science orientation, reflecting its background in the natural sciences. As has already been discussed, this has meant it lacks a strong social science orientation and a social theory. Its utilization of Structuration theory was considered and developed further in Section 3.5. The self-organizing holarchic open systems (SOHO) theory of Kay et al. (1999) offers a broader position and scope to incorporate more fully social input and considerations of networks, instabilities, less structured cycles, etc., while retaining some of the adaptive cycle insights of RT. Regardless, RT contains helpful tools for organizing and assessing SES (e.g., RT workbooks, and a considerable number of existing examples of its application).

3.7 Conclusion

This study will use the RT adaptive cycle for analysis as a way to understand the history of human occupation and its interaction with weka at Cape Foulwind. However, it will only be used as a heuristic for two reasons: First, this study is interested in local people’s understandings and positions rather than developing a strict model and then applying their understandings to it. Second, RT is a descriptive framework or metaphor that is not necessarily applicable to all situations.
An implicit assumption of RT is that humans play a dominant role (i.e., management is about stopping systems falling into ‘unwanted regimes’ to meet human welfare needs). In this sense RT focuses on researching SES management techniques so that management can be undertaken. RT presumes to know how things are and what is best and places this over people and places in its analysis. In contrast, RT also recognises that we cannot know the whole so it focuses on preserving options for the future by retaining diversity, allowing scope for innovation, retaining tight feedbacks, fostering social networks, etc. (Walker & Salt, 2006).

The understanding developed in this chapter and Chapter 2 questions some of the suppositions of RT. It proposes that individuals are fundamentally embedded in systems/networks as holders of perspectives. These are non-dualistic accounts of perceptions (akin to Merleau-Ponty’s notion of the ‘lived body’), which are not just held by humans. Perspectives are part of the ongoing emergence of self-organisation and novelty in the world and the ongoing emergence of systems concepts themselves. In addition, and which will be considered in the next two chapters, perspectives are both affective and cognitive.

This highlights several key points. First, how to treat inhabitants’ understandings and feelings about places; are they to be considered secondary to the RT adaptive framework? ANT’s actor symmetry suggests we do not ever just manage the system it also manages us, it evolves and constrains our conceptual and physical world. Second, is the normative question of how we want the system to be. Who is ‘we’? How do we get to know the legitimate ‘we’? Is it merely the inhabitants who express an understanding conducive to the RT focus on retaining diversity, etc? Diversity, it would seem, includes options that may constrain future options. Third, the idea of the fluidity of networks questions the scalar nature of system analysis - can we really track down key scalar variables?
4 Cognitive science

4.1 Introduction

Cognitive science studies conceptual systems (Lakoff & Johnson, 1999) and more specifically, cognition. It is an interdisciplinary endeavour involving disciplines such as neuroscience, developmental and cognitive psychology, computer science, artificial intelligence (AI), linguistics, phenomenology and philosophy (Lang, 1999; Varela et al., 1991; Anderson, 2007). The array of disciplines contributing to cognitive science, along with its immaturity (Varela et al., 1991), its rapid developments in knowledge (Lakoff & Johnson, 1999), and how the mind and cognition is conceptualised (Beer, 2000), create a range of understandings of what cognition might be, as well as creating an ongoing reassessment of what cognition is. For example, traditionally cognition has been described as referring to thought and inferences, in contrast to perceptual experiences, sensations and feelings. The latter are thought to only provide input into thinking and reasoning (Honderich, 1995). More recently, Tang (1999) described cognitive science as “the study of mental processes in all its aspects” (p. 675) and (Varela et al., 1991, p. 5) as “the study of knowledge and the human mind”.

This broader understanding of cognition includes all mental operations involved in “language, meaning, perception, conceptual systems and reason” (Lakoff & Johnson, 1999, p. 12). This expansion has partly developed from an increased interest in phenomenological approaches within cognitive science itself. In particular, the phenomenology of Heidegger and Merleau-Ponty embeds and expands cognition into the body and world, and so links perception and action to cognitive processes (Clark, 1997; Gallagher, 2005; Wheeler, 2005). Indeed, there is an increasing agreement across a number of disciplines (genetics, neurosciences, behavioural sciences) of the importance embodiment plays in cognition at both the conscious and non-conscious levels (Gallagher, 2005). Early influences in the development of embodied cognition were motor theories of perception (e.g., William James) that emphasised cognition’s relation to sensorimotor abilities. In the 1980s there was interest from linguists in abstract concepts being based on bodily and physical metaphors (Larkoff & Johnson, 1999). Developments in robotics produced routines that interacted with the environment rather than using abstract internal representations (e.g., Brooks, 1991). The integration of these various influences above has produced the embodied approach to cognition, where the mind is understood primarily in the context of its relationship with a physical body interacting with the world. The central premise is that humans have evolved from organisms whose mental abilities were used primarily for sensorimotor processing in immediate interactions with their environment (Wilson, 2002).
The theoretical account developed in Chapters 2 and 3 develops an embedded and interactive understanding of how human–weka interaction can be understood as occurring. This chapter primarily outlines the ideas behind situated and embodied cognition from physical, biological and conceptual perspectives in order to develop further support for the overall philosophical position in the study. This involves a rejection of cognitivist understandings of cognition which tend to downplay the importance of interaction.

Following a brief outline of the relatively short history of cognitive science, I will discuss the situated and embodied developments in cognitive science. I will then consider the problem of decoupled cognition and the use of representations, which sits as a significant argument against a situated-embodied approach. Finally, I will discuss the more radical approaches embodying self-organised and systems that have been outlined in Chapter 3, and link with the philosophical position taken in this study developed in Chapter 2.

4.2 Cybernetics, cognitivism and connectionism

Cognitive science as a field of research began in the 1940s. It was associated with the theory of cybernetics, the development of which paralleled Bertalanffy’s general systems theory (see Section 3.3.1). Cybernetics was developed by a small group of researchers (engineers, mathematicians and neuroscientists) looking at patterns of organisation, particularly communication, feedback and networks. This group wished to describe the mind through acquiring an understanding of neural mechanisms and describing them mathematically (Capra, 1996). Although there were ongoing debates on whether the mind could be fully described in logical terms and also about levels of explanation (e.g., personal vs. sub-personal) the outcome pursued was a logical model at the neuron level. Each neuron was considered as a logical on/off gate or threshold device that could link with other neurons in a network. It was through this conception that cybernetics made some significant advances that permeate cognitive science explicitly and implicitly today. It was also central to the establishment of systems theory, information theory and the first concepts of self-organising systems (Varela et al., 1991).

This cybernetic success led the way for cognitive science to take up a computational model or analogy during the 1950s as a way to represent cognition (Varela et al., 1991). This became known as cognitivism. Cognitivism’s basic position is that the ability to make decisions about behaviour requires the facility to represent the world in certain ways. For this to occur, agents need to be able to represent relevant portions of the world in their minds (Varela et al., 1991). This is achieved

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30 Cybernetics and the systems approach associated with it developed as a basis of more recent embodied and dynamical systems approaches to cognition.
through postulation of symbols that stand in for features of the world (Anderson, 2003). These symbols are manipulated according to explicit formal rules (Capra, 1996). The notion of these symbol based representations, their existence, role and form are the subject of much ongoing discussion in cognitive science (Clark, 1997; Wheeler, 2005; Vacariu et al., 2001; Anderson, 2003).31

There are three layers to cognitivism’s notion of symbolic computation - physical, symbolic and semantic. Cognitivism claims a reified symbolic level over and above the physical (neurobiology), and on top of the symbolic level, a third semantic layer. Although the symbolic level is physically realised it is not reducible to the physical level, i.e., the symbols can be manifest in a range of physical forms, including highly distributed ones (e.g., in some versions of connectionism). Likewise, the semantic layer is not reducible to the symbolic layer although there is some dispute over this within cognitivism (Varela et al., 1991). This highlights two main problems. The first is how the syntactically manipulated symbolic expressions get their meaning32. The second is that while there is a physical link lying in the idea that the symbols are instantiated within the physical structures (i.e., neurons) it is still not clear how this is connected back to the body as behaviour and experience (Varela et al., 1991).

During the 1980s connectionism became important as an alternative to abstract symbolic computational cognitivist models of brain functioning (Clark, 1997; Varela et al., 1991). Connectionism is sometimes known as PDP (parallel distributed processing) or neural networks, and is based on what is known about biological brain function and structure. Neural networks are groups of massively interconnected multilayered networks of neurons that have no central controller and are consequently considered to have self-organising properties that allow global cooperation to emerge spontaneously. The interconnectedness of the network means that functioning is distributed throughout the brain and allows simultaneous (parallel) processing and redundancy. Their close physical structural and functional parallels with biological brains means connectionist models do not have the same high level of abstraction as cognitivist symbolic models (Varela et al., 1991). The

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31 For example, first a realist position sees them as a direct mapping of the stimulus; second, mental presentations as ideas are understood as mental codes, symbols or abstract characterisations. A third approach, constructivism, highlights an ongoing elaboration of perceptual stimulus from sensations along with cognitive (and affective) operations themselves originally derived from past perceptions (Reber, 1985). Constructivism has a range of positions within it. Most significantly it lies implicit in dynamical systems approaches.

32 This issue does not arise in the application of the cognitivist schema in artificial intelligence (known as GOFAI (Good Old Fashioned Artificial Intelligence)) (Anderson, 2003), as the symbolic and semantic are layered together through the human programmer’s input. In other words the programmer programs in meaning through the syntax structures of the symbolic language (Varela et al., 1991).
parallels between what is known about biological brain architecture research in neural networks models has undermined many of the assumptions of cognitivism. However, it still leaves some questions unanswered such as the nature of representations and how humans can undertake planning and logic. This will be discussed in Section 4.3.2.2.

4.3 Embodied and situated cognition

At about the same time as connectionist theory was developed the first threads of the embodied cognition approach appeared within cognitive science. Embodied cognition’s concern for the role of the body in cognition paralleled an increasing interest with situatedness; the effects on cognition from continuing interaction with the agent’s everyday environment (Varela et al., 1991). There is some overlap between the embodied and situated approaches to cognition as our everyday situated world is also our embodied world. The key emphasis for both approaches at the philosophical level is overcoming the dualism of mind and body and mind and world, that is understood as part of the broader Cartesian legacy (Wheeler, 2005).

In embodied and situated cognition, meaning is not considered to be held in symbolic structures in the head but fundamentally in the social and physical world within which the agent is embedded. Perception is not simply considered to arise from sensations which are received, operated on, and output as behaviour, as implied in the cognitivist approach (Wilson, 2002). It involves, instead, a focus on the interface (organism) rather than the internal (sub-personal level). Nevertheless, it does not necessarily reject such notions as representations but, rather, it reconceptualises them (Clark, 1997; Varela et al., 1991).

Embodied cognition both allows and promotes a reconsideration of the ontology of mind as the mind becomes both extended and naturalised. However, the extent to which a separate ontology for the mental is maintained varies. For example, the mind might be fully naturalised but only in the sense it has a physical (material) basis, and not in the sense of being reducible in an explanatory manner33 to the physical. In this case, it is not considered to be a ‘thing’ causally attached to the brain. For example, some philosophers such as Searle maintain an irreducibility of consciousness (mind). He sees consciousness as distinctively subjective, and as ontologically different from objective phenomena (Honderich, 1995). As it is assumed that cognition is at least in part a conscious event, his position questions whether cognitive science can ultimately clarify cognition in purely physiological terms. On the other hand, naturalising of the mind into the brain has made the brain

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33 The mind may be considered reducible from an evolutionary standpoint (in a functional sense), i.e., the mental is ultimately adaptive to environmental (as a coupled system) constrains.
and its sub-personal neurophysiological structures, for many, the proper unit of study of the mind (e.g., Churchland’s eliminativism) (Rockwell, 2005).

By contrast, developments in embodied cognition spread the mind physically from just being a neural structure in the brain, into the body (in action), primarily by considering the nervous system as a whole and also the role of hormones (Rockwell, 2005). In this view, the mind is not just seen as a property of interacting cranial neurons, but is equally dependent on the “interactions among a brain, a nervous system, a body, and a world.” (Rockwell, 2005, p.xii). Under this proposal Rockwell (2005) suggests that the mind-brain relationship is not strong enough to be either an identity or to possess a strict causal relationship but is best described through the term ‘supervenience’ (Rockwell, 2005).

Table 4.1 Comparison of approaches in cognitive science (based on Clark (1997)).

<table>
<thead>
<tr>
<th></th>
<th>Memory</th>
<th>Problem solving</th>
<th>Cognition location</th>
<th>Environment’s role</th>
<th>Body’s role</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitivist</strong></td>
<td>Symbolic database</td>
<td>Logical inference</td>
<td>Centralised in brain modules</td>
<td>A problem domain</td>
<td>Input output mechanism</td>
</tr>
<tr>
<td><strong>Connectionist</strong></td>
<td>Pattern re-creation</td>
<td>Pattern completion &amp; transformation</td>
<td>Centralised in whole brain</td>
<td>A problem domain</td>
<td>Input output mechanism</td>
</tr>
<tr>
<td><strong>Embodied</strong></td>
<td>Pattern re-creation</td>
<td>Pattern completion &amp; transformation</td>
<td>Brain, body, environment &amp; interface</td>
<td>Active resource</td>
<td>Part of computational loop</td>
</tr>
<tr>
<td>(moderate)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Embodied</strong></td>
<td>Pattern re-creation</td>
<td>Pattern completion &amp; transformation</td>
<td>Brain, body, environment &amp; interface</td>
<td>Integral to cognitive process</td>
<td>Integral to cognitive process</td>
</tr>
<tr>
<td>(radical)</td>
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Rockwell’s (2005) position lies at the more radical end of the two main positions in embodied cognition (Table 4.1). These positions are complicated by the number of disciplines involved, resulting in a variation of terminology and conceptual frameworks. A more moderate position is taken by Clark (1997) who proposes that cognitive activity is embodied to the extent that this occurs not just in and with the head, but also in and with its body and environment. This being the case, analysis involving embodied and environmental elements that have been shown to directly affect or support cognition is easy to legitimate (Anderson, 2007a; Wilson, 2002), and is well supported (Clark, 1997). The more radical position extends this by proposing that the body and environment do not just support cognition but are integral to it. It extends and integrates cognitive processes into the world primarily through the use of dynamical systems. This more radical position has gained less acceptance (Clark, 1997). The approach to cognition this study takes aligns most closely with the embodied (radical) position.
The following sections will discuss situated cognition and embodied cognition under separate headings. This split is in part for convenience of discussion rather than an assumption that strict boundaries exist between these approaches. This discussion will also involve addressing some more specific concerns in regards to the role of representations. This is because it is a key point of contention between embodied and situated approaches and the cognitivist approach in cognitive science and, importantly, relates directly to the question of immanence.

4.3.1 Situated cognition

The situational framework, according to Beer (2008a), has three core ideas associated with it. First, action in the world is more fundamental than abstract descriptions of it. Second, the immediate environment is core to an actor’s behaviour, offering constraints, opportunities and the context of meaning for an activity (the immediate environment is considered to be both social and physical). Third, there is an ongoing interaction of the actor with the environment.

The situational framework traces many of its philosophical, formative influences to the phenomenology of Heidegger. The challenge of Heidegger’s early phenomenology, as outlined in Chapter 2, to cognitivism and Cartesianism has been noted (Varela et al., 1991; Clark, 1997), and developed, by a number of scholars (Wheeler, 2005). Beer (2008a) also notes the importance of the ecological psychology of Gibson (1979) who highlighted the role an organism’s environment has in perception, as well as the way the environment’s structure offers (or constrains) possibilities for action for a particular organism.

Beer (2008a) emphasises that situation and action are closely linked as action always takes place within a specific situation. This situational context is not generally a static one so agents need constantly to adapt their behaviour (actions)34. There is evidence that this occurs not in the cognitivist sense of, sense-model-plan-act. Rather is undertaken, depending on the activity, actively through a continuous, perceptually-based reassessment of the situation as it develops (Clark, 1997). In addition, situations that are developing quickly may not allow enough time for a “cognitive planning process” or even require this sort of accuracy, and so only a rapid heuristic is required (Semin & Smith, 2002).

Another important influence on situated cognition comes from social psychology, where social situatedness of behaviour is a central theme. It has been shown that behaviour is considerably influenced by the social situation the agent finds themselves in. In particular, people are sensitive to expectations of who they are in communication with, and the situation in which they are

34 Taking this a step further, Noë (2004) argues that perception itself develops out of such whole body situated action.
communicating (Semin & Smith, 2002). This situational aspect is an important consideration to be reflected in undertaking social research (e.g., in the creation of fuzzy cognitive maps and interviews in this study). At the social level, the systems and network-based approaches discussed in Chapter 3 emphasise interactive and situated actors.

The most significant criticism of the situational cognition focus is the recognition that there are large amounts of cognitive activity that do not entail ongoing interaction with the environment in any direct way (e.g., planning, imagining, and remembering) (Wilson, 2002). This creates problems for arguments that situational cognition is the basis of human cognition on human evolutionary grounds. In this respect, although there was some requirement for fast, coupled situational responses for early human survival (e.g., hunting) there was much that was not (e.g., food gathering which requires planning and memory, social and cultural development) (Wilson, 2002). Anderson (2007a) agrees that although it is not possible to describe all human cognitive activity as directly situated, all cognition is ultimately derived from and is for environmental interaction. Whether this is described and analysed as decoupled does not undermine the basic situated cognition position. Consequently, evolutionary adaptation can be thought of as being the situational history of action. This does not require that there be a direct connection between cognition and action or that every action needs to be for overtly adaptive purposes (Anderson, 2007a).

Lakoff & Johnson (1999) address the problem by stretching out the evolutionary time frame. Lakoff & Johnson’s (1999) argument is that our present modes of abstract thought (e.g., reason) developed through, and are based in, evolutionary structures that existed in our preceding evolutionary forms. The structures were primarily sensori-motor in form and consequently based in situational needs. However, this is not just inherited in actual physical bodies and neuronal structures but also through inference rules inherited from our evolutionary environment. These dynamic and structural linkages are exposed in metaphorical thought structures (Anderson, 2003). In contrast, Gallagher (2005) generally avoids the evolutionary perspective and rather considers situatedness from the perspective of individual development. He argues that individual cognitive development is intrinsically linked to ongoing experiences.

The overlap between situated cognition and embodied cognition is revealed in the preceding discussion. Situated cognition is always an embodied cognition, while embodiment opens up the temporal scale of situatedness in developmental and evolutionary terms. The following section considers more fully the physical, biological and conceptual aspects of embodied cognition.
4.3.2 Embodied cognition

The following sections on embodied cognition are divided into three broad headings following Beer (2008a): the physical; the biological; and, the conceptual. The physical encompasses the physical attributes of the body. The biological covers its biological identity (e.g., evolution, neurology, development). Conceptual embodiment is the manner by which abstract thought is affected by the body.

4.3.2.1 Physical and biological

For Beer (2008a) the physical aspect of embodiment considers the role of the physical attributes of the body in cognition (e.g., shape, size, interaction, and layout of sensors and appendages). The importance of this aspect arose in developments in AI, where embedding AI into a robotic body enabled accounting for environment impacts on behaviour (Brooks, 1991a). However, it also has more significant implications in that it allowed a way to address the cognitivist problem of how real world meaning can be acquired by abstract symbols. This is called the physical grounding problem (Anderson, 2007) or the frame problem (Rockwell, 2005, p. 137) - named through the attempt to use *frames* or scripts to *ground* abstract symbols and avoid trying to store the “whole world in the head”.

For Anderson (2003) the physical grounding problem is one of the fundamental issues that embodied cognition can contribute too. He suggests the shift from Descartes “thinking thing” to a more Heideggerian approach of human being-in-the-world (i.e., interactive coping is central) is an important development in resolving the physical grounding problem. He expands this problem to what he calls the physical grounding project (hypothesis). It “centrally involves understanding how cognitive contents (however these are ultimately characterised, symbolically or otherwise) must ultimately ground out in (terms of) the agent’s embodied experience and physical characteristics” (p. 92). The physical grounding hypothesis proposes that embodiment (experientially and physically), rather than merely an influence on how cognition is undertaken, facilitates cognition and intermeshes it with ‘meaning’ through an ongoing interaction. The physical grounding hypothesis is not reducible to neuronal physiology as embodied cognition implicates the whole body due to “many different material characteristics, structural features, relational properties, dynamic attributes, organisational levels and development stages” (Anderson 2007, p. 128).

This intermeshing of the bodily with the cognitive is clearly shown and developed by Gallagher (2005). He suggests that there is “a large amount of evidence from a variety of studies and disciplines to show that the body, through its motor abilities, its actual movements, and its posture, informs and shapes cognition” (p. 8). Gallagher’s (2005) approach is not just about extending the
mind into the body (i.e., how the mind can be replaced by bodily processes) but involves extending
the body into the mind (i.e., how the body can be considered mental) (Legrand, 2005). This is not just
trying to develop a closer correlation between the mental and physical; Gallagher (2005) considers
this too dualistic. Rather, he is concerned with how the mind is accomplished by the body, not just
the brain.

As has been outlined in Chapter 2, it is the phenomenologist Merleau-Ponty who has
highlighted the role of our physical embodiment in this process, and made bodily involvement in the
world central to lived experience. Gallagher (2005) claims such a purely phenomenological approach
does not give adequate account of our embodiment, as subjective experiences are unable to be
correlated with neuronal structures. Conversely, sub-personal third-person approaches to mind,
whether functionalist, computational or representational, are always over simplified as they do not
begin with the pre-noetic effects of our active situated embodiment. For Gallagher (2005) both of
these risk bypassing the essential role of the body. Consequently, Gallagher (2005) has started to
develop a new vocabulary to integrate these first- and third-person aspects\(^{35}\). The post-structuralist
and systems-based position developed so far also potentially provides such a vocabulary by
tentatively linking these two aspects.

As touched on above in Section 4.3.1, the evolutionary element also needs to be considered
because our evolutionary history may also have important consequences for our cognitive
architecture (Beer, 2008a). Anderson (2007a) suggests that cognition evolved as a tool for organisms
to cope with their environment and that we have gone through a particular evolutionary history that
impacts on how cognition is organised and also how adaptive it is. There has been a refinement to
the understanding of this process through an emphasis on development. This developmental shift
can be considered as a change from the blueprint metaphor (the phenotype develops in a genetically
predetermined manner no matter what the environment) to a recipe metaphor (the phenotype
develops based on its genetics but the final outcome depends on environmental factors) and then to
an emergence metaphor (the phenotype develops in reciprocal feedback between genes and
environment - epigenetics) (Baxter, 2007; Lickliter, 2007). This highlights an adaptive development
involving the ongoing interaction of brain, body and world. Such developmental approaches see the
process as inherently dynamic and so have parallels to systems theory. An example of this is the
development systems approach of Gottlieb (Valsiner, 2007).

One implication of this refinement is that it draws the body and mind closer, as is required by
the situated, embodied interaction involved in phenotypic development. A second implication is that

\(^{35}\) In psychology bridging the gap between subjective experience and objective reality is called the ‘hard
problem’ (Honderich, 1995).
it highlights the plasticity of the mind (neurodevelopment). This is because this understanding has a more ontogenetic emphasis suggesting adaptation from flexibility in development from an individual’s ongoing interaction with the environment. Neural organisation and structure is considered to develop as it is used (Moore, 2008).

This section has highlighted the role of physical in informing cognition and grounds it in embodied experience and physical characteristics. It also noted the importance in evolutionary processes of ongoing interactive development. It suggests that adaptive capacities lie in the multifaceted interactions of brain, body and world rather than just in the cognitivist brain, or biological body (Clark, 1997). However, the nature of representations and their use in decoupled cognition (e.g., conceptualisation) remains a difficulty for a situated-embodied cognitive approach. The next sections consider the use of representations and how they might be reconsidered within embodied cognition.

4.3.2.2 Conceptual

Introduction

This section broadens the preceding section, with which it overlaps, to consider the problem of how the conceptual can be addressed within an embodied mind framework. It will initially briefly discuss how the body might support conceptualisation, through sensimotor aspects, the use of scaffolding, and language and metaphor. However, it will concentrate mostly on what Anderson (2003) and Clark (1997) identify as perhaps the central problem for embodied cognition: How abstract decoupled thought or the conceptual might be understood. As has been outlined in discussion of the cognitivist approach, decoupled conceptual thinking is considered to be representational in nature (Smith, 2005).

The problem of conceptual thought is closely related to the physical grounding problem, which has been discussed above, and concerns how meaning is acquired in cognitivist approaches. The physical grounding problem also relates to the first- and third- person ‘hard problem’. This is because how representations are ‘conceptualised’ reflects on the extent to which there is a separate world that we represent, and consequently the form of objectivity (i.e., the nature of third-person understanding). This position will be explored in this section and an embodied, dynamical systems approach to representations and the conceptual proposed. This links to both the preceding sections on embodied cognition and evolution, and to the philosophical and systems chapters, and leads into a brief overview of dynamical systems theory as applied to cognition. It also leads to the following chapter on emotion and its role in cognition and, more broadly, in our immanence.
Scaffolds

Lakoff and Johnson (1999) show that the nature of our perceptual and motor systems play a central role in conceptual development (e.g., the colour definitions we use are related to the centre-periphery structure of our colour response curves in brain neural structures). Also, neuronal structures used for rational inferences are also used for perception and bodily movement. Moreover, metaphors derived from sensorimotor domains are used in many abstract concepts (Lakoff & Johnson, 1999).

At another level, the conceptual is considered in some approaches to be reliant, for its reasonable functioning, on ongoing situated interaction with the world. Clark (1997) calls this ‘scaffolding’, and it concerns the use of environmental props to support problem solving, and prompts for remembering. In this manner, scaffolding extends the mind outside the brain as the environment becomes a crucial element in its functioning. He argues in particular that scaffolding complements connectionist approaches, as neural networks are fundamentally interactive pattern-completion structures rather than computational structures good at internally based linear processing. Clark (1997) also suggests that the human ability to manipulate the external environment has created ever increasing supportive “designer environments” (p. 191) expanding our ability to problem solve. In the process of creating fuzzy cognitive maps the use of pen and paper could be considered as scaffolding. Without them, due to the complexity of the maps, the maps would be difficult to conceptualise. In addition, drawing the maps allows ongoing interaction, checking and sometimes amendment of the relationships that have already been drawn, and the development of new ones in relation to these.

Neurodevelopmental plasticity is also important in this process as it allows for ongoing adaptive ability, as different scaffolds are being continually developed and used at a social level (e.g., computers (Anderson, 2003)). This is not just an extension of the mind as in using the world to help the mind, but redefining the boundaries (ontologically) of where the mind lies (i.e., the boundaries of the system are changed). This widening and integrating of brain function with body and environment lies in contrast to the positing of structures to represent the world. The next section discusses this idea as part of the development of a more integrated approach.

Representations

The intangibility of the sub-personal means that there are a number of approaches to the role and form of representations. Cognitivists and connectionists both posit representations but have different understandings of their nature. At the cognitivist end of the continuum there are ongoing attempts to extend the notion of representation to accommodate criticism from, and insights within, embodied and situated cognitive science (Markman & Dietrich, 2000). While in the connectionist and
dynamical systems approaches there are moderate positions (e.g., Clark, 1997; Vacariu et al., 2001) that attempt to synthesize the classical representational position with the embodied one. In this respect, for Clark (1997) the important question about representations is not really whether they exist, as he argues all approaches to cognition posit some form of representational type of process. In his view the rejection of representations is based on a too restrictive view of what they are and that most phenomena are not as representationally needy as made out. Rather, it is how they are to be characterised as mental entities, how they are instantiated at the physical level, and indeed to what extent these can be considered separate entities, that is at question (Vacariu et al., 2001). Clark (1997) proposes the notion that representations and associated computation should be retained in cognitive science but not constrained to a particular form.

Anderson (2003) does not deny that representations may be used, as complex agency requires both reactive and deliberative faculties, but that they must be selective and ultimately physically grounded via lower faculties which govern things such as movement (perception and action). There are also more radical embodied approaches taken by Brooks (1991), Varela et al. (1991), Wheeler (2005), Smith (2005) and Stewart (1995) that either deny the usefulness of the concept of representations or attempt to considerably reconceptualise their form (e.g., Keijer, 2001; Stewart, 1995). For these thinkers cognition is best studied through non-computational and non-representational ideas (e.g., dynamical systems) (Clark, 1997). An approach that reconceptualises and grounds representations is discussed in Section 4.3.4.

It is important to note that the approaches that might deny the existence of representations only question the sub-personal structures involved and not the personal level experience of them. This relates to the claim that at a phenomenological level representations are sub-personal entities developed from folk psychological first-person personal level understandings (Keijer, 2002). In other words, it ‘appears’ that we think through the use of representational-like pictures. In parallel, it also appears that we are separate entities looking out on the world. This has much to do with our physical embodiment, (i.e., the strength and layout of human perceptual functions). Noë (2004) argues that humans’ strong visual abilities are involved with this, and that, instead, touch should be the perceptual facility to base our cognitive metaphors on. This raises the question of whether a new metaphor would change the perception of the use of representations at the personal level?

### 4.3.3 Dynamic approach

The dynamical systems theory (DST) approach can stand alone as an approach to cognition but is most powerful when used in conjunction with an embodied and situated approach to cognition (Beer, 2000). An overview of embodied and situated cognition has been given above, and the basic
principles of the dynamical systems and CAS were outlined in conjunction with Delueze’s thought in Section 3.4.

Expanding on Section 3.4, a dynamical system can be considered through either the use of dynamical models or dynamical system theory. Dynamical models are applied mathematical models used to model natural phenomena using calculus and differential equations. On the other hand, as discussed in Section 3.4, dynamical systems theory is a method of understanding dynamical systems geometrically (Van Gelder, 1998). The dynamical approach is more general and abstract than connectionism as it is not concerned specifically with the physical nature of phenomena. In this respect, the DST approach expands connectionist network concerns with the neuronal physical substrate of cognition to an analysis of the entire brain, body, environment relation as a dynamical system. Its explanation is focused on tracing perturbations caused by external and/or internal events on the unfolding trajectory of the cognitive system (Van Gelder, 1998).

There are a number of key distinctions between dynamical approaches to cognition and computational ones. First, dynamicists see cognition as embedded and hence as the shared accomplishment of brains within multimodal bodies within contexts (Van Gelder, 1998). According to Van Gelder (1998) the dynamical approach has been successful as an explanatory framework over a wide range of natural phenomena. This enables it to integrate cognition as a dynamical system within other dynamical systems, highlighting its embeddedness. Second, for dynamicists cognition is considered to be embedded in time. Dynamical systems are fully temporal and time is a continuous flow in which systems interact and evolve as an ongoing process without end points. By contrast, computational approaches understand cognition as a sequential set of events taking place through time (sense-act-think), and so a process with a start and end (Van Gelder, 1998). The third, as has already been discussed, is symbolic representations. Wheeler (2005) notes that in principle there is no conflict between representations and DST. Many structures in dynamical systems could act as representations (e.g., attractors, states, etc.). However, the existence of representations is a sticking point in DST as their fixed nature tends to undermine cognition as fundamentally a “continuous co-evolution of acting, perceiving, imagining, feeling, and thinking.” (Thompson, 2007, p. 43).

There are concerns with the dynamicist approach. For example, classical symbolic computational and connectionist accounts of cognition have been criticised for supposing that mind is distinct from the brain and body. By contrast, the dynamic approach has been criticised for going to the other extreme; eliminating the mind in favour of the brain and body (Bickhard, 2008). Some theorists do not see DST as a full replacement for existing frameworks. For example, Gallagher (2005) is not committed either way, and sees the usefulness of both emergent and representational models. In addition, Clark (1997) is concerned that DST is too abstract and, in contrast to more traditional
component analysis, its approach based on emergence does not ultimately allow for an explanation of how the mechanisms involved actually operate.

At the empirical level, a number of studies have shown the usefulness of the dynamical approach. These include experiments involving Piaget’s A not B error, the lexical and grammatical structure of language, active categorical perception, and muscular dynamics (Smith, 2005; Rockwell, 2005; Van Gelder, 1998; Beer, 2008). These experiments highlight the temporal, interactive and developmental nature of cognition. However, this empirical work is still limited in scope (Clark, 1997), as such the dynamical approach is yet unable to account for many aspects of cognition. However, Van Gelder (1998) suggests there is general agreement that many aspects of cognition will turn out to be dynamical in nature. Ongoing empirical investigation is needed to clarify this. While Beer (2008) suggests that because it supplies a common language for the analysis of a range of phenomena that DST holds potential as a “unified theoretical framework for cognitive science, as well as an understanding of the emergence of cognition in development and evolution.” (p. 97). The next section considers this broader view of cognition.

4.3.4 Constructivism and pre-representation

This final section expands the discussion of representations through taking a broader philosophical and evolutionary approach compatible with dynamical systems and embodied and situated cognition. This is a concern with the function of cognition and representations rather than the previous discussion’s concern for their structure.

Stewart (1995) sets out the difference between representationalist and non-representationalist approaches to cognition from a philosophical perspective, and develops a definition of cognition in the terms of objectivism and constructivism. He argues that representations are fundamentally objectivist. This is because, although representations and their formal rules of manipulation are considered to be internal to the cogniser, to actually do anything they must reference the external world in some manner. This referencing or grounding of symbols, according to Stewart (1995), is fundamentally objectivist as it requires “a unique and pre-given reality to serve as a reference” (p. 109). In contrast, and consistent with an embodied and situated approach to cognition, he pursues a constructivist account that sees representations as being recursively emergent from ongoing interactions of the cogniser and world. They do not reference a pre-given reality as one is not considered to exist; rather reality lies in the interaction.

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36 Objectivism can be defined as the metaphysical position that there is a unique and ultimately knowable reality lying independent of any observer.
This is a breakdown of the subject-object dichotomy where the subject and object can both be identified but are also inseparable (Stewart, 1995). Stewart’s (1995) ‘action-sensation’ understanding of cognition is akin to the notion of autopoiesis\[^{37}\] in living systems generally where the system produces the entity from its own circular functions (Varela et al., 1991). Indeed, Stewart (1995) argues that autopoiesis and cognitive action-sensation are essentially identical and, consequently, that all living things can be considered to be cognitive\[^{38}\]. This constructivist approach is also implied in a developmental approach to evolutionary theory as discussed in Section 4.3.2.1. Stewart’s (1995) systems based constructivist approach is compatible with the philosophical position taken in Chapter 2, where subjects, as cognitive entities, are emergent from the world as embodied. The subject is not foremost or assumed. Rather, the subject and object both lie immanent within and emergent from ongoing material flows.

Within Stewart’s (1995) constructivist account representations become the “pre-presentations of the anticipated consequences of an agent’s actions for its own future perceptions” (p. 113). Pre-presentation means there is still representation of sorts but it is not a symbolic one, it is an anticipation of the perception-action recursive loop. Expanding the perception-action loop to the neurological level, studies have shown that spatial neural patterns change with each act of perception (i.e., they are constructed with each perceptive act). They cannot just be isolated to each perceptual event as they depend on the present context and past experience existing as the global dynamical state of the brain. According to Freeman (1997) the implication is that each perceptual state is a product of the present state of the brain/body system that also articulates a desired state of the sensory consequences of the perception. This highlights a plasticity allowing adaptation over the shorter term and also for global changes in development in the longer term. This is not, however, a pre-presentation of future perspectives. This is because perspectives are in part pre-subjective and so cannot be revealed or fully anticipated at the subjective level (see Chapter 3).

### 4.4 Conclusion

The central goal of this chapter has been to outline the ideas behind situated and embodied cognition from physical, biological and conceptual perspectives, and so develop links with the theoretical development outlined in Chapters 2 and 3. This chapter shows how a situated, embodied 37 Autopoiesis is central to the phenomenological approach of Varela et al. (1991) as it enables biological autonomy and so the development of subjectivities or perspectives.

38 This position is developed by Varela et al. (1991) with their notion of the enactive mind, where the mind is understood to enact the world in which it lives. In ecological terms, it creates its own niche, a niche that did not exist prior to the agent’s existence.
subject can be understood in cognitive terms. It attempts to address some of the issues involved in this understanding. The central premise being that the mind cannot be separated from the rest of the organism and its functions at physical, biological, or conceptual levels. It includes both its external interactions and internal milieu (Rudrauf et al., 2003). Cognition is considered fundamentally relational and developmental at evolutionary and individual scales. It is expanded to include all our mindful interaction in, and with the world, and is considered a product of such ongoing recursive interaction. DST provides a way to model and understand this process. Concepts of self-organisation, circular causality and shifting attractor basins create a dynamic and non-linear understanding that go beyond computational and representational models.

Embodied and situated cognition has been contrasted in particular with the cognitivist approach to cognition and its associated representational understanding. Cognitivism’s strength in offering an explanation for decoupled cognition is a weakness in the approaches to a situated and embodied cognition. However, this has been partially addressed through reconstituting representations as perceptually based pre-presentations through the use of a systems based mechanism. This bypasses the physical grounding problem by removing the need for objectivist references to an external reality. Likewise, the ‘hard problem’ can be partially addressed, or at least reconstituted, because how representations are ‘conceptualised’ reflects on the extent to which there is a separate world that we represent, and consequently the form of objectivity. Although some theorists such as Varela still see consciousness as fundamentally irreducible (Rudrauf et al., 2003) this becomes a question of what it is being reduced to. The systems concern with relation and emergence allows room for the supervenience of the mental onto the physical. This is not just, however, to brain neurology but the broader brain, body, environment nexus (Rockwell, 2005). This means “the embodiment of mind - whether approached from the first - or third person point of view - always has the character of a descriptive phenomenology.” (Rudrauf et al., 2003, p. 30).

This account provides a position for understanding people when they create fuzzy cognitive maps and their discussion in interviews. They can be considered as expressing a situated, embodied perspective of the world. My informants are not transposing representational accounts of the situation in their heads to the FCMs or talk. Rather, they are actively creating the maps and discourse at the time of their construction and discussion as an expression of their everyday embodied and situated interaction with the material world, which the maps and talk themselves become part of. They are showing its networked relations from their perspective. The FCM construction itself is interactive, with myself as the researcher and with the pen and paper acting as scaffolds. The map’s construction is merely a subset of such expressions in their everyday lives, understood as involving the ongoing evolving process of interaction that takes up the world’s
possibilities. The meaning of weka and their situation (networks) develops and evolves with the creation of maps themselves, it is inherent in it. The interviews can be considered in a similar manner but involving less formal scaffolds.

Finally, Zeimke (2008) argues that embodied cognition can show how cognition is embodied, but not how meaningfulness eventuates. This is because such meaningfulness is more than merely biological, it is social, cultural and affective. The embodied and situated (experiential) approach addresses some of these social and cultural aspects, however, the role of affect has not been highlighted. Affect or emotion is central to the notion of responsive anticipatory and motivated active sentient agents that do things. For Varela "affect or emotion is at the very foundation of what we do every day as coping with the world; reason or reasoning is almost like the icing on the cake. Reason is what occurs at the very last stage of the moment-to-moment emergence of mind. “ (Varela, 1999b cited in Rudrauf et al., 2003, p. 58). So, too, it is central to a situated and embodied account of cognition. Chapter 5 further considers affect, emotion and their relation to cognition and meaning.
5 Affect and emotion

5.1 Introduction

As set out in Chapter 2, phenomenological and post-structuralist developments in Continental thought emphasize our immersion and the integration of the mental and physical as well as the importance, for some thinkers, of the role of affect. The implication is that affect is central to our immersion and everyday activities. This chapter will briefly explore theories of affect and emotion and their understandings of the relationships of affect and emotion to knowledge and embodiment. This will inform the study through clarifying how an approach to affect and emotion can be consistent with the interactive focus of the theoretical development in the foregoing chapters. The final understanding of affect and emotion developed is important for contributing to a fundamentally interactive understanding of the human-weka relationship.

The first sections in this chapter set out the debates lying within contemporary theories of emotion and focus on physiological and expressive (behavioural) aspects of emotion and affect. Some concerns with these approaches are outlined and intentional or cognitive aspects of emotion are considered. Theories are then outlined that attempt to integrate these two positions. Aspects of emotion associated with the social are next outlined that bring into the focus an interactive theory of emotion. This is developed further into an immanent approach to emotion that understands emotion as essential to meaning. The rest of this section will give a brief background on the concept of emotion and its use in this chapter.

It was shown in Chapter 4 that classical cognitivist theories of cognition understand it as purely a mental process. By contrast, many theories of emotion tend to start at the opposite direction and consider emotion to be associated primarily with the body and not the mind. Thus the objective in this chapter then becomes bringing the mind into emotion rather than the body into cognition.

The study of emotion involves a range of theoretical approaches and associated meanings of emotion, which makes emotion a difficult term to define (Reber, 1985). In general, contemporary theoretical approaches to emotion encompass four aspects. These include understanding emotion as

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39 In medicine there is a long history of emotions being understood as physiologically based disturbances, and more recently as hormonal and brain chemical changes (e.g., depression)(Solomon, 1997). Although this approach fits well with a continuity between humans and other life, from this perspective emotions come to be seen as an unintelligent and irrational part of human nature (Lutz, 2003).
an instigating stimulus (perception), physiological correlate (somatic), cognitive appraisal (cognition), and a motivational property (behaviour, feelings) (Reber, 1985). This encapsulates a number of theories of emotion. LeDoux (1996) notes eight general theories, including: evolutionary (emotions as bodily responses evolved for survival); discursive (emotions as ways of acting in given social situations); psychoanalytic (emotions as unconscious impulses that are often repressed); ideational (emotions as thoughts about situations people are in); social constructions (emotions form between people rather than within individuals), and William James’ position (emotions as mental states responding to bodily changes). As will be seen in the following discussion, some of the theories overlap and integrate various aspects of each other.

In addition, Rorty (2004) argues that a delineation between emotions, moods, motives and attitudes is very difficult to sustain due to their subtlety and complexity. This derives from their evolving patterns of everyday use (folk psychology) upon which most theories of emotion are derived (Griffiths, 2003). However, I will use the term emotion throughout the following discussion to cover this affective family (emotions, moods, motives and attitudes). In addition, I propose affectivity is primarily about feelings, as it is the ‘felt’ that makes affective psychological phenomena distinctive. Because feelings are the basis of affect I will call affect ‘feeling’ in the following discussion. Feeling is investigated phenomenologically, although as discussed (see Chapter 2), thinkers such as Henry and Deleuze do not see feelings as essentially subjective.

Phenomenology, along with physiology are the two main methods of investigating emotion. Physiological approaches tend to be focused on studies of neurophysiology (the various brain states and structures associated with emotions) and the observation of behaviour. Phenomenological approaches look at the level of subjective experience associated with, or as, emotions. In addition, theories of emotion tend to lie between the extremes of emotions having a biological basis or existing as cultural products (Milton, 2002).

All of these elements are contained in a contemporary debate over various theories of emotion. A central split is between theories that understand emotions as primarily arising from physiology and those that emphasise the role of cognition in emotion (Deigh, 2004). There has been reluctance to give cognition such a role. This is associated with the conviction in Western thinking that emotion impedes rational thought. The conventional view is that rationality and emotion are opposed and that emotion distorts rational thinking. This has its roots as far back as Plato and this separation is still central to modern cognitive science (LeDoux, 1996). A second position is an

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40. Feelings generally have more inner subjective connotations, and affect less so (e.g. ambience). However, I do not wish to retain this inner and outer separation so will use feeling to refer to both.
approach which suggests that emotion supports reason by supplying it with desires and purposes, etc. (Damasio, 1994, 1999). A third position is a radical one, ultimately supported by Milton (2002), that asserts, following William James, that rationality itself is a feeling and so emotion and rational thought are continuous. I take an approach in common with the philosophical position of this research. This understanding recognises emotions as bodily states bound up with cognition and as being essential to it.

5.2 Theories of emotion

5.2.1 Jamesian and Darwinian theory

The first of the two main contemporary theories of emotion is derived from William James who argued that we have the physical response (emotion) first and then a feeling about it (Deigh, 2004). In other words, our feelings are our perceptions of our own bodily responses that “follow directly the perception of an exciting object” (James, 1950 cited in Deigh, 2004, p. 25). For James it is the involuntary physiological response that makes emotion; without such a change there is no emotion (Robinson, 2004).

There are a number of findings that support James’ theory. For example, strong links have been found between distinctive bodily patterns and the ‘basic’ emotions (anger, disgust, fear, joy, sadness, surprise). In addition, neurological structures associated with emotions have been found to also be involved with perception. It has also been found that changes in the body (e.g., facial expressions) can elicit emotions. Finally, from an introspective perspective James asks what an emotion might be without some sort of bodily response, no stirred stomach, tears or smile (Prinz, 2004).

There have also been a number of concerns expressed about James’s theory. The first is that reduced perceptions in the body do not always reduce emotion as would be suggested by the theory (see Damasio, 1999). The second is that not all emotions involve physiological changes. Some emotions of long duration such as loneliness, guilt, intellectual interest, or love may not have bodily changes, or sometimes do and sometimes do not (Prinz, 2004). Prinz (2004) suggests such variation creates the question of whether all these types of events should be called emotions. He argues, however, that they can all be shown to involve a somatic state of some sort; if they did not there would be a need to question the sincerity of someone’s claim to possess an emotion such as love. The third concern is that there are not enough types of bodily changes for all the types of emotion. One response to this is to identify emotions with neurophysiological processes which contemporary developments of James’s physiological position have done (e.g., Damaiso, 1999). However, these
tend to invert James’s original position as the feelings associated with neurophysiological events are what identify emotions, and so emotions effectively become epiphenomena (Deigh, 2004). A second response is that emotions can be differentiated through what elicits them in addition to their physiological changes (Prinz, 2004). This is associated with the final main concern with the James’s theory. This is that it does not explain the intentional aspect of emotion. This is that emotions have an object that consequently allows cognitive assessment. Of the concerns with James’s theory this one, unlike the others, is not so easily addressed. Consequently, cognitive appraisal theories have been developed that propose that emotions involve judgments of objects (Prinz, 2004). These are discussed in Sections 5.2.2 and 5.4 below.

In addition to James’s approach there are biological theories based on Darwinian evolutionary theory. Darwin was interested in involuntary emotions and how they may be, or may have been, adaptive for present humans or their ancestors. He proposed a set of basic facial expressions that he considered innate (true expressions of emotion) and were common across cultures (and some animals too), and distinct from conventional emotions developed within certain cultures. Each set includes a subset of related emotions (Deigh, 2004).

Recent Darwinians suggest that true expressions are based in neurophysiological events which cause facial expressions. Consequently, they see a distinct genetically defined range of emotions as natural kinds produced by an array of neurophysiological events (Deigh, 2004). There is some evidence in neuroscience for different emotions involving different parts of the brain that are not necessarily connected, and that the distinct associated feelings also have this discontinuity (LeDoux, 1996). Consequently, for LeDoux (1996) the analysis of emotion should be undertaken at the level of the brain so these various centres of emotion can be assessed. In contrast, Thompson (2007), taking a whole organism enactive approach, argues that this becomes a straight mapping of input to output and leaves no room for autonomy. As with James’s theory this does also not allow for any object of emotion, only a cause or stimulus.

Frijda’s (2003) evolutionary approach also highlights emotion’s functional role for improving and preserving life. However, his is an interest in the behavioural aspects of emotion in contrast to James’s concern with primitive physical responses and associated feelings. Like Damasio (1999), functionally, emotions express whether events are congenial or not through the feelings they encompass, and also whether some form of behavioural or physiological response is required. This is experiential and broader than more localised indications of the organism’s state (e.g., reflexes, and healing) as it involves the behaviour of the whole organism. It is also far more flexible and can respond to complex environmental information. Affects are these non-propositional signals which relate to the organism’s concerns and goals. It is not always clear, however, that concerns are not
also bound up in emotions themselves (i.e., emotion creates concerns as much as signalling them). Consequently, and second, the emotion itself may elicit a behavioural response involving the awareness of an event’s meaning. This ethical aspect is discussed further in Section 5.5.

### 5.2.2 Emotion as cognition

Many contemporary approaches see emotions as cognitive entities which, hence, are more like thoughts that appraise how we are in the world rather than pure responses to perceptions of it. This cognitive element is lacking in many Jamesian and evolutionary based biological approaches. Like biological theorists, most cognitive theorists agree that emotion includes physiological, expressive and experiential elements. However, in contrast to biological approaches, cognitive theorists are interested in the causes of emotion at the cognitive-experiential level. In this sense, they invert the biological theorist’s priorities of physiological over behavioural over experiential (Encyclopaedia Britannica, 1998).

Some theorists (Damasio, 1999; LeDoux, 1996; Robinson, 2004) suggest that one way the biological and cognitive can be brought together is within ‘two-stage’ theories. These involve that emotions be considered as consisting of both the sensation of somatic change and a cognitive evaluative or appraisal process. However, in these approaches it is difficult to separate affective appraisals from cognitive ones (Robinson, 2004), and they tend to require a more cognitivist understanding of cognition.

Other cognitive approaches to emotion understand emotions as a form of intentional state and often as judgements, beliefs, interests or attitudes, and so are also called belief or judgement theories (Robinson, 2004). In these theories beliefs or judgments either cause or constitute emotions. The causal theory suggests the need to identify emotions and beliefs separately and creates the problem of what an emotion is, if it is not a belief; it could be a feeling but according to Calhoun (2004) not all emotions have a distinctive feel to them that separates them from other emotions. Consequently, identifying an emotion often means knowing the person’s beliefs (Calhoun, 2004). The second more dominant theory is that beliefs constitute emotions, or that emotions are beliefs. This produces a problem of belief conflicts (cognitive dissonance). This occurs in situations where someone claims a certain belief or understanding that is inconsistent with their emotional response. Ways out of this problem include suggesting that some emotions may be non-cognitive, but this just re-introduces the original problem that cognitive approaches are trying to address (Calhoun, 2004).

A broadly cognitivist understanding underlies these positions and is reflected in Deigh’s (2004) definition of cognition. This sees the cognitive element of emotions as propositions encoded as representations that require language (i.e., the mind holding beliefs about a separate reality) (see
Section 4.2). This narrow view based on linguistic propositions tends to deny the existence of emotions in animals and infants. Cognitivist views do also allow broader views of cognition, for example, that it includes all types of information processing. Indeed, De Sousa (2004) argues that a very broad conception of the cognitive (i.e., any theory that posits the movement of information within an organism as a cognitive theory of sorts) would mean it is not clear what a non-cognitive theory of emotion is proposing.

Recent developments of the embodied mind in cognitive science (see Chapter 4) link mind (cognition) back to the body and so draw together emotion and cognition at the same time. To consider some implications of this, the next section will discuss the social constructionist approach to emotion.

5.2.3 The social construction of emotion

Milton (2002) suggests that sociological approaches to emotion in recent decades have viewed emotion as a cultural product and so placed it in the same realm as knowledge and ideas. Such cognitive views of emotion, and their interest in social influence on emotional definition and responses can lead to relativism. Her objection to these approaches is that they do not allow us to ‘feel the world’, but only a culturally defined version of it. According to Milton (2002) this is because in social construction models of culture, knowledge is considered to consist of social representations of the world. These representations are passed on socially so that a culture consists of an array of different representations of, for example, the weka. This, Milton (2002) suggests, implies that the non-human environment can only be understood through culture and not through embodied firsthand experience. This does not show how the constructs came to initially arise and so denies the role of the non-human environment in knowing.

An example of the social construction approach are Lutz’s (2003) studies in which she argues that emotion language and emotions themselves are socially shaped and constructed. She highlights the variable roles and function of emotion in society. She rejects distinct and discrete emotions, although does not deny some basis in biology, the primary influence on them is understood as cultural. Lutz (2003) argues that although emotions are experienced as physiological events and psychic feelings that surface in our bodies, they have social origins in the way things called emotions are attributed and understood as, for example, fear, joy, anger, etc. Consequently, “emotion can be viewed as a cultural and interpersonal process of naming, justifying, and persuading by people in relationship to each other.” (p. 144). Importantly, Lutz (2003) links these interpersonal relations to the broader notion of culture and then to material environments.
Lutz (2003) moves away from representational understandings of language use and highlights the interactiveness implied in the cultural embeddedness in the physical world. Consequently, I suggest Lutz (2003) avoids to some extent the sort of social construction Milton (2002) is concerned about. Milton’s (2002) objection is for an ontological relativism, rather than Lutz’s (2003) position which is an epistemological relativism (see Section 2.0). However, the broadly immanent, materialist, embodied account proposed so far in this study also questions both Milton’s (2002) and Lutz’s (2003) epistemological relativism. This account does not deny the influence of the social on emotions, but do not consider the reality to be a social invention, or to lie in some separate realm that we represent in different ways, but something we are both immersed in and constructed by through a process of ongoing interaction. Emotions are considered a manifestation of such interaction.

Recognition of a social role in emotional understanding immediately draws in the issues of folk psychology. As part of folk psychology emotions are part of our everyday understanding of ourselves. Consequently, how emotions are theorised in everyday activities (e.g., folk psychological understandings may consider various emotions as biologically or culturally derived) impacts on how we understand their role in our lives, and understandings of them. These responses are interpreted by individuals as natural and involuntary. This means that the folk psychology of emotion should not be considered as just descriptive but also prescriptive, and that everyday beliefs or understandings about emotion should be considered as cultural products and not just introspective events. As such, everyday understandings about emotions have a role in developing a cultural understanding. Finally, these everyday understandings are evolving, suggesting that as various understandings become exposed as socially defined, they lose their function as being natural and involuntary.

Social constructionist approaches have sometimes not recognised evolutionary and biological basis of emotions. However, because emotion is in part a cultural product does not mean that there are no universal emotions, or that cultures construct emotions entirely differently. We live in essentially the same world and the same kind of embodied beings with social commonalities (born helpless, social, embodied, mortal, etc.). A middle ground seems to be an approach that recognises the validity of both aspects; emotions have a biological-physiological element and also a social cognitive element, where they are understood as in part being learned and developed in society (Solomon, 1997). These in turn become reflexively part of folk-psychological understandings.

Finally, the concerns of this study are primarily for people’s relationships with the natural world. To this end Milton (2002) develops an ecological theory of emotion based on how we come to know the world. It retains a biological basis, while extending the cultural to include the non-human.
Her approach leads into a fully embodied account that is able to be linked with a situated and embodied account of cognition, in contrast to a straight biological approach to emotion.

5.3 An interactive theory of emotion

Milton (2002) argues that we gain knowledge of our environment directly through perception. She uses the work of Gibson (1979) and Neisser (1976) to support this. Like Merleau-Ponty, for Gibson all perception is achieved by the whole embodied individual not only the sense organs. Similarly, Gibson did not consider awareness to lie in the mind, as the central point of the nervous system, but to involve the whole body-mind system (see Chapter 4). This whole system is interlaced with the world to the extent that perception is considered to involve an active environment, whose structure offers (or constrains) possibilities for action for a particular organism (Milton, 2002).

Neisser (1976, cited Milton, 2002) understands perceptual skill as the basis of all knowledge and enables the perceiver to move around the world, understand language, recognise others, etc. Unlike Gibson, Neisser retains some separation between the mental processes and perceptual processes. From this understanding a theory of mind becomes a set of anticipatory schema that develops over time from past perceptions. This is developmental in contrast to an innate schema already in place which environmental encounters stimulate. It consequently considers our innate abilities to be learning mechanisms (Milton, 2002). Gibson’ and Neisser’s positions also imply that someone deprived of social interaction will still develop a practical understanding of their environment as it is its own source of meaningful information (Milton, 2002).

Neisser’s (1976, cited in Milton, 2002) notion of anticipatory schema could be considered more like pre-presentations. In this manner, they are fundamentally interactive as was developed in Chapter 4 (Stewart, 1995) (Section 4.3.4), rather than representational. Highlighting that emotion is part of Neisser’s (1976, cited Milton, 2002) perceptual cycle, Milton (2002) argues that Neisser’s anticipation (for picking up particular information), in his anticipatory model of perception, ties with interest as the central emotion of knowledge (i.e., interest in ‘knowing how’ for everyday coping). Milton (2002) suggests that anticipation and interest should be considered as corresponding emotions. Interest exists as the prime motivator to some extent in all our normal day to day activities (Milton, 2002). Indeed it “literally determines the content of our minds and memories, for it plays a

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41 In Section 6.3.1 it is noted Gibson’s (1979) position includes an element of separation (i.e., Gibson posits affordances as somewhat objectively definable properties of the world waiting to be picked up).
large part in determining what we actually perceive, attend to, and remember.” (Izard, 1991, p. 92-93, cited in Milton, 2002)

Feelings of interest about a place, for example, may then affect the knowledge we acquire about it, which may then affect our feelings about it. We always have some interest about place as we are situated in and interact with it. This is an approach to the basis of local knowledge (see Section 6.4).

For Neisser (1976, cited in Milton, 2002) interest is primarily invoked in the context of active engagement, while for Izard (1991, cited in Milton, 2002) it is through change and novelty. Surprise is an intense knowledge-centred neutral emotion of novel events that is facilitated by the environment and increases the memorability of happenings (Whitehouse, 1996, cited in Milton, 2002). In this way emotions are learning mechanisms that enable information to be gathered and also affect the way it is retained and used. This suggests that knowledge is not emotionally neutral as emotion allows its development and so lies implicit in all cognitive thought and consequently reason (Milton, 2002). Feeling as interest is both active in, and responsive to the world. Learning allows further anticipation and so enhances reflexivity and ability to adapt.

This approach provides little detail of emotions other than their motivational role (as an epistemology), but does integrate emotion and cognition within a consistent neurological model. Milton (2002) suggests that other emotions such as fear, anger and love, are less central to knowledge production than interest but are still associated with it by affecting the focus of interest. In this manner, these other emotions are incorporated into Neisser’s perceptual theory. However, this does not address immanence; the idea that we are always already in the world. Solomon (2004) immerses emotion in the world as an ontology rather than just as a way of knowing (epistemology). How emotion might fit into such an account has already been surveyed briefly in Chapter 2.

5.4 Emotion, immanence, valuing and meaning

In common with the position set out in Chapter 2, Solomon (2004) argues emotions are about the world from within it, in an existential sense (i.e., our being-in-the-world, through which we engage and understand the world we are immersed within). In this way they are constitutive rather than descriptive of the world. Solomon’s (2004) concern relates to long term enduring emotions.
Emotion for Solomon is an experiential, practical and engaged bodily judgement. This links with Heidegger (Dasein) and suggests much human knowing is embedded in what we do. What we do depends on how things are. Emotion offers a guide, through pleasant or unpleasant feelings, to how the world is and how we are in the world. However, Solomon’s (2004) concern for “expectations, evaluations (‘appraisals’), needs, demands, and desires” (p. 77) tends to undermine his interest in the immanence of emotion to some extent.

The immanence of emotion is a concern with its ontological aspect; as the nature of existence. It gives us what is irreducibly meaningful, what things are as well as an expression of the world, what it is to be and how it is to be. In parallel, as argued in Chapters 3 & 4, such immanence lies implicit in the DST approach. It links emotion-cognition with a positive ontology of energy, desire and relationality consistent with Delueze’s thought. DST is also a relational epistemology; we know of processes, as a process ourselves, and so are immersed in them. The implication is that emotion is central to everyday knowing. This immanent understanding is considered in relation to valuing and meaning and by implication, ethics.

In the traditional view, emotions are seen to undermine ethics as a rational deliberation. The modern emphasis on reason in morality has meant the role of emotions in ethics has tended to have been neglected. However, some earlier thinkers saw emotion as essential to ethics (e.g., Rousseau, Hume). Also, in more recent times authors within post-modern thought have promoted emotion as being central to ethics (Smith, 2001; Milton, 2002). The importance of emotion is highlighted through three points: First, there are many emotions which have overt ethical connotations (e.g., rightness, certainty, doubt, care). Second, emotion’s role in organising attention focuses on the means of ethical acts. Third, they act as an end to consideration by giving what we care about (De Sousa, 2004).

Regarding the first two points, the role of emotion in motivation, and focusing on what is of most concern to us has been discussed in Section 5.3, while the first point is derived from the third point, in that emotion’s ethical connotations reflect what we care about. The third point is the crucial one. Regarding this, De Sousa (2004) asks to what extent does the emotional system supply information about the world outside our bodies? In this sense, he is concerned about their ability to decipher value or worth. He proposes that some emotions do relate to perceptions of value. These values should not be placed on a continuum of good to bad but are complex and fuzzy. Emotions are not separate but are constituted by multiple contrasts and evaluative responses. They flow and overlap. This entails biological, personal experiential and social elements together as none on their

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44 Long term emotions are sometimes called moods. Heidegger understood moods to have existential concerns.
own will produce a holistic valuation, that according to De Sousa (2004) is as close as we get to a “normative human nature” (p. 74). In this understanding they are cognitive in the sense that they give insight to the nature of things, although they are not cognitive in a propositional sense.

De Sousa’s (2004) position highlights emotions’ complexity but retains an element of separation between the valuer and the world. This can be partly addressed by considering Milton’s (2002) claim that the conventional understanding of value (noun) has been presented as cognitive phenomena due to the emphasis on values as guides to decision making rather than considering valuing (verb) as the way we live and interact in the world. However, this conventional understanding is a cognitivist understanding of cognition where entities are considered to be held in the mind as representations, rather than considering cognition as interactive. The situated and embodied view of cognition can be considered as an ongoing embedded process of valuing where decision making becomes wholly interactive. The intermeshing of situated and embodied cognition and emotion at a number of levels (e.g., knowing, action) has already been outlined (Section 5.3). Consequently, like De Sousa (2004), Milton (2002) argues that emotion and feeling are central to the valuing process. This is an important change in emphasis but, I suggest, valuing still leans towards a subjectively initiated process. In contrast, meaning is a similar (Milton, 2002) but more reticent term that allows for the development of a more immanent position.

Heidegger proposes that at one level meaningfulness just ‘is’. It lies as part of our immanence - as the world we always already know. It only becomes an issue when some form of separate external reality is postulated. For Merleau-Ponty meaning is not applied to the world by the mind but arises in the symbiosis that resolves around our embodied (living, moving and affective) relation to things and others within a natural and cultural context. This meaning echoes the organism’s history, anticipatory state and present context. The organism does not process information as such, but yields meaning as part of its own organization. So representations understood as pre-presentations (see Section 4.3.4) are processes that embody meaning and are patterns of activity that are interlaced between the brain, body and world and arise in this structural coupling (Thompson, 2007).

The analysis of action depends on considering feeling-emotion, as already noted “affect or emotion is at the very foundation of what we do every day as coping with the world” (Varela, 1999b cited in Rudrauf et al., 2003, p. 58). In these situations the predictive power of models based on physics and chemistry do not hold. Rather, the orientated actions of self-organising agents require the telling of stories of how agents do or might understand their worlds (Gangle, 2007).

Freeman (1997) emphasises the existential tendencies in the autonomy that lies in self-organisation. “The essential message of existentialism is that humans – and animals – create
themselves by their own actions.” (p. 1181). They do this by perceiving stimuli as the result of a “goal-orientated search for knowledge” (p. 1181). However, these actions are undertaken in-the-world, so we create ourselves out of the world, and in this way never create ourselves in any pure sense. Emotions are neither pure reactions to the world or purely proactive.

5.5 Conclusion

In this chapter I have progressively discussed and critiqued a number of theories of emotion and developed this towards a position supporting the post-structural/phenomenological account of it developed in Chapter 2. This has been difficult, as Lutz (2003, p. 146) notes “[t]he relationships among the physical, the mental and the emotional are some of the thorniest tangles in our conceptual forest”. This chapter reflects this complexity and difficulty. This lack of clarity is partly because emotion is so close to us - for Henry, emotion gives all that is, for Merleau-Ponty and Heidegger, it colours all we do, while for Deleuze, to some extent, it drives all we are. Consequently, it impinges on theorising itself. In addition, because of this scope the concept itself cannot really cope with the diversity of events and processes that are shoe-horned into it.

In the preceding discussion, feeling has become a central feature of emotion due to its role in interest (knowing), motivation (doing), wellbeing (how we are), and in immanence (what things are). This is a move away from earlier third-person theories to the first-person concerns of phenomenology. In the introduction I suggested that feeling is the essence of emotion but noted that some authors thought they were distinctive; that we can have emotions without ‘feeling’ them. In this respect, my concerns are not primarily with emotions as such, but rather the way feeling is interlaced with and colours cognition. The discussion so far has highlighted, using the general term ‘emotion’ as a de facto for felt psychological experience, how this might be theorised. Emotion links the embodied behavioural aspect of emotion - and so with embodied cognition and with material immanence - with the sometimes more ‘mental’ notion of feeling.

A range of theories of emotion contribute to this: These include emotion as a biological aspect (are embodied as are all mental activities); also as cognitive through being bound with knowing and doing) - but not in the sense of cognitivism – rather an embodied cognition; as a way of knowing (epistemological) that focuses attention. Theories also consider emotion as having a motivational, regulatory and adaptive role. Emotions should be considered developmental and plastic from ongoing interaction with the environment and not neurophysiological modules carried from one generation to the next. Emotion is also social in the sense that more complex emotions

45 De Sousa (2004) argues that if cognition is not just considered propositional emotion is always cognitive.
appear to require social interaction as well as emotions at least being partially socially defined. As part of a folk psychology, emotion is bound with the reflexivity of cognition.

Importantly, emotion is of (and in) the world – it has an ontological element; it gives us what is irreducibly meaningful, what things are as well as an expression of the world, what it is to be and how it is to be. Merleau-Ponty, Heidegger and Henry all propose affects are what we live rather than know, and so we are always in a feeling state of some sort. They are part of our embodied relations to the world. Like situated and embodied cognition:

“A theory of affect and emotion must engage with questions of materiality. Be this in terms of body–brain–culture assemblages or our intimate and prosaic entanglements with the object world, we do not see how such a theory can proceed without beginning to distribute the composition of affect and emotion throughout the world, through, for example, the nervous system, hormones, hands, love letters, screens, crowds, money . . .” (Anderson & Harrison, 2006, p. 334)

As set out in Chapter 2, this chapter has tried to incorporate (de-centred) subjectivity (which in this chapter is manifest as feelings) and a larger field in which subjectivities lie (which in this chapter is manifest as affects). Along with this is the relationship between the first- and third-person analysis. Third-person analysis is expressed as biological, social constructionist and systems accounts of emotion. First-person analysis is phenomenological and includes considerations of immanence. However, it is not as simple as this as biological and social constructionist accounts are also partly phenomenological. The biological-physiological shows itself in a phenomenological analysis through these bodily processes being present to consciousness, as part of emotional experience (Solomon, 1997). In the social development of emotions, experiential features of the social world are present to consciousness and associated with emotions. This is not just an unconscious process of shaping emotions but involves ideas and expectations (Solomon, 1997). This creates the reflexiveness of folk psychology, which informs both participants and observers of what emotion might be.

Finally, emotion can now be considered in relation to FCMs, interviews, resilience (systems) theory and local knowledge (situated knowledge). In regards to FCMs the approach outlined in the conclusion of Chapter 4 can be developed to include emotion. Essentially, this is to consider emotion to be intermeshed with a situated and embodied understanding of cognition. Here it becomes a central element in the cognitive process – instigating and focusing ongoing interaction with the world. In addition, emotion gives the meaningfulness that lies as the basis of any cognitive assessment. This is an immanent and action oriented account of their everyday interactions.
Beyond this, meaning does not just arise through individual feelings about weka but incorporates the ‘feeling of place’ (as discussed in Chapter 6), or the common affective world of the participants. This partly lies in the fact that biologically the participants live within the common physical environment, as well as in the same basic culture and community. They have common experiences with weka. In this sense their FCMs are never quite entirely their own; they are the ‘networked’ places:

“Here, thinking through affect and emotion should lead to questions over the emergence of subjectivities from more or less unwilled affectual and emotional assemblages and the consequences of such questions for reflexivity, responsibility, intentionality, autonomy and identity. “ (Anderson & Harrison, 2006,p. 334)

This richness suggests significant limitation of the use of FCMs, as they are an attempt to encapsulate this world in a simple causal based network.

The notion of sense of place has been mentioned in Chapter 2 through Heidegger’s thought. Emotion is a key element in this along with situated activities in a practical interaction with place and local knowledge. All these elements can be found in the theory of emotion developed in this chapter. This is considered further in the next chapter on place and dwelling.
6 Place

6.1 Introduction
Several disciplines, in particular, human geography, sociology and environmental psychology have an interest in the notion of place. These disciplines point out that places are not just physical settings but encompass meanings and emotions people associate with the settings. How those meanings and emotions are conceptualized, however, varies between disciplines (Davenport & Anderson, 2005). This, along with a range of approaches within each discipline, has produced a range of assumptions, purposes and methods and created a fractured intellectual landscape in the study of place. There has been little attempt to try and synthesise these traditions (Bott et al., 2003).

Agnew & Duncan (1989 cited in Kruger & Jakes, 2003) suggest that place has been used in three primary ways in social theory. First, place as has been constituted as *location*, which relates to its economic, social and cultural significance. Second, place has been understood as *locale*, as the setting for everyday activities. Third, there has been considerable discussion of *sense of place*, which focuses on individual and group identification with an area through interaction with it.

The aspect of place that I wish to focus on is sense of place which is often considered to be the overarching concept in the study of people’s subjective relationships with the environment (Rogan et al., 2005). In the following discussion this will be considered in relation to locale. This is because locale stresses the role of everyday activities in the development of sense of place.

Underlying and linked with the concept of sense of place are several other well used concepts; place attachment, place dependence (Kaltenborn, 1997) and place identity (Cheng et al., 2003). Again, there is no clear and consistent use of these terms. I will not be utilizing these concepts specifically in this discussion and, as mentioned, will instead concentrate on the broader notion of sense of place and how this has been developed into an interactive and embodied approach.

Within this array of concepts and approaches Davenport & Anderson (2005) suggest sociologists have often taken a social constructionist approach to place. This involves “exploring the shared values and symbols that when applied to a landscape create common meanings.” (p. 627) (e.g., Egoz et al., 2001). Psychologists have taken a cognitive approach (see Section 4.2) claiming that

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*Place attachment and place identity are, at times, used in conjunction with phenomenologically based existential expressions of place (Manzo, 2003) such as rootedness (Hay, 1998), insider/outsider (Tuan, 1974) and dwelling (Heidegger, 2000). Place attachment is considered as the bonding of people to places (Altman & Low, 1992 cited in Manzo, 2003), while place identity describes the dimensions of self that are associated with a place (Cheng et al., 2003). Place dependence is considered as the perceived strength of association between a person and specific places (Jorgensen & Stedman, 2001). These notions are bound up with affective relationships with the environment (Manzo, 2003).*
“individuals process information internally about their environment, which subsequently shapes their attitudes and behaviors towards their environment.” (Davenport & Anderson, 2005, p. 627). Geographers, by contrast, have frequently taken a phenomenological approach which “examine[s] how spaces become places through personal activities and experiences.” (Davenport & Anderson, 2005, p. 627). As discussed further below, this usually involves a subjective focus on how places are assigned value.

The following sections first set out briefly the importance of phenomenology in place theory, then outline how this is developed by Ingold (2000) into an embodied and material approach to place. This is then related to the idea of local knowledge and also to interaction with wild animals.

6.2 Phenomenology and sense of place

The notion of a sense of place itself comes from phenomenological approaches to human geography. Phenomenology has been used mostly to develop an empathetic understanding of personal subjective views of the world (Johnston, 1979). However, as outlined in Chapter 2, in its classical Husserlian eidetic form, phenomenology is not concerned with subjective meanings in themselves but instead is the science primary experience, explicating the “science of beginnings” (Pickles, 1985 cited Johnston, 1979, p. 97). So a phenomenological understanding of place is not just a process of gathering together a group of individual descriptions. Rather, it attempts to reveal what is essential in the “taken-for-granted settings which seamlessly interweave to constitute sense of place.” (Stefanovic, 1998, p. 33). Auburn & Barnes (2006) suggest that this approach has been diluted in much phenomenological research, which has instead become an uncritical sampling of peoples’ expressions of their subjective experiences.

As already discussed, phenomenology also considers the ontological nature of humanity. Heidegger’s (2000) notion of being-in-the-world or our immersion in the world is the fundamental irreducible aspect that underlies all subsequent attempts at analysis. This is not a search for essences, nor does it reify descriptive subjective experience, but an ongoing revealing of our ontological immersion in the world and in place, and is a way of existing in the world that he calls dwelling. This highlighting of immanent relation(ships) has been outlined, and developed further, in Chapters 2 & 3.

Heidegger’s phenomenological position does give scope for intersubjective concerns, whether taken-for-granted or not, as the individual is understood as being fundamentally embedded and their understandings arising from interaction with place (social and physical) rather than being purely imposed by the individual. Indeed, many commentators argue that culture and social relations shape personal interaction with, and so affect people’s sense of place. These relations include social power relations (Shamai & Ilatov, 2005; Stokowski, 2002), cultural symbols, ritual and myth and
language (Relph, 1976 cited in Shamai & Ilatov, 2005). Cheng et al. (2003) suggest that places are continuously reconstructed through social and political processes. Some types of meanings are promoted by some social groups over others in order to protect their interests and sense of place. Related to this, Gregory (1978 cited in Johnston, 1979) criticises the phenomenological approach for its tendency to ignore the constraints of social action and material imperatives. In other words, it ignores the social, economic, political, historical and material circumstances that impact on subjectivities. I do not wish to deny the role of tradition and language, but to highlight that they are continuously recreated and developed through situated, embodied interaction with place.

To this end, Anthropologist Tim Ingold has taken the phenomenological approach towards a fundamentally interactive and embodied account of place. The next section will give a brief overview of his thought, which has much in common with the philosophical and theoretical position developed in the previous chapters.

6.3 Place and ‘taskscapes’

6.3.1 Place

Ingold’s (2000) thought is concerned with the separation within the field of anthropology of realist and idealist approaches. This in turn reflects the separation of the material sciences and those related to the human mind with its associated linguistic, cultural and social products. In common with the stance of this study, Ingold (2000) considers both of these approaches inadequate for understanding persons.

The realist approach understands people as biological entities and generally as discrete, bounded organisms and downplays their embeddedness in a field of relationships. In the idealist position, people are persons constructed from their history of experiential growth within the social world. In this disembodied account, culture is understood as a set of relatively stable symbolic meanings passed on intergenerationally that shapes the experience of individuals. This meant, that explaining the differences in understandings of different groups of people required the study of variations in symbolic culture, while the practical day to day context of activities tended to be ignored.

In contrast, practically based habitus anthropological theory of Bourdieu proposes that cultural patterns lie in the everyday world of practical engagement. Cultural models, as an interior symbolic, are not independent of and do not precede this interaction. Culture exists only through such interaction and is continuously recreated in it. Variation in action and expression is not due to different cognitive schemata, but develops from different experiences and consequent practical
attunements (Ingold, 2000). Ingold’s (2000) position follows Bourdieu and has much in common with the theoretical approach developed in the previous chapters, which considers people as material beings immersed in the world, mentally (cognitively and affectively) and physically. People are organism-persons, who exist foremost in the context of an active engagement with the world made up of many kinds of beings, not just human. In this respect, social relations are a sub-set of ecological relations. This position helps recognize that animals, as other beings, are similar kinds of agents.

Ingold (2000) rejects a genetic blueprint model of development. Instead, he supports a fully developmental position where organisms are active as a “creative unfolding of an entire field of relations within which other beings emerge and take on the particular forms that they do, in relation to the others” (p. 19). This parallels the epigenetic understanding outlined in Section 4.3.2.1. In addition, he argues that social constructionist versions of cultural (or social) theory can be critiqued in the same manner. In Ingold’s (2000) approach, the biological, mental and the social are amalgamated under a relational theory of developmental interaction.

This suggests that knowledge should not be considered as, either a cultural overlay passed on directly from one generation to another (tradition), or intrinsic to objects. Cultural information about the world becomes knowledge when related to our perceptual experiences, which are partially facilitated through being shown by others, as a developmental education of attention (Ingold, 2000). This is not a universal knowledge able to be applied anywhere, but knowledge of particular places based in feeling and “consisting in the skills, sensitivities and orientations that have developed through long experience of conducting one’s life in a particular environment.” (Ingold, 2000, p. 25). Here, “feeling is a mode of active, perceptual engagement, a way of being literally ‘in touch’ with the world” (Ingold, 2000, p. 23). He is referring, in particular, to indigenous cultures, but his concern with individual development and experience means it applies to other cultures as well.

Consequently, culture itself is developed in practical, interactive, embodied life and not passed down as a set of mental representations. My participants, who are farmers, are farmers primarily because they ‘practice farming’ not because they literally take on a culturally defined schema or set of representations of what it is to be a farmer. This also means that in my analysis I am not searching for mental schema (cultural frameworks) or certain culturally defined discourses to explain what they do and say what they do. Rather, I am looking at what they say and do as reflecting what their perspectives and relationships are. This is a concern for networks rather than social structures.

This focus on the practical means, according to Ingold (2000), much of what is normally called cultural variation (or variation in values and attitudes), are variations in skills. He is not suggesting here just bodily techniques but “the capacities of action and perception of the whole
organic being (indissolubly mind and body) situated in a richly structured environment.” (p. 5). For Ingold (2000, p. 5), skills are “conceived of as the embodiment of capacities of awareness and response by environmentally situated agents”. They can be understood as an extension of the basic perceptual response described by Stewart (1995) (see Section 4.3.4). This can help remove the separation between the works of humans and non-human animals. In common with culture, Ingold (2000) claims skills are not passed on directly, either biologically or culturally, from generation to generation but are redeveloped each time in interaction with the environment and so vary with experience and interaction.

Skills are situated and embodied, they are immersed in a world of active relations that are an inescapable part of existence and which, Ingold (2000) calls the dwelling perspective. This is adopted from Heidegger’s notion of dwelling in Being & Time. For Heidegger the world continually comes into existence around the inhabitant (Dasein) and the significance of its many elements depend on them being incorporated into regular patterns of everyday activity (see Section 2.2.2). This world is not one of surrounds, but one highlighted by Heidegger in which we are immersed and in which meaning is immanent (Ingold, 2000). This common world gives us common understandings rather than disparate experiences that need to be organised through an underlying cultural schema.

The active perceptual relation, central to the dwelling perspective, has parallels with the ecological psychology of Gibson, which emphasizes the movement of the whole organism in perception and was outlined in Section 5.3. However, Gibson posits affordances as somewhat objectively definable properties of the world waiting to be picked up. In the phenomenology of Heidegger (and Merleau-Ponty) “the world emerges with its properties alongside the emergence of the perceiver in person, against a backdrop of involved activity” (Ingold, 2000, p. 168).

Ingold’s (2000) approach oscillates in this dialectic of the subject and object trying to capture the play between fluid networks and specific activities (i.e., some form of essence or stable boundaries of place). This tension is exposed in Ingold’s use of Heidegger’s notion of dwelling but also using Gibson’s conception of affordances. These affordances or essences are traceable through specific activities. Ingold (2000) also attempts to break down these essences and notes that unlike space, places are centres without hard boundaries. Elements of the landscape may delineate it, but they are also integral parts of it. Boundaries only form in relation to the activities of the people and animals living there. Consequently, place may be best considered to be made up of networks of relations, or cyclic systems existing at multiple temporal and spatial scales, some consistent, some changing. (see Section 3.5.5). This suggests Resilience Theory’s use of defined boundaries must be always considered as tentative.
6.3.2 Taskscapes

Ingold’s (2000) approach connects place with landscape. Landscape is not ‘nature’ as something separate from humans. It is the familiar place of our dwelling, as part of us as we are a part of it. Because we always exist within a landscape its order is implicit rather than explicit. The landscape is the complex mosaic known to those who are dwelling there (Franklin, 2002). It is created through embodied active practical human projects that continuously recreate the natural and social landscape as ‘taskscape’. The taskscape reflects and constitutes the “pattern of dwelling activities” (p. 154).

These activities are not inscribed on an inert landscape as some record of past cultural activity, but entwined into it with the activities of plants and animals as an ongoing process. What this means for wilderness, for example, is that it involves a different set of activities that allows the activities of plants and animals to dominate. This is a more reticent human dwelling, involving an unfolding that does not just give priority to human ‘tasks’ but sensitive to tasks of other inhabitants (i.e., plants, animals) and so is still a taskscape.

The Cape Foulwind landscape is a taskscape, involving both natural processes and human endeavour. The history of human interaction has substantially changed this landscape. This has occurred particularly through a colonial history of forestry, gold mining, and farming (see Section 14.2). Different technologies change the way it is interacted with (Rival, 1993 cited in Franklin, 2002). For example, at Cape Foulwind excavators have allowed new techniques for developing the land.

Ingold (2000) claims the taskscape is primarily what we hear rather than what we see, as this reveals the actual activity that is occurring (e.g., the sound of machinery, the call of the weka). The taskscape is not only one of activity but interactivity as things (people, animals) respond to each other’s activities. Weka respond to the activities of humans, themselves changing the taskscape (both aurally and physically), to which in turn humans respond. These complex networks of cycles can be simplified and conceptualised as a socio-ecological system. Ingold (2000) takes this a step further and suggests that such response also includes the inanimate world. This is because life is an unfolding of an ongoing process of becoming, where the organism is manifest within a matrix of organism-environment relations, and which has parallels with Deleuze’s thought. However, Ingold (2000) does not extend this to subjectivity itself.

The taskscape is never completed. Landscapes are not artifacts or artificial in the sense that they are not preconceived and then completed when that image is met. Rather, they are always under construction by humans and non-human processes. Put into systems language, they are open socio-ecological systems. They are constructed by the very act of dwelling (Franklin, 2002). We are dwellers before we are builders and the things we build (including landscapes) arise out of our
fundamental immersion and in our everyday engagement with our surroundings. Ingold (2000) suggests that “modern thought then rediscovers dwelling as the occupation of a world already built” (p. 185), rather than one undergoing continuous construction involving our care and belonging to the world. Dwelling in the Cape Foulwind landscape can be considered in this way. It is a landscape with a generational social continuity and construction. Mining, forestry then farming are the tasks, and prior to that Maori dwelling, that have made this landscape physically what it is and what its inhabitants are and know.

The following sections pick up on the practical embodied and interactional concerns of Ingold (2000). Firstly, in relation to what local knowledge might be, and then how contemporary interactions with wild animals could therefore be conceptualised.

6.4 Local knowledge

Closely related to place, is the notion of local knowledge, which can be understood to be bound up with peoples’ experience of place (Harrison et al., 1998). Further to this, and as set out in the preceding section, place is considered as the centre of our involved embodied activity and is continuously being created as an interactive taskscape. As discussed in Chapter 5, knowing is considered to be intimately tied with emotion through cognition. Consequently, place is the essential cognitive and emotive setting where we dwell. Local knowledge is a concept that attempts to capture the knowing that is this immersion in the world.

There is a central distinction in the use of the concept of local knowledge. This lies between local ecological knowledge (LEK) and traditional ecological knowledge (TEK). The term ‘local knowledge’ is originally linked to research on the development of TEK in traditional non-western societies. TEK “can be defined as a cumulative body of knowledge, practice, and belief that pertains to the relationship of living beings (including humans) with one another and with their environment, and it evolves from adaptive processes and is handed down through generations” (Anadon et al., 2008, p. 618). Sometimes also called ‘local people’s knowledge,’ “LEK refers to the local expertise of people who may not have a very long-term relationship with the local environment compared with indigenous people, but nevertheless have local wisdom, experience, and practices adapted to local ecosystems” (Ballard et al., 2008, p. 38). LEK refers to predominantly individual experiential knowledge of place, that will also include knowledge passed down from previous generations (if they had lived there), but it is not strictly TEK in the indigenous sense suggested above. However, it does include what might be called traditional knowledge based on Western scientific and religious understanding of the relationship of humans and animals (Western ecological knowledge (WEK)).
The existence of WEK highlights the extent to which local knowledge is a hybrid generated from many sources. As discussed above in Section 6.3.1, this is consistent with the idea that knowledge is not passed down in some pure form but recreated in each generation in interaction with the local environment which allows an ongoing hybridisation to occur. Woodley (2004) refers to Gidden’s structuration theory, and its concern with the relationship between large and small scales (in space and time), to propose that the local environment has expanded to become influenced by and include (or become networked with) other places, and ways of knowing associated with them. Local knowledge becomes continuously recreated and also hybridised with different types of knowledge and practices. Woodley (2004) is concerned that this can introduce practices that ‘displace’ people by reducing the “close proximity to resources and the functional knowledge of resources and social cohesiveness.” (Woodley, 2004, p. 4).

Ingold’s (2000) position would suggest that embodied interaction tends to ground networked hybridised knowledge in the local landscape. I suggest this involves networks existing as part of a contextual knowing, reflecting a situated embodied cognition as discussed in Chapter 4. The associated emphasis on embodiment might consider the strength of the networks to lie in everyday activities. For example, ‘Farmers’ knowledge is an implicit part of their everyday action.

This type of knowledge is not necessarily expressed verbally. Often discussions between farmers and researchers generate accounts of what farmers usually do or think, but it is more difficult to unravel how this presentation of knowledge relates to action. This is because “[f]arming practice depends on the unfolding of events – more akin to a flexible performance than a fixed system.” (Warburton & Martin, 1999, p. 9). Furthermore “[k]nowledge is not something an individual has “more” or “less” of, but rather reflects the specific forms of practice undertaken in daily life; thick in some areas, thin in others” (Robbins, 2006, p. 191). This is a emphasis on action, on knowledge as an ongoing engagement of “knowing how that rather than knowing what and why, the latter,... tends to be the emphasis in western science.” (Woodley 2004, p. 3).

Moller et al. (2004) consider how local knowledge and scientific knowledge might be integrated. They reflect on the relationship between the use of TEK and science in the management of harvested species. In particular, they focus on the harvest of titi by Maori on the islands around Stewart Island. Moller et al. (2004) outline what they see as the complementarities between science and traditional ecological knowledge for population monitoring. These include: (1) matching diachronic information of traditional local knowledge with the synchronic information of science; (2) the way traditional local knowledge notes extreme events and science averages events; and (3) and that traditional local knowledge is less precise (qualitative, fuzzy) but gives good overviews for developing the more precise testing mechanisms made by science (quantitative). There remains a
strict dichotomy between subjective and objective knowledge in this approach, rather than highlighting relationships and affect in all ways of knowing. The list of complementarities shows this close relationship between the ‘two types’ of knowledge. Any differences are really a matter of emphasis rather than type.

This similarity is highlighted further by Moller et al. (2004) when they suggest “[t]he emergence of adaptive management, or “learning by doing” as a method of understanding ecosystems may be considered an indirect acknowledgement of the similarities between traditional management and scientific management.” (Moller et al., 2004, p. 12). Their research was primarily focused on population monitoring rather than people’s relationships, although it stresses that the knowledge that comes from such relationships is important for management and can then be conceptualised within an adaptive systems framework. Due to the complementarity outlined above, Moller et al. (2004) suggest that neither LEK nor science can by itself address all environmental impacts (e.g., how to manage weka on private land). As outlined in Chapter 3, there is recognition that conventional scientific approaches may be insufficient for understanding CAS and their associated complexity.

Moller et al.’s (2004) concern is with sustaining wild resources (i.e., *titi*) rather than living with wild animals. My participants do not have the same intense relationship with weka that, for example, Maori have with *titi* as a harvest species. This is because their livelihood does not depend on weka, rather, it is more a concern with weka as part of place. This again brings up the question of how this relates to local ecological knowledge? Does non-indigenous lay persons’ (e.g., contemporary farmers) interactive ecological knowledge have the attributes of TEK suggested by Moller et al. (2004) (i.e., diachronic, sensitive to extremes and fuzzy)? The foregoing discussion highlighting embodied dwelling would suggest LEK be treated in a similar but not analogous manner to TEK, as TEK still carries an intergenerational tradition of interaction with place that LEK may lack.

### 6.5 Wildlife

In common with much literature on place, and in contrast with approaches to local knowledge, which highlight embeddedness, the literature on human wildlife interaction is often subjectively based and uses attitudinal concepts.

Teel et al. (2007) utilise a value-attitude-behaviour framework in their analysis of contemporary human wildlife interaction. This cognitive hierarchy model “contends individual behaviour toward wildlife is driven by specific attitudes, and these attitudes are directed by wildlife value orientations. The latter are defined as basic beliefs that give personal meaning of right and wrong and an ideal life to one’s more basic values in relation to wildlife.” (Teel et al., 2007, p. 300).
Using this model, Teel et al. (2007) argue that the values people in the West hold in relation to the environment and wildlife have changed during the 20th century. This is linked to a broad cultural change from materialist to post-materialist values associated with the process of modernization from industrial to post-industrial society. “Materialist values... focus on safety, security, and economic stability, whereas post-materialist values focus on belongingness, quality of life, and self actualization.” (p. 298). In the materialist view, wildlife is a food resource while in the post-materialist view, which Teel et al. (2007) describe as mutualism, wildlife is considered “as capable of living in relationships of trust with humans, as life forms having rights like humans” (p. 299) associated with a growing need for belongingness.

An important point here, and noted by Teel et al. (2007), but treated as a consequence of cultural change rather than as part of it, is that this includes not just a change in relation but an associated change in interaction with wildlife. The more urban post-materialists interact less with wildlife and with the natural environment than the preceding materialists. In this manner, each generation develops from the previous in ongoing interaction with wildlife rather than just involving symbolically based cultural change. The previous chapters reconceptualised beliefs, values and attitudes as fundamentally involving embodied interactive processes rather than comparatively static culturally based subjective overlays onto the world.

In another attitudinally based study, DeStefano & Deblinger (2005) highlighted how attitudes to wildlife vary over time and proposed that changes in abundance were a central ‘driver’ in this. When some species are low in number they are considered endangered and valuable, while as their numbers increase their nuisance or danger value also increases and they come to be considered as pests. DeStefano & Deblinger (2005) also suggest the type of interactions and personal experiences people have with wild animals effects their status as pests. However, they relate this to concerns over tolerance and do not explore the types of interactions themselves. Consequently, DeStefano & Deblinger’s (2005) paper is not about adjusting human behavior to wildlife, which is seen as a given, but controlling wildlife to fit in with humans. Wildlife are not treated as interactive participants in a SES, or a set of actants in a network, but as a resource to be controlled.

Again, as noted, this approach focuses on attitudes, (i.e., the values people ascribe to wildlife) rather than relationships held with them. McCleery et al. (2006), in assessing the use of attitudinal surveys by the wildlife sciences, noted shortcomings in their use. For example, the assumption is that attitudes are able to predict behaviour, which is often not the case. To help improve the use of attitude studies they suggest focusing them closely on the subject of concern.
(e.g., weka) and targeting the audience to those who have had experience with the subject. The broad implication here is that the strength of attitudes as a predictive construct may rely on people having had close and possibly embodied interactions with the subject. This would give attitudes a basis in relationships already held and not just subjective culturally derived ascriptions which appear to hold limited predictive force.

This is not to deny the importance of culture on relationships people have with wild animals but involves the potential for rethinking symbolic culture as interactive topological networks (Latour, 2005). Whatmore & Thorne (1998) attempt to “reimagine wildlife topologically – as fluid, relational achievements that configure ‘human’ and ‘animal’ categories and live in intimate, if not necessarily proximate, ways.” (p. 450). Whatmore & Thorne (1998) reconsider the location of wildlife in Western culture. They consider that contemporary renditions are of wild animals inhabiting wilderness separate from human places; as endangered species defined by genetics, science and international agreements. They argue for including them in the places inhabited by humans. This will enable treating wild animals as fully active agents, whose existence and behaviour influence and make up heterogeneous social networks. Whatmore & Thorne (1998, p.451) suggest:

“...that animals are best considered as strange persons, rather than familiar or exotic things. Their presence in heterogeneous networks is multidimensional – corporeal, creative, social. Making their presence felt in our accounts of those networks presents serious theoretical and practical problems, which science (social and natural) has barely begun to admit.”

This is a phenomenological-post-structural “performative conception of wildlife” (Whatmore & Thorne, 1998, p. 451). It recognises the role of culture but integrates it thoroughly into dynamic corporeal networks, which undermine culture’s autonomy. Labeling animal inhabitants as wild, and so separate, has tended to undermine “the ceaseless intertwinings of human-animals lives ... which haunt the places we inhabit” (p. 451). The separation has made ‘wild animals’ only things science interacts with as biodiversity (genes and species) to be protected and kept separate. “It is a spatial imaginary that has helped to deprive us of a language of connection, or kinship, beyond the ‘human’” (Whatmore & Thorne, 1998, p. 451). Breaking down this separation would require physically reducing the gap so humans interact with non-domesticated animals.

It is participants’ physical embodied interactions with weka that are the focus of this study. What networks ensue, and what their relations with weka are, are the threads to be traced. Do they understand them as wild animals? As active agents? How does this interaction reflect on the relationship with place? Do they change their lives to live with them as wild animals, or as Whatmore
& Thorne (1998) put it “recognizing the place of the wild on the ‘inside’ of this shared dwelling place” (p. 450).

6.6 Conclusion

This chapter has drawn together the central elements of the preceding theory chapters and applies them to the themes of place, local knowledge and relationships with wild animals. These three topics lie interrelated at the core of this study.

The themes of the preceding chapters are developed in Ingold’s thought in his concern for our technical embeddedness in landscape (taskscape) as a field of relationships. This is described by Franklin (2002) in the following terms: “we have to deal with cultures that make and are in turn made through landscapes and tasksapes ... The world looks different this way and to see it and sense it requires a more active study of engagement in the world ... The social is not thought of as existing prior to this landscape but emerging through it.” (p. 71-72). This changes the methodologies to be used for investigation of human/non-human relationships. They become focused on action, relationships and everyday activities.

Ingold (2000) argues that meaning is not a series of symbolic layers overlaid on the landscape. That emphasis on subjective and cultural interpretation downplays immanence. Rather it is “immanent in the contexts of people’s pragmatic engagements with its constituents.” (p. 154). Franklin (2002) argues that transformed people (e.g., colonial people like those at Cape Foulwind) become re-embedded as part of identity building (e.g., as West Coasters) that becomes dominated by practical and embodied experience. Or, in other words, the things they do there, and in the process create and become created by the place as a landscape (i.e., they dwell here). This, along with the redevelopment of culture in each generation through interaction with the environment, tends to muddy the distinction between the indigenous and non-indigenous and TEK and LEK.

It could be argued that an emphasis on practical, embodied relationships loses the emotional aspects associated with place. Seamon (1982) emphasised this aspect by incorporating Heidegger’s later thought (see Section 2.2.3) as an understanding of dwelling that moved away from the primacy of practical engagement central to Ingold’s (2000) taskscapes. However, as set out in Chapter 5 the emotional is central to embodied practical engagement as the body in action is fundamentally an emoting vehicle.

A position was developed in the preceding chapters that question the purely phenomenological approach taken by Ingold (2000). This hybridised phenomenology, in part, rejects the centrality of consciousness, but retains affective de-centred subjectivities, materially developed as an emergent autopoietic entity. In this approach, subjectivities are not considered so much as
being “in-the-world” but as being “of-the-world”. This was used to develop a broader view of values - as valuing - that entailed a rejection of attitudinal approaches and highlighted an ongoing interactive process of engagement. It is one that understands individuals as holders of a perspective. This is a local knowing under laid by our cognitive/emotional embodied relations with the world.

Consequently, the concept of dwelling and place is understood as more fluid and networked than traditional Heideggarian based conceptions of it, while the embodied concerns highlight material practices and the affective ‘atmosphere’ (Thrift, 2008). This is not phenomenological concern with things (places) in themselves but how phenomena are related. This is an investigation of people’s everyday material interactions (which has a fundamental emotional aspect), and it is proposed, lie as the basis of relationships with place.

The notion of a reciprocal emergent relationship between people and place lies implicit in a systems approach. Oreszczyn (2000) argues that by taking a systems approach, it is people’s relationships with the environment which need to be emphasised rather than people’s valuation of the environment. For Oreszczyn (2000) “‘relationship’ encompasses the way we interact and engage with an environment of which we are an integral part.” (p.109). A systems approach, as set out in Chapter 3, allows the biophysical, social aspects to be considered along with more individual emphasis of phenomenology.
7 Weka ecology

7.1 Introduction

The weka (*Gallirallus australis*) is a large, brown, endemic, flightless rail. Western weka (*Gallirallus australis australis*) is one of four forms (subspecies) of weka. The other three subspecies being the North Island weka, the Buff weka and Stewart Island weka (Department of Conservation, 1999). Weka are thought to have evolved from a colonisation of New Zealand by a flighted banded rail (Wilson, 2004).

Weka historically have been birds of the main islands of New Zealand (including D’Urville Island) but not of smaller islands or islands greater than 5 km from the coast of the main islands (Beauchamp, 2004). Weka were once widespread throughout all the main islands of New Zealand. The North Island weka occurred in all parts of the North Island. There are now only very small remnant populations. The Stewart Island weka occurred on Stewart Island where it has now almost vanished and survives on some surrounding islands. The buff weka was found on the east coast of the South Island from where it has now disappeared. A population survives on the Chatham Islands where they were introduced in 1905 and are now common and hunted for food by Chatham Islanders. Western weka historically occurred on the western side of the South Island from Marlborough to Southland. They now only survive in the Marlborough Sounds, the West Coast of the South Island approximately as far south as Ross, in isolated pockets further south, and in Fiordland (Schmechel, 2004). Western weka are classified as a species at risk and ‘declining’, while two other weka subspecies are classified as endangered and ‘nationally vulnerable’ (Miskelly et al., 2008).

The western weka population shows the greatest morphological diversity of the four subspecies. There is a cline formed from north to south and east to west (Marchant and Higgins, 1993). Due to this variation The Weka Recovery Plan 1999-2009 (Department of Conservation, 1999) recognises two western weka groups, the northern populations and the ‘Fiordland’ (populations with black morphology). This research relates to the western weka population at Cape Foulwind on the northern West Coast of the South Island and so is part of the northern group. However, more recent investigation into the history of Western weka suggest that there have be a number of introductions of weka by humans onto the West Coast and the West Coast Western weka may be derived from a mix of subspecies (Gareth Hopkins pers.com.).

Weka are dietary generalists and will consume small vertebrates, invertebrates, carrion, eggs and fruit. Their core diet is fruit and soil and litter dwelling invertebrates. They are an important species for forest regeneration as they distribute the seed of fruit bearing plants, and are one of the few remaining large birds in New Zealand to do so (Department of Conservation, 1999). Weka use
and occupy a wide range of habitats including forests, scrublands, wetlands, sub alpine grasslands and rocky coasts. They also occupy diverse modified landscapes such as rough farmland (Department of Conservation, 1999).

Weka have been translocated in the North and South Islands but most attempts have failed. Historical and contemporary translocation of weka to offshore islands has proved more successful (Schmechel, 2004). Weka are known to predate other fauna on offshore islands, particularly seabird eggs and chicks and has been a concern on islands where they have been introduced (e.g., Open Bay Islands off South Westland) (Wilson, 2004). Weka can also add to the threat to some invertebrate species (e.g., *Powelliphanta* snails) (Walker, 2003). Consequently, weka are now considered ‘pest’ birds on many offshore islands where they have been introduced and the Department of Conservation has now removed some populations (e.g., Whenu hou, Titi Islands). However, weka predation on other species on the mainland can be considered as part of the natural ecology.

Research suggested in the Weka Recovery Plan 1999-2009 (Department of Conservation, 1999) for North Island weka includes targeting “...landscape management issues, and predator problems that are known to have prevented the re-establishment of weka” (p. 21). Such research includes ecological factors but also human factors. In this vein, Russell (1994) notes that once a weka population has declined or disappeared from an area it is frequently difficult to re-establish both practically and politically.

### 7.2 Population fluctuations and densities

Historically mainland weka have had highly fluctuating populations (Beauchamp, 2004) as well as being historically unevenly distributed (Beauchamp, 1999). Western weka, for example, were in common in Westland during the 1860s (Brailsford, 1996 cited in Beauchamp, 2004) and also at Cape Foulwind (Matthews, 1957). Anecdotal reports suggest they died out during the 1920s at Cape Foulwind and in Westland and recovered during the 1960s (Beauchamp, 2004). Anecdotal reports also suggest that the weka population in the Cape Foulwind area has been relatively stable since the 1960s recovery. In recent times (late 1980s) western weka populations have collapsed in the Golden Bay lowlands (Beauchamp, 1999; Hayward, 2001) and in the 1970s the large population of North Island weka in the Gisborne area also collapsed (Beauchamp, 1997). On the main islands it is now only the Marlborough Sounds and the West Coast of the South Island where weka still survive in relatively dense populations (Beauchamp, 2000). No West Coast population, however, is as high as in pre-European times (Harper 1896 cited Department of Conservation, 1999).

In their overview, Marchant and Higgins (1993) note there was little data available on weka abundance. However, from the data available densities were higher on islands with 0.8 birds/ha on
Kapiti Island (Beauchamp 1987a), and 1.6 paired adults/ha on Kawau Island recorded (Beauchamp & Chambers, 2000). On the mainland 0.3 birds/ha were recorded in the Marlborough Sounds (Beauchamp, 1987b). Beauchamp (2004) estimated adult weka densities in Westland to be between 0.3 and 0.78 ha⁻¹. The large difference in densities is related to habitat variations.

7.3 Threats

The exact nature of threats to weka populations has not been clearly identified. There are an array of factors proposed (Department of Conservation, 1999). The impacts of these factors vary in time and space and several factors may interact. These factors are discussed in the following sections.

7.3.1 Mammalian predators (cats, stoats, ferrets, dogs)

Coleman et al. (1983) Westland study suggested that stoats (*Mustela erminea*) were not important predators of weka. In contrast, Beauchamp (1999) proposed that the rapid decline of weka in the Golden Bay lowlands in the late 1980s may have been associated with stoat density peaks. The data from weka translocations undertaken in Totaranui in 2006-2007 highlighted the impacts of stoats, particularly on the smaller females. While a ten year study at Motu in the North Island found approximately 15% of juvenile weka (up to 12 months old) are being killed by stoats (F.Kemp pers. com.). van Klink & Tansell (2003) found stoats had killed three, and probably five, of 15 radio-tagged weka in a South Westland study. In common with the Totaranui releases these were all smaller birds (i.e., below 1200 gm in weight.) In common with kiwi, smaller weka may be more susceptible to stoat predation (van Klink & Tansell, 2003). Other predators implicated in weka deaths include ferrets (*Mustela furo*), wild and domestic cats and dogs, and harrier hawks (*Circus approximans*). There is no quantitative data available on these threats (Department of Conservation, 1999).

7.3.2 Climatic variations affecting food and water supplies.

In his study of the weka population collapse in Golden Bay Beauchamp (1999) concluded that weka are not usually killed by climatic extremes. However, they can be impacted by long dry periods (i.e., sometimes associated with La Nina events on the West Coast) through impacts of food supplies (Beauchamp, 1987a). This can put more stress on the birds and increasing susceptibility to other factors such as disease. Weka can also be negatively impacted by extremely wet conditions (i.e., often associated with strong El Nino events on the West Coast) which impacts on breeding success (Beauchamp, 1999).
7.3.4 Disease (blood parasites, nermatodes)

Beauchamp (1997a) notes that although disease is frequently suggested as a cause of weka decline, few dead weka are found during widespread decline events, and no disease or parasite has been identified as being a cause (Heather & Robertson, 1996 cited in Beauchamp, 1997a). Coleman et al. (1983) attributed some losses in their western weka population study to liver lesions typical of the parasitic granulomas.

7.3.5 Road-kill

Road-kill has been noted as a factor in North Island weka mortality (Carroll, 1963; Beauchamp et al., 1998). Bramley (1994 cited in Beauchamp, 1997) suggests that road kills along with predators were the major cause of the death of adults in the Rakauroa area of the eastern North Island. Department of Conservation (1999) also notes road-kill is a possible factor in the decline of weka numbers. There is little published empirical data available on weka road-kill with one record of 93 road-killed western weka counted over 7060 km of road travelled in North Westland during 1997 (0.013 deaths km$^{-1}$) (Department of Conservation, 1999). A study of weka road-kill of weka at Cape Foulwind was undertaken as part of this study (Freeman, 2010). It found that c.365 weka a year were killed on the public rural roads (c.65.2km) around Cape Foulwind per year. This was estimated as being 2.0 – 4.0 % of the local population.

7.3.6 Habitat loss

Bramley (1994, cited Department of Conservation, 1999) suggests initially the human impacts on natural weka habitat may have been softened by the introduction of high fruit producing weed species and invertebrates. However, in recent times the removal of scrub, riparian and roadside margins and weedy patches in rural landscapes has reduced the quality of habitat for weka (Beauchamp, 1997a cited in Department of Conservation, 1999). Beauchamp (1997) suggests the loss of cover associated with farm and land clearance may have been connected with weka decline in some areas of the East Cape Region in the 1980s. There has been no specific research on the effects of habitat change on weka distribution and density.

7.4 Territoriality

Weka are generally a territorial species. Adult birds form pair bonds, establish territories and raise chicks within those territories. Pair bonds are in place all year and tend to last the birds’ life
time. Unbonded adults and sub-adults usually establish home ranges (Marchant & Higgins, 1993). Territorials are considered birds or pairs that dominate a certain area and have priority to that area’s resources. Non-territorials are birds that have a lesser priority to resources (i.e., have home ranges) and which includes sub-adult and adult birds.

Beauchamp (1987a) suggests that territoriality in weka reflects the behavioural traits of many rails. Weka aggression towards other weka and spacing calls helps create the territorial system. The system remains in place where resources can be readily defended, and where defense of the resources is outweighed by the benefits of doing so. However, these costs and benefits are not stable and may vary between populations due to factors like population density, food availability, habitat variation, climate etc. This in turn affects the type of territorial system existing (Brown, 1964 cited in Beauchamp, 1987a). Because variations in food availability are shorter than the life span of weka, Beauchamp (1987a) proposed that weka tended to have more stable territories held throughout the year. This reduced the cost of maintaining territories as the boundaries remained relatively stable. Beauchamp (1987a) found that weka territory sizes were organized around seasonal periods of lower food availability.

The access to resources associated with territoriality leads to improved condition and survival of individuals, and stability for breeding. Pairs of weka are required to maintain territories (Beauchamp, 1987a). The importance of territoriality to weka is shown, in Beauchamp’s (1987a) Kapiti Island study, by the short period between loss of a mate and obtaining a new one, and the degree of site fixation in situations of disturbance and lack of food. Non-territorials lived in a less socially stable environment with subsequent higher energy expenditure and mortality. Beauchamp (1987a) also suggested that territoriality stopped over exploitation of patchy resources, meaning in poor environmental conditions some pairs would be more likely to survive.

Beauchamp (1987a) found the location of territory boundaries was associated with a combination of their historical location, topographical features and areas of high quality habitat. Anecdotal evidence from this study found high quality habitat around houses often became a territorial boundary.

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47 In this study weka are placed in the following categories: (1) Juveniles - birds less than 12 months old until they establish a home range (2) Sub-adults - pre-breeding age (< 12 months old) birds with a home range (3) Adults – territorial or non-territorial breeding age birds.
7.5 Breeding

Weka breeding productivity is closely related to the available food supply and can occur year-round if the food supply is adequate (Department of Conservation, 1999). Weka can be very productive in habitats with good food supplies producing up to 15 young a year (Beauchamp, 1997). In North Westland, breeding was found to occur between August and March (Coleman et al., 1983). In the Marlborough Sounds the main breeding period was August to October, although some breeding took place throughout the year (Beauchamp, 1987b).

Beauchamp (1987a) found a complex set of factors involved in weka age at first breeding. These were: its age at territorial establishment, the age of its partner, the condition of both birds, and the territory size and timing of establishment of the pair. Most birds established territories in their second year with only a few doing so in their first year. There was often a large delay between territorial establishment and first breeding (up to 5 years). However, Beauchamp (1987a) notes when weka are moved from population (i.e., dense territorial population) and environmental (i.e., food availability) constraints, like other rails, they may readily breed in the first year.

On Kapiti Island, the general condition of the population gave good guidance on the number of pairs that attempt to breed. In years with good food availability breeding attempts were earlier but fledging success depended upon food supplies during the parental care period. Females lost between 12% and 20% during incubation and 20% to 24% during parental care, while males lost between 13% to 18% and 19% to 24% respectively (Beauchamp 1987a).

Parental care of chicks ended when the chicks became independent feeders or parental condition and food availability became low. This was between 40 and 108 days on Kapiti Island. Early ending of care occurred if parental moult started (Beauchamp, 1987a).

The density of weka appears to affect the sizes of clutches laid. This is because female egg production depends on the use of female body reserves as there is inadequate time between egg laying (1 or 2 days) to accumulate the nutrients required. However, when many eggs are laid (e.g., 5-6) some accumulation will be required. On Kapiti Island, territories overlap and densities are approximately 1.7 per hectare and there are many non-territorial birds so leaving the nest vacant risks predation of eggs by other weka. At Double Cove the densities were c.0.2 ha, territories did not overlap and there were few non-territorial’s so there was the ability to leave the nest and accumulate more nutrients for egg laying (Beauchamp, 1987a). At Cape Foulwind densities are somewhere between the two, and territories do abut. This might suggest an intermediate production of eggs between Double Cove (i.e., up to 6 chicks hatched) (Beauchamp, 1987b) and Kapiti Island (i.e., mean number of 2.3 eggs laid (range of 1 to 5) with a mean of 1.3 young successfully raised) (Beauchamp, 1987a).
Beauchamp (1987a) found that good food availability throughout the year tended to expand the breeding season. However, at Double Cove improved condition of the birds did not necessarily mean more breeding attempts, so behavioral factors might also be involved (e.g., territory size) (Beauchamp, 1987b).

7.6 West Coast weka studies
Coleman et al.’s (1983) study in the Grey Valley is the only weka population study undertaken on the West Coast. Although, Beauchamp (2004) undertook some baseline assessments on the West Coast in 2000 and 2003. The only specific study of the Cape Foulwind population is a call counting program undertaken by the Department of Conservation. These spacing call counts, aimed at assessing temporal changes in population densities, began in 1997 at five sites in the Westport area (McClellan, 2002). It is based on this data that McClellan (2001) suggests that the highest weka populations in the Cape Foulwind area are in rural areas\textsuperscript{48}.

Beauchamp (2004) notes, following a survey on the West Coast undertaken in 2000, that densities were higher than in the Marlborough Sounds and in some areas higher than the farmland average of 0.6 birds per hectare when weka were common in the East Cape of the North Island. Pasture supplies a good invertebrate food supply for weka and patches and corridors of scrub and forest provide refuges from predators, and dispersal/movement cover as well as food supplies. Beauchamp’s (2000) assessment of this survey work was that although the sex ratios and population densities in various habitats have not been defined there is a healthy population on the West Coast.

This study adds to this information through further data collection and the development of an IBM of the Cape Foulwind population.

7.7 Study site
The Cape Foulwind peninsula is a low lying, relatively flat, triangular area of land on the northern west coast of the South Island. The Paparoa Range lies to the southeast and Te Kuha/Mount Rochfort ranges to the east. The Tasman Sea lies to the west and north. The southern extent of the peninsula plain is delineated approximately by the Totara River, its eastern extent by State Highway 6, and its northern edge, for the purposes of this study, is at the Buller River. The peninsula is approximately 15,000 hectares in total area. The Cape Foulwind peninsula landform consists of a

\textsuperscript{48} Very low counts were obtained from the three established call counts sites in unmodified areas (< 15 per hour). The other two sites in rural modified sites showed much higher numbers (> 40 per hour in 2001 and 2002) (McClellan, 2002).
complex of fluvial and marine terraces. The flat terrace surfaces have generally poorly drained, leached soils (McPherson, 1978). The area has a large range of habitats and land uses – traditional farmland, developed farmland, pākihi scrubland and terraces, small areas of indigenous and exotic forest, wetlands, estuaries, coastal dunelands, and rocky and sandy shorelines. Approximately 85% is used as agricultural land, traditionally dry stock farming (cattle, sheep and deer) with some dairying. However, dairy farming has expanded considerably in the past 20 years, which has resulted in the removal of substantial amounts of scrubland. Weka use areas of low scrub vegetation (commonly gorse *Ulex europaeus*, blackberry *Rubus ursinus*, rank grasses, and native vegetation such as manuka *Letospermum scoparium*, ferns and *Coprosma* spp) for cover.

The peninsula has a cool temperate maritime climate with annual rainfall of approximately 2200mm p.a., which is evenly distributed throughout the year. The area a has approximately 1900 bright sunshine hours p.a. Rainfall increases and sunshine hours decrease closer the Paparoa Range to the east. The peninsula has a mean annual temperature of 12.2 degrees Celsius (NZ Meteorological Service, 1981).
8 Methodology

8.1 Introduction

This is primarily a qualitative study concerned with exploring residents’ relationships and interactions with weka, and modelling how the residents’ activities impact on weka conservation. The study involves gathering and analyzing data from a variety of sources and is therefore considered to be metadisciplinary. These sources include the relevant scholarly literature, ecological fieldwork, fuzzy cognitive maps, semi-structured interviews and output from the models created. In doing this, the research draws upon methods and theory from a number of disciplines. The complexity created by this also means there are layers to the methods proposed. As has already been outlined, systems theory is the overarching theoretical scheme and is used in ecology, IBMs and FCMs. This method of research is both broad and detailed.

Manuel-Navarrete (2005) suggests that a metadisciplinary approach poses research challenges as it does not present clear boundaries for what constitutes progress for the subject of study. However, it does provide opportunities for integrating knowledge from a range of disciplines and investigating the full complexity of a subject. Metadisciplinarity encapsulates trans-, inter- and multi-disciplinary research. In transdisciplinary research the boundaries of disciplines are of less importance. Knowledge is produced using theoretical approaches and methodologies that themselves cross disciplinary boundaries (e.g., systems theory). In multidisciplinary approaches the disciplinary boundaries are maintained (e.g. methodologies and validity criteria, etc.) and data are presented together and compared. In interdisciplinary research knowledge is produced through explicit integration across disciplines (Manuel-Navarrete, 2005). This research is mostly transdisciplinary in that systems theory will be used as an overarching theoretical and methodological basis. However, there will also be aspects of multidisciplinarity and interdisciplinarity used (e.g., data from different disciplines used for the IBM).

Due to the complexity involved in this transdisciplinary research any outcomes should be considered contingent and incomplete. Consequently, one of my concerns in this study is that my analysis may be inadequate, in that it may involve a misinterpretation and consequently a misrepresentation of my informants. This is associated with my ability to incorporate in my discussion my experience of my informant’s lives, the place they live, and my analysis. Traditionally, it is understood that a researcher is attempting to interpret participants’ understandings through developing a partial sharing of their meanings. This is an epistemological approach that attempts to know the participants’ world and so assumes it to be distinctive, in the first instance, from that of the investigator.
By contrast, I am primarily approaching this study ontologically from which an epistemology is derived. This kind of approach invokes a common world as its basis and, hence, does not assume a primary separation between participant and researcher that needs to be bridged. Consequently, as an investigator, accessing the ‘subjective’ understandings of my informants does not primarily involve a reflexive approach of attempting to put myself in the place of the informants. Rather, it involves ontological concerns, where I as an investigator, through interacting and living among my informants take up aspects of their world (Jurich, 2000). The informants’ talk and physical practices are not just reflexive acts but part of their embodied immersion and, in my role as a participant-researcher, these need to be recognised. However, I can never fully reveal this aspect of the investigation, as I cannot finally reveal my participants’, or my own, immersion. This approach reduces apprehension I have about misunderstanding my informants, their practices, and the socio-ecological systems I am investigating.

By taking up this understanding the aspect to be addressed in this chapter is to clarify a methodology that aligns with the philosophical position outlined in Chapters 2 to 6. The methodological approach this position implies is the use of interpretive, qualitative and pluralistic methods but with the recognition that positions are not just subjectively based so involves tracing networks, fluid structures and agencies (hybrids). Participants’ talk and actions are considered as perspectives that are immersed in the social and material world. This world is considered to be a dynamic, emergent, complex becoming consistent with contemporary systems science and the post-structural position outlined in Chapter 2. A final concern is how to analyse and categorise these understandings. For this I will use a grounded theory approach.

8.2 Abduction
This transdisciplinary study utilizes mostly qualitative methods. For qualitative research, the two main logical underpinnings of methods for theory development are induction and deduction. These are primarily logical processes rather than scientific methods. The inductive approach can be understood as involving the derivation of generalisations from particular instances (e.g., particular observations of a phenomenon). When applied to scientific practice it focuses on seeking causal explanations through the development of ‘theories’ from a sampling of instances (Crotty, 1998). This approach is frequently used in qualitative research for the development of ‘theory’ through the data collection process (e.g., grounded theory) (Thomas & James, 2005). This is in contrast to deduction where the consequences, either empirical or conceptual, are logically derived from the theory (premises) methods (Yu, 1994). The deductive process moves from the general to the particular.
A criticism of both inductive and deductive methods is that they are not primarily concerned with the origin or creation of the hypothesis (i.e., induction does not explain how theories about data emerge and deduction does not explain the origins of logic) (Haig, 1995). Abduction has been suggested as a way to address this concern.

The abductive explanatory inferential approach is based on the philosophy of Charles Peirce (1839-1914) (Haig, 1995). Peirce, following Kant’s philosophy, considered abductive processes to reveal the nature of an absolute reality developed from an ongoing and self-corrective effort of the entire intellectual community (Yu, 1994). Peirce’s philosophy is a form of realism that allows for a range of epistemologies. However, Yu (1994) expresses some concern with Peirce’s metaphysical position, and instead stresses a unity between reality and truth, therefore breaking down Pierce’s epistemological/ontological dualism and its associated transcendental understandings on knowing reality.

Yu’s (1994) position involves an inter-subjective epistemology based on an ontology of interconnectedness - “I am part of reality, and reality is part of me; truths carry perspectives and perspectives contain truths.” (Yu, 1994, p. 5). According to Yu (1994), this philosophical adjustment does not deny the validity of Peirce’s abductive scheme.

This approach to abduction is elaborated by Hoffman (1997). Abduction “consists in examining a mass of facts and in allowing these facts to suggest a theory. In this way we gain new ideas but there is no force in the reasoning.” (Peirce, 1905, c.:CP 8.209 cited in Hoffman, 1997). Hoffman (1997) proposes that an abductive inference is given from “perspectives, background theories etc.” (p. 2). This in turn is embedded in the notion of context, which is a “specific relation between habits of interacting entities.” (p. 2).

I suggest that these relations are recognized as patterns. Abductively developing explanations of new or surprising patterns or relations involves taking a new perspective within existing, known patterns and “[a] central condition for taking new perspectives is activity.” (Hoffman, 1997, p. 2). This “is a relation of mutual dependence between the habits of a cognitive actor and the habits of the world in which (s)he exists.” (Hoffman, 1997, p. 4). For Peirce this relation involves perceptual or embodied activity. This suggests that abductive insight is situated and derives from the world in which it takes place. This understanding of abduction has much in common with Merleau-Ponty’s thought (see Section 2.3). New ways of knowing occur through the ongoing interaction of the biological and personal aspects of the lived body and sedimented cultural knowledge it sublimes. They are creative insights motivated by pleasurable feelings of breaking through or overcoming while also entailing a feeling of necessity (Hass, 2008). In this understanding - and as developed in Chapter 5 - affect becomes vital to any such process.
The position developed in the theory chapters that we are affective, embodied and immersed in the world points towards this understanding of abduction. We “already know” so to speak, and interconnections and ideas and judgments come to us from the world of which we are a part. There is no standing apart in any pure objective (or subjective) sense. Instincts, for example, are not an inborn ability but habits of action within certain situations, “determining but changeable programs of activity within a certain world: their function is defined by their relatedness to this world.” (Hoffman, 1997, p. 5)

The important point is that abduction is understood as a creative act in formulating propositions. It is not the inductive approach, used in some approaches to grounded theory, where theory is pulled out of the data without the full recognition of what the researcher brings to the research (i.e., background, bias, etc.) (Thomas & James, 2005). Abduction is also not a historically developed research methodology as this creates the difficulty of how such a methodology arose in the first instance – through yet a higher level methodology? (Hoffman, 1997). In addition, the context of the use of such a methodology in everyday investigation is not accounted for. It is also not theory in the sense that it is explanatory or predictive, but consists of propositions, which can then be developed and tested further. Yu (1994), for example, develops an outline for exploratory data analysis that encompasses abduction, deduction and induction. The goal of the abductive stage is to “explore the data, find a pattern, and suggest a plausible hypothesis; deduction is to refine the hypothesis based on other plausible premises; and induction is the empirical substantiation.” (p. 1).

In a similar manner, Haig (1995) suggests that once a number of propositions have been developed they can be appraised using a set of criteria to find the one with the best explanation. As well as empirical testing this involves assessment for clarity, consistency, parsimony, density, scope, fit to data, and explanatory power (Haig, 1995). The theory of explanatory coherence is another appraisal method. This uses three criteria: consilience (i.e., explanatory breadth); simplicity (i.e., fewer assumptions); and analogy (i.e., supports theories already found to be credible) (Haig, 1995).

### 8.3 Grounded Theory

The inductively based Grounded Theory method begins with general research questions rather than focused research hypotheses. The method entails a combination of systematic coding, analysis and theoretical sampling, that allows sense to be made of diverse patterns, through developing theoretical ideas at a higher level of abstraction. This occurs through the application of a systematic set of procedures to initially general and open research questions. This is not intended to be purely descriptive, as it requires identifying constructs or categories, analysing their relationships, context, and the processes involved. Codes and categories display emerging ideas in preference to
describing topics. These categories and concepts guide subsequent data collection, which allows a ‘saturation’ of recurring categories and the follow up of unexpected findings (Charmaz, 1990). Once categories get to the stage of being able to be defined succinctly they are available for analysis as concepts. “Two analytic processes contribute to raising terms to concepts – constant comparison and continued questioning.” (Charmaz, 1990, p. 1168). This allows the further development of concepts into theories.

In this particular logic of theory construction, data collection, analysis and theory formulation are interrelated (Charmaz, 1990). In addition, even with the emphasis on data collection, existing theory is also used as a framework and treated as data (Oreszczyn, 2000). This involves continually ‘re-sampling’ or reading theory as well as the data collected. The theory explored and developed in this study colours the understanding of the data and also how Grounded Theory might work (e.g., what concepts might be and where they ‘come from’). Furthermore, Grounded Theory recognises that theorists explicitly shape their data from the beginning. This involves both the data collection process and the theoretical development itself.

According to Charmaz (1990), Grounded Theory does not involve discovering patterns in the data, but “discovering the ideas the researcher has about the data after interacting with it.” (p. 1169 (italics in original)). Charmaz (1990) also notes that much qualitative research uses implicit methods that rely on the researcher’s skills and ability. Grounded Theory removes this emphasis on individual skills by giving a clear set of analytic guidelines and procedures to develop concepts about data. Grounded Theory is a processual method rather than a static one. It provides opportunity for qualitative research to develop “durable, substantive and formal theories” as well as being “a rigorous qualitative methodology distinct from quantitative” methods (Charmaz, 1990, p. 1163).

In this respect Charmaz (1990) notes that Grounded Theory has both phenomenological and positivistic elements. However, this attempt to be both subjective and objective creates a central tension in Grounded Theory. Relatedly, Charmaz (1990) argues that one of the main problems with Grounded Theory is that it does not make its epistemological assumptions clear. This can lead to studies using Grounded Theory assuming a theory of reality without making it explicit and in which “[t]he relation between subjective and objectivist realities remains unspecified” (Charmaz, 1990, p. 1164).

Charmaz (1990) makes her philosophical position clear as a social constructionist approach to Grounded Theory. As already discussed, social construction considers people’s creation of taken-for-granted interactions, emotions, definitions, ideas, and knowledge about world and self (i.e., the meanings people ascribe to their situations) (Charmaz, 1990). The question remains what and where individuals create these meanings from. From a social constructionist perspective a Grounded Theory
report is also “a social construction of the social constructions found and explicated in the data.” (p. 1165). This ultimately leads to a reflexive instability. This study takes a subtler position where any ‘social construction’ is of the world and not reified into the participants or the researcher. As has already been argued, I consider it to be the common embodied world in which we are immersed and trace how we use, express, and live in it. This is not to deny an emergent self (autopoietic) and the required study of individuals’ understandings, self and intent. However, these are not free standing.

As noted in Chapter 2, phenomenology does not assume a transcendental individual (i.e., it considers how individuals live in the world rather than how individuals interpret the world). Phenomenology does, however, still retain the notion of transcendent consciousness and this has been questioned in the post-phenomenological position discussed in Chapter 2. However, phenomenology “fosters the researcher’s study of the multiple dimensions and realities of a person’s lived experience.” (Charmaz, 1990, p. 1161) that is central to this study. Charmaz (1990) suggests the issue of the difference between social construction and phenomenology does not undermine the use of Grounded Theory as this can be addressed in the Grounded Theory analysis (i.e., we still collect data in the same way but ascribe its significance in different ways).

Relatedly, Thomas & James (2005) have criticised Grounded Theory’s claim to produce (1) explanatory theories and (2) predictive theories. Thomas & James’ (2005) criticism has its basis, I suggest, firstly in the social constructionist position from which their critique proceeds and, secondly, through using a definition of theory used in the natural sciences. On the first point, explanation, Thomas & James’ (2005) criticism understates the ability to trace regularities and patterns in the social world through its focus on the meanings people attribute to reality. By contrast, if the meanings attributed to reality are understood to be emergent from interaction between people and world (including the natural world, which is of vital concern in this research), what is being investigated is a constituted reality - and how it is to be investigated becomes less clear. However, a constitutive view allows more scope for the existence of, and the tracing of, regularities and patterns because of the strengthened notion of a common world. The constitutive approach reflects more closely Haig’s (1995) and Hoffman’s (1997) positions based on Peirce’s abductivism.

On the second point, Thomas & James (2005) are concerned with Grounded Theory’s claims to produce theories, and that this is not backed up by its methodology. Charmaz (1990) describes a theory in Grounded Theory as explicating a phenomenon and specifying concepts which categorise it, explaining relationships and providing a framework for predictions. I agree, however, with Thomas & James (2005) that Grounded Theory should not be considered to produce predictive theories in the manner of the natural sciences. The complexity in the social world, and even more so in the socio-ecological concerns considered in this study, do not allow this to occur. Consequently, I am not
claiming to be producing theories in this manner. Grounded Theory itself inadvertently gives scope for this understanding, as Charmaz (1990) suggests, through the lack of clarity in its description of key terms (e.g., theory, category, saturation). Indeed, as a primarily qualitative method Grounded Theory tends to produce a complex analysis of a multifaceted world rather than producing generalisations. I understand Grounded Theory to produce conceptual frameworks which explicate phenomena, specifying concepts which categorise them, as well as explaining relationships, but that are not necessarily predictive.

Thomas & James (2005) also express concerns related to Grounded Theory’s use of the inductive method. Concerns with the inductive method have been briefly discussed above along with an alternative method for exploratory data analysis (and the development of ideas) based on abduction. Finally, Thomas & James (2005) express a concern about the constraints Grounded Theory places on analysis through its emphasis on procedure rather than interpretation, while at the same time oversimplifying complex meanings and interrelationships. This is in contrast to more open ways of organizing data. These problems can be addressed through attention to my role as a researcher and by being actively aware of these issues.

8.4 Grounded Theory use in this study
This study uses Grounded Theory as a way to organise data. Analysis and conceptual framework development is based on the abductive approach discussed previously. Also, as discussed above, theories will be better understood as propositions which are then developed through further sampling into an explanatory framework. The theoretical development in the first six chapters is important to the study and so in some respects I use a hybrid Grounded Theory that allows theory to guide ideas in the data more than in a traditional approach to Grounded Theory. Also, given the open and complex understanding of the nature of reality the exploratory framework or concepts developed do not necessarily claim to be an explanation or prediction, but rather, a construct to enhance understanding and guide thinking (Warren, 2005).

Grounded Theory emphasises that conceptual framework development is a process. It is considered to evolve and develop throughout the research in an iterative manner. Different data sources (e.g., FCMs, IBM, interviews, stories, literature) provide different perspectives (Oreszczyn, 2000) on the socio-ecological system as well as describing different parts of it. The gathering together of data from diverse perspectives allows the corroboration and verification of findings and is known as a triangulation strategy (Stratford et al., 1999).

Grounded Theory is used in two levels in the study. As has been discussed, in order to explore more fully the importance of weka for local residents beyond the causal reasoning required
for the development of FCMs, the individuals who created the FCM were also interviewed. A qualitative semi-structured interview approach was used involving the use of open-ended questions. A set of themes were developed revolving around the interactions, feelings, responses and actions of residents towards weka. A Grounded Theory approach was used to organise and analyse this interview data in combination with the FCMs.

This first level research process broadly followed the one outlined by Strauss (1987). Initially, it involved a literature review of the theoretical basis of the research and then the carrying out of fieldwork. On completion of the fieldwork the interviews were transcribed verbatim. Following their transcription the individual interviews were organised through a summarisation process. Significant topics in the data were grouped into categories and given headings. Interpretation of the organised data then took place. This involved analysing the categories across all the interviews for patterns representing themes and relationships. Tools central to this process of developing a framework for understanding the data included: continual questioning, making comparisons and developing concept maps (Davenport & Anderson, 2005). This was followed by further theoretical investigation to enhance theme (hypothesis and concept) development. This layer of research, and the research in general, followed an iterative process within the empirical data, and between the empirical data and propositions.

Second, at a broader scale an abductive/deductive/inductive approach (Yu, 1994) was used for conceptual development of the research project as a whole. This second level of Grounded Theory analysis incorporated data from the FCMs, IBM, theory and first level Grounded Theory analysis. In this way these other parts of the study contributed another layer to the Grounded Theory analysis. This overlies the methods used for the collection of the data for the IBM and the FCMs as it supplies their conceptual background, while this theory development supports and validates the Grounded Theory method itself. This was done through exploring and considering literature on continental philosophy, systems, networks, and the range of methods used to collect the study data. Finally, the results of this second level of Ground Theory analysis is incorporated into an RT analysis of the Cape Foulwind SES.

The themes and concepts developed from the Grounded Theory analysis of the interview data were compared with the themes from the analysis of the FCMs. This was performed on an individual and group basis. The FCMs were also a data source for the Grounded Theory development of the interviews.

The methods, along with the methodology for the development (testing, validation) of the IBM, are discussed in Chapter 9 and the methods used for the collection of ecological data on
western weka are outlined in Section 8.7.5 and FCM and interviews in Sections 8.7.2 and 8.7.4 respectively.

8.6 Conclusion

Using Grounded Theory as a guiding methodological framework is appropriate for this study, as it gives some structure to the analysis, while being compatible with the underlying philosophical position, including systems ideas. This is particularly the case because a framework for organizing and analysing distinct methods of data collection (e.g., FCMs, IBM, interviews, stories, literature) was required. Haig (1995) highlights the suitability of Grounded Theory in this respect as a general (interdisciplinary) theory of scientific method.

However, as has been discussed, there are aspects of Grounded Theory which have not been taken up in their entirety and yet other aspects which need to be kept in mind during its use. My approach only loosely uses Grounded Theory. It does not explicitly use the ongoing sampling and categorising of the data. However, it involves developing themes using all the empirical data gathered via a range of methods, as well as using the associated theoretical investigations. Charmaz (1990) notes that Grounded Theory theorists construct theory from the data they gather as an inductive process. However, I consider the categories, etc. developed as abductively based. There is also the question of the individual theorist’s role in constructing the theories. I suggest a researcher is immersed in the world and the ‘connections’ found are developed from the world in an abductive manner. In addition, I am not proposing that ‘theories’ are being produced.

Alternative methodologies considered include Soft Systems Methodology (SSM) and ethnomethodology. However, SSM assumes that the people involved in the situation perceive a problem. As such, it is a framework for problem resolution rather than a qualitative framework for sociological investigation (Bunch, 2003). Ethnomethodology focuses on peoples’ everyday interactions. This approach is not possible in this study as interactions with, and discussion over, weka are only intermittent in people’s lives. The amount of time for research data collection would be excessive. There is, however, some ethnomethodological data collected for the research taken from my general interactions with people in the area.

As discussed in Chapter 3, Resilience Theory – another potential conceptual framework - does not appear to consider explicitly the individual’s understanding of the situation (although it does consider “mental models”). RT is based on the researchers’ understanding what the system is and how it works (e.g., the adaptive cycle). Individuals are abstracted out as part of the ‘social system’ rather than considered embedded in the world. This is not fully compatible with the philosophical approach used in this study. While the method is similar in respect of the researcher
developing conceptual frameworks about a situation based on the data and theory, the underlying philosophical position is quite different, so the results are understood in a different way. Consequently, this study’s theory and methods reconsider Resilience Theory’s social understanding and methods.

8.7 Methods

8.7.1 Socio-ecological modelling

Socio-ecological modelling is the overarching method for the analysis of the weka and human socio-ecological system in this study. This is a method that is distinct from, but overlaps with, the methodology which is based on the philosophical position (i.e., embodied, system/network, embedded, material, etc.) and that incorporates systems concepts.

As outlined in Chapter 3, the systems approach was based on open complex adaptive systems (CAS). According to Eidelson (1997), there is a distinction between merely using CAS as an “elegant metaphor” (p. 63) and attempting the development of accurate models. Eidelson (1997) suggests the development of models of complex adaptive systems should concentrate on searching for regularities or patterns between the individual components that make up the system, and the broader system. They should also focus on the system’s instabilities as this is where critical parameters associated with its patterns of behaviour are most readily revealed. In addition, longitudinal studies are most likely to discover these transition points. Standard statistical methods can fail to pick up the significance of these unstable zones. Eidelson (1997) recommends computer simulation modelling as an important tool in CAS research.

Although there is no framework that is universally agreed upon for conceptualizing the ways open social and natural systems are linked, the Resilience Theory approach to socio-ecological systems is used in this study (Berkes & Folke, 1998). Other approaches include: (1) Common property - which concentrates on the importance of social, political and economic institutions in governing the relationship between social and natural systems; (2) Ecological economics - which analyses to what extent natural capital can be substituted with other forms of capital and what limits this may place on economic systems (Adger, 2006); (3) Gloster’s (2000) socio-ecological model for action research – which addresses change in socio-ecological interactions associated with action research methods.

There are also adaptive management approaches – which investigate how human and ecosystems evolve together. The resilience framework already discussed is an adaptive management approach (Adger, 2006).
All of the socio-ecological modelling traditions discussed above endeavour to “elaborate the nature of socio-ecological systems while using theories with explanatory power for particular dimensions of human environment interactions” (Adger 2006, p. 269). This also occurs at the applied level and in this research it is intended that the practical modelling tools being used relate to the particular scales deemed most important for this study. As has already been outlined, these tools will be FCMs and an IBM.

The IBM techniques are confined to western weka habitat use. Extending this approach to the human actors as a socio-ecological agent-based model (ABM) has proven to be difficult. Human management decisions in these models are frequently extremely simplified (e.g., An et al., 2005). In particular, the individual and socio-political context including the use of local knowledge, the influences of attachment to the landscape, flora and fauna are sidelined. As such, the ABM approach when applied to cumulative human individual decision making does not attempt to address complex human psychological and social factors such as individual actors’ psychological frameworks (cognitive processes, perspectives, motives, and plans etc) or the social and communication networks.

Because of this difficulty, very few socio-ecological ABM models have been developed - An et al. (2005) and Monticino et al. (2006) being two notable exceptions. Instead, socio-ecological modelling tends to use a combination of methods such as agent-based models with participatory role-playing games and geographic information systems (Castella et al., 2005). These models attempt to integrate local people’s ecological understandings and values into the models. These participatory methods, of which FCMs are one, align with a soft systems approach where people are understood to perceive situations or systems in different manners and with each one having validity (Checkland, 1981). Hanson (1995) calls this parallogic, which rests on a constructivist view of reality and considers that any judgment about the validity of a view needs to be made within its context.

It is in light of these difficulties, and the need to integrate landowners’ understandings and decisions in landscape change modelling that neural network analysis of FCMs has been used. The FCMs become one sub-model of broader, loosely integrated FCM/ABM socio-ecological model.

In summary, the combination of FCMs and an IBM are used as the modelling techniques for the study because: (1) They address the most important scale of concern in this case (i.e. the individual/household and local landscape); (2) The different modelling techniques address the difference between human and natural systems; (3) Both techniques allow the inclusion of knowledge from a range of sources; (4) FCMs allow scenario modelling not offered by other qualitative techniques; (5) FCMs allow modelling of peoples’ understandings of natural systems, rather than a researcher’s interpretation of their understandings; (6) FCMs allow the integration of

49 The differences between individual based models and agent based models is discussed in Section 9.2.
understandings into social FCMs; (7) IBMs emphasis on interaction, heterogeneity and emergent properties are systems properties are not addressed in most ecological modelling techniques.

8.7.2 Fuzzy cognitive map methods

Twenty FCMs were developed with a range of residents in the area (e.g., farmers and rural-residential lot owners). These residents were recruited primarily through recommendations from preceding participants, and in this respect were not random. The number of possible participants was limited due to the small population in the study area. Including both farmer and non-farmer landowners allowed a more diverse range of FCMs to be developed and comparisons between the two groups to be made. Technical details on FCMs and their use are outlined in Chapter 10.

The participants were presented with an example FCM on another subject and a two simple questions: (1) What are the important factors/variables affecting weka in the Cape Foulwind area; and, (2) how do these factors affect each other? I made it clear that the FCM is about how they understand the present situation at Cape Foulwind. Some initial guidance on how to form the FCM was generally required. This was done in a non-controlling and consistent manner (Özesmi, 2006).

The steps in this process are straightforward (Kahn & Quaddus, 2004):

1. The identification of the key domain issues or concepts;
2. The identification of causal relationships among these concepts;
3. The estimation of causal link strengths between the concepts.

Initially, a pencil and an A3 sheet of paper were used for the informants to draw up a FCM using circled nodes and linking lines. However, following a suggestion from a participant, small squares of paper were used to write the concepts on. These were then able to be moved on an A3 sheet to experiment with their location relative to the others before being attached with sellotape.

All but one of the interviews and FCMs were completed in a single session. The FCMs were always drawn up before the interviews so that the interview discussion did not unduly influence the FCMs. Also, most people enjoyed the interview more than the production of the FCM. This meant if the FCMs were left until the end of the session there was the risk they would not be completed. I considered leaving the FCMs with participants to complete in their own time. However, this was not done because, first, they may not finish them; second, I wished to be involved in the process to retain some consistency in guidance.

Guiding the FCM creation was difficult, as it involved keeping a balance between enough guidance (as people are not familiar with them) and too much guidance and so over-influencing the FCM. Some participants required continuous prompting during the production of their FCMs. They tended to produce the simplest FCMs. The most difficult part was determining the direction and
strength of causality between the nodes and this was where the most help was required from me. Three participants thought that many of the weightings were guesses. P11WNF thought that the situation (particularly regarding people’s responses) was more complex than the FCM allowed. Two participants thought that if they did another map the next day it would be different from the one they had just done. P10MNF, by contrast, thought it was a good way to gain an understanding of the situation quickly and easily.

The participants were asked, after completing the FCM, what they thought about the method. Responses varied, but many of the participants found the FCM process intimidating at first. Most settled into the task once they were underway. One commented that it “felt like a test” and was a little concerned that people do not have enough time to think about and mull over how they would draw their map. Many appeared to be more relaxed doing the interview and talking and consequently gave rich accounts.

8.7.3 Individual based modelling methods

The IBM methods are described in Chapter 9.

8.7.4 Interview methods

Nineteen of the twenty in-depth interviews were undertaken in the same session as the FCMs. The interviews started with informing the participants of the confidentiality of the information they would provide. They were also informed of their ability to: (2) refuse to answer any questions, or terminate the interview at any time; (2) ask for any or some of their answers not to be recorded; (3) remove their interview from the study within three months of it being undertaken. The participants were asked to sign a consent form agreeing to their participation and potential publication of the results. This background also applied to the FCMs.

The interviews were based on a series of sixteen open-ended questions. The interview process involved starting with the initial question and then prompting and exploring answers further. In effect, the process became a guided conversation. The interviews were recorded on a cassette tape and then transcribed verbatim.

Following feedback from participants, some changes were made to the interview process. It was found that doing the FCM and interview was taking too long for some people so some of the questions were reconsidered and amalgamated with others.
8.7.5 Weka ecology methods

The primary focus of the weka ecology research was to develop an IBM to model the impacts on the weka population caused by landscape disturbance and habitat loss (see Chapter 9 for details of the IBM development). The aim of the weka fieldwork methods was to collect data for the parameterisation of the IBM. Due to financial and time constraints, only a subset of the individual level and population level data required for this was able to be collected. This data was used to complement data from other weka research. The study was mostly undertaken on private land and this did put some restrictions on fieldwork access. A range of data collection methods were used: Spacing call counting; Telemetry; Colour banding; Road-kill carcass collection; Observation; Collection of anecdotal information.

The broad range of methods used is compatible with the methodological approach taken in the research that understands different collection methods as being complementary. This also enables as much information as possible to be collected for the IBM. The IBM is a qualitative model so the use of qualitative data was appropriate. Table 8.1 outlines the main types of data required and the particular methods used to collect those data. Data on other aspects of weka behavior were also gathered throughout the study.

<table>
<thead>
<tr>
<th>Data required</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding season and productivity</td>
<td>1. Observation</td>
</tr>
<tr>
<td></td>
<td>2. Colour banding</td>
</tr>
<tr>
<td></td>
<td>3. Telemetry</td>
</tr>
<tr>
<td>Territory and home range sizes</td>
<td>1. Telemetry</td>
</tr>
<tr>
<td></td>
<td>2. Colour banding</td>
</tr>
<tr>
<td></td>
<td>3. Call counts</td>
</tr>
<tr>
<td>Cover requirements</td>
<td>1. Call counts</td>
</tr>
<tr>
<td></td>
<td>2. Telemetry</td>
</tr>
<tr>
<td>Habitat use</td>
<td>1. Call counts</td>
</tr>
<tr>
<td></td>
<td>2. Telemetry</td>
</tr>
<tr>
<td></td>
<td>3. Observation</td>
</tr>
<tr>
<td>Juvenile dispersal</td>
<td>Telemetry</td>
</tr>
<tr>
<td>Distribution response to habitat change</td>
<td>1. Call counts before and after</td>
</tr>
<tr>
<td></td>
<td>2. Telemetry</td>
</tr>
<tr>
<td>Adult and juvenile</td>
<td>1. Road kill counts (road kill)</td>
</tr>
</tbody>
</table>

Table 8.1  Weka ecology data collection methods used in the study.
mortality

1. Call counts

2. Anecdotal (predation, dog kills)

3. Telemetry/Colour banding

4. Mustelid trapping

5. Observation

Adult sex ratios

1. Call counts

Food supplies

1. Dissection of dead birds (condition and stomach and gizzard contents)

2. Observation

8.7.5.1 Spacing call counts

Beauchamp (2006) assessed basic demographic parameters from nine weka populations. This indicated that adult survivorship was the most important factor in weka population stability. Consequently, monitoring the adult population is the recommended approach for population monitoring. These data also showed that for longitudinal population monitoring needs to be able to measure the change in the adult numbers to 95% accuracy. This research is interested primarily in spatial changes so this level of accuracy was not required. However, the impacts of multi-generational longitudinal effects were also a factor.

Density of weka can be difficult to estimate. This is because weka that are visible tend to be non-paired adults and sub-adults which are more mobile, while the paired adults are seldom seen (Beauchamp, 2006). Paired adult weka, however, are crepuscular and they also use spacing calls on most evenings to establish their position relative to neighbours and to also locate their mate. The best monitoring method to count adult weka is through spacing call counting, although the method is still being refined (Beauchamp, 2009). The benefits of call counting can be improved if it is also used to assess population sex ratios and turnover and can be checked against a banded population (Beauchamp, 2006).

Weka spacing calls consist of a ‘Cooeeet…..’ for 20 or less repetitions. This is given by a single bird or a pair together. The male call is lower pitched and slower. There can be up to four sets in a chorus, but there is usually only one set. There can be minutes or hours between choruses (Beauchamp, 2004). These calls are most frequently heard in areas with dense populations. They are sometimes heard during the day but occur mostly in the evening (Beauchamp, 2004). Choruses tend to constitute calls of the immediate neighbours as well as more distant birds. One pair tend to start a chorus and the birds in the vicinity reply with a chorus (pers. ob.).
Beauchamp (2000) suggests that, to be confident that changes in call rates reflect population changes, weka biological factors (e.g., breeding, moult ing) need to be taken into account as they influence call rates (Beauchamp, 2006). Department of Conservation (1999) notes that environmental factors such as rain, wind, and the state of the moon can also impact on weka call activity. However in Bramley & Veltman’s (2000) study only site location and time of year were found to be significant factors. Bramley & Veltman’s (2000) study area had much lower weka densities than at Cape Foulwind so the other variables may also be important in the Cape Foulwind population. By undertaking counts at the same time each year, and in similar weather conditions (settled, dry, wind speed below 10 knots), the confidence that any changes in call rates reflect actual population change can be increased.

Beauchamp (2000) recommends that for spatial population comparisons call counts should be all made on the same night. This reduces the need to take into account variations caused by biological and environmental factors and eliminate the requirement for detailed population assessments. Because I undertook all the call counting myself, counting at different sites on the same night was not possible.

**8.7.5.2 Time of year**

Beauchamp (2006; 2009) found that on Kawau Island moulting and breeding activities suppress the number of spacing calls in North Island weka. In that population breeding occurs in the spring months and the moult occurs during the post-breeding period in adults, in January and February (Marchant & Higgins, 1993). In contrast to the Kawau Island data, Bramley & Veltman (2000) found that highest call rates were in January and February.

Observational evidence at Cape Foulwind suggests the timing of the breeding and moult periods is similar to Kawau Island. Consequently, I used the March- May period recommended by Beauchamp (2009) and Beauchamp & Chambers (2000) to undertake call counting. Eighty per cent of the call counts were undertaken in the March-May period (Figure 8.1). Some call counts were undertaken at other times of the year when associated with specific land development activities. The call counts undertaken at each site were temporally grouped as close as possible depending on the weather.

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50 Bramely & Veltman (2000) assessed the impact of six environmental variables (moon amount, cloud amount, temperature, wind direction, wind speed, rain) along with listening site and month of year.
8.7.5.3 Length of counts

All call counts were undertaken for 90 minutes starting at 30 minutes before sunset as recommend by Beauchamp (2006, 2009). This was based on previous data from the West Coast suggesting that weka calling started at about sunset (Eastwood, 1998 cited in Beauchamp, 2006).

8.7.5.4 Number of call count nights

Beauchamp (2006) made some recommendations for obtaining robust data from spacing call counts. These were: (1) When the location of interest is an area or region (e.g., Cape Foulwind area) at least three nights call counting are undertaken (at all weka densities) and at a minimum of five different locations; (2) When the interest is in a site (e.g., land development sites) at least three call count nights, and preferably more, as a minimum in populations of moderate to high densities (i.e., > 0.6 weka/ha). In lower densities at least five nights should be undertaken. This is because in lower densities weka may not be in hearing range of each other and so do not respond to neighbour’s calls. This can give very low detection rates (Beauchamp 2006). More recently, Beauchamp (2009) has recommended that there be at least four count nights. All counts should occur over a period of 30 days and in suitable environmental conditions.
In the relatively high weka densities at Cape Foulwind three count nights per site were used for both site and area analysis. In total, 27 different sites were used in the area analysis. The use of three nights is supported by Bramley & Veltman’s (2000) study where 72% of weka calling on any one night allowed 98% detection over three nights. There were also practical concerns, which related to the ability of one person to do more than the 88 call count nights undertaken during the required time of year and in suitable weather conditions. As already noted, this study is aimed at assessing spatial habitat differences rather than longitudinal population changes and so did not necessarily need the 95% accuracy required for the assessment long term population stability and change⁵¹ (Beauchamp, 2006).

To assess the appropriateness of using three call count nights at Cape Foulwind the data collected were analyzed to estimate the percentage of weka calling over three nights (Table 8.2). Over 23 sites a nightly call count detection rate of 67% was calculated giving a 90% detection rate for three nights.

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⁵¹ Statistical analysis of some West Coast data collected has shown that call counting was capable of showing change in status of weka to the 5% level. To achieve this at a regional scale requires approximately 20 nights of counting based on 4-5 sites and 4-5 nights listening at each site (MacAskill & Eaton, 2000).
Table 8.2 Calculation of detection rates over three nights of spacing call counts at Cape Foulwind.

<table>
<thead>
<tr>
<th>Location</th>
<th>Night 1</th>
<th>Night 2</th>
<th>New birds</th>
<th>Night 3</th>
<th>New birds</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landcorp Lake (preflip)</td>
<td>20</td>
<td>17</td>
<td>2</td>
<td>15</td>
<td>0</td>
<td>22</td>
</tr>
<tr>
<td>Landcorp Lake (postflip)</td>
<td>17</td>
<td>15</td>
<td>8</td>
<td>17</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Carters Pine</td>
<td>15</td>
<td>16</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>19</td>
</tr>
<tr>
<td>Bulls Road</td>
<td>32</td>
<td>42</td>
<td>8</td>
<td>36</td>
<td>0</td>
<td>38</td>
</tr>
<tr>
<td>Bulls Road (postflip)</td>
<td>25</td>
<td>18</td>
<td>3</td>
<td>17</td>
<td>6</td>
<td>34</td>
</tr>
<tr>
<td>Lighthouse</td>
<td>21</td>
<td>14</td>
<td>3</td>
<td>16</td>
<td>0</td>
<td>24</td>
</tr>
<tr>
<td>Virgin Terrace</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>6</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Brunnings road</td>
<td>12</td>
<td>12</td>
<td>4</td>
<td>11</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>Cement works</td>
<td>22</td>
<td>20</td>
<td>4</td>
<td>16</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Wilsons Lead trig</td>
<td>24</td>
<td>16</td>
<td>4</td>
<td>19</td>
<td>4</td>
<td>32</td>
</tr>
<tr>
<td>Doug's Place</td>
<td>14</td>
<td>9</td>
<td>4</td>
<td>10</td>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>Landcorp corys (preflip)</td>
<td>19</td>
<td>15</td>
<td>5</td>
<td>25</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Giants grave #1</td>
<td>19</td>
<td>26</td>
<td>6</td>
<td>22</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>Landcorp Bulls</td>
<td>18</td>
<td>15</td>
<td>8</td>
<td>24</td>
<td>10</td>
<td>36</td>
</tr>
<tr>
<td>Landcorp Dairy hill</td>
<td>22</td>
<td>23</td>
<td>6</td>
<td>19</td>
<td>2</td>
<td>28</td>
</tr>
<tr>
<td>Landcorp mine pond</td>
<td>21</td>
<td>21</td>
<td>7</td>
<td>20</td>
<td>2</td>
<td>30</td>
</tr>
<tr>
<td>Landcorp mine pond (post flip)</td>
<td>20</td>
<td>19</td>
<td>7</td>
<td>14</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>New Bucklands</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Caroline terrace</td>
<td>23</td>
<td>23</td>
<td>8</td>
<td>17</td>
<td>1</td>
<td>32</td>
</tr>
<tr>
<td>Mountain Creek</td>
<td>27</td>
<td>28</td>
<td>13</td>
<td>24</td>
<td>3</td>
<td>44</td>
</tr>
<tr>
<td>Wilsons Lead corner</td>
<td>27</td>
<td>13</td>
<td>4</td>
<td>29</td>
<td>10</td>
<td>41</td>
</tr>
<tr>
<td>Wilsons Lead corner (post flip)</td>
<td>20</td>
<td>27</td>
<td>10</td>
<td>20</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Landcorp tram dairy</td>
<td>10</td>
<td>6</td>
<td>2</td>
<td>16</td>
<td>8</td>
<td>20</td>
</tr>
</tbody>
</table>

| Total                           | 434     | 399     | 121       | 406     | 60        | 614   |
| % detection                     | 71%     | 65%     | 66%       |         |           |       |
| Detection rate %                | 80%     |         |           | 90%     |           |       |

Average detection rate per night 67% 23 sites

8.7.5.5 Call count locations

Call counts were undertaken at 27 sites in total between March 2006 and June 2010. The sites were chosen in two ways. The first were to assess the population densities of the Cape Foulwind area as a whole. For this 20 counting sites were identified using a semi-random stratified method. Call counts were undertaken at 19 of these sites. This procedure involved breaking the area into 20 3 x 3 km squares and then randomly generating points within each square that became the call count sites (Figure 8.3). The approach was not truly random because some sites were moved so that they could be either physically or legally accessed.
The balance of the call count sites were situated in areas where land development was to be, or had taken place. There were eight additional sites involved in this and most involved undertaking call counts before and after development had taken place (Figure 8.2). At some sites call counts were done within several months of the land being developed to complement telemetry data on weka behavioural responses to habitat disturbance (i.e., Mountain Creek, Mine ponds). Call counts were also undertaken at sites which had been developed between one (i.e., Landcorp lake, Landcorp dump), and eight years, previously (i.e., Landcorp dairy hill, Landcorp Dion, Virgin Flat Road). This allowed an assessment of population changes from land development over the longer term.

Call counting sites that were elevated were used where possible to improve the ability to identify the locations of weka (Beauchamp, 2006). However, the Cape Foulwind area is relatively flat so this was not always possible and twelve sites were on flat ground. Beauchamp (2006) notes that the distance of the location of the birds tends to be over-estimated on flat ground.

![Figure 8.2](image)

**Figure 8.2** The locations of all the call count sites. At six of the sites two sets of counts were undertaken, one before and one after land development had occurred.
8.7.5.6 Call count procedure

The call counts involved counting both close and distant calls. Where the location of the calling weka could be identified, their direction, distance and sex were recorded as well as the number of times they called. These close calls, lay within a maximum radius of approximately 400m of the recording site. The total number of calls heard outside this close call zone was also noted, along with their general direction (distant calls). The different habitat types were also identified within the call counting zone.

A number of environmental factors were also recorded. These were: (1) Temperature and wind speed and direction at start and end of count; (2) Moon size and its presence/absence; (3) rainfall and cloud cover during the count; (4) Rain over the past 24 hours; (5) The amount of noise and its source/s; (6) Moisture content of the ground. The percentage of counts that were undertaken in good weather conditions (i.e., no rain, wind speed below 10 knots) was 89%.
8.7.5.7 Density analysis

The aim of this portion of the study is to model the impact of changes in the weka population from human habitat disturbance. Because of this, and the complex nature of the landscape, the analysis of weka densities from call counts required a different method than the standard minimum polygon approach (Beauchamp, 2009).

This density analysis involved first collating the data from each set of three nights call counting by overlaying the identified close call locations. Where weka call locations generally coincided on different nights was counted as one bird or pair. An overall adult density for the site was calculated from this grouped weka figure by assigning the groups to a particular habitat. The total number of weka groupings was divided by the total hectares of each habitat type surrounding the call count site to give a density.

The sites varied a great deal with some being considered a single habitat type while others had five or six types of habitat. This mixed matrix of habitat types at many of the call count sites means the habitat density calculation has to be treated with caution as in some respects the ‘habitat type’ is this mixed matrix and the associated boundaries between them. At sites with a mix of habitat types there is the risk of assuming that because weka are heard calling from a particular habitat that that is the only one they are using. Weka are generalists and will use a range of habitats for food and roosting, protection, nesting, etc. (Marchant & Higgins, 1993). However, this approach does give an indication of weka home range/territory areas and which habitats, or mix of habitats, are most favoured in establishing these.

The densities of distant birds were also calculated. This involved calculating the number of times close birds called. A ‘repeated call’ figure was calculated from this and applied to the total distant calls recorded to calculate an estimate of the total number of distant birds calling. This assumed that the distant birds were calling the same number of times as the close birds. The distant zone was considered to be the area between a c.400 and c.800 metre radius from the call site. This method was unable to be verified for accuracy and needs to be treated with caution as distant birds are often in different habitats in varying densities, and topography and wind direction influenced the area within which calls can be heard.

Site densities using the standard minimum polygon method were also calculated to allow comparison with close call weka densities found in other studies. This was primarily used with the random stratified sites to gain a relative overall population estimate for the area. Minimum polygon density calculations tend to produce higher density calculations than the habitat approach. The untested assumptions of the method were: (1) All sites have 400 metre coverage; (2) I was able to place weka reasonably accurately within 400m of each site; (3) The majority of weka was not moulting.
at the time. The tested assumptions of the method were: (1) The number of weka calling over three nights in the 90 minute listening period represented c.90% of the site fixed adult weka in the area; (2) The random stratified sites enable a minimum average breeding adult weka density to be established for Cape Foulwind; (3) The majority of weka were not breeding at the time (Beauchamp, 2009).

8.7.5.8 Telemetry

Some weka studies (Coleman et al., 1983; Beauchamp, 1987; 1987a) traced the movement of a large number of birds through banding and re-capture and observation rather than using telemetry. These were more intensive studies than this multidisciplinary study. Telemetry was used in this study to enable the tracking of weka in the predominantly dense low vegetation at Cape Foulwind. However, I did not have sufficient telemetry transmitters available to do a full telemetry based study (i.e., 20 transmitters).

Telemetry techniques were used primarily to obtain data on juvenile dispersal and to monitor adult movement, habitat use, reproductive success, home range/territory size and survival prior to and following land disturbance. Telemetry techniques were use to identify the location of 18 weka throughout the study. A Sirtrack™ 20gm, two stage, backpack mounted transmitter (Tx) with mortality signal was used for tracking the birds. TR4 (borrowed from DOC, Buller Area office) and Regal 1000 (borrowed from Lincoln University) receivers were used at various times of the study along with a hand-held 3-element Yagi antenna. A Garmin™ GPS76 GPS was used to record location information. These data were collated using ARCGIS™ V9.2. Harnesses were made up to attach the transmitters to the birds. Graham (Chippy) Woods (DOC, Punakaiki) showed how to attach the harnesses.

Weka were caught in cat cage traps (300 mm x 230 mm x 550 mm in size) baited with cheese. In some cases the traps were left out over night but in other cases an area was explored until weka were found and the birds attracted into the cages.

The sub-adult or adult birds monitored were in areas that were to have land development taking place. The transmitters were attached to these birds between 4.5 months and 1 week before the land development occurred at three different sites. This was used for ascertaining home range areas before and after disturbance. Transmitters were also placed on five juveniles in order to obtain data on juvenile dispersal. I established the bird’s locations between one and three times a week, mostly during the day and in the early evening. Their activities at the time were noted if they were seen. There were problems with retaining transmitters on birds (mean time of attachment 95 days (3.2 months), maximum 272 days (9 months)). Juveniles were particularly difficult in this respect because allowing room for them to grow meant that the harnesses had to be attached loosely.
Weka telemetry monitoring effort is set out in Table 8.3.

Table 8.3 Weka telemetry monitoring effort.

<table>
<thead>
<tr>
<th>Weka #</th>
<th>Number of location recordings</th>
<th>Time Tx attached (days)</th>
<th>Adult/juvenile</th>
<th>Fate of Tx/bird</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>31</td>
<td>136</td>
<td>Adult</td>
<td>Killed by dog</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>6 (same bird as 4)</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>3</td>
<td>23</td>
<td>121</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>4</td>
<td>39</td>
<td>212</td>
<td>Adult</td>
<td>Killed by dog</td>
</tr>
<tr>
<td>5</td>
<td>35</td>
<td>151</td>
<td>Adult</td>
<td>Left area</td>
</tr>
<tr>
<td>6</td>
<td>13</td>
<td>14</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>7</td>
<td>32</td>
<td>272</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>8</td>
<td>28</td>
<td>121</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>9</td>
<td>4</td>
<td>21</td>
<td>Adult</td>
<td>Not heard</td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>106</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>11</td>
<td>36</td>
<td>182</td>
<td>Adult</td>
<td>Not heard</td>
</tr>
<tr>
<td>12</td>
<td>22</td>
<td>121</td>
<td>Adult</td>
<td>Not heard</td>
</tr>
<tr>
<td>13</td>
<td>19</td>
<td>121</td>
<td>Adult</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>15</td>
<td>10</td>
<td>10</td>
<td>Juvenile</td>
<td>Poisoned</td>
</tr>
<tr>
<td>16</td>
<td>7</td>
<td>60</td>
<td>Juvenile</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>17</td>
<td>1</td>
<td>2</td>
<td>Juvenile</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>18</td>
<td>3</td>
<td>60</td>
<td>Juvenile</td>
<td>Not heard</td>
</tr>
<tr>
<td>19</td>
<td>3</td>
<td>7</td>
<td>Juvenile</td>
<td>Killed by dog</td>
</tr>
</tbody>
</table>

8.7.5.9 Colour banding

Due to the temporal variability in weka behaviour and biology, Beauchamp (1987a) found to banding studies needed to be undertaken over several years. In this study, an attempt was made to establish banded study groups in two habitat types (developed and undeveloped land). However, difficulty with regular access onto private land, time constraints, limited field support, the lack of visibility of weka, and a lack of awareness of its usefulness in the early stages of the research, meant this was not entirely achieved.

Twelve weka were successfully caught in one habitat type (undeveloped land). Either one or two colour bands in different colour combinations were attached to their legs. The weka were caught in the vicinity of my home so I would have more opportunities to see the birds again. The areas where the birds were caught, or known to frequent, were checked regularly throughout the monitoring period and their activities and interactions were noted.
Table 8.4 Colour banded weka and monitoring periods.

<table>
<thead>
<tr>
<th>Weka #</th>
<th>Name</th>
<th>Period monitored (months)</th>
<th>Adult/juvenile</th>
<th>Fate of bird</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lemon</td>
<td>36</td>
<td>Adult</td>
<td>Still alive</td>
</tr>
<tr>
<td>2</td>
<td>Scarlett</td>
<td>0.2</td>
<td>Juvenile</td>
<td>Dispersed</td>
</tr>
<tr>
<td>3</td>
<td>Bruno</td>
<td>3</td>
<td>Adult</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>4</td>
<td>Blondie</td>
<td>24</td>
<td>Adult</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>5</td>
<td>Squeak</td>
<td>3</td>
<td>Juvenile</td>
<td>Dispersed</td>
</tr>
<tr>
<td>6</td>
<td>Tussock</td>
<td>24</td>
<td>Adult</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>7</td>
<td>Squeaky</td>
<td>2</td>
<td>Juvenile</td>
<td>Dispersed</td>
</tr>
<tr>
<td>8</td>
<td>Trouble</td>
<td>21</td>
<td>Adult</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>9</td>
<td>Whitey</td>
<td>0.1</td>
<td>Adult</td>
<td>Not re-found</td>
</tr>
<tr>
<td>10</td>
<td>Paddy</td>
<td>0.2</td>
<td>Adult</td>
<td>Not re-found</td>
</tr>
<tr>
<td>11</td>
<td>Moonie</td>
<td>0.1</td>
<td>Adult</td>
<td>Not re-found</td>
</tr>
<tr>
<td>12</td>
<td>Junior</td>
<td>1</td>
<td>Juvenile</td>
<td>Killed by dog</td>
</tr>
</tbody>
</table>

The data collected from the colour banding was limited, statistically. It did, however, allow ongoing and regular observation of weka activities. In this respect it gave an indication of movement, mortality, the breeding and moulting period, and breeding success of weka in the area. Weka colour band monitoring effort is set out in Table 8.4.

8.7.5.10 Road-kill observations

In order to assess mortality risk for weka at Cape Foulwind an attempt was made to gather some information on threats. By far the most detailed data collected was for road-kill. The road-kill research methods are fully described in Freeman (2010) and are not repeated here. The assessment of other threats (i.e., dogs, stoats, poison/traps, humans for sport) were limited due to the difficulty of obtaining data.

8.7.5.11 Road-kill carcass collection and measurement

The relevant aspects of the road-kill methods for this study are carcass collection and measurement. Weka carcasses were collected from 25.1km of rural public roads and road-sides on the Cape Foulwind peninsula as they were encountered. This occurred over a period of two years (February 2006 to February 2008). The location, date and time of the carcasses collection was recorded. The carcasses were weighed, measured and dissected for sexing and ageing. Badly
damaged carcasses were recorded but not collected, as they were difficult to obtain measurement data from. This may have created some bias in the dissection data. If the sex of a bird could not be ascertained from dissection, it was classed as male or female using discriminant functions based on external measurements (Department of Conservation, 1999). Age class was determined from the size and shape of wing spurs (Beauchamp, 1998).

The carcasses were stored in a freezer at the Department of Conservation office in Westport until they were dissected. Following dissection the carcasses were given to local Iwi (Maori sub-tribe) for their use. Each carcass was thawed for 24 hours and then measured and dissected. The data collected was: Weight (to the nearest 10gm); Impact condition (good, moderate or poor); Sternal fat thickness (to 0.1 mm); Wing spur length, shape and sharpness (Beauchamp, 1998); Bill depth (to 0.1 mm); Culman (to 0.1 mm); Tarsus width (to 0.1 mm); Tarsus length (to 0.1 mm); Mid toe length (to 0.1 mm); Mid toe and claw length (to 0.1 mm); Left and right testes length (to 0.1 mm); Follicle diameter (to 0.1 mm); Eye colour; Leg colour.

8.7.5.12 Observations

Observations took place when undertaking telemetry, colour banding and call counting. Observations were also made of the weka inhabiting the area around my house as I went about day to day activities.

8.7.5.13 Collection of anecdotal information

Anecdotal information was collected during the interviewing and creation of FCMs with local residents and landowners. It was also collected from general conversations with people. When the same information was mentioned by more than one person it was considered to be more reliable.
9.1 Introduction

This chapter initially discusses the theoretical background for developing individual based models (IBM). In doing this it considers key concepts such as pattern orientated modelling and fitness. It then discusses a conceptual framework and key aspects that need to be addressed when developing an IBM. The details of the weka IBM developed for this study are then discussed. Next, the model verification and validation approaches used are outlined, and the results of this testing presented. Finally, the framework used for the final scenario modelling is set out. The results of the scenario modelling are recorded in the Chapter 12.

9.2 Individual based models (IBMs)

Complexity science presents a theoretical understanding in which fundamental processes, such as feedback, self-organisation and hierarchical structures, lead to emergent phenomena in complex adaptive systems (see Chapter 3). Through this understanding complexity science has provided some important theoretical tools to deal with complex interaction between social and ecological processes and how individual decisions accumulate in broader systemic change, while those decisions are embedded within those very processes. These complex adaptive systems can be conceptualized and implemented as agent-based complex system models (Grim et al., 2005). Agents in these models are considered as emergent system elements (see Section 3.4.2) that possess an ability to adapt to their environment.

Using these agent based, bottom-up models involves collecting “relevant information about entities at a lower level of the system (in “agent-based models” these are individual agents), formulate theories about their behaviour, implement these theories in a computer simulation, and observe the emergence of system-level properties related to particular questions.” (Grimm et al., 2005, p. 987). The understanding here is that the emergent properties of complex adaptive systems can be described through a set of simple rules (Holland, 1995).

Levin et al. (1997 cited in An et al., 2005) give an overview of using a complexity approach in ecosystem modelling in particular, and consider its advantages over the more traditional modelling approaches to be the:

- Incorporation of substantial local and individual characteristics;
- Recognition of the stochastic nature of complex systems;
Explicit characterization of the impact of activities at one scale has on patterns at another.”

(p. 54)

Agent based simulation models are also called multi-agent simulations (MAS). MAS sometimes make a distinction between models that simulate human agents and their environment and models that simulate animals or plants and their environment. According to Bousquet & LePage (2004) individual based modelling is used by ecologists primarily in order to take in the role of heterogeneity. In contrast, ABMs place more emphasis on the decision making process of agents and the social organization in which they are embedded. As such, IBMs can be considered to put more emphasis on the emergent collective behaviour residing in the agent –agent and agent-environment interactions rather than complex individual abilities (Guerin & Kunkle, 2004). There is, however, some overlap between the two. This lies in the ability of individuals, or agents, to make deliberative decisions or reactive adaptations to their environment depending on how the particular model has been implemented.

In this research an IBM has been developed to model western weka population dynamics in relation to habitat use while the portion of the system related to human decision making has been modelled through neural network analysis of FCMs (see Chapter 10). The linking of the IBM and FCMs allows the development of a model of the interaction of both parts of the system. The rest of this discussion will focus on IBMs rather than ABMs.

Individual based modelling was first developed in the 1980s by researchers who argued that individuals’ genetic uniqueness, and the fact that they are situated and interact locally, was being overlooked in ecology (Bousquet & LePage, 2004). It was motivated by “the desire of ecologists to understand natural complexity and how it emerges from the variability and adaptability of individual organisms.” (Grimm & Railsback, 2005, p. xi). In addition, Lomnicki (1992) suggests that populations or ecosystems are more abstract entities than individuals, the implication being that individuals’ boundaries are more clearly empirically defined than the theoretical boundaries of ecosystems or populations and so are a better basis for model development. Grimm & Railsback (2005) call this ecological focus on the individual, ‘individual based ecology’ (IBE). Because of its shift in emphasis some theorists argue that individual based theory and associated modelling presents a radically new research programme in ecology while others propose it as an extension of classical theory (DeAngelis & Mooij, 2005). DeAngelis & Mooij (2005) note that there are “five major types of individual variation considered in IBMs: spatial, ontogenetic, phenotypic, cognitive and genetic.” (p. 147). The IBM in this study models only spatial, ontogenetic and phenotypic variation in weka. Such IBMs are sometimes called spatially explicit population models (SEPM).
Based on a basic biological assumption that individuals are unique and differ from each other both behaviorally and biologically (DeAngelis & Gross 1992), the individual approach to ecological modelling assumes that the properties of the system emerge from the behaviour and properties of the individuals that compose it. The population level properties such as persistence, resilience, and spatial and temporal abundance are considered to emerge from the interaction of individuals. These individuals, in turn, have traits that allow them to adapt to their environment toward the ultimate goal of genetic fitness (Grimm & Railsback, 2005). The position taken in this study varies slightly from this neo-Darwinian emphasis on ‘genetic fitness’ by taking a co-evolutionary approach that lies implicit in the fundamentally interactive nature of systems (see Sections 3.4.3 and 4.3.2.1). Some modellers place less emphasis on fitness as such but still used reproductive success as an important goal of individuals (Topping et al., 2003).

By contrast, in classical theoretical ecology, individuals (for example, in models of population size) are aggregated and represented with birth and death rates, and immigration and emigration. These analytic models attempt to model the broader system. This requires a simplification through statistically aggregating the individual members of populations into, for example, state variables and assuming that all members of the population are the same (DeAngelis & Gross, 1992).

Individual based ecology also creates a different emphasis on field work. Rather than just observing population density in various kinds of habitat, IBE also studies the processes of survival, growth and adaptation of individuals (Grimm & Railsback, 2005). This emphasis produces a requirement for large amounts of data which has been a point of criticism of the individual approach to ecology (Grimm & Railsback, 2005). Ultimately some aggregation is required and stochastic processes are often used to implement this in IBMs. This is discussed in the sections to follow.

Another approach used to overcome these high data needs involves modelling itself. Grimm & Railsback (2005) argue that we do not need to know everything to develop a model. Knowledge is always incomplete and that is why models are developed in the first instance. There is a requirement to filter out the essential elements that enable the model to represent the features of the system of interest. Being clear about a model’s purpose is one way of doing this. The model then becomes a purposeful, and consequently simplified, representation of the system rather than just an attempt to model the whole system (Grimm & Railsback, 2005). For example, for this study’s IBM the purpose is to model the impacts of habitat change on the weka population and its dynamics at a landscape scale. Elements that are not essential to understanding weka habitat use were aggregated or ignored (e.g., weka movement at the scale of hours and metres were not modelled).

The key assumptions and features of IBMs can be summarized as (Grimm & Railsback, 2005):
• Ecological systems are understood and modelled as groups of unique individuals from whose interaction broader system properties and dynamics develop;
• IBM allows the study of the relationship between emergent properties and individual adaptive behaviour;
• Rather than using differential calculus IBMs use complexity concepts such as emergence, self-organization and thresholds. They use computer based simulation models to do this;
• Field observations are important for developing IBMs. They allow the identification of patterns to organize and test a model’s theory.

There does not appear to have been any individual based models developed for weka habitat use. There has been, however, an analytic stochastic simulation model developed for impacts on weka from pesticide use. This model uses statistical variation in state variables rather than spatially simulating individuals (D. Tomkins pers. com. Landcare Research). There have been numerous individual based models developed for modelling elements of ecological systems such as vegetation dynamics in forests (Grim & Railsback, 2005). More relevant for this study is that a number of the models have been developed involving birds (Topping et al., 2003, Letcher et al., 1998, Stillman et al., 2003), habitat use (Cramer & Portier, 2001), and animal movement (Westervelt & Hopkins, 1999). There have also been a number of IBMs developed for agricultural landscapes (Topping et al., 2003, Jepsen et al., 2005). Most IBMs focus on individual species due to the complexity of developing models for multiple species (Jepsen et al., 2005).

9.3 Software Tools
There are a number of software platform types used for individual based model simulations. They include: (1) Procedural programming languages; (2) Object-orientated programming (OOP) languages (e.g. C++, JAVA); (3) General high-level modelling environments; (4) Graphical modelling environments; (5) Agent-based modelling environments (e.g., Swarm, RePast); (6) High-level agent-based modelling environments (e.g., NetLogo) (Grimm & Railsback, 2005).

OOP languages, and the modelling environments derived from them, are considered as good platforms on which to implement IBMs, because their object based structures allow easy implementation of agents. Some modellers do not use modelling environments because a straight OOP language such as C++ or JAVA gives more flexibility, and there is a steep learning curve for new users either way (Topping et al., 2003).
Following some initial experimentation with the agent based modelling environment RePast, this IBM was developed using the NetLogo high-level modelling language and environment. NetLogo is considered a less powerful platform than some other agent-based modelling environments. However, it has proved to be easy to learn and flexible enough to achieve what this project required. It has a built-in parameter testing environment, a very active user community and the platform is undergoing continual development and improvement. Indeed, several incremental developments of the platform occurred while developing the weka IBM.

There are some advantages in using a less powerful platform. First, it encourages simplification of the model. Grimm & Railsback (2005) highlight the primary importance of reducing models to the simplest state necessary to simulate the real world situation. Increasing the number of parameters and interaction possibilities very rapidly increases the model’s complexity making the testing and validation process much more difficult. Second, there is a reduction in the time required learning to program in the platform. In this research project developing the IBM is only one aspect of the study and reducing the time spent on it was beneficial to the project as a whole.

9.4 Western weka IBM

9.4.1 Overview

The following sections give an overview of the individual based model developed as part of this study. It sets out the model development process and the data used. The model development process was an iterative modelling cycle as set out in Grimm & Railsback (2005). This involves: (1) Formulating the question; (2) Assembling hypotheses for the essential processes and structures; (3) Choosing scales (spatial and temporal), state variables and parameters; (4) Implementing in software; (5) Analyzing, testing and reviewing the model and software.

An overview of the development process is outlined in Figure 9.1. As already discussed, the conceptual framework of the IBM was based on CAS with further input from modelling concepts, general biological theories, and specific biological knowledge of weka. This framework was then implemented in software and tested for errors (see Section 9.4.8). The model was then run and the patterns it produced compared to actual biological patterns gathered from weka fieldwork and literature. The model was then used to simulate various scenarios of habitat change at Cape Foulwind using New Zealand Landcover II database maps of the area.
9.4.2 Formulating the question

The western weka IBM purpose is: *To assess the effects of land development practices on western weka habitat use at a landscape level.*

Because the weka IBM is modelling habitat and population change it is both spatially and temporally explicit. It also requires the model to be intergenerational and represent mortality and reproduction of individual lifecycles. The main drivers were considered to be mortality risk and food supply along with reproductive success (Beauchamp, 1987a). In addition, because weka is a territorial species, dispersal mechanisms were considered to also be an important factor.
9.4.3 Assembling hypotheses for the essential processes and structures

9.4.3.1. Conceptual framework and formulation

When developing a model to represent a real system it is important to identify the variables that are essential to do this. This is because the purpose of modelling is to develop a simplified representation of the real system to allow questions to be answered about it. There are two facets to this. The first is deciding about how IBMs generally, and any IBM in particular, are structured and what elements need to be included in it. This involves developing a hypothesis on how the real system works. This is based on knowledge of the system and information about similar systems (in this case weka ecology). The theoretical basis of IBMs is CAS. Consequently, included in the IBM’s conceptual design are broader theories about how to model these hypotheses based in CAS (e.g., adaptation, interaction, emergence, prediction, thresholds, etc.).

Second, and derived from the first, is the ecological information required to implement the model. The approach used iterates through internal design and implementation and external patterns both supplied to, and produced by, the model, to attempt to derive the essential features required (Grimm & Railsback, 2005).

9.4.3.2 Theory development in weka IBM

A general approach to the theory development cycle is proposed by Grimm & Railsback (2005, p. 60). This involves: (1) Proposing alternative theories; (2) Identifying test patterns; (3) Implementing proposed theories in IBM (i.e., as individual traits); (4) Analyzing the IBM to test the proposed theories; (5) Repeating the cycle to refine theory and test it.

Theory development for the weka IBM utilized this development cycle, although not always in a fully formal manner, and has occurred as part of the general development of the IBM. As each sub-part of the model was developed various behavioural hypotheses and model structures were considered and tested. The ones that produced the most biologically realistic patterns, as far as they were known, were retained. A more formal development/testing process was undertaken once the complete model was working satisfactorily. This allowed changes to be made in relation to population-level patterns produced by the completed IBM.

9.4.3.3 Two core modelling concepts

There are a number of modelling concepts that Grimm & Railsback (2005) recommended considering in the development of an IBM. These are based on the experience of others developing
IBMs. Probably the most important two are pattern orientated modelling (POM) and state based theory. The rest of this section gives an overview of these two modelling concepts, along with a set of additional ones, and how they were used in the weka IBM.

9.4.3.4 Pattern orientated modelling

In addition to concerns over their large data requirements, IBMs have been criticized for the lack of a theoretical framework that allows a consistent and coherent approach to their development, and permits general theories to be proposed and tested. The complexity involved in IBMs’ focus on tracing the relations between the adaptive behaviour of individuals, and emergent complex system patterns, that makes these concerns difficult to address (Grimm et al., 2005). Grimm & Railsback (2005) suggest that pattern orientated modelling (POM) supplies framework to address this.

POM follows the scientific goal of the explanation of observed patterns. Patterns exist both at the individual level and at the broader systemic level (e.g., population level). According to Grimm & Railsback (2005) the existence of emergent patterns suggests the existence of underlying mechanisms producing them. The purpose of an IBM in this respect is to allow the tracing of the underlying mechanisms in the traits or behaviour of individuals. An important aspect of understanding complex adaptive systems is how these various patterns are linked together (Grimm et al., 2005). Bottom-up models that simulate individuals derive the properties of the system from the properties of the system’s elements; they are reductive models (Lomnicki, 1992). A more circular understanding of emergence questions the reductive IBM assertion to some extent as these models really oscillate between reduction and holism. A self-emergence (autopoietic) position, however, would understand the individual as more basic, at least empirically. By contrast, analytic models can be considered holistic models as they model only the emergent patterns (Lomnicki, 1992).

The POM approach involves identifying essential patterns, at both the individual level and higher systems level, and identifying how well the model outputs reflect these patterns. Consequently, ideally the patterns that are used exist at different hierarchical levels and spatial and temporal scales. Tracing these characteristics in a model usually requires the identification of more than one pattern as the production of one system level pattern can be modeled in a number of different ways. This is less the case with multiple patterns. Patterns are used to guide the model’s design, including its resolution, processes and structure. The model can then be tested and developed further with more sensitive identified patterns. This process forces the modeller to be

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52 This considers emergent organisation is both a product of and a context for the individuals (Bousquet & LePage, 2004) (see Section 3.5.2).
clear about the decision structures that are being used and how they are tested (Grimm et al., 2005). In summary, the “multiple patterns observed in real systems at different hierarchical levels and scales are used systematically to optimize model complexity and to reduce uncertainty.” (Grimm et al., 2005, p. 987).

At a theoretical level, in contrast to just developing IBMs to answer questions about a particular situation, IBM is a way of experimenting with theories about how this interaction occurs. In this way simulation modelling can be considered as a way of learning about particular issues using a model. If only one model is constructed with one set of decision-making rules there is a risk that it is tailored to reflect a limited empirical data set. A more robust approach is to develop two or more models with different sets of decision-making rules based on various theories of what individuals do. In this study model versions with structural differences associated with dispersal behaviour, mate attraction, and movement were developed. In addition, numerous other small structural differences occurred as the model was developed and some rejected over others for being less representative of the patterns observed.

This POM process is not one of falsifying hypotheses against data. Rather, because all theories are incorrect at some level, and because the data being used is qualitative or uncertain, the aim is to use a broad range of data to evaluate usefulness of alternative theories. The usefulness of these theories is judged by how well they represent population-level behaviour. They do not need to explain detailed individual behaviour, which allows for considerable simplification (Grimm & Railsback, 2005).

The complexity of an IBM is important. If an IBM is too complex it will be difficult to understand how patterns emerge from it. If an IBM is too simple, realistic patterns will not emerge from it. There is a zone between these two extremes where the benefits of a model are optimised (Grimm & Railsback, 2005). Designing the model around observed patterns links the model to real processes and their dynamics. Along with being clear about the model’s purpose this helps indicate what is essential to include in the model and what is likely to be unnecessary.

A crucial point is to know when to stop elaborating and when to start using the model to solve problems. With the weka IBM development this point became obvious and involved a combination of factors. These being: (1) Increasing complexity of the model making it difficult to trace errors and understand its functioning; (2) Limitations on the amount of empirical data available for inputs and verification appearing to undermine gains made through any further development of behavioural detail; (3) The robust state of the model and reasonably realistic patterns it was producing suggesting the essential features of the system had been captured; (4) Constraints on the amount of time available to do this part of the project.
A POM approach is also useful for reducing parameter uncertainty. It does this by helping to make the model more structurally realistic and this causes the model to have lower parameter sensitivity. It also means that the interaction between parameters is more realistic so allowing the calibration of unknown or poorly known parameters (inverse modelling) (Grimm et al., 2005). Software such as Netlogo allows automated testing of parameter sets and hence for inverse modelling to be easily undertaken.

9.4.3.4.1 POM in the weka IBM

This section sets out the application of POM in the weka IBM. The patterns used for the weka model assessment and output was at two levels:

1. **Population level**: (1) Change in population density from land development; (2) Densities in a large range of habitat types; (3) Overall population density and its persistence; (4) Average population age; (5) Average weights of male and female adults.

2. **Individual level**: (1) Weight ranges (male and female); (2) Dispersal patterns (juvenile and non-territorial adults); (3) Reproduction rates (percentage of females reproducing and chicks fledging per female per year); (4) Juvenile and adult mortality rates.

As outlined above, the more the model can produce these patterns simultaneously the more realistic its structure is likely to be. The use of these patterns in model analysis and testing is discussed below in Section 9.4.8. This involved considering which processes can be removed while still producing the patterns noted above (i.e., which processes are responsible for the patterns).

The data used to ascertain these patterns was gained from literature and field studies. Population level patterns were acquired primarily through call counts in the Cape Foulwind area during the study. Individual level information was obtained through literature on weka, telemetry tracking and colour banding studies, as well as road-kill carcass collection. See Chapters 8 and 12 for a discussion of the field study methods used and the results.

9.4.3.5 State-based (predictive) theory

Theoretical approaches used in IBMs assume that individuals adapt by responding to changes in their environment or themselves with the intent of improving their fitness. This assumes that individuals know their present state (e.g., health) and that they select habitat to maximise reproduction. This is a function of their growth, energy reserves and probable survival to the reproductive date (Grimm & Railsback, 2005). Some of their responses or behaviours contribute directly and clearly to improving their fitness while others do not. State-based predictive theory
(Grimm & Railsback, 2005) refines this general theory by assuming that individual fitness is considered into the future. Individuals are expected to know to some extent what this fitness is by making very simple predictions of habitat conditions over a certain period of time. This “expected fitness” is developed by assuming the individuals have psychological models or representations of their environment. This is then used to predict the implications of their present decisions for their future fitness.

State-based predictive theory is not used in this IBM. This is because it is not assumed that weka hold representations in their heads about the world as implied in this theory. Rather, in common with humans (see chapter 4) weka are considered to have mental abilities that are primarily used for sensorimotor processing in immediate interactions with their environment (Wilson, 2002). Weka in this manner are not analysing projected representations of their future fitness when they make decisions, but make those decisions fully in and with the environment they presently exist within.

In this immanent approach, where weka are immersed in the world/ habitat, I am proposing that weka decisions are weighted primarily toward their present environment. This simplified interactive decision making process I will call ‘state based theory’.

### 9.4.4 Conceptual design checklist

In addition to the two core modelling concepts discussed above are a set of key conceptual components. These make up a conceptual design checklist recommended by Grimm & Railsback (2005) for ensuring that IBMs address the key conceptual elements that need to be considered when designing an IBM.

#### 9.4.4.1 Emergence

One of the key aims in individual based modelling is to model the system level properties that emerge from the interaction of individuals with each other and their environment. Consequently, emergence is a central concept in IBMs. Grimm & Railsback (2005) stress the difference between emergent system properties and imposed system properties. Emergent properties are not just the sum of the properties of individuals. This is because they are of a different type from those properties (e.g., each weka has a location but only the system has a spatial pattern). In addition, as already noted, emergent system level properties cannot easily be predicted from the behaviour of individuals.

Consequently, emergent outcomes are not imposed but rely on the circumstances and history of each individual weka. The emergent properties in relation to weka habitat selection arise
through a number of interactive processes. These are: (1) The mechanisms by which habitat affects individuals’ fitness; (2) The kinds of habitat available and how they are arranged spatially and temporally; (3) The ways that individuals interact with each other; (4) The weka population’s abundance and structure.

Modelling behaviour as emergent requires an understanding of the mechanisms that produce that behaviour and so exploring what these mechanisms might be. This requires a more complete understanding of the system than treating behaviour as purely stochastic (see Section 9.4.4.6). Emergent behaviours are generally more complex than imposed behaviours and this complexity increases rapidly with increasing numbers of such behaviours (Grimm & Railsback, 2005).

The properties that are considered emergent in the weka IBM are: (1) weight; (2) age; (3) mortality; (4) spatial distribution; (5) dispersal movement; (6) home range/territory selection; (7) productivity. The imposed outcomes in the weka IBM are: (1) Initial locations, (2) Available food in various habitats; (3) Cover amounts in various habitats; (4) Mortality risk in various habitats; (5) Movement within home ranges and territories; (6) Dispersal speed; (7) Movement through, and avoidance of, held territories; (8) Size of home ranges and territories; (9) Territory maintenance.

9.4.4.2 Adaptive traits and fitness

Adaptive traits and fitness are concepts that further develop the state based theory discussed above. They assume that individuals make decisions based on maintaining their fitness. In this study fitness is linked with co-evolution as a central part of the IBM’s conceptual foundation. This is based on the premise of systems’ ability to adapt to, and also change, their broader environment. The use of adaptive traits and fitness concepts also allows the modelling to be based on real biological processes which in turn allow and encourage the use of observed animal behaviour (Grimm & Railsback, 2005).

Not all behaviour is directly adaptive. Observed behaviour that cannot be directly linked to increasing fitness, but is still assumed to do so, is called indirect fitness seeking. This is a good way to model for traits that appear to be hardwired and do not involve complex decisions (e.g., bonding with a mate).

Fitness that is considered directly adaptive (called direct fitness seeking) are modelled as adaptive traits. Adaptive traits are decision procedures for situationally-based specific behaviours to increase fitness (Figure 8.2). Fitness is ultimately understood as reproductive success. This does not just involve passing on genes but also passing on the environment they exist within and adapt to (see Section 4.3.2.1). Genes are not a blueprint for adaptive traits as adaptive traits are considered to involve learning and experience (Grimm & Railsback, 2005). However, due to the complexity of including learning algorithms in individuals, in this study individuals’ decisions are modelled as
mechanistically unchanging with variation included using stochastic methods (see Section 9.4.4.6). As discussed above, a state based theory is used rather than a predictive state based theory to model decision making processes.

Adaptive traits are used for modelling tradeoffs that individuals make between the key fitness elements – survival, growth and reproduction (e.g., growth versus survival). Adaptive traits allow mechanistic decisions to be modelled and emergent properties to arise, and vary with life history phases (Grimm & Railsback, 2005). The fitness elements for the weka IBM are (these are present targets for fitness to be high): (1) Survival to reproduction; (2) Establishing breeding territory (non-territorial weka); (3) Maintaining breeding territory (territorial weka); (4) Accumulation for energy for reproduction; (5) Attainment of reproduction size (juveniles). Fitness elements vary with life stages:

- **Juvenile** – grow to breeding size, survive mortality risks, establish a home range;
- **Non territorial adult** - find mate, find and establish breeding territory, retain breeding condition, survive mortality risks;
- **Territorial adult** – Retain mate and territory, survive mortality risks, gain condition for breeding.

The weka IBM uses a simple set of fitness elements based around the need for food, the requirement of cover and finding a mate. Dispersing weka are assumed to know to some extent (100 m around them) the quality of the habitat that they are moving through. Weka without mates know where the nearest weka are (300m around them, through hearing spacing calls) and are attracted to other unpaired birds. The importance of finding habitat with cover, which is considered to considerably affect their mortality risk, depends on their present state of hunger which weka are also considered to know.

The IBM uses fitness measure calculations to evaluate the fitness outcomes of individual’s alternative actions (e.g., use of alternative habitats) (Figure 9.2). Fitness measures are simplified models that represent one or more fitness elements. While the fitness elements are targets to be achieved for high fitness, fitness measures are actual states of fitness. The fitness measures are: (1) Present mortality risk; (2) Number of offspring; (3) Present habitat quality; (4) Present hunger state (juveniles); (5) Present weight; (5) Present age.
Adaptive traits are implemented in the weka IBM using a state-transition principle (Jepsen & Topping, 2004). Weka behaviour (e.g., dispersal, reproduction) is described as states and a set of decision rules exist for each behaviour type based on fitness elements and fitness measures. Weka transition between behaviour types when the conditions associated with a particular behaviour type are met. These condition changes can be produced by internal (e.g., hunger state) or external events (e.g., obtaining a mate) and may involve probabilities (see Section 9.4.4.6). As noted above, weka are divided into a number of types. These types are associated with life history stages (juvenile (J), sub-adult (this includes non-territorial adults) (SA), adult (A)) and sex (male (♂), female (♀)).

The weka IBM is broken up into a number of behavioural states used by different weka types. The duration of each behaviour state is a minimum of one full day (24 hours) which is the time step of model. Discrete scheduling is used (see Section 9.4.4.7). The following list gives an overview of the behavioural states. The manner in which the event decisions are prioritised is discussed under adaptive traits and fitness elements/measures, above.
1. **Setup** (♀, ♂, J, SA). At model setup all parameters are assigned initial values. This includes environmental variables and constants.

2. **Fledgling** (♀, ♂, J). Juveniles are assumed to mature fledge when they approximately 80 days old. They also need to be large (weight) enough for this to occur. At this time they either establish a home range adjacent to their natal area or move to a dispersal phase. The juveniles are disassociated from their parents at this time. They are given a sex at a ratio of 1:1.

3. **Dispersal** (♀, ♂, J). 50% of juveniles disperse from their natal area. Their movement involves checking to see if they are presently in the territory of other weka, if so they move out of it. Otherwise, they check the area ahead to see if it is ocean or has very little cover. If so, they change direction and then move, depending on their present state of hunger, into the best area 100 metres from their present location for either food or cover.

4. **Establish home range** (♀, ♂, J, SA). Weka will establish a home range if adequate cover exists. Home ranges vary in size from 5 ha to 15 ha depending upon the food production rate of the location.

5. **Sub-adult and non-territorial adult movement** (♀, ♂, SA, A). 30% of sub-adults and non-territorial adults will leave their home range area when they reach a certain hunger threshold during the spring and summer months. They move around using the same criteria as juvenile dispersal until another suitable home range area is found.

6. **Find mate** (♀, ♂, SA, A). Once a home range area is established sub-adults (if they are old enough) and non-territorial adults check the surrounding 300 m radius area for other single weka of the opposite sex if they have adequate food. They then move towards the nearest other suitable weka and bond with them.

7. **Establish territory** (♀, ♂, A) Weka will establish a territory at the location they have bonded with a mate (there is no checking of patch condition, as they are already in a home range area so conditions will be suitable). Territories are set to a size of 5 ha.

8. **Adult movement** (♀, ♂, A). Adults move around inside their territory to the patch in the territory with the highest food amount. There is no assessment undertaken for variations in mortality risk within the territory.

9. **Reproduce** (♀, A). This is assumed to occur in the spring months, primarily, but can be all year round if female weights are high enough. 90% of females will have chicks if over a minimum weight taken from a random normal distribution. The number of chicks produced
depends upon the female’s weight, which is assumed as an indicator of female’s condition. Female weight is reduced by 10% when chicks are born.

10. **Feeding** (♀, ♂, J, SA, A). Weka feed in every time step off whatever patch they have occupied. There is no differentiation made between roosting and feeding time. A simplified budget is kept for each weka that utilizes its weight as a measure of its condition. This is calculated by subtracting the amount of food obtained from the amount of food required daily (this is estimated). Weka food consumption depends on energy use which varies for breeding weka. The environmental food production rate varies seasonally.

11. **Die** (♀, ♂, J, SA, A). The weka is removed from the simulation. The risk of this occurring is based on its age, the mortality risk in the patch it is occupying, and a stochastic background mortality rate.

12. **Update environment.** The amount of food eaten each day is removed from the total amount of food grown each day. The environmental food production rate varies seasonally.

13. **Update outputs.** This includes the onscreen simulation information and output data files.

### 9.4.4.3 Prediction

As discussed in the previous section, the weka IBM does not use the state based prediction approach of Grimm & Railsback (2005). Consequently, it does not use explicit prediction. This is because it is questionable whether weka are able to predict future environmental conditions required to predict their future fitness. The weka IBM assumes that weka use the existing conditions to assess their fitness over the future time horizon. Their future fitness lies implicit in their present fitness state which they attempt to retain as high as possible relative to the goals of their present life stage.

### 9.4.4.4 Interaction

Interaction with other individuals can be either direct physical interaction or indirect interaction through competition for common resources (e.g., food) (Grimm & Railsback, 2005). In the weka IBM sub-adults/non-territorial adults and dispersing juvenile birds interact with each other through indirect competition for food. Direct interaction occurs through the phase of searching for a mate and bonding into a pair. Direct interaction also occurs where territorial weka interact with adjoining, and sometimes overlapping, territorial neighbours, along with sub-adult/non-territorial birds through territory incursions. Such interactions are based on protecting food supplies and chicks within territories. Dispersing weka do not interact with territorial weka to any great extent as they are considered to avoid territorial areas.
When these direct interactions do occur they are not explicitly modelled. This is due to the spatial and temporal scale of interactions, which are simplified to patch level (1 hectare) and the daily (24 hours) time step. This means the small temporal and spatial scale interactions that occur below these levels are unable to be modelled. It is assumed that the territory holding birds dominate any such interactions and retain their territorial area.

The model also assumes territorial weka have direct interaction with surrounding neighbours through spacing calls and so have some knowledge of the surrounding weka density and distribution of other weka. This is important for organizing and retaining territorial spacings. Such knowledge is modelled implicitly in the IBM by allowing territorial establishment only outside existing territories, and fixing territorial boundaries after establishment so spacings are retained.

9.4.4.5 Sensing abilities

In IBMs individual animals need to be able to sense the environment to enable adaptation to changing conditions. According to Grimm & Railsback (2005), there are three questions that need to be considered when deciding on the sensing ability of individuals in IBMs. These are:

- What kind of information does the individual have?
- How much information does it have?
- How accurate is that information?

They recommend that it is best to use simple assumptions about sensing ability rather than detailed and complex representations. In the weka IBM it is assumed that weka have limitations on what they know in relation to the distance they can sense and the amount of information they have. Following this recommendation, the model makes some simplifying assumptions about weka’s ability to sense that are necessary for its aims. These are:

- As already noted, that weka are able hear other weka, and through the use of spacing calls, know their location within 300 metres. This allows weka to retain their territorial and home range spacings and find their existing mates;
- That weka know the general habitat (cover and food availability) in adjacent patches. This occurs through exploration. This is because as sensing processes can operate on a shorter timescale than the daily one used in the weka IBM (i.e., weka spend some of the day exploring the surrounding area and interacting with other weka below the resolution of the model) (Grimm & Railsback, 2005);
- That weka know their own condition in relation to their present weight;
- That weka know when they need more food (i.e., their condition is poor). At some point this may become dominant over looking for a reproductive territory, etc;
• That weka can recognize their mate and off-spring through sight and sound;
• That weka know when there is high mortality risk (i.e., weka avoid traveling without cover during the day where there high risk from hawk predation);

9.4.4.6 Stochasticity

Stochasticity is the use of pseudorandom numbers and probabilities to represent variability in processes in an IBM. Representing processes as stochastic means, either that there is a lack of information about them or that the modeller chooses to do this in order to avoid having to model the details of the process. The stochastic approach is an empirical one in that it is used to reproduce observed behaviours that have been described probabilistically. If it is supported by observations it will produce realistic outcomes within the bounds of the conditions the observations were made under. Outside these conditions it is subject to extrapolational uncertainty (Grimm & Railsback, 2005).

In contrast to using stochasticity the advantages of a mechanistic model are that it allows relating decisions directly to adaptive behaviour or direct fitness seeking. Modelling a process in a mechanistic manner it assumes it is known how the process works. In other words, it is explanatory. (Grimm & Railsback, 2005). Frequently, because the details of mechanisms are rarely completely known or able to be explicitly modelled, a deterministic process with a stochastic component is used in IBMs (i.e., model as much as is known mechanistically and model the rest as variability) (Grimm & Railsback, 2005). For example, if A occurs then B occurs with the probability of C. Retaining the mechanistic (or logical) element means the decision can be adaptive while the probabilistic element can make the behaviour more realistic. This approach also allows the use of incomplete, qualitative or ‘soft’ information that lacks solid quantitative data. For example, weka mortality in the weka IBM is partially mechanistic as hunger and starvation is modelled through ongoing interaction with the environment but other mortality risks (e.g., from predators, old age, disease, etc.) are modelled stochastically as survival probabilities.

There are a number of decision making processes in the weka IBM that are purely stochastic. These are: (1) Sub-adult/non-territorial dispersal decisions; (2) Juvenile decisions to stay in their natal areas; (3) Annual weather variation. Some are mechanistic: (1) Adult movement within their territories; (2) Sub-adult/non-territorial movements within their home range; (3) Home range and territory sizes. Other processes use a mix of mechanistic and probability as discussed above. These are: (1) Weka background mortality; (2) Movement directions; (3) Female reproduction decision; (4) At what point juveniles become sub-adults; (5) Number of chicks produced; (6) Whether juveniles or
sub-adults/non-territorials move into territories; (7) Establishment of home ranges/territories in developed farmland habitat.

Stochasticity is also commonly used to create variability in initial populations of individuals. The weka IBM uses this approach for weight, age and sex of the individuals by using variability drawn from a normal distribution.

**9.4.4.7 Scheduling**

In IBMs events do not happen concurrently but are scheduled to occur in a discrete order during each time step. This means that one event can affect other events within each time step. Consequently, the ordering of events is important as it can affect the results of the model (Grimm & Railsback, 2005).

There are two main ways of scheduling time used in IBMs. The first is dynamic scheduling. This does not have a strict set of discrete events scheduled in each time step; rather actions are scheduled by the activities of the individuals. For example, a weka might move into a patch occupied by another weka triggering a dominance procedure to execute. One weka then has to move again and so potentially creating further dominance contests.

In this IBM the simpler method of discrete scheduling is used. In discrete scheduling the exact order of events are specified and predetermined. Each event is assumed to occur once in each time step and the temporal relationship between events within each time step are ignored. This allows a simpler model to be produced and a model that is easier to analyze. Dynamic scheduling is only needed in situations where the order of execution of interactions has a large impact on results (Grimm & Railsback, 2005). There no processes where it was considered important to have dynamic scheduling in the IBM.

Another consideration is the choice between synchronous and asynchronous updating. Synchronous updating is revising the modelling environment (i.e., the cells or patches) once only each time step after all the individuals has had their effect. Asynchronous updating involves updating the environment after each individual has its effects. The weka IBM uses a combination of asynchronous and synchronous updating for the environment. This is because weka compete to some extent for resources, particularly dispersing juveniles. The weka IBM uses asynchronous updating in the adult and juvenile action routines (i.e., each individual completes its movement, eat,

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53 For example, weka are generally confined to discrete areas (i.e., home ranges, territories). Holders of territories are considered to always be dominant, and home ranges can be considered impervious to a large extent. This situation means there is no need for the dynamic scheduling of movement. There are also no other areas where it would be considered necessary (e.g., eating, reproduction, mate selection).
reproduce, and mortality actions prior to the following individual). It is also used to reduce the amount of food available on a particular cell after it has been eaten from. Synchronous updating is used for the re-growing of food on all the patches at the end of each day (time period) once all weka have completed their action routines.

### 9.4.4.8 Observation

There are three approaches to observation in IBMs. The first is as an omniscient observer, the second is from the perspective of an individual within the model, and the third as a virtual ecologist. The first is most commonly used and allows any data at all about the model behaviour to be collected. The second involves the collection of data from a particular individual and allows assessment of how it interacts in the environment. The third involves collecting data from the model using the same techniques as an ecologist in the field would, and with the same limitations. This allows direct comparison of model output to be made with field data (e.g., weka call counting). Using this in combination with an omniscient observer allows the tracing of bias in field data collection (Grimm & Railsback, 2005). In the weka IBM the standard omniscient observer is used and a range of data is collected from the model (see Section 9.4.8.4).

### 9.4.5 Model scales and state variables

#### 9.4.5.1 Spatial resolution and extent

**Cell size:** 100 x 100m (1 hectare each)

**Extent:** Cape Foulwind area (~15000 hectares). I broke this into four areas for modelling (NW, NE, SE, SW) as the model is too slow to model the entire area at once.

**Time step:** 24 hours

#### 9.4.5.2 Types of model entities

This section describes the variables used in the modelling platform:

1. **Environmental variables/ processes that drive the model:** (1) Habitat variation; (2) Food supply; (3) Mortality risks.

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54 There are no strict rules for deciding how to order, or group, actions of individuals in IBMs (Grimm & Railsback, 2005). In the weka IBM all of the actions of adult weka (move, eat, reproduce, mortality) occur before those of juvenile weka (move, eat, mortality). This is because adults are considered dominant and so their activities take priority over juvenile actions.
2. **Habitat units state variables:** (1) Habitat type; (2) Cover amount; (3) Food availability; (4) Mortality risk (this considers: humans, dogs, stoats, cats, hawks, vehicles); (5) Home range areas held; (6) Territory areas held; (7) Maximum food production rate; (8) Seasonal food production rate; (9) Movement corridor rating.

3. **Weka state variables:** (1) Age; (2) Sex; (3) Weight; (4) Hunger status; (5) Location (x & y); (6) Bonded with mate; (7) ID of mate; (8) Whether mate is dead; (9) Whether holds a home range; (10) Home range patches ID; (11) Whether holds a territory; (12) Territory patches ID; (12) Present mortality risk; (13) Whether juveniles stay in their natal area; (14) Amount of energy use; (15) Closest neighbouring weka; (16) Whether have offspring; (17) Whether still have previous offspring; (18) Age of offspring; (19) Number of offspring; (20) Whether have a new home range.

### 9.4.5.3 Major structural assumptions

The **temporal scale** of 24 hours was chosen because the model’s purpose is to assess the impacts of habitat change over a number of weka generations. This means running simulation periods of up to 60 years. Shorter time scales of less than 24 hours would become very long simulations. In addition, the model does not need details of micro daily events (e.g., differentiation between roosting time and eating time) because the model is primarily considering landscape and population level events.

The **spatial scale** (1 hectare) was chosen because larger sized patches would not allow detail of home range and territory scale activities to be modelled. Smaller patches would make modelling the real landscape data difficult as the simulation would become very large and slow.

The weka IBM assumes there is no immigration/emigration outside the Cape Foulwind area. This should mostly hold as the area is surrounded by the Buller River to the east, the Tasman Sea to the north and west and the Paparoa mountains to the south and southeast. However, it is possible due to the high densities on the Cape Foulwind coastal farmland, that there is some emigration into the Paparoa Range area. This would be limited by the generally poorer habitats lying between the farmland and the Paparoa Mountains. Weka densities on the pākihi terraces separating the farmland from the mountains are low (0.15 ha^-1). Likewise the weka densities in the forested ranges of Buller tend to be low in relation to the Cape Foulwind farmland area (Buckingham, 1999).

### 9.4.6 Implementation in software

#### 9.4.6.1 Overview of sub-models
Software implementation of the IBM in NetLogo went through a number of stages (versions) of increasing model complexity. Testing of the whole model was carried out at each stage. Testing of the sub-models was also carried out throughout development. The main sub-models are: (1) Grow food; (2) Juvenile dispersal; (3) sub-adult and non-territorial movement; (4) Territorial adult movement; (5) Eat; (6) Reproduce; (7) Die.

The weka sub-models are based on a state based model as outlined above (see Section 9.4.3.5). A number of fitness measure models were developed under the weka sub-models. There are three distinct weka sub-models (juvenile, sub-adult/non-territorial, territorial adult) because the habitat use in these life phases are different. The sub-models have been be designed and tested separately and kept as simple as possible. The sub-model details are based on the general structure outlined above.

**9.4.6.2 Habitat**

The model *habitat types* are: large road, small road, house, wetland, coastline, pākihi, developed pasture, undeveloped pasture, indigenous forest, stream/river/lake, sea, urban area, young forest, exotic forest. These each have four main parameters associated with them: (1) Food availability; (2) Available cover; (3) Mortality risk; (4) Corridor. The value of these parameters were estimated and set out in Table 9.1.
Table 9.1 IBM habitat quality values.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Max food production rate @ (2.5 = most food)</th>
<th>Mortality risk $$ (10 = highest risk)</th>
<th>Cover # (10 = most)</th>
<th>Corridor$^*$ (10 = best links)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>2.2</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>Wetland</td>
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<td>2</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Coastline</td>
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<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Pākihi</td>
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<td>5</td>
<td>5</td>
</tr>
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<td>Developed pasture</td>
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<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Undeveloped pasture</td>
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<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
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<td>3</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>River/stream/lake</td>
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<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Urban area</td>
<td>1.0</td>
<td>9</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Sea</td>
<td>0.0</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Exotic forest</td>
<td>1.5</td>
<td>3</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Quarry</td>
<td>0.5</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Scrub</td>
<td>2.0</td>
<td>3</td>
<td>7</td>
<td>9</td>
</tr>
</tbody>
</table>

The parameters in this table are estimated using data from literature, field studies and reverse parameterisation.

@ Maximum food production rate is a qualitative measure of food production in each habitat type. It is expressed as a value from 0 to 2.5, where 0 is no food and 2.5 the most food.

$ Mortality risk is a qualitative measure of such risk in each habitat type. It is expressed as a value from 0 to 10, where 0 is no risk and 10 is very high risk.

# Cover is a qualitative measure of vegetative cover over c.40cm high in each habitat type. It is expressed as a value from 0 to 10, where 0 is no cover and 10 is complete cover.

* Corridor is a qualitative measure of vegetated links in each habitat type. It is expressed as a value from 0 to 10, where 0 is no corridors and 10 is complete cover. Unless an area is a very large open landscape, corridors might not be important because weka readily move into open areas in the hours of darkness (pers. ob.).

9.4.6.3 Observer plan

The outputs used in the weka IBM were:

- **Graphical display:** (1) Weka location, sex and life stage; (2) Patch status per time step – food amount, territory or home range, habitat type; (3) Days, seasons, years; (4) Percentage of adult weka holding a territory; (5) Percentage of weka with offspring; (6) Sex ratio; (7) Total number of adults and juveniles; (8) Adult weka hunger status (mean and minimum); (9) Adult weka weights (histogram and
mean); (10) Adult weka densities in various habitat types; (11) Movement tracks of individuals; (12) Average food available on patches.

**Output file**: Data output and saved to a file once a year (1\textsuperscript{st} March) is: (1) Total number of adults; (2) The percentage of sub-adult/non-territorial weka; (3) Total adult density; (4) Adult density on developed pasture; (5) Adult density on undeveloped pasture; (6) Mean age of adults; (7) Mean weight of adult males; (8) Mean weight of adult females; (9) Percentage of adult males; (10) Chicks fledged per female; (11) Percentage of females breeding; (12) Juvenile annual mortality (%); (13) Adult annual mortality (%); (14) Percentage of adults holding territory; (15) Mean food available per ha; (16) Mean territory size; (17) Percentage of weka < 1 year old; (18) Percentage of weka aged 1-3 years; (19) Percentage of weka aged 3-15 years; (20) Percentage of weka aged >5 years; (21) Percentage chance of a weka dying per year.

**9.4.6.4 Schedule**

The model uses discrete stepped time with synchronous and asynchronous agent updating that execute the following general actions: (1) Update habitat variables; (2) Adult weka undertake their move, eat, reproduce and die routines; (3) Juvenile weka undertake their move, eat and die routines; (4) Screen and file based output data produced.

**9.4.6.5 Initialization**

Initialization was based on an estimated distribution of age and weight classes and actual landscape patterns and sex ratio.

**9.4.6.6 Input data**

Data from the literature on weka ecology were used as the major data source for the IBM. These were complemented with local fieldwork undertaken as part of this study. This involved collecting data from a number of sources. The weka ecology methods section in Chapter 8 sets out the methods used to collect this data. The results of this are included in Chapter 12.

**9.4.7 Model parameters and variables**

Many of the parameters and variables\textsuperscript{55} for the weka IBM have been taken from the literature on weka biology and ecology. Due to the lack of information on the West Coast western

\textsuperscript{55} (P) Parameters are aspects which are programmed in directly. (V) Variables are considered to be emergent from a combination of other variables, parameters and the model structure.
weka much of this information has been taken from the more intensively studied mixed North Island 
weka/Western weka population on Kapiti Island (Beauchamp, 1987a) and other South Island 
populations (i.e., Double Cove, Marlborough Sounds (Beauchamp, 1987b), and central Westland
(Coleman et al., 1983)). The Cape Foulwind population lies in a different habitat from all of these 
sites. It is a mixed matrix of farmland, scrub, wetlands, forest on low and flat land with reliable
rainfall. This type of landscape appears to favour weka (McCellan, 2002; Coleman et al., 1983) and
locations with similar habitat such as the Chatham Islands also have high weka densities (A.
Beauchamp pers. com.)

Setting the parameters and aligning the model with expected variables required the
collection of some site specific data. These data are also required for model verification and testing
(Grim & Railsback, 2005). Tables 9.2 & 9.3 set out the weka and habitat parameter/variable data
used and also notes the data that were collected locally. Details of the methods used for the field
data collected in this research are set out in Chapter 8, and results presented in Chapter 12 along
with the IBM modelling results.

The weka IBM lacks particular site specific parameter (P) data on: (1) Minimum breeding age;
(2) Female minimum breeding weight; (3) Minimum age pair bonds; (4) Minimum weight before
death; (5) Cover requirements. Some local data were collected on these parameters which gave an
indication of their values.

The weka IBM lacks, in particular, site specific variable (V) data on: (1) Juvenile annual
survival rates; (2) Adult annual mortality; (3) % adults breeding per year; (4) Juvenile and adult
dispersal. Limited local data were collected on these variables which gave some indication of their
values. Other studies (Beauchamp, 1987a; F. Kemp pers.com; Marchant & Higgins, 1993) have shown
these variables (patterns) to be temporally highly variable within populations.

Reverse parameterization (inverse modelling) was also used in the IBM development to help
refine the parameters and variables. This involves refining parameters that there is little knowledge
of, but can be developed through fitting them to the rest of the model. This is effectively an element
of the pattern orientated modelling approach outlined in Section 9.4.3.4.1. The data collection
methods are discussed fully in Chapter 8 and the results in Chapter 12.
<table>
<thead>
<tr>
<th>Parameter/variable *</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P) Clutch size</td>
<td>Mean 1.1 (1-6 range)* 2.8 (Marlborough Sounds)</td>
<td>Coleman et al., 1983 Beauchamp, 1987b</td>
</tr>
<tr>
<td>(V) Max broods per year</td>
<td>4 (depends on food supply)</td>
<td>Carroll, 1963; Marchant &amp; Higgins, 1993 This Study</td>
</tr>
<tr>
<td>(V) Breeding success</td>
<td>Average 27.1% pairs successful each year (Kapiti Island) Marlborough Sounds varied with food availability 75% pairs successful each year*</td>
<td>Beauchamp, 1987a Marchant &amp; Higgins, 1993; Beauchamp, 1987a This study</td>
</tr>
<tr>
<td>(V) Juvenile annual mortality</td>
<td>32% mean over 10 years* 20% to 70% over 5 years*</td>
<td>Fiona Kemp (pers.com) at Whitikau. Beauchamp, 1987a</td>
</tr>
<tr>
<td>(V) Adult annual mortality</td>
<td>Average 14% (max 37%) territorial birds death or displacement* 37.5% (1985) territorial birds death or displacement (Marlborough Sounds)*</td>
<td>Beauchamp, 1987a Beauchamp, 1987</td>
</tr>
<tr>
<td>(P) Incubation period</td>
<td>27 days*</td>
<td>Beauchamp, 1987a; Marchant &amp; Higgins, 1993</td>
</tr>
<tr>
<td>(P) Parental care period</td>
<td>Up to 60 days in Marlborough Sounds Up to 80 days*</td>
<td>Beauchamp, 1987b This study</td>
</tr>
<tr>
<td>(V) Breeding season</td>
<td>Spring in Marlborough Sounds Aug-Nov with some breeding throughout the year*</td>
<td>Beauchamp, 1987b, 2004 This study</td>
</tr>
<tr>
<td>(V) Breeding success (number of chicks)</td>
<td>Varied 0.4 to 1.1 fledging per pair (Kapiti Island). 1 – 4 (average = 1.5)*</td>
<td>Beauchamp 1987a This study</td>
</tr>
<tr>
<td>(V) Lifespan</td>
<td>6.5 years (mean) Kapiti Is* 4 years (mean) Marlborough Sounds*</td>
<td>Beauchamp 1987a Beauchamp 1987</td>
</tr>
<tr>
<td>(V) Age classes</td>
<td>Motu population 21% &gt; 5 years old* Double cove c.25% &gt; 5 years old*</td>
<td>Beauchamp 2004 Beauchamp 1987b</td>
</tr>
<tr>
<td>(P) Pair bonds</td>
<td>Tend to last lifetime unless one partner dies*</td>
<td>Beauchamp 1987a</td>
</tr>
<tr>
<td>---------------</td>
<td>---------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>(V) Sex ratios</td>
<td>53% male and 47% female (adults at Cape Foulwind)*</td>
<td>This study</td>
</tr>
<tr>
<td>Growth rate</td>
<td>Depends on food supplies. On West Coast tend to be good*</td>
<td>Beauchamp, 1987a; Beauchamp, 2004</td>
</tr>
<tr>
<td>(P) Minimum breeding age</td>
<td>150-270 days Females 18 months in Marlborough Sounds One male bird found breeding at 12-14 months*</td>
<td>Beauchamp, 1987a; Beauchamp, 1987b</td>
</tr>
<tr>
<td>(V) Territory size</td>
<td>4.5 ha (mean) 10ha(max) 3.0 ha (mean) (0.3 ha min. 7.5 ha max.)*</td>
<td>Coleman et al., 1983</td>
</tr>
<tr>
<td>(V) Home range area size</td>
<td>11.9 ha mean (0.5 ha min – 69ha max) Mostly forest habitat 1.0 – 7.5 ha 3.0 ha (mean) (0.3 ha min. 7.5 ha max.)*</td>
<td>Coleman et al., 1983</td>
</tr>
<tr>
<td>(V) Percentage of sub-adults/non-territorials</td>
<td>6 - 12% Marlborough Sounds 30% average (Kapiti Island) (but varied considerably)*</td>
<td>Beauchamp, 1987b</td>
</tr>
<tr>
<td>(P) Juvenile weight at independence</td>
<td>500-800 g*</td>
<td>Coleman et al., 1983</td>
</tr>
<tr>
<td>(P) Adult movement</td>
<td>Up 1km for food Sub-weka may move up to c.5km*</td>
<td>Marchant &amp; Higgins, 1993</td>
</tr>
<tr>
<td>(V) Juvenile dispersal</td>
<td>At ~ 60 days move beside parents then within 120 days move further away (up to &gt; 9km and 2 km per day) 0 - 1150 m (n = 5)*</td>
<td>Beauchamp 1987a</td>
</tr>
<tr>
<td>(P) Juveniles dispersing outside natal area</td>
<td>c.80-90% c.75%*</td>
<td>Beauchamp 1987a</td>
</tr>
<tr>
<td>(P) Female min breeding weight</td>
<td>750-800g (estimate from my data)*</td>
<td>This study</td>
</tr>
<tr>
<td>(P) Minimum age pair bonds</td>
<td>364-728 days 150-200 days*</td>
<td>Beauchamp, 1987a</td>
</tr>
<tr>
<td>(P) Minimum weight before death</td>
<td>200 gm below expected weight for size*</td>
<td>Beauchamp, 1987a</td>
</tr>
</tbody>
</table>
Table 9.3 IBM Parameters – Habitat. (P) indicates a parameter and (V) a variable.

<table>
<thead>
<tr>
<th>Parameter/variable</th>
<th>Value</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P) Cover</td>
<td>Spatially variable*</td>
<td>Estimated for Cape Foulwind habitat types</td>
</tr>
<tr>
<td>(P) Mortality risks</td>
<td>Spatially variable Depends on a range of factors: 1. Predation; 2. Disease; 3. Food supply - Climate variability; 4. Road-kill - Cape Foulwind c.500-600 birds pa*</td>
<td>Estimated for Cape Foulwind habitat types Freeman, 2010</td>
</tr>
<tr>
<td>(P) Corridors</td>
<td>Not considered vital for dispersal movement. Weka observed 50-200m from cover in open ground at night*</td>
<td>This study</td>
</tr>
<tr>
<td>(P) Climate</td>
<td>Used a random variation around a mean*</td>
<td></td>
</tr>
<tr>
<td>(P) Water</td>
<td>Assumed to be adequate and available at Cape Foulwind*</td>
<td></td>
</tr>
</tbody>
</table>

* Which version of the parameter or variable was actually used in the weka IBM.

9.4.7.1 Model controls

The model allows control over the initial setup of: (1) The number of adults and juveniles; (2) Annual mortality; (2) Food production on developed and undeveloped pasture; (3) Food consumption rate; (3) Home range/territory sizes; (4) Number of chicks per brood; (5) Female breeding weight. The model controls also allow for changes in the base-maps. Base-maps from the New Zealand landcover database version II (LCDBII) at 1:25000 scale were utilised. The Cape Foulwind area was broken in four base-map sub-areas (called NW, NE, SW, SE) and each sub-area modelled separately. This is because the entire area was too large to run in the model at a scale of...
1:25000. Figure 9.3 shows an example of a base-map used in the model for the north western area of the Cape Foulwind modelling area. These maps were adjusted to show the expected land cover in the various scenarios (e.g., present, development).

![Figure 9.3 An example of LCDBII base map used in the weka IBM. This pictures the NW area showing present development. Different colours indicate various habitat types.](image)

### 9.4.8 Model analysis

There are two main parts to model analysis. The approach used was based on the one used by An et al. (2005). The first part involves testing the model for proper functioning of the programming, and testing for software coding errors (verification). The second part involves analysing the general behaviour of the IBM in relation to its formulation and how well it reflects empirical patterns (validation). A number of methods were used to undertake model verification and validation (Table 9.4). Ultimately, verification and validation are not separate processes and often the validation of model formation is bundled up with verification of the software (Grimm & Railsback, 2005). This model testing process also required the establishment of a default baseline model. Once verification and validation were completed the model was used to simulate various scenarios and for complexity exploration.
All of the model analysis remained simple and did not use statistical tests. This is due to the qualitative nature of the model, which means refined statistical testing would not be valid. It would also give the impression the model is producing outputs that have an implied accuracy that does not actually exist.

Table 9.4 IBM test methods (based on An et al., 2005)

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Testing stage</th>
<th>Content</th>
<th>Completed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Verification</td>
<td>Progressive building and debugging</td>
<td>Beginning to completion</td>
<td>Spot checks, visual pattern checks, code reviews</td>
</tr>
<tr>
<td>2. Validation</td>
<td>Empirical validation</td>
<td>Beginning to completion</td>
<td>Individual &amp; population validation See Table 9.7</td>
</tr>
<tr>
<td>3. Experience/expert opinion</td>
<td>On completion</td>
<td>See Table 9.8</td>
<td>Yes</td>
</tr>
</tbody>
</table>

# This uses the most sensitive variables from the sensitivity analysis.

9.4.8.1 Software verification

Software testing or verification is required to ensure that the software version of the model faithfully reflects the model formulation and also checks the software for errors in the code. This testing can be difficult because the outcomes of the model tend to be complex so identifying software errors can be difficult. However, it is important to do because the emergent properties of the interacting agents exist only in the software and not in the actual model formulation (Ropella et al., 2002).

The reliance of IBMs on the robustness of the software in producing modelling outcomes has made many ecologists wary of their validity. An important part of increasing an IBM’s credibility is through implementing a thorough testing and verification process in model development. According to Ropella et al. (2002), this has been inadequately addressed in many IBM developments.

In general, the testing and verification should include the following aspects (Ropella et al., 2002; Grimm & Railsback, 2005):

- **Design the model before implementing its code.** Some basic sub-models were designed initially for the weka IBM;
• Provide the ability to observe all parts of the model. An extensive set of outputs (e.g., graphs, histograms, parameter read-outs) were developed for the weka IBM;

• Understand how the model executes. Flow diagrams of all sub-models and the overall model were developed to aid understanding;

• Have other people critically review the code. This has not been done because no one was available when needed;

• Develop diagrams and written descriptions of the code to aid understanding. Flow diagrams of all sub-models and the overall model were developed to aid understanding;

• Develop multiple representations of the model and its software and run parallel testing. This was done to some extent as model development occurred;

• Use a well proven and commonly used software platform dedicated to IBM. Netlogo version 4.1 has been used;

• Test software throughout the model development cycle using a planned, multi-level, experimental strategy (e.g., spot checks, extreme input tests). This was undertaken during model development at sub-model and full model levels;

• Provide tools for thorough testing and verification (e.g., visual displays). An extensive set of outputs (e.g., graphs, histograms, parameter read outs) were developed for the model;

• Thoroughly document testing regime. The testing regime was documented.

Model verification runs in parallel with the model development and model validation process. A recommended technique is to develop the model slowly by starting a simple model and only adding new features once it has been thoroughly tested (An et al., 2005). This approach was used with the weka IBM. Testing included checking each sub-model as it was developed and the full model as they were integrated into it. This debugging process was progressive and iterative as construction and verification of the model requires ongoing adjustments to the software, that in turn need testing.

Model verification also included uncertainty testing to check the robustness of the model under a range of parameter conditions. This included both extreme tests and combination tests. Model design flaws or programming bugs can be indicated by the tests giving unrealistic results during these tests. Extreme tests involve setting each major mechanistic parameters to their realistic minimum and maximum values (Table 9.5). Combination testing involved a set of model runs combining the most sensitive parameters (Table 9.6).
<table>
<thead>
<tr>
<th><strong>Parameter</strong></th>
<th><strong>Definition</strong></th>
<th><strong>Default value</strong></th>
<th><strong>Min, Max</strong></th>
<th><strong>Mean weka population at 10 years</strong></th>
<th><strong>Mean weka population at 15 years</strong></th>
<th><strong>Mean weka population at 20 years</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Clutch size</td>
<td>Mean clutch size</td>
<td>3, 6</td>
<td>1, 2</td>
<td>1242 (186)</td>
<td>1245 (206)</td>
<td>1205 (218)</td>
</tr>
<tr>
<td>Annual mortality</td>
<td>Background mortality (% p.a.)</td>
<td>12%, 25%</td>
<td>1%, 10%</td>
<td>2042 (307)</td>
<td>1967 (269)</td>
<td>1917 (264)</td>
</tr>
<tr>
<td>Hunger days (juveniles)</td>
<td>Number of days die without enough food</td>
<td>80, 120</td>
<td>10</td>
<td>373 (158)</td>
<td>266 (151)</td>
<td>147 (66)</td>
</tr>
<tr>
<td>Initial sex ratios</td>
<td>% of males in population</td>
<td>53, 120</td>
<td>80</td>
<td>1932 (266)</td>
<td>1908 (304)</td>
<td>1879 (268)</td>
</tr>
<tr>
<td>Home range and territory size</td>
<td>Mean home range and territory size (ha)</td>
<td>1 (5 ha), 2 (13 ha)</td>
<td>0 (1 ha)</td>
<td>44 (32)</td>
<td>6 (3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Juvenile weight</td>
<td>Juvenile weight at independence</td>
<td>500, 2 (13 ha)</td>
<td>300</td>
<td>2236 (322)</td>
<td>2166 (343)</td>
<td>1912 (491)</td>
</tr>
<tr>
<td>♀ breeding weight</td>
<td>Minimum ♀ breeding weight</td>
<td>750, 850</td>
<td>300</td>
<td>2776 (370)</td>
<td>2738 (465)</td>
<td>2500 (371)</td>
</tr>
<tr>
<td>Home range and territory cover</td>
<td>Chance of establishing terr/home range in various cover amounts</td>
<td>100, 90</td>
<td>50</td>
<td>2300 (287)</td>
<td>2157 (277)</td>
<td>2023 (489)</td>
</tr>
<tr>
<td>Juvenile dispersal</td>
<td>% Juveniles dispersing</td>
<td>50, 90</td>
<td>10</td>
<td>1549 (307)</td>
<td>1479 (283)</td>
<td>1309 (249)</td>
</tr>
<tr>
<td>Non-territorial movement</td>
<td>% non-territorial adults able to move away from their home range</td>
<td>30, 90</td>
<td>10</td>
<td>1409 (463)</td>
<td>1232 (438)</td>
<td>1093 (436)</td>
</tr>
<tr>
<td>Annual food</td>
<td>Variation in annual food</td>
<td>0.2, 90</td>
<td>0</td>
<td>1940 (415)</td>
<td>1933 (413)</td>
<td>1853 (396)</td>
</tr>
</tbody>
</table>
The parameters used for the extreme tests were mechanistic. Variables that were considered as having emergent properties were avoided, as they are not driving or controlling parameters. These included: (1) Juvenile survival; (2) Dispersal range; (3) Adult survival; (4) Adult weight. Some variables have an initial or underlying mechanistic element as well as an emergent element. These were also not included in the extreme testing. These were: (1) Sex ratios; (2) Percentage of females breeding; (3) Number of broods per year.

The most extreme variations in the results were associated with food availability (global food amount, annual variation, juvenile hunger, small home range/territory size) (highlighted in Table 9.5). There were also large variations associated with constraints on breeding success (female breeding weight, juvenile to adult weight). There were lesser impacts from small mean clutch sizes, percentage of dispersing juveniles, percentage of sub-adult/non-territorial movement, and high annual mortality.

Overall, the testing shows the model to be robust to parameter variations, as well as producing intuitively correct results. The extreme setting of some variables causes a collapse of the population as would be expected. Some of the more interesting results are the robustness of the model to high background mortality rates (as may be expected from high predation rates, etc.). However, higher rates still may reach a threshold causing a collapse – this is tested in the threshold testing (see Section 12.3.4). The model was sensitive to variations in the food supply, both in absolute terms, and temporally. The only variable where very high densities of an average of c. 1 weka per hectare were reached was with high global food availability.

### 9.4.8.2 Combination tests

This test (Table 9.6) uses the four most sensitive parameters from the sensitivity test (Table 9.8) and combines them into 16 different sets.
Table 9.6 IBM input parameter combination test. This test uses the four most sensitive parameters from the sensitivity test (based on An et al., 2005).

<table>
<thead>
<tr>
<th>Global Food amount</th>
<th>% juveniles dispersing</th>
<th>Developed pasture cover variation</th>
<th>Annual weather variation</th>
<th>Mean weka density over 20 years$</th>
<th>%difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8</td>
<td>30</td>
<td>2</td>
<td>0.1</td>
<td>Baseline 2097 (111)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
<td>1011 (193)</td>
<td>- 52%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>1232 (60)</td>
<td>- 42%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>1291 (226)</td>
<td>- 39%</td>
</tr>
<tr>
<td>70</td>
<td>2</td>
<td>0.1</td>
<td>Baseline</td>
<td>1515 (43)</td>
<td>- 28%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
<td>1347 (153)</td>
<td>- 36%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>1557 (43)</td>
<td>- 26%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
<td>1383 (287)</td>
<td>- 34%</td>
</tr>
<tr>
<td>1.3</td>
<td>30</td>
<td>2</td>
<td>0.1</td>
<td>Baseline 2250 (60)</td>
<td>+ 7%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
<td>2100 (229)</td>
<td>+ 0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>2266 (38)</td>
<td>+ 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>2199 (187)</td>
<td>+ 4</td>
</tr>
<tr>
<td>70</td>
<td>2</td>
<td>0.1</td>
<td>Baseline</td>
<td>2400 (43)</td>
<td>+ 14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.3</td>
<td>2232 (374)</td>
<td>+ 6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>2475 (38)</td>
<td>+ 18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.1</td>
<td>2387 (413)</td>
<td>+ 14</td>
</tr>
</tbody>
</table>

-Results from 16 combinations of 20 simulation runs of 20 simulation years.
-Model starts 2200 weka (2000 adults, 200 juveniles) @0.51 ha. Standard deviations are in brackets.
-The habitat map used for this analysis was LCDBII NE CF 1:25000 scale.

The model gives reasonable results across all the combinations. These results can give an indication of the relative importance of each parameter on weka densities. They show that global food supply has the largest effect on the weka density. Juvenile dispersal has the next biggest influence followed by developed pasture cover amount. However, there was only a relatively small amount of developed pasture in the habitat map used. Increased weather variation (0.3) caused decreased weka densities and considerably increased weka density variation. The lowest densities were recorded with a combination of low food, low dispersal, low cover and high weather variation. The highest densities occurred with high food, high dispersal, high cover and low weather variation.

### 9.4.8.3 Model validation

Model validation involves checking the correspondence between the empirical data, conceptual model and the software model. Models of complex open systems will never be completely validated in the manner of establishing mathematical proofs (An et al., 2005; Grimm & Railsback, 2005). However, being thorough about the validation process is important for the model's
credibility (Bousquet & Le Page, 2004). Validating a model includes considering the model’s structure and its parameterization.

There are a number of approaches to validating models. These include (Grimm & Railsback, 2005): (1) Comparing models or model versions; (2) Comparing output against observed data; (3) Sensitivity and robustness analysis; (4) Using experience and expert opinion of results; (5) Conducting controlled simulation experiments.

All of these methods were used for validating the weka IBM. A range of versions of the model and sub-models were developed and compared. Verification of the software and conceptual implementation was also checked through extreme and combination testing. Once this was done the model was parameterized and a baseline or default model developed by comparing output from the model against observed data (Table 9.7). Sensitivity analysis was then undertaken using the baseline model as a reference point (Table 9.8). An et al. (2005) did this by applying statistical t-tests between observed data and model outputs but, because of the qualitative nature of this model this quantitative approach was not considered necessary. The modellers’ own experience was also used in the validation process. Finally, designed controlled experiments were undertaken throughout the model development process. This involves a process of posing alternative hypothesis for individual behaviour and testing to see which one best reproduces the population level patterns (Grimm & Railsback 2005).

Both artificial and real landscape patterns (Landcover Database II maps of portions of the Cape Foulwind landscape) were used in the modelling. This allowed evaluation of the model results with population level observed empirical patterns. The use of artificial landscapes allows for experimentation of how landscape structures affect weka population patterns. It is hoped that this might give some understanding of what might be the best cover patterns to leave in place when land development occurs.

### 9.4.8.4 Baseline model

The basic validation of the model with empirical data was undertaken with all the settings at default for 30 simulations runs of 20 years. The output data were compared with the known and estimated empirical data to check for consistency (Table 9.7). Graphical representations of the results from Table 9.7 are set out in Figures 9.4 to 9.9.
Table 9.7 Comparison of baseline IBM outputs and empirical data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Known or estimated empirical values^</th>
<th>Values from model runs* &amp;</th>
<th>Min average from model runs*</th>
<th>Max average from model runs*</th>
<th>% difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dev. pasture adult density</td>
<td>0.24 (0.08)</td>
<td>0.26 (0.03)</td>
<td>0.19</td>
<td>0.31</td>
<td>+ 8%</td>
</tr>
<tr>
<td>Undev. pasture adult density</td>
<td>0.41 (0.21)</td>
<td>0.46 (0.05)</td>
<td>0.36</td>
<td>0.56</td>
<td>+ 11%</td>
</tr>
<tr>
<td>Scrub adult density</td>
<td>0.98 (0.49)</td>
<td>0.69 (0.09)</td>
<td>0.53</td>
<td>0.85</td>
<td>- 30%</td>
</tr>
<tr>
<td>Pākihi adult density</td>
<td>0.15 (0.14)</td>
<td>0.16 (0.03)</td>
<td>0.09</td>
<td>0.22</td>
<td>+ 6%</td>
</tr>
<tr>
<td>Wetland adult density</td>
<td>0.34 (0.33)</td>
<td>0.31 (0.09)</td>
<td>0.15</td>
<td>0.49</td>
<td>- 10%</td>
</tr>
<tr>
<td>Exotic adult density</td>
<td>0.5 (1.0)</td>
<td>0.40 (0.07)</td>
<td>0.28</td>
<td>0.54</td>
<td>- 20%</td>
</tr>
<tr>
<td>% holding territories</td>
<td>70-94%</td>
<td>61% (4.6)</td>
<td>30%</td>
<td>69%</td>
<td>c.20%</td>
</tr>
<tr>
<td>Average territory size (ha)</td>
<td>3 (0.3 – 7.5)</td>
<td>4.2 (0.2)</td>
<td>3.9</td>
<td>4.5</td>
<td>+ 71%</td>
</tr>
<tr>
<td>% females breeding</td>
<td>27 – 80%</td>
<td>65% (9.7)</td>
<td>41%</td>
<td>81%</td>
<td>c.10%</td>
</tr>
<tr>
<td>Annual juvenile mortality</td>
<td>20 - 70%</td>
<td>52% (10.6)</td>
<td>39%</td>
<td>71%</td>
<td>c.10%</td>
</tr>
<tr>
<td>Annual adult mortality</td>
<td>14 - 37%</td>
<td>31% (6.2)</td>
<td>24%</td>
<td>49%</td>
<td>c.15%</td>
</tr>
<tr>
<td>% age &lt; 1 year</td>
<td>12 – 38%</td>
<td>30% (7.9)</td>
<td>13%</td>
<td>43%</td>
<td>#</td>
</tr>
<tr>
<td>% age 1 – 3 years</td>
<td>10 – 79 %</td>
<td>26% (6.9)</td>
<td>13%</td>
<td>39%</td>
<td>#</td>
</tr>
<tr>
<td>% age 3 – 15 years</td>
<td>10 - 78 %</td>
<td>54% (8.8)</td>
<td>38%</td>
<td>70%</td>
<td>#</td>
</tr>
<tr>
<td>% age &gt; 5 years</td>
<td>21- 30%</td>
<td>34% (7.4)</td>
<td>21%</td>
<td>48%</td>
<td>c.10%</td>
</tr>
<tr>
<td>Average age</td>
<td>4</td>
<td>3.9 (0.4)</td>
<td>3.2</td>
<td>4.9</td>
<td>- 3%</td>
</tr>
<tr>
<td>Sex ratio</td>
<td>53%</td>
<td>56% (3.2)</td>
<td>48%</td>
<td>60%</td>
<td>+ 3%</td>
</tr>
<tr>
<td><strong>Individual level</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female weight</td>
<td>779</td>
<td>676 (18.3)</td>
<td>623</td>
<td>696</td>
<td>- 13%</td>
</tr>
<tr>
<td>Male weight</td>
<td>1150</td>
<td>958 (29.1)</td>
<td>867</td>
<td>990</td>
<td>- 17%</td>
</tr>
<tr>
<td>Chicks per female</td>
<td>1.5</td>
<td>1.8 (0.1)</td>
<td>1.6</td>
<td>2.0</td>
<td>+ 20%</td>
</tr>
</tbody>
</table>

* Averages from 30 simulation runs of 20 simulation years. Model starts with 2200 weka (2000 adults, 200 juveniles) @0.51 adult weka ha. Standard deviations of averages of all runs are combined in brackets.

^ See Table 9.2. Some parameters are not directly applicable to Cape Foulwind population
# These parameters are highly variable. These parameters are derived from the model though reverse parameterization and are considered realistic.
& The standard deviations between modelled adult densities and the empirical values are not directly comparable.
**Figure 9.4** Comparison of observed versus modelled data for adult weka densities in various habitats. The observed data is from observations made at Cape Foulwind.

**Figure 9.5** Comparison of observed versus modelled data for average adult weka weights. The observed data are averages from observations made at Cape Foulwind.
Figure 9.6 Comparison of observed versus modelled data for percentage of females breeding per year. Note: Modelled minimums and maximums are averages over 20 model runs. The actual minimums and maximums for any one model run are likely to more closely reflect the observed figures.

Figure 9.7 Comparison of observed versus modelled data for annual juvenile mortality. Note: Modelled minimums and maximums are averages over 20 model runs. The actual minimums and maximums for any one model run are likely to more closely reflect the observed figures.
Figure 9.8 Comparison of observed versus modelled data for annual adult mortality. Note: Modelled minimums and maximums are averages over 20 model runs. The actual minimums and maximums for any one model run are likely to more closely reflect the observed figures.

Figure 9.9 Comparison of observed versus modelled data for age classes. Note: Modelled minimums and maximums are averages over 20 model runs. The actual minimums and maximums for any one model run are likely to more closely reflect the observed figures.
Figure 9.10 Percentage of females breeding annually. Plots from 20 model runs of 60 years using map LCDBII NW 1:25000 scale with no development. The graph displays a considerable amount of variation amongst model runs.

Figure 9.11 Annual juvenile mortality. Plots from 20 model runs of 60 years using map LCDBII NW 1:25000 scale with no development. This graph displays a considerable amount of variation amongst and within model runs.
Figure 9.12 Annual adult mortality. Plots from 20 model runs of 60 years using map LCDBII NW 1:25000 scale with no development. This graph displays much less variation amongst and within model runs than juvenile mortality in Figure 9.11.

The baseline model gives a representative set of outputs across a range of parameters at both the individual level and population levels (Table 9.7). This includes averages that align closely with known empirical data at a population and individual level (Figures 9.4 to 9.9)) as well as realistic amounts of annual variation in outputs (e.g., percentage females breeding, juvenile mortality, adult mortality, (Figures 9.10, 9.11, 9.12). The most important empirical parameters are those gathered on this weka population as part of this study (i.e., adult habitat densities, weka weights, sex ratios). A good correlation is shown between this data and model outputs. An exception to this is a larger variation in territory size in the empirical data, which was related to the constraints of the model.

The ability of some of the model outputs to align with the empirical data is compromised due to a considerable amount of imprecision in some of the empirical data. The model itself helps reduce this lack of accuracy through reverse parameterization (e.g., age classes).

9.4.8.5 Sensitivity analysis

Sensitivity analysis can supply important information about how the model operates. A model that is not overly sensitive to parameter changes is considered robust and likely to be more representative of actual systems which tend to include multiple feedback and compensatory....
mechanisms. A very sensitive model is undesirable given the uncertainty in model inputs. Parameters that are found to be most sensitive to change (i.e., cause the largest changes in the model outputs) need the more refined empirical data (An et al., 2005; Grimm et al., 2005).

A sensitivity analysis of the final model was undertaken by varying certain parameters over a range of values (+ 50%). This was done in Netlogo using the built in ‘behaviour space’ tool. Behaviour space is a batch processing tool that allows parameters to be systematically varied alone, or in combination, over succession of model runs. Details of the sensitivity analysis are noted below in Table 9.8. The habitat map used for this analysis was LCDBII NE 1:25000 scale.

**Table 9.8 IBM sensitivity tests for model input parameters (based on An et al. 2005)**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default value</th>
<th>+50% perturbation</th>
<th>Mean weka density over 20 years</th>
<th>Different from baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baseline</strong></td>
<td></td>
<td></td>
<td>2097 (111)</td>
<td></td>
</tr>
<tr>
<td><strong>Environmentally based parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual mortality</td>
<td>12%</td>
<td>17%</td>
<td>2014 (105)</td>
<td>- 4%</td>
</tr>
<tr>
<td>Clutch size</td>
<td>3</td>
<td>5</td>
<td>2388 (119)</td>
<td>+ 14%</td>
</tr>
<tr>
<td>Sex ratios</td>
<td>53</td>
<td>79</td>
<td>2093 (87)</td>
<td>- 0%</td>
</tr>
<tr>
<td>Juvenile dispersal</td>
<td>50%</td>
<td>75%</td>
<td>2243 (108)</td>
<td>+ 7%</td>
</tr>
<tr>
<td>Home range/territory size</td>
<td>1</td>
<td>2</td>
<td>1990 (104)</td>
<td>- 5%</td>
</tr>
<tr>
<td>Developed pasture cover</td>
<td>2</td>
<td>3</td>
<td>2205 (103)</td>
<td>+ 5%@</td>
</tr>
<tr>
<td>Adult movement</td>
<td>30%</td>
<td>50%</td>
<td>2028 (118)</td>
<td>- 3%</td>
</tr>
<tr>
<td>Annual weather variation</td>
<td>0.2</td>
<td>0.3</td>
<td>1847 (352)</td>
<td>- 12%</td>
</tr>
<tr>
<td>Global food availability</td>
<td>1.0</td>
<td>1.5</td>
<td>3013 (479)</td>
<td>+ 44%</td>
</tr>
<tr>
<td><strong>Internal biological parameters</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juv-adult weight</td>
<td>500</td>
<td>750</td>
<td>1360 (101)</td>
<td>- 35%</td>
</tr>
<tr>
<td>♂ Breeding weight</td>
<td>750</td>
<td>1125</td>
<td>1151 (457)</td>
<td>- 45%</td>
</tr>
<tr>
<td>Hunger days</td>
<td>-80</td>
<td>-40</td>
<td>1869 (133)</td>
<td>- 11%</td>
</tr>
</tbody>
</table>

# A 50% perturbation range used because: (1) it should not so large that it becomes an extreme test (2) it needs to produce a measurable response in weka density.

$ The standard deviation in parenthesis follows the average value.

@ This output depends on the amount of the developed pasture type being modelled – there was only 3% of developed pasture in this test model.

Results are from 30 simulation runs of 20 simulation years. Model starts 2200 weka (2000 adults, 200 juveniles) @0.51 ha.

The sensitivity testing (Table 9.8) shows the model has a high sensitivity to many weka internal biological parameters. The values for these variables were decided as part of the model development process and testing to produce the most robust and empirically valid model. They have
been included here to show their importance in relation to environmental parameters. Their sensitivity shows there is a considerable amount of uncertainty around the model’s outputs in a quantitative sense. However, the overall less sensitive environmental parameters suggest some qualitative (trends) validity to model outputs. The external or environmental parameters in relation to landscape changes are the ones that were modelled further in the combination testing (Table 9.6). The four most sensitive of these parameters were chosen: Global food availability; Juvenile dispersal; Developed pasture cover variation; Annual weather variation. (Clutch size was not used as it is directly related to changes in food availability which is covered by two other parameters. Cover amount was included as it is locally anthropocentrically driven and the focus of the IBM. Juvenile dispersal too may be influenced by land development.). Some general outcomes from the sensitivity analysis were:

- Initial sex ratios have no influence as 50/50 birth rates soon equalize the ratios;
- Increases in background annual mortality did not have large impacts on the population in the model as compensatory feedback occurs;
- The population tended to more unstable (higher standard deviations) with the inclusion of variables with large differences from the baseline (global food availability, breeding weight). Increased annual variations in weather, which affects food supply, also created greater instability;
- Larger homerange/territory sizes did not produce an increase in population;
- Juvenile dispersal had a larger effect than adult movement.
10 Fuzzy cognitive maps

10.1 Introduction

The aim of the chapter is to introduce and give some background on the development and use of fuzzy cognitive maps. First, it discusses the concept of fuzzy logic. It then introduces the biological basis of neural networks, and gives a brief description of developments in artificial neural networks. It then gives an overview and description of the functioning of FCMs. Finally, it discusses the development of FCMs for use by lay people and methods to analyse FCMs.

Fuzzy cognitive maps were used as a way to gather information from landowners about their understanding of the role of weka on their properties. They were also used as a social scenario modelling technique and linked with the IBM into a socio-ecological model. One of the advantages of FCMs in this context over other social scenario modelling techniques, such as agent based modelling, is that the representation of the system is made up of the actors’ understandings rather than ones imposed by the modeller. A limitation with FCMs, however, is that they are not fully dynamic in that temporal change in people’s understandings is not represented without developing subsequent maps.

There has been some use of fuzzy cognitive maps for developing expert ecological models (Ramsey & Veltman, 2005; Hobbs et al., 2002). In this context they have been used as an alternative and qualitative approach to modelling dynamic systems when the availability of quantitative data is limited or cannot be obtained (Ramsey & Veltman, 2005). However, it appears fuzzy cognitive maps have not been used widely beyond the work of Özesmi (Özesmi 1999; Özesmi & Özesmi, 2004; Özesmi, 2006) for eliciting and modelling lay persons’ understandings of ecological systems. Giordano et al. (2005) developed lay person cognitive maps and compared these with local land managers’ cognitive maps. They then applied a methodology based on fuzzy semantic distance for analysis of the cognitive maps. This is a different use of FCMs from that used by Özesmi and FCM use in this research. This is because Giordano et al. (2005) analyse variation in understandings between managers and lay people rather than modelling the system itself.

10.2 Fuzzy Logic

When studying the world through a systems framework it becomes clear that system description and scale delineation is often difficult. Associated with this is the problem of how to group system elements. In dynamic systems these grouping are not stable and elements may not clearly lie in any particular group (McGlade, 1999). McGlade (1999) suggests that one way to address this problem is through the use of fuzzy logic. She argues that Fuzzy logic’s fundamentally multivalent
approach to the representation of causal relationships may indeed be a better approach for ecological system characterization than bivalent approaches.

Relatedly, in setting out a case for fuzzy logic, Kosko (1993) considers the difference between logical truths and factual truths. Logical truths reside and are proven within the formal relationships of a symbolic system. Factual truths lie in statements made in natural language that describe the relationships of things in general. In the former, truth is internal to the system and relates to the coherence of the system itself (e.g., mathematics). The formal relationships between symbols are either considered to be true or false. However, these can only be proven within the system itself. In factual truths, statements only correspond to things. Statements may be largely true but they are also a little bit false. Kosko (1993) suggests there is a gap or fuzzyness between how we speak of the world of objects and the objects themselves. However, the position developed in this study avoids this language/object separation and suggests that language reflects a fuzzy world. Regardless, according to Kosko (1993), bivalence based systems miss much of fuzziness by removing the graduations that are implicit in how we speak of the world and that are in the world. According to Kosko (1993) scientific knowledge is caught between the gray graduated empirical world and the bivalent logic of mathematics and scientific causal reasoning. Kosko (1993) also discusses how paradox and contradiction can be considered half true and half false and fuzzy logic handles these without difficulty by not asserting that there are just true and not-true positions. Fuzzy logic lies as an important aspect of fuzzy cognitive maps as do neural networks discussed below.

10.3 Neural Networks

Artificial neural networks are simplified mathematical models of the parallel processing architecture of biological systems. The human brain is an example of an extremely complex biological neural network. Biological neural networks are made up of cells called neurons. Neurons are interconnected with other neurons via structures called dendrites, axons and synapses. Dendrites and the neuron body are areas where transmitted information is received from other neurons. The information is passed via chemical changes at sites called synapses. The neurons do not actually join at the synapses but are separated by a microscopic gap called the synaptic cleft. Axons are the structures that transmit information to other neurons again via synapses (Korn, 1991). The human brain contains perhaps 100 billion neurons each of which has up to 10,000 synaptic connections. Because the neurons are massively interconnected and their activities occur in parallel, complex feedback mechanisms emerge (Kosko, 1993).

The chemical transmitters (neurotransmitters) at the synaptic gaps can either be excitatory or inhibitory. Some synapses tend to involve excitatory connections and some inhibitory. The amount
of excitation or inhibition (termed excitatory or inhibitory post-synaptic potentials) varies at each individual synapse. Inhibitory transmitters can cancel out the effects of excitatory transmitters. The sum of excitatory and inhibitory input received by the entire neuron (not the synapse) determines whether or not a neuron will ‘fire’ an action potential. This occurs when a certain summed threshold of excitatory transmitters is reached. This activation is transmitted along the axon as an electrical pulse. This in turn causes a chemical secretion at the synaptic gaps which then causes stimulation of the connected neuron/s. If this stimulation, along with stimulation from other neurons via other connected synapses, reaches a certain threshold level the following neuron/s will then also be activated. When a neuron activation occurs it will generally cause one pulse, however, large net excitatory input can cause neurons to pulse repeatedly (bursting). Due to physiological reasons (i.e., a neurons ‘refractory’ or resting period) this has a maximum frequency of approximately 1 kHz (Korn, 1991).

Learning occurs as the rate, type and amount of neurotransmitter released at each synapse adjusts and changes through stimulation. Consequently, patterns are produced in the mesh of neurons and synapses. These patterns can be thought of as an area of neurons resonating (Kosko, 1993). However, the exact mechanisms of synaptic plasticity and its relationship to learning are not well understood (Peretto, 1992).

Artificial neural networks attempt to model this process but are orders of magnitude less complex than biological neural nets. Like their biological counterparts, key features of artificial neural networks are the acquisition of knowledge through learning and the storage of that knowledge within inter-neuron connection strengths called synaptic weights (i.e., defined in terms of network changes). In its basic design an artificial neural net has its neurons organised in layers. Each layer is connected to the neurons in the preceding and following layers (or the input and output layers). All but the simplest neural nets have three or more neuron layers, which means at least one layer is ‘hidden’. Data are input into the neural net and propagated layer-by-layer from input layer to output layer through the neuron layers. At each neuron weighted inputs (i.e., each input weighted by the corresponding weight of the connection or input weight) are presented on its input connections and these values summed. The resulting value is compared with a certain threshold value by the neuron’s activation function. If the input exceeds the threshold value, the neuron will be activated, otherwise it will be inhibited. If it is activated, it sends an output on its outgoing connections to all connected neurons that receive it as a weighted input. This process continues through the network. Depending on the learning algorithm it is also possible that information is propagated backwards internally through the neural net. This allows more sophisticated learning (Peretto, 1992).
Neural network learning or training can either be ‘supervised’ or ‘unsupervised’ depending on the type of network and the learning algorithm used. Supervised learning involves presenting known input and output patterns repeatedly to the network (i.e., the output from the previous run becomes the input for the subsequent run). The network’s parameters (weights) are then adjusted until a suitably low error between the actual and predicted outputs is obtained or the network no longer continues to learn (Korn, 1991). In an unsupervised network, the network adapts purely in response to its inputs without the required output being specified. These networks can learn to identify structure in their input and are used for classification, compression and clustering of data. These unsupervised networks are used for the fuzzy cognitive map analysis discussed in the following section.

There are a number of types of neural networks. The simplest is the static feed-forward networks also known as perceptron networks. In their most simple form they use one or two layers of neurons and have no external or internal feedback mechanisms. They use learning rules such as the Hebbian learning rule. The Hebbian learning rule involves changing of neuron input weights by multiplying a neuron's input with its output and the network’s learning rate (Korn, 1991). This is a mathematical depiction of the Hebbian rule’s underlying assumption that if an input causes the output to increase then the connection strength between them should increase. Learning rate indicates the rate of this increase and thus it allows for gradual changes in weights in a learning setting that aims to minimise the network prediction error.

More sophisticated networks also use internal local feedback of inputs between neuron layers. This is in contrast to the forward pass of inputs from the input to output layer that is used in the feed-forward networks. Examples of these dynamic feedback networks are the Hopfield networks and Kohonen feature maps. Hopfield network architecture consists of a set of neurons, where each neuron is connected to each other neuron and there is no differentiation between input and output neurons. Hopfield networks are mostly used for the storage and recognition of patterns (pattern-associators). Because of their symmetrical connections, these networks tend to settle into distinctive activation patterns for varying inputs or initial conditions. For pattern recognition applications, neural networks are trained to associate a range of input patterns with a particular output pattern. In auto-associative pattern-associators the output is a “corrected” version of the input itself (Korn, 1991).

Auto-associative neural network architecture is the basis of FCM (Reiman, 1998 cited in Özesmi, 1999). Kosko (1993) developed bidirectional associative memory (BAM) architecture for analysis of FCMs. This is a development of a Hopfield network using a simplified circuit arrangement (Korn, 1991). FCMs also use a development of the Hebbian learning rule that Kosko (1993) calls the
differential Hebbian learning rule. Differential Hebbian learning says that if a change in node A has a corresponding upward or downward change in node B the connection strength goes up. If a change in node A leads to an opposing movement in node B the connection strength goes down.

10.4 Fuzzy Cognitive Maps

Fuzzy cognitive maps (FCM) have their roots in graph theory and ‘digraphs’ (directional graphs) used by quantitative anthropology for structural analysis of observations (Özesmi, 2006). Axelrod expanded digraphs for use by the informants themselves, which he called cognitive maps. In 1986 Kosko integrated cognitive maps with fuzzy logic and so developed fuzzy cognitive maps as well as a method to analyse the maps within a neural network. Carley developed some statistical techniques to use with FCM and social groupings in 1988 (Özesmi, 2006).

FCMs are suitable for modelling of domains that are characterized by qualitative or imprecise data expressed verbally. These domains often involve many issues that are interrelated in complex ways. FCMs allow feedback amongst their concept nodes. This is an important part of the dynamic nature of the maps as it allows causal effects to be spread around the FCM through a sequence of interactions. Cognitive maps do not incorporate these feedback mechanisms. The feedback mechanisms and subsequent emergent properties cannot be easily incorporated into linear models (Kahn & Quaddus, 2004).

FCMs consist of a network of interconnected nodes whose structure represents ‘fuzzy’ degrees of causality between the nodes. As has been implied above, FCMs can be viewed as being analogous to a neural network. The nodes are analogous to neurons and the causal links to synaptic weights. The construction of a FCM requires the identification of a set of variables representing the system. These may include logical propositions, assertions, etc. that are called state variables. The state variables or nodes \((C_i, C_j)\) are connected together by directed edges or arcs. The arcs \((e_{ij})\) are given a weighting that indicates the relative strength of the interaction between the two associated nodes. The edges are directed to indicate the direction of the effects between the nodes. The weighting range lies between the values of \(-1\) and \(1\). These represent full –ve or +ve causality, respectively. The values between these represent different levels of fuzzy causality between the nodes (Hobbs et al., 2002).

The mathematical state or snapshot of a FCM can be represented as a bit vector which shows the node activation state. For example, the state vector of a FCM with six nodes \((011000)\) shows that nodes two and three are activated and the other four are not. The causal arcs \((e_{ij})\) linking the nodes are represented as an \(n \times n\) two dimensional adjacency matrix \((E)\), where if \(n\) is the number of nodes, and the number of elements in the matrix is \(n^2\) (Figure 10.1) (Kahn & Quaddus, 2004)
Figure 10.1: FCM adjacency matrix for 5 concept nodes. Node 1 is represented by row 1 and column 1 and node 2 by row 2 and column 2 etc. The arc weightings going out of each node are represented by the columns and the arc weighting going in to each node by the rows.

$$E = \begin{pmatrix}
0 & 0 & 0.3 & -0.3 & 0 \\
-0.4 & 0.9 & 0.2 & 0 & 0 \\
0.2 & 0 & -0.3 & 0.2 & 0.6 \\
0 & 0 & 0 & 0 & 0 \\
-0.2 & 0.1 & 0 & 0.5 & -0.3
\end{pmatrix}$$

One of the most useful aspects of developing an FCM is that it allows the nodes \(C_i\) and causal arcs \(e_{ij}\) representing the relationship between the corresponding concepts to interact with each other in the form of a neural network as a dynamical system. This dynamic analysis of an FCM is sometimes called “tuning”. Mathematically, tuning is achieved by multiplying the initial state vector values \(C_n\) (i.e., node states) with the adjacency matrix \(E\) to generate in one calculation step the values of the weighted sum of inputs going into all nodes and repeating this process up to a maximum of approximately 30 phases until the node activations either stabilise or do not. Implicit in this calculation is the fact that the activation function is linear and therefore, the weighted sum of inputs becomes the node output. Like a neural network and due to the interconnection of the nodes the new output value of any one node depends upon the present values of all the other nodes. In simple terms the computation of node outputs is achieved by summing all weighted inputs into the nodes followed by the application of a linear function at each time step which determines the level of activation of the nodes. This is generally described by \(f\sum C_i e_{ij}\) where \(f\) is the activation function. Commonly used activation functions for FCMs include sigmoid, logistic and linear functions (Kahn and Quaddas, 2004). I used a linear function \(1/(1+e^{-1*x})\). This transforms the node output into the continuous interval of \([0,1]\) (Figure 10.2).
Figure 10.2 Computation of a node’s output. $C_1(k) \ldots C_i(k)$ represent the states of nodes connected to node $j$ and $e_{ij}$ are the arc weights between other nodes and node $j$ at time $k$. $C_j(k+1)$ is the output of Node $j$ at time $k+1$ following computation by $f(\sum C_i e_{ij})$.

Tuning an FCM can show the patterns lying in the connection weights and nodes that represent the state the system will find itself in given the cause-effect relationships and the feedback structures that are embedded within it. Tuning can show whether single assertions are consistent with a proposed network of understandings described in the FCM as a whole. Through tuning, many FCMs tend to converge to an equilibrium point, where the node activation pattern stabilises. Kosko (1993) calls this an ‘attractor basin’. Some FCMs may cycle between attractor basins; others still may not have a definable attractor basin but act in a chaotic manner (Kosko, 1993).

Tuning also allows the possibility of setting (clamping) the initial state vector (node) values to represent a particular system state you wish to investigate. For example, one of the state vector (nodes) may be set to “on” (which might represent an increase in the prices obtained for farm outputs) and the other nodes set to “off”. The tuning of an FCM can be used to predict the future state of the system given the “what-if” question proposed by the initial state vector settings (i.e., high farm output prices) (Kahn & Quaddus, 2004). If the tuning results in the node states stabilising at a fixed point equilibrium it gives a deterministic outcome on the state the system will produce. In contrast, a system that stabilises into a cyclic pattern will indicate a likely cycle of events the system will produce. Chaotic patterns obviously suggest a less stable dynamical system (Kahn et al., 2003).

Developments of FCMs include taking into account time delay or sequencing of the causal events (Kahn & Quaddus, 2004). In addition, Carvalho & Tome (1999) propose rule based FCMs to address FCMs’ limitations in addressing non-monotonic and non-symmetrical causal relationships.
Vasantha Kandasamy & Smarandache (2003) proposed a development of FCMs that overtly includes a representation of indeterminacy between nodes where no causal relationship can be defined.

10.5 Fuzzy cognitive map use

FCMs are based on the concept of fuzzy sets. These relate to sets in the same way fuzzy logic relates to logic. Fuzzy sets are analogous to classical set operations but the membership of sets is not clearly defined. They allow imprecision in relationships to be clearly modelled. This is done by reducing the information to two or more categories whose boundaries overlap. These sets have soft boundaries showing the uncertainty in the information. Some elements can be members of more than one set. These fuzzy sets can be linguistic representations (e.g. low, medium, high) or numbers between [-1, 1] representing the state variable and arc strengths of the FCM. If quantitative data is going to be used (i.e., the input data is not already fuzzy) as an input into the FCM it needs to go through a process called ‘fuzzification’. This is a process where it is sliced up into a set of descriptive categories – much like histogram bins (Ramsey & Veltman, 2005). This fuzzification process allows the use of a number of data types in the creation of the maps (Ramsey & Veltman, 2005).

Traditionally, FCMs have been developed directly with individuals who have expert knowledge in the field. The experts draw a FCM as a digraph. Nodes are identified and causal lines (arcs) with direction and strength (as either linguistic descriptions or numbers between –1 and 1) of the arcs are then drawn between the nodes. It was Özesmi (1999) who explicitly shifted the use of FCMs from encoding ‘expert knowledge’, to using them to code lay people’s understandings of the system concerned. There is also a shift in emphasis from FCMs that represent people’s knowledge of causal relationships to what the structure and causal relationships in the FCMs might show about people’s beliefs and values, or as proposed in this study, relationships. FCMs can help show how the whole understanding on a topic or situation behaves under different circumstances. As has been discussed, tuning the FCM can show how those understandings relate to each other and to the entire FCM.

Özesmi (2006) suggests some of the advantages of using FCMs for social research are that the interviewees themselves draw up the relationships and concepts on the topic that make sense to them. This is in contrast to surveys and questionnaires where pre-set questions are set to be answered. In contrast to qualitative approaches, such as open-ended interviewing, the potential for bias by the interviewer is also reduced, as is the difficult process of deriving themes and relationships. FCMs also allow the comparison of data from different groups, statistical analysis, and neural modelling. Outlined below are a range of analysis techniques that were used in this study:
• Computational neural analysis of the FCM as discussed above. The software to be used for this is the Fuzzy Thought Amplifier (Fuzzy Systems Engineering).
• Density analysis to analyze the structure of FCMs. This is developed through dividing the number of connections in the FCM by the maximum number of connections possible (Özesmi, 1999).
• The centrality of a node can be assessed by summing its input and output weightings. The higher the value compared to other nodes the more important the node is to the FCM (Özesmi, 1999).
• The complexity of a FCM can be assessed through its input-output ratios. The higher sum of inputs relative to the sum of outputs suggests a more complex FCM (Özesmi, 1999).
• Condensation is a way of simplifying complex maps into cognitive interpretation diagrams (see Section 11.2.2). It involves replacing groups of variables with a single variable. Deciding on which groups to replace can be done either quantitatively or qualitatively (Özesmi, 1999). A qualitative approach to this will be undertaken as part of this study.
• FCMs can also be merged to develop social and stakeholder group FCMs (Özesmi, 1999; Kahn & Quaddus, 2004). These can be used to compare FCMs developed by different social groups and develop FCMs representing consensus among groups. This will be undertaken as part of this study.

In addition to these were techniques that were not used in this study:
• Standard statistical analysis of concepts (nodes) and connection statements (weights) across the collection of stakeholder produced FCMs. Özesmi (1999) proposes that this should only be done if the FCMs are all developed on the same subject and by the same interviewer.
• Cluster analysis can be used to show how strongly variables are connected to each other and indicate how complex the map is (Özesmi, 1999).

As mentioned above, Özesmi (1999) describes the use of fuzzy cognitive mapping techniques with individuals as more open and holistic than other qualitative interview techniques, as it allows insights into reasoning, beliefs and values. Indeed, Özesmi & Özesmi (2004) discuss the use of FCM’s in representing a number of differing psychological phenomena ranging from people’s views and opinions (Özesmi, 1999) to their wants, desires, perceptions, goals and concerns (Özesmi & Özesmi, 2004). However, it is not clear that this insight is developed further through attempting to understand how these factors affect the causal cognitive maps that are produced, or how they may be incorporated into FCMs. This study attempts to develop a framework to do this by considering how affect, cognition are related through an embodied and experientially based world, and how FCMs are a product of this.
11 Interview and FCM results

11. 1 Interview results

11.1.1 Introduction

The following analysis is primarily descriptive. It does not analyze the situation through the use of underlying social constructs such as power, nor does it try to draw out the ‘taken for granted’ that might secretly impinge on action. This focus on description is deliberate. As set out in the theory chapters, its assumption is that the world is an ongoing unfolding in which the participants, weka and myself are both immanent and networked. Rather naively, I am sure some would say, I treat what people say and do as ‘how things are’. This is in the sense that people’s accounts are emergent and immersed actions in the world and, in that way, are ‘truthful’.

At one level the socially focused part of this research is based upon story telling through both interviews and the creation of FCMs. I am producing a story about the world through attempting to analyze others’ stories. But it is also about people’s activities - what they do. Their motivations and actions are bound up with these stories and are in part revealed through them. As such, these stories can also be considered as being ‘of’ the world. Both storytelling and practical acts can be considered as practices. The interview section concentrates on the informants’ responses to my questions. The questions I posed expose my prejudices, concerns, awareness of the situation, and also what I was attempting to understand.

The fieldwork for this research was carried out where I live. This meant that when approaching people I was at least in part accepted as a member of the local community. However, the acceptance to the research within this community is variable. Some participants were very supportive and understood the study as possibly contributing to the protection of weka in the area. Others were less interested.

There are many quotations in this section, as I would like people to speak for themselves as much as possible. I also wish to convey the complexity and richness of the participants’ discussion. A primary aim of the interviews was to establish the extent to which FCMs can be considered to represent people’s broader understandings of the system being represented in the maps. However, the interviews are also used as a method to gather data for research more generally and in relation to the theoretical approach being taken. The questions were developed to try and establish the extent of the type of feelings that weka elicited for them and their associated knowledge, and also in
relation to the Cape Foulwind area as their home. There are two main sections to the interview and FCM assessment:

1. The assessment and the development of themes from the interviews;
2. The relationship of the interviews to FCMs.

The relationship between interviews and FCMs is explored by comparing individual participants’ interviews and FCMs and then comparing the social FCMs with the general interview themes.

11.1.2 Overview of themes

The following is a brief overview of the themes that emerged from my investigations and also the structure of this chapter.

The themes in the interviews were not developed through standard Grounded Theory methods. The reasons for this are discussed in the methodology Chapter 8. As a researcher I understand myself as thoroughly immersed in place. Instead of attempting to stand apart in a subjective or objective manner I accepted this immersion and applied all the knowledge - both theoretical and empirical - I obtained to allow for an abductive process to occur. In other words, abductive hunches, ideas, etc. do not arise in an isolated subjectivity but from a subjectivity fully immersed in the world, and of the world. Consequently, the preceding theory development was crucial to what was traced and developed as themes in the interviews. In one sense the theory was as much data as the interview data and is the reason for the amount of detail in the theory chapters. The meta-themes of embodiment, affect and place were already developed.

Several themes were identified from the interviews through the process outlined in Chapter 8 and are discussed below. These were: (1) The importance of place; (2) The importance of native wild animals; (3) Weka and place; (4) Weka features (physical, calls); (5) Nuisance and appreciation; (6) The role of interaction with weka; (7) Weka as active agents; (8) Local knowledge (experiential knowledge). These will later be discussed in relation to the FCM social cognitive interpretation diagrams (CIDs). This allows a way to consider how the CIDs might capture these themes and how FCMs may be considered a reflection of interactions the participants have, and emotions associated with weka and place. I wish to highlight the situated, embodied aspect of the participant’s expression and its link with emotion as developed in the theory chapters. These both lie as meta-themes or threads within the themes discussed below.

I have used codes to identify each participant. This is a five to seven character code made up of the following:

1. P = participant
2. 1-20 = participant number
Much of the following analysis of FCMs in this chapter divides the participants into two groups (farmers and non-farmers), and it is tempting to do the same for this interview analysis. However, this over simplifies the relationship between individuals and their understandings. As will be shown, there is much overlap in many respects between these groups in their relations to weka. Their commonalities and differences will be noted as the discussion proceeds and in the conclusion of this section. The presentation of the interview results is broken into two parts:

1. Weka, emotion, place and interaction;
2. Understandings of Weka and their ecology.

### 11.1.3 Weka, emotion, place and interaction

#### 11.1.3.1 The importance of place

All the participants liked living in the area. For most participants an emotional element entered into this. This included both farmers and non-farmers. The expressions they used included: like, feel, beauty, contentedness, enjoy. Nearly all the participants regularly physically interacted with the landscape, either as farmers, or lifestyle block owners, or recreationally. Their activities and interests are reflected in the aspects of the area which are most important to them.

The classical phenomenological expression of dwelling - place as home, contentment and familiarity - was also an element for some participants:

“*I just like the feel of the place. You get to know a place fairly well after a period of time you always feel, feel comfortable there.*” (P10MNF)

Ambience or affect was directly commented on by P18MNF:

“*I like the ambience of the place, I like people’s lack of pretention...social, the social feeling of the place.*”

This ambience appears to be focused on the social. However, for many, and especially the non-farmers, an important element of this feeling for the area involved its naturalness. P3MWNF, who were relatively new arrivals in the area, liked the natural aspects, forest, wildlife, etc. in this area. They thought it

“*a bit of a privilege doesn’t it being able to live in somewhere that is so wild.*”

P17MNF has been in the area for 22-23 years, about 12 in Charleston and 10 where he lives now. He lives there as he likes the natural environment:
“there is bush everywhere and I can see the sea and I can see the mountains, and arr, yeah, yeah. A damn good place to live.”

Also mentioned were opportunities to interact with aspects of the natural world: P1WNF had been living there all her life (34 years), she emphasized that:

“it’s beautiful, it’s untouched.... variety of places to go and explore.... outdoor opportunities there are, it’s pretty .... its quiet”

P16MNF had lived there since 1974, although with a 10 year break. He lives here:

“mainly [for] the nature, mostly, wilderness and nature, recreation opportunities”

The social aspect of place was also important for others. P11WNF has lived here all her life. She like living here because:

“I just find the quality of life is fantastic here, and yeah, the people and the environment, and you know I’ve got home here and feel very content...and I really love the beauty of the place.”

For others the social aspect dominated:

“I live here because my job is here, ha ha. What do I most enjoy? Probably because my family is here, being close to them.” (P20WNF)

Small scale and family famers tended to have more interest in the natural environment as did women who lived on farms (e.g., P13WF, P4WF). P6WF likes living here:

“[b]ecause of the environment, its wild, its not, its sort of untouched, its got..... extremes of weather, the best of the weather, umm, and it’s got sort of the wild coastline and the bush and the mountains, it’s you know, it’s quite rugged. Umm, that’s the main reason, and you know a variety of friends but it definitely the environment that’s the key for me.”

Male participants who were farmers did not tend to emphasise the importance of natural values as much as the others. They were the only ones to mention the economic aspects:

“I s’pose cause it’s a good place to live, make a dollar.” (P5MF)

“I like the opportunities here and ahh, farming opportunities... Yeah I like being able to, um, turn something unproductive into something productive in the way of farm, you know farmland...yeah, land’s cheaper here, that’s allowed us to expand.” (P7MWF)

By contrast P3MWNF expressed an interest in” getting to know your place and looking after it.” This might be considered an active response to care for it. This is also mentioned by other participants and was often more directly associated with caring for wildlife.
11.1.3.2 The importance of native wild animals

“[I]t’s really important to me to have native wildlife around… I mean it’s all connected with my feeling for the place and the beauty. I suppose it’s great to have sea and mountains and forest, but it even better to know that that’s habitat and the wonderful species that have been living there for thousands of years… they actually really important to maintaining those ecosystems. You know without them it wouldn’t be as special, it wouldn’t be the same…”

(P11WNF)

All the participants said they liked having native wild animals around. Weka were one among a number of these species that were enjoyed:

“I have to say I enjoy having tuis, singing, ones you can see obviously, pigeons.. around the backyard. Weka, of course, they are in the backyard all the time. (P1WNF)

P20WNF has some enjoyment of native wild animals:

“native birds, can be good to watch…. I have weka in my garden, ha, um a lot of native birds actually.”

P10MNF had a broader view commenting that native animals also provoked a sense of being embedded in a larger world:

“it’s a constant reminder that you are part of a much bigger thing than just your little world … [as well as making] … the place feel special”.

Some species were less liked than others:

“the pukekos well they’re quite a nuisance in fact, I think that half the time I am planting for wildlife around here because, the ducks and the geese, the swans and the pukekos and the weka, well you know the wekas are pretty neutral.” (P7MWF)

This important element of nuisance is discussed further in the following sections. Some appeared to prefer non-native wild animals in the first instance. When P9MF was asked whether he liked wild animals around he referred to possums, pigs and deer and was concerned his grand children might grow up not knowing what they were. P17MNF was a keen hunter and commented that:

“deer, ha ha. Yeah, deer are good. Yeah, like all birds and sorts of wildlife. Not too keen on possums.”

For P10MNF the most important native animals tended to be the rarer ones. Moments with rare species or rare interaction with native species were the most appreciated:

“I have to be honest it is a special moment to handle a kiwi, or see dolphins arr frolicking, umm but having said that I guess its because we arr don’t see them very often.”

By contrast, P8MF said:
“I like them around, but umm, yeah all the natives really. Especially the birds I guess, well that’s the most obvious ones...”

This highlights the idea that the most commonly seen animals may be the most appreciated and enjoyed. This theme is developed further in the following sections. Others - such as P8MF - were more reticent towards having native animals around, although he was in a minority for both farmers and non-farmers:

“Yeah, it’s ok, yeah.( Int: Any in particular?) ... umm, probably white heron ... in the main, I don’t , I don’t dislike pukekos and wekas.”

P4WF explained the importance of having wild animals around in the context of running her farm and retaining elements of both conservation and development:

“...but not sort of fanatical... I do sort of look out for them but ... I like to think that I work in with everything.”

She has left some parts of her farm in forest and developed other parts for farming:

“Like there’s lots of areas on my farm that I’ve not cleared deliberately and never ever would, and there’s lots of areas that I have, cause I need, you know just for survival, cause that’s what farm, you know I farm and that’s my income.”

Many participants commented on weka (this in part because they knew the study was on weka) as wild animals they enjoyed having around (this is discussed further in the next section).

11.1.3.3 Weka and place

Many participants emphasized the importance of weka to the identity of the area. P4WF thought that weka belonged:

” I suppose it’s, they sort of belong, that’s what I like about them. This is a feeling of what should be here.”

P3MWNF expressed similar sentiments:

“Yeah, its the call at night and just seeing them around and scuttling across the road, they’re they’re pretty much part of the place.”

It was participants who liked weka who stressed the idea of weka belonging (e.g., P10NF, P4F, P11NF, P16NF, P18NF). Also the ability to interact with weka was seen as important:

“Aww I would, yeah I yeah , I do like living with them. Yeah, I wouldn’t like to see them go...”

(P4WF)

Some others (farmers) were ambivalent about having weka around but still felt they were a part of their feeling of place:
“Well they are a pest, yeah let’s get that straight, they are a pest. They are a pest to us because of um, of where we are...round the house and stuff like that...Where they are a pest, where people get driven literally mad by them I guess we, we, we put up mesh fences to stop them getting in. As I say we look at them as a pest, if a week went by and you didn’t see one, god you would think what the hells going on here, yeah. Cause yeah they’re just, just part of the place just like a bloody starling ... And the wekas are a bit like that, like you would miss ‘em.” (P9MF)

For others weka’s belonging was linked to their evolutionary status. P10MNF stressed the idea that weka intrinsically belonged to this area through broader evolutionary processes:

“they have been here a long time and umm, nature, nature has a great way of developing, evolving and arr if something wasn’t there in their natural form, through evolution, it wouldn’t be here would it, in simplistic terms. But that’s the way I see it. If nature intended it to be here then it is important.”

Also:

“well they look neat, they are pretty neat interesting birds, and they are sort of our, arr you know they are native and they are supposed to be here...I don’t really dislike anything about them.” (P17MNF)

Relatedly P11WNF also stressed her understanding of their present ecological role:

“from what I have learnt they also play an important role in eating large, they are able to digest large fruit of trees such as miro and others, which some other bird species can’t handle.”

This was sometimes contrasted to the lack of weka in other places so weka became an identifying aspect of the area. For example, P3MWNF enjoyed the experience of weka here that they had not had elsewhere. While P16MNF said:

“Arr, I like them because they are such an iconic bird. I like the fact they are here, as in other parts of the country they are extinct or going downhill, so they are really special to me.”

For other participants the experience of weka added to the place:

“they add a little bit of something to it, a little bit of character, I mean you don’t get a lot of you know flightless native birds that you can see wandering around the place, they’re quite rare and that because, I mean even with kiwi and things like that they tend to [be] much further away from humans’ habitation...” (P20WNF)

For several participants this extended to suggesting that weka should be considered icons of the Buller District or the West Coast:
“they’re the kiwi aren’t they, kiwi of Cape Foulwind plain... they would be a great little icon for Cape Foulwind wouldn’t they, for Westport. We could have a giant weka in town.”

(P3MWNF)

This is making weka locally more valuable by turning them into an icon of the district and making people aware of this. This iconic value is symbolically based rather than an interactive account of valuing. However, it is based, in the case of weka, on local human interaction with them. P18MNF draws this out further:

“I think they should become the national icon of the West Coast, ha. They kind of thrive in the rain, they are opportunists, like West Coasters are opportunists, arr they’re bold, cheeky ...

...”(P18MNF)

This is suggesting more than weka as an icon because they are nowhere else, rather he equates them with the place, its characteristics and the characteristics of the people there. Here weka are an element of place; giving, reflecting and constituting it. This is layering weka character onto the local people, or indicating the local peoples character to themselves or, better still, their interactions with weka creating their character. In this way, both the weka and human characters are seen as reflecting the environment that is ultimately based on our situated embodied interaction with it.

11.1.3.4 Weka features (physical, calls, behaviour)

Beyond their character many participants also liked weka’s physical features. These physical and behavioural attributes such as their size, omnivorousness, flightlessness and territoriality are not separate from their character as they tend to facilitate it. In participants description these were sometimes mixed together:

“I like their sort of gregarious nature, their kind of slightly evil look in their eye, and I like their legs, you know, yeah, they’re sort of, they’re so leggy and thick and kind of attached to the earth looking. Umm, yeah, and I like the sort of skittish way they run, you know they, they’re feathers, just the look of them. Yeah, they are kind of hilarious. Yeah, so I like them.” (P15WF)

“I like their, I like the way they look, their feather patterns and their, their wonderful eyes and their feet. Their whole sort physical appearance is just fantastic, and the way they move, they’ve got this fantastic sort of way of stalking through the, through the litter. Umm, their curiosity as well, they are just so courageous and um I just really admire the way they, they kind of, always these dare devilish sort of nerves to try and sate their curiosity.”(P11WNF)

These accounts are full of emotional descriptors (e.g., like, hilarious, wonderful, evil, fantastic, devilish, courageous) about their physical appearance and activities. Weka character is revealed as
being important to their relation with humans and is discussed further below. Weka calls were commented on by many participants (half of the non-farmers and two of the farmers) often described in a manner that expresses their deeper feelings of the place and the weka’s close connection with that. P2WNF called it “an enduring memory”, while P3MWNF said:

“I know that that will stay with me the rest of my life that sound of the weka at night you know... it’s sort off that very distinctive sound of this place.”

One participant couple were trying to instill the call of the weka as part of the place into their children and so promoting the same emotional bonds they had:

“No we get the kids, the children will listen to their calling, when we are sitting down here at tea, or just after tea or something, and you will hear it. And arr, so I made a point of that, still do.” (P7MWF)

Another described the call of the weka as part of this feeling of contentment:

“So arr I always find it comforting, especially at night when you hear the different calls of the different wildlife, with your weka calling at night I find it very comforting.” (P10MNF)

This emotional response can be linked to both individual memory and can be understood as affect; an ambience of place that exists prior to subjectivities and is incorporated by them as emotions. Taking this further, P11WNF commented on the call of weka belonging to the place meant that its loss potentially acted as an indicator of how things are in the natural world:

“I like, I like just the sound in the evening, you know at dusk when you hear them, you know it sort of belongs, and if I don’t hear that and I am at home I think that something might be wrong.”

This is a loss of comfort, a disturbance, an indicator of a broader change as well as a change in itself. One participant claimed to like weka for entirely different reasons:

“...they taste beautiful especially with a bit of ??? sauce (Int: ha, ha, you have eaten them in the past?) yeah...very occasionally, yeah, well they are better than chicken, I prefer them to chicken.... Yeah a cross between chicken and duck.” (P8MF)

He was not the only participant to have eaten weka; both P5MF, P2WNF had also eaten weka.

11.1.3.5 Nuisance and appreciation

There is a tension between weka being a nuisance to people living in the area and people’s appreciation of them. P4WF and P2WNF both liked weka but would remove individual weka that became too much of a nuisance in either their garden or house. P6WF dislikes them when:

“They ruin the lawn, they make a hell of a mess of the lawn sometimes. Sometimes they pull out plants... I’ve been, um planting pretty plants out... they keep pulling it out, and they
die…and occasionally I think I feel like giving them a bit of cayenne pepper, to stop them doing it but I haven’t done it…”

The reactions of some of the participants were reflected in P6WF’s thoughts on local people generally. Local people dislike them because:

“They’re cheeky and do all of that and get inside the house and people like perfect houses and veggie garden…”

Many participants, both farmers and non-farmers, thought more extreme measures were common:

“Um, aww……um, most people swear and curse at them in their gardens and I know people that you know have dogs and don’t mind the dogs chasing them and killing them. Um, yeah……um, aw no some people have a yeah, its depends how serious gardeners and whether they like fencing....” (P12WNF)

P8MF was sympathetic towards people with weka damaging their gardens, in relation to people having their dogs kill weka:

“…and I guess you can understand it if they are not environmentally minded because they are such a pain in the butt in your garden.”

In this respect he thought that, “the bulk of people, the majority of people would be happier without them, or a lot fewer of them, or certainly in their own backyards.”

And:

“But, um,…yeah the bulk, although there obviously are a percentage that think similarly to myself that do appreciate them, like having them around. But even that gets tempered when the odd one does come inside or shit all over the place, or roots up your garden or whatever.” (P8MF)

Some were tolerant within limits:

“…in my house actually, haa …ummm, I don’t mind as long as they don’t’ defecate or steal my things. I was quite surprised … quite cute really, but um, I will be shutting the door … haa… so they can’t you know, come in.” (P1WNF)

Interestingly, while nearly all of my participants thought that many locals did not like weka most of the participants themselves appreciated and adapted to weka (with some inadvertent dog-kills and road-kills and impacts from land development). This tension between weka’s inquisitive nature and their nuisance value is revealed in the following:

“the only thing I can say I don’t like about them is they come in and shit in my house, its about the only thing I dislike about them…Aww,…….But the thing I arr like about them the most is their character, they have got a bit of character” (P14MF)
P3MWNF said because they were native species they should not be treated as pests. Others, however, thought weka were pests along with other native species such as paradise shell duck and pukeko. There was no distinction made between native and non-native animals in this respect. However, all the participants were aware that weka were native birds. It is perhaps the case that people do not differentiate between native and non-native nuisance species. For P9MF having some animal pests around is considered just how things are, the nature of things, things that have to be coped with:

“We can’t stop the damn things, no matter how we swear and curse, but all of a sudden [if] there was no starlings you’d be wondering you know, where the starlings had gone.”

On farmland P19MF did not consider weka to be in high enough numbers to be a real problem but he:

“dislike[s] their scavenging nature, ‘cause that’s generally in relation to us, umm, and arr......that’s, and aww the mess they make when they are um.... found to be in the wrong place at the wrong time ... it can get abit frustrating getting into the calf meal ... I don’t pay good money to be feeding them, they can have it second hand if they want, through the dung or whatever or..ha,...”

Furthermore P19MF commented that:

“Arr, they have a role to play, yeah ... so, yeah I ... what they do on the farm is not arr, as I said before in probably a bit of a neutral effect. You know, given, umm, and including their scavenging nature, the beneficial stuff probably equals that anyway.”

This was supported by P4WF who said that, unlike pukekos, weka are not detrimental to farming and even “could be quite beneficial.” On farmland weka were not considered to be a pest in the same way as pukekos or paradise duck which eat pasture plants (P19MF). Weka can damage new grass but they also eat Porina beatle which can damage the pasture on a large scale:

“ That, that’s, that is a positive, despite that fact that is also a wee bit destructive, but at least its , its a .....? a well equalised by the benefits...it’s not all negative.” (P19MF)

Indeed they can be considered to have a positive role:

“Well they turn all the cow pats over don’t they, so that helps break them up ...and they do get into that grass grub because they did a big patch on the lawn, they are in some way useful.” (PSMF)

For some participants the tendency of weka to be a nuisance was counteracted by the economic benefits of having them around. For example, in regards to a tourist facility, P20WF said:
“I mean even though sometimes they do get into the rooms and poop, um they would rather have them than not, because of the positive impact they have on visitors to the area.”

There was another aspect of weka that was thought to be an important part of the Cape Foulwind area. This was their potential role in tourism and associated with this the undervaluing of weka compared to other native species:

“[O]ut at the seal colony, which is the most visited place around here, you know the weka there... there loads out there... and that’s sort of an important part of the appreciation of the Westport area... What annoys me is you hardly ever see weka as a New Zealand bird, you know, it’s always kiwi or kakapo, this and that. Weka’s very, very low down on the list... but they are so much more visible... You would think they would be higher up there in people’s um you know, minds of New Zealand birds than they are.” (P7MWF)

“The way I look at it we have kind of got a unique opportunity to to keep weka here, most of the country lost them... yeah like we have got a chance of actually saving it and having a good weka population, and all the advantages that go with that... Timaru attracts people to see little blue penguins, ... attract people to see weka.” (P16MNF)

These economic and pragmatic concerns contrast with the more emotive aspects that balance weka’s nuisance value. P9MF sums up this nuisance-appreciation tension well:

“... and the fun these little kids get following these wekas around. The weka don’t mind, the wekas wander off and go into the shed. Yeah, and the kids love them and it would be a shame if they suddenly disappeared off the face of the earth. But in saying that I’m not going to give you any money to conserve the weka.”

11.1.3.6 Adaptation of weka and humans

Participants who appreciated weka often bracketed their negative interactions with ways to adapt to the impacts:

“they can get in your house and crap on the floor, and eat your chickens and eat your chickens eggs, but, and wreak your bloody garden.” But “... Arr, they are not actually difficult to keep out of gardens.” (P18MNF)

And:

“[P]eople say aww they get in the garden, I don’t care, if they get in the garden and pull out stuff it doesn’t really matter cause it’s my... I need to put up a fence if it is causing a problem”. (P3MWNF)
P3MWNF also said they would just keep the door closed if weka started getting in. For P12WNF adapting to weka was something that developed over time. Initially they decided:

“... well are we going to fight them ... And then we started to learn more about them, that it was their strong hold and you know, and we decided that we ... you know, we’d just live with them and foster them, yeah, adapt to them ha ha, we could change easier than they could, ha ha. So, yeah so we started making weka fences, they’re quite easy to keep out really”.

This change can be understood as entailing a re-valuing through interaction and learning leading to adaptation. A number of participants (P6WF, P3MWNF) described this process as ‘changing attitudes’. However, they proposed education and media to provoke such change rather than self-instigated change from interaction. Adapting to weka was mostly mentioned by non-farmers, farmers were more interested in controls to avoid interactions (e.g., dogs around house), although this was not the case with all farmers, particularly small, family farmers. Furthermore, other participants, mostly non-farmers, stressed that adaptation did not just entail physical measures to control weka but an acceptance that weka live there and will sometimes do things you do not want them to do. P20WNF said weka should be considered:

“part of what it is to farm or live or whatever in this district. I think that it is..., yeah it is better to live with them than saying, no I’m not having them and you know trying to get rid of them...yeah, and an acceptance thing, you know you have got to accept that if you are living here that that’s what was here first...”

In this way weka are considered wild animals and original inhabitants not to be controlled. Some participants also commented on the adaptability of weka to different environments. P4WF saw weka as adaptable and so able to live successfully in a number of habitats:

“So they learn, they are pretty, they are very intelligent, very adaptable and yeah.” They are also able to move around easily, “they are obviously quite adept at moving around the countryside...”

Particularly habitats humans create:

“Umm, they seem to do well, well the biggest populations I have seen is around humans. Around places like the seal colony carpark, Les Warren park, and where there is land development there is a lot of birds, when they are flipping. Cause back in the bush they are quite dispersed, you don’t see them in large numbers anywhere that I know of in the bush.”

(P16MNF)

This is a positive impact of humans on weka, without human activities there would likely be fewer weka in the area. However, this adaptability was sometimes used as a way of not having to be concerned about their population as it was thought they would adapt to whatever happens:
“...and arr they are sort of fairly well known as great survivors and able to cope with massive change...” (P10MNF)

This was also seen as something to admire in weka by P18MNF:

“... I like the fact that they are survivors, if we do get climate change the weka will hang on...”

The implication is that they are not at risk. Seeing them as adaptable means they can cope with change, especially with the high numbers at Cape Foulwind. There is therefore no need to worry about them:

(P9MF) “...that’s what I mean by the change in habitat, you know they have adapted to where, you go over to the shed on real rough day when there is a thunder and lightning storm going on, really raining, and you go and you go and see the shed there’s more wekas in the shed than there is people.”

11.1.3.7 The role of interaction with weka (situated and embodied)

The importance of interaction with weka has already been suggested. Some participants also highlighted the significance of weka being associated with an ability to interact physically with them. P12WNF commented:

“... the weka are the most obvious and they’re the ones you interact with the most because they’re there,. ..there’s all the other birds but they’re, but you don’t sort of have a personal interaction with them like you do with wekas...wekas have a bit of character too.”

P1WNF likes it that weka are reasonably tame and she is able to interact with them:

“ They are quite groovy little dudes really.....I like that fact that they live right next door and that they just mind their own business. Yeah ... and the fact that they are not too phased by me...Umm the ones you see most often you tend to like. Mind you kiwis are amazing to me ‘cause you don’t see them really, they’re there but you don’t see them.”

However, P18MNF thought that the important point was that people can interact with them:

“It’s nice that they a available for people, not not like kiwis, kiwis... you see em, there’re not like kiwis, you never see a bloody kiwi, just hear them if you’re lucky.”

There is a separation here between liking animals you interact with and see (and most participants saw weka on a daily basis), and animals you perhaps wish to see. The force of actual interaction is highlighted by P15WF as interacting with wild animals on her land gives her a sense of connection:

“ Umm, why do I like it...well, ‘cause it makes me, well I get a lot of pleasure, I like seeing them, but I like feeling sort of connected to things, umm to the environment...”

Interactions are often instigated by weka. For example P7MWF said they see weka everyday:
“in the garden and on the roadside, and the house. On the farm tracks... sometimes they are
in the house ... and then we chase them out. Interaction, well that’s interaction. If we see one
at the door there we throw a shoe at it.”

Weka are the active engaging agents in this process as many of the participants such as P11WNF and
P13WF do not interact with them but just observed them:

“...I always enjoy seeing them come into the yard and poke around...I tend to just sit back and
watch them, try and get photos of them. Particularly, you know with the grand kids around,
they tend to get a great thrill out of it.” (P10MNF)

It is weka’s activities that often provoke a more interactive engagement from people (e.g., fencing
them out, chasing them out of the house). Some participants described a more active role with
people (that did not involve removing or killing them). For example, P3MWNF said one local farmer’s
children they know catch them and play with them. Interactions were sometimes amusing:

“You know when you see your wife sort of, chasing a weka around the bloody house, trying to
hose it to get it out of the garden, all sorts of things, it’s a good laugh, a bloody joke …”
(P9MF)

In contrast with these many forms of interaction, there were also people who did not end up
interacting as much with weka because:

“I think people with dogs don’t even think about them really, ‘cause the dogs keep them
away so it’s not a problem.” (P12WNF)

Having dogs that chase weka means people most likely do not interact with them to the same extent,
or the same way, as people without dogs. By interacting less with weka the relationship people have
with them changes. That change could be in either a more favourable or less favourable direction.

The importance of interaction was shown in another way. For example, P14MF commented:

“I love all animals... I like dogs and cats, dogs and cats and cows. But they have all got their
own good points, you know, every animal’s bloody, I like them all.”

He gave this first answer when asked about native wild animals, when prompted further about native
animals:

“Umm, native ones yeah. Well they have been here longer than we have so, we have got to
work in with them, not them work in with us.”

His first comment relates specifically to animals he interacts with the most. These were the ones that
came to mind first, and presumably the ones he likes the most. In some ways P14MF demonstrated
a fairly pragmatic view of animals, perhaps reflecting his farming background:

“I just let them [weka] do their thing. Like I said before, I don’t mind them standing at the
window eating the bugs off the windows if they are on them. They do a job.”
11.1.3.8 Encouragement

Most participants did not actively encourage weka around their houses (e.g., P16MNF, P5MF, P11WNF, P7MWF):

“Well, I don’t feed them ... don’t encourage them with food...if they annoy me I shoo them away.” (P1WNF)

Having the enjoyment of weka around did not require encouragement through feeding them. There were four participants (all women) who did feed them from time to time. P12WNF feeds them occasionally:

“...you have to clean up after them a lot of mornings, on the back verandha, their droppings you know, shitting everywhere, you know. Sometimes that worse than others, ha ha, but pukekos do that as well so... the nature of having them there yeah.” (P12WNF)

Others encouraged them less directly through retaining habitat. P18MNF encourages them by having:

“a few wild areas, wild areas that I don’t cultivate, ha ha. And I planted all the trees, so there’s more tree cover.”

One participant encouraged them for economic reasons as visitors liked to see them. To encourage the weka to remain they fed them bread:

“...we just throw it into the bush and it seems wekas get it first to be honest, ha ha” (P20WNF)

11.1.3.9 Weka as active agents

Some of the preceding discussion has highlighted the active nature of weka themselves in their interaction with humans. P3MWNF commented that weka:

“are actually coming into your garden or your space or whatever.”

Sometimes humans also used weka, exploiting weka as tools:

“I remember one helped me on the farm...we were trying to get...an electric cable through a culvert pipe, quite a narrow pipe. It was a long pipe and the wire, just couldn’t get the wire through ‘cause it kept bunching up and wouldn’t get out the other side. There was a weka mucking around so I got the dog to catch it and um, I grabbed it and tied a bit of string to its leg and put him in the end of the culvert and he ran out the other side, and grabbed him and unhooked the string and let him go and just pulled the cable through with the string.” (P8MF)
More two-way arrangements also existed. P14MF told a story about a friend who, he suggested, had a weka as a pet:

“I like the one I told you before about me friend, he’s got a pet one, and every day it comes up to the sliding door and jumps about a foot in the air and smacks its head on the window, and me mate says to me well that’s it’s ahhh, it’s telling me to feed it.” (P14MF)

Like many animal-human relationships of this type, his friend is being used by weka for food. It is not really a pet and his friend has no control over the weka beyond its food collection. P16MNF saw commonalities between conventional pets and weka:

“… almost a bit like the family dog … a cheeky creature that fits well with humans, or like to be around humans ‘cause humans provide food in the same ways humans provide food for dogs...”

An intentionality (liking to be around humans) is attributed to weka in this quote. Weka take advantage of human presence mostly through food that humans might supply (e.g., chicken eggs, compost bins, hand feeding) and also through change humans make to their habitat. This active aspect of weka was recognized by most participants through their particular character, both farmers and non-farmers, and was often seen in positive terms and was respected:

“Yes, its great having the weka around. One of the things I like about them is their attitude, they’re not shy or retiring. Yeah, yeah that’s right, a good personality…” (P3MWNF)

P9MF commented on their inquisitive nature:

“I s’pose I have studied them a bit, some [of] the antics they get up to, but they are the most inquisitive bird that I know of, you know they like to poke their nose into everything…”

And intelligence:

“They do come round at night ‘cause they know the dogs are asleep... They are pretty sharp, they seem to know when the dogs are off and when they are not.” (P14MF)

Many participants liked this active inquisitiveness. It also makes them visible and interactive which, as noted above, is also the aspect that makes some people dislike them. Another reason for disliking them was given by P4WF. This was because at times they were:

“quite aggressive, they’re quite ... quite, quite you know, violent animals ... are quite, quite mean”.

This comment followed the participant’s experience of seeing them attack hares and hedgehogs. Others tended to suggest that that was just how weka were:

“...and they can be aggressive, but you don’t see that side too often... but that’s just their, their way.” (P6WF)

Several participants attributed emotional responses to weka. P5MF said:
“I have seen one get run over, has been dying on the road and its mate, or partner will come back and sort of grieve, it must have some you know bond, I have seen them do that.”

P2WNF also attributed emotion responses to weka and described them as being happy or liking things. This gives emotions to other entities in the world, rather than only humans. This section also highlights an animated world. In other words, the perceptions of weka were not just imposed on them, but weka were seen as fully active in the process of the relationships held with them.

11.1.3.10 Loss of weka

Many participants, both farmers and non-farmers, gave emotive responses to the potential loss of weka from the area. Some were more aimed at the loss of weka itself:

“...would be saddened, I would be saddened, I think a lot of other people would too...”
(P10MNF)

For other participants the emotional responses were combined with other elements such as a cause, or potential cause of the loss:

“I would be pretty annoyed, yeah you know, would really miss them...its something that I see that’s unique, I’m going back to that call at night, you know that’s quite unique and for us not to look after that for the next lot of children who come along, you know. But this is one little thing that um we could you know do a bit of work on and actually preserve that aspect, and probably, you know got it in our hands, you know, at this very moment to keep that going.”
(P7MWF)

His annoyance is aimed at people for not taking enough care or responsibility and as a farmer in the area was aware of his own responsibility. This is associated with an interest in weka’s uniqueness that makes this place distinctive and different from other places, along with associated feelings of loss for him and his children. P2WNF expressed similar annoyance or anger:

“would be really pissed off [if weka numbers dropped away] ... yeah it would be really, it wouldn’t be the same without them, there’s always been wekas here since I’ve been here, so they are sort of part of it ..imm ...there wouldn’t be a day I don’t see several wekas”

P12WNF thought, in relation to weka on her property, that her personal effort might have been in vain:

“Aww I would be disappointed considering that I have tried to you know, help them, you know. I’m not hindering their, you know... I have made more weka habitat here than was here before, so yeah, I would be yeah, be disappointed if they vanished.”

P13WF aimed her concerns more abstractly at the environment. The loss of weka:
“would bother me greatly, yes it would because there would be something seriously wrong with our environment. The sparrows have disappeared, the frogs have disappeared so ... it’s not good, it’s not a good sign.”

Weka loss would be part of a general decline in the environment, even though the other species she mentioned were not native species and their decline may be of benefit to indigenous ecosystems. Rather, weka is considered one of the general contemporary mix of species that live in the area, all equally important. While for P14MF there was no real personal concern for weka there was a more general notion of loss and disruption:

“Aww, yeah it would be pretty sad ‘cause it would be just another one bites the dust, won’t it. There just have been too many. Everything plays their role in the circle, doesn’t it. Yep, take something out something else suffers. So I’m of the mind you have got to look after what’s around, you know.”

For others this concern was incorporated with the extinction of species in general rather than weka specifically.

“I think it would be a real shame, yep, an absolute shame, just like anything else goes extinct or endangered aye ... it would be an absolute tragedy I think, yeah.” (P17MNF)

Also mentioned were potential social impacts of the loss of weka associated with its uniqueness to the area:

“I think it would be quite sad actually, I think they are quite iconic to the, to the region. As I said there are not many places where you get flightless birds, you know...and and I think it’s nice, it’s just a little bit different, you know. I mean people don’t see that in other places around the country... but I think it’s nice, you know they are running around in your garden.”

(P20WNF)

It is their role in making the district itself unique and different that is emphasized as well as personal experiences with them. P7MWF suggested their loss may be in part related to their very abundance:

“Because it’s [weka’s call], we take it for granted, but you know, as you say in Golden Bay they went, it may not be something to take for granted.”

Weka would only really be appreciated once they had gone:

“Umm because it is like anything you don’t really, you don’t value it until it is gone...”

(P10MNF)

This view was not held by most of the participants who did appreciate weka. The loss of weka was expressed in emotional terms by most participants and often related to place. This was not just expressed in relation to their personal experiences with weka but included potential social and
ecological impacts. This interconnects weka with social and ecological systems and also, I suggest, these systems with emotional responses.

11.1.3.11 Local knowledge (experiential knowledge)

In general most participants had some knowledge of basic weka ecology and risks to weka. This is shown more directly in their FCMs. However, many felt their knowledge was limited. P1WNF, although enjoying weka and seeing them regularly, suggested that:

“I don’t actually know that much about wekas, I’ve watched them but you know they only ... I don’t follow them home, where they nest ... I don’t know. ... umm, ... I have watched them a lot ... there’s quite a lot of them around there ... I know that they have killed on the road, and I know that our neighbour kills them as well in his traps which is a shame ... ”

P12WNF also claimed that she did not know much about them but had some knowledge of the number of chicks and number of broods the local birds had, and their territorial interactions. This is personal experiential knowledge about particular weka she interacted with. It is usually difficult to easily tell different weka apart, but if they have a distinguishing feature they will often be named (e.g., Hop-along, Rod, Wonky, etc). Most of the knowledge participants had about weka related to their direct experience of them, (e.g., farmers note things they see on the farm). An exception was some more general knowledge about weka being native and uncommon in most of their original range. This was an important piece of knowledge for some participants.

P19MF had little knowledge of weka even though he had grown up in the area and ran a farm:

“Don’t know too much at all apart from the fact that they like predominantly scrubby areas, umm and arr..... I don’t generally pay a huge amount of attention to them.”

His priority was in running his farm rather than observing weka:

“Um, but I don’t generally spend a lot of time watching them anyway, so they could well be out there and I just don’t pay attention.”

This suggests the focus of interest is often associated with everyday activities. In contrast, P20WNF liked weka but had limited knowledge of them and also had no stories to tell about them. This may be because of a lack of interaction with them through only living here for a short time and also living in town. A more general lack of participant knowledge about weka could be partially attributed to weka spending much of their time under low cover and so sometimes being difficult to see. Weka are also very secretive in their nesting habits:

“... I think have only found about three nests in about the last 30 years, so they are pretty secretive nesters. The ones I have found have been pretty deep in sort of heavy rush, rush
bushes or some where you just wouldn’t find them unless your dog sniffed them out and you heard a bit of a yelp when he gets pecked on the nose…”(P8MF)

Several participants commented on seasonal variations in their visibility (P4WF, P6WF):

“[T]here are certain times of the year when they seem to sort of just go off into the bush don’t they, you can go for days weeks and not see one... And you don’t even hear them call and then all of a sudden, you know spring comes and then its all on again yeah, whether they are half pie hibernate or what I don’t know, or go for a different food source.” (P4WF)

Others also noticed variations in weka they saw but could not account for them:

“yeah, but have never worked out a pattern of why you see them sometimes why you don’t.” (P7MF)

In contrast, P9MF had some thoughts about this:

“on a real good summer they seem to disappear they go into margins into bush and in swamps... some of our sandy ground here can get quite hard in the summer, and if the ground turns hard and it gets really dry they move out, they either move out into the swamps and bush margins and the... yeah the wet areas or they move close to the bloody house so we can feed em!”

However, this relates to summer rather than winter disappearance discussed above. Others noticed variations in densities in different land types. P3MWF thought that there were much lower numbers of weka on pākihi land. All this knowledge was ‘local knowledge’ as it was gleaned from personal observation.

11.1.3.12 The role of stories (as local knowledge)

Nearly everyone interviewed had a story about a weka experience. Weka are abit like the weather, providing something in common to talk about. Stories mostly related to individual experiences. For P15WF the weka story that came to mind was about weka getting inside the house. Perhaps because it is not common that wild animals just wander into your house it is considered a unique experience. Such home invasions are memorable:

“... ha ... I s’pose if a weka got in the house an shit over everything you might have a bit of a story ...” (P5MF)

Likewise:

“Well you certainly have stories about them if they come inside because you really do have to open all the doors, you have to umm gently go around and they’re going all over the place, and they make awful messes sometimes ... their messes are quite...aww, well just cleaning up, they just, you never get, sometimes you never get the stain out ..unbelievable.” (P6WF)
Other stories related less to interactive events than to stories about weka themselves. P9MF commented on how land development activities attracted weka;

“...and that was the day we counted, we had 15 diggers working in a row and we counted 15 um, no 30 wekas per digger in this particular area... these wekas were jumping in getting the bugs and all the worms and the worms being dug up. And they just couldn’t believe it, and my boss couldn’t believe the number of wekas we were counting. There was just hundreds of em, hundreds of them. And this went on right through the development...”

Or about the feats and qualities of weka:

“we had some sheep skins out here, a whole big sheep skins...and the weka dragged them like across the lawn into the bush, a whole sheep hide, ha, ha, yeah. Had a couple of ducks ...quite big ducks and they dragged them, they were dead , yeah, down the drive down the hill. Ducks, like twice the size of weka, damn strong.” (P17MNF)

P18MNF’s story was about how good weka were at returning to their homerange/territory. This is about weka being nuisance as well as about qualities of weka that he admires:

“Aww, yeah that they are good homers, arr when they were plentiful at Denniston we used to export them to Westport and they used to come back in about three days....yes same bird, definitely the same bird, ‘cause I clipped a couple of feathers on one, and yeah he came back....Then I started taking them over the Buller River and I think that stopped it. Then someone said they can actually swim so I chucked one in the dam at Denniston, yeah, I think the Buller might be a bit more of a challenge, it’s a bloody long way across, ha ha . None of them ever came back.”

Participants tended have more stories if they were both interested in and interacted with weka. The two participants with the least interaction (P20WNF) and least interest (P19MF) had the fewest stories.

11.1.3.13 Participants’ understandings of others’ responses

Some participants thought there was a diverse range of local opinion towards weka (e.g., P16MNF). P10MNF said:

“There are a lot of people that think they’re great, but on the same hand there are a lot of people who think arr, you know they will just kill them for the fun of it. And arr they will put their dogs onto them, and they will think it’s fun.”

Experiences with local children produced this comment from P3MWNF:

“[t]here seemed to be a lot of anecdotal stories of their dogs just getting stuck into weka..”
However:

“[w]ell you never know because kids can be a bit, well it’s cool because it’s our dog and all of that sort of thing.”

P7MWF highlighted the nuisance problem in this:

“I know lots of people who always set the dog on them as soon as they see them. I’m sure it’s just because of the house thing.”

Others thought that other people did not really dislike weka rather they were perhaps indifferent:

“[T]here would be a real variety, some people would love them, you know, some of farmers would love them, they like seeing the birds, and other people just wouldn’t care. Seem indifferent or you know disparaging especially if they were getting into their gardens they wouldn’t like it.” (P15WF)

By contrast, in P17MNF’s view most people like having weka around. P18MNF felt, along with P4WF and P7MWF, that:

“…my feeling is that people’s attitudes are changing, for the better. That’s just, I can’t quantify that, but just a feeling, as I said earlier about weka signs….and publicity in the newspaper….education basically, yeah, people have written a lot of stuff about weka capital of the world, I think that makes a real difference.”

Rather than discussing how many people like or dislike weka he comments on trends and change and associates this with feeling (as a way of knowing). He said that his attitude towards weka had changed over time. When he first arrived in the area and there were lots of weka getting into his garden he regarded them as pests and removed them and once or twice killed them. However, from the mid 1980s onwards he began to appreciate them more. By contrast, he also suggested that the amount of weka killed on the road might indicate that perhaps there had been little change:

“the traffic densities are not such that most of the time it’s safe for you to slow down or swerve or whatever, yeah…..so that’s , that’s probably indicative of or not, of not, of people not changing their attitudes to wekas.”

In this vein, P3MWNF para-phrased responses they heard from local people to new weka warning signs on local roads as:

“[A]ww, bloody, what’s the point of those signs I just speed up”.

These responses came from people P3MWNF did not necessarily expect would say that. Some participants thought that people living in the area all their lives tended to be indifferent to weka (e.g., P4WF, P11WNF):

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56 A weka road-kill survey at Cape Foulwind showed little change in road kill following the installation of warning signs (Freeman, 2010).
“So I think, I think that people that come here from outside probably appreciate them, and I think a lot of people that have grown up here just sort of take them for granted.” (P3MWNF)

P19MF suggested a possible reason for this, as he thought weka numbers were higher in the past:

“[M]y feeling is that the more long term residents are probably arr, appreciate them a lot less than some of the more recent arrivals ... But generally speaking the longer term residents are probably more, have less sympathy for them ... arr particularly arr given that they would have been around at the time when the populations would have been higher, and arr ... would have more reason to be annoyed with them.” (P19MF)

Here the amount of dislike is partially related to the weka population, with lower numbers appearing to be better. While P4WF suggested beyond a certain group:

“I think people are getting more aware of them. A lot of people are indifferent, then you have got that, the older sort of, not the older, but the die hard population is still basically, think they are a nuisance.”

By contrast, one participant noted that visitors to the area appreciated weka. Many participants (P4WF, P6WF, P1WNF, P9MF) commented on what they believed visitors thought of weka. Visitors from within New Zealand were the most intrigued with them. During farm land development P9MF commented that visitors to the site were fascinated by the number of weka around;

“I don’t know how many pictures, they took video camera movies, they took still pictures...”

Visitors’ reactions to interacting with weka may well influence the importance weka have for local people. This includes economic benefits already mentioned along with the influence of others’ reactions as contributors to the local networks. The appreciation of weka is sometimes reflected in visitors’ actions:

“People, locals go down to Les Warren park and let out their dogs, and I know there’s times dogs have chased the wekas and the campers are really really upset when a dog catches a weka, I hear they have got stuck into the dog owners sometimes.” (P16MNF)

11.1.4 Understandings of Weka and their ecology

11.1.4.1 Threats to weka

The major threat to weka on private land mentioned by both farmers and non-farmers were dogs. It concerned P4WF considerably:

“Well, the dogs, dogs are the biggest problem, yeah. Its dogs, you know dogs, even if someone wants tries to shoot them, you know they are not going to get many. But a dog can, just, yeah, dogs are shocking. They are the biggest threat to them. That, well that was even, in what Heaphy’s journal wasn’t it, when he was walking down and he got to Tauranga Bay,
they were starving and thought they would get weka there and there wasn’t any weka, the
dogs, they [Maori] had left dogs behind and they had just all gone. And I quite believe it they
will just, dogs are just quite efficient at running a weka down, imm ... I have a bit of a crusade
trying to stop people you know, killing them. Especially with dogs, my thing is with dogs.
People with their dogs, yeah.”

As mentioned, a number of participants thought that many people used dogs to keep weka from
becoming a nuisance:

“...dogs would be the biggy I’d say, especially if people not only allow but encourage it, and
people have dogs specifically to for, you know, killing wekas ...”(P8MF)

It was not just domestic dogs but also sometimes farm dogs:

“Most farmers seem to be a, seem to be pretty blasé about them. They don’t seem worried at
all. Um, there’s, there is probably still too many dairy cockies’ dogs that kill wekas. But
because we are sheep, sheep ... I don’t know of any shepherd that encourages dogs to kill
wekas.” (P9MF)

P9MF said if he had dogs on his farm that were inclined to chase weka he would sell them off to
farms where there were none. Eleven of the participants had domestic or farm dogs. Three were
concerned about their own dogs occasionally killing weka:

“It’s embarrassing a little, you know, but I have to admit there’s been a bit of a, odd...um,
weka kill around here because of dogs, sadly. But I know, I know quite quickly too, tie wekas
around their necks and do all sorts of things.” (P6WF)

P3MWNF were very concerned and got some bird aversion training for the dog. The dog was shot at
by one of the neighbours for apparently killing one of the weka he was fond of and fed:

“ I wouldn’t’ve questioned it if he had shot her (W) - no that’s right he had every right to.”
While another knew his dogs at least kept the weka away but did not comment on whether this
involved the dogs killing weka. He noted he saw weka regularly:

“Yeah, everyday.... Everywhere around the farm, you see them all the time, they’re
everywhere. There’s not many around here, not many around me house...yeah, ‘cause me
dogs.” (P14MF)

This represents another tension between people enjoying owning dogs but realizing they may be
putting weka at risk as they are aware of the damage dogs can do to weka. It shows again the
complex nature of the importance of weka as they lie entangled in affective networks of place.
Another threat which was not commented on frequently (P1WNF also mentions traps) but was
emphasised by P10MN concerned possum traps. As a possum trapper in the 1960s and 70s he told
how they caught a lot of weka in the gin traps:
"aww hundreds, hundreds, probably thousands..."

Participants varied in their views of the impacts of land development on weka (this will be discussed further in relation to their FCMs in Section 11.2). Many farmers who made comment on land development either thought its impacts on weka was either neutral or positive. For example P9MF commented that during their land development work:

"... we were quite concerned, because we thought that what we were doing was going to have a bit of an effect but you go down there at night time you see these groups of wekas which are going back into the grasses. Then I say once the development grew we found that the bugs [grass grubs], they have always been these bugs but of course we have dried that grass out, there’s a bloody millions more of them, and so now we seem to have more bloody wekas.”

The other interesting point associated with this comment is the broader ecological changes or feedbacks land development appeared to have created. The infestations of grass grub are often controlled with pesticides. The drying out of developed land may also have another impact in that weka may be forced to move around more in dry summers on developed land:

"on a real good summer they seem to disappear they go into margins into bush and in swamps... some of our sandy ground here can get quite hard in the summer, and if the ground turns hard and it gets really dry they move out, they either move out into the swamps and bush margins and the... yeah the wet areas or they move close to the bloody house so we can feed em.” (P9MF)

The development of large areas of land can mean weka have fewer places to move to. P9MF stressed how in their land development work they had not removed any of the existing bush and had fenced riparian margins. He also noted the high costs involved:

“And that’s part of the consent process, what I mean is we went into that with our eyes open, we know that we were going to have to spend a certain amount of money, and arr, ... but that’s what it’s cost us because we have had to leave stuff off.” [Legislative requirements and company policies provided the impetus for this to occur] “I work for ***, *** is committed to doing these things so I’m committed.”

This suggests the reason for adjusting their land development practices for weka was because they had to, rather than that they wanted to. Some other participant farmers (P7MWF, P4WF, P15WF) did leave areas of land for weka and other native species on a voluntary basis. All non-farmers thought land development and associated loss of habitat either negative, neutral, or did not know:

“Yeah, I the loss of habitat has been big I think, if they um, if they can, you know, just leave a little corner of the paddock and leave a bit of a habitat there for the weka and other wildlife
and um, I think it will arr, soon play dividends in the long term, and arr , the way the world is going with the, the farmers do want to keep up a clean green image.” (P10MNF)

P16MNF thought that while land development had an initial positive effect it was also reducing the habitat available by reducing cover:

“Yeah, I have heard that in some operations 30 or 40 wekas around the machine and that is obviously is a big boost in the way of food the wekas, but then once it’s developed, particularly if it’s really big blocks then there is going to be no cover for the wekas and I doubt if they could survive there... something I see happening in the Buller is that you are getting more and more of your kind of scrubby ground or low quality farmland is being turned into very high quality farmland so every year there would be probably 100s of hectares becoming unavailable to weka”

Road-kill was another threat to weka that was mentioned by many of the participants but was not often discussed further. Road-kill is frequently seen and experienced but is considered an accident. Perhaps it is something that is an unintentional by-product of an essential practice (driving) and so not able to be controlled. Likewise predation by stoats was also not often brought up in the interviews, but was highlighted in the non-farmers’ FCMs (see Section 11.2). In contrast to road-kill, this is probably because it was rarely experienced and so little is known about it. P16MNF comments that weka are good predators being able to kill kittens, rats and:

“I am sure they would eat young stoats, you know we think of stoats eating wekas but I’m sure ... I have got a friend who saw a fight between a weka and stoat once, you know, it was a very gruesome fight and they kind of after a while went out of range ...but it was kind of like evenly matched between an adult weka and stoat...”

11.1.4.2 Mitigation

A number of participants emphasised the importance of raising awareness of weka (e.g., P3MWNF). P4WF suggested this had already begun. She said she grew up with a whole culture of killing weka:

“[T]hat sort of whole culture there of killing weka, and it really is, yeah, and yeah, I have sort of grown up you know listening to it, hearing it and it was just, yeah, everyone was like it. When I was growing up at school I can’t think of anyone who saved weka... But it’s definitely changing a lot now, but it still needs to change a lot more, it’s the kids isn’t it that will do it, and then just getting the farmers behind you, because they own the bulk of the land.”

Making weka more valuable to people was seen as one way to make people more aware. Like P6WF, P4WF sees knowing more about them – ‘awareness’ - as vital to getting people to value them. This is in contrast to first-hand interaction (on which their concerns are based):
“... go out and talk to people and say, this is, this is the last place. You have just go and do it that way. And keep writing letters and putting pamphlets, and putting articles in the paper, on the radios and things like that. You just have to, to keep a profile, and just keep umm being aware of umm, I think you just got to be very aware of their population, what’s happening.”

(P6WF)

P3MWNF were also concerned about raising the awareness of the indigenous and endangered status of weka. They felt that in the past, for example, local veterinarians had not always treated weka as important compared to kiwi. While P14MF appealed to people’s ethics:

“You know, all you can do is um you know spread the word and hopefully people will treat them like they should, you know.”

By contrast, controlling weka was not considered possible as they are wild:

“you’re pushing shit up hill, ‘cause they are individual and they’re un-trainable, they’re f**ken wild, so what are you going to do?”

The emphasis here is not on trying to change weka, which you cannot do, so hopefully people might change. Another approach involved physical actions landowners could take. P13WF actively tries to protect local birdlife, and so took personal actions and responsibility:

“because I can see in my lifetime I have noticed a decline. Things are changing and that worries me so I keep traps set, and keep the rats and stoats and mice and whatever else I catch in traps around our immediate area, just help the bird population.”

Retaining habitat was seen as an important mitigation measure for some participants:

“... I think they should and I think all they need would be to leave some areas of scrub basically, some areas of gorse and manuka, hedgerows, strips, patches in corners, arr and then leave it up to the wekas.” (P18MNF)

P16MNF thought retaining the right sort of vegetation played a role in protecting weka from dogs:

“dogs are quite a big predator on weka in areas where humans are, and so cover, that weka can get through that dogs can’t is really important for their survival, like say blackberry, gorse type scrubby bush. That’s what will protect wekas from dogs.”

P12WNF experienced having few weka at her property before there was some scrub cover. This is reflected in her concerns with some recent land development practices:

“I mean the dairy farming at the moment I think is awful ‘cause they have just taken everything off, and it must be better for their land to leave margins of bush and flax and things just to stop erosion and runoff into drains and stuff like that, and I think good farming practice and wekas would go ok together... I’m a bit anti dairy farming at the moment, you know. The old style ones where people left bush and stuff...”
It is the corporate dairy farm rather than family farms she is concerned about. P15WF links this to more ethical imperatives that involve compensation:

‘...we can’t just ride roughshod over anything, just because we want to do it, so I think it is critical that um you know wherever there is land development for farming there needs to be um planting, to provide food for birds.”

P20WNF takes this concern in a slightly different direction:

“...people to accept that they should be there, that they have just as much right as us, um, that they shouldn’t like willfully go out and destroy them or get their dogs to destroy them or, you know aim for them on the road, or yeah ... that kind of willful destruction...”

The concern here is with intentional killing rather than for loss of weka as an unintentional by-product of practices such as land development. There is tension in both P20WNF and P15WF’s positions which implicitly allow for land development and its potential impacts on weka but which also place limits on what could be done. P17MNF sums up how the generally perceived risks to weka might be mitigated:

“probably the most important would be corridors of um bush, or arr scrub or whatever. Arr, you know in farmland. Arr probably more awareness about arr with dogs, stopping them, arr...catching, you know people working on predators is a bit that probably isn’t doing harm either, yeah. Umm, yeah a little bit of awareness on the road, but I think the major one is arr having you know, sort of corridors or patches of scrub in farmland. I think that, that has got to be the biggest one for sure.”

11.1.4.3 Thresholds

Only two participants commented on possible thresholds involved in the collapse of the weka population:

“[t]he weka population really healthy and everything and then it goes down a little bit, and a little bit, and a little bit, and then there is suddenly a point at which it will just collapses... You think everything’s fine but they reach a critical number that all of a sudden they have just gone.” (P7MWF)

This highlights the recognition of a lack of knowledge and the existence surprises. P9MF was concerned that weka might induce their own collapse through being too high in numbers:

“You know I always wonder whether it will be a bit like people, whether if we do get too many wekas, the food chain that’s about, will they eliminate themselves or disease or something.”

This tends to disconnect such events from human activities (i.e., from socio-ecological systems) and insulate weka population change as a naturally regulated event.
11.1.4.4 Weka population changes

P4WF said she saw her first weka in the area in about 1965. Her father had seen them when he was younger (1920s) but then did not see any again until the 1960s.

“See there were none there, and it wasn’t because the dogs, there just hadn’t been any”.

P16MNF told a story suggesting that there were few weka in an area to the north of Westport in the 1940s. P9MF agreed to some extent:

“There was bugger all of them about... I can remember a long way back you know, to when I went to school and that, and there was never the amount of wekas that there was now.”

However, he suggests that seeing fewer weka was in part because there was more cover around and so they were harder to see:

“...but I think the wekas were always there... but they were always there but they had a hell of a lot more cover, and we didn’t see them.”

He does not link this directly to the idea that following land development there is less cover and so there may appear to be more weka:

“But I remember seeing wekas, but nothing like we see now. I see wekas around my house now than I would have seen over the whole of dad’s farm.”

Weka may be forced to use areas around houses now where there is more cover. From the 1960s until now some participants were unsure of population changes:

“... no, I wouldn’t like to say that there had been any decrease or increase. But, yeah, you seem to see them a lot when they have got chicks. That’s probably when you notice them more I guess when they have got 3 or 4 chicks on the side of the road or whatever…” (P8MF)

P6WF and P4WF found it difficult to assess whether the population was stable or increasing due to seasonal variations in visibility, with – fewer being seen in winter;

“I sort of feel the countryside it’s probably a bit less but its every summer or when they start increasing it really surprises me that there are really masses of them around, and then I worry at sort of other times, you know when you see the farmland that’s been umm, its just total grass, where umm I don’t know, umm yes I guess it varies, umm, yeah it’s hard to know actually.” (P6WF)

P7MWF were more confident that little population change had occurred:

“But um, yeah, no the populations, like some you will go for a time when you don’t see them, but I don’t think the population’s gone it’s just, I don’t know, what they are up to, doing different things, or in another part of the area or something... [based on calls they heard]No I don’t think, from what we hear at night there are still plenty out there...”
P14MF also had not noticed a change in the weka population, but bracketed that in terms of their visibility:

“I can’t honestly say that, I don’t reckon it’s changed since my...no, no, they’re still pretty prolific. They’re everywhere, um, yeah. Just the amount you see on the roads and that, yeah you know that’s in the open.”

Another thought the weka population had definitely declined:

“I’m sure they, there would have been more, I’m sure, arr........we arr.... yeah I was born in the early 60s, so there were definitely more round then, we had, we had, there six boys in our family, and arr, we had arr 3 or 4 dogs running around all the time, there was always wekas about, you know, around the house, although we had a bit more scrub around as well....” (P19MF)

Similarly, P10MNF thought weka numbers may have declined over the past 40 years:

“I think there was more weka around. But I would be only guessing, it would only be a guess. I don’t [know] whether it was the fact that I was covering the country more, because we used to cover it... yeah, possuming, all the farms virtually everywhere so we used to see lots and lots of weka. But that’s just the general feeling I get is that we don’t see as many as what we used to.”

He recognizes this is related to what he was doing (experiential knowledge). PSMF suggested that the more recent land development has meant that there were now fewer weka than there used to be, although he said that “it’s just a presumption”. This variation in positions and recognition of a lack of knowledge associated with a range of variables may indicate that there may have not been a significant change since the 1960s. However, there is a general view that there were few weka in the area between the 1920-30s and 1950-60s.

11.1.5 Conclusion

The interviews exposed a set of rich and often tension filled relationships that local people have with weka. They show how weka and humans provide, through their characteristics as species and individuals, responses to each other. They highlight the very interactive relations involved.

The participants showed strong feelings for the place in which they lived. Weka were frequently linked to place and bound up with feelings of place, although the strength of this varied among the participants. The physical features of weka and, more importantly, their calls and character, contributed to the ambience of place within which emotional responses arise and are constituted. It is weka’s very nature that makes up both their positive and negative attributes. As
inquisitive interactive agents participants’ feelings about weka are as much ‘created’ by weka as bestowed upon them through people ‘giving’ them value.

Weka instigate interaction through their assertive nature and tameness. The results suggest that people’s emotional responses (like/dislike) for weka develop mostly from their actual physical interactions (e.g., being in the house, disturbing gardens, feeding them, etc.). This motivated most participants, even those who like them around, to take action against them. Many who did like them adapted themselves to fit in with weka ways.

Most of the participant’s knowledge of weka has been gained through observation and interaction with them. This includes recognition of seasonal and spatial variations in habitat use, call counts as an indication of number of weka around, recognition of a range of threats, productivity, impacts of weather, impacts of food supply on breeding, secretive nests, and the local population history. Although there was a basic knowledge held by all participants, longer term participants who interacted with them regularly tended to have more of this knowledge.

Weka are active agents within networks that link, and make up, the local ecology and human social networks. Within local social networks, participants thought there were diverse views of what others thought of weka (i.e., like, not-like, indifferent). Many participants thought that long term residents disliked weka more. These networks connect to outside the local area and the positive responses to weka by an increasing numbers of visitors may be influential on local perceptions. This is reflected in participants’ suggestions that views were changing. There was interaction with weka in the past, which resulted in different perceptions, but there are new networks now.

Most participants had emotive responses over the potential loss of weka, and of other species. The loss of weka was seen not just as an experiential loss but also as an economic and social loss (this connects with larger socio-ecological system).

Dog-kill, in particular, along with road-kill and wild animal predators, were seen as threats to weka. In contrast, the impacts of land development on weka numbers were contentious, and marked some separation between farmers and non-farmers. This was partially due to lack of knowledge about what the impacts are. Many farmers who made comments on land development thought its impacts on weka were either neutral or positive. It was not clear whether farmers would respond if numbers dropped markedly. At present, they do not think numbers are decreasing and also do not see land developed as a major threat or cause of loss. They may also wish to see lower numbers of weka. One participant commented that a sudden collapse of the weka population was possible.

For some participants reducing these threats involved raising awareness about them. Some suggest this is already happening and involves education about weka (rather than experiences of
them). There were varied views of personal role/responsibility in protecting them. Retaining habitat (cover) was considered important by most. Mitigation measures proposed linked to participants’ personal experiences. Some suggested multiple approaches.

Underlying the concern with weka population change is past population fluctuations in the area. It appears that there were lower numbers from the 1920s to the 1960s. Overall, there appeared to be little social memory of lower numbers and that was only a generation ago. However, there was some awareness of possible collapse (thresholds), but these were not grounded in any notion of how or when that might occur. There was also the idea of retaining a balance between nature and production. Participants were unsure of population changes post-1960s. There is a complicating factor in that there was more cover prior to the last 10-15 years so weka were possibly less visible. There was no recognized problem with the present weka population (which appears healthy).

Finally, there is the question of how what they know about weka is reflected in their FCMs. How does what they feel about weka and Cape Foulwind (their concerns, etc.) reflect in their FCMs? In other words, to what extent do FCMs reflect a local ‘feeling-knowledge’ of people and place? To frame the discussion I will suggest that interviews can bring subtleties that the FCMs do not and vice versa. That is, they are complementary.

In summary, the important findings from the interviews were:
- Local people have rich and often tension filled relationships with weka;
- Weka are appreciated as being part of the Cape Foulwind place whether they were liked or not;
- New people to the area expressed more concern for weka;
- Interaction with weka was important in the development of knowledge about weka;
- Interaction with weka was important in the development of the local significance of weka;
- Weka are considered unique and special to Cape Foulwind place;
- Weka are a taken-for-granted part of affective, interactive, embodied background or ‘given’ of Cape Foulwind;
- Weka are treated as active agents by the participants;
- Weka considered to have emotional responses (by some participants);
- Many informants accept and adapt to weka;
- Weka have a role in creating local human character;
- There is as much variation in perceptions of weka among farmers as between farmers and non-farmers;
• Participants’ experience with weka is that they are adaptable and the local weka population is not at risk although it was under some pressure from various threats.

11.2 Fuzzy Cognitive Map results

In common with the interviews, a total of 20 FCMs were developed with 22 people. Participants were evenly spread between female (n = 9) and male (n = 9). In addition, two of the FCMs were completed with couples. The participants’ ages ranged from c.30 to c.65 years. All but two of the participants lived in or around the Cape Foulwind peninsula area or Westport. The other two participants lived further south near Punakaiki, where weka are also common.

The participants were separated into two groups. These were people who lived in the area and were actively farming (n = 10) and people who lived in the area and were not farming (n = 10). Two different groups were chosen to allow comparisons between the groups. The primary group (farmers) owned farmland, and so controlled how it is managed. Members of the first group also primarily interacted with weka in their day to day activities as farmers. The majority of the members of the second, non-farmer group lived on lifestyle blocks and so interacted with weka regularly, while two lived in urban Westport.

This Section does not present the results of individual FCMs. These are discussed further in Section 11.3. The FCM data presented in this section is the amalgamated FCM data for: (1) All the FCMs; (2) Farmers’ FCMs; (3) Non-farmers FCMs. The results of the social FCM scenario modelling data are given in Section 11.4.

An accumulation analysis was completed to assess how many FCMs needed to be collected to ensure an adequate sample (Özesmi & Özesmi, 2004). It was found that after approximately 15 maps there were few new concepts being mentioned (Figure 11.1). Consequently, it was decided that adequate saturation had been reached following the collection of twenty FCMs.
Figure 11.1 Variable accumulation curve (number of new variables) for all FCMs.

The maps tended to be quite simple with low numbers of variables (mean = 12.5) and connections (mean = 19.7) (Table 11.1). There was little difference in map indices between the farmer and non-farmer averages of the individual maps, other than the non-farmer maps having a higher number of connections (23 ± 9 S.D vs. 17 ± 5 S.D). The mean time taken to complete the maps did not vary greatly between the groups.
Table 11.1  Means and standard deviations of basic indices of individual FCMs grouped as all maps and farmer and non-farmer maps.

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</tr>
<tr>
<td>Maximum time (min.)</td>
<td>90</td>
<td>90</td>
<td>75</td>
</tr>
</tbody>
</table>
The analysis of the mentioned variables (Figure 11.2) showed all the participants mentioned weka numbers, road-kill, and dog-kill in their FCMs. Overall, the variables mentioned did not vary considerably between groups. The major exceptions were nuisance and stoat predation. Only 40% of the non-farmers mentioned the nuisance aspect of weka, while 80% of the farmers did, while all non-farmers mentioned stoat predation and only 20% of the farmers did.

### 11.2.1 Full social fuzzy cognitive maps

Full social maps were developed by amalgamating all the individual maps. This is a process of placing all the variables from the maps into one matrix and adding the connection weights from the maps together using matrix addition. In this way the full complexity of each individual map is retained in the social FCM. The resulting social maps are very complex and difficult to analyse. Table 11.3 gives the indices summary for the full social maps. They all have high numbers of variables and connections.
Table 11.2 Summary of indices from the full social FCMs.

<table>
<thead>
<tr>
<th>Details of full social FCMs</th>
<th>All maps</th>
<th>Farmer maps</th>
<th>Non-farmer maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of maps</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>No. of variables, N</td>
<td>68</td>
<td>47</td>
<td>43</td>
</tr>
<tr>
<td>No. of transmitter variables, T</td>
<td>27</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>No. of receiver variables, R</td>
<td>4</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>No. of ordinary variables, O</td>
<td>37</td>
<td>23</td>
<td>27</td>
</tr>
<tr>
<td>No. of connections, C</td>
<td>197</td>
<td>99</td>
<td>129</td>
</tr>
<tr>
<td>Connection/variable, C/N</td>
<td>2.90</td>
<td>2.11</td>
<td>3.00</td>
</tr>
<tr>
<td>Complexity, R/T</td>
<td>0.15</td>
<td>0.26</td>
<td>0</td>
</tr>
<tr>
<td>Density, D</td>
<td>0.043</td>
<td>0.045</td>
<td>0.070</td>
</tr>
</tbody>
</table>

11.2.2 Cognitive interpretation diagrams (CIDs)

Highly complex maps (e.g., the full maps above) are difficult to understand. Consequently, simplified versions of the social FCMs were developed. A qualitative aggregation process was used to break variables into broader categories along with their connections. These categories were then treated as an individual variable along with their associated connections. The simplified system is represented as a cognitive interpretation diagram (CID) (Özesmi & Özesmi, 2004).

Table 11.3 Summary of indices from the CIDs.

<table>
<thead>
<tr>
<th>Details of Cognitive Interpretation diagrams (CID)</th>
<th>All maps</th>
<th>Farmer maps</th>
<th>Non-farmer maps</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of maps</td>
<td>20</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>No. of variables, N</td>
<td>18</td>
<td>18</td>
<td>19</td>
</tr>
<tr>
<td>No. of transmitter variables, T</td>
<td>5</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>No. of receiver variables, R</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>No. of ordinary variables, O</td>
<td>13</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>No. of connections, C</td>
<td>35</td>
<td>25</td>
<td>29</td>
</tr>
<tr>
<td>Connection/variable, C/N</td>
<td>1.94</td>
<td>1.39</td>
<td>1.53</td>
</tr>
<tr>
<td>Complexity, R/T</td>
<td>0</td>
<td>0.1</td>
<td>0.14</td>
</tr>
<tr>
<td>Density, D</td>
<td>0.108</td>
<td>0.077</td>
<td>0.080</td>
</tr>
</tbody>
</table>

Below are copies of the CIDs developed (Figures 11.3 to 11.5). They still remain quite complex (e.g., the full social FCM drops from 68 states and 197 connections to 18 states and 35 connections). Özesmi & Özesmi (2004) suggest 12 state variables are typical for analysis, but higher numbers are also used (e.g., Giles et al. (2007) used 18). I think in this study relatively complex CIDs are required as many aspects of the full maps are quite similar so simplifying them too much would
remove some of their more subtle differences. In the construction of the CIDs there is a risk of oversimplifying the system described in the full social maps.

The following presentation of the results highlight what are considered the most important aspects of the FCM CIDs. The All FCM CID (Figure 11.3) shows the importance of weka population in the maps as the central variable. It shows several strong negative influences on weka numbers (road-kill, dog-kill, predators and land development), and two strong positive influences (food supply and habitat retention). There is only one strong output from increasing weka numbers and that is nuisance, with a much weaker link to appreciation. This suggests that weka are considered by participants as primarily a nuisance. However, the CID is more multifaceted than this and an element of concern is shown in the role of attitudes in reducing the impacts of land development, road-kill and dog-kill. In addition, participants also recognize weka as having a number of positive and negative pressures on them, and most of these as being human related, and sometimes in quite complex way.

**Figure 11.3** The CID developed from all the FCMs (n = 20). Negative causal connections are represented by red dashed lines and positive connections by black solid lines. Thicker lines show stronger links.
Road-kill and dog-kill were considered the only strong negative influences on weka numbers in the farmers CID (Figure 11.4). These are both things they observe – weka dead on the road, and weka killed by dogs. Non-farmers, in addition, emphasise predation and the impacts of land development. These are events which are less obvious and more difficult to observe. In the farmer CID, positive influences remain food supply and habitat retention, along with small positive impacts from farm activities and weka’s ability to adapt. Nuisance, as the only output from changes in weka numbers, is not a strong effect. Attitudes are unimportant in the farmer CID and their mitigating effect in reducing human impacts on weka, seen in the All CID, is not evident. In comparison with the All CID, the impacts in the farmer CID are reduced and simplified, and the more complex feedbacks between the impacts on weka and humans seen in the All CID are less evident. The interviews suggest the farmer CID is an oversimplification of more complex and varied relations held by farmers with weka. The FCM CIDs help distil out some of the basic differences between farmers and non-farmers, but at the risk of missing the complexities. The farmers’ maps were no more developed than the non-farmers’ maps, and, in this respect, did not indicate a greater understanding of the socio-ecological system than the non-farmers.

The non-farmer CID (Figure 11.5) is considerably more complex than the farmer CID and has many similarities to the all-maps CID. The non-farmer CID shows the importance of the impacts of land development. It also showed people’s ‘attitudes’ played a more important role. In this way they had a more reflexive understanding and saw the system as being more open to change created by people. The position taken in this study is that people do not hold attitudes but rather construct perceptions. In this respect, non-farmers can be considered to have a more ‘modern’ separatist understanding of the relationship between humans and nature and between the mental and physical. However, non-farmers use of the word ‘attitudes’ also suggests they have a recognition of interactions and feedbacks existing in social-ecological connections. The non-farmers CID also included more external factors such as government policy, 1080 and the economy that were not included in the farmer CID.

The farmers CID suggests that farmers had a position based on a more immersed view, but without the recognition of emergence and feedback between the social and ecological. It does not make a judgment about any change being necessary. In this respect weka are considered subservient to human activities and not as an active entity. As discussed above, the interviews revealed a richer and more complex relationship for farmers and non-farmers than is captured by the FCMs.
**Figure 11.4** The CID developed from all the farmer’s FCMs (n = 10). Negative causal connections are represented by red dashed lines and positive connections by black solid lines. Thicker lines show stronger links.
**Non-farmer CID**

![Non-farmer CID Diagram](image)

*Figure 11.5* The CID developed from all the non-farmers FCMs (n=10). Negative causal connections are represented by red dashed lines and positive connections by black solid lines. Thicker lines show stronger links.

### 11.3 Individual interview and FCM comparison assessment

This section summarizes the results of a comparison between participants’ individual interviews and their FCMs. This analysis shows the broad range of FCMs produced, and whose idiosyncrasies reflect a range of understandings and experiences with weka. It also showed some common themes based around common experiences and interactions which are shown as the interview themes and in the FCM CIDs.

The aim of this comparison is twofold. The first is to assess the extent to which the individual FCMs reflect the relationships and meanings expressed in the interviews. The second aim is to use the data from the FCMs and the interviews in a complementary manner to develop a more complete
picture of the participants’ understandings/perceptions. These results are considered broadly within the themes already developed in the theory chapters and applied in Section 11.1 of the overall interview assessment.

The individual comparisons show, overall, that individual FCMs reflect the participants’ experiences and concerns expressed in the interviews. There was a considerable amount of consistency found between the two when taken from an embodied and situational perspective. Many participants’ situated, embodied interaction with weka can be directly traced, through the interviews, to the concerns and interests participants had in relation to weka. This was also shown in the FCMs, and most strongly in: P6WF, P10MF, P13WF, P12WNF, P7WMF and P15WNF FCMs. For these participants they range from personal experiences of weka family life, road-kill, land development and weka calls, all based in direct daily interaction with weka and, therefore, experience of their behaviour and character. This finding suggests that such interaction is not ‘one-sided’ as being a purely socially derived understanding overlaid on weka. Rather, weka appear as active agents in this process of valuing derived from ongoing interaction through everyday activities where the participants do not represent the world but live in it.

There were exceptions and some participants who had little interaction with weka produced FCMs which were as complete as any others. For example, P20WNF had had less interaction with weka than most participants, but still produced a complex FCM. Her map could be considered generic rather than ‘biased’ towards personal experience, and so derived from social networks such as educational, work-related and vicarious personal interactions, ultimately resulting from the direct experience of others. This indicates when there is a lack of direct experience it is filled by knowledge derived from others’ experiences.

The interviews gave a basis from which to make an assessment of the relationship between knowledge and affect. In particular, the extent to which FCMs can be considered as an expression of knowledge or also as an expression of affect. All the participants had positive feelings for the place where they lived and most emphasised the natural world in this. Most also had positive feelings towards weka. These emotional responses were reflected in a limited way in the FCMs in the participants’ common emphasis on threats to weka (i.e., mixed up in how causes were considered). Another area of the FCMs where participants’ feelings for weka can be detected is in whether participants thought people should change their actions towards weka. For example, the non-farmers, who nearly all had positive feelings towards weka, produced FCMs with a distinctively normative element. On the other hand, farmers who, overall, had fewer positive feelings towards weka, produced descriptive FCMs (i.e., a link between affect and motivation).
However, the ability to track this link was not always easy and participants with quite different feelings about weka produced quite similar FCMs (e.g., P12WNF, P19MF). This may be associated with the way emotions are expressed (i.e., associated with a manner of expression). This can make the parallel between the participant’s feelings about weka, shown in the interviews, and the form of their FCMs, difficult to trace as the affective aspect cannot be directly coded into the FCMs. Certainly, the interviews were much more directly revealing of the affective aspect. The results suggest that separating feelings and knowing does not really appear to be possible and so FCMs are an expression of both. This agrees with the theoretical development that feeling is bound up with all knowing and so will be integral to FCMs. It also supports the notion that FCMs are a reflection of lay persons’ understandings of the situation (Özesmi & Özesmi, 2004).

It was found that interviews complement FCMs by giving them an embodied context. This allows for a fuller analysis of people’s perceptions by aligning the knowledge expressed in the FCM to their everyday experiences, activities, and biography. In this respect the interviews give a richer picture and provide some guidance on why participants produced the FCM that they did. Being aware of these biographies (which were explored a little in the interviews) allows a link to be made between the FCMs and the participant’s everyday experiences of weka and place, as well as tracing idiosyncrasies in individual FCMs. The participants’ biographies can be considered to be the accumulation of their day to day experiences. Using the FCMs’ ability to order and trace the implications of understandings, and the contextualization allowed by the interviews, in a complementary manner thus provides a more detailed picture than could be obtained by using only one of these methods.

The interviews also provide information on the relationship between talk and action. For example, the interviews showed that P12W, P3MWNF, and P7MWF physically did things for weka in adapting to their presence. Other participants might say similar things (i.e., the need for adaptation) in their FCMs but not have consistent physical responses. P4WF’s concern and feeling towards weka are shown to some extent by her FCM, but her associated actions (e.g. dog training, leaving forest aside) are not revealed in the FCM.

There were also limitations noted in the ability of FCMs to capture the full richness of the participants’ understandings. The comparison of interviews with FCMs shows ways in which the FCMs were incomplete. This is partly because the FCM format is unable to cope with the complexities of understandings. In parallel, the interviews suggested feedbacks in the FCM were often not fully developed, for example, some participants (e.g., P3MWNF) expressed concerns over the loss of weka yet this was not shown in their FCM. This appears partly due to the potential complexity that can be developed, and also that many relationships are not considered. In this respect the amalgamation of
individual FCMs into CIDs can be useful as these kinds of oversights can be compensated for to some extent.

In some cases threats that were considered significant to weka in the interview were not mentioned in the FCM (e.g., P11WNF). By contrast, some aspects showed up strongly in the FCM analysis but were not revealed as being significant in the interviews (e.g., P5MF). There are possibly three reasons for this. The first, as already mentioned, is that the FCMs were unable to capture the full complexity of understandings; the modelling then produced ‘unintended’ results. There may have also been mistakes made in drawing the FCMs. The second, is that the FCM may expose an understanding that the participants have, but try to downplay in the interviews (e.g., some farmers in particular involved in land development accentuated positive effects of their activities.). This downplaying appears to be easier to do in the interview than in the FCM due to the inability to foresee the outcomes of the complex interactions coded in the maps. Also, it is possible some people wish to engage earnestly with a researcher, while others do not, particularly if they feel the research may impact on their activities. The third factor is due to the numerous ways FCMs can be constructed (e.g., the number of ways states can be expressed) and the complexity of interactions.

This is reflected in the fact that many participants (e.g., P11WNF and P17MNF) said that some of the weightings were guesses, and did not know what value to give them. In other words, they did not have enough knowledge to cope with the full complexity of the situation. This means there is no prior explicitly known whole FCM in the first instance; rather it is an interactive creation. This suggests two aspects. First, that the FCMs were created on the spot, interactively with myself, the question and the pencil and paper. Second, the situation expressed was manifest as combinations of concerns, experiences and feelings and expressed in a different manner in the interviews but with ultimately similar assertions as the FCMs they produced. Indeed, the creation of FCMs may involve quite intuitive and emotional assertions (i.e., feelings about what is happening and what is important). The theoretical development showed emotion and conception are not separate and so FCM are always in part emotional constructs. Emotion becomes intrinsic to the participant’s expression of what they know. In addition, the interviews showed that emotion was intrinsic in relations with weka for most participants. In these respects, laypersons’ FCMs are best considered not as a priori constructs but as creative responses to people’s situated, embodied affective existence.

FCMs tend to show a cohesiveness or integration of participants’ understandings as they are forced to link things together. This ‘forced’ linking, however, does not necessarily reflect a participant’s actual understanding (i.e., they may not normally consider whether or not links exist or in what direction they may go). The use of the FCM method requires the participants to express their
understandings in a systematic format. It was found some people were more ‘systematic thinkers’ than others and so produced more developed maps. For example, P8MF produced a well connected map quickly and easily with complex outcomes. This does not necessarily reflect more knowledge of weka but just that he was good at doing FCMs (i.e., he thinks systematically).

Some participants themselves expressed concerns about the validity of FCMs. For example, P11WNF thought that she was just stereo-typing people’s responses in the weightings and thought that the situation (particularly regarding people’s responses) was more complex than the FCM allowed. Finally, she thought that if she did another map tomorrow it would be different from the one she had just done. This is partly related to a concern about guesses. It also reflects the dynamic nature of the situation where her previous experience of doing an FCM would influence subsequent ones. In contrast P18MNF did not think he gained any insights from doing the FCM, and it merely reflected his present understandings, with the implication that he would re-produce the same map if he did it again.

There were other complicating factors. One, was that not all the FCMs were drawn up in the same circumstances. Some participants were busy (e.g., P14MF) and did not have a lot of time to draw the maps. Two, some participants were not particularly interested in drawing the maps, or in the subject. Other participants were, by contrast, very interested in the process.

The important findings of this Section were:

- Individual FCMs reflect people’s experiences and concerns shown in the interviews;
- Many participants’ situated, embodied interaction can be directly traced through the interviews to the concerns and interests participants had as expressed in their FCMs;
- The interviews provide information on the relationship between talk and action;
- Interviews complement FCMs by giving them an embodied context and allow tracing the background to the FCMs;
- Interviews give a richer picture and provide some guidance on why participants produced the FCM that they did;
- Interviews show ways in which the FCMs were incomplete;
- There were inconsistencies between FCMs and interviews in part because: FCMs were unable to capture the full complexity of understandings; mistakes in drawing FCMs; FCM may expose an understanding that the participants have but try to downplay in the interviews; the numerous ways FCMs can be constructed;
- For lay people there is no prior explicitly known whole FCM. So FCMs are best not considered a priori constructs but creative responses to people’s situated, embodied emotional existence.
Some participants thought weightings were guesses as they did not have enough knowledge to cope with the full complexity of the situation. The situation expressed was manifest as combinations of concerns, experiences and feelings;

There was variation in the participants’ ability to think systematically;

Using the two methods in a complementary manner provides a richer picture than could be obtained by using only one of these methods.

To summarize, considering the FCM and interviews together produced a broader understanding than would use of the FCMs alone. The use of FCMs enables understandings to be captured in a systematic way that allows a formal modelling process to be undertaken. The inclusion of interviews allows the FCMs to be contextualized more readily and considered within more open general themes than can be developed from interviews. The interview process also highlights some of the limitations of the use of FCMs.

The analysis of individual FCMs showed some common themes among non-farming participants and also among the farming participants. Factors common to non-farmers FCMs were:

1. Concern with attitudes;
2. Prescriptive;
3. All of the non-farmers thought that land development may be negatively impacting the weka population;
4. All of the non-farmers were concerned about the security of the local weka population.

There was more variation in perceptions among the farmers particularly between those who were actively undertaking land development and those who were not. In addition, a male-female distinction exists, although this is probably just coincidental as in general men and women both run the farms together. Factors common to farmers’ FCMs were:

1. Concern with nuisance;
2. Descriptive;
3. Five of the farmers expressed a concern about the security of the local weka population;
4. Six of farmers did not think land development was negatively impacting the weka population.

### 11.4 FCM Policy Option Simulations

This section discusses the results of the output from neural network modelling of the three CID.s. Chapter 10 outlined neural networks and their use in analysing FCMs through a process of ‘tuning’. The neural network modelling undertaken in this study involved this process using the Fuzzy Thought Amplifier software (Fuzzy Systems Engineering). An initial ‘tuning’ of the FCMs was done to give a baseline (steady state) outcome using the FCMs initial state settings. ‘Tuning’ also allows the possibility of setting (clamping) the initial state vector (node) values to represent a particular system.
state you wish to investigate. For example, one of the state vector nodes may be set to ‘on’ (which might represent an increase in the prices obtained for farm outputs) and the other nodes set to ‘off’. The results of this are compared to the initial baseline outcomes. If the tuning results in the node states stabilising at a fixed point equilibrium it gives a deterministic outcome on the state the system will produce. In contrast, system that stabilises into a cyclic pattern will indicate a likely cycle of events the system will produce. Chaotic patterns obviously suggest a less stable dynamical system (Kahn et al., 2003). The neural network modelling undertaken in this study all produced fixed point equilibrium outcomes.

Figures 11.7 to 11.11 show the outputs of setting one or more state vector nodes to ‘on’ (high) or ‘off’ (low) (Table 11.4). The outcomes of this on various state vector nodes are assessed. Figure 11.6 provides an example of an output graph and shows the state node being clamped or held and the outputs associated with a range of other states. There were two sets of scenario models (policy option simulations) undertaken. The first scenario models (Figures 11.7 to 11.9) the impacts on the weka population, appreciation and nuisance from changes in land development and the weka population (See Table 11.4 Scenario 1). The second models (Figures 11.10 to 11.12) the impacts on the weka population, appreciation and nuisance primarily from a range of pressures on the weka population (See Table 11.4 Scenario 2).
**Table 11.4** The relationship of the scenarios and state vector settings.

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>State vectors held (high or low)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst case</td>
<td>Land development, road kill, dog kill, predation, vegetation clearance, poison, people killing weka (all set high)</td>
</tr>
<tr>
<td>Increased land development</td>
<td>Land development (set high)</td>
</tr>
<tr>
<td>Decreased land development</td>
<td>Land development (set low)</td>
</tr>
<tr>
<td>Decrease weka population</td>
<td>Weka population (set low)</td>
</tr>
<tr>
<td>Increase weka population</td>
<td>Weka population (set high)</td>
</tr>
<tr>
<td>Increase attitude</td>
<td>Attitude (set high)</td>
</tr>
<tr>
<td>Increase nuisance</td>
<td>Nuisance (set high)</td>
</tr>
<tr>
<td>Increase government policy</td>
<td>Government policy (set high)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scenario 2</th>
<th>State vectors held (high or low)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease land development</td>
<td>Land development (set low)</td>
</tr>
<tr>
<td>Decrease road-kill</td>
<td>Road-kill (set low)</td>
</tr>
<tr>
<td>Decrease dog-kill</td>
<td>Dog-kill (set low)</td>
</tr>
<tr>
<td>Decrease predators</td>
<td>Predation (set low)</td>
</tr>
<tr>
<td>Decrease new people</td>
<td>New residents (set low)</td>
</tr>
<tr>
<td>Decrease tourists</td>
<td>Tourists (set low)</td>
</tr>
<tr>
<td>Decrease economy</td>
<td>Economy (set low)</td>
</tr>
<tr>
<td>Decrease attitudes</td>
<td>Attitude (set low)</td>
</tr>
</tbody>
</table>
Figure 11.7 The modelled impacts on the weka population, appreciation and nuisance from a range of simulation scenarios for the all-maps CID.

Figure 11.8 The modelled impacts on the weka population, appreciation and nuisance from a range of simulation scenarios for the farmers CID.
Figure 11.9 The modelled impacts on the weka population, attitudes and nuisance from a range of simulation scenarios for the non-farmers CID.

The all-map CID FCM scenario modelling aligns very well with the IBM modelling in relation to the weka population’s responses to land development and other pressures. The all-map CID FCM scenario modelling (Figure 11.7) shows a decrease in land development as being beneficial for weka and an increase as being detrimental. This suggests residents overall have a good knowledge of the SES in relation to weka in this respect. Other cumulative pressures (e.g., dogs and road-kill) are included as part of worst case scenario and there is a significant impact on the weka population recognized. Both appreciation and nuisance of weka decrease as weka population decreases and both increase as the weka population increases. This suggests if there are more weka around people appreciate them, but they also become more of a nuisance. Conversely, if there are fewer weka they are less appreciated, and so there is less interest in retaining them. This tends to support the notion of the importance of interaction.

Like the all-map CID modelling the non-farmer CID FCM scenario modelling (Figure 11.9) also shows a decrease in land development as being beneficial for weka and an increase as being detrimental. Non-farmers also recognize a significant cumulative impact from multiple threats. Interestingly, the increasing or decreasing weka numbers were not seen to have any effect on nuisance. Appreciation was not a state included in the non-farmers CID. They used the more normative term of attitudes. ‘Improving attitudes’ is seen as good for weka numbers.
The farmer CID FCM scenario modelling (Figure 11.8) does not align as well with the IBM results and shows a significant inconsistency on the impacts of land development where increased land development does not impact on weka but decreased land development does. This could involve an element of cognitive dissonance that is revealed in the FCM. As with the other CIDs, the worst case scenario was recognized as having a significant impact on the weka population, although a lesser impact than that recognized by the all-map and non-farmers’ CIDs. Farmers also recognised a decrease in weka population caused a decrease in nuisance and an increase having increasing nuisance. Significantly, no effect on appreciation was recognized. Attitude change was not an element for the farmers’ FCMs as they do not perceive anything wrong so there is nothing to change.

The second set of scenario modelling also uses the all-map, farmers’ and non-farmers’ CIDs (Figures 11.10 to 11.12). This modelling considers the impacts on the weka population from decreasing the particular pressures on the weka population one at a time. For all the CIDs decreasing land development, road-kill, dog-kill, and predation are considered all to have positive impacts on the weka population. Predation is only a significant factor in the non-farmers’ CID. The all-map model (Figure 11.10) shows an increase in nuisance and also appreciation indicating the tension between these. The farmer scenario model (Figure 11.11) does not indicate any increase in appreciation with increasing weka population, which suggests the nuisance element is more important for farmers. Decreasing ‘new people’ leads to a decrease in the nuisance factor as new people are seen as encouraging weka. The non-farmer model (Figure 11.12) indicates that a decrease in attitudes will negatively impact on the weka population.

In summary, land development is the controversial threat. The CID modelling shows all participants agree on the impacts of dogs and vehicles and, to some extent, predators. While the policy modelling for all the CIDs shows decreasing land development creates an improvement in weka numbers. In contrast the farmers’ CID shows no change in the weka population with increasing land development. Another interesting aspect is the lack of importance of nuisance and positive effect of improved ‘attitudes’ in the non-farmers’ CID modelling and the importance of nuisance and lesser importance of appreciation in the farmers CID.
Figure 11.10 The modelled impacts on the weka population from decreasing particular pressures individually for the all-maps CID.

Figure 11.11 The modelled impacts on the weka population from decreasing particular pressures individually for farmers CID only.
11.5 All-map CID and interview themes comparison

The FCMs were amalgamated into social FCMs and a set of central themes was developed from the interviews. These were discussed in Section 11.2. In this short section the all-map CID (Figure 11.3) is further considered in light of the overall interview themes. This comparison is more limited than the individual comparisons as both the interviews and FCMs are further simplified and abstracted. This section compares the all map CID with the themes which were developed from all the interviews and is set out in Table 11.5. If I wish to compare the farmers’ CID and non-farmers’ CID I would need to develop particular interview themes for each which has not been done.

Comparisons at this level are more difficult than at the individual level and the difference between the information gained in the interviews and CIDs was greater than at the individual level. In this respect, the use of interviews may be even more useful in clarifying the complexity and depth of relationships involved.
<table>
<thead>
<tr>
<th>Interview theme</th>
<th>Comment in relation to CID</th>
</tr>
</thead>
<tbody>
<tr>
<td>The importance of place</td>
<td>The knowledge of place shows in the CID through the multitude of interactions associated with weka. Previous discussion (Section 11.3) has shown the affective elements associated with this that lies implicit in such knowledge.</td>
</tr>
<tr>
<td>The importance of native wild animals</td>
<td>The CID shows the complexity of interactions weka have with a multitude of factors which suggests recognition of their importance as a native wild animal. A FCM developed with, for example, hares might produce a map less connected with such a wide range of factors.</td>
</tr>
<tr>
<td>Weka and place</td>
<td>The CID shows the complexity of interactions weka have with a multitude of factors that make up the Cape Foulwind place.</td>
</tr>
<tr>
<td>Weka features (physical, calls)</td>
<td>This is shown in the CID mostly as a negative influence via the ‘nuisance’ theme. There is some positive influence shown through appreciation.</td>
</tr>
<tr>
<td>Tension between nuisance and appreciation</td>
<td>This is shown well in the CID as a feature of the system.</td>
</tr>
<tr>
<td>The role of interaction with weka</td>
<td>The CID shows a wide range of forms of interaction with weka. However, these interactions are not at the personal level. This is not surprising given that the participants were asked to draw a FCM of the system for Cape Foulwind and not of their back garden.</td>
</tr>
<tr>
<td>Weka as active agents (actors)</td>
<td>This is shown in the CID through the themes of ‘nuisance’ and ‘appreciation’. However, this active role of weka is not strong in the CID as it is dominated by influences on the weka population.</td>
</tr>
<tr>
<td>Local knowledge</td>
<td>This is shown well in the CID where nearly all the information on the CID is local and experientially derived.</td>
</tr>
</tbody>
</table>
12 Weka ecology and IBM results

12.1 Weka ecology results
This section presents the results of the empirical data collected at Cape Foulwind. It initially presents an overview of the data collected from each of the primary methods used (spacing call counts, telemetry, colour banding). It then presents the results organized around particular topics. The general aim of this is to highlight the data that contribute to, or are used for, the IBM parameters (see Table 9.2).

12.1.1 Spacing call counts
Analysis of all the call count sites showed that 93% of the close calls occurred during the hour after sunset. This peaked in the period 30-50 minutes after sunset. After this time the number of calls began to decline (Figure 12.1). A similar pattern was found when the close call counts were separated into call count locations where a below average number of calls were recorded (<31 calls for entire count) and sites where above average call numbers were recorded. The peak calling period was less pronounced at the sites with lower calling numbers (Figure 12.2).

![Figure 12.1 Mean total close weka calls for each 5 minute period at Cape Foulwind. Total listening nights = 88. Zero (00) is the time of sunset.](image-url)
A single pair calling in each five minute counting interval was the most common single type of call combination observed. However, multiple calls by more than one pair were, overall, more frequent (Figure 12.3). Associated with this, the call count data were analyzed to check if there was any trend towards increased frequency of calling in higher densities. A weak trend towards this was found (Figure 12.4). This gives some support to the observation that weka tend to call more reliably in the presence of other weka (Bramley & Veltman, 2000).

There is a range of biologically specific results obtained from the spacing call counts and these are discussed in the relevant sections below.
Figure 12.3 Histogram of frequency of weka call in each 5 minute interval. The graph is for close calls at all sites.

Figure 12.4 Call frequencies per weka in relation to weka densities. It shows a trend toward weka calling more frequently in higher densities. Note that this is the number of close weka recorded per site per call count night.
12.1.2 Telemetry

Of 17 weka that had transmitters attached to them, five were juveniles, seven were adult male, and five adult female. A summary of some of the results obtained from the telemetry is in Table 12.1. These results are discussed further in the relevant sections below.

**Table 12.1** Weka telemetry result details.

<table>
<thead>
<tr>
<th>Weka #</th>
<th>Male/Female</th>
<th>Age</th>
<th>Paired</th>
<th>Adult/Juvenile</th>
<th>Breeding success (chicks/year)</th>
<th>Fate of tx/bird</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 to 3</td>
<td>No</td>
<td>Adult</td>
<td></td>
<td></td>
<td>Killed by dog</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td>Adult</td>
<td></td>
<td></td>
<td>Tx fell off (same bird as weka 4)</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>No</td>
<td>Adult</td>
<td>2 (2007)</td>
<td>Killed by dog</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>1 to 3</td>
<td>Yes</td>
<td>Adult</td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>&lt; 1</td>
<td>No</td>
<td>Adult</td>
<td>Left area</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>1 to 3</td>
<td>No</td>
<td>Adult</td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>No</td>
<td>Adult</td>
<td></td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>1 to 3</td>
<td>Yes</td>
<td>Adult</td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>1 to 3</td>
<td>Yes</td>
<td>1 (2007)</td>
<td>Not heard</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>No</td>
<td>Adult</td>
<td>1 (2008) (died)</td>
<td>Not heard</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>F</td>
<td>1 to 3</td>
<td>Yes</td>
<td>Adult</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>1 to 3</td>
<td>Yes</td>
<td>Adult</td>
<td>Not heard</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>1 to 3</td>
<td>No</td>
<td>Adult</td>
<td></td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>M</td>
<td>2 months</td>
<td>No</td>
<td>Juvenile</td>
<td>Poisoned</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>2 months</td>
<td>No</td>
<td>Juvenile</td>
<td></td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>6 weeks</td>
<td>No</td>
<td>Juvenile</td>
<td></td>
<td>Tx fell off</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>2 months</td>
<td>No</td>
<td>Juvenile</td>
<td></td>
<td>Not heard</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>M</td>
<td>2 months</td>
<td>No</td>
<td>Juvenile</td>
<td>Killed by dog</td>
<td></td>
</tr>
</tbody>
</table>

Where cells are blank no data is available

12.1.3 Colour banding

Twelve adult weka had colour bands placed on them. Of these, five were male, four female and three were of unknown sex (Table 12.2). The two pairs that were seen regularly had well defined territories that were maintained all year round.

There was a range of results obtained from the telemetry and these are discussed in the relevant sections below.
Table 12.2 Colour banded weka result details.

<table>
<thead>
<tr>
<th>Weka #</th>
<th>Name</th>
<th>Male/female</th>
<th>Adult/Juvenile</th>
<th>Breeding success (Chicks/year)</th>
<th>Mate</th>
<th>Fate of tx/bird</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lemon</td>
<td>F</td>
<td>Adult</td>
<td>1 (2009)</td>
<td>Tussock</td>
<td>Still alive</td>
</tr>
<tr>
<td>2</td>
<td>Scarlett</td>
<td>?</td>
<td>Juvenile</td>
<td></td>
<td></td>
<td>Dispersed</td>
</tr>
<tr>
<td>3</td>
<td>Bruno</td>
<td>M</td>
<td>Adult</td>
<td>2 (2009)</td>
<td>Blondie</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>5</td>
<td>Squeak</td>
<td>?</td>
<td>Juvenile</td>
<td></td>
<td></td>
<td>Dispersed</td>
</tr>
<tr>
<td>6</td>
<td>Tussock</td>
<td>M</td>
<td>Adult</td>
<td>1 (2009)</td>
<td>Lemon</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>7</td>
<td>Squeaky</td>
<td>?</td>
<td>Juvenile</td>
<td></td>
<td></td>
<td>Poisoned</td>
</tr>
<tr>
<td>8</td>
<td>Trouble</td>
<td>M</td>
<td>Adult</td>
<td>2 (2010)</td>
<td>Blondie</td>
<td>Disappeared/died</td>
</tr>
<tr>
<td>9</td>
<td>Whitey</td>
<td>F</td>
<td>Adult</td>
<td></td>
<td></td>
<td>Not re-found</td>
</tr>
<tr>
<td>10</td>
<td>Paddy</td>
<td>M</td>
<td>Adult</td>
<td></td>
<td></td>
<td>Not re-found</td>
</tr>
<tr>
<td>11</td>
<td>Moonie</td>
<td>F</td>
<td>Adult</td>
<td></td>
<td></td>
<td>Not re-found</td>
</tr>
<tr>
<td>12</td>
<td>Junior</td>
<td>M</td>
<td>Juvenile</td>
<td></td>
<td></td>
<td>Killed by dog</td>
</tr>
</tbody>
</table>

12.1.4 Threats

12.1.4.1 Dogs

Three of the 19 telemetry (16%) birds were considered to have been killed by dogs. All were found dead (thrown around but not eaten) in the proximity (back/front yards) of houses with dogs. Anecdotal evidence of dogs killing weka was common in the area, and is apparently at times encouraged by some dog owners.

12.1.4.2 Predators

*Harrier hawks.* Weka are very sensitive to hawks flying nearby and quickly move into cover when they see one. One bird was observed running into cover when an airplane flew overhead, possibly mistaking its shape for a hawk. A hawk was observed unsuccessfully attacking one of the colour banded male weka while the weka was feeding during the day. The number of weka killed by hawks is unknown and difficult to estimate.

*Stoats.* There was no evidence of stoat predation on weka. Stoats are regularly seen in the area. Eight stoats in four traps (1456 trap nights) were caught on my property in 2009.
12.1.4.3 Poison

One telemetry juvenile weka was found dead on 21/10/2008 following a poisoning programme using Feratox™ poison sealed in starch casings and stapled to trees. The dead weka showed no external injuries and was seen in good health 48 hours previously. The body was dissected and pieces of bait found in its stomach.

12.1.4.4 Road-kill

By far the most detailed data collected for the threats was for road-kill. The full road-kill research results are described in Freeman (2010). Only the road-kill results relevant to developing the parameters for the IBM are given here.

300 weka carcasses were recorded over an average of 470 survey days (across all the roads surveyed) from a possible total of 728 days (i.e., 65%). It is assumed all these weka were killed by vehicle strike, giving an average road-kill rate of 6.0 km\(^{-1}\) per year over 25.1 km of local rural roads.

Most of the carcasses were collected in the spring (n = 24) and summer (n = 12), but fewer in winter (n = 11), and least of all in autumn (n = 5). The unbalanced distribution of data means that seasonal comparisons can be considered as only preliminary. The number of weka found dead per kilometre of survey effort was highest during the period from August to December (62% of all road-kill). There was significant seasonal variation in road-kill per kilometre of survey effort (Figure 12.5: \(F = 4.139, \text{d.f.} = 3, P = 0.020\)).
Figure 12.5 The number of weka killed on all the study area roads by season calculated using monthly weka road-kill per kilometre surveyed (February 2006 – February 2008).

The total weka road-kill for all the main public roads in the Cape Foulwind area was estimated at 356 per annum (Table 12.3). This calculation was expected to overestimate road-kill because fewer vehicles used the entire length of dead end roads. These roads make up about 28% of the public rural roads at Cape Foulwind. Approximately 18% of the total estimated road-kill was attributed to these dead end roads. Balancing that was the potential underestimation due to the exclusion of some small minor roads from the assessment.
Table 12.3 The estimate of weka road-kill on major public rural roads at Cape Foulwind. The figures assume a weka density consistent with call count data. Annual mortality is calculated using the average survey days per year for all surveyed roads (235 days).

<table>
<thead>
<tr>
<th>Major public rural roads</th>
<th>Traffic volume (VPD y(^{-1}))</th>
<th>Weka killed per surveyed day/km y(^{-1})</th>
<th>Road length (km)</th>
<th>Estimated annual weka mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alma Road</td>
<td>409</td>
<td>0.015</td>
<td>2.2</td>
<td>8</td>
</tr>
<tr>
<td>Okari Road</td>
<td>110</td>
<td>0.005**</td>
<td>5.0</td>
<td>6</td>
</tr>
<tr>
<td>Wilsons Lead Road</td>
<td>500*</td>
<td>0.019**</td>
<td>11.0</td>
<td>49</td>
</tr>
<tr>
<td>Airport Road</td>
<td>168</td>
<td>0.007**</td>
<td>3.5</td>
<td>6</td>
</tr>
<tr>
<td>Virgin Flat Road</td>
<td>77</td>
<td>0.014</td>
<td>7.3</td>
<td>24</td>
</tr>
<tr>
<td>SH6</td>
<td>852</td>
<td>0.031</td>
<td>11.9</td>
<td>88(^{1})</td>
</tr>
<tr>
<td>SH67</td>
<td>1540</td>
<td>0.037</td>
<td>5.1</td>
<td>47(^{1})</td>
</tr>
<tr>
<td>SH67a (to Carters Beach)</td>
<td>1914</td>
<td>0.035**</td>
<td>3.9</td>
<td>32</td>
</tr>
<tr>
<td>SH67a (Cape Foulwind)</td>
<td>1100*</td>
<td>0.035**</td>
<td>10.6</td>
<td>88</td>
</tr>
<tr>
<td>Bulls Road</td>
<td>56</td>
<td>0.004**</td>
<td>4.7</td>
<td>8</td>
</tr>
</tbody>
</table>

* Traffic volume estimated
\(^{1}\)Actual figures
**Data interpolated from model developed from known figures (Freeman, 2010)

Weka dissections revealed that 73% of the carcasses were males and 27% were females ($\chi^2 = 4.92$, d.f. =1, $P = 0.027$), and 38% of the birds were less than one year old, 52% were 1 to 3 years old, and 10% between 3 and 15 years old. Seasonally, males were over-represented in winter and spring deaths (83%) ($\chi^2 = 7.062$, d.f. = 2, $P = 0.008$), but summer and autumn deaths comprised a relatively even mix of males (47%) and females (53%) ($\chi^2 = 0.029$, d.f. =1, $P = 0.864$). There was little difference within the age classes except in summer, when slightly more first year birds were killed ($\chi^2 = 4.929$, d.f. = 2, $P = 0.085$) (Figure 12.6).
12.1.5 Weather

There was not a detailed enough survey done to fully assess the impacts of weather variation in the Cape Foulwind population. However, evidence from other populations (i.e., Kawau Island) (Beauchamp & Chambers, 2000) suggests that there are impacts from dry weather.

There was some anecdotal evidence of the impacts of weather on weka. For example, one local farmer, with free draining sandy coastal land, found weka were falling into water troughs and drowning during dry summer weather after attempting to drink out of them. He put in rocks in the bottom of the troughs to allow them to escape. While other evidence suggests that in dry summer weather soils in free draining developed pasture turned hard. This makes it difficult for weka to obtain food so they left these areas moved back into the scrub and forest. A record dry November in 2010 forced a resident breeding pair with chicks to move away from their territory on my property.

The Cape Foulwind area has moderately high annual rainfall and long wet periods can occur at times, while prolonged dry spells only occur rarely\(^\text{57}\).

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\(^\text{57}\) On average Westport experiences periods where no rain is recorded for at least 15 days once every 5 years. (West Coast Regional Council (2002) Natural Hazards Review. DTec Consulting)
12.1.6 Breeding

Data from banded and telemetry birds suggest that weka breeding at Cape Foulwind has a significant spring peak. The six pairs for which data were obtained all bred in the period from September to November. It is also possible that the high road-kill rates in the spring months is associated with breeding-related activity, and if so would support a spring peak in breeding (Freeman, 2010) (see Section 12.1.4.4). Anecdotal evidence suggests breeding outside this period and multiple clutches occurred around houses where there was an increased food supply.

Telemetry and colour band data gave an average 1.5 chicks per female (n=6) per year. The average percentage of known territorial females successfully breeding in 2007-2009 was c.75% (n = 8). Due to the lack of data annual percentages cannot be given.

12.1.7 Home range and Territory sizes

 Territories and home range sizes averaged 1.23 hectares (n = 11) from the telemetry results. All these birds were in undeveloped pasture and six were monitored for less than two weeks which may mean that data collected was not sufficient to give a realistic indication of their usage area. For the weka monitored for greater than a month the average size was 2.2 hectares (n = 5) (minimum 0.3 hectares, maximum 4.7 hectares). The estimated territory size for one colour banded pair was 2.5 hectares. These sizes align well with the 2.5 hectares average territory size for undeveloped pasture estimated from call counts (Table 12.4). The data obtained were not conclusive but suggested that the birds increased their area of usage following land development.

Average territory sizes in the various habitats calculated from call count densities are presented in Table 12.4. The calculation uses the inverse of the call count density recorded in each habitat type. It assumes territories all abut each other so that there are no gaps between them.
Table 12.4 Average territory sizes estimated from weka call counts.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Territory size (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road</td>
<td>0.3</td>
</tr>
<tr>
<td>House</td>
<td>1.0</td>
</tr>
<tr>
<td>Wetland</td>
<td>2.9</td>
</tr>
<tr>
<td>Coastline</td>
<td>0.0</td>
</tr>
<tr>
<td>Pākihi</td>
<td>6.6</td>
</tr>
<tr>
<td>Developed pasture</td>
<td>4.1</td>
</tr>
<tr>
<td>Dev pas (&lt;18 months)</td>
<td>6.8</td>
</tr>
<tr>
<td>Undeveloped pasture</td>
<td>2.5</td>
</tr>
<tr>
<td>Indigenous forest</td>
<td>0.9</td>
</tr>
<tr>
<td>Riparian</td>
<td>0.8</td>
</tr>
<tr>
<td>Urban</td>
<td>0.0</td>
</tr>
<tr>
<td>Exotic Forest</td>
<td>2.0</td>
</tr>
<tr>
<td>Quarry</td>
<td>7.5</td>
</tr>
<tr>
<td>Scrub</td>
<td>1.0</td>
</tr>
<tr>
<td>Mean territory size</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Observation of colour banded birds suggested that territories were protected most vigorously during the breeding season and less so at other times of year. Both sub-adult/non-territorial and territorial adult weka were found to have a strong site fixation. Birds staying as close as possible (i.e., nearest available cover) to their original location following land development and complete removal of all vegetation, as well as, in some cases, re-contouring of surface features in their home range/territory areas. Weka tended to crowd into the surrounding undisturbed areas initially (at one site eight weka were recorded in 50 x 50m area of isolated vegetation after the surrounding area was cleared of all vegetation.)

12.1.8 Dispersal and movements

The movement of weka directly after land development is not modelled in the IBM. This is because longer term population adaptation to the new habitat was considered more important. However, the loss of habitat that occurred when the land was first developed was found to impact on the affected weka. From the total of eight (three paired) weka monitored through the land development process it was found weka initially moved into surrounding areas with some cover, while still using the disturbed site for foraging at night. These displaced weka have to compete with weka with established home ranges/territories outside the disturbed area. Some weka (two out of eight) moved away from the area completely. Weka 10 (telemetry) moved away two months after having its home range developed. It is assumed that Weka 5 (telemetry) moved prior to having its
home range area developed, though it may have been forced to move from the adjoining area that had already been developed (Table 12.5).

Table 12.5 Sub-adult/non-territorial weka movement details.

<table>
<thead>
<tr>
<th>Adult</th>
<th>Date</th>
<th>Movement distance (m)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weka 5</td>
<td>30/7/2007</td>
<td>2900</td>
<td>Tx not found</td>
</tr>
<tr>
<td>Weka 10</td>
<td>24/7/2008</td>
<td>1200</td>
<td>Tx fell off</td>
</tr>
</tbody>
</table>

The dispersal distance of the five juveniles monitored varied between zero and 1150m from their natal area (Table 12.6). In all cases, except one, these distances cannot be considered the final dispersal distance as the weka were either killed, or could no longer be followed. In the case of Weka 17 the bird was seen three months later 180 m from its natal area.

Table 12.6 Juvenile weka dispersal details.

<table>
<thead>
<tr>
<th>Juvenile</th>
<th>Dispersal distance (m)</th>
<th>Time tx on (days)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weka 15</td>
<td>0</td>
<td>10</td>
<td>Poisoned (Feratox™)</td>
</tr>
<tr>
<td>Weka 16</td>
<td>1150</td>
<td>60</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>Weka 17</td>
<td>180</td>
<td>2</td>
<td>Tx fell off</td>
</tr>
<tr>
<td>Weka 18</td>
<td>320</td>
<td>60</td>
<td>Tx not heard after 60 days</td>
</tr>
<tr>
<td>Weka 19</td>
<td>1140</td>
<td>7</td>
<td>Killed by dog</td>
</tr>
</tbody>
</table>

12.1.9 Weka habitat use

The minimum polygon count method call counts undertaken at 18 randomly stratified sites indicated an average of 0.77 adult weka ha⁻¹ at Cape Foulwind. This gives a total population of 11652 ± 2463 weka (± 95% confidence level). Using all the surveyed sites using the minimum polygon method a very similar average of 0.76 territorial adult weka ha⁻¹ (n= 24) was obtained. The population was not spread evenly around the sites (Figure 12.7). Densities varied with habitat type with lowest densities generally found to be in pākihi followed by developed pasture, undeveloped pasture and scrubland (Table 12.7). Densities recorded varied from 0.23 adult weka ha⁻¹ to 1.38 adult weka ha⁻¹.
Figure 12.7 Random stratified call count results for minimum polygon density calculations.

Table 12.7 Random stratified weka call count site details.

<table>
<thead>
<tr>
<th>Call count site</th>
<th>Predominant habitat/s</th>
<th>Min. polygon density (adult weka ha(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virgin Terrace</td>
<td>Pākihi</td>
<td>0.23</td>
</tr>
<tr>
<td>New Bucklands</td>
<td>Pākihi</td>
<td>0.33</td>
</tr>
<tr>
<td>Dougs Place</td>
<td>Forest/pākihi</td>
<td>0.49</td>
</tr>
<tr>
<td>Landcorp tram dairy</td>
<td>Developed pasture</td>
<td>0.56</td>
</tr>
<tr>
<td>Brunnings road</td>
<td>Developed pasture</td>
<td>0.58</td>
</tr>
<tr>
<td>Virgin Flat Road</td>
<td>Developed pasture</td>
<td>0.59</td>
</tr>
<tr>
<td>Cement works</td>
<td>Forest/undeveloped pasture</td>
<td>0.63</td>
</tr>
<tr>
<td>Lighthouse</td>
<td>Scrub/undeveloped pasture</td>
<td>0.65</td>
</tr>
<tr>
<td>Wilsons Lead trig</td>
<td>Undeveloped pasture</td>
<td>0.73</td>
</tr>
<tr>
<td>Maries</td>
<td>Undeveloped pasture/Ind forest</td>
<td>0.78</td>
</tr>
<tr>
<td>Carters Pine</td>
<td>Undeveloped pasture</td>
<td>0.8</td>
</tr>
</tbody>
</table>
When the weka densities recorded are broken down into various habitat types the densities ascertained were lower overall and had greater variation (Table 12.8 and Figure 12.8)(see Section 8.7.57). Average adult densities calculated using this method and for all call count sites (n = 27) was calculated at 0.49 adult weka ha$^{-1}$. This represents a total adult territorial population of approximately 7366 paired weka.

Table 12.8 Estimates of the habitat associated distribution and total number of adult weka at Cape Foulwind. This data is calculated using the habitat type density method.

<table>
<thead>
<tr>
<th>Habitat type</th>
<th>Weka density (adult weka ha$^{-1}$)</th>
<th>% habitat type at Cape Foulwind</th>
<th>Total number of adults</th>
<th>% of weka in habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>House</td>
<td>1.00</td>
<td>0.1</td>
<td>15</td>
<td>0.2</td>
</tr>
<tr>
<td>Quarry</td>
<td>0.13</td>
<td>0.2</td>
<td>4</td>
<td>0.1</td>
</tr>
<tr>
<td>Riparian</td>
<td>1.21</td>
<td>0.4</td>
<td>73</td>
<td>1.0</td>
</tr>
<tr>
<td>Urban</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetland</td>
<td>0.34</td>
<td>0.7</td>
<td>34</td>
<td>0.5</td>
</tr>
<tr>
<td>Coastline</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road</td>
<td>2.92</td>
<td>1.1</td>
<td>469</td>
<td>6.4</td>
</tr>
<tr>
<td>Recently disturbed</td>
<td>0.15</td>
<td>1.3</td>
<td>29</td>
<td>0.4</td>
</tr>
<tr>
<td>Exotic forest</td>
<td>0.5</td>
<td>1.3</td>
<td>100</td>
<td>1.4</td>
</tr>
<tr>
<td>Ind forest</td>
<td>1.1</td>
<td>5.3</td>
<td>923</td>
<td>12.5</td>
</tr>
<tr>
<td>Pākihi</td>
<td>0.15</td>
<td>6.7</td>
<td>153</td>
<td>2.1</td>
</tr>
<tr>
<td>Scrub</td>
<td>0.98</td>
<td>11.6</td>
<td>1702</td>
<td>23.1</td>
</tr>
<tr>
<td>Dev pasture</td>
<td>0.24</td>
<td>16.7</td>
<td>611</td>
<td>8.3</td>
</tr>
<tr>
<td>Undev pasture</td>
<td>0.41</td>
<td>53.5</td>
<td>3268</td>
<td>44.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>100</strong></td>
<td><strong>7366</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
Figure 12.8 Adult weka densities (ha\(^{-1}\)) in the various habitat types. This data is calculated using the habitat type density method.

Figure 12.9 Estimates of the habitat associated distribution and total number of adult weka at Cape Foulwind. This figure uses data from Table 12.8.
The results suggest that habitat types supporting the bulk of the adult weka population are undeveloped pasture and scrub (c.68%) (Figure 12.9). High densities were found along roads and in the indigenous forest area (which is patchy at Cape Foulwind), but due to these habitat low overall amounts they held a relatively small percentage of the population (c.18%). Developed pasture was estimated to contain 8% of the adult population. However, strictly speaking it is difficult to assign weka to habitat types in this way, and it is best thought of as the predominant habitat at the site they inhabit. This is because in the mixed matrix landscape at Cape Foulwind weka are not using just one type of habitat but different types for food and cover, etc. (pers. ob.).

Figure 12.10 The trend in adult weka densities in varying habitat vegetative cover amounts. Cover amounts are estimated where zero is no cover and ten is complete cover. The cover amounts figures are those used in the weka IBM.

Comparing the estimated cover amount in all habitat types and adult weka densities a weak trend was found of increasing densities with increasing cover (Figure 12.10).

12.1.10 Weka habitat loss

Approximately 2500 hectares of rough pasture has been developed at Cape Foulwind over the past decade. Call counts show that densities in developed pasture are lower at 0.24 adult weka/ha than in rough pasture at 0.41 adult weka/ha. The weka IBM results (Section 12.3) give some indication of the impacts of this on the weka population.
12.1.11 Age and sex structure

Table 12.9 gives the age structure of the Cape Foulwind population derived from road-kill carcass collection and captured birds. There is potentially a bias in both data sets. The road-kill data are possibly biased towards young weka who have less experience on roads and are more mobile (Freeman, 2010). The capture data are possibly also biased towards younger sub-adult weka as they are more likely to be captured in cage traps (A Beauchamp pers.com), and in some cases juveniles were deliberately caught. Three of the captured birds are now considered to have become greater than three years old during the monitoring period.

Table 12.9 Cape Foulwind weka population age structure.

<table>
<thead>
<tr>
<th>Age class</th>
<th>Captured birds (n=21)</th>
<th>Road-kill carcasses (n=52)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>28%</td>
<td>38%</td>
</tr>
<tr>
<td>1 - 3</td>
<td>71%</td>
<td>53%</td>
</tr>
<tr>
<td>3 - 15</td>
<td>0%</td>
<td>10%</td>
</tr>
</tbody>
</table>

The overall Cape Foulwind population sex bias calculated from the call count analysis was 53% male and 47% female. The road-kill carcass collection data showed a significant bias toward males being killed, but this was not considered representative of the male/female balance of the population as a whole (Freeman, 2010).

12.1.12 Weight and size data

The weka in this population were generally no larger than other West Coast western weka populations. However, like other West Coast western weka populations, the weka were heavier than the Marlborough Sounds western weka population (Table 12.10). The high weights suggest the Cape Foulwind population has good food supplies and birds are generally in good health (Beauchamp, 2004).
Table 12.10 Measurements details for various western weka populations.

<table>
<thead>
<tr>
<th></th>
<th>Marlborough¹</th>
<th>Westland¹ #</th>
<th>South Westland²</th>
<th>Cape Foulwind (this study)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female</td>
<td>Male</td>
<td>Female</td>
<td>Male</td>
</tr>
<tr>
<td></td>
<td>(n=9)</td>
<td>(n=2)</td>
<td>(n=9)</td>
<td>(n = 3)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Culman</td>
<td>46.8, 1.2</td>
<td>50.5, 2.4</td>
<td>45.7, 1.5</td>
<td>46.5, 1.3</td>
</tr>
<tr>
<td>Bill depth</td>
<td>20.2, 0.7</td>
<td>23.5, 1.2</td>
<td>19.6, 2.1</td>
<td>22.9, 1.2</td>
</tr>
<tr>
<td>Tarsus</td>
<td>54.1, 0.9</td>
<td>60.5, 2.6</td>
<td>54.3, 0.1</td>
<td>67.4, 2.7</td>
</tr>
<tr>
<td>Tarsus width</td>
<td>11.1, 0.4</td>
<td>12.8, 0.7</td>
<td>11.0, 0.3</td>
<td>12.6, 0.5</td>
</tr>
<tr>
<td>Mid-toe</td>
<td>53.2, 1.8</td>
<td>58.4, 2.8</td>
<td>55.0, 1.5</td>
<td>62.3, 2.2</td>
</tr>
<tr>
<td>Mid-toe and claw</td>
<td>66.5, 2.5</td>
<td>73.0, 3.2</td>
<td>67.2, 2.8</td>
<td>74.9, 3.2</td>
</tr>
<tr>
<td>Weight</td>
<td>630, 1110</td>
<td>720, 1480</td>
<td>720, 1200</td>
<td>960, 1480</td>
</tr>
</tbody>
</table>

#All weka measured were dead.
¹Data taken from Beauchamp (2004).
²van Klink & Tansell (2003)
Figure 12.11 Adult male weka weight by month. This shows a distinctive annual variation with a winter peak. Sample size (n= 42).

Figure 12.12 Adult female weka weight by month. This shows a distinct annual variation with a winter peak. Sample size (n=18).
The adult weka weight data show an annual cycle of weight change in both male and female weka (Figures 12.11 & 12.12). This is consistent with that found in other studies (Carroll, 1963). To give a representative average weight for the population samples need to be taken consistently throughout the year. The graphs show the weight samples were well spread throughout the year. The sample sizes do not coincide directly with those in Table 12.10 because several individuals were not included in the weight by month charts as they were juveniles.

12.2 IBM modelling results

12.2.1 Model Scenarios

This section sets out the results of the IBM scenario modelling that followed the completion of verification and validation as out in Chapter 9. Because the model is qualitative, and so represents trends rather than quantitative outcomes, the scenario modelling produces a ranking of alternatives. The scenario modelling has two main aims. The first is to model the change in the weka population that occurs under the various land cover scenarios. The second is to assess the resilience of the weka population under the same scenarios. The latter involves systematically adjusting the most important environmental driving variables to pinpoint scenarios which are most susceptible to changes in these. The driving environmental variables were at the population level and were determined to be: developed land cover amount, background mortality, food availability and weather variation. This process may also allow the identification of thresholds associated with complex non-linear interactions. These may involve points where the weka population declines rapidly and does not recover. This relates to questions such as how much land development can occur before reaching population thresholds? Does threshold sensitivity to other events (e.g., increased predation, food availability, etc.) change when more land development has occurred? These questions can be encapsulated into two main hypotheses:

1. That mitigation measures are important in helping reduce impacts of land development on the weka population;
2. That increased land development makes the weka population less robust to other pressures.

The first part of the results looks at the first of these hypotheses through scenario modelling, while the second section (complexity exploration) considers the second hypotheses, particularly in relation to thresholds.
12.2.1.2 Scenario modelling

The scenario modelling was broken down into three parts:

1. **Pre-development.** Modelling the situation prior to land development starting. This was completed using New Zealand Land Cover Database II (LCDBII) maps (x4) for all of the Cape Foulwind area. These maps do not tend to show recent developed pasture so can be considered the *pre-development* situation at Cape Foulwind. This was used as the baseline model output to compare the other scenario models.

2. **Development.** The LCDBII maps (x4) were then manipulated to include land development areas. The first group of maps was where actual land development has occurred (*present development*) and the second group included potential land development areas (*possible development*). This modelling did not include any mitigation measures.

3. **Mitigation.** The LCDBII development maps (x4) were further manipulated to include patches of non-pasture (scrub) vegetation within the land development areas. The scrub pattern used was the optimum pattern developed from the pattern testing undertaken in Section 12.3.2. This was completed for both of the land development scenarios (i.e., present and possible).

**Table 12.11** IBM Scenario modelling results. Cape Foulwind is broken up into four areas. Each area is modelled separately for the four different scenarios.

<table>
<thead>
<tr>
<th>Map (LCDBII 1:25000)</th>
<th>Scenario</th>
<th>Average Weka numbers over 20 years (Std. Dev. in brackets)</th>
<th>Hectares of developed pasture</th>
<th>% diff of weka population from pre-development</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE</td>
<td>Pre-development</td>
<td>1864 (125)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Present development</td>
<td>1726 (74)</td>
<td>588</td>
<td>-7</td>
</tr>
<tr>
<td></td>
<td>Possible development</td>
<td>1367 (113)</td>
<td>1765</td>
<td>-27</td>
</tr>
<tr>
<td></td>
<td>Present development plus mitigation</td>
<td>1790 (80)</td>
<td>547</td>
<td>-4</td>
</tr>
<tr>
<td></td>
<td>Possible development plus mitigation</td>
<td>1542 (94)</td>
<td>1641</td>
<td>-17</td>
</tr>
<tr>
<td>NW</td>
<td>Pre-development</td>
<td>1578 (96)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Present development</td>
<td>1478 (94)</td>
<td>646</td>
<td>-6</td>
</tr>
<tr>
<td></td>
<td>Possible development</td>
<td>1195 (90)</td>
<td>1687</td>
<td>-24</td>
</tr>
<tr>
<td></td>
<td>Present development plus mitigation</td>
<td>1482 (78)</td>
<td>601</td>
<td>-6</td>
</tr>
<tr>
<td></td>
<td>Possible development plus mitigation</td>
<td>1305 (84)</td>
<td>1569</td>
<td>-17</td>
</tr>
<tr>
<td>SW</td>
<td>Pre-development</td>
<td>1743 (129)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Present development</td>
<td>1495 (129)</td>
<td>946</td>
<td>-14</td>
</tr>
<tr>
<td></td>
<td>Possible development</td>
<td>1438 (112)</td>
<td>1500</td>
<td>-17</td>
</tr>
<tr>
<td></td>
<td>Pre-development</td>
<td></td>
<td>Present development</td>
<td></td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------</td>
<td>---</td>
<td>---------------------</td>
<td>---</td>
</tr>
<tr>
<td>Present development plus mitigation</td>
<td>1591 (105)</td>
<td>880</td>
<td>-9</td>
<td></td>
</tr>
<tr>
<td>Possible development plus mitigation</td>
<td>1474 (147)</td>
<td>1396</td>
<td>-15</td>
<td></td>
</tr>
<tr>
<td>SE</td>
<td>Pre-development</td>
<td>1907 (119)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Present development</td>
<td>1723 (190)</td>
<td>601</td>
<td>-10</td>
<td></td>
</tr>
<tr>
<td>Possible development</td>
<td>1505 (137)</td>
<td>1252</td>
<td>-21</td>
<td></td>
</tr>
<tr>
<td>Present development plus mitigation</td>
<td>1745 (121)</td>
<td>559</td>
<td>-8</td>
<td></td>
</tr>
<tr>
<td>Possible development plus mitigation</td>
<td>1633 (94)</td>
<td>1165</td>
<td>-15</td>
<td></td>
</tr>
<tr>
<td>Total all maps*</td>
<td>Pre-development</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Present development</td>
<td></td>
<td>-9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible development</td>
<td></td>
<td>-22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present development plus mitigation</td>
<td></td>
<td>-7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possible development plus mitigation</td>
<td></td>
<td>-16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

These results are from 20 simulation runs of 20 simulation years. The model starts 2200 weka (2000 adults, 200 juveniles) @0.51 ha consistent with weka densities at Cape Foulwind in each habitat type. *In the all-map totals only the percentages were averaged as the four maps overlap slightly and so weka number totals will not be accurate.

The scenario modelling suggests an average overall loss of c.9% of the weka population from land development (c. 2500 ha) in the period since development started approximately 10 years ago. Continued development (c. 4800 ha) may produce a further loss to c.22% below pre-development levels. Furthermore, these modelling results suggest increasing amounts of weka population loss as the amount of land development expands (Table 12.11 & Figure 12.13). If mitigation involved the reinstatement of c.7% (see Section 12.3.2) of lost cover these values may be reduced to c.7% and c.16%, respectively. These figures are not consistent across all the areas modelled and vary depending on the habitat patterns and vegetation types involved.
Figure 12.13 The association between hectares of developed pasture and the decrease in adult weka numbers. These data are taken from Table 12.11 (scenario modelling results) and includes data from all four base-maps. Best fit is an exponential regression line. The modelling data shows a trend to increasing amounts of weka population loss as pasture development increases.

12.2.2 Mitigation exploration

A series of scenarios were developed to test which patterns and amounts of scrub cover were most effective at retaining weka numbers on developed pasture areas. The optimized scrub patterns were then used for the scenario modelling of land development that included mitigation measures.

Initial testing involved modelling a range of patterns (Table 12.12 & Figures 12.14 & 12.15) at 7% (150ha) and 14% (300ha) total scrub cover on artificial landscape that consisted only of developed pasture and scrub. Small percentages of scrub cover were chosen as it was felt that landowners undertaking land development would be aiming at minimizing the amount of non-productive land they would be prepared to put aside.
Table 12.12 Landscape pattern mitigation patterns results. Background is developed pasture with various scrub patch patterns.

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Pattern detail</th>
<th>Average adult weka density over 20 years</th>
<th>Ha of scrub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev pasture only</td>
<td>No scrub</td>
<td>500 (71)</td>
<td>0</td>
</tr>
<tr>
<td>Linear (x6)</td>
<td>6 lines x 100m wide. Each line 600m apart</td>
<td>770 (43)</td>
<td>300</td>
</tr>
<tr>
<td>Linear (x3)</td>
<td>3 lines x 100m wide. Each line 1200m apart</td>
<td>664 (63)</td>
<td>150</td>
</tr>
<tr>
<td>300 ha patch</td>
<td></td>
<td>785 (45)</td>
<td>300</td>
</tr>
<tr>
<td>150 ha patch</td>
<td></td>
<td>664 (36)</td>
<td>150</td>
</tr>
<tr>
<td>50 ha patches</td>
<td></td>
<td>801 (37)</td>
<td>300</td>
</tr>
<tr>
<td>50 ha patches</td>
<td></td>
<td>632 (43)</td>
<td>150</td>
</tr>
<tr>
<td>16 ha patches</td>
<td></td>
<td>811 (57)</td>
<td>300</td>
</tr>
<tr>
<td>16 ha patches</td>
<td></td>
<td>635 (40)</td>
<td>150</td>
</tr>
<tr>
<td>5 ha patches</td>
<td></td>
<td>794 (49)</td>
<td>300</td>
</tr>
<tr>
<td>5 ha patches</td>
<td></td>
<td>664 (45)</td>
<td>150</td>
</tr>
<tr>
<td>1 ha patches</td>
<td></td>
<td>781 (46)</td>
<td>300</td>
</tr>
<tr>
<td>1 ha patches</td>
<td></td>
<td>692 (42)</td>
<td>150</td>
</tr>
<tr>
<td>50 ha and 1 ha patches</td>
<td></td>
<td>805 (45)</td>
<td>300</td>
</tr>
<tr>
<td>16 ha and 1 ha patches</td>
<td></td>
<td>662 (46)</td>
<td>150</td>
</tr>
<tr>
<td>16 ha and 1 ha patches</td>
<td></td>
<td>784 (51)</td>
<td>300</td>
</tr>
</tbody>
</table>

Each run of the model was seeded with an initial population of 500 adults and 50 juveniles. The model was run for 20 simulation years with 20 replicate runs of each scenario. Total spatial area modelled was 2150ha. 150ha = 7% coverage, 300ha = 14% coverage. Cover in developed pasture = 1. The highlighted lines show the optimum patterns for 150ha and 300ha.
The modelling suggested that there was some variation in densities with various scrub patterns. Smaller sized patches were slightly more favoured with lower (7%) cover amounts (Figure 12.14), while medium sized patches were best with slightly higher amounts of cover (Figure 12.15).
This suggests that with a low amount of mitigation scrub cover (7%) it is best to use many smaller patches, but if more scrub (e.g., 14%) is to be left, it is best to leave larger patches. At 20% cover with a mix of large (16ha) and small (1ha) patches densities are similar to pre-development levels (see below).

Due to the qualitative nature of the model the lack of variation in the results suggests either scrub patterns are not of high importance, or the model does not handle this aspect well. By contrast the total amount of cover did give large changes in weka density (Table 12.13 and Figure 12.16). The balance figure was 28% scrub cover, as this represents, at 0.45 weka per hectare, approximately the same weka densities as un-developed pasture (0.46 adults per hectare). The percentage of undeveloped pasture required to be retained to balance loss to developed pasture will be higher as it has lower weka densities than scrub.

This result suggests, for weka conservation purposes, that the priority is to retain as much cover as possible when undertaking land development, while the patterns of these areas is secondary.

<table>
<thead>
<tr>
<th>Pattern of scrub cover</th>
<th>Average adult weka density over 20 years</th>
<th>Ha of scrub</th>
<th>Ha of undeveloped pasture</th>
<th>% scrub of cover</th>
<th>Weka density/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dev pasture only</td>
<td>550 (71)</td>
<td>0</td>
<td>2150</td>
<td>0</td>
<td>0.23</td>
</tr>
<tr>
<td>16ha and 1 ha patches</td>
<td>662 (46)</td>
<td>150</td>
<td>2000</td>
<td>7</td>
<td>0.31</td>
</tr>
<tr>
<td>16ha and 1 ha patches</td>
<td>784 (51)</td>
<td>300</td>
<td>1850</td>
<td>14</td>
<td>0.36</td>
</tr>
<tr>
<td>16ha and 1 ha patches</td>
<td>901 (55)</td>
<td>450</td>
<td>1700</td>
<td>21</td>
<td>0.42</td>
</tr>
<tr>
<td>16ha and 1 ha patches</td>
<td>975 (40)</td>
<td>600</td>
<td>1550</td>
<td>28**</td>
<td>0.45</td>
</tr>
<tr>
<td>16ha and 1 ha patches</td>
<td>1064 (55)</td>
<td>750</td>
<td>1400</td>
<td>35</td>
<td>0.49</td>
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</tbody>
</table>

Each run of the model was seeded with an initial population of 500 adults and 50 juveniles. The model was run for 20 simulation years with 20 replicate runs of each scenario. Total spatial area modelled was 2150ha.

**28% cover (0.45 weka per hectare) represents approximately the same weka densities as undeveloped pasture (0.46 adults per hectare).
This modelling represents a 20 year period and assumes that the cover patches have either been left as part of the initial clearance during land development or have been rehabilitated subsequently, and successfully re-colonized by weka. Call counts for this study show that the latter occurs readily. Empirical evidence also showed that when development occurs first any remaining scrub patches are very important and weka congregate in them, at least for the short term.

**12.2.3 Long term trends**

The model was run for 60 years with what are considered normal conditions with and without development occurring. The model suggests that under the possible development scenario, and without further events occurring that places pressure on the population, it should remain sustainable, although at lower population levels (Figures 12.17, 12.18 & 12.20).
Figure 12.17 Plots from 20 model runs of 60 years using map LCDBII NW 1:25000 scale with no development. The graph of number of adult weka displays a considerable amount of variation amongst model runs. Compare with Figure 12.18 showing possible development.

Figure 12.18 Plots from 20 model runs of 60 years using map LCDBII NW 1:25000 scale with possible development. The graph number of adult weka displays a considerable amount of variation amongst model runs. Compare with Figure 12.17 showing no development.
12.2.4 Complexity exploration

This section explores the hypothesis that increased land development makes the weka population less robust to other pressures. Land development has already been shown to reduce weka population densities; however, it also has the potential to change how individuals interact with each other and the landscape. There are a number of feedbacks involved in this which are captured and modelled in the IBM\textsuperscript{58}. These may create thresholds (or tipping points) which cause rapid changes in the population level if they are reached. The modelling in this section attempts to trace any thresholds in the weka population, and if land development changes where these might lie. The parameters used for the environmental threshold/resilience testing were:

- Background mortality;
- Annual variation of food availability;
- Developed pasture cover amount;
- Global food amount.

\textsuperscript{58} For example, habitat changes in developed pasture areas may increase mortality risks, reduce food availability (or ability to feed), affect social structures, breeding success, and reduce dispersal abilities etc.
These parameters are not exactly the same as the sensitivity analysis (see Section 9.4.8.5) as the focus here is on analysing environmentally driven thresholds. Initially, the existence of these thresholds was traced separately for each variable across different levels of development (i.e., present, possible development and mitigation habitat maps) using the NW area map. Threshold value tests started from the baseline parameters used for model validation (see Section 9.4.8.4). The testing involved reducing the values of the variables until the weka population started to collapse. The model output parameter used for tracing thresholds was the average number of steps (over 20 model runs) before complete population loss occurred under the different development scenarios. Table 12.14 and Figures 12.20 to 12.22 show the results of this modelling.

**Table 12.14** Assessing for threshold/resilience of the weka population in various scenarios. The analysis in broken into separate base-map areas.

<table>
<thead>
<tr>
<th>Base-map</th>
<th>Driver</th>
<th>Parameter settings</th>
<th>Number of runs not reaching 20 years</th>
<th>Average model steps completed</th>
</tr>
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<tr>
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<td>Background mortality @</td>
<td>12%</td>
<td>0</td>
<td>7300</td>
</tr>
<tr>
<td>development</td>
<td></td>
<td>20%</td>
<td>0</td>
<td>7300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30%</td>
<td>0</td>
<td>7300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40%</td>
<td>0</td>
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</tr>
<tr>
<td></td>
<td></td>
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<td>1</td>
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<td>80%</td>
<td>20</td>
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</tr>
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<td>Global food amount #</td>
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<td>7300</td>
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<tr>
<td>development</td>
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<td>0.8</td>
<td>0</td>
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<td>0</td>
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<td>0</td>
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<td>Cover amount</td>
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<td>7300</td>
</tr>
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<tr>
<td>1</td>
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<td>0</td>
<td>7300</td>
<td></td>
<td></td>
</tr>
<tr>
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<td>Background mortality</td>
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<td></td>
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</tr>
<tr>
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<td>Background mortality</td>
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</tr>
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<tr>
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<td></td>
</tr>
<tr>
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<td>19</td>
<td>5559</td>
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<td>20</td>
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<td>0.3</td>
<td>18</td>
<td>5641</td>
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</tbody>
</table>
These results are from 20 simulation runs of 20 simulation years. The model starts 2200 weka (2000 adults, 200 juveniles) @0.51 ha consistent with weka densities at Cape Foulwind in each habitat type. The habitat map used for this analysis was LCDBII NW CF 1:25000 scale.

@ Background mortality reflects the mortality from all mortality pressures (see Section 13.1.3)
#
% Annual weather variation sets the annual variation in global food amount.
$
See Table 9.1 for a description of cover amount.

Figure 12.20 The weka population status with a range of settings of global food amount and land development amounts.
Figure 12.21 The weka population status with a range of settings of background mortality and land development amounts.

Figure 12.22 The weka population status with a range of settings of annual weather variation and land development amounts.
Global food and background mortality both show quite marked threshold points where beyond certain values the population collapsed in less than 20 years (Figures 12.20 and 12.21). In addition, an increasing amount of developed pasture showed some trend toward making the model more sensitive to these two thresholds. This is not just suggesting that, for example, mortality increases, but that the population is more sensitive to mortality pressures. For background mortality, the threshold moved from c.50% to c.40%. Also, including mitigation in the global food variable decreased the threshold point from c.0.5 to c.0.4. (i.e., weka become less sensitive to food availability decreasing). Increasing amounts of annual weather variation produced a steady linear decrease in the population (a soft threshold) for all the different developed cover scenarios (Figure 12.22). No thresholds were found for changes in the amount of cover available in the developed pasture areas.

Because the variables associated with thresholds may act in combination some exploration of impacts of combinations of threshold was undertaken. The four threshold variables were modelled in 24 combinations (Table 12.15).

Table 12.15 Combination threshold tests (based on An et al., 2005)

<table>
<thead>
<tr>
<th>Model run number</th>
<th>Global Food amount</th>
<th>Background mortality</th>
<th>Developed pasture cover variation</th>
<th>Annual weather variation</th>
<th>Average days until population collapse</th>
</tr>
</thead>
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<tr>
<td>1</td>
<td>0.6</td>
<td>40% (99.891)</td>
<td>2</td>
<td>0.4</td>
<td>5414 (1486)</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td>0.5</td>
<td>3412 (2047)</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>1</td>
<td>0.4</td>
<td>4565 (1770)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>0.5</td>
<td>4763 (2063)</td>
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<tr>
<td>5</td>
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<td>0</td>
<td>0.4</td>
<td>4028 (2105)</td>
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</tr>
<tr>
<td>6</td>
<td>50% (99.863)</td>
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<td>0.4</td>
<td>4542 (1249)</td>
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<tr>
<td>7</td>
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<td>0.5</td>
<td>4088 (1579)</td>
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</tr>
<tr>
<td>8</td>
<td></td>
<td>1</td>
<td>0.4</td>
<td>4312 (1480)</td>
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</tr>
<tr>
<td>9</td>
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<td></td>
<td>0.5</td>
<td>3767 (1472)</td>
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<tr>
<td>10</td>
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<td>0</td>
<td>0.4</td>
<td>4266 (1429)</td>
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<tr>
<td>11</td>
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<td>3790 (1729)</td>
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<tr>
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<td>40% (99.891)</td>
<td>2</td>
<td>0.4</td>
<td>4349 (1714)</td>
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<td>0.5</td>
<td>3221 (1644)</td>
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<tr>
<td>14</td>
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<td>1</td>
<td>0.4</td>
<td>4202 (1647)</td>
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<td>0.5</td>
<td>3437 (1707)</td>
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<tr>
<td>16</td>
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<td>0</td>
<td>0.4</td>
<td>4384 (1728)</td>
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<tr>
<td>17</td>
<td>50%</td>
<td>2</td>
<td>0.4</td>
<td>3187 (1680)</td>
<td></td>
</tr>
<tr>
<td>18</td>
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<td>0.5</td>
<td>3890 (1386)</td>
<td></td>
</tr>
<tr>
<td>19</td>
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<td>1</td>
<td>0.4</td>
<td>3174 (1536)</td>
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<tr>
<td>20</td>
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<td></td>
<td>0.5</td>
<td>3649 (1399)</td>
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<tr>
<td>21</td>
<td></td>
<td></td>
<td>0.5</td>
<td>2675 (1459)</td>
<td></td>
</tr>
<tr>
<td>22</td>
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</tr>
</tbody>
</table>
Results from 16 combinations of 40 simulation runs of 20 simulation years. The model starts 2200 weka (2000 adults, 200 juveniles) @0.51 ha. Standard deviations are in brackets. The habitat map used for this analysis was LCDBII NW CF 1:25000 scale present development. See Figure 12.14 for details of factors modelled.

There was a considerable amount of variation in outcomes around the threshold points in the combination tests. This is associated mostly with the stochastic nature of annual weather variation, and the weka population’s response to this. This can be seen in the variation between the odd and even run numbers in Figure 12.23. However, there was an overall decreasing trend in weka numbers as the combinations of thresholds were slowly passed.

The modelling results suggest that around the threshold points the most influential factors were (in order of importance) annual weather variation, global food supply and background mortality. The amount of developed pasture cover was not important (Figure 12.24). In other words, the amount of cover in developed pasture was not close to a threshold point as far as the population was concerned. The variables with active thresholds, at the spatial and temporal scales modelled, can be considered as fast cycle factors at the population level. Developed pasture amount, and the
associated cover amount, can be considered as a slow cycle factor for the weka population as a whole, which slowly reduces the overall population and also changes the threshold points of the faster cycle factors.

Figure 12.24 The relative importance of each variable described through the influence it has (measured in total number of days) on changes in the population around the threshold point for each variable. The values at taken from Table 12.15. The exception is developed pasture cover which is not near a threshold. This is shown by its lack of importance in comparison to the other three variables.
Figures 12.25 & 12.26 A display of the analysis of combination thresholds suggests a decreased population retention time when the variables are combined around their thresholds. The first three groups of columns are each variable modelled alone and the forth column group shows the combined outcome. The graphs are for a global food setting of 0.5 and 0.6 respectively.
Figures 12.25 & 12.26 suggest that combinations of variables lying on or close to their thresholds increase the weka population loss.

The typical pattern of population loss that occurs when a combination of thresholds is reached and then pressures maintained, and that will cause a total collapse of the weka population, is shown in Figure 12.27. The population initially decreases rapidly and then more slowly. The population is at 45% of its original value at 1 year, 24% after 2 years, 14% after 3 years, 9% after 4 years, and 5% after 5 years. It takes almost 12 years for the population to die out completely. However, other factors such as increased predation pressure and stochastic events that were not adjusted and linked into the model to account for varying population levels are likely to occur. These make this a rough estimate only.

The rapid loss of weka at other sites (e.g., Golden Bay lowlands (Beauchamp, 1999)) may be associated with reaching a threshold/s. The population then rapidly decreases to a few individuals that do not recover if pressures remain. In addition, pressures on low density populations may be different from those on high density ones. For example, food availability may be less important and predation more so.

![Figure 12.27](image-url) An example of the declining population curve for a population modelled at a combination of thresholds (global food 0.6, background mortality 50%, weather variation 0.4). The black line marks the average of 20 model runs. Average days until population loss is 4312.
12.2.5 IBM modelling conclusion

The IBM results suggest the weka population was resilient given the existing pressures it is under (i.e., road-kill, dog-kill, habitat loss, and predation). However, mitigation measures are important in helping reduce impacts of land development, while further land development would make the population less robust to the other pressures. The IBM results suggest the weka population is most sensitive to environmental variation (e.g., el Niño/la Niña events) and associated changes in food availability. The IBM results also showed irregular patterns in population numbers associated with irregular patterns in environmental conditions and did not suggest any general cycles (Figure 12.19). The IBM also suggested thresholds may exist associated with global food availability, and higher background mortality. The modelling suggested that further land development can make the weka population more sensitive to these thresholds, while mitigation measure can move these thresholds and make the population more resilient. Potential collapses could occur if these are reached alone or in combination with a potential rapid loss of much of the population. Weka also have the ability to increase their populations as rapidly as they are lost. Weka populations that are constrained only by climatic events or are primarily density-dependent can double their population within 12 months (Miskelly & Beauchamp, 2004 cited in Beauchamp, 2005). The IBM outputs suggested that the Cape Foulwind was able to recover quickly from years with poor food availability.

The IBM gives a large amount of scope testing various ideas and scenarios. However, the limited modelling undertaken meets the basic aims of this research. Attempting to model other aspects would be beyond the scope of the model’s aims and design. Finally, this is a qualitative model that only shows trends and it cannot place absolutes against the threshold points or population levels.
13 Weka ecology results and IBM modelling discussion

13.1 Weka ecology

This chapter discusses the weka data collected at Cape Foulwind. It also considers its relationship with data from other weka studies. This is because there is local empirical data required for the IBM that was not obtained, so data from other studied populations were collected to use with the available Cape Foulwind population data. This is both at the level of individual parameters as well as for expected model outputs. Consequently, this section also discusses how the parameters were derived from this combination of data for use in the weka IBM.

The ‘analysis’ of the data collected takes place within the IBM and is reflected in its results, and so there is no attempt in this section to do more than a simple analysis of the results.

The focus of the discussion is in relation to the factors that dominate avian demography. These factors are clutch size, number of clutches per year, annual juvenile and adult survivorship (Rickefs, 1973 cited in Beauchamp, 1987a). In the IBM developed in this study the first two are incorporated into the number of young produced annually. The second two are reflected in annual juvenile and adult mortality. All these factors can be highly variable temporally and spatially within populations and between populations. This variability, and interaction between the factors, makes the establishment of population parameters difficult, as is making comparisons between studies of different populations (Beauchamp, 1987a).

IBMs explicitly model such factors and their variability (temporally and spatially), along with a range of other animal and environmental parameters. This means they offer a way of attempting to understand these factors, their interactions, and emergent properties associated with them.

13.1.1 Adequacy and limitations of methods

Due to weka’s cryptic and crepuscular nature, and a limit on fieldwork time and assistance available, spacing call counting was used in preference to other methods. The major limitation associated with call counting is that it does not supply basic demographic data. It also supplies little information on individual behaviour, and both are important for the IBM development (see Chapter 9).

Spacing call counting is a method still being developed (Beauchamp, 2009) and the calculation of habitat densities in the complex Cape Foulwind landscape was not definitive. The use of one observer (I personally did 87 out of the 88 call counts) helped give consistency between sites and allow comparisons between them. Three nights of call counting at each site proved to be adequate due to the moderate to high weka densities in the area. The results show that due to the
low number of calls recorded on average in the half an hour before sunset the counting time period could be reduced to just one hour after sunset at Cape Foulwind in high weka density areas.

To supplement call counting the more intensive methods of telemetry tracking and colour banding were used to gather data on individual behaviour. There were difficulties with the telemetry and many of the transmitters fell off or were pulled off the birds in dense vegetation. The loss of transmitters could be partly caused by my lack of experience in attaching them. Also, initially the electrical shrink-wrap tubing that attached the harness strings together was too light and broke. This was rectified in later attachments.

Colour banding was not entirely successful. Of the birds that were colour banded 25% were not seen again, despite regular searches being made. Another 17% of the weka dispersed and were not able to be followed after that occurred. The selection of birds for telemetry and colour banding was not entirely random as the weka that tend to be caught in traps are more often the more visible and mobile sub-adults/non-territorials and adults (Beauchamp, 2009). This bias was possibly reduced somewhat by trapping the weka at dusk when all weka tend to be more active and visible.

There were not enough individuals successfully monitored for the data sets to be statistically robust over a number of years. Through learning about the modelling process, in hindsight, it would have been valuable to have obtained more basic local data over a greater range of individuals for both IBM parameterisation and verification purposes. This was not achieved and so data obtained from other populations (island and mainland) was used to help parameterise and verify the model. This includes, in particular, Beauchamp’s 1987a study on Kapiti Island and Coleman et al.’s 1983 study in Westland. When combined with the local data that was collected it was deemed to be adequate for the aims of the IBM (see Chapter 9).

13.1.2 Threats

There is a range of threats to weka at Cape Foulwind discussed in the results. These include stoats, dogs, wild cats, harrier hawks, road-kill, and shooting. The impact of harrier hawks and shooting was not able to be quantified. Wild cats are present at Cape Foulwind, but not in high numbers. There have only been a few sightings of ferrets in Westland (King, 2005) and none have been recorded in the Cape Foulwind area. The other threats are discussed below.

13.1.2.1 Stoats

Stoat predation did not appear to be high at Cape Foulwind as there was no evidence of it found. There are significant numbers of stoats in the Cape Foulwind area as evidenced from my own and others’ trapping in the area. Stoat numbers can be reduced as a result of by catch of possum control operations. There is a suggestion that a lowering of stoat numbers by Animal
Health board operations (AHB) in the West Coast coastal lowlands have enabled the weka population to be successful (Gerry McSweeney pers.com.). Under this proposal the impacts of AHB operations undertaken in the area would have allowed for high weka numbers in the early 1970s and low numbers in the 1980s and high numbers in the last decade. There is anecdotal evidence for low weka numbers in the 1980s in Charleston. However, this reduction would be expected to be over the whole Cape Foulwind area if AHB controls were impacting on stoat numbers and this appears not to be the case.

It is possible that an increase in stoat densities could impact weka numbers through, for example, changes in prey associated with higher densities. However, Coleman et al. (1983) did not consider stoats were an important threat to weka in North Westland as weka had re-established in their study area since the arrival of stoats. The increase in weka densities at Cape Foulwind over the past 40-50 years would also have occurred with stoats in the area. The slightly larger size of Western weka (Table 12.10) at Cape Foulwind compared to other sites (including Coleman et al.’s (1983)) weka may make them less susceptible to stoats. In addition, examples of stoats being implicated as significant predators of weka are in low weka density populations and following translocations (e.g., Beauchamp et al., 1998; Beauchamp et al., 2000; Mike Ogle pers.com), rather than in high density populations such as Cape Foulwind.

13.1.2.2 Dogs

The results from the study suggest that potentially significant numbers of weka are killed by dogs. Two of the three study weka killed were by the same dog at the same location. This suggests that dog-kill is likely to be confined to certain high risk sites involving uncontrolled dogs (i.e., around houses and areas frequented by the public). Uncontrolled dogs around houses likely kill all weka moving into the area (e.g., dispersing juveniles). In these situations it is likely an area develops around the site where no weka reside. These sites become population sinks. The juvenile weka in this study killed by a dog probably met with this situation. In the relatively high weka densities at Cape Foulwind the lack of other weka at such sites are probably initially quite appealing to juvenile weka.

One-off events, where many weka are killed by an out of control dog/s may also occur. Study participant PFM9 related how two of his neighbour’s dogs ran rampant, killing many (dozens) of

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59 An intensive Animal Health Board (AHB) possum control programme to reduce TB infection cattle - using both ground and aerial control methods - was started nationally In 1972. Funding for this control was reduced around 1979 resulting in an increase in the number of TB infected cattle herds over a 14-year period. Infection rates only started declining again when funding for possum control was secured around the mid-1990s (Imogen Squires (West Coast Animal Health Board), pers.com.).
weka in a block of scrub and forest near his farm some years ago. Farmers tended to stress that
working farm dogs do not normally harass weka as they are trained not to chase birds.

Due to the patchiness of the risk, both temporally and spatially, the impact of dog kill on the
Cape Foulwind weka population as a whole is difficult to quantify.

13.1.2.3 Poison

The risks to weka from poison are also difficult to quantify at Cape Foulwind. One of the
study birds was likely killed by Feratox (encapsulated cyanide). It was due to these risks that Feratox
was banned for use in weka areas on public conservation land in June 2004 (Beauchamp, 2005).
However, the Animal Health Board continues to use it on private land on the West Coast in weka
areas as part of its Bovine TB poisoning programs. Discussions with the Animal Health Board
suggested a certain amount of weka by-kill was known, and accepted.

Following land development, infestations of grass grub (*Costelytra zealandica*) can occur. Grass grub’s larval stage eats the roots of pasture species such as white clover and ryegrass and can cause serious damage to pasture (Fenemore, 1984). Insecticides such as Nufarm Dew™600 are used by farmers at Cape Foulwind to control grass grub. Dew™600 is ecotoxic and “[v]ery toxic to terrestrial vertebrates and terrestrial invertebrates.” (Nufarm product data sheet). There is anecdotal evidence of ducks dying and sick weka being seen after pasture has been sprayed with Dew™600 at Cape Foulwind. The impacts on weka are unknown but potentially significant, if large areas are sprayed.

13.1.2.3 Road-kill

The weka road-kill survey undertaken as part of this study found a mean of 2.9 weka killed
on the 25.1 km of surveyed roads per week (Freeman, 2010). Extrapolation to all the major rural
public roads on Cape Foulwind (c.65.2 km) produced a conservative estimate of c.356 weka killed
per year. Using the total population figures derived from *minimum polygon density* calculation
method, the estimated annual mortality from road-kill removes 2 – 3 % of the local weka
population. When the *habitat type density* calculation method is used, this estimate becomes
c.4% of the local population.

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60 Another species that can impact on pasture is the manuka chafer (beetle) *Pyronota festiva*. The beetle feeds on the flowers of manuka trees but like the grass grub its larva feeds on the roots of grasses.

61 To calculate the total weka population 30% was added to the paired adults weka populations figures to account for juveniles and sub-adults.
Call counts undertaken by the Department of Conservation between 1998 and 2002, suggest little change in the weka population over this period at the two sites located within or close to the study area (McClellan, 2002). However, this result is not very robust because too few count sites were included and there were changes in the details of the methods used between years. This cannot be used as a comparison to predict whether road-kill is really reducing the present weka population without further investigation, particularly as traffic volumes have increased by c.25% on State Highway 6 between 2002 and 2008 (Transit New Zealand, 2006; New Zealand Transport Agency, 2009).

The lack of correlation found between monthly traffic volumes (or other risk factors which remained relatively static) and monthly variations in weka road-kill on State Highway 6, suggests that seasonal variation in kill rate is linked with weka life history factors. Other studies (Clevenger et al., 2003; Grilo et al., 2009; Clarke et al., 1998) also found that seasonal increases in road mortality of small and medium sized vertebrates were closely linked with breeding and dispersal activities.

13.1.3 Threats summary

Due to the larger range of threats to weka at Cape Foulwind, mortality rates are expected to be higher than those recorded on Kapiti Island. An estimate of the impacts of road-kill has been made (Freeman, 2010). Mortality from other threats (predators, dogs, cats, poison and shooting) is extremely difficult to estimate and is likely to be temporally and spatially highly variable.62

Beauchamp (1987a) found that the annual territorial adult mortality on Kapiti Island averaged 11% for males, and 12% for females, both having varied between 6% and 21% during the study period. Annual mortality for sub-adults/non-territorials was higher being about 50%. Recruitment in the Kapiti population was extremely variable due to variation in breeding success caused by variation in food supply and weather conditions, along with variation in juvenile mortality. In a study on the North Island juvenile mortality was also found to be highly variable between years (averaging 32% over ten years) but varying between 0% and 75% (Fiona Kemp pers.com.). The factors implicated include the Kapiti Island factors (food availability and weather) and also predation (stoats and cats). Robust estimates of adult and juvenile mortality were not able to be obtained from

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62 For example, the form of the predation pressure on weka varies between weka populations. Bramely (1996) notes that cats and ferrets are important weka predators at Rakauroa (west of Gisborne). Beauchamp et al’s. (1998) study of a weka decline in the Bay of Islands showed stoats and dogs were important predators. There were few cats and no ferrets in the area. Predation by dogs and ferrets caused the failure of a weka translocation project at Karangahake Gorge (Beauchamp et al., 2000), and stoats and dogs (along with road-kill and traps) were the major factors of weka loss in translocation at Totaranui in 2006 and 2007 (Mike Ogle pers.com.).
this study. Juvenile mortality is very difficult to acquire data on without telemetry, particularly for cryptic species such as weka which utilised low scrub for cover.

The background mortality for the IBM was set at 12% for males and females, but it was also varied for different age classes and habitat types. The actual figure emerged from these settings along with changes in food supplies and weka densities in various habitats. The baseline model average adult weka mortality per year was c. 30% (Table 9.3).

13.1.4 Territoriality

The territory sizes in Cape Foulwind were calculated across all habitats to average 3.0 ha (min. 0.3 ha, max. 7.5ha) from call count studies. In contrast, the territory size at Double Cove in the Marlborough Sounds averaged 4.5 ha (2.6-15.8) (Beauchamp, 1987). On Kapiti Island they averaged 1.96 ha (0.7 - 4.5) (Beauchamp, 1987a).

In the IBM the average territory size emerged as 3 - 4 hectares in size. This was slightly larger than the empirical data due in part to constraints on the model design imposed by the modelling platform. To simplify the model, and due to the lack of empirical data, homorange areas were modelled to be the same size as territories.

Beauchamp (1987a) found territory boundaries to be quite stable, especially for established pairs. Much of the monitoring done for this study was with birds whose territories were disturbed by land development, so it is difficult to comment on territory boundary stability. However, in the IBM boundaries were modelled as being stable as it did not model land development occurring. Beauchamp (1987a) also found boundaries were sometimes defined by topographical features. The data collected at Cape Foulwind suggested some territorial boundaries lay at topographical boundaries. Roads were one example (i.e., a roadside pair that was monitored was not recorded on the opposite side of the road). The high road-kill in the spring months could be associated with territorial boundaries lying along roads, and weka being distracted in their territorial interactions during the breeding season and so making them more susceptible to being struck by vehicles.

By contrast Beauchamp (1987a) found that sub-adult/non-territorials birds varied in their time of residency and had a home-range area made up of a principal use area and a less used larger range. The size of the principal use area varied between 0.4 and 3.5 ha (n=12). Some sub-adults/non-territorials had two principal use areas mostly held at the same time. I did not find any indication of sub-adults/non-territorials holding more than one principle area at Cape Foulwind, while the home range areas did not appear to overlap appreciably.

Beauchamp (1987a) noted that weka sometimes formed aggregations at food sources. These are seen at Cape Foulwind with large numbers (anecdotally 100+) of weka seen around groups of...
excavators exposing the soil when undertaking land development (P9MF). Many of these birds may be sub-adults and adults who had already had their home-range or territorial areas stripped of all vegetation by the excavators.

On Kapiti Island, Beauchamp (1987a) found that if one bird in an established pair died, the remaining bird re-paired with a non-territorial and retained the territory (this was noted in two occasions in this study and accounted for in the IBM). Alternatively, the remaining bird is displaced by neighbouring pair (or it held the territory alone), or a neighbouring bird disserted its mate and paired with the single bird.

13.1.5 Movement

**Juvenile dispersal**

Bramley’s (2001) North Island weka study found juvenile weka dispersing up to 3.5 km from their natal area. The dispersal results from this study are lower than those recorded by Bramley (2001). This is, in part, due to the distances recorded being limited by weka being killed or the transmitters falling off. There were some related constraints in Bramely’s (2001) study (i.e., short life span of the transmitters). Dispersal distances recorded on Kapiti Island averaged 1.3 km and a maximum of 5km (Beauchamp, 1987a). Longer distances have been recorded on the mainland, >5km in the Marlborough Sounds (Beauchamp, 1987) and 9 km in Westland (Coleman et al., 1983). Given this, it is considered the data collected at Cape Foulwind probably underestimate juvenile dispersal distances. Bramley (2001) suggests dispersal may be less likely in low densities because dispersing weka are less likely to find mates. In the relatively high weka densities at Cape Foulwind this is unlikely to apply and the constraint on dispersal is more likely to be associated with a lack of unused suitable areas to disperse into.

On Kapiti Island only about 10-20% of juveniles remained near their area to become territorial or sub-adults (Beauchamp, 1987a). In the IBM juvenile dispersal is modelled based in the empirical data from Cape Foulwind, but allowing longer dispersal distance in common with other studies (i.e., dispersal up to c.5km with 50-75% of juveniles dispersing).

**Adult movement**

Some adult movement was recorded at Cape Foulwind where two unpaired birds moved their home range areas between 1 - 3km. In one bird, movement occurred several months after most

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63 North Island weka have been observed to sometimes produce a ‘mate finding’ call when a mate is lost (Beauchamp, 2009). This call has not been observed in the South Island. In April 2010 a male weka was heard to be making a similar call at Punakaiki village. It occurred intermittently for over six months in intervals of up to c.1 hour at a time.
of its home range area was flipped. The other bird moved prior to its home range area been flipped. For the former, the movement appears to be associated with habitat disturbance and potentially a reduction in food availability associated with this, rather than being forced to move through territorial disputes. For the latter, pressure from other weka associated with the flipping of nearby land may have been a contributing cause. Both of the birds moved during the winter months (July) when food availability is most likely to be lowest. On Kapiti Island Beauchamp (1987a) noted that weka beyond two years of age moved around very little, but this low level of movement occurred all year round. In the IBM this movement is modelled by allowing 30% of birds holding a home range to move once each winter should their weights drop below 70% of their optimum weight.

13.1.6 Breeding

There is a considerable contrast between the average percentage of known territorial females breeding successfully at Cape Foulwind (2007-2009 was 75% (n = 8) with the less productive Kapiti Island population. On Kapiti Island, over 5 years an average of 40.9% of pairs attempted to breed each season, and of these, an average of 26.8% was successful.

In the IBM the percentage of pairs successfully breeding is an emergent property and highly variable. It averages approximately 60% (Figure 9.6). This emergent value was based on the following parameters: Average chicks raised per year 1.6 and the primary breeding season was modelled as Spring (September – November). Both of these are based on Cape Foulwind data. Maximum broods per year depend on the female’s condition but is generally only one. The minimum pair bonding age is 12 months.

13.1.7 Gender bias

The high percentage (73%) of male weka found killed on the roads at Cape Foulwind may indicate a male bias in the population. Coleman et al. (1983) found such a male population bias (68%) in their West Coast study. However, such bias varies with population cycles (Marchant & Higgins, 1993), and a significant male bias in the adult population was not indicated in call counts undertaken in the study area. If the apparent gender bias in weka road-kill is real, it could place additional stress on the population, as weka are generally monogamous (Marchant & Higgins, 1993).

Beauchamp (1987a) found there was a bias towards females in the sub-adult/non-territorial population on Kapiti Island in a period of poor food supplies. Such a pattern may also help identify what is implicated in a population decline (i.e., if there are declining numbers with a female bias food supplies could be implicated). Beauchamp (1987a) suggested the reason for this was that males used up more energy enforcing territories so had less time to feed and so were more susceptible to
food shortages in winter. On the mainland there has been a male bias found. This is possibly associated with females being more susceptible to stoat predation due to their smaller size. However, as noted above there was no evidence of stoat predation at Cape Foulwind.

The initial adult sex ratio was modelled as 53% male bias based on the empirical data from Cape Foulwind.

13.1.8 Age Structure

Table 13.1 gives an indication of the age structure of the Cape Foulwind population derived from roadkill carcass collection and captured birds. Most (90%) of the weka killed on the roads were less than three years old. This would suggest a bias toward young birds, as studies of other populations show a much higher average age; 6 – 6.5 years (Beauchamp, 1987a), but as low as 4 years in the Marlborough Sounds (Beauchamp, 1987). On the other hand, Beauchamp (2004) concluded that West Coast lowland weka populations appear to be productive, with a high turnover and a young demographic and more likely to be similar to the Marlborough Sounds mainland population. The captured bird data support this observation.

Due to the method of ageing (using wing spurs only) used there may be considerable inaccuracy in aging of the Cape Foulwind birds. In contrast, the study on Kapiti Island used a banded population. The age assessment may also be affected by my lack of experience in aging weka using wing spurs.

<table>
<thead>
<tr>
<th>Age class</th>
<th>Kapiti Island (Beauchamp 1987a) (n=51)</th>
<th>Cape Foulwind road-kill (n=52)</th>
<th>Cape Foulwind captured birds (n = 21)</th>
<th>Motu (F. Kemp 2003 cited Beauchamp 2004)</th>
<th>Marlborough Sounds (Beauchamp 1987b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>12%</td>
<td>38%</td>
<td>28%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 - 3</td>
<td>10%</td>
<td>53%</td>
<td>72%</td>
<td>79%</td>
<td>c.75% (&lt; 5 years old)</td>
</tr>
<tr>
<td>3 - 15</td>
<td>78%</td>
<td>10%</td>
<td>0%</td>
<td>21% (&gt;5 years old)</td>
<td>c.25% (&gt; 5 years old)</td>
</tr>
</tbody>
</table>

Beauchamp (1987a) found that the weka population age structure on Kapiti Island depended upon the environmental conditions over the previous 14 years. This in turn affected breeding and mortality in adults and so turn-around within the population. This longitudinal dynamic process will
be automatically incorporated into the IBM, although due to the younger population, it is likely to be less than 14 years.

13.1.9 Population type

The Kapiti Island weka population has comparatively high longevity along with low breeding rates. This is characteristic of k strategy species and this situation probably also existed on the main New Zealand islands in pre-human times. In existing mainland populations, increased inter-specific competition for food, changes in habitat and higher mortality rates (e.g., predation by exotic species, road-kill) has forced weka to tend towards an r strategy species, characterised by increased mortality and productivity. Consequently, breeding weka tend to only defend young within overlapping territories (Beauchamp, 2005). However, their behavioural plasticity may mean that depending on the productivity of the habitat and mortality pressures weka may tend toward either k or r strategies within populations. The range of habitats at Cape Foulwind may produce such combinations.

In parallel with the proposal above, long standing populations can be split into four groups (DOC 1999, p. 79-80). Those with:

1. “Restricted breeding periods, relatively high numbers of weka in older age groups and moderate to low weights.

These are likely on islands with territorial populations controlled by density dependent factors. The structure favours older weka and loss of most young because they cannot find space (i.e., Kapiti Island pre 1996).”

2. “Restricted breeding periods, low numbers of weka in older age groups and relatively low weights.

Indicates populations that have periodic instability due to environmental or internal population demographic factors. (i.e., Kawau Island).”

3. “Year round breeding, with most weka younger than 6 years and moderate to high weights. “

“These populations are found where there has been a major loss and the population is in recovery, or where there is high population turnover associated with high productivity (i.e., Chatham Island).”

This should also apply to the Cape Foulwind population (Table 13.1). Data from this study suggest that most weka are less than 6 years old and the population has high adult weights.

4. “Year round breeding but few, and generally paired, first year weka with moderate to high weights.”

These are generally found on the North Island mainland when the population is in decline (e.g., from predation pressure).
Table 13.2 Breeding and territorial attributes, and density estimates based on minimum polygons of mapped calling weka (following Beauchamp, 2003).

<table>
<thead>
<tr>
<th>Population</th>
<th>Breeding</th>
<th>Territoriality</th>
<th>Density (paired adults)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chatham Island</td>
<td>All year peaking in spring and summer</td>
<td>Territorial</td>
<td>0.5 – 1.2 ha</td>
</tr>
<tr>
<td>Marlborough Sounds</td>
<td>All year peaking in spring and summer</td>
<td>Semi-territorial or territorial depending on density</td>
<td>0.2 – 0.3 ha</td>
</tr>
<tr>
<td>Westland</td>
<td>All year – peak unknown</td>
<td>Semi-territorial or territorial depending on density</td>
<td>0.001 – 1.0 ha</td>
</tr>
<tr>
<td>Cape Foulwind</td>
<td>All year peaking in spring and summer</td>
<td>Territorial</td>
<td>0.2 - 1.4 ha (Average 0.77 ha)</td>
</tr>
</tbody>
</table>

Furthermore, Beauchamp (2004) suggests that the large size and high weights of weka on the West Coast obtained from studies by Coleman et al. (1983), Van Klink & Tansell (2003), Beauchamp (2004, p. 2) and supported by this study (see Table 12.10), indicate that where defendable resources exist weka on the West Coast would: “

1. be territorial and densely pack in some areas;
2. attain moderate to high densities in good habitats of >1 weka per ha;
3. breed more than once a year with little risk to the breeding birds;
4. have >30% in the spur 3 cohorts (Beauchamp, 1988);
5. raise more than 2 young a brood”.

A population with these characteristics would indicate that it is strong. If not, there may be factors limiting it (Beauchamp, 2004). The data obtained in this study suggested the Cape Foulwind population meets criteria 1 and 2 and probably 4 above. In relation to 4, as noted, the age data are not robust as most data are derived from road-killed birds that appear likely to have a bias towards young birds. Criteria 3 and 5 are not as clear as the population appears to have distinctive breeding season – although some birds are breeding all year where they have a good food source (e.g., around houses). Some pairs raised more than two chicks but data from this study showed an average of two chicks per brood. As mentioned above, this might vary among habitat types.

The IBM outputs reflect the population characteristics noted in Table 13.2. It also models the Cape Foulwind population with high adult weights reflecting the empirical data collected. The age distribution and population turnover is an emergent property of the model that develops from the interaction of a range of factors.

3.1.10 Population dynamics

The population type is reflected in the Cape Foulwind weka population dynamics. The weka IBM suggested the Cape Foulwind weka population is relatively susceptible to food availability and
somewhat less so to mortality pressures (predation, road-kill, dog-kill, posion, etc.). The model also suggests that land development through loss of cover (and possibly food availability) makes the population less resilient to these stressors. By contrast, Beauchamp (1987a) found the factors that controlled the population dynamic on Kapiti Island were food availability, along with the structural factor of social organization. More specifically, changes in population density on Kapiti Island depended upon the interrelation between the condition of individuals (their weight), the amount of food available and the species’ behavioural characteristics (e.g., territoriality). This in turn affected the breeding productivity and survivorship of the individuals (Beauchamp, 1987a). These factors and their interactions were included in the Cape Foulwind weka IBM, although weka condition and territoriality were not specifically investigated.

In summary, the fieldwork and modelling results suggest the weka population at Cape Foulwind will have most of the same factors dominating the population dynamics as identified in the well studied Kapiti Island population (Beauchamp, 1987a), but with a different emphasis on each. The important varying factors are a more varied diet, more consistent food availability, higher background mortality and population turnover, lower densities and larger territories, and a more diverse landscape cover matrix. This is consistent with observations that mainland populations are exposed to more competition and higher mortality rates than those on islands (Beauchamp, 2005).
14 Resilience analysis of the socio-ecological system at Cape Foulwind

14.1 Introduction

This resilience analysis of Cape Foulwind is based in the historic developments at Cape Foulwind, along with the theoretical background developed on systems, SES, and RT in Chapter 3. The dynamics of social ecological systems has been described in Chapter 3 using the adaptive cycle and interactions across scales within this as a panarchy. What needs to be kept in mind is that the adaptive cycle should be viewed “as a useful metaphor and not as a testable hypothesis.” (Carpenter et al., 2001, p. 766). In addition, the use and application of Resilience Theory is fundamentally focused on the management of socio-ecological systems in order to retain it in a desirable configuration (The Resilience Alliance, 2007).

As has been outlined, resilience in this case is being used to understand the relationship between weka and land development at the spatial scale of Cape Foulwind and the temporal scale of decades. The temporal scale used affects the classification of elements of the system as fast or slow. In this study, cultural change in relation to weka (i.e., sense of place), along with property rights, and climate changes are considered slow. Landscape change can occur at a fast temporal scale, while the loss of weka populations can also occur at a fast rate. At the spatial scale, interactions are classified as either ‘small’ or ‘large’. These range from the scale of one to five hectares (paddock) to global extra-regional scales and tend to be interconnected. For example, weka immigrating into the area may allow weka to persist at the paddock scale, in parallel subsidisation of farming from outside the region allows farming to persist at a large scale to create significant changes in the landscape (e.g., fertilizer, fuel, electricity, chemicals, machinery, credit).

The key social players in the system are landowners who own c.85% of the land in the area. There are also governance bodies responsible for environmental management on private land under the Resource Management Act 1991 (West Coast Regional Council, Buller District Council). The Department of Conservation, which administers most of the balance of the land under the Conservation Act 1987, also has an advocacy role for the protection of native species and ecosystems within the Resource Management Act. Local and nationally based conservations groups (e.g., Forest & Bird Protection Society, Buller Conservation Group, Landcare Trust) can influence policy decisions of local and central government.

The RT analysis in this chapter is based on RT workbook for scientists (The Resilience Alliance, 2007) along with other literature. Previous discussions on FCMs, interviews and IBMs provide inputs
into this RT analysis by contributing an understanding of the SES in relation to weka, by local residents (although this is much broader than just the SES and includes place). It also includes modelling of the impact of landscape change on weka, and possible responses to changes to the weka population by the residents.

The first sections of the chapter will set out an historical overview of the changes that have occurred at Cape Foulwind. (e.g., original vegetation, forest clearance, fire, pākihi development, general weka population fluctuations etc). Following this, recent and present farm development change and its associated dynamics are outlined. The discussion will then develop what I understand are the adaptive cycle transitions at Cape Foulwind over the past century leading up to their present ecological and social locations. I will then elaborate on the potential regime shifts and threshold locations associated with these. This is considered primarily first from the state of the weka population and, second, the economic status of farming and socio-cultural links with place. These will be further broken in scale – patch, farm, region - to consider the interlinking of scales and how these spatial scales might interact, where thresholds might lie, and what associated ‘cascades’ might exist (Kinzig et al., 2006). It will then consider a range of scenarios for the SES at Cape Foulwind and then the role of learning and the possibilities for adaptation.

14.2 Cape Foulwind historical overview

14.2.1 Original landscape

The pre-European vegetation of the Cape Foulwind peninsula was a mix of forest and pākihi. Dumont d’Urville, when sailing close to Cape Foulwind on January 12, 1827, thought that if there were any people in the area they must have been where there were “attractive sites and fine grassland suitable for cultivation” (Macdonald, 1973, p. 7). But d’Urville, like other early explorers, was misled by the open appearance of the pākihis lying immediately behind Cape Foulwind. The pākihis seen by d’Urville from the sea may have been the eastern older higher uplifted terraces adjacent to the Paparoa Range. Confirmation of pākihis on Cape Foulwind peninsula itself come from James Mackay, who exploring the area in 1857, travelled overland from the Buller River mouth south “inland across the pākihis to avoid the bluffs of Cape Foulwind gaining the sea at the mouth of the Okari River” (Macdonald, 1973, p. 13). An 1864 painting of the Cape Foulwind area from the slopes of Mount Rochfort by John Barncoat showed a mix of forest and pākihi north of Westport (Macdonald, 1973).

The Cape Foulwind peninsula landscape consists of a set of marine terraces formed in succession by the high sea levels of the inter-glacial periods of the late Quaternary period. Because of
the rising land these marine deposits, wave cut platforms and sea cliffs have become uplifted above the high sea levels of the present post-glacial period (Aranian period). There are four main cycles of deposit and cliff formation. The first and oldest deposits are associated with the Waihero inter-glacial (c.350,000 BP). The associated formation at Cape Foulwind peninsula is called the Caledonian. These terraces are the most eastern and lie at approximately 100 to 200 metres above sea level (Figure 14.2). The second formation is the Addisons which is associated with the Terangi inter-glacial period (c.210,000 BP). The third set of deposits has been broken into two sub-cycles made up by the Virgin Flat and Waites formations. These were both formed during the last Otarian inter-glacial approximately 100,000 BP and lie between 20 and 40 metres above sea level. The sediments found in these deposits show they were formed in environments that included estuaries, swamps and lagoons. The fourth set of deposits is being formed in the present Holocene post-glacial environment (McPherson, 1978). The vegetation on this low lying coastal deposit would have been hardwood-beech-podocarp forest in areas not directly adjacent to the coast, and a smaller stature mix of broadleaf taxa such as northern rata (M. robusta), kiekie (Freycinetia banksii) and nikau palm (Rhopalostylis sapida) would have been dominant along the coast itself (Burge & Shulimeister, 2007).

Rigg (1962 cited in Moar & Suggate, 1979) described the semi-pākihi and true-pākihi vegetation on Cape Foulwind peninsula. The semi-pākihi lay on the Waites Formation on dissected lagoonal or estuarine sands. Moar & Suggate (1979) suggest that this area was covered in podocarp forest in pre-European times (Figure 14.1), while Burge & Shulimeister (2007) note that there is little information on the original vegetation but suggest a native vegetation typical of other terrace surfaces on the West Coast. This consisted of mixed podocarp-broadleaf-beech forest dominated by kahikatea (Dacrycarpus dacrydioides), rimu (Dacrydium cupressinum) and hard beech (Nothofagus truncata). Kahikatea would tend to dominate in wet areas while rimu and hard beech dominated in the older surfaces with poor soils. The poorly drained sites would be occupied by plants such as manuka (Leptospermum scoparium), pākihi rush (Restionaceae) and umbrella fern (Gleichenia spp.) (McPherson, 1978). This vegetation mix is consistent with the compositions of the few remaining forest remnants in the area. The high and older Addisons, Virgin Flat, Caledonian formations were true-pākihi, with peaty soils and cemented marine gravels. The existence of stumps and logs of Silver pine (Dacrydium colensoi)/Yellow pine (Halocarpus biformis)/Yellow silver pine (Lepiothmnus intermedius) found under the surface in these areas suggests they were previously forested in parts (pers. ob., Moar & Suggate, 1979). The oldest formation, the Caledonian formation, probably had less forest than the Addison and Virgin Flat formations and was the ‘grassy’ area seen by d’Urville. Moar & Suggate (1979) note that in 1979 these areas were dominated by manuka, sedges and fern but the land was being converted to grassland farming. In conclusion, there was a
mix of pākihi and forest on Addisons, Virgin Flat formations, although the percentage cover of each type is unknown. On the Caledonian formation the percentage of pākihi is likely to be higher.

Figure 14.1 Vegetation cover Cape Foulwind area c.1850. Formations from Moar & Suggate (1979). Logging tramways from McPherson (1978).

Johnson (2005) remarks that there has been much conjecture about the formation and ongoing process of development of West Coast wetlands, of which pākihi are a type. For example, Mark & Smith (1975) propose that a succession from pākihi to mixed beech-podocarp forest tends to occur and use evidence from South Westland in support of this. The edge of the site they studied showed a gradual progression from bog land species, to manuka, to silver pine, to beech-podocarp forest. This succession is very slow due to the poor and saturated soil conditions.
In contrast, there are proposals that the opposite occurs at times. This proposed spreading of pākihi into forest arises due to the development of very infertile soils and iron pan resulting in conditions unsuitable for beech-podocarp forest but allows the establishment of silver pine. On the Cape Foulwind terraces Rigg (1962, cited in Mark & Smith, 1975) suggests that the pākihi have developed mostly from forest (hence the existence of buried timbers), although he suggests there may also be periods (e.g., warmer, dryer conditions) of forest succession, which is occurring at present. In addition, the removal of forest, through, for example human, disturbance or fire, can leave the soils more saturated due to lower transpiration and encourage pākihi development and retention. Although, against this theory McDonald (1955 cited in Mark & Smith, 1975) found little difference in soil moisture content after logging operations.

The vegetation mix in the area, as described above, probably supported moderate numbers of weka similar to what the remaining areas of the mixed native landscape support today. Densities from call counts undertaken for this study suggest these ranged from 0.15 adults per hectare (pākihi) to 1.1 adult per hectare (indigenous forest) (see Section 12.1.9). The confirmation that there were weka at Cape Foulwind at the arrival of Europeans is confirmed by Charles Heaphy. Heaphy noted weka at Cape Foulwind when he passed through in 1846. His dog killed 23 (along with nine wood pigeons) in three hours at Tauranga Bay (Nelson Examiner, 3 May 1846: www.paperspast.natlib.govt.nz). Heaphy crowned the weka as “the queen of wild fowl” on his journeys to the West Coast in the 1840s, although not for conservation reasons; “Hail to thee weka! – tender as a chicken, gamey as a pheasant, gelatinous as a roaster” (Rogers, 2005, p. 26).

14.2.2 Human occupation

Human occupation at Cape Foulwind is broken into three main phases and related broadly to the Resilience theory (framework) adaptive cycle for SES. I concentrate on European occupation which began in the 1860s and the impacts of this on weka abundance. I do not just consider the change to the landscape itself but the social and individual factors motivating that change.

Initial occupation was related to gold mining and forestry, while later occupation was related to agricultural land use and associated development. At a national level PCE (2004) have broken agricultural development into six stages. These are general stages and do not necessarily overlay onto the progression of agricultural development on the Cape Foulwind peninsula. However, they enable a link to be made between the changes that have occurred at Cape Foulwind and larger extra-regional drivers. Farming development at the regional level also lies within a national and international context. Consequently, the drivers for change need to be considered at this wider scale.
These six stages have been incorporated into three main phases of development at Cape Foulwind. The first phase is not primarily related to agriculture.

14.2.3 Phase 1 drivers

In 1866 gold was discovered on the terraces behind Westport and in April 1867. A miner named Addison found gold on the pākihis on what was to be known as Addison’s Flat. By December 1867 the population of Addison’s Flat diggings was 1500 (Macdonald, 1973). The alluvial gold lay in marine and fluvial sand and gravel deposits primarily in the Addisons, Virgin Flat and Waites Formations. The Addisons mining field covered much of the central and eastern side of Cape Foulwind peninsular (Figure 14.2). This area was disturbed by ongoing sluicing and mine workings. The gold mining slowly declined from the 1870s until the 1900s and by the First World War had almost ceased (MacPherson, 1973).

Logging began in the area in the 1870s. There were at least three sawmills at Cape Foulwind and one logging tramway that extended many miles, crossing the Okari River three times. McPherson (1978) shows three logging tramways in the western Cape Foulwind area (although none of these are shown to cross the Okari River) (Figure 14.1). These tramways allowed for the logging and clearance of the apparently extensive podocarp-broadleaf-beech forests of the western Cape Foulwind plain. Logging also occurred on the eastern portions of the area with the Omanu Creek sawmill opening in 1918. Flax milling was also undertaken at Cape Foulwind (Bennett, 2005).
Fire has probably had an important role to play in suppressing forest succession during the last 150-200 years following initial mining and logging. This is both on the previously forested semi-pākihi areas and the true-pākihi areas. The initial regeneration of the logged semi-pākihi is likely to have been in manuka and other pioneer species. Pākihi vegetation, especially manuka at certain ages and densities, is very flammable in dry conditions (Johnson, 2005). These areas were burnt frequently by settlers and farmers during this time (Moar & Suggate, 1979). Pākihi fires do not generally penetrate any surrounding forest so a sharp edge between the forest and pākihi species develops (Johnson, 2005).

In pre-human times natural fires started on the true-pākihi terraces, for example by lightning, would have occurred but at a much lower frequency than human fires. Evidence for this is found in
manuka serotiny. Johnson (2005) found serotiny in manuka at German Terrace just north of Westport that was consistent with previous studies at other North Westland pākihi sites (Bond et al., 2004 cited Johnson, 2005). It is proposed that manuka select for serotiny in sites that are regularly affected by fire, suggesting that natural fires were not infrequent on North Westland pākihi, and more common on larger pākihi areas. These natural fires on pākihi slowed or stopped the process of colonisation by forest species.

Other activities in the Cape Foulwind area during the 1860s-1920s period were associated with supplying the growing coal town of Westport. Rock was quarried and railed for the harbour works in the Buller River (completed in 1886). Farming was only small scale, supplying milk and eggs for local consumption (Bennett, 2005). Farming appeared to only be intensive along post-glacial formation fringing of the Buller River and the coast. The earliest noted farming of the area was two cattle runs to the south of Westport established in 1863 (Macdonald, 1973).

Three of the agricultural changes described by PCE (2004) are incorporated into this first phase of development at Cape Foulwind. These stages were the pre-1840 exploitation of resources where native species were harvested (e.g., Fur Seals at Cape Foulwind) and the 1840s-1860s stage of extensive pastoralism and then its collapse (MacLeod & Moller, 2006). This occurred predominantly on the east coast of New Zealand and does not apply to Cape Foulwind. This was followed by the 1870s-1920s expansion of a permanent grassland system through forest removal. This occurred at Cape Foulwind with the logging of coastal areas that were then put into pasture. The forests of the western peninsula were logged and burnt for the creation of rough pasture.

This phase of mining, milling and small scale farming can be conceptualized within the RT framework to include social release (Ω), followed by reorganization (α) and growth (r) phases as new resources were developed and exploited (Figure 14.7).

There was substantial disturbance to the ecology of the Cape Foulwind area during this period. A large proportion of Cape Foulwind was either mined or logged and subsequently regularly burnt. The weka population probably went through an adaptive phase in this period that caused changes in the population (Figure 14.7). First, nutrients initially released by disturbance created by logging and mining, are likely to have increased weka numbers. Associated with this is the loss of cover that followed from subsequent regular burning (Moar & Suggate, 1979) would have made some areas difficult to survive in, in the short term. Broadly, this is equates to release (Ω), reorganization (α) phases.

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64 Serotiny is an adaptation exhibited by some seed plants, in which seed release occurs in response to an environmental trigger (e.g., heat, drought) rather than spontaneously at seed maturation.
The impact of fire on the previously forested area was probably more important than on true-pākihi, as fires occurred there naturally (Johnson, 2005). Weka were probably already in low numbers on true-pākihi so not affected greatly by fire. They were likely to move back into surrounding forest (although some would have been trapped and killed especially in fires covering large areas and that moved quickly). In addition, the miners and loggers would have kept dogs with them which would also have impacted on weka. Heaphy notes that weka were not welcome around the settlements of the time (Nelson Examiner, 3 May 1846: [www.paperspast.natlib.govt.nz](http://www.paperspast.natlib.govt.nz)). For this reason there is likely to have been a decline around the settlements and mining areas (e.g., Addisons Flat). Residents may have also killed weka for food.

### 14.2.4 Phase 2 drivers

This phase links in with two PCE (2004) stages. These are the early intensification of agriculture in the 1920s to 1940s and its diversification in the 1950s and 1960s. McLeod & Moller (2006) link these two stages together at a national level, as I do here for the Cape Foulwind area.

During the 1920s-1940s farming was sometimes developed on unsuitable land (PCE, 2004). In the Buller area, for example, the government subsidized a land clearance scheme using bulldozers, and some 800 hectares was cleared throughout Buller. At a similar time, the Cawthron Institute (Nelson) unsuccessfully endeavored to sow pasture onto the surface of the pākihis at Sergents Hill. The Government spent £1.25 million attempting to drain land (without much success) (Bennett, 2005). During this period, farm science began to develop and improved the available fertilizers and pasture species (PCE, 2004).

During the 1950s-1970s these scientific developments along with technological developments (e.g., electric fences, tractors, top-dressing aircraft) approximately doubled farm production nationally between 1945 and 1970 (PCE, 2004) while the area of land in pasture remained relatively constant (MacLeod & Moller, 2006). At Cape Foulwind during the 1960s, dairy farming was carried out along the sandy postglacial coastal strip between Westport and Cape Foulwind and along the banks of the Buller River. Farming on the coastal strip south of Cape Foulwind was confined to sheep and cattle farming (McPherson, 1978). Sheep and cattle were also the predominant livestock on the undeveloped and un-drained true-pākihi and semi-pākihi country of the bulk of the Cape Foulwind peninsula. For example, during the late 1960s Lands and Survey, owners of the 5000 ha Cape Foulwind Farm at the time, began development by over-sowing and running cattle, although
the farm ran mostly sheep and a small number of deer. Some small dairy blocks were also developed (Rural Delivery, 2005).

Improvements in farm outputs at the national scale were probably not achieved on inland areas of Cape Foulwind, at least until very late in the period. Aerial photos of the Virgin Flat area of Cape Foulwind in 1974 show little developed pasture in this locale and the area dominated by pākihi. While Moar & Suggate (1979) noted that in 1979 most of this now semi-pākihi area, dominated by manuka, was being rapidly replaced by pasture.

The Cape Foulwind SES during this period could be understood as a continuation of a weak and long conservation (K) stage of the adaptive cycle developing from the disturbance of earlier mining and milling with ongoing burning and the slow development of rough pasture farming. Weka can be considered as moving through growth (r) to conservation (K) (as more rough pasture was slowly created and burning decreased (Figure 14.7). By end of the period weka numbers were likely increasing steadily on the rough pasture land with adequate cover.

14.2.5 Phase 3 drivers

PCE (2004) propose the period from 1980s to the present as one of further intensification and diversification in New Zealand agriculture. This was in part related to, and complicated by, a major economic shift that occurred during this period. From the late 1960s to the mid-1980s the New Zealand government developed a set of policies aimed at retaining full employment through protecting domestic production. This was done in part through financial subsidies to farmers and high tariffs on imported goods (e.g., farm inputs such as machinery) (Figure 14.3). This process insulated New Zealand from open market indicators and increased government expenditure as wool prices dropped in the late 1960s, along with spikes in the price of oil in 1973 and 1979. In addition, Britain’s membership of the European Economic Community (EEC) in 1973 impacted on New Zealand’s primary agricultural export market (MacLeod & Moller, 2006).

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65 The wet pākihi ground was best suited to light stock (e.g., sheep and deer). Deer farming did not become legal in New Zealand until 1969 (MacLeod & Moller, 2006). The Landcorp Cape Foulwind Farm stocked 9500 deer in 2005 (Rural Delivery, 2005)
From 1984 the Government policy changed course towards reducing intervention in the economy and encouraging the use of open market prices. Producer subsidy equivalents\(^{66}\) (PSE) of up to 45% for lamb meat were removed and the marketing control of exports deregulated. The removal of output subsidies meant sheep meat and wool prices fell while the removal of input subsidies forced input prices up, especially for fertilizer and credit. For example, in 1986 the incomes of sheep and beef farmers fell 60% compared to the previous year, while the incomes of dairy farmers fell 25% mostly from increased debt servicing costs and the loss of fertilizer subsidies (Lattimore, 2006). The recovery of dairy farmers’ incomes began in 1988 and increased further from 1991. The income of sheep and beef farmers rose more slowly from 1987. All farm incomes stagnated during the ‘Asian crisis’ years from 1996. In recent times, farmer incomes have fluctuated markedly. Major conversions to dairy farms began after a large rise in dairy prices in 2001 (Lattimore, 2006). The 2008 Westland Milk Products payout was the highest ever recorded at NZ$8.29/kg milk solids (MS). The 2009 payment was much lower as world commodity prices plummeted, although it recovered somewhat in 2010 (Figure 14.4).

\(^{66}\) Producer subsidy equivalents (PSE) are the total subsidy incorporating producer output subsides (deficiency payments) and subsides on imported input goods and materials (Lattimore, 2006).
There were two major responses to deregulation. The first was concentrated on increasing the value and quality of farm products, and the second on increasing material inputs to improve production (PCE, 2004). The important factor for this discussion is the second one and MacLeod & Moller (2006) show that although there has been a drop in the total number of stock on New Zealand farms over the past 20 years (related to a drop in sheep numbers), the intensity of farming has increased, as has its diversity. They argue the intensification has been continuous and has increased further in the last decade. This increase is calculated using the quantity of produce extracted per unit area of land. Dairy production per hectare has increased at a rate of 1.4% per year since the early 1970s and sheep meat 2.1% and wool 0.3% since 1975. Beef farming production has probably shown less change, although they note the data available for beef is difficult to decipher.

This increase in outputs can be traced through an increase in farm inputs. Non-nitrogenous fertilizer use doubled between 1961 and 2001, while nitrogenous fertilizer use increased over 60 times in this period. The most rapid increase in use was during the 1990s. Pesticide use, which includes herbicides, insecticides and fungicides, tripled between 1993 and 2001 (MacLeod & Moller,

\[67\] In the Buller District there was a substantial increase in dairy cow numbers between 1998 (27782 on 126 farms) and 2007 (45013 dairy cows on 129 farms) (Statistics New Zealand).
There has also been a large increase in the use of supplementary food stock imported from overseas. Although there is no long term data available on farm (fuel and electricity) and off farm energy inputs, they have most likely increased considerably over the past four decades due to fertilizer use, off farm feed, and in some areas the use of irrigation (MacLeod & Moller, 2006). Also during this period there has been a substantial increase in rural land prices (MacLeod & Moller, 2006).

The factors involved in the response to the 1984 subsidy removal are complex, and it took some ten years for the agricultural industry to adjust and recuperate. Sheep farming suffered the most and has been the slowest to recover. There are a number of hypotheses in regards to recovery covering the micro-level (i.e., most efficient and adaptive farms survived) to the macro-economic factors such as commodity prices (MacLeod & Moller, 2006). The farmers whose farms survived the economic reforms were those who coped with the shorter-term adjustment and remained farming long enough to benefit from the recovery of farm prices (Lattimore, 2006). “They won in large part because they developed and adopted new technology to boost farm productivity.” (Lattimore, 2006, p.16).

Another important post-1984 change has been the movement to dairy farming, particularly over the past decade. The conversion has mostly been debt funded and dairy farming now makes up 64% of agricultural debt in New Zealand (Greig, 2010). This debt rose 160% between 2000 and 2009. Greig (2010, p. 11) notes that “[t]he recent world economic crisis has affected NZ dairy farmers. Volatile milk prices, increasing farm working expenses, and declining land prices have had solvency and liquidity implications.” High levels of debt create a financial risk to farm businesses and can affect their survivability. Credit for farming development became more difficult to obtain following the 2009 worldwide recession.
14.2.6 Phase 3 and West Coast and Cape Foulwind

These post-1984 adjustments can be seen in changes to farming on the West Coast as a whole which has involved a move away from dry stock farming to dairying (Figure 14.5). For many years dairying was not a major contributor to the West Coast economy, only in the late 1990s did it begin to expand substantially – along with dairying throughout New Zealand. In 2005 Westland Milk Products spent $63 million on expanding its dairy processing plant (Rogers, 2005). At Cape Foulwind it was during this period that land development (flipping) began and was closely associated with dairy land conversions.

Early experimentation in improving pākihi soils included conventional open drains, and explosives to break up the iron pans but these were not successful. The recent availability of hydraulic excavators has allowed the breaking up of the iron pans to be undertaken economically, and drainage to be improved significantly (Ross, 2006). For example, unflipped pākihi dairy pasture has been found to have an infiltration rate of 3 - 4 mm/ hour while three year old flipped pasture has a rate of 28-52 mm/ hour (MAF, 2006).

The change in infiltration rates has some permanent effects on the hydrology of catchments. An assessment undertaken for Landcorp Farming Ltd suggested that flipping will increase water infiltration, which will mean a higher proportion of rainfall will go to groundwater causing a
reduction of 32% to 35% in instantaneous peak flows in water ways. It will also increase the soil’s water storage capacity, therefore increasing base flow levels in perennial waterways. A slight increase in the soil evaporation rates is also expected (Sinclair Knight Merz, 2005). Anecdotal evidence from farmers suggests the flipped ground can become very dry in summer dry spells.

Cape Foulwind farmer, Alex King developed flipping in the early 1990s. Since then it has been taken up by a number of other farmers at Cape Foulwind. Flipping has become a vital tool for improving farm productivity on Cape Foulwind farms. The improved drainage increases pasture growth and reduces ‘pugging’, caused by heavy stock in particular, that damages the pasture. Farm production improvements include one farm that has doubled its milk production since flipping its pasture while, for another, the rate of return on flipping was 37% (MAF, 2006). On land that was flipped ten years previously there is no sign of iron pans reforming (Ross, 2006).

In another farm example, Landcorp Farming Ltd Cape Foulwind farm (5000 ha in area) started flipping their land in 2000. By 2006 four new dairy units had been developed at (c. 400 ha each). In 2008 another dairy unit was established (c.400 ha at Bulls Road). Approximately 2000 ha in total have been developed into dairy. In addition, some deer blocks have also been flipped (c. 500ha). Pasture growth three years after flipping is high and increasing and carrying capacity has trebled. However, it is the good dairy prices that have made the development viable (Rural Delivery, 2005). The total cost of Landcorp’s farm redevelopment (i.e., including new races, fences, water supplied, culverts etc.) is approximately $10,000 per hectare (Rural delivery, 2005). However, basic flipping costs are $2500 to $5000 per hectare (back to pasture) (MAF, 2006). In total, Landcorp have invested approximately $20 million in land development at Cape Foulwind over the past decade. Much of this money has come from outside the region.

This land development requires large inputs in fossil fuel and fertilizers. These inputs come from outside the farm and so are ecological subsidies that disconnect local carrying capacity of the land from the stock carrying capacity. Ecological subsidies include the substantial increase in fertilizer use. Most phosphate fertilizer comes from Nauru and Christmas Island and provides a substantial ecological subsidy in New Zealand over the past 40 years. This is a move away from traditional use of clover to fix nitrogen into soil. At Cape Foulwind due to the low acidity and nutrients of the pākihi soil, and the dilution of the soil through mixing underlying gravels and sands, a heavy application of lime (3-5 tonnes per hectare), dolomite (2 tonnes per hectare), and fertilizers are required. The fertilizers used are a serpentine super, potash and sulphur mix (1 tonne per hectare) and a nitrogen fertilizer (300 kg hectare) (Rural Delivery, 2005). In addition, ongoing applications of fertilizer, at higher than usual rates, may be required because of higher leaching losses through the now freely draining soils (MAF, 2006). Flipping also allows easier application of fertilizer. Once the land is flipped
tractors can be used rather than a crop duster aircraft. At Cape Foulwind a large input of energy is required to develop the land. This subsidy, by way of fossil fuel, is short term and is not required in the longer term.

In some ways the development at Cape Foulwind is a microcosm of the intensification and diversification changes at the national level. At a national level intensification has been in part a byproduct of the increasing cost and lack of availability of land. This has meant the energy and finance of farmers has gone into increasing production on existing land. This has been enabled through advances in technology (MacLeod & Moller, 2006). At Cape Foulwind, this includes a move from low production to high production land through developing it, as well as a move from sheep/beef to more intensive dairy farming. Dairying is the only real alternative to sheep/cattle as the area is too wet for most horticulture.

Cape Foulwind has followed national trends but required the extra ingredient of a specifically developed local technique (flipping) to enable the trend to be followed. It also depended upon individual farmer’s position and decisions. A number of farms at Cape Foulwind have not followed this trend. Land development at Cape Foulwind is embedded in a network of changes from a global to a local scale.

Below is a summary of the drivers involved post-1995 land development at Cape Foulwind:
- Technological developments (flipping techniques and machinery);
- National trend toward intensification of farming in open market post-1984 subsidies removal;
- Higher profits available from dairying compared to sheep/cattle;
- Climate well suited to dairying (mild, consistent rainfall) but not well suited to arable or horticulture crops;
- Development considerably increases land values so the investment is not lost;
- Restriction on the amount of naturally occurring land suitable for dairying;
- Trend towards increased farm/herd size;
- A cultural and economic imperative for growth and expansion;
- Credit availability.

### 14.3 Resilience analysis of Cape Foulwind

#### 14.3.1 Adaptive cycle

The rest of this chapter entails a resilience analysis (see Section 3.6) of the Cape Foulwind SES based in part on the preceding sections. In particular, it concentrates on the existing phase three
changes. Figure 14.6 shows a timeline of the major local and regional changes associated with the Cape Foulwind landscape over the past one and half centuries. Figure 14.7 links these changes with the estimated adaptive cycle changes based on the three agricultural phases outlined in Sections 14.2.3 – 14.2.6 above.

Prior to phase one, both the human and weka populations were likely within a conservation stage (K) that included small scale (temporal and spatial) cycles at Cape Foulwind. For weka, these cycles were probably associated with intermittent fires on the pākihi areas, and along with the small population of Maori, from environmental variables (e.g. weather, food availability). During phase one gold mining and forestry are socially considered to be a phase of initial release (Ω) and then reorganization (α) and growth (r) as an influx of people and extractive industry flourished. Likewise for weka it was a phase of release (Ω) as the landscape was reformed and new opportunities arose. Phase two involved the completion of mining and forestry and the rapid growth (r) phase to a slow expansion of farming at Cape Foulwind, which can be considered a long social conservation (K) phase. For weka it was a period of reorganization (α) and adjustment to the new landscape (including fire) and then growth as new rough pasture expanded and then a phase of conservation (K).

Phase three involved what became a more marked system transition both socially and for the weka population. The 1984 tariff removal implemented a economic social release (Ω), reorganization (α) and growth (r). The latter cycle phases were still ongoing until 2008 as a combination of high milk prices, local innovation, economic conditions, cultural and political changes created a window of opportunity for rapid land development to occur. Since 2008 and the global recession this growth has stalled. For weka extensive land development has created a period of release and re-organization.

Past social regime change or collapse at Cape Foulwind can be traced. The first was associated with natural resource depletion (i.e., running out of forest to fell, and gold to mine). The second is the economically linked loss of farming subsidies which has led to the present shift associated with land development and has allowed the Cape Foulwind SES to reorganize agricultural practices (to dairying which is more intensive and profitable) to generate livelihood.

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68 This change could have been characterized as two regimes changes, one for milling and one for mining. However, the milling and mining were associated and occurred at about the same time.
Figure 14.6 A Cape Foulwind timeline (Regional and Cape Foulwind scales).

- **2000**: Excavators available and flipping techniques developed
- **2000**: High milk commodity prices
- **1950**: Weka numbers increase
- **1950**: Pākihi and rough pasture
- **1950**: Rough dry stock farming expanding
- **1950**: Otira tunnel opens
- **1950**: Rough dry stock farm development
- **1900**: Pākihi predominates (expands)
- **1900**: Denniston mine opens
- **1900**: Deforestation from milling
- **1900**: Gold mining of Buller pākihis begins
- **1850**: Mixed beech, podocarp and pākihi
- **1850**: Small population of Maori
- **1300**: First European explorers
There is anecdotal evidence that the weka population decreased markedly or died out completely in the Cape Foulwind area during this time. This was possibly at a regional scale (e.g., there were also few weka at Barrytown and Seddonville) and was possibly associated with disease.

Figure 14.7 Schematic of land disturbance cycle at Cape Foulwind. The vertical (Y) axis represents weka population and economic value of land. See Section 3.6.1 for RT definitions.

This basic analysis of the adaptive cycle at Cape Foulwind is developed further in the rest of this chapter. The RT scientist workbook (The Resilience Alliance, 2007) recommends following the basic analysis of the adaptive system transitions by setting out the mental models of how the system is conceptualized by stakeholders. However, I consider such mental models to be better characterized as interactively based understandings. These understandings were traced through the FCMs and interviews. The outcomes of these are incorporated into the analysis in the RT in the following sections. However, this analysis mostly considers the outcome of the FCMs as they are aimed at being able to model the SES along with the IBM.
14.3.2 Regime shifts

A regime shift occurs when a system reaches a threshold. This involves a consequent movement of its state space from one attractor basin to another with a different set of internal controls and structure (Walker & Salt, 2006). There are three main potential regime shifts identified in the existing SES associated with weka and land development (Table 14.1).

The identification of three main regime shifts is consistent with Gunderson & Hollings' (2002) assertion that interaction between different spatial and temporal scales can be controlled by just a few key variables. In addition to this tractability, understanding of complex SES comes from a “rule of hand” – i.e., understanding a panarchy and its adaptive cycle requires a model of at least 3-5 interacting components. The characteristics of these regimes shifts are set out in Table 14.1.

The first regime shift relates to changes in the weka population (ecological) linked with land development. This changes the system to lower numbers of weka, while the landscape becomes dominated by pasture with ongoing agricultural inputs and a different hydrology. The second involves a landowner response to the loss of the weka population (socio-cultural). This changes the system to either an increase or decrease in interest in the status of weka, and is a socio-cultural system shift. The third is the landowners’ ability to undertake land development and is associated with economic changes. This shift produces a system with increasing external subsidies and rapid land development. The drivers for these were discussed in Section 14.2

<table>
<thead>
<tr>
<th>Regime shift</th>
<th>Characteristics</th>
<th>Driver/s</th>
<th>Temporal Scale</th>
<th>Spatial scale</th>
<th>Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Changes in weka numbers</td>
<td>Slowly changing</td>
<td>Land development</td>
<td>Years</td>
<td>Farm</td>
<td>Ecological</td>
</tr>
<tr>
<td>Amount of land developed</td>
<td>Slowly changing</td>
<td>Economic and cultural factors</td>
<td>Years</td>
<td>Farm</td>
<td>Economic</td>
</tr>
<tr>
<td>Landowner response to weka loss</td>
<td>Unknown, may be abrupt</td>
<td>Change in weka numbers</td>
<td>Decades</td>
<td>Farm</td>
<td>Socio-cultural/ experiential</td>
</tr>
</tbody>
</table>

These regime shifts lie as a subset of the main interactions set out in Figure 14.8. This involves breaking SES’s into three domains (ecological, economic, socio-cultural) at three scales (patch (small), farm (medium), region (large)) (Kinzig et al., 2006). In this study the spatial scale of concern is the farm scale, both ecologically and socially, and the regime shifts being considered lie
within this scale. Regime shifts can occur at all scales, and all scales and domains are interlinked. Therefore the scales above and below the scales of concern also need to be considered (The Resilience Alliance, 2007). In this case the extra-regional is also important as it contains economic drivers, and perhaps, increasingly, climate change factors.

**Figure 14.8** Overview of main interactions (Format from Kinzig et al., 2006). The main regime shifts considered are identified in bold.

Significantly, Kinzig et al.’s (2006) framework use for analyzing regime shifts at Cape Foulwind can be traced from the FCMs developed as part of this study. The interactions in Table 14.2 are based on those from the FCM CID developed from all local landowners (Figure 11.3). The CID for all landowners was used, rather than just the farmers CID, because it gives a broader and more complete understanding of the system. FCM’s can be used to find out how people understand the system and interactions between scales and domains.

The FCMs did not directly identify commodity prices as an important driver (interaction) along with availability of technology (technology is not a driver but a facilitator). However, these involve extra-regional elements that were not asked to be considered in the FCMs. The importance of weka for place was bundled up in the tension nuisance and appreciation.
Table 14.2 Interactions derived from FCM – all-maps CID.

<table>
<thead>
<tr>
<th>Domain/scale</th>
<th>Patch</th>
<th>Farm</th>
<th>Regional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecological</td>
<td>Veg. clearance</td>
<td>Habitat retention</td>
<td>Predators</td>
</tr>
<tr>
<td></td>
<td>Food supply</td>
<td>Dog kill</td>
<td>Poison</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weka adaptability</td>
<td>Road-kill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>People killing</td>
<td></td>
</tr>
<tr>
<td>Economic</td>
<td>Land development</td>
<td>Government policy</td>
<td>Tourists</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Economy</td>
</tr>
<tr>
<td>Socio-cultural</td>
<td>Appreciation</td>
<td>New residents</td>
<td>Nuisance</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Attitudes</td>
</tr>
</tbody>
</table>

Figure 14.8 above shows the elements involved in the regime shifts. By contrast, a state-transition model shows the linkages and outcomes of events (Figure 14.9). Regime shifts lie as part of these processes, where the outcomes produced are distinctively different creating a new set of interactions. The state-transition model shows a conceptual model of the present, and possible future (i.e., temporal), changes occurring at Cape Foulwind during phase three of the cycle (i.e., what states it can be in). This separates the system from the drivers and just describes the possible outcomes that may exist. This model is based on information gathered from the ecological fieldwork, IBM results, FCMs and interviews.
In the state-transition diagram (Figure 14.9) the regime change associated with the decrease of weka numbers lies in the process of land development from rough pasture and scrub to pasture. It lies in the farm scale and the scale of years. However, it connects with the patch scale (and days) for individual weka and the regional scale (and decades) for the weka population itself. The weka ecology system is presently undergoing this regime shift and it has been assessed to lie overall at the reorganization stage. This is a period of low resilience as resources are reorganized in potentially novel ways. For example, weka may move from being predominantly k selected to r selected as cover becomes scarce and territories compressed in and around the land development areas. The drivers for this link with the other two regime shifts are discussed below.

Regime change means the weka population is less resistant to pressures (i.e., closer to thresholds (edges of basins of attraction)). This cannot be shown in the FCMs but the FCM scenario modelling results indicate the participants’ recognition of significant pressures on weka. The IBM results suggest incremental land development creates large scale landscape change that, in turn,
makes the weka population more susceptible during crises (e.g., weather extremes, or increased predation, etc.).

Landowner response to weka loss is a regime shift with yet unknown outcomes. The shift involves a change in the system of interactions with weka at the individual farm scale. It affects, at the farm scale, individual decisions over landscape change. The response may either be a lack of concern or concern at this scale. Here the driver relates to weka numbers and so a feedback exists between this and land development. The system has not reached this regime shift as it not generally acknowledged that weka numbers are declining, although the ecological fieldwork showed that this was the case (see Chapter 12), and the FCMs and interviews showed that the participants recognized that there were a number of pressures on the population. This part of the panarchy, the socio-cultural domain at the farm scale, is still in a K (conservation) phase of the adaptive cycle. However, due to other shifts in the system (i.e., land development) it is losing resilience and moving towards possible release.

The regime shift associated with the amount of land developed, is also focused on the farm scale. This is the scale at which individual farmers make decisions over land use. This is included in the centre of the state-transition diagram and is a fundamental element of the SES. As has been outlined, there are a number of key drivers for this. These are mostly extra-regional and economic. Global forces associated with commodity prices are beyond the scope of this study but must be taken as a constraint on the system as this local regime shifts may be instigated by global changes. There are also cultural drivers at the regional and farm scale level. These drivers act as feedbacks from the landscape. This regime shift has taken place and lies in the r (growth) phase of the adaptive cycle.

Rammel et al. (2007) suggest evolving systems can be locked into their own success and selection criteria which have built up and limit future directions (e.g., short term success of increased productivity, optimization of current practices, increasingly controlled environments creates lock-in situations). Land development at Cape Foulwind may be doing this. It is economically beneficial which encourages more development to be undertaken, to the detriment of the local ecology. However, it does involve risk, since, with such a large investment required, production needs to be kept high to pay debt.

To summarize, there are three regime shifts recognized, one each in the ecological, economic, and social domains. They are focused on the farm scale spatially and temporally at years and decades. They are all in different phases of the adaptive cycle (Figure 14.10), and are all interlinked. They are also linked to the patch scale where individual weka live and paddocks are
developed. This in turn is connected to the regional scale associated with weka population viability and resilience, and to the extra-regional scale with economic and cultural drivers.

Figure 14.10 Location of the relevant identified regimes shifts in the adaptive cycle.

14.3.3 Thresholds

The FCM CIDS analysis (Table 14.2) was used to identify interactions and relate them to regime shifts. Potentially the system thresholds can also be derived from this. However, this is incomplete as the FCMs do not allow the complete tracing of thresholds as they are not dynamic models. The dynamic IBM allows some assessment of ecological thresholds in relation to weka (see Section 12.2.4).

The interaction between thresholds associated with various scales and domains, along with potential cascading effects, can be considered using Kinzig et al.’s (2006) framework (Figure 14.11). Theoretically, cascading regime shifts could occur across all domains and scales. However, Kinzig et al. (2006) found in their assessment that they occurred in a common set shown in Figure 14.11.
Figure 14.11 This diagram is based on Kinzig et al. (2006) and FCMs from this study. It relates to an assessment of thresholds at various scales and domains and the links between them.

Figure 14.11 shows the possible links (arrows) between various thresholds and so possible cascades (sequences) of thresholds being crossed. These cascades could result in significant impacts on the weka population. For example, when an increase in commodity prices reaches a certain point it would cause more land development at the farm scale, creating loss of cover at patch scale for weka and a decrease in the viability of the weka population at regional level. Where all these thresholds actually lie is not fully known. However, IBM results (see Chapter 12) show that thresholds shift closer to weka population collapse with increased land development.

Kinzig et al. (2006) propose that in most studies thresholds between alternative regimes (e.g., few and many weka) are often related to one dominant and slowly changing variable (e.g., between developed and undeveloped land). However, other variables in other domains (i.e., ecological, social, cultural) can influence this as they move closer to or pass thresholds and so moving their, and the SES’s, attractor basins, as well as causing potential cascading effects.

Kinzig et al. (2006) suggests that socio-cultural thresholds are important to SES and that these are often not accounted for. At Cape Foulwind, the socio-cultural threshold lies in the importance of weka to land owners’ sense of place and the interaction of this with their nuisance value. What can be shown is that the point of social concern for weka has not yet been reached. This may be partially because there appears to be no distinctive threshold for weka to collapse as has been shown to occur in some other systems (Carpenter et al., 2001). Rather, there is a slow decrease
in numbers while the social system continues its growth path. This is because the impacts on weka do not create a change in the local economy as it is not reliant on weka. However, feedbacks may still exist and at some point loss of weka may provoke a social response. If it did occur this social-cultural threshold may be abrupt. Such a shift would cascade down through the different domains and scales to improve the viability of weka. The risk is that the loss of weka decreases their association with place and so this feedback fails.

The socio-economic threshold appears to be more distinctive than the ecological as when (and where) the right factors come into play land development occurs rapidly. Of all the thresholds only land development itself involves a degree of irreversibility. This means the ecological system will not be able to be restored once the land development has taken place. However, it would still be viable for weka so it is not irreversible in this respect.

14.3.4 Scenarios

Table 14.3 describes five possible scenarios for the Cape Foulwind SES association with the weka population. The scenarios are based on the possible outcomes of the interlinking of the domains and scales as described in Figure 14.11 and the regime shifts and thresholds discussed in the previous two sections.

FCMs are not dynamic models so only reflect understandings in the present situation. These understandings are likely to change as the situation changes so the neural network based scenario modelling undertaken is limited by this, and also by a number of other factors identified in Section 11.3. In this respect, Scenario 1 is the only scenario for which the FCM modelling is valid. Using the FCM scenario modelling in other scenarios does not account for the different understandings the participants may have in those situations. However, the FCM scenario modelling is used for the other scenarios, where possible, to give some indication of the residents’ likely responses. The IBM outputs are also qualitative in nature and so should be considered only as trends.

Scenario 1 (current situation) (Table 14.3) represents the ten year period up until 2008 which was one of increasing farm development associated with improving milk prices and falling wool and meat prices, along with development of flipping techniques and availability of machinery. This has produced an increasing loss of cover for weka along with changes in food and water availability. Based on the IBM modelling weka numbers remain (c.9% decrease) down from their pre-development level but are sustainable, although less resilient to disturbance. Should weka numbers start to decrease, perhaps from a combination of pressures which is recognised in the modelling, the all-map CID FCM scenario modelling suggests a slight decrease in appreciation and also nuisance with decreasing weka numbers. This modelling suggests residents will not respond in the present
situation. Likewise, the farmer FCM CIDs suggest nuisance is the primary driver for farmers, so farmers will not respond to weka loss in the present situation.

Scenario 2 (flipping continued) is associated with economic elements which encourage and enable further land development. This in turn places more pressure on the weka population. The IBM modelling suggests weka numbers will further decrease from their pre-development level (c.22% decrease) and will be less resilient to disturbance than in scenario 1. Increases in production can reduce response diversity creating less social (i.e., all the farms are dairy farms so completely reliant on milk prices) and ecological (i.e., pasture mono cultural with no seed banks) diversity. The IBM results show this pushes the weka population closer to a threshold of possible collapse. The all-map CID FCM scenario modelling suggest residents are aware more land development will further decrease weka numbers. However, it does not suggest they will respond since, even though they remain appreciative of weka, fewer weka will also decrease their nuisance value.

Scenario 3 (land reversion) arises from economic slow down and a change in use back to dry stock. This may also be driven by decreasing returns that do not enable the large debts incurred during farm development to be serviced. The flipped areas are free draining so will cope with cattle more readily than in the past. Some land may revert back to scrub and forest. Flipped areas will not readily return to pākihi communities. Species such as gorse are likely to invade and will only slowly be replaced by native species as much of the seed bank was buried in the flipping process. Weka numbers will increase as scrub cover returns and the all-map FCM scenario modelling suggests participants were aware of this. There is no response anticipated from landowners towards weka in this scenario.

Scenario 4 (improve habitat with present flipping) represents improving the habitat through restoration without further land development. Weka numbers remain lower (c.7% decrease) than their pre-development level but are sustainable. This mitigation scenario is not able to be explicitly modelled in the FCM. However, as in scenario 1 restoration appears unlikely to occur without community pressure on landowners as weka numbers are not noticeably lower.

Scenario 5 (improve habitat after flipping continued) represents improving the habitat through restoration with further land development. The modelling suggests weka numbers remain lower (c.16% decrease) than their pre-development level but are sustainable, although less resilient to disturbance. This mitigation scenario is unable to be explicitly modelled in the FCM so the likelihood of restoration occurring with or without community pressure on the landowners is unknown. Good farm returns allow restoration to occur.
Table 14.3 Present and potential states of the Cape Foulwind SES.

<table>
<thead>
<tr>
<th>Possible future states</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scenario 1: Current situation</strong></td>
</tr>
<tr>
<td>- Moderate commodity prices</td>
</tr>
<tr>
<td>- Mixed vegetation</td>
</tr>
<tr>
<td>- Dairy dominant</td>
</tr>
<tr>
<td>- ~ 40% of land developed</td>
</tr>
<tr>
<td>- IBM shows a c.9% decrease in weka numbers</td>
</tr>
<tr>
<td><em>(IBM scenario = present situation)</em></td>
</tr>
<tr>
<td><strong>Scenario 2: Flipping continued</strong></td>
</tr>
<tr>
<td>- High milk prices</td>
</tr>
<tr>
<td>- Low fuel prices</td>
</tr>
<tr>
<td>- Easy credit</td>
</tr>
<tr>
<td>- IBM shows a c.22% decrease in weka numbers</td>
</tr>
<tr>
<td>- Weka not important for place</td>
</tr>
<tr>
<td>- % of land developed increased</td>
</tr>
<tr>
<td><em>(IBM scenario = possible development)</em></td>
</tr>
<tr>
<td><strong>Scenario 3: Land reversion</strong></td>
</tr>
<tr>
<td>- Low milk prices</td>
</tr>
<tr>
<td>- High fuel prices</td>
</tr>
<tr>
<td>- Move to dry stock</td>
</tr>
<tr>
<td>- IBM shows no change in weka numbers</td>
</tr>
<tr>
<td>- Might return to forest in longer term where there would be</td>
</tr>
<tr>
<td>moderate weka numbers</td>
</tr>
<tr>
<td><em>(IBM scenario = pre-development)</em></td>
</tr>
<tr>
<td><strong>Scenario 4: Improve habitat with present flipping</strong></td>
</tr>
<tr>
<td>- High milk prices</td>
</tr>
<tr>
<td>- Retain/restore some vegetation</td>
</tr>
<tr>
<td>- IBM shows a c.7% decrease in weka numbers</td>
</tr>
<tr>
<td>- Weka important for place</td>
</tr>
<tr>
<td><em>(IBM scenario = Present development plus mitigation)</em></td>
</tr>
<tr>
<td><strong>Scenario 5: Improve habitat after flipping continued</strong></td>
</tr>
<tr>
<td>- High milk prices</td>
</tr>
<tr>
<td>- Retain/restore some vegetation</td>
</tr>
<tr>
<td>- IBM shows a c.16% decrease in weka numbers</td>
</tr>
<tr>
<td>- Weka important for place</td>
</tr>
<tr>
<td><em>(IBM scenario = Possible development plus mitigation)</em></td>
</tr>
</tbody>
</table>

14.3.5 Adaptability

Adaptability can be broken into two parts. The first is the adaptability of the SES as a whole. Carpenter et al. (2001) describe this adaptive capacity as being related to the existence of mechanisms for evolution of novelty or learning. They suggest that in biotic systems such adaptive capacity is related to genetic diversity. This is because the rate of evolution is relative to the variability that selective forces can work on. This does not just have to be ‘competitive’ selection but
can also involve elements of redundancy, co-operation and species function, which in ecosystems in turn relates to heterogeneity in landscape mosaics. In this biological respect the SES at Cape Foulwind is losing adaptability.

The second is the adaptability lying within the social system. Due to a common systems theory foundation this overlaps with biotic adaptability. However, it has a focus on the adaptability associated with human agency. In this respect, Gunderson et al. (2006, p. 2) describe adaptability (and transformability) in terms of “complex self-organizing processes that involve interactions among key actors in the system, knowledge and understanding of the system, and the provision of conditions or opportunities for change”. By contrast, Carpenter et al. (2001) argue that in social systems adaptive capacity is related to the existence of networks that create problem solving flexibility and a power balance among interest groups. In addition to the existence of flexible networks, Gunderson et al. (2006) suggest that social adaptability also highlights the function of different types of learning.

A tension lies between the notion of self-organization, and its lack of central control, and the capacity of human foresight in managing and influencing outcomes in SESs. Limitations in such capacity refers back to previous discussions in the theory chapters in relation to immersion, autopoiesis, systems, networks and place. This suggests while the outcomes of complex systems can be influenced by intentional activities, they do not control them. Walker et al. (2006) argue that although this might be the case, human activities dominate many SES and so their activities, intentional or not, have a significant impact. The capacity and scope to manage the SES determines whether people can successfully stop the SES crossing to undesirable regimes or returning to desirable ones. Desirability is both a practical and ethical concern. This ethical element is central to the discussion in Chapter 15.

Some of the elements of self-organization, networking and learning have been shown to exist at Cape Foulwind in relation to the response to the loss of subsidies as social release and reorganization occurred. This release did not perhaps occur for the entire social system, but a reorganization of farming practices occurred due to economic pressures. In this manner a ‘soft’ threshold was reached. Regardless, this led to the development of ‘flipping’. This shows the Cape Foulwind rural community has had the social capacity to respond with innovative approaches. The nature of the community (i.e., a small long standing farming community with good internal networks) probably also contributed to this. This adaptability may have changed over the past decade as the social domain moves into the r phase and flexibility is removed through large debt and subsidization from outside the region. Also, any adaptation associated with weka decline has not occurred as yet for the land owners, so the social threshold where landowners take action, either on their own
properties, or are led by changes in regulations, is not known. Because weka are not at a release stage, local conservation groups are not active on the issue. They are also less active in the district than they were in the past when the district was economically stressed (pers. ob.).

As Walker et al. (2006, p. 7) suggest, avoiding crossing thresholds requires “innovation and skills, agreement on what to do, and a combination of options in terms of access to natural capital, financial resources and infrastructure”. Access to financial resources and infrastructure was important at Cape Foulwind as the social adaptation required a cross-scale interaction in the form of extra-regional subsidization. Andries et al. (2006) propose such cross-scale interaction dominates back loop dynamics (i.e. the release and reorganizational part of the adaptive cycle). However, if resilience and sustainability are the aim there needs to be a balance created between subsidization and the ability to self-organise. Self-organisation is a cornerstone of RT (and CAS generally), but is reduced through extra-regional subsidization (Gunderson et al., 2006; Rammel et al., 2007).

Walker et al. (2006) suggest that the institutions for monitoring and responding to environmental and social changes determine the tightness of feedbacks among social and environmental components and hence the triggers for adaptation to occur. As suggested in the theoretical development discussion, this does not just lie in institutions but in local knowledge derived from day to day interaction (see Moller et al., 2004). Correspondingly, for Carpenter et al. (2001) the ability to re-organize is related to endogenous rather than external drivers. This suggests the scope for self-organization in the SES lies primarily with the residents, and so any governance should be by residents in preference to outside entities. Carpenter et al. (2001, p. 777) note that “[i]ndicators of the ability to self-organise should assess the extent to which system components are forced by the management regime rather than the self-organizing within the management regime.”

This research considers the endogenous drivers to such self-organisation.

The need for adaptation in RT is considered to occur in the reorganization stage that follows a move past a threshold at one or several domains or scales. Theorists focus on the necessity for the existence of networks to allow or foster novelty to arise. The actual emergence of novel ideas at an individual level can be conceptualized as an abductive process involving interaction and intuitive processes etc. (see Chapter 8). Such abductively based cognitive processes should not just be considered to be associated with social networks, as stressed in RT (Gunderson et al., 2006), but also in the full networks proposed in ANT where the actors are not just human, and where humans can be considered as loci of growth in unfolding fields of relationships (Ingold, 2000).

In this manner, the theoretical development suggests the affective, embodied (experiential) connection with place is important as a basis for such networks. Weka and the landscape are considered active agents in the networks through affect and interaction. Networks become the basis
of intuitions about what people within the network care about, particularly in situations where there are no crises as such.

There are also risks with adaptability. Walker et al. (2006) suggest that high adaptability can inadvertently lead to a loss of resilience. This may occur as an increase of resilience in one place may lead to a loss of resilience elsewhere or at a different scale (or different domain – e.g., at Cape Foulwind social adaptability led to loss of ecological resilience). Also, the ability to adapt to unknown shocks may be decreased by an increase in adaptability to specific or regular shocks. By contrast, in cases where adaptation leads to an increase in efficiency of resource use there may be a reduction in the response diversity (e.g., land development at Cape Foulwind has increased efficiency economically but there is now less ecological and social diversity).

### 14.3.6 Social learning

As mentioned above, a key element of adaptability is the ability to learn (Carpenter et al., 2001). Anderies et al. (2006) suggest that three different kinds of social learning can take place in a SES. These are incremental, episodic and transformational and were outlined in Chapter 3. The social part of the Cape Foulwind SES is considered to have moved through an episodic learning phase over the past two decades. This involved questioning old ways of farming which were not highly profitable and developing solutions to this to create a new system regime. At the present time it is considered that the social part of the SES is involved in incremental learning as the existing farm management and development approach is built upon. There is the potential movement of the socio-cultural domain into the release stage in relation to weka, which may create another episodic learning phase.

It is not considered that a transformational learning event has occurred at Cape Foulwind. The present SES is tenable socially, and farmers can re-vegetate patches of land and reduce the impacts on weka. Transformational learning events are characterized by the involvement of several levels in a social-ecological panarchy and can be driven by changes in social values, or resource crises. It involves the capacity to develop a new system (different regime) when the present one is untenable (Walker et al., 2006). They give scope for a SES to reinvent itself and requires social-ecological memory. This learning is limited by focusing only on existing social concerns and its associated social history. “The key to transformational learning is to know what to keep in terms of memory, experience, and wisdom and what to discard” (Anderies et al., 2006, p. 3). In the discussion chapter the question of how to understand what guides knowing “what to keep” is elaborated. It is suggested this also applies to the other types of learning as decisions are made incrementally in daily situations as much as in large events.
The lack of transformational learning can be traced through an analysis of the cycle of learning at Cape Foulwind. Landowners have not recognised the potential loss of weka. People may have accepted weka dying out in the past (mid 20th century) but there was much undeveloped pasture (so there was good habitat) and the loss was unlikely to be associated with human changes but possibly disease. In this respect this present event is new or a surprise. However, there is no social memory to fall back on to link land development with weka loss. A repetition of cycles, which can occur if higher-level scales provide memory (e.g., seed banks and institutions) (Walker et al., 2006) is not occurring. The cycle could reoccur in a similar manner in the future but some parts of the system will not be able to return to their original regime due to changes in the hydrology.

Walker et al. (2006) claim an important element of learning is experimentation. Experimentation is necessary to develop and test knowledge for coping with change and uncertainty. This is enhanced using active adaptive management and further again if adaptive governance is taken up. This is effectively an SSM approach (see Chapter 3). Even in the episodic learning that has taken place in the cycles of the Cape Foulwind SES there is a need for experimentation. In the most recent cycle there has been substantial monetary capital and cross-scale subsidization. This both supplies resources to allow experimentation, but it can also allow mistakes to be made without learning from them, as solutions can be bought in. This is occurring to some extent at Cape Foulwind at present where landowners do not necessarily recognize the impacts their practices are having on the ecology. For example, the loss of diversity associated with creating a monoculture; the development of pest problems; creating dry ground in summer as soils become freely draining; diluting soil fertility and so creating a need for fertilisation. All these can be addressed with the importation of externals – fuel, equipment, pesticides, fertilizer and electricity. In effect, the subsidization has weakened the feedbacks from the local system as it has been limited to experimentation undertaken only within the socio-economic sphere.

Taken further, Carpenter et al. (2001) argue that there can be a mismatch between stakeholder understandings and the ‘real’ dynamics of a SES. At Cape Foulwind it is not so much that understandings are misaligned (FCMs show residents (farmers) recognize the elements and basic interconnections of a system) but rather they emphasize some relationships and not others. The theoretical approach espoused suggests these are at least in part derived from experiential differences from persons immersed in a common world. In addition, is the problem that the future states are unable to be known. The research suggests that there are no obvious thresholds associated with the weka population; rather the decline associated with land development has considerable annual fluctuations or noise. This noise suggests that longer-term memory associated
with experience is important. However, when the species involved is not a ‘vital’ species (e.g., titi (Moller et al., 2004)) this is less likely to be carried as experiences are less significant.

14.3.7 Conclusion

In the RT analysis of the Cape Foulwind SES the main system variables identified for weka were cover amount and food availability (i.e., total amount and variability). For farmers, the variables were sense of place, farm production and the economy. Land development at Cape Foulwind is reducing the suitable habitat for weka through loss of cover. The IBM modelling suggests cover loss is also making the weka population less resilient to other pressures and environmental variations. A number of regime shifts and thresholds were identified associated with these variables. However, these were difficult to measure due to their nature and methodological limitations. An overview of the major characteristics of the RT assessment is given in Table 14.4.

There were a number of drivers identified in the Cape Foulwind SES adaptive cycles. These included extra-regional forces, in particular commodity and oil prices. At the regional and local level the main drivers associated with weka were considered to be: The importance of weka (place); the amount of vegetation cover; the number of weka, and farm debt. The overall vulnerability and resilience of the system is changing with slow variables (i.e., residents’ relations with place, environmental shifts, property rights, economic imperatives). Carpenter et al. (2001) note that land-tenure systems and cultural characteristics are important slow variables.

The impacts on weka have been delayed behind the social phases and a release (Ω) and reorganization (α) is presently occurring for weka at patch and farm scales. The IBM is a model of this back-loop part of the adaptive cycle across a number of scales. Anderies et al. (2006) suggest that cross scale interactions dominate back-loop dynamics and the IBM incorporates this aspect.

The system is in r (growth) phase socio-economically so the best opportunity for retaining patches of cover may have been lost. Patches of cover can still be put in but it will be more difficult than leaving existing areas initially. The window of opportunity for normalizing the retention of patches of scrub for weka was likely in the early 2000s (i.e., the reorganization phase). The FCM models this social situation at this r phase of the cycle. The FCMs produced a decade ago by the residents may well have been quite different.
Table 14.4. Resilience Measures for Cape Foulwind (based on Carpenter et al., 2001). *Carpenter et al. (2001) only consider the socio-economic domain and not the socio-cultural domain. The latter is the focus of this study.

<table>
<thead>
<tr>
<th>Characteristic of the system</th>
<th>Cape Foulwind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resilience of what</td>
<td>Weka population</td>
</tr>
<tr>
<td>Resilience to what</td>
<td>Land development</td>
</tr>
<tr>
<td>Measure in model</td>
<td>Non-linear change in the weka population to land development with an indistinct threshold.</td>
</tr>
<tr>
<td>Biophysical field measures</td>
<td>Hectares of developed pasture to weka population.</td>
</tr>
<tr>
<td>Interpretation of biophysical field measures</td>
<td>Nearly directly related to perturbation size. Inversely related to attractor size (i.e., more ha developed fewer weka)</td>
</tr>
<tr>
<td>*Socio-cultural field measures</td>
<td>Landowners’ interest in retaining weka</td>
</tr>
<tr>
<td>*Interpretation of socio-cultural field measures</td>
<td>Inclination to retain scrub cover during and after land development.</td>
</tr>
<tr>
<td>Socio-economic field measures</td>
<td>Landowners’ ability to improve farm profit from development</td>
</tr>
<tr>
<td>Interpretation of socio-economic field measures</td>
<td>Amount of land developed. Directly related to attractor size.</td>
</tr>
</tbody>
</table>

The change in weka population in relation to the amount of land development is a useful surrogate for resilience of the SES as a whole, as it reflects biological change from socially created landscape change and the feedback of such changes into the social system. However, this might be limited by the impact the loss of weka has on the social system (i.e., the weka loss will not impact on the viability of the social system at Cape Foulwind).

Adaptability and learning in the Cape Foulwind SES was found to have been limited primarily to the socio-economic domain at the present time. The experimental development of flipping techniques has been successful for improving socio-economic benefits for the area. This state of the SES is considered a beneficial or improved state by the landowners. Over time as debt is paid off there should be more social flexibility to the SES than the pre-development regime. If mitigation is put in place the impacts on the weka population can be reduced. However, in the short term high returns are required to pay off debt making the SES lie close to a socio-economic threshold and so less resilient. In the medium and long term it is also tightly bound up with the economic system through requiring inputs (i.e., removal of weeds, pests, fertiliser inputs) to retain a simplified ecosystem of pasture. This makes the SES less socio-economically resilient, as well as less ecologically resilient in relation to weka. It was noted that the balance between cross-scale subsidization and self-organisation is critical. Excessive subsidization can produce perverse incentives (e.g., the need to retain high productivity, to the detriment of the local ecology) and this may be occurring to some extent at Cape Foulwind. Finally, the developed land, if left, will move into a different succession (it
will more quickly become forest), due to hydrology changes, and this is a path of potential non-
return in the system.

FCMs were found to be a useful way to extract and model social information. This is
particularly the case for imposed policy, but is more difficult to use for self-imposed controls by the
landowners in response to feelings for weka and place. This is because the FCMs are not temporally
dynamic or, as shown in the results, they do not fully incorporate the complexity of the
understandings of the residents. The interviews were important for developing a fuller
understanding but were not explicitly used in RT scenario modelling. The results from the IBM were
useful in illuminating the potential impacts on weka.

These concerns are reflected in the finding that the RT assessment at Cape Foulwind does
not align neatly with the adaptive cycle. However, Resilience Theory offers a useful way to analyse
the situation within systems thought. In the ecological and socio-cultural domains the thresholds and
consequently regime shifts are difficult to define or have not been reached. In this sense it is not
clear that the entire SES is moving through an adaptive cycle as such. Regional changes in the SES in
relation to weka may be better characterized as more general changes in resilience without regime
shifts. At the smaller farm scale the ecology can be considered to be going through an adaptive cycle.
Similarly, economically the adaptive cycle can be applied more readily.

The RT analysis is weakest in the socio-cultural aspect of the SES. The socio-cultural sub-
ystem is the focus of this research with its emphasis on affect and immersion, local knowledge,
embodiment and the subsequent relationships participants hold with place and weka. The notions of
place and dwelling have been developed as overarching constructs to encapsulate these ideas.
Chapter 15 will consider how the situation at Cape Foulwind might be considered within this
framework. In doing this it will consider the role of ethics - How do we decide what we do, or not do,
or want in a system?
15 Discussion

15.1 Introduction

Mugerauer (2010) outlines three phases in the development of social ecology. The first phase involves an evident separation of nature and humans through the division of the natural and social sciences. The second phase involves the implementation of complexity theory involving non-linear and emergent interactions linking social and ecological systems as outlined in Chapter 3. Resilience Theory, as it is presently predominantly implemented, lies within this second phase. Mugerauer (2010) argues that tension lies in this present second phase research, due to the use of complexity theory based holistic understandings along with residues of dualistic theories. He suggests a third phase entails overcoming this tension through the development of a consistent and comprehensive philosophical background. This would involve developing non-dualistic frameworks to describe ways of knowing and practices.

This research lies within the bounds of the third phase in that it attempts to incorporate an ontology and epistemology consistent with complexity theory and developments in post-structural thought with an empirical study based in a RT approach. A difficulty exists in this third phase of Resilience Theory analysis. As Mugerauer (2010) notes, it is a challenge to develop non-reductive theoretical concepts that do not cause further confusion. This problem exists to some extent in this research, in particular in the integration of empirical and theoretical aspects.

This theoretical development can be applied as a set of meta-themes associated with the research aims. These can be summarised as: (1) How the participant’s views/assertions/feelings were associated/derived primarily from their everyday practical activities and interactions; (2) How participant’s knowing was affective and embodied as well as conceptual/rational. How participants FCMs (and interviews) are products and also expressions of this way of knowing; (3) How participants’ are immersed in a common world; (4) How weka can be considered actors in co-constituting the SES with the participants; (5) How the situation can be understood through systems/network concepts.

Primarily this chapter discusses the results of the research in light of the theory development. However, there is a tension here, as embodied/emotion immersion is seen as fundamental, so I need to treat the theoretical development (and myself as a researcher) as arising from embodied, affective, immersed practices. Such immersion implies that it cannot be fully theorised in a dualistic objective sense. However, it can be theorised to the extent that theorising is considered as an embodied/immersed activity.
In bringing these approaches together it may be that this research project, in practice, might not have faithfully followed its original aims and objectives, and has, at times, wandered into exploration; no apologies are made for this. This thesis has an exploratory ‘flavour’ consistent with a relational philosophy. Because of this there are many threads in the thesis.

The discussion first considers the empirical methods used, their practicalities, shortcomings, benefits, and suitability in relation to the study. It then considers what the study results and theory development reveal about the relationship of people and weka at Cape Foulwind. It does this through following a number of themes: place; local knowledge; actors; and, ethics. It also discusses how this might influence or change the Resilience Theory analysis undertaken in Chapter 14.

15.2 Empirical modeling and method results

15.2.1 Introduction

This section discusses the empirical methods used in this transdisciplinary research (i.e., FCM, IBM, ecological fieldwork, open ended interviews). It concentrates on their practicalities, benefits and shortcomings and suitability for this study. Many of these aspects have been addressed in other chapters and this is noted where it occurs. It also considers the methods as a whole. In this respect the methods have been shown to have a common philosophical basis so an element of compatibility among them is already established.

15.2.2 Individual based model

The advantages of IBMs are their emphasis on interaction, heterogeneity and emergent properties which are system based properties not addressed in most ecological modelling techniques. This involves the inclusion of individual and local characteristics, the incorporation of complex system properties, and the explicit linking of multiple scales. The IBM also allows a large amount of flexibility in modelling scenarios as all variables and parameters are able to be varied. The advantages of the IBMs are discussed more fully in Section 9.2.

The limitations of the IBM, both practically and theoretically, are outlined more fully in Chapter 9. This includes the qualitative nature of IBMs which mean that its results must be considered as trends only. In addition, the amount of data required to develop an IBM is large, depending on what its aims are. In this case the aim was to develop an inter-generational, spatially explicit model of the weka population. Population specific data for many of the parameters was not able to be obtained and this limited the robustness of model. In addition, were the limits to the detail that could be modelled and the ability to produce model structures that reflected weka behaviour.
This includes, for example, where weka may be more mobile than IBM allowed, making them less susceptible to food shortages than the model suggests. Related to this, weka’s behavioural plasticity in different environments is not modelled. This appeared to be a feature of weka populations (see Section 13.1.9). In this respect the IBM does not capture the full complexity of weka behaviour or the Cape Foulwind landscape and the interaction between the two. Another constraint on IBM development is the large amount of time required to develop, test and run the model.

The IBM produced results that were realistic, both during the empirical validation phase and in the scenario modelling. These results are set out in Chapters 9 and 12 and discussed in Chapter 13. Given the resources available and time constraints I was satisfied the IBM produced was successful in meeting the project’s aims. The method could be improved by using more complete local data. It would have also benefited from further refinement, using better programming skills than I had, to produce a more robust model.

15.2.3 Weka fieldwork

A range of methods were used for the weka fieldwork. They are fully discussed in Chapter 8. The call counts were generally easily undertaken and successfully completed. The telemetry was successful but the loss of transmitters was an issue. The colour banding method was less useful as the birds proved difficult to find in the low, thick vegetation in the area. In this respect the telemetry was the more practical method for gathering movement data on individual weka. The adequacy of the weka fieldwork methods used is discussed more fully in Section 13.1.1.

The data obtained from call counts were particularly useful (within the limitation of the method (see Section 12.2.1)) and were the basis for the verification of the IBM. The telemetry data on individual weka behaviour were important for the design of the IBM. Overall, the methods used were useful for collecting a range of data on weka at both a population level and at an individual level that were required for the development of the IBM.

One aspect that impacted on the suitability of the methods was the amount of time and resources available for the work. This was a multidisciplinary study undertaken on a part-time basis. The data were collected mostly by one person, as I had no field assistant, except for some very valuable help from my partner with attaching telemetry transmitters and leg banding. This ultimately meant that there was a lack of data collected in some areas of the weka ecology part of the study.

There were also some shortcomings in the data collection design. The study would have benefited from a better overall data collection design focused on the most important factors for weka population dynamics (e.g., clutch size, number of chicks, annual mortality, etc.) in the two main
habitat types being studied. Collecting these data would have helped the development and verification of the IBM.

15.2.4 Fuzzy cognitive maps

Mendoza & Prabhu (2006) claim information about complex interacting social and natural systems is often incomplete or fuzzy or vague. Any modelling of them is inherently qualitative so quantitative models cannot capture them. In this respect the FCM modelling is not intended to “predict the dynamics of the system; rather, it is best suited for broad understanding of general relationships and associations or ‘connectiveness’ of the components of the complex system.” (Mendoza & Prabhu, 2006, p. 192). Mendoza & Prabhu (2006) also noted that simplified causal relationships in FCMs are incomplete and so the results must be treated with caution and considered within the broad context of the issue. Some RT scenarios are developed and discussed in Section 14.3.4 with the proviso that only one of the scenarios is fully valid for the FCM use. However, the collection of FCMs was found to be an effective, quick and relatively easy way to collect and model the understandings of people living as part of the SES. The understandings in the FCMs, at the levels of both the individual FCMs and the CIDs, (see Section 11.3) were found to reflect participants’ experiences and concerns as expressed in the interviews.

One of the aims of this study was to consider the use of FCMs for ‘mapping’ laypersons’ understandings. This is a shift in emphasis from understanding FCMs as representations of people’s understandings of causal relationships, to what the structure and causal relationships in the FCMs might show about people’s understandings. For lay people there is no prior explicitly known whole, so FCMs were not considered, a priori representational constructs, but creative responses to, and products of, people’s situated, embodied emotional existence. They show an ‘everyday’ pre-reflective or performative understanding, bound up with initial emotional and cognitive responses of the meaning of the situation (see Section 5.6). That involves circumstances with incomplete knowledge of complex situations under which people often make their ‘day to day’ decisions. The disadvantage is that this means the FCMs do not involve a considered and ‘systematic’ understanding that requires carefully assembling information.

However, FCMs were found to help organize people’s understandings of the situation into a structured form. This form recognises the fuzzy nature of understandings, and the complexity and interconnectedness of the world in a systems format, although in FCMs this was very simplified as it is not temporally dynamic or layered (hierarchical). FCMs allow neural network scenario modelling not offered by other qualitative techniques. Such modelling is of peoples’ understandings of natural systems, rather than a researcher’s interpretation of their understandings. FCMs allow these
understandings to be integrated into social FCMs. The neural network modelling showed in some cases that participants’ understandings were not always logically consistent. Such an inconsistency was shown in the farmer CID around the impacts of land development. This could be considered to expose misunderstandings or tensions associated with the complexity within the participant’s understanding. Through this structuring FCMs may also expose understandings that the participants have, but attempt to downplay in the interviews.

The major shortcomings of FCMs were that they did not allow tracing of practices, or what the participants actually did in relation to weka. This was more readily traced through the interviews where participants were able to talk about what they did. It was also found that FCMs did not fully capture the richness and complexity of participant’s understandings. This is because the FCMs required participants to structure their understandings in a limited and simplified ‘cause and effect’ (although fuzzy) framework. In this respect there was variation among the participants in their ability to think systematically and so develop FCMs easily. This produced apparent inconsistencies between the FCM and interview data which were further contributed to by mistakes in drawing FCMs and the fact that there are numerous ways to construct FCMs. The participants themselves discussed some shortcomings of the method. Some thought weightings were guesses as they did not have enough knowledge to cope with the full complexity of the situation, or that their map was a creation that would not be the same if they did it again. This is not surprising given the FCMs were shown to express a combination of concerns, experiences and feelings. These limitations were discussed further in Section 11.3.

I suggest the use of FCMs can be improved through using them in conjunction with interviews as used in this study. The interviews were important for assessing the importance of weka and the extent people care and interact with them. They gave guidance on how to understand the FCMs within the broader context of inhabitants’ understandings. The other reasons for using this combination of methods are outlined in Section 8.7.1.

The FCMs obtained as part of this study showed both similarities and differences with FCMs in other studies. Özesmi & Özesmi (2004) assessed six studies that used FCMs and a common methodology. The averages for the individual maps over a range of factors from Özesmi & Özesmi’s (2004) studies, along with the equivalent data from this study, are set out in Table 15.1.
Table 15.1 Comparison of the mean values of various FCM factors from six studies using FCM undertaken by Özesmi & Özesmi (2004) and this study.

<table>
<thead>
<tr>
<th>Variables, N</th>
<th>Özesmi &amp; Özesmi, 2004</th>
<th>This study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter variables, T</td>
<td>8 ± 3 S.D</td>
<td>5 ± 2 S.D.</td>
</tr>
<tr>
<td>Receiver variables, R</td>
<td>4 ± 3 S.D</td>
<td>1 ± 2 S.D.</td>
</tr>
<tr>
<td>Ordinary variables, O</td>
<td>11 ± 3 S.D</td>
<td>7 ± 2 S.D.</td>
</tr>
<tr>
<td>Connections, C</td>
<td>37 ± 7 S.D</td>
<td>20 ± 8 S.D</td>
</tr>
<tr>
<td>Connection/variable, C/N</td>
<td>1.6 ± 0.3 S.D</td>
<td>1.6 ± 0.4 S.D.</td>
</tr>
<tr>
<td>Complexity, R/T</td>
<td>0.6 ± 0.3 S.D</td>
<td>0.42 ± 0.8 S.D.</td>
</tr>
<tr>
<td>Density, D</td>
<td>0.08 ± 0.03 S.D</td>
<td>0.13 ± 0.04 S.D.</td>
</tr>
</tbody>
</table>

The individual maps in this study had only half of the mean number of variables (13 ± 2 S.D) and connections (20 ± 8 S.D) of Özesmi & Özesmi’s (2004) study. The connections in this study had a higher standard deviation indicating a larger variation in the number of connections. Reasons for this might include that this study was concerned with a particular species rather than whole ecosystem or socio-ecological systems which were the focus of the studies Özesmi & Özesmi (2004) considered. In addition, the other studies were more problem orientated or, in other words, they involved recognized problems and so participants were possibly more focused on the issue and so had more knowledge about it. In this study, the status of weka in the area was not, at the present time, understood as a major concern.

The connection/variable ratio and complexity figures were very similar, although there was more variation between maps in this study. The proportion of transmitter and ordinary variables was also similar, although the number of receiver variables was somewhat less. The high number of transmitter variables relative to receiver variables indicates that my participants perceived the system as having many forcing functions or outside controls. The low number of receiver variables relative to the ordinary variables suggests that my participants understood the system to have a number of circular processes. The maps in this study were slightly denser than the ones Özesmi & Özesmi (2004) assessed. The low value for complexity shows the participants perceived the system had many outcomes. In other words, there are many factors within and influencing the socio-
ecological system involving weka at Cape Foulwind. This result is reinforced by the interviews and RT analysis where land development is recognised as one factor, among many, affecting weka.

15.2.5 Interviews

The open-ended interviews allowed the collection of data on the rich and complex interactions of individual participants with weka. This included participants’ idiosyncrasies, emotional responses, and personal histories. It also allows the collection of information about what local inhabitants knew about weka. The qualitative and individual nature of the method is compatible with the philosophical approach used. The method was practical given that the number of participants was limited by the small population of farmers at Cape Foulwind and given the aims of the study. The method is, however, time consuming, especially the transcribing and analysis of the data. It is not able to be modelled statistically or with neural networks.

The interviews were critical in allowing participants’ understandings of weka and place to be explored in relation to the FCMs. This relationship has been discussed in Section 11.3. Significantly, the interviews provided a richer picture than the FCMs and provided guidance on why participants produced the FCM that they did. However, the interviews lacked the recursive, interconnected framework of FCMs which meant they were more open to allowing participants to express their perceptions less consistently. Other limitations included the fact that the questions inevitably limited participants’ responses. A different set of questions would perhaps have produced a different emphasis. Many of the participants were also busy and this created pressure to shorten the interviews as the FCMs were recorded in the same session. This meant some themes were not explored as much as they might have been with less time pressure.

Interviews collect participant’s talk rather than observing their activities. However, there is a difference between the participants’ saying what they might do and what they have done. In this respect it was accepted that the participants had done what they said they had done. This allowed the interviews to be linked to their daily practices. At a broader philosophical level this is considered to reflect Merleau-Ponty’s approach to verbal expression where, like physical action, it is an expression of the lived body.

The themes from the interviews were developed through a Grounded Theory process. It is likely this was biased by both the theoretical position and its interests, and also by the associated focus of the empirical methods. However, this is legitimate as the themes emerged from the exploration the subject both theoretically and empirically. The outcome is to some extent ‘getting what you are looking for’. But it is not clear that this can be avoided in research based on a relational ontology and epistemology.
15.2.6 Methods and models as a whole

This study is concerned with, and based in, the everyday world of experience. These concerns imply the use of interpretive, qualitative and pluralistic methods. Indeed, Mugerauer (2010) recommends methods to investigate this poststructuralist lifeworld that include historical research, open-ended interviews, participant observation, qualitative ecosystem indicators, attention to sense of place and the values of diverse groups. This transdisciplinary study used all of these methods to some extent except participant observation. Mugerauer (2010) also suggests it is important to utilise a number of methods to investigate this lifeworld. This richness of methods and data is required to adequately understand the complexity and heterogeneity of phenomena. Such methods can be used to capture to some respect both the whole and the parts, through moving back and forward between them in the fashion of the hermeneutic circle (Gadamer, 1975).

Using all these methods together produced a rich understanding of weka, their ecology, and the participants’ relationships with weka. The methods were also suitable as they were compatible with the philosophical position taken. The shortcomings of each particular method are discussed above. These methods are both incorporated into, or complement the model development:

- FCM (complemented by interviews and attention to sense of place);
- IBM (based on fieldwork, interview data, literature);
- RT (historical research, and the FCM, IBM and interview results).

The IBM and FCM did not allow the full scenario modelling of the SES system. However, the methods as a whole did allow the inclusion of residents’ understandings within the modelling process. This required not treating them as ‘stakeholders’ in a biophysical system but as immersed in place and their understandings as being central to the SES.

The use of FCMs, along with an IBM for use for modelling within RT, is a new approach. What each modelling method offers over other modelling approaches (e.g., statistically based ecological models) have been set out in Chapters 9 and 10. The benefits of the use of the modelling methods together as outlined in Chapter 8 can be summarised as: addressing the most important scale of concern in this case (i.e. the individual/household and local landscape); addressing the difference between human and natural systems; allowing the inclusion of knowledge from a range of sources; and, being systems based. The main limitations of the approach related to its qualitative nature and lack of quantitative rigor. Quantitative approaches, as has been argued, tend, however, to be incomplete in ways that are addressed by the methods used in this study.
The use of Grounded Theory, as set out in Chapter 8 was only explicit in the theme development from the interview data. At the level of the study as a whole, its use was more implicit and bound closely with the theory, as a guide to focusing what was important about the data.

A discussion of the Resilience Theory method of analysis is undertaken in Chapter 3 and a full RT analysis undertaken in Chapter 14. Resilience Theory was found to be a useful method of analysis as it supplies a framework to organise disparate data. However, as a framework, RT is not generally applied to the cultural/experiential aspect of the SES well. Addressing this aspect has been a focus of this research.

The focus on the farm scale in this study meant that the data collection did not concentrate on broader external drivers (i.e., economic, ecological, cultural) that are central to a RT analysis, and as shown in Chapter 14 also to be important to the SES. This reflects the problem of the large amount of data required to model the SES successfully. Because of shortcomings with data collection and modelling, the complexity of the SES, and limitations within the RT framework, the Cape Foulwind SES (in relation to the weka population) is not entirely successfully modelled within the RT framework. However, the study does identify potential ecological thresholds and tendencies, along with some social attractors that contribute to the present use of the RT method of analysis. This contribution is elaborated in the following sections.

15.3 Implications for Resilience Theory analysis

15.3.1 Introduction

This section addresses two main aspects. First, what was learnt in the study about weka and people and the Cape Foulwind SES and, second, how what was learnt can be applied to reinterpret the Resilience Theory analysis of the Cape Foulwind SES.

What was learnt about the phenomena relies to some extent on the theoretical approach taken, and the emphasis this has on what is important (ontology and epistemology), and the methods used. This involves two aspects that should be kept in mind.

As mentioned previously, the first is how the results reflect or are a product of the theoretical understanding used. This includes how the methods initially chosen might affect the understandings drawn out. The methods used concentrate on gathering data on the everyday understandings and activities of the informants, and their relations with weka and the Cape Foulwind area. This qualitative approach considers that the themes and categories developed are emergent from the data. This point also relates to my role as a researcher who is physically, cognitively and emotionally engaged with weka, the place, and the human community as a resident, as well as through the study
fieldwork. Related to this, the results from this research are not presented as predictive or explanatory but as a qualitative understanding that is consistent with CAS and networks. The results could be interpreted from another theoretical perspective (e.g., social constructionist or positivist) and a different understanding could be developed. Consequently, considering the relevance of the results in part involves relating it to other studies, including other studies relating to West Coast communities. It raises the question of whether or not people-place-animal relationships are different because of different theoretical approaches.

The second aspect is a consideration of how the discussion can be considered to interpret the results in light of the theoretical approach taken (i.e., what can be said about the results in relation to the theoretical approach). For example, that the results show that the participants are affective, and action orientated and that weka and their population dynamics can be modelled as an IBM.

This section breaks the analysis up into several themes considered from an embodied, situational approach that is based on phenomenological and post-structural thought and consistent with the immersive and inter-connective implications of systems theory. According to Mugerauer (2010, p. 7) this approach opens a way for: (1) Utilising an empirical phenomenology that describes diverse understandings of local ecologies; (2) Considering what human and non-human actors do in producing and managing SES (i.e., shows their everyday relationships and interactions); (3) Addressing political and ethical questions in particular settings based in everyday living; (4) Developing models and narratives to inform debate (e.g., tensions of retaining wild animals on productive landscapes, recognition of a place for wild animals in production landscapes).

Reflecting the themes above, this section first discusses the importance of place and affect at Cape Foulwind and relates this to the role of local knowledge. It then considers how weka are actors in this place and how that can disturb existing boundaries. Finally, it explores how an ethical understanding might lie in the Cape Foulwind SES and its evolution.

15.3.1 Dwelling and Place

15.3.1.1 Interaction and practices

In their investigation of two West Coast communities’ relation to place Sampson & Goodrich (2009) question a focus on the domination of symbolic significance in the study of place. They argue for the importance of the role of physical setting and practices. In concluding they suggest that “locales provide a set parameters or boundaries to the possibilities of what can be symbolically drawn upon.” (p. 913). Here ‘locale’ is a particular bounded location. The implication is that the symbolic itself must arise from interaction with other locales (i.e., temporal and spatial networks) rather than from a particular locale alone. However, their analysis does not further investigate how
the material aspect of place can be understood to underlie, as a material network, the notion of a symbolic significance of place.

The meaning of places no doubt has an element of social symbolic definition but these too can be understood to emerge from earlier material practices, or material practices in other places, and the responses and subjectivities developed from those interactions. Consequently, I have argued that the social contexts ultimately lie in embodied practices as proposed by Ingold (2000), where the meaning of the landscape is “immanent in the contexts of people’s pragmatic engagements with its constituents.” (p. 154). I do not wish to deny the importance of social influences but I am attempting to trace their origins rather than understanding the social as the only origin.

The study results which show the importance of interaction in the development of the local ‘symbolic significance’ of weka. However, other birds such as kiwi still held significance showing the importance of wider networks operating beyond the local interactive level. This involves the recognition that knowing is an experiential, situated, affective, embodied (local) process as well as consisting of networks based in language and artifacts that hybridises such place-based situational knowing. Bell et al. (2008) trace this network through language and the notion of a local dialect. Local dialects arise from the dynamic relationship between place and knowledge. “A local dialect is, in this sense, a specific environmental discourse open to change, but framed by experiences of place held in common by other interlocutors.” (Bell et al., 2008, p. 279, emphasis added). The theoretical approach used in this study suggests that local dialects are more than framed by experiences of place. This is because it treats language not as a structure overlying reality suggested by ‘framing’ but an active creation and response to our ongoing experience. It does not construct the world but expresses it in terms put forward by Merleau-Ponty. For Merleau-Ponty, language, through its expressive functioning conveys our emotional response to our embodied immanence in the world (Flynn, 2008). This understanding changes the emphasis from analyzing discourse to interpreting situated action. However, discourse analysis is also valid because it is “expression” and so like FCMs and all practices, it is a skill developed through interaction, within both the social and extra-social.

Bell et al.’s (2008) lack of focus on physical practices means they do not relate changing discourses or attitudes to changes in interactions, but understand the changes in interactions to be associated with changing discourses and attitudes. Likewise, in this study some of the non-farmer participants emphasised the importance of changing attitudes towards weka to reduce human impacts on them. The results of this study suggest new meanings become attached to weka (i.e., its cultural categorization) as interactions of people with the weka, and indeed the environment more generally, change. I suggest such a change can be understood to be related to changes in practices/skills. This is an ‘education by doing’ and follows Ingold’s (2000) notion of a taskscape as a
technical embeddedness of reciprocal relation, where people are created by the landscape as they also create the landscape through an ongoing interaction. This understanding is developed into an ethical understanding in the following sections.

The centrality of interaction is shown by the interest the participants had in weka and other wild animals. Comments such as liking the most obvious native birds (P19MF), and appreciating the ones they can interact with (P1WNF, P20WNF) highlight this. This interaction shows in the depth of knowledge of weka revealed in the FCMs. Significantly, such interaction does not just need to be positive interaction, as revealed in the tension between nuisance and appreciation of weka. This was shown in some farmers’ ambivalence about the presence of weka, but they still felt weka were a part of the of the Cape Foulwind place:

“...As I say we look at them as a pest, if a week went by and you didn’t see one, god you would think what the hells going on here, yeah. Cause yeah they’re just, just part of the place just like a bloody starling ... And the wekas are a bit like that, like you would miss ‘em.”

(P9MF)

This shows an interactive complexity not considered in some other studies. For example, Hunt et al.’s (2006) study of farmer attitudes to birds on South Island farms, found the common birds fell into three groups. These were either iconic native or endemic species, pest or nuisance species, or culturally valued introduced or native game species. My study only considered one indigenous species but found the ‘classification’ of weka to be variable between individuals and ‘within’ individuals. Weka was classified as an iconic native, and an endemic species, and a nuisance and sometimes treated as a ‘game’ species.

This interactive complexity is shown in a comparison of the understandings of the farmer and non-farmer participants. This showed that farmers had greater amounts of interaction with weka than non-farmers and were more varied in their responses. This suggests that with more interaction there is a more varied range of experiences and more complex understandings are developed. The latter is supported by tensions that develop over interacting with weka for both farmers and non-farmers (i.e., weka tended to become a nuisance with regular interaction for many as well as being appreciated). In addition, some farmer participants had little interest in weka, or their practices were focused on different aspects of the landscape. This was less the case for non-farmers.

Furthermore, there was more variation in perceptions on the impacts of land development among the farmers who were actively undertaking land development. By contrast all the non-farmers thought farm development had a negative impact on the weka population, based on the loss of vegetative cover. Farmers may not recognise loss of cover as a negative as they see such loss as
beneficial to their farming. Indeed, the farmers said they were seeing more weka, potentially because as there is now less cover. In addition, weka were considered adaptable and able to survive and so were not considered at risk.

The importance of local interaction is seen in some participants’ assertion that although weka might be classified as endangered this was not important as there are many weka at Cape Foulwind. By contrast wider networks are shown in the importance placed by some participants (mostly non-farmers but also some farmers) of their decline in other parts of New Zealand meant they were even more important at Cape Foulwind. Weka made the place unique. Participants who were more recent inhabitants expressed these concerns more as weka possibly were less taken-for-granted and they had also had less experience of the ongoing nuisance aspect of weka.

To summarise, the approach in this study is not that place just constrains practices but also invokes them. The mental, as has been argued (see Chapter 4), is primarily material and practical. This study considers participants as immersed, situated and embodied binds them to their natural and social environments which they are expressions of, and is expressed by them and the results support this understanding. It is a common world where social understandings and language are continuously recreated through ongoing interaction (Ingold, 2000).

15.3.1.2 Affect and belonging

The role of interaction has been recently highlighted in New Zealand in the 2010 debate over the government’s proposal that parts of Schedule 4 land presently excluded from mining (Mining Act 1991) be opened for mineral exploration and mining. In a letter to the Conservation Minister the New Zealand Conservation Authority stated that “[m]ining is purely economic activity. It is transitional, concerned only with exploitation; it enters onto land with which it has no association, and for which it has no affection, extracts what it wants and departs” (New Zealand Conservation Authority, 2010, p. 3).

In this example, an interactive association with a place is a seen as key. Affect, too, is considered vital. This study suggests that every practice is bound in affect. At Cape Foulwind, all the participants have interactions, and hold affection for the land and its inhabitants. Affect invokes a sense of place from place. Weka were frequently linked to place and bound up with feelings of place, although the strength of this varied among the participants. The physical features of weka and, more importantly, their calls and character, contributed to the ambience of place within which emotional responses arise and are constituted (Wylie, 2005). The role of affect and interaction with place is well shown in the study through the relationships with weka. Descriptions of weka based in
interactive experiences are full of emotional descriptors about their physical appearance and activities (e.g., like, hilarious, wonderful, evil, fantastic, devilish, and courageous).

Elements of Heidegger’s conception of dwelling and place as home, contentment and familiarity were found in the participants’ understandings. As commented by P10MNF “I just like the feel of the place. You get to know a place fairly well after a period of time you always feel, feel comfortable there.” This was often related to the natural world. However, these traditional, ‘Heideggarian’ conceptions were reconsidered and developed (see Chapter 2) to align with Merleau-Ponty’s lived body and Deleuze’s relational networks. Thus, this post-phenomenological research does not involve a phenomenological concern with things (places) ‘in themselves’ but how things are related. This does not understand landscape (or place) as consisting of authentic and inauthentic subjective understandings or something subjects impose meaning upon.

Bell et al. (2008, p. 287) found that a “sense of felt continuity between people and natural forces has a powerful role in forging identity linked to attachment to place” This may have been less so in the more human impacted landscape of Cape Foulwind compared to the Lakelands of Finland in their study, but it still existed for some participants. P10MNF commented that native animals also provoked a sense of being embedded in a larger world “it’s a constant reminder that you are part of a much bigger thing than just your little world …” For others it was more than this reflecting their feeling for the place: “[I]t’s really important to me to have native wildlife around…I mean it’s all connected with my feeling for the place and the beauty.” (P11WNF).

The interactive and affective is epitomised in the notion of place as a soundscape (Ingold, 2000). Participants highlighted the affective force of the call of the weka; some made their children listen to it. P2WNF called it “an enduring memory”, P3MWNF agreed and also said “…it’s sort of that very distinctive sound of this place.” The call produced feelings of comfort and home to some participants. This natural ambience of place could be considered to exist prior to subjectivities and is incorporated by them as emotions (Wylie, 2005).

Weka can be considered as a taken-for-granted part of the affective, interactive, embodied background or ‘given’ of Cape Foulwind. This immersive ‘just here’ underlies the tension of nuisance and appreciation as ‘being here’ can be considered as ‘just what the world is’ and invokes some form of care in its existence. This can be considered to underlie the more explicit normative recognition of weka’s belonging. These ethical aspects are discussed further in Section 15.3.4.

This understanding of weka belonging may contribute to the lack of concern participants had about the large amount of Conservation land on the West Coast (some 85% of the land area), and the notion that weka conservation should be undertaken there, rather than on private land. By contrast Blackett et al. (2005) found that, because of the large areas of land protected in the conservation
estate on the West Coast compared to other regions of New Zealand, their participants thought wetlands were adequately protected without having to protect them on private land.

Weka can be considered as part of an affective network of place, bound up with the participant’s affections for their dogs, farms, cars, families, friends and gardens. This, in turn, is linked with their practices. In this manner farmer’s feelings for Cape Foulwind were also connected with the breaking in of the land, the hardship of farming the land without development, and without subsidies, the months of wet dull weather and saturated soils, the mining history, and the localism. P9MF commented that they developed the land “so at least they can farm it”. The visual change in the landscapes from “West Coast” farm scapes to modern productive farm scapes more akin to Taranaki or Waikato had an aesthetic appeal to some participant farmers (e.g., PFM9).

It is important to consider what this highlighting of affect means for an RT analysis. This is not directly addressed here but is developed in the following sections in a consideration of what ‘place’ implies for ethics. I suggest place as affective, embodied and relational becomes an account of a SES within a phenomenological/post-structural understanding. However, this is no longer place as Heidegger’s rustic authentic rural landscapes; as a nostalgia for the traditional. Ingold (2000) avoids this rusticness this in his notion of temporal landscapes by first seeing them as time-embedded rather at a fixed point in time, and second as being rhythmic within a seasonal cycle. RT evokes landscape rhythms too, although not regular ones and not a perpetual return so invoking the unforeseen, and so requiring social adjustments.

15.3.2 Local knowledge

15.3.2.1 Participants’ knowledge

Both the interviews and the FCM results showed that the participants had a good knowledge of weka and their ecology. Some participants had a sound knowledge of possible mitigation measures as well as behavioural knowledge such as responses to climatic events, clutch sizes, and threats. Indeed, the all-map CID FCM scenario modelling aligns very well with the IBM modelling in relation to the weka population’s responses to land development and other pressures. However, this was not entirely the case for the farmer CID and this is discussed below.

However, there were limits to my participant’s knowledge and this is reflected by Blackett et al.‘s (2005, p. 14) findings from their West Coast farmer study where “[e]nvironmental knowledge of the research participants was generally patchy and lacked cohesion…” as it was generated from personal experience. A lack of knowledge was readily admitted by many participants. For example P7MWF commented “yeah, but have never worked out a pattern of why you see them sometimes why you don’t.” My participants possibly had a greater or a ‘thicker’ (Robbins, 2006) knowledge of
weka than Blackett et al.’s (2005) participants did of wetland as they had a more engaged interaction with weka.

Some of the participants’ knowledge was expressed through stories. Stories mostly related to individual experiences with weka. They were also often associated with extreme events. (e.g., hundreds seen around diggers, weka homing ability, weka in their house). Nearly everyone interviewed had a story about a weka experience, although, participants with more interaction tended to have more stories. Weka are a bit like the weather, providing something of common interest to talk about. In this respect they could be considered a given, as background or a taken-for-granted of which, generally, little direct notice is taken. In this sense weka exist as an implicit, yet significant, element contributing to the ambience of place. This reflects the comments in Section 15.3.1.2 on weka being ‘just here’. Also it was suggested by several participants that long term residents tended to take weka for granted through familiarity or considered them purely as a nuisance. This was not found to be the case overall and most long term resident participants still appreciated weka.

Participants’ stories, through which they express and capture their experiences about weka, should not be considered only as stories as compared to scientific knowledge. “[W]e should resist the temptation to assume that since stories are stories they are, in some sense, unreal or untrue, for this is to suppose that the only real reality, or true truth, is one in which we, as living, experiencing beings can have no part at all.” (Ingold, 2000, p. 191). Stories are fuzzy and idiosyncratic, they incorporate elements of both personal and vicarious experience, and they express our everyday practical world, with its uncertainties, incompleteness and uniqueness; its overturning, and its surprises.

In common with this there remains a tension between post-structural thought and the realist tradition of the biological sciences. As such, a question remains over the ability to link the two together in a useful way (Goldstein, 1999).

As set out in Chapter 2 and 3 Deleuze & Gauttari, like many other philosophers in the continental tradition, do not believe that full objective knowledge is possible through science (Mugerauer, 2004). They also do not suggest that their proposals are scientific theories but rather assemblages (ongoing recombinations) of events and affects. This reflects a position that denies things having single stable identities or essences (Schroeder, 2005) and follows a new thread in science that is interested in the particular (Mugerauer, 2004). Furthermore, as has been set out, in the approach used in this study the binary of realism and idealism no longer applies. Immanence suggests that there is no distinction; the ‘real’ is by its nature, relational, somewhat disordered, and full of difference, a process, unfolding, and wild. Subjectivities, and their expressions (e.g. stories), as manifestations of it will reflect this nature in their undecidability, changing relations and
fundamental understandings, hybridised knowledge and affective dispositions. Fundamentally, this research
emphasises people’s everyday embodied, affective relationships and the way of knowing derived
from this.

Consequently, reflecting the philosophical understanding, and as developed in Chapter 3,
complexity science (and systems theory in particular) is intended to supplement reductionist science.
However, RT does not attempt to fully incorporate the implications of the philosophical background
associated with complexity science and its associated threads as set out in Chapters 2 & 3. This is not
to suggest that complexity science is a cohesive philosophy, it remains fragmented (Maugeraur,
2010). Incorporating the significance of local knowledge, as both explicit experiential knowing and an
implicit immersive ontology, lies in drawing this understanding into an RT analysis. The results of this
study show the relevance of this knowledge and the depth of its understandings. This local
knowledge was complex incorporating a range of experiences and was complemented through social
networks (e.g., media, discussions with others). It also contained tensions and inconsistencies.

This highlights the inhabitants’ knowledge hybridisation with other types of knowledge, such
as scientific knowledge. This hybridisation has been characterised as topological networks of the
close and distant and local and general. The hybrid nature of local knowledge produces complex
places, as a dynamic with other places brings new experiences and types of knowledge (Bell et al.,
2008). For the present inhabitants at Cape Foulwind this globalisation of local knowledge (and place)
has existed from colonial beginnings when practices from other places were brought to the area. In
addition, knowledge is recreated in each generation in interaction with the local environment
(Ingold, 2000) which allows continual hybridisation to occur. In this respect, my informants showed
some scientific knowledge (e.g., ecosystems concepts), but their knowledge was dominated by their
embodied experiential knowing.

Bell et al. (2008) found that although the local people incorporated scientific knowledge into
their knowledge they thought scientists ignored their local knowledge. This has not been the case in
this research where local knowledge has been fully incorporated into the analysis as the scientific
based fieldwork from this study was integrated in the IBM. I suggest that local knowledge is part of
the ‘ecology of place’, as it shows how the inhabitants understand and interact with place. It “is
derived from and contributes to people’s emplacement within their surroundings and contributes to
their knowledge and awareness of self-identity.” (Bell et al. 2008, p. 286).

15.3.2.2 Resilience Theory

The results of this study also show that this experiential/cultural element is important to the
ongoing development of the Cape Foulwind SES (see Chapter 14). In a participatory governance
model local knowledge is ‘fed into’ the analysis, while the RT analysis is ‘fed back’ into the SES so as to become incorporated into local knowledge. I suggest that care should be taken in attempting to manipulate such knowing. This first is based in the recognition that local knowledge becomes continuously recreated and also hybridised with different types of knowledge and practices. However, as already noted, this can introduce practices that ‘dis-place’ people by reducing the “close proximity to resources and the functional knowledge of resources and social cohesiveness...” (Woodley, 2004, p. 4). I suggest this displacement has not entirely occurred at Cape Foulwind. The new farming practices are creating some separation from the local ecology but not to the extent that interactive knowledge, at least of weka, has been lost.

In this study local knowledge was used at two levels in RT. At the first level it is used to inform and complement data collected about the SES. FCMs are a useful way to gather such information from inhabitants (with the reservations already noted, see Section 11.3). This information was used in the development of the IBM. At the second level, local knowledge is understood as the knowledge of the human participants in the SES upon which they base their decisions. In this sense it is - as I have suggested - central to the functioning of the SES itself and so is critical to understanding the SES, and its analysis. Treating local knowledge in this way, as relationships, is more subtle than collecting ‘stakeholder’ views, or treating local knowledge as merely another data source.

In the more formal RT analysis undertaken for this study (Chapter 14) a central question is how does an immersed, affective, material approach to knowing relate to RT? Primarily it relates to how RT and the SES are understood by inhabitants. The FCMs do show, however, that the participants can understand the Cape Foulwind SES and weka in basic systematic terms but that their everyday understanding is more experiential and affective and less explicitly conceptual. Participants did not show any sign of conceptualising the SES in RT terms, which are abstract, complex and non-obvious (i.e., only one mentioned thresholds and none different regimes). In this respect the RT theoretical approach is an organizing overlay.

15.3.3 Actors and boundaries

15.3.3.1 Actors

This section considers how the inhabitants consider weka in their everyday interactions and practices and what can be learnt about weka from such relationships. This contrasts with an approach that considers weka from a purely natural science perspective as objects of study. While a natural science perspective is adopted in this research in the field work and the development of the IBM, the IBM lies as a boundary between a statistical and a post-structural account of weka and
treats weka as having individual emergent behaviour. The post-structural account understands weka, like humans, as autopoietic entities existing within a field of relationships and as being active in these relationships.

Within post-structural theory, weka, as wild animals, can be considered in the context of ‘hybrid geographies’ (see Chapter 6). Hobson (2007) argues that the non-human, and wildlife in particular, are “…a relational achievement spun between people and animals, plants and soils, documents and devices in heterogeneous social networks which are performers in and through multiple places and fluid ecologies” (Whatmore, 2000, p.37 cited in Hobson 2007, p. 9). In this study these ‘multiple places and fluid ecologies’ are stabilised through materialising them. I also expand social networks into socio-ecological network-systems. So when weka are considered as food, as entertainment, as a nuisance, as engaging, as characters, as road-kill, as endangered species, as ancient inhabitants, as contemporary inhabitants, as tools, as constituents of place, as emotionally intelligent beings, as objects, or as wild animals, this arises from weka behaviour and the nature of their existence and our embodied existence as much as from a cultural overlay. If weka were not inquisitive and bold they would not have most of these attributes, and the human inhabitants and their relationships with place would not be the same either.

The empirical results reflect the importance of the physical presence of weka and show weka, as actors, influencing the participants with their character and through their existence, so making up the matrix of place (emotionally and practically). Weka’s physical attributes such as their size, omnivorousness, flightlessness and territoriality are not separate from their character as they tend to facilitate it. In participants’ understandings of these were sometimes mixed together. Participants understood weka as influencing their lives through their daily interactions and influence they had on their activities. They put up fences, closed their doors, slowed down their cars, kept dogs, removed weka etc. Again, the complexity and tensions that characterise the relationship between weka and the participants can be considered as resulting from both the behaviour of weka and from the behaviour of the participants.

Unlike the interviews, the FCMs do not show the active nature of weka well but rather show them as dominated by external pressures. The FCMs showed participants only responded through ‘attitude’ change (as suggested in the non-farmers FCMs) and that is derived from the social world and not from first-hand interaction. Although some participants themselves (i.e., personally) described change in their interaction with weka as being derived from such interaction. Here interaction is recognised, but not the implications of such interaction as the actors remain purely human and social. Consequently, my participants do not see themselves as ‘responders’ in relation to
weka, but understand themselves as choosing to respond to weka. They understand themselves to be agents in their relationships with weka.

This tension between human agency and weka as actors emerges further as weka were considered by some participants to have emotional responses and intelligence, like humans, and as ‘individuals’ with specific tendencies. This could be considered to show the human propensity to anthropomorphise the natural world. I suggest the argument that this is ‘incorrect’, and serves to subordinate and obscure weka behaviour, is associated with dualisms that attempt to separate the human from the non-human. An alternative is that animals, such as weka, do have these sort of behaviours regardless of how we choose to articulate them. Weka are active in material practices and in the ‘affective fields’ of participants’ lives. They contribute to the material, interconnected, immersive world of the participants’ existence. They impinge on everyday lives and change and mould skills and practices. Their engagingness creates a nuisance, and affection, their adaptiveness provokes an understanding of resilience that may not actually be the case.

Many participants’ interactions can be directly traced to the concerns and interests participants had in relation to weka. They range from personal experiences of weka family life, road-kill, land development and calls, all based in direct daily interaction with weka and, therefore, experience of their character. In this respect weka become analogies for and, reciprocally, guides for the participants lives. A good example is weka parental skills and dedication to their chicks which was commented on by several participants who were parents themselves. This finding suggests that such interaction is not ‘one-sided’ as being a purely socially derived understanding overlaid on weka. This reciprocity can be also considered at a social level where the character of weka, and West Coast people, interface. This is reflected in P18MNF’s comment that “I think they should become the national icon of the West Coast, ha. They kind of thrive in the rain, they are opportunists, like West Coasters are opportunists, arr they’re bold, cheeky …”. This steps towards equating weka with the place, its characteristics and the characteristics of the people there. Here weka are an element of place; giving, reflecting and constituting it. This is layering weka character onto the local people, or indicating the local peoples ‘character to themselves, or better still, interactions with weka contributing to participants’ character.

15.3.3.2 Boundaries

This interrelation between weka and people begins to undermine boundaries. Klaver (2004) suggests “[a] boundary is not a static entity, but operates, is at work, between various entities, mutually constructing them and itself in the working.” (Klaver, 2004, p. 45). It is the role of boundaries in delineation that allows phenomena to be separated and their interconnections understood. Boundaries are essential to understanding but should not be considered static. These
movements of interfaces or boundaries activate new delineations and new understandings (Klaver, 2004).

As has already been implied, boundaries that concern weka and people are multiple and interlaced. As wild animals, weka lie among boundaries of abundance and rarity, indigenousness and exoticness, between the iconic and mundane, nuisance and appreciation, wild and domestic, between being protected and being pests. The results show that the boundaries that do exist for many of the participants are also porous and fluid and best described in a networked (topological) manner. This suggests that some of these boundaries are to some extent ‘straw men’ when it comes to the everyday and ongoing interactions.

Tovey (2003, p. 210) describes this in conventional dualistic sociological terms but highlights the uncertainty: “Modern Western culture is not monothematic but dualistic and ambivalent, characterised by a contestation between rational and romantic orientations to nature.” As Birke and Parisi (1999, p. 61) put it, there is the ‘generic animal’ as “irrational, instinctual (quite unlike many of the animal kinds with which we might share our daily lives).” Birke & Parisi (1999) paint a picture of animals as social and interactive, with much more in common with humans than not.

Regardless, the most decisive boundary, I suggest, between the human and non-human, still exists (Whatmore & Thorne, 1998). In other studies (e.g., Rikoon, 2006; Stratford et al., 1999) this human-nature boundary is never disturbed, as animals, as a part of nature, are considered separate and analysed as social symbolic constructions. The realism of natural science complements this separation through considering animal inhabitants as objects science interacts with as biodiversity (genes and species) to be protected and separated.

The results of this study question this boundary. This questioning involves a concern about an instability created by lack of consistency in ‘labelling’ weka. However, the results of this study show that this ‘labelling’ is traced to interaction and the action of weka as much as the participants. Furthermore, this variation in labelling in discourse is less varied in physical practices. The boundary between culture (human) and nature (non-human) can be understood to be co-constituted and materialized as practices. Weka’s acts of disturbing practices rearrange our boundaries which in turn rearranges the world. The recognition of this instability, according to Haraway (1991 cited in Klaver, 2004) shows the world is a “coding trickster with whom we need to learn to converse.” (p. 52). Klaver (2004) sees the consummate coding trickster as the coyote or the fox as they play with our boundaries. They follow us, but don’t let themselves be domesticated; instead they eat our chickens, rummage through our garbage, and pluck our blankets.” (p. 53).

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69 Because of their unexpected and surprising behaviours, tricksters ,“test existing boundaries and rules, but with positive results. These tricksters are so common that the myths appear universal. Native Americans personified these traits in the spirits of coyotes and ravens.” (Gunderson & Folke, 2011, p.1).
Weka too rummage through our rubbish, they also invade our houses, take our eggs, pull up our plants, and eat our pet’s food; a New Zealand coyote tinkering with our boundaries. They straddle the conservation land/ rural land boundary and so challenge its existence. Weka are an endangered species but locally abundant. Weka are ‘border dwellers’ that can show a way (i.e., mingling of nature-culture – wild animal and humans) to live (dwell) that does not separate the two (humans and nature). Weka can show that wildlife already live in our domesticated lands. Weka invade participants’ everyday experience and so make it up; giving and requiring participants an opportunity to converse and rearrange, rethink and react to this boundary. Weka are boundary objects, intermediate cases. Indeed, ecologically, weka are boundary dwellers, preferring ecotones, places of transition and edges, to live.

Weka, as a boundary case, are adaptable and robust enough to retain their identity across different human groups with different interests and interactions (e.g., farmers and non-farmers). Weka will not be ignored, they, through their interactive character, continuously remind the participants of their existence. Just as significantly, weka cross other boundaries being neither fully wild nor fully tame. An important point is that weka were not pets, but wild animals, they were not treated in the controlled manner of pets that “are socialized to become part of human society.” (Birke & Parisi, 1999, p. 61). Pets in some ways do question human animal boundaries as they are often treated as humans, however they do not deform human-nature boundaries in the manner non-domesticated animals do.

Deleuze’s notion of becoming overrides orderly dualisms, such as between humans and animals. Becoming sits in a topological space, where boundaries develop, shift, and redevelop. Participants treat weka differently at different times of their lives, and depending on the practices they are involved in. Hundreds of weka get killed on the roads around Cape Foulwind every year (Freeman, 2010) by cars (and sometimes tourists) imported from overseas. Cape Foulwind farming practices express elements of global influences, commodity markets, excavators made in Japan/Korea, oil imported from the Middle East, while land development techniques (flipping) were developed locally. This is a network of elements brought to bear on weka and people of Cape Foulwind involving both close and distant elements, stretching and deforming time and space. Consequently a systems analysis becomes more networked encompassing fluid boundaries between system scales and domains. Depicting weka as a boundary object between nature and culture does not deny the contributions of the sciences of zoology and ecology, or the social sciences in coming to know weka. Instead, this post-structural approach uncovers the actors and relationships that exist in such knowing.
Considering weka as actors within an RT analysis makes the systems more recursive. In particular, it recognises the impact the activities and existence of weka has on the social part of the SES (i.e., in the character of people, in the responses of people, in the feeling of place, in the process of valuing). Embodied interaction with weka can shift human - animal, and conservation - private land boundaries. This recognition lies at the core of this study as an animated world involves such a shift of boundaries. The challenge for RT is to account for the fluid nature of boundaries. There is also a need to consider how the normative sits in such an account. This is considered in the next section.

15.3.4 Ethics

15.3.4.1 Desire and undecidability

The desirability of outcomes is often considered as independent from an RT analysis. This means the trade-off between social and environmental objectives becomes a separate political decision rather than the role of an expert RT analysis which merely presents the biophysical outcomes (Lebel et al., 2008; Anderies et al., 2006). To this end The Resilience Alliance (2007, p. 5) states that political desirability is “the way society (in general or a particular segment) regards the flows of goods and services from one regime of a system in contrast to another regime.” However, implicit in an RT analysis is a non-neutrality reflected in Daily’s (1997 cited in Folke, 2006, p. 257) comment that the RT outcome is to maintain the “capacity to sustain natural resources and provide ecosystem services for societal development”. Bound up in this tension in promoting RT is that experts may not take into account the needs and rights, or even understandings, of local people when maintaining ecological resilience for social purposes (Lebel et al., 2006). This risks domination of the inhabitants’ understandings abstracting them away from everyday lives and experience. The theoretical development in this study attempts to include the question of inhabitants’ desirability within the RT analysis by incorporating inhabitants’ understandings. This approach allows the consideration of ethics within an RT analysis.

As set out in Chapter 2 the existence of a phenomenological subject has been an important element in a philosophical position which emphasizes immersion, and with that, risks the loss of a subject able to make decisions (ethical) and an ‘other’ to consider in such decisions. Ross (2004) traces these concerns between phenomenology and relationality through an ethics based on a material exuberance and abundance. Abundance relates to desire as a material expression of a future of other species and kinds we are unable to make stable (fecundity). Ross (2004), following Levinas, argues this has two aspects that need attending to: The first is the risk of a normative neutrality of Being implied in “[t]he incessant murmur (bourdonnement)” (Levinas, 1978 cited in Ross, 2004, p. 251) of the ‘there is’ associated with notions of immersion. Second, is the prospective
nature of fecundity whose production is infinitely beyond the human. Ross (2004) notes that Levinas sees non-neutrality residing in subjectivity creating a responsibility to ‘other’, but that the other, for Levinas, is primarily human. Consequently, Ross (2004) has concerns that Levinas’s (and Heidegger’s) phenomenologically based ethics for nature are derivative from human ethics. For Ross (2004) bourdonnement and material fecundity is primary, undermining a subjectively based ethic. In parallel, in Derrida’s thought it is difference, trace, etc., beyond and before the subject, beyond critique, that creates a double bind of perhaps or maybe. The open future gives undecidability as a condition of responsible decision making. It becomes – always gestural or performative as the “inhuman ethical political position of humanity” (Ross, 2004, p. 253) that lies beyond humanity but within the world.

The phenomenological subjective thread of this combination links desire with the personal qualities of anticipation, motivation and interest as was established in Chapter 5. Interest exists as the prime motivator to some extent in all our normal day to day activities (Milton, 2002) and interconnects the cognitive, emotional, experiential and the physical. In combination with this, as outlined in Chapter 2, lies a non-relational counterpoint that is manifest as an affective de-centred reticent subject. In Chapter 5 it was concluded that affect (as feeling) is central to everyday coping, and ultimately how we are, and how things are, and consequently feeling has an important ethical role. In simple terms we ‘feel’ what is right to do. Some commentators within post-modern thought have promoted emotion as being central to ethics (Smith, 2001; Milton, 2002). In this view ethical understanding is not considered either as objectively discovered rules or principles or subjectively relativistic. However, it is still an embodied subject (performance) that makes a decision as elaborated above. It creates a tension in the subject – and such an affective, ‘thoughtful’ and reticent ethics shows in my informants’ undecidability. The participants in this study tended to have a flexible ethical relationship regarding weka. This suggests another thread to undecidability that is expressed as a flexibility and adaptability to situations, experiences, and feelings.

Heidegger’s notion of dwelling and its reticence and openness has parallels with undecidability and flexibility. Stefanovic (2004) shows that, for Heidegger, both ethics and ontology are interpreted through the concept of dwelling. Foltz (1995) notes (cited in Stefanovic, 2004, p. 57) “ethics is the understanding of what it means to dwell within the midst of beings as a whole, and thus it concerns our bearing and comportment as a whole, toward beings.” As already noted this relates to an ethos -not in a world pre-ordered by morality and its associated transcendent structures but one based on ethics. Ethics is contingent on relations of the personal, natural and social which vary in space and time. Dwelling is an ethic of ‘letting be’ that grants leeway for things to disclose themselves and endure. It involves placing limits on our needs to control and organize. However, it
should be noted that this does not deny use, but a use without domination. This involves primarily a recognition or sympathy with the thing that is gained through the experience of interacting with it (Foltz, 1995). Finally, Popke (2009) takes a similar position to Heidegger highlighting the importance immersion and interaction. However, he suggests the need to look past just “individual encounters and experiences” (p. 84) and rather to such events as being of a common-world and an ethic of care developing from this.

Broadly this approach resolves as reciprocity. Abram (1996) notes that if nature is not understood to have meaningful agency, as something capable of reciprocity we can just take what we will. An animated world lies in the embodied and developmental understanding of cognition where mind and perception actively reciprocate with the world. Systems theory can act as a theoretical basis for this (see Chapter 3) and incorporates the uncertainty in non-linear understandings of CAS. This complexity as revealed in undecidability and flexibility is exposed in the primary tension in participants between nuisance and care for weka.

Reciprocity can be considered through the systems concept of feedback and how place/environment and other actors ‘feeds back’ into inhabitants. Feedback is not just cognitive but fully embodied, emotive and epigenetic. At one level the approach in the study enhances feedback though incorporating a post-structural understanding questioning dualisms which suppress some types of feedback (e.g., between the mental and physical). At another level, excessive subjective reflexivity is eschewed. Feedback based in reciprocity does not use the concept of stakeholders. Using the concept of stakeholders implies an inert world, rather than an animated one, that only gains fullness through these varied ‘views’. In a reciprocal and animated world the world itself acts as a guide through our immersion, feeling and cognition. Ethical decisions are second order feedbacks (i.e., feedback about responses to feedback) in this sense they have a reflexive aspect but it does involve not a pure reflexive (post-modern) consciousness, but an autopoietic one based in immersion with a material grounding.

The participant’s ethical flexibility was shown through care for weka being reflected in some practices and not others. Practices of care are focused on non-essential activities rather than the effects of by-products of participants’ ‘essential’ practices. For example, road-kill is frequently seen and experienced but is considered an accident. It is something that is an unintentional by-product of an essential and dominant practice (all the participants drove or used cars) and so is not able to be easily avoided without substantial changes in such practices. Land development is a similar case but such tension was confined to the farmers where land development is considered an essential practice. Bell et al. (2008) found a similar response where local fishers were all supportive of conservation of the Siamaa seal but, like some local farmers in relation to weka, they rejected that
their practices might be impacting on the seal population. While Blackett et al. (2005, p. 14) found their “[p]articipants did not think humps and hollows had any effects on the environment except increased water volumes during high rainfall events and a reduction in the amount of swamp/pākīhi land. These effects were not often considered negative; they were simply effects.” This was not the same as at Cape Foulwind where the effects were not denied, but more subtly were not recognized. However, participants also recognise (both farmers and non-farmers) personal responsibility and suggested measures to protect weka from the range of pressures on them. This, in turn, reveals a tension between physical practices and discourse. Some were aware of this inconsistency between their practice in their discourse (e.g., P18MNF, P4WF), while others appeared to be oblivious, or did not see such inconsistencies (e.g., P9MF).

As already mentioned, farmers’ knowledge was primarily practically based and considered about doing (action). This occurred in a partly reactive manner to unpredictable events (e.g., weather, animals, and economies). This may be one reason why farmers’ knowledge of weka was more descriptive than that of non-farmers. It is knowledge based on how things are done but contains an element of being unable to control all the forces involved. An ethic that lies in this everyday practical engagement as a taken-for-granted doing may invoke a certain conservatism - ‘this is how things are and this is the way we do things’. So nothing is seen amiss with their present practices. Farmers could be characterised to some extent as ‘pragmatists’ where getting things done overrides ethical concerns. This descriptive understanding may be influenced by land management agencies in placing ‘environmental’ rules on the management of the land and so taking on a normative role. However, it may also invoke a reaction against control by outside agencies. This concern about outside control was not mentioned by any of the farmer participants, although it was a significant element in Sampson & Goodrich’s (2009) study of another West Coast community. The non-farmers had a more prescriptive understanding, and questioned existing farming practices. One reason for this is, in contrast to the farmers, changes to farming practices prescribed for the protection of weka do not directly impact on the non-farmers’ everyday lives.

15.3.4.2 Rights and relationships

The ethical position put forward here is in contrast to an expanded rights-based ethics (the moral status of animals) approach to environmental ethics. Influential approaches of rights-based extensionist approaches to animals as moral subjects are those based on an ability to suffer (sentience) and their existence as ‘holders of a life.’ (Hobson, 2007). This approach allocates animals individual interests in parallel with humans which is the basis of equal consideration (Tovey, 2003). Kirkman (2004) notes that much of this type of environmental ethics is ‘is-ought’ based (i.e., if we are
able to recognise a connection between humans and nature we will respect it (facts-values)). Smith (2001, p. 15) highlights that moral extensionist approaches “attempt to provide a rubric to determine right and wrong by those not intimately associated with the circumstances- that is bureaucrats, governments, law courts, and so on.” This is embedded in conventionalism that “operates to reflect and reinforce our current social structures.” That is, is based on present structures “human classification and social responsibility.” (Hobson, 2007, p. 9).

By contrast the position developed in this study has a focus on ‘intimate associations’ or relationships. This highlights “that human beings are ‘organic’ and ‘embodied’ as well as cultural, reasoning and reflexive, and to their material interdependence, as organically embodied, with other animals.” (Tovey, 2003, p. 211). But it also emphasises social interdependence and that humans and animals stand in social relationships to one another. Hobson (2007, p. 3) argues that viewing sociality as a more-than-human achievement is a thoroughly political move as it questions the very exclusions of people and things that have come to constitute modernity.” In other words, weka are considered actants and so it is not just about allocating them moral regard (and rights) as entities but considering them active participants in the ethical sphere and as political subjects.

I suggest that without relationships ethics risks being reduced to rules (laws, policies) to the extent people do not fully utilise or develop an ethical sense, as they are not required to. The ethical responsibility towards weka at Cape Foulwind then becomes a matter to be addressed by land management authorities rather than residents. For example, one participant commented (P9FM) that they only undertook mitigation to protect the indigenous ecology because legislation required them too. Significantly, this farm was corporate owned. However, they also protected forest remnants derived from company policy, but there is no personal experience driving it. This is exposed in the descriptive understandings of the many of the farmer participants. As farming becomes more commercially based (e.g., absentee owners) embodied experience of ‘place’ is lost as the basis of an ethic, so land management agencies become more important. By contrast, several farmers on family owned farms showed care (e.g., P4WF, P7MWF, and P15WF) in that they have left some parts of their farms in natural vegetation.

A relational approach (as an ontology) to ethics conveys the role animals play in social and lives (i.e., impinge and influence the everyday living as the ‘political’) rather than conceptualising the way we ought to treat them. “[T]hey are an explicit part of the encounters and negotiations of the everyday that need to be dissected in and of themselves.” (Hobson, 2007, p. 10). My participants recognise sentience and ‘lives’ in weka so this contributes to their relationships with them.
15.4 Reassessment of Resilience Theory for weka conservation at Cape Foulwind

15.4.1. Overview

A full RT analysis for weka at Cape Foulwind was developed in Chapter 14 showing the drivers and associated phases over the past one and half centuries. The likely impacts on the weka population from the various scenarios modelled are set out in Table 14.3. This Section will not develop the various scenarios for weka conservation further, but considers this analysis in light of the previous sections of the discussion. The socio-cultural sub-system has been a major focus of this research with its emphasis on affect and immersion, local knowledge, embodiment and the subsequent relationships participants hold with place and weka. The notions of place and dwelling (Ingold, 2000) have been employed as overarching constructs to encapsulate these ideas. This section, then, explores a reconsideration of the Cape Foulwind SES using these ideas as outlined in the previous Sections.

Although the embodied interaction between weka and the participants are considered primary in this study, tracing many of the potential interconnections has not been attempted (i.e., a full network account - including social networks). Some of these interrelations have been interpreted within a RT analysis. This includes the analysis of economic drivers, social drivers, etc. outlined in Chapter 14 (i.e., agricultural changes, commodity prices, etc.). The system-network position developed does not deny the usefulness of an adaptive cycle framework or systems based notions of thresholds, attractors, feedbacks, adaptation etc., and hopes to contribute to it. It does, however, question the reification of the agents into holding socially derived mental models with the implied separation of the mental from the physical.

To summarise the discussion so far, Chapter 14 found that social adaptability and learning in the Cape Foulwind SES has been limited primarily to the socio-economic domain at the present time. It also outlined three kinds of social learning associated with changes in SESs - incremental, episodic and transformational. The emphasis on interactive, situated local knowledge in this study does not deny that these types of learning occur but could only trace incremental and episodic learning in the SES. It found learning in the Cape Foulwind SES as predominantly experiential and incorporated with this, networks and hybridisation as local knowledge. At a personal level, participants learnt about weka through interaction and adapted to their presence. The system property of feedbacks were, in the socio-cultural domain, associated with changes in interaction with weka (this is also associated with the ecological shift of a change weka numbers). Because these feedbacks involve local
embodied interaction they were tight feedbacks. However, the socio-cultural response to the feedback was not able to be identified clearly as the feedbacks were not strong (i.e., more land clearance meant more weka are seen so the loss is not recognized). These feedbacks became more complex when considered from an interactive perspective. It was proposed that the ethical has a role in socio-cultural thresholds as it situates desirability, both within periods involving thresholds and also outside these periods.

15.4.2 RT and affect

As already discussed, desirability is an important term in RT, but one that has not been clearly addressed. Desirability has ethical connotations and the foregoing discussion in Section 15.3.4 develops an ethical approach that is closely linked to desirability. In relating this ethical approach to RT interactive relationships and the role of affect is important.

This is shown in Holling et al.'s (2002) tentative linking of the RT $\alpha$ phase with feeling (see Section 3.6.3). The $\alpha$ phase – is in the back-loop or reorganisation phase - is understood as the most crucial phase in the adaptive cycle as it is most sensitive to small changes that set up the ongoing development of the system. Most RT studies are undertaken in the period of ecological or social crises (back-loop). Feelings can heighten memory of past novel events and so are crucial to guiding the reorganisation of systems following disturbance (Holling et al., 2002). As developed in Chapter 5, the motivational role of feelings is also important for the implementation of changes. In addition, emotions as learning mechanisms are considered more generally to be involved in a reflexive, adaptive socio-ecological process and so have a role in adaptation.

It is suggested that feeling is also important in other adaptive cycle phases, as the relationships developed in the front-loop (non-crises) part of the cycles are the basis of responses in times of crisis. In addition, because different scales and domains of SES’s (panarchy) are often in different phases, as they are at Cape Foulwind, understanding the affective relationships within the SES in all phases is important. This lack of synchronisation of the domains and scales means the period when ethical responses are most important might lie outside broader socio-economic reorganisational phases, as is the case in this study.

This is shown in the study where the social recognition of the impact of land development on weka has not yet occurred (i.e., in this study the socio-cultural domain does not lie in the back-loop but in the fore-loop conservation stage (Figure 14.10)). As set out in Chapter 14, this is likely because of a lack of awareness of the impacts on weka, and because weka do not create a change in the local economy as it is not reliant on weka. However, feedbacks may still exist and at some point loss of weka may provoke a social response if numbers dropped considerably. If it did occur this socio-
cultural threshold may be abrupt. Such a shift would cascade down through the different domains and scales to improve the viability of weka. The risk is the loss of weka decreases their association with place and so this feedback fails or, alternatively, people miss what is lost and try to regain it. The outcome is unknown. However, the central importance of interaction exists.

This situation is expressed in conventional Resilience Theory terms (Carpenter et al’s, 2006; Gunderson et al., 2006) by Walker et al. (2006, p. 8) “In the social domain, crises need to be perceived as such to have an impact on mental models, because large-scale changes that are not perceived as crises do not challenge the prevailing mental models.” This suggests crises are needed to change ‘mental models’. The notion of (representational) mental models and the implication that local inhabitants have little understanding of the processes in play, are both rejected in this study. Rather, it is proposed that ‘understandings’ are continuously evolving through experience and learning. A ‘crisis’ under this understanding derives from a change in interaction, and disturbs situated embodied relationships that, rather than mental models.

15.4.3 RT, individuals and complexity

Anderies et al. (2006) suggest that to develop an understanding of RT there is a need to develop formal models that generate back-loop behaviour (i.e., collapse and reorganisation) across scales. The IBM developed in this study can create back-loop behaviour (thresholds) across ecological temporal and spatial scales but this does not occur within the existing parameters at Cape Foulwind. The FCMs do not model back-loop behaviour because they are snapshots of the present understanding of a social situation, which is not in a back-loop part of the cycle. This reflects Andries et al.’s (2006) observation that only parts of the cycle occur in formal models which means they must be stitched together (qualitatively) to attempt to model the full cycle. This is the case in this study. Consequently, Andries et al. (2006) argue that the management of SESs is more of an art than a science and suggest that “context and experience matter” (p. 8). This suggests that ultimately the inhabitants are in the best position to ‘manage’ the situation. They know the context (local knowledge) and have the experience of place (situated).

Residents’ relationships have been associated with the notion of sense of place. Sense of place is considered a social attractor and is shown in this study to be important to the adaptability of the SES. The results suggest this is where the primary influences in residents’ desires and subsequent choices between actions lie in relation to weka. Their continuously changing relationships with weka are important role in creating complexity, tensions, instability (undecidability) and novelty for adaptation. Dillon (2000) stresses the importance of novel events, where complex feedbacks within and throughout open systems break down notions of boundaries.
These rich, often tension-filled, and changing relationships with weka are not necessarily linked to broader phases of the adaptive cycle. Neither is it clear that those changes can be characterized as the adaptive cycle or that the complexity at the individual level can be modelled as an adaptive cycle. Walker et al. (2006) note that the adaptive cycle does not apply to all situations (e.g., no release or conservation phases). Exceptions may occur when under the influence of large external disturbances and when there is a lack of important forms of capital. By contrast, the results of this study suggest that the Cape Foulwind weka-focused SES is not represented comprehensively by the RT adaptive cycle because: (1) Inhabitants’ understandings are not purely ‘rational’ and systematic by nature; (2) The adaptive cycle does not dynamically include inhabitants’ interactive relationships and ethical understandings in its analysis; (3) The Cape Foulwind SES analysed involves only a single species; (4) The social and ecological changes are spatially and temporally variable within the landscape.

The results show that weka contribute to or, in part, ‘make up’ the affective networks of place that the participants and myself are bound to by living our everyday lives at Cape Foulwind. An environmental ethic of sorts sits quietly here. This is an affective, relational, experiential placeness – an ethos. This is not considered as a set of explicit conceptual rules; it is installed from the world, our experiences and interactions. As such it is complex, situated, and fluid within, and among, individuals. Farmers did not hold one ethical position and non-farmers another. This point is reflected in Robbins’ (2006, p. 198) research; “debates over nature and environmental uncertainty cannot be seen as simple rhetoric or ideology, but rather as more deeply contested truths, that people form and defend based on highly variable personal, idiosyncratic, experience.” This reflects the variation in my participants’ discussions. Although non-farmers had a more normative relationship with the situation at the level of discourse, given the nature of their commitments this was less obvious in their practices. This is because if weka became inconvenient most participants took action to remove them. While many compromised their activities to some extent to protect weka, for most participants there were limits to this. It may be found that participants’ responses would be more consistent at a crisis stage (i.e., weka were consistently less important during a social crisis and more so during an ecological crisis).

To summarise, this study shows that relationships with weka and place are complex. This experiential complexity shows the need to consider the nature of relationships and ethics within a RT framework. It also highlights the need to understand the socio-cultural aspect of SES during and outside economic and ecological crises periods.
15.5 Summary and conclusion

15.5.1 Theory and SES

The New Zealand biodiversity strategy (2000) is a key New Zealand government policy document. Its statement on the value of biodiversity gives reasons for its importance. This includes its inspirational nature, its uniqueness, the existence of national icons, the supply of ecosystem services, the existence of medically and commercially valuable species; the pure economic value of biodiversity; New Zealand’s clean and green ‘brand’; and the intrinsic value of the variety of life. It does not mention experiential value; the everyday experience of the local landscape, or living with weka. This relates to everyday experience that is not necessarily inspirational. More specifically, and related to this research, Macleod et al. (2008, p. 7) “suggest research into the specific effects of intensifying agricultural practices and the perceptions and attitudes of farmers and the general public to farmland birds and farmland in general are important first steps to achieving more sustainable agricultural land use.” Macleod et al.’s (2008) approach is more personal but it does not focus on interactions. This study attempts these first steps, although through a slightly unconventional philosophy that is implicit in Macleod et al.’s (2008) use of the term ‘perceptions’.

Such an approach is supported by Mugerauer (2010) who expresses concerns with ‘representationally’ based research. He notes that it increases the amount of information available but does not recognise the immersive nature of such information or recognise its own incompleteness and interconnected feedbacks between inhabitants and the physical world implied by complexity theory and poststructuralist thought. Mugerauer (2010, p. 3) highlights “the importance of heterogeneities and particularities”, two dimensions important to the new epistemology of complexity and post-representationality. This research has incorporated both these dimensions. The first, as outlined in Chapter 3, involves systems concepts such as dissipative structures (Capra, 1996), self-organisation (Kauffman, 1995), autopoiesis (Varela et al., 1991), and dynamic systems (Fuchs, 2003). Mugerauer (2010) places these theories under the umbrella of the term ‘complexity theory’.

The second post-representational dimension relates to post-structural approaches explored under the overarching notion of immersion in Chapter 2. These approaches question the notion of representation, as set out in Chapter 4, to “stress that perception and cognition are not representations but performative constitutions” (Mugerauer, 2010, p. 1) that de-centre the subject. In this account, subjectivities do not revolve around a fully reflective consciousness but are ‘constructed’ and emerge through ongoing interaction. The understanding in this study is not completely ‘non-representational’ but reconsiders ‘representations’ as dynamic interactive guiding
mechanisms (see Chapter 4). It also explores and utilises affective threads associated with developments in post-representational thought (Thrift, 2008) and links it with theories of sense of place based in Heideggers’ philosophy with a significant embodied aspect derived from Merleau-Ponty and connected through Deleuze’s work to complexity theory. The results show the importance of interaction and affect in participants’ relationship with weka and place.

The material focus of the study takes up Ingold’s (2000) notion of a taskscape and shows how the Cape Foulwind landscape has developed, and is developing, through ongoing interaction between the human and non-human. The RT framework allowed this to be conceptualised as a complex, interactive and dynamic biological-physical-social process. The complementary use of post-structural concepts allowed the RT analysis to be consistently integrated into an understanding of the individual participants. This, in turn, allows the participants’ understandings to be considered as coming from immersed actors, both as a product and producer of their embodied, affective lives at Cape Foulwind. The anti-reductionist nature of systems theory emphasises interrelation and process, embeddedness and change, as a world always beyond us, which in previous work (Freeman, 2002) was called ‘wildness’.

The results show that the entirety of the participants’ understandings of weka cannot be traced to their embodied interaction and so other factors also exist. However, these factors, whether representationally or symbolically based, can be characterised as involving central material nodes of interaction (i.e., Cape Foulwind as an interactive node for weka) that expand outwards and overlap and intermingle as networks of meaning. These embodied interactive nodes are everywhere with everyone, and they can be considered to dominate subjectivities whether involving social or natural engagements. The ‘symbolic’ is always ultimately based in such nodes and finally always remains connected to them.

A hybrid social theory that is based on Structuration theory, ANT, and Deleuze’s philosophy was discussed in Section 3.5.4. This suggested cycles in network formation that can be conceptualised as systems. It extends the conceptualisation of the social in socio-ecological theory and, more specifically, Resilience Theory. Networks question a strict adaptive cycle framework and systems approaches allow simplification of complex networks for analysis. Ingold’s (2000) position would suggest that embodied interaction tends to ground such networked hybridised knowledge in the local landscape. The results show how situated embodied interaction can be shown to be a significant factor in peoples’ knowledge and perceptions. Weka respond to the activities of humans, themselves changing the taskscape (both aurally and physically) that in turn humans respond to in multiple complex networks of cycles and rhythms and which can be simplified and conceptualised as a SES. The consistency of the study findings with this approach suggest is it is a feasible ‘alternative’
rendering of the situation. However, it might not apply equally as well to other less interactive situations with wild animals. In this respect this research approach and emphasis should be considered complementary to other research.

‘Systems theory’ is ultimately derived from this everyday existence. Inhabitants’ knowing is intrinsic to understanding the affective, material, normative system itself. As already discussed, an RT analysis itself is always to some extent a normative or ethical analysis. Incorporating residents’ local knowledge into the analysis overtly incorporates this ethical aspect. Consequently, action on weka conservation will be undertaken because people think they ought to do it, and are motivated to do it. This contrasts with a purely rule-based or governance approach to conservation of weka.

In summary, the main contributions of this study are: (1) Developing an encompassing theoretical position for understanding SES. This was applied to the study as a whole; (2) Improving knowledge of the western weka population at Cape Foulwind and the impacts of land development; (3) Developing an expanded understanding of the limitations and use of FCMs; (4) Providing an outline of an approach to RT that encompasses inhabitants’ understandings.

15.5.2 Study limitations

There is an underlying difficulty inherent in applying the approach used in this study. As Mugerauer (2010) argues, old epistemologies can hide appropriate new theories. Dualisms implicit in the categories of ecological and social are not overcome by merely linking or adding them together at a conceptual level. Doing so creates obstacles to developing integrated theories that are founded in the recognition of the intertwining or inseparability of the human and non-human.

Making such changes, as Lingis (2004) claims, can be considered as discourse staking out a territory in which to operate. It brings terms, models, and methods from one field to another. It allows new things to be seen (e.g., boundaries, concepts, etc.). However, it also risks creating a difficulty in expression and also conceptualisation, and no doubt this occurs to some extent in this study. In addition, in this transdisciplinary study the different chapters focus on different aspects and disciplines. So each chapter to some extent becomes bound to the way (or language used) in which each discipline expresses itself. This is difficult to overcome, especially in the discussion where integration is attempted. In addition, the broad range of qualitative methods used, along with a theoretical approach based on the notion of relation, risks making the study disparate and not fully resolved. Significantly, the approach used implies such limitations on research so this is not considered a significant issue.

In the empirical part of the study this concern with a lack of clarity is revealed in Rikoon’s (2006, p. 202) argument that it is at “times of conflict that the boundaries of diverse forms of
knowledge become most overt and in which the need to mediate contrasting constructions of the environment are most critical.” This suggests that my participants may only start to stress certain aspects of their understandings when the situation becomes tenser. This study does not involve an overt problem situation as the landowners are largely prosperous and the weka population appears sustainable at present. In this respect it is a study of the everyday life of the Cape Foulwind landscape - one of those long periods of relative stability that arguably lies at the basis of responses that arise in situations of crisis or transition. Without insight into the relationship in these situations it is difficult to make sense of responses in less settled situations.

This both limits and widens the research. It limits it by not being able to predict scenarios as there are no strong trends in the weka population and no crises, or transition points that the human participants need to respond to. This is reflected in the theoretical approach that does not aim to, or even recognise the ability to, find ultimate solutions. The research is widened by considering both a less researched empirical situation and utilising the theoretical framework that allows the integration of phenomena.

The other difference with Rikoon’s (2006) emphasis on the exposure of knowledge at crisis points is that this study does not take a social constructionist position which in itself often concentrates on looking for contrasts or conflicting views in order to resolve conflicting ‘stakeholder’ accounts (i.e., “Resolutions of environmental conflicts in most public arenas require a decision about whose construction of the environment should be protected, and whose construction should be discounted.” (Rikoon, 2006, p. 202)). Rikoon (2006, p. 202) goes on to say that “[i]n these contexts, settlement rarely depends on any objective measure of whose construct is ‘better’, but rather on which competitor has the greater power—usually political and economic power—to influence the decision-makers.”

I am not suggesting that notions such as power are not useful in understanding these situations. Popke (2009) notes a lack of consideration of the effects of power is seen as a limitation in post-structural accounts; “while the in-common of the social may be ontologically and materially performed, it is on a stage whose architecture is, at least to some extent shaped by a set of powerful global narratives that still have much to say about the nature of our events, encounters and collectives.” (Popke, 2009, p. 86). However, the everyday is a part of, and also disturbs questions and changes such dominations. Likewise, I do not wish to deny the role of tradition and language such as the broader history of European and New Zealand culture (Andrews, 2009) and its sedimented meanings carried in language, artifacts and practices, and their influence on the contemporary practices and concerns of my informants. There is no doubt the relationship between language and practices, immersion and reflexivity is subtle and complex. However, I wish to highlight that practices
are continuously recreated and developed through situated interaction with the world. This involves rethinking symbolic culture in the form of interactive topological networks (Latour, 2005) based primarily in material practices.

15.5.3 Modelling

Crane (2010) argues that although models are useful and probably necessary heuristic devices to help analyse complex SES for governance purposes, they come at a cost. This is because of every model’s tendency to reduce such systems to mechanist interactions and in doing this it misses the perspectives of the people who live their lives within these SESs. For such people “a social–ecological system is more than just a useful heuristic construct. It is the very material, social and symbolic landscape that contextualizes and constitutes their lived experiences.” (p. 10). The imposition of scientists’ explanatory frameworks (e.g., systems theory) over and above the ‘folk’ knowledge implies its epistemological primacy (i.e., etic over the emic). So while inhabitants would still likely recognise such empirical models, “those models would be evaluated from positions situated within the system; positions that implicitly include normative values vis-à-vis empirical phenomena.” (Crane, 2010, p. 11).

In the approach taken in this study the participants’ world is firstly based in their material interactions so their understandings are a valid material understanding (i.e., local knowledge). Further, the normative is also not entirely ‘symbolic and constructed’ but related to material interactions. Crane (2010) suggests biophysical models act as boundary objects linking and realigning both inhabitants and land management understandings. I suggest for this to be the case such a model needs to incorporate both etic and emic understandings. Only then can the discussions associated with it “have the potential to more effectively integrate both technical and normative positions relating to potential adaptation pathways.” (Crane, 2010, p. 10). This involves recognising that models are not neutral or objective etic accounts but are themselves normative ones. Recognising this reduces the treatment of inhabitants as naive or un-insightful. An affective, embodied, situated philosophy neatly underpins this account.

For modelling to be useful in such a participatory context, Mendoza & Prabhu (2006) argue that it should be able to be understood by the participants but also structured enough to be useful in resource management decision making. The results from this study supports Mendoza & Prabhu’s (2006) assertion that FCMs are one modelling tool that encompasses the “technical expertise of scientists, and the ‘folk’ knowledge of the stakeholders” (p. 190). The FCMs created in my study suggest that the participants were able to recognise the processes at Cape Foulwind and weka in systematic terms.
For these reasons, the results of this study do not claim to identify pure causal links and so cannot be used to predict how events may unfold. This is consistent with the non-linear mathematics involved in CAS that produces attractors as a replacement for linear mathematics (Mugerauer, 2010). However, Mugerauer (2010) notes it is still not clear how this post-positivist understanding of causality, prediction and explanation relates to the natural science move away from certainty to statistical probabilities and best explanations, as well as their ability to explain and predict. Nor does it indicate how they can best be translated into present scientific and technological practices.

Mendoza & Prabhu (2006, p. 181) suggest anticipatory models that take into account multiple views and the complex issues involved with resource management problems should be viewed as “problem structuring tools” rather than tools that solve issues or give optimum solutions.

This study shows beyond these tensions there are other factors limiting the modelling of the Cape Foulwind non-crisis SES. This includes such factors as: (1) ongoing change from interaction; (2) some disparity between action and discourse; (3) the implicit importance of some essential practices; (4) the existence of affective networks and the role of affect; (5) the understanding of weka as actants; (6) the role of immanence. Many of these factors likely apply to the modelling of other SESs.

15.5.4 Governance

The issue of governance has a central theme that parallels the one in the previous section; the tension between the etic and emic.

Crona & Hubacek (2010) outline how shortcomings in command and control approaches to resource management were exposed in the social and environmental crises that tended to arise from attempting to control SESs. Contemporary management interventions are considered a social response, but above the level of the residents. In this respect there are four main kinds and scales of governance interventions proposed for SES by The Resilience Alliance (2007): Policy and institutions; fiscal and monetary; management guidelines; and, education. It is suggested the different types are applied to different phases of the adaptive cycle.

Other collaborative ‘governance’ approaches have been developed (participatory methods) that focus on ongoing learning associated with the inclusion of knowledge from various sectors of society. Mendoza & Prabhu (2006) state that participatory methods are commonly accepted as the most effective approach for sustainable resource management. However, this requires more knowledge of the social processes involved and the relationships among the various social actors (Crona & Hubacek, 2010). Participatory approaches allow the integration of local knowledge, the inclusive exploration of issues, and the recognition of the complex nature of problems (Mendoza & Prabhu, 2006). However, participatory approaches have been criticised by resource management
practitioners, scientists and managers for a lack of rigour and lack of an analytical framework (Mendoza & Prabhu, 2006). To this end, Dougill et al. (2006) note the difficulty of integrating scientific and local knowledge and perceptions as well as highlighting the lack of consensus on how to do so. Goldstein (1999) suggests strategies to do this. These are: (1) Highlight the significance of place based knowledge (2) Search for scientific approaches that are most compatible with place-based activity. This study does both of these things. It suggests systems as a potential way to bring science and place knowledge together and also highlight the importance of place knowledge.

Another limitation identified in the research is that a conventional participatory approach considers “multiple stakeholders and their multiple interests, plurality of perspectives, and the empowerment of local communities and stakeholders.” (Mendoza & Prabhu 2006, p. 180). This gives stakeholders the ability to have an active and direct involvement in planning decision making. However, the term ‘stakeholders’ implies separate sets of individuals holding separate sets of interests. Where decisions are based on attitudes, stakeholders and mental models, it is assumed that the right/best thing to do is an assembly of various positions. The world itself is treated as inert rather than animated and only gains fullness through these varied ‘views’.

Due to these concerns, this study has taken holistic approach to the relationships of weka and people on the Cape Foulwind Peninsula. It has attempted to address the situation starting from a basic philosophical position and developed various threads to support this. It has collected a range of empirical data, modelled it in various ways, including an RT analysis. The abductive methodology used meant that the theoretical development was as important as the empirical data.

The study has proposed an affective, embodied, situated interwoven reality where people are primarily embedded in the everyday. This world is considered to be a dynamic, emergent, complex becoming consistent with contemporary systems science and the post-structural position outlined in Chapters 2 & 3. This is a reality that resists a complete reflexive exposure. The study traces how the participant’s ‘views’ of weka arise, and shows their complexity that is based on interaction. This complexity exists within individuals and within participant groups. These relationships tend to resist tidy categorisation and the development of simple covering theories. Weka are active agents in the affective, embodied network of the Cape Foulwind place; they are an engaging nuisance. They are wild animals that contribute to, and make up, the lives of the participants.

The study also found weka population is being put under some pressure through land development. In this respect, the study has finally considered questions about what ought to be done and who makes the decisions. At one level the answers are obvious: Either work with the farmers as a researcher to retain vegetation cover on their land to help maintain the weka
population; or, work with the land management bureaucracy to achieve the same outcome. Taken from the theoretical position of this research the answers are not quite so clear, as any answers link back to the participants’ understandings. In this respect, this study’s interest is as much about how people respond to changes in the experiential non-human aspect of place and less about education or intervention. If local people are not concerned this does not mean that the social structures are inadequate, or the networks misaligned, feedback delayed, or at an individual level that they are ‘heartless’, ‘misinformed’, or ‘in denial’.

The answer from the participants in regards to the protection of weka is a general, but complex, ‘yes’. Consequently, taking a governance approach whose outcome is to impose rules on the landowners at the earlier social re-organisational stage may, in this case, be premature. It would also remove the opportunity for landowners themselves to respond. This ethical approach parallels the importance of self-organisation in CAS’s and the role of endogenous processes in change (Carpenter et al., 2001). The understanding of an ethic developed in this discussion suggests this short-circuiting might not be the best approach in the long term, as landowners’ ethical responsibility is removed. Thus, the basis of a cultural ethic of place is at risk of being circumvented and, furthermore if interaction disappears, is then lost.

The situation could be encapsulated in what the study shows as the central tension between care and nuisance and how participants react to this. This sits on a thoroughly interactive boundary where the outcomes are not known and cannot easily be modelled.

This leaves the question of how can this study can be used as a social learning tool? The modelling itself could be considered “as a tool for anticipating change within the system ... enabl[ing] a greater degree of self determination over the processes of cultural transformation that accompany ecological and livelihood change.” (Crane 2010, p. 10). This could trigger a response from the inhabitants. In this respect the study informs; It lets the inhabitants make decisions without overriding inhabitants’ knowledge. This knowledge is a hybridisation of ‘voices’ – as sciences, systems, participants, weka, and the landscape are all given a voice in this study. All are valid, and all contribute to the ‘topological network-systems’ that make up the place of Cape Foulwind. This is recursive, as ‘informing’ also incorporates inhabitants’ knowing and so in this respect it becomes knowing about their own knowing. As an alternative, the results could create a change in governance (i.e., changing land management policies for land development). Indeed, information from this study may be important for provoking a response. However, there is an element of undecidability here. A tension lies between invoking governance or letting the ‘lifeworld’ prevail.
The quarry to the north noisily expands its shallow chasm.
The farmer to the east digs up his paddocks to drain them.
The green smudge of a pine block way off to the south gets slowly larger.
A new slip appears on the flanks of the Paparoas.
Two bittern boom this year.

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References


