BRIEF COMMUNICATION: Re-designing New Zealand's productivist livestock production systems: Current strategies and next steps

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Abstract

Intensive, monotonous and specialized pastoral livestock production systems (productivist systems) are under significant pressure to reduce environmental impacts, increase biodiversity, animal welfare, and resilience. Efficiency/substitution strategies have been advanced to improve them, focusing on adjusting system components to reduce externalities of regulatory concern. They have received much research attention, policy and farmer support. However, many argue environmental impacts are not sufficiently reduced, and biodiversity, animal welfare and resilience remain unchanged. Biodiversity farming strategies have also been promoted, based largely on their application to less productive land. They are more spatially and/or temporally complex, less specialized, and promise to reduce multiple environmental impacts, improve support for biodiversity, animal welfare and increase resilience. However, few systems have been designed for highly productive land, there is insufficient amount of supporting research, and less policy support and awareness among farmers. Therefore, there is a high degree of uncertainty about their supporting farming practices, ecosystem services, and viability. Through multi-disciplinary research teams, and holistic and expanded spatial and temporal perspectives, Universities can play a key role in exploring, *ex ante* evaluating, and demonstrating new innovative system alternatives, that reduce this uncertainty and facilitate the transition to healthier viable animal production systems.

Keywords: Livestock production systems; re-design

Introduction

Intensive, monotonous and specialized pastoral livestock production systems are often referred to as productivist agricultural systems (e.g. Wilson & Barton 2015). They developed incrementally, following World War II, to maximize yield through the removal of heterogeneous site-specific conditions (Duru et al. 2015). This was accomplished through the addition of external inputs such as water, fertilizers, pesticides, fuel and/or food stocks (Hutson et al. 2013), and the replacement of heterogeneous green infrastructure with monotonous swards (Foley et al. 2005). Green infrastructure consists of networks of natural, semi-natural and artificial vegetated elements and water bodies in pastoral landscapes (e.g., shelterbelts, riparian vegetation and waterways) that provide many private and public ecosystem services (McWilliam & Balzarova 2017). They are often viewed by farmers as external to animal production systems. However, they can be designed to provide valuable private ecosystem services, such as forage in support of animal welfare (Gregorini et al. 2017), as well as a healthy aesthetic experience to the public (Nassauer et al. 2001; Gobster et al. 2007), in support of the social license to farm. This license is the approval the public gives to farmers that enables them to farm (Edwards & Trafford 2016). When it is firmly in place there is an alignment between public and farming industry values (Rolleston 2015). This is considered an indicator of sustainable farming (Beef and Lamb New Zealand 2015).

Productivist systems are internationally criticised for their environmental impacts (e.g. United Nations 2011) and pressure to re-design them is high (Gregorini et al. 2017; Le Gal et al. 2011). In New Zealand, their impacts include pollution of waterways (Parliamentary Commissioner for the Environment (PCE) 2013), degradation of lowland ecosystems, including indigenous biodiversity (MfE and Statistics New Zealand 2015); high greenhouse gas emissions (Saunders & Barber 2007), and reduced animal welfare (Gregorini et al. 2017). All jeopardize public perceptions of pastoral farming (MfE 2001), undermining the social right to farm.

This paper explores two prevailing strategies for increasing the healthy function and appearance of productivist animal production systems, and their current level of research, policy support and implementation among farmers. It then outlines next steps for advancing the transition to viable and healthy system alternatives.

Prevailing strategies for re-designing productivist systems

Efficiency/Substitution design strategies

The most popular strategy for redesigning productivist systems is referred to as ecological intensification (Hochman et al. 2011), weak ecological modernization (Duru et al. 2015), and efficiency/substitution-based agriculture (Duru et al. 2015). Hereafter, we refer to such strategies an efficiency/substitution design strategy.

These strategies focus on altering components of one specialized animal production system in order to reduce environmental externalities for compliance with regulations (Duru et al. 2015). This is accomplished by increasing the efficiency of the use of inputs such as water or fertilizers (Kuisma et al. 2013), using precision technologies (Rains et al. 2011), replacing chemical with organic inputs (Singh et al. 2011), using genetically modified organisms (Godfray et al. 2010), and implementing good farming practices (Ingram 2008).

In terms of green infrastructure on both productivist and efficiency/substitution-based systems, many New Zealand farmers are increasingly incorporating it, particularly riparian and wetland vegetation (McWilliam et al. 2017). They are inadvertently implementing what is referred to as a sparing nature conservation strategy (Waggoner 1996) largely at the field spatial scale. In these strategies, farmers "set aside" land for nature conservation (Fischer et al. 2008) as they do not view green infrastructure as contributing to production. Nature and agriculture are believed to be incompatible. Visually, this leads to "islands" of green infrastructure that sharply contrast with areas of pasture and crops. Wherever possible farmers conserve and plant it within un-productive areas, but may put it in productive areas where it provides sufficient private ecosystem services such as animal shelter, or where it enables policy compliance (McWilliam et al. 2017). The resulting green infrastructure systems tend to be small in area and fragmented and are often not designed to support specific ecosystem services (McWilliam et al. 2017).

Promoters of a sparing strategy argue that if agricultural production can be intensified on the most productive areas, then remaining land could be permanently set aside for nature conservation (Green et al. 2005). However, within productive landscapes sparing of significant areas is only likely to happen on government-owned land since private landowners are unlikely to sacrifice significant areas to uses they view as unproductive (Fischer et al. 2008). And, where there is little green infrastructure, there is more likely to be little mitigation of the environmental impacts of productivist or efficiency/substitution-based systems (Matson & Vitousek 2006).

While these strategies have received much research and policy support, and are being implemented among some farmers, several studies indicate resultant systems fail to significantly reduce some environmental externalities (Levidow et al. 2012; Marsden 2012) in large part because externalities are not reflected in agrifood prices (Levidow et al. 2012). In addition, they do not address indigenous biodiversity, animal welfare or increase resilience.

Biodiversity design strategies

A second strategy for re-designing productivist systems is referred to as ecologically intensive farming (Kremen et al. 2012), eco-functional intensification (Levidow et al 2012), strong ecological modernization, and biodiversity-based agriculture (Duru et al. 2015). Hereafter, we refer to these strategies as a biodiversity design strategy. The goals are to reduce the negative impacts of productivist agriculture, provide additional private and public ecosystem services, and improve system resilience.

Goals are accomplished by reducing external inputs, matching the farm system to the biophysical capability of the land, introducing multiple production systems through time and/or space, and by increasing green infrastructure. The result is a heterogeneous spatial and temporal complex of crops, livestock, forestry and/or green infrastructure sub-systems. Mixed systems have been implemented for thousands of years, but in industrializing nations their sub-systems began to be separated in the Middle Ages (Smith et al. 2012). Since the 1990s; however, they have been promoted as ways of maintaining overall production levels where intensive specialized systems lead to unacceptable environmental impact (Smith et al. 2012). They have also been promoted as ways to reduce environmental impacts, enhance biodiversity, animal welfare (Gregorini et al. 2017), and increase carbon sequestration (Montagnini & Nair 2004). Resilience might also be increased as ecosystems with spatial and temporal variability have higher adaptive capacity and resilience in the face of disturbance relative to monotonous systems (Walker & Salt 2006). For example, they are known to reduce the risk of pest outbreaks, pathogen transmission, and buffer climate fluctuations (Schiere et al. 2002). Furthermore, multiple production systems have the potential to improve income stability as the price of one product may increase as another declines. They might also improve cash flow, as the sale of one product can provide early returns while another is still maturing (Hawke & Knowles 1997; Lin 2011).

In terms of their green infrastructure, biodiversity farming systems are employing more and/or higher functioning green infrastructure in enhanced sparing and sharing strategies. Enhanced sparing strategies can provide private benefits to farmers via certification programmes. For example, one New Zealand dairy company's certification program awards price premiums in return for setting aside at least 5% of farm area in green infrastructure (McWilliam & Balzarova 2017). The higher production cost is recovered through premium pricing to new markets willing to pay for products they view as healthier. Consortiums of food companies and retailers are also providing financial incentives to suppliers who meet environmental production standards. They use technologies such as blockchain, to increase food supply chain transparency. Blockchain is a ledger system that allows access to information about the origins and production methods of food (Clancy 2017).

Green infrastructure sharing strategies are also increasingly being promoted. They are categorized as sharing if they are viewed by farmers as contributing to production. For example, shelterbelts that produce lumber, firewood, fruit, or nuts, or that are seen as essential to animal production (e.g., as shelter or forage) are sharing green infrastructure. And, plants previously considered "weeds" are increasingly being planted in pastures for their contribution to animal welfare, and health (Gregorini et al. 2017), in addition to reducing urinary nitrogen excretion (Beukes et al. 2014). Visually, this leads to farms appearing more nature-like or natural in appearance as the green infrastructure is integrated into areas of production, rather than appearing to be separate. Research is required to determine whether the appearance of farm systems with these characteristics project a healthier farming image among the public in support of the social licence to farm compared with the more dichotomous and monotonous characteristics of productivist or efficiency/substitution systems.

Unfortunately, while there have been many applications on marginal farm land (Wilkinson 1999), few of these systems have been designed for productive land (Duru et al., 2015). Designing farm systems that respond to site-specific conditions through time is complicated compared with the "one size fits all" designs of productivist systems. In addition, there is a lack of research evaluating such systems (Miles et al. 2017) and therefore a high degree of uncertainty surrounding interactions between biodiversity farming practices and their ecosystem services. Furthermore, there is a lack of policy support and awareness of these alternative systems among farmers (Smith et al. 2012).

Conclusion

Alternatives to productivist animal production systems have yet to be developed that are proven ecologically healthy and viable. Efficiency/substitution solutions do not adequately mitigate many of their environmental impacts, nor do they increase low indigenous biodiversity, animal welfare or improve system resilience. Their solutions are too narrowly focused on adjusting productivist system components and do not significantly alter their current levels of intensity, monotony and specialization that are root causes of negative externalities. Biodiversity strategies, on the other hand, are conceptually promising as their characteristics are significantly different to those underlying productivist systems. Biodiverse systems, within less productive landscapes, tend to less intensive (at least in terms of a single production system). They are more diverse in terms of both production systems and biodiversity, and because of these characteristics tend to be more resilient. However, we know little about what these systems might look and function like in productive agricultural lands. Are they truly ecologically healthy? Do they look healthy to the public in support of the social right to farm? Are they viable? Do they provide farmers and farm workers a good quality of life? Do they support healthy communities, including other business sectors such as tourism? Do they support high animal welfare and well-being? Do they help to support indigenous biodiversity in the landscape? And, how might they be governed effectively? All these questions need to be answered through research to reduce the uncertainty and their risk of failure prior to their uptake among farmers.

Designing and evaluating the multiple facets of these systems, which are often interrelated, requires more holistic, synthetic and complex systems thinking than the reductionist thinking that is so familiar and fundamental to scientific enquiry. Animal production systems are made up of different interrelated sub-systems occurring at different spatial scales, from the field to the region. For example, while a grazing system might be designed at the intra-field scale to support on farm animal production; water systems that support entire communities need to be designed at the catchment scale. These systems also function over different time scales, from daily, weekly, seasonally to over many years (Le Gal et al. 2010). Thus, system alternatives need to be designed at multiple spatial and temporal scales and involve multiple stakeholders beyond the individual farmer (Sayer et al. 2013).

Universities are well-placed to advance the identification of innovative alternatives though interdisciplinary teams of experts who work together to bring the necessary expertise and multiple spatial and temporal system perspectives to the design process. They can also lead in the *ex ante* evaluation, demonstration, testing and adaptation of these alternatives to reduce uncertainty and the current high level of risk associated with their adoption among farmers.

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