AN ECONOMIC EVALUATION OF THE BENEFITS OF RESEARCH INTO BIOLOGICAL CONTROL OF *CLEMATIS VITALBA*

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PREFACE

The economic consequences of scientific research have received greater emphasis in recent times. This has led research decision makers to make wider use of ex-ante economic analysis as an aid in allocating research funds. The extent to which the potential economic consequences of research can be estimated using information derived from existing markets varies between projects.The degree of certainty with which the outcome of a research project can be predicted is also variable. The tools of economic analysis provide the means of evaluating projects such as those aimed at prevention of environmental degradation which has no value assigned by the market-place. They also enable evaluation of projects with uncertain outcomes.

The work reported in Research Report 203 provides an example of "non-market" valuation of a biological control program. Using a technique known as contingent valuation, the amount members of society would be prepared to pay for the implementation of such a project has been estimated. Their willingness-to -pay is assumed to be equal to the value they place on this research. As more than one interpretation of the results can be made this method provides an upper and lower bound rather than a point estimate of society's valuation.

The issue of uncertainty in research project appraisal has been addressed by other work undertaken in the Agribusiness and Economics Research Unit. Research Reports 201 and 202 provide examples of the use of economic analysis to evaluate research programs which have highly uncertain outcomes. These reports deal with projects whose outcomes can be largely valued using a market approach.

Further work in the area of research investment evaluation is continuing in the AERU. An assessment of the benefits of introducing specialist pollinators for red clover seed crops is presently being undertaken. Evaluation of the economic benefits of a biological control program for Rose-Grain aphids has also been completed.

Further development of the method described in this report will undoubtedly occur. It provides a valuable framework for the assessment of many research projects, particularly those concerned with environmental issues which frequently have "non-market" outcomes. Its use can contribute significantly to informed deployment of scarce research resources.

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Assistant Director

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Many people provided assistance with this study, which could not have been completed without their efforts. These include the thirteen hundred individuals throughout New Zealand who responded to the survey, thereby making the study possible.

The authors are extremely grateful to Richard Hill and Pauline Syrett of the DSIR for their assistance and guidance in the initial stages of the project.

Carol West (DSIR) and Phillip Lissaman (Queen Elizabeth II National Trust) put considerable effort into finding suitable photographs for the questionnaire, as did a number of other people whose photographs were not included.

Thanks are also due to the Noxious Plants Officers from all Regional Councils and members of DOC staff who provided details of the present costs of *Clematis vitalba* control.

Sincere appreciation is expressed for the work done by Geoff Kerr of the Centre for Resource Management for his advice on the methodology and his analysis of the data.

The initiative for the study came from DSIR Plant Protection. Funding was provided by the Department of Conservation, the Noxious Plants Council, the Wellington Regional Council, the Wellington City Council, Lower Hutt City Council, Wainuiomata District Council and Eastbourne Borough Council.

SUMMARY

Clematis vitalba, or Old Man's Beard is a weed which is invading New Zealand's native bush. Introduced as a garden species, it has now spread into native bush in many areas of the country and is regarded as a very serious threat to native forests. The plant, a deciduous vine, climbs existing vegetation, smothering and eventually killing the trees below it.

Present control measures include chemical application and hand-cutting or pulling, but the weed is still spreading in many areas. Consequently scientists are considering implementation of a research program with the aim of identifying and introducing biological agents which would control *Clematis vitalba*. An economic evaluation, undertaken to determine whether such research is justified, is the subject of this report.

The study comprised two parts. The first involved the estimation of the benefits of such research to New Zealand society. There is no market value for scenic resources such as native bush. Consequently a non-market valuation technique known as contingent valuation was used to elicit the community's willingness to pay for the research, as a proxy for the benefits they expect to receive from it. A postal survey of 3,000 randomly selected adult New Zealanders was conducted and valid responses were received from 46 percent of them.

The second part of the study consisted of collection and compilation of data on existing control expenditure from local authorities and Department of Conservation officers.

Three major conclusions emerged from the study. The first was that New Zealanders are prepared to pay significant amounts of money for a chance of controlling *Clematis vitalba*. Upper and lower bound estimates of $111 million and $44 million were estimated.

The second conclusion was that the problem of damage to native bush by *Clematis vitalba* should be dealt with from a national perspective. Although the weed is not found in all regions of the country the study found that individuals from all over New Zealand were prepared to pay similar amounts for research into biological control.

Finally the study concludes that the resources currently devoted to the control of *Clematis vitalba* are considerably less than the value to New Zealanders of preventing its further destruction of native bush, and that funding of research into biological control is fully justified.

CHAPTER 1

INTRODUCTION

1.1 *Clematis vitalba* - Background

Clematis vitalba, commonly known as Old Man's Beard, is a native of Europe which was introduced to New Zealand as a garden plant early this century. In areas where conditions were favourable the plant spread into the native bush and has now covered hundreds of hectares of native forest. It is a deciduous species which flowers in summer and has conspicuous white fluffy seed heads which persist on the vine during winter. The vines, which can grow to over 26 metres in height in New Zealand (Ravine, 1989) use other plants as a means of support, growing rapidly over host plants, depriving them of sunlight and eventually killing them. All that remains is a tangled thicket of *Clematis vitalba* draped over the stumps of dead vegetation.

The plant is reproductively efficient, producing large numbers of feathery seeds which are dispersed by wind, water and animals. Dispersal by water is particularly effective and, as can be seen from Figure 1, clumping of infested areas along waterways is common.

Clematis vitalba was recognised as a threat to native bush during the 1960s and efforts to control its spread in native reserves began in a sporadic fashion during the 1970's. "During the 1980's more effective control methods were developed. Informal strategies followed, which concentrated on clearing reserves with light infestations and leaving reserves considered impractical to clear. This is basically the approach that the Department of Conservation inherited and now follows." (Ravine 1989).

Control is undertaken by a combination of handpulling or cutting and chemical application.

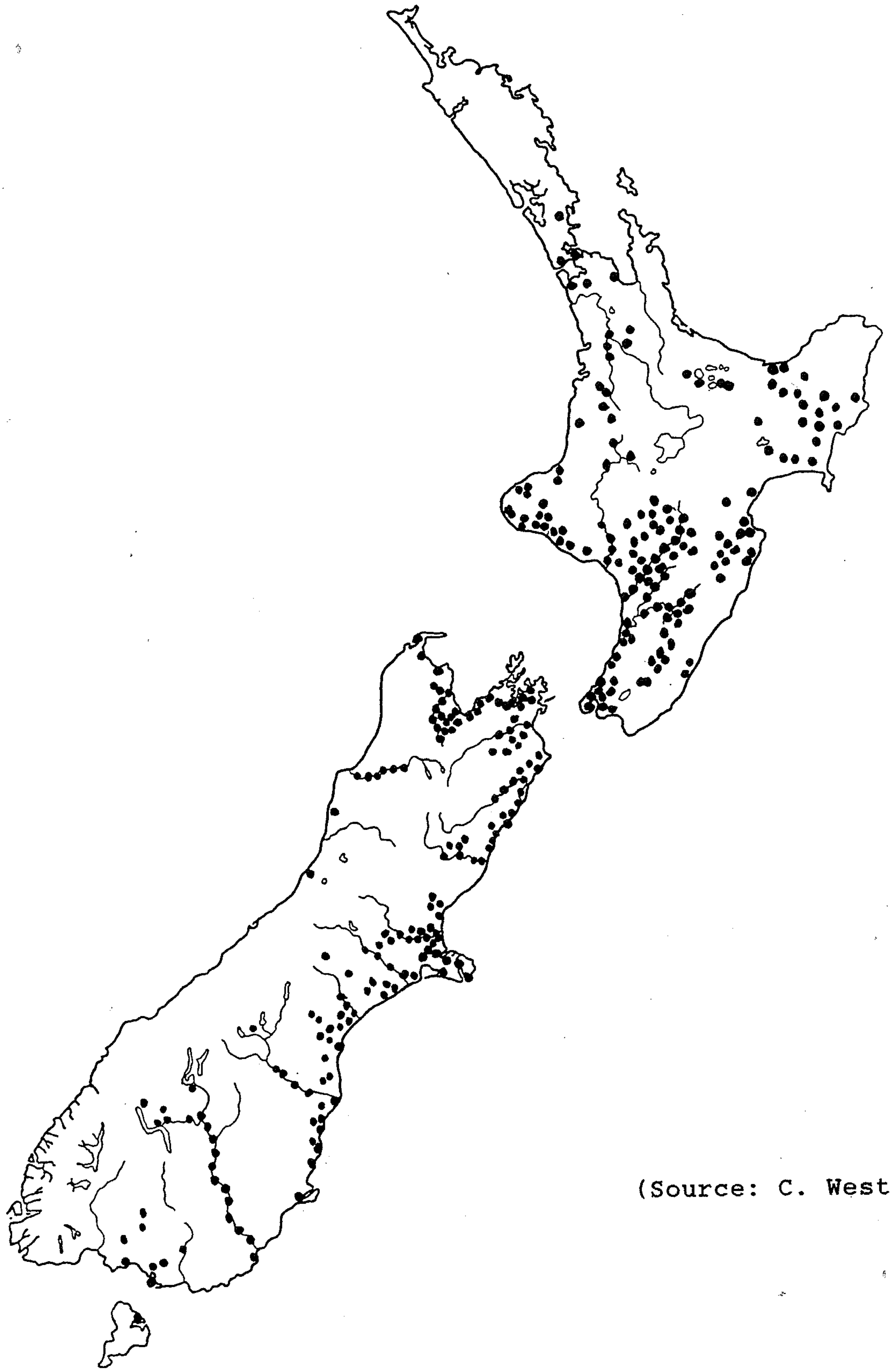
In addition to the efforts of the Department of Conservation *Clematis vitalba* has been gazetted a Class B "target" noxious weed in 33 (approximately 37 percent) of the local authorities which existed prior to the current local authority restructuring. In these areas, as well as the efforts of local authority staff, landowners are legally required to control *Clematis vitalba* on private property.

1.2 Distribution

Clematis vitalba is found throughout the country from north of Auckland to Stewart Island. River banks and urban areas in Wanganui, Taihape, Mangaweka, Manawatu, Wellington, Nelson, Waimea Plains, Marlborough Sounds, Kaikoura Coast, Canterbury Plains, Christchurch and the Clutha are most seriously infested. Many other areas are lightly infested (West 1987). In a number of these the weed has been gazetted a Class B 'target', thus placing on the landowner a legal obligation to eradicate it. Figure 1 shows the distribution of *C.vitalba* as recorded by a distribution survey carried out during the mid 1980s (West unpubl.).

The plant colonizes forest edges where there is plenty of light and moves towards the centre of the forest as the outer trees fall over. It gets access into forests along roads, waterways and other gaps. It can also be found along riverbanks and in gardens and shelterbelts.

Figure 1
Distribution of Clematis Vitalba in New Zealand



(Source: C. West)

1.3 Biological Control

The rapid spread of *Clematis vitalba*, the expense of chemical control and the impracticality of controlling large infestations, particularly in inaccessible locations, by currently available means have led DSIR Plant Protection staff to consider biological control measures. Biological control involves the identification and introduction of insect or disease agent(s) which would control *Clematis vitalba* without having adverse impacts on other species of plants.

Such research has a relatively low probability of a successful outcome, that is of finding a biological agent which will have a sufficiently damaging impact on the *Clematis vitalba* population to prevent further damage to native bush and allow some regeneration of areas damaged but not killed.

"Biological control can never eradicate a plant from its environment; it can only make it less dominant there. Successful control would mean that plants would grow less vigorously, produce fewer seeds, and be far less abundant. In short, the weed would not damage the underlying forest and would behave much more like the native clematis species already present in New Zealand forests.

At this stage, it is impossible to predict how successful this particular biological control programme will be. For example, it is not known how many biological control agents are available, how well each would establish or how well they would perform if released in the New Zealand environment. Such questions can only be answered once the programme is underway, or in some cases, once it is complete. Each programme is unique. It is true that many biological control programmes have not had any economic impact on the target weed, but it is equally true that many weeds around the world have been so well controlled, they are no longer regarded as weeds. However, such judgements can only be made in retrospect, not at the beginning of a project. While biological control is a high risk investment, this must be weighed against the high cost of doing nothing." (Richard Hill (DSIR) pers. comm)

If successful, the research project will have a high payoff in terms of saved expenditure on other means of control and, perhaps, a higher level of control than can be achieved with limited resources by those alternative means. In addition, if biological control of *C. vitalba* can be achieved, the input of chemical sprays into the environment will be reduced which will be seen by many as an advantage.

1.4 The Purpose of the Study

The primary purpose of this study was to assess the economic benefits to New Zealand society of research into the biological control of *Clematis vitalba*. Scenic resources such as the native bush do not have a value assigned to them by the market-place as they are "non-market" goods which are not bought and sold. Consequently the market provides no estimate of the cost to New Zealanders of damage to native bush by *Clematis vitalba*. Techniques exist, however, which permit estimation of that cost by determining the amount that society would be willing to pay to avoid the further occurrence of that damage.

This study employs one such technique, known as contingent valuation to estimate New Zealand society's willingness-to-pay for research into the biological control of *Clematis vitalba*. This estimate of the value of such research will provide decision makers with a basis for determining whether the research program should be implemented.

A second aim of the study is to collate all the available information on present and projected levels of expenditure on the control of *Clematis vitalba* by local authorities and the Department of Conservation. Resources do not permit a survey of private landowners in affected areas to elicit details of their expenditure on *Clematis vitalba* control. Using this information the minimum savings to be achieved if the research into biological control is successful can be estimated.

1.5 The Organisation of the Report

The remainder of this report is organised into four chapters. Chapter 2 reports the presently employed methods of *Clematis vitalba* control and their costs. In Chapter 3, the commonly used techniques of non-market valuation are described and their suitability for this study discussed. The survey methodology and analysis are described in Chapter 4 and the results of the analysis and its implications discussed in Chapter 5.

CHAPTER 2

CONTROL OF *CLEMATIS VITALBA* - CURRENT METHODS AND COSTS

2.1 Methods of *C.vitalba control*

There are a number of methods available for controlling infestations of *Clematis vitalba* at present. These range from purely manual to purely chemical. These methods are extremely effective providing they can be applied to the whole infestation but they are all costly. Methods include:

a) Cutting vines at approximately one metre above ground level during winter then spraying regrowth with 'Roundup' in spring or early summer. This method minimizes damage to surrounding vegetation but effectively kills *Clematis vitalba*.

b) In areas where access is difficult the whole infestation is sprayed in summer thus increasing damage to indigenous vegetation. As the method is less effective repeat spraying is necessary.

c) Helicopter spraying with "Roundup" has been experimentally used and has found to be effective although moderate damage to indigenous vegetation is incurred.

d) Isolated plants may be hand-pulled or individually treated with a granular herbicide.

These methods have been employed both by the Department of Conservation and by local authorities throughout much of New Zealand.

2.2 Costs of *C.vitalba* Control

The expenditure on the control of this weed varies enormously between areas according to the distribution of the plant. In order to determine total publicly funded expenditure on *C.vitalba* control, letters were sent to DOC regional offices and to the noxious plant officers of all district noxious plants authorities. Staff in each area were asked for the levels of expenditure on control in recent years and for any projected levels of expenditure for the future.

2.2.1 Department of Conservation

At the time of the study the Department of Conservation (DOC) was in the process of restructuring. The eight 'old' conservancies were being further divided into 14 regions. The new regions at this time had only skeleton staff. Consequently letters were sent to the staff responsible in each of the old regions requesting information. In some areas only historical and current expenditure data was available as information on planned expenditure in the new conservancies was not yet known.

The expenditure data received from DOC officers is summarized in Table 1. Most of the data recorded were approximate only. The total includes expenditure on both DOC estates and Unallocated Crown Land.

Table 1

Expenditure by DOC on *Clematis vitalba* Control

			($)		
Old Conservancy	1985/86	86/87	87/88	88/89	89/90
Auckland	0	0	0	0	0
Waikato	500	500	2000	2000	4000
Bay of Plenty	0	0	0	0	3000
Manawatu/Wanganui	-	-	256000	261000	446000
Nelson/Marlborough	-	-	24600	29000	39000
West Coast	-	-	50000	50000	61000
Canterbury	0	0	0	0	2000
Otago	0	0	0	0	0
	500	500	332600	342000	555000

Little information was available on planned future expenditure at the time of the study. The old Waikato Conservancy estimates that $1,500 to $2,000 will be required in the Te Kuiti area (S.Kelton pers. comm); $8,500 will be required to complete eradication on DOC estates near Rotorua (C.Richmond pers. comm). Estimated levels of expenditure for the areas covered by the Old Wanganui Conservancy for the next three years were $193,500, $139,500 and $95,500 respectively (B.Fleury pers.comm). Expenditure in Canterbury may increase to $10,000 per annum over the next five years (M.Mason pers. comm). A trial on herbicide application rates and impacts is about to be undertaken in the Tapanui area of the Old Otago Conservancy (G.McKinlay pers. comm).

The net present value discounted at 10 percent ($ 1989) of DOC expenditure on the control of *Clematis vitalba* is estimated to be $1.39 million.

2.2.2 District Noxious Plants Authorities

A list of ninety District Noxious Plant Authorities (DNPAs) and additional local authorities was furnished by Mr John Randall of the Noxious Plants Council. Unfortunately, at the time of the study, all local authorities were undergoing restructuring and the responsibility for noxious plants control was being transferred to the fourteen new Regional Councils. The extent to which information on *Clematis vitalba* control had been transferred to the Regional Councils differed between regions.

In the first instance letters were written to all of the DNPAs in October and November, 1989. As many of these were unanswered by January, the Regional Councils were asked to provide the information, or contact names in the old districts. Finally, responses were received from, or on behalf of, eighty of the ninety authorities listed. The quality of information received varied markedly between areas. A number of officers gave details of the number of sites in the area but were not able to determine the proportion of total noxious plants control expenditure devoted to *Clematis vitalba*. Several officers noted that although *Clematis vitalba* was widespread in their areas and a problem of increasing severity, permission to have the weed gazetted as a Class B target had been declined. Expenditure on its control was not, therefore, part of the authority's budget. In general, authorities in which the weed is gazetted as a Class B target provided more detailed information and responses were received from all but one of these. Areas such as the Wellington Region and Buller, where major initiatives have been taken, were able to provide precise expenditure data.

In Wellington the Regional Council has implemented a major assault on *Clematis vitalba* on a regional basis. This has included the temporary employment of a Coordinating Officer.

On the West Coast a large-scale program which has the aim of eradicating *Clematis vitalba* from the Buller watershed has been underway since 1985-86 and is expected to continue for some years yet. A high level of expenditure is also undertaken annually by Palmerston North City Council which believes that areas of bad infestation have been attacked and control is in hand.

Because of the variability in the form and quality of the information received from DNPAs accurate estimation of their total expenditure is impossible. A summary of the information provided by each DNPA is provided in Appendix 1. In Table 2 the results of an attempt to quantify DNPA expenditure are shown. The amounts shown are in real (1989) dollars since a number of officers gave the approximate value of control work undertaken during the current financial year and indicated that the amount of work undertaken had been approximately constant during the past five years. Where actual dollar values were given for past years, the CPI was used to inflate them to 1989 dollars. These figures must be thought of as "the bottom-line" only as some expenditure is known to be excluded, and under-estimation by some authorities seems possible.

Table 2

DNPA Expenditure on *Clematis vitalba* Control
in Real 1989 Terms

Region	1985/86	86/87	87/88 ($ 1989)	88/89	89/90
Northland	-	-	-	-	-
Auckland	450	450	450	450	450
Taranaki	750	750	1300	1280	1250
Bay of Plenty	1400	1400	1400	1400	1400
Gisborne	-	-	-	-	-
Waikato	600	600	600	600	600
Hawkes Bay	-	19440	3530	-	-
Manawatu/Wanganui	35800	31000	28610	36600	32600
Wellington	3550	3000	2760	2650	88000
Nelson/Marlborough	-	-	-	-	-
Canterbury	7760	8260	6480	11000	14500
West Coast	92910	45840	87220	74730	50000
Otago	7100	10800	12130	13800	15000
Southland	800	950	1035	1075	1140
Total	151120	122490	145515	143585	204940

The estimated net present value (at 10 percent discount rate) of these "bottom-line" expenditures is $923,253.00 or an average of $184,650.00 per year.

In total the identified costs of *Clematis vitalba* control by District Noxious Plants Authorities and the Department of Conservation to date have a net present value of approximately $2.3 million.

CHAPTER 3

NON-MARKET VALUATION OF *CLEMATIS VITALBA*

3.1 The Value of Non-Priced Resources

Estimation of the value to New Zealand society of research into the biological control of *Clematis vitalba* is not straight forward since there is no market for goods such as native bush although they clearly have considerable value to many members of society.

The value which an individual places on a resource development project is commonly estimated using one of three measures (Kerr, 1985a). These include:

Equivalent Surplus: the amount the individual is willing to pay (WTP) to prevent a resource degradation.

Compensating Surplus: the amount the individual must be paid to willingly accept a resource degradation (willingness to sell) (WTS).

Marshallian Compensating Surplus: a measure intermediate between the equivalent and compensating surpluses.

Adopting the rationale of Bishop (1979), the appropriate measure for use in valuing the project, which is designed to develop a biological control method for *Clematis vitalba*, is Willingness to Pay (WTP). This is the maximum amount the gainers from the project would be prepared to pay to the losers if necessary (i.e. those who believe that either the expenditure on research, or the introduction of biological control agents will have a negative effect).

The value which individuals place on a non-priced resource may have several components including:

Use value:	the value placed on the current use of a resource.
Option value:	the value of retaining the option of future use of an irreplaceable, unique resource even if there is no intention to take up that option (Weisbrod 1964).
Preservation value:	includes the value of simply knowing a resource is there (existence value) and the value of preserving the resource for the use of future generations (bequest value) (Kerr 1985a).

The value of a particular resource project may include any or all of these values, depending on the type of resource being preserved. In the case of the *Clematis vitalba* control project, where the resource to be saved is New Zealand's native forest, it is probable that for many individuals all three values will be reflected in their willingness to pay.

3.2 Methods of Estimating Non-Market Values

Two methods of estimating non-market values are widely accepted; the Travel Cost Method (TCM), and the Contingent Valuation (CV) Method.

3.2.1 Travel Cost Method

The travel cost method uses the cost of travelling to a site as a proxy for the price of visiting that site. A series of zones, of different distances from the site, are defined and the visitation rate from each zone estimated by interviewing site users. Additional information relevant to site usage, e.g. age, income, racial background, is also obtained and may be incorporated into the model.

The cost of travelling from each zone to the site is treated as the price of entry to the site for individuals from that zone. Thus it is possible to assess demand for the site at different prices if it is assumed that users will react to a change in entry fee in the same way as they react to a change in travel costs.

This method has been used in several New Zealand studies including the valuation of a walking track, a lake and a recreational hunting area (Kerr, 1985b).

There are, however, several features of TCM which make it unsuitable for the present study.

Firstly, TCM is generally applied to a particular site for which there are assumed to be no close substitutes. While Kerr (1985b) outlines two analytical techniques which may be used to overcome the problem of substitute sites, the large number of areas where native bush is presently or potentially threatened by *Clematis vitalba* makes TCM impracticable for this study.

Secondly TCM estimates only the value placed on the current use of a site. Where the resource to be valued is effectively 'native bush', the option and preservation values may well be at least as important as the use value. Consequently, TCM is likely to result in a serious undervaluation of the costs of *Clematis vitalba*.

In addition, trips to native bush areas are likely to be multiple purpose expeditions. Either the visitor will visit more than one location on the same trip (e.g. an organised tour) or more than one activity will be carried out. Thus it is difficult to allocate the joint costs of the trip to particular locations although one adhoc method has been suggested (Kerr 1985b).

3.2.2 Contingent Valuation Method

The Contingent Valuation Method of valuing non-priced resources elicits individuals' WTS or WTP directly using one of several approaches.

If personal interviews are possible, after explaining the implications of the proposed change, the interviewer may enter into a bidding game with the respondent. The interviewer suggests an opening bid and, by an iterative process, the respondent's final bid is reached. Estimates obtained by this method are subject to a starting point bias problem i.e. the initial bid suggested by the interviewer may affect the final outcome (Boyle and Bishop, 1984).

Alternatively, the interviewer may simply ask open-ended questions to elicit the respondent's WTS/WTP.

In a mail survey two CV approaches are possible. Either open-ended questions may be asked, or the respondent may be asked to accept or reject a single offer. The latter method is known as dichotomous choice.

The dichotomous choice approach has the advantage that it is simple for the respondent to understand and respond to. Being asked to accept or reject a single offer for a resource which they have not previously considered in monetary terms is easier than being asked outright what they would be willing to pay.

The results of a dichotomous choice survey are also relatively easy to analyse using a logit model which allows translation of the discrete (yes/no) responses to offers of a specific sum into measures of maximum WTS/WTP. This model is briefly described in Section 3.3.

Estimates of WTS/WTP obtained by CV methods may be subject to bias from two sources:

i) Hypothetical Bias: The monetary value of resources may well be an issue the respondent has not dealt with before in the real market. If he/she is not given, or does not take the time to consider the implications of the decision, the estimated WTS/WTP will be inaccurate.

ii) Strategic Bias: Individuals may believe that by overstating their WTS or understating their WTP the results of the survey will support the outcome they desire. For example, if WTP is understated, either the cost passed to the individual for a project's implementation will be reduced, or the project will not be undertaken. Individuals are unlikely to overstate their willingness-to-pay unless they are certain that they will not actually be asked to do so.

Kerr (1985) notes that these potential sources of bias would appear to raise serious doubts about the validity of CV techniques. He briefly reviews several studies which attempt to verify estimates of WTP/WTS obtained by CV techniques against estimates obtained by other techniques or against actual WTS/WTP. His conclusion is that CV can provide meaningful estimates of how a proposed change in a non-market priced good is valued but requires care in its application and verification of responses.

It was decided that contingent valuation was the most appropriate technique for conducting this study. As a national survey was necessary to obtain a wide cross-section of respondents, resources dictated that a postal survey was the only feasible approach. Dichotomous choice questions were included since they are better suited to the postal survey than are open-ended questions.

3.3 The Use of the Logit Model in Contingent Valuation

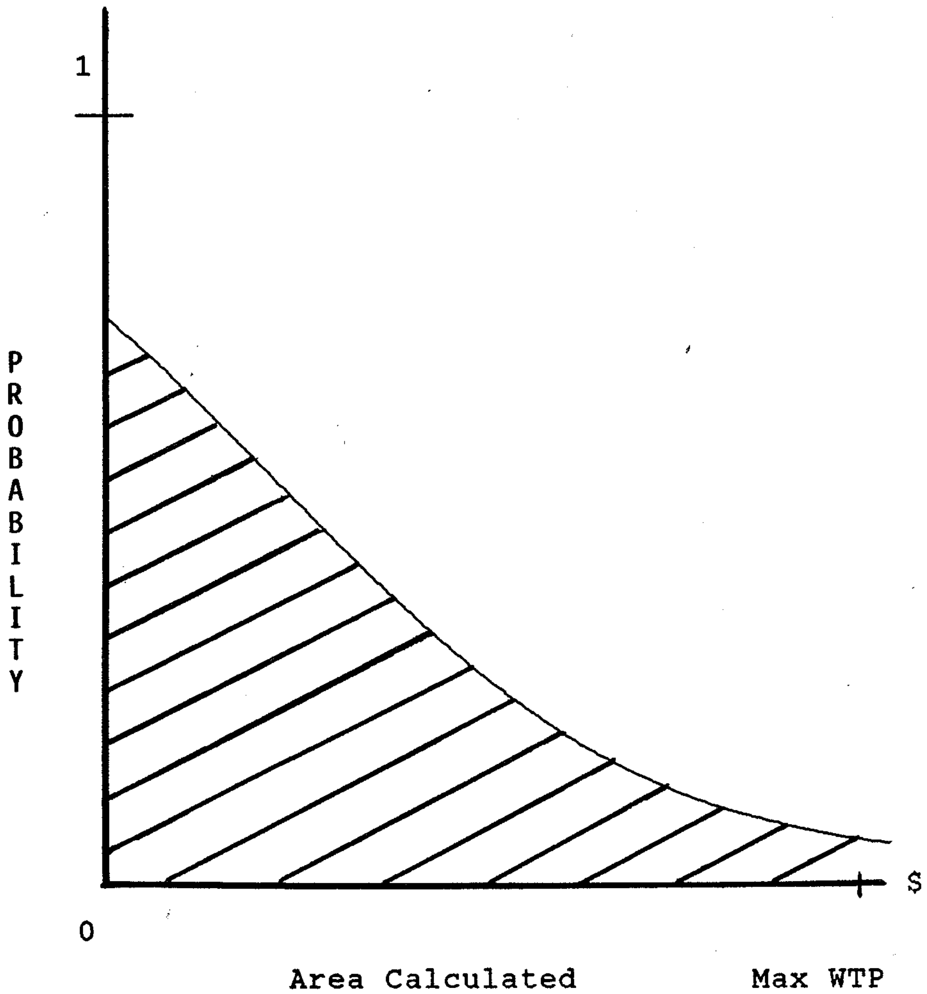
Models of qualitative choice such as the Logit or Probit models are widely accepted as valuable techniques in valuing non-market resources (Kerr 1985a). In simple terms, the logit model is used to infer an individual's maximum WTP from the pattern of acceptances to and rejections of specified sums generated by respondents to a survey.

The form of the equation estimated using the maximum likelihood technique is:

$$\text{Log} \frac{(\text{Prob Yes})}{(1 - \text{Prob Yes})} = \alpha + \beta x1$$

where X1 is the dollar amount (Loomis, 1985). Other explanatory variables and dummy variables for characteristics such as income, frequency of resource use etc., can be incorporated into the model. The expected willingness to pay of individuals surveyed is equal to the area under the resulting logit curve which may be calculated using integration between defined limits as shown in Figure 2.

Figure 2: The Logit Model



The significance of all the estimated coefficients of the logit model when maximum likelihood is used is tested using the Chi-Square distribution. Individual coefficients may be tested for significance using an analogue of the t-test used in ordinary least squares regression (Pindyke and Rubinfeld, 1981).

CHAPTER 4

THE METHODOLOGY

The value to New Zealanders of research into the biological control of *Clematis vitalba* was estimated using the contingent valuation of willingness-to-pay approach discussed in Chapter 3. A postal survey was carried out during November and December 1989 in which respondents were presented with information about *Clematis vitalba* and then asked to make a series of dichotomous choices.

The parameters affecting the national willingness-to-pay for this research are summarized in the following equation:

WTP = f (Probability of Success, Benefits of Success)

Benefits of Success = Reduction in cost of present control measures + Benefits of better control + Benefits of reduced chemical input to environment - Any disadvantages of an introduced insect or disease.

4.1 The Sample

As the response rate to surveys of this kind is inevitably low, a large sample size is desirable. Financial resources in this case restricted the sample size to 3000 and it was hoped to receive 1000 valid responses.

It was decided that the sampling unit should be the individual, and the population included all adult New Zealanders i.e. those over 18 years of age. The sample was randomly selected from current electoral roles, thus ensuring that it was automatically stratified by region. The sample represented 1.4 percent of the 2,190,274 individuals listed on the electoral roll at that time.

4.2 The Questionnaire

The questionnaire was prefaced by a description of *C.vitalba*, its distribution and effects on native bush, to ensure that all participants had some perception of the problem. The description was enhanced by two colour photographs showing similar areas of bush, one of which was severely affected by *C.vitalba*, the other unaffected. The photographs were as similar as possible in terms of composition of bush, season, light conditions etc.

Respondents were then asked whether they would be prepared to contribute $1 towards the research into biological control. If they were not prepared to do so, they were asked why.

The payment vehicle selected for the study was a "once-only" tax payment. It was recognised that the word "tax" automatically invokes a negative response from a number of people. However, the alternative mechanisms of "rate payments" or "donations" were even less satisfactory because they do not affect all, or most, individuals equally since donations are purely voluntary and rates paid only by property owners.

In each questionnaire, respondents were asked to accept or reject two levels of a one-off taxation payment. These "bids", which varied between questionnaires, were randomly selected amounts in the range $2 - $100.

In addition respondents were asked to complete several questions on issues which might be expected to influence their valuation, including prior knowledge of the problem, their use of native bush areas and their age. A copy of the questionnaire is included in Appendix 2 of this report.

The questionnaire was pre-tested on 50 individuals from differing backgrounds and some minor changes were made before final printing. From the pre-test it was determined that the appropriate upper value to be used in the dichotomous choices offered was $100. None of the individuals in the pre-test sample was willing to pay more than this.

4.3 The Survey

The questionnaire was posted with a covering letter during late November 1989 and a reminder letter was sent to those who had not responded by December 20. The final date for responses to be included in the analysis was January 24 1990, by which time 1294 valid responses had been received. As 195 of the questionnaires were returned marked "gone-no-address" the sample size was reduced to 2805 and the response rate achieved was 46.1 percent. This response rate is relatively high for a survey of this type.

CHAPTER 5

RESULTS AND CONCLUSIONS

The majority (91.7 percent $\pm$ 1.6 percent) of respondents were prepared to make at least a token payment ($1) to fund research into the biological control of *Clematis vitalba*. This degree of willingness to "play the game" is high in comparison with other studies using the contingent valuation technique (Kerr 1985a).

Only eighty four (6.5 percent) of the respondents to the survey indicated that they failed to understand, or were unwilling to "play the game", by refusing to pay $1.00. Sixty eight (5.3 percent) of these were excluded from the analysis because their unwillingness to pay stemmed from their objection to taxation as the payment vehicle. They wrote that they already pay too much tax, that they feel that there is too much bureaucracy or that they believe research should be funded out of existing tax revenues. The remaining 16 did not answer the contingent valuation questions.

The responses of those who were unwilling to contribute to this project whatever the payment mechanism, were included in the analysis. The main reasons given by these respondents were that they were unable to afford any extra expense (40), and that they did not want insects or diseases introduced to New Zealand (13).

5.1 Consumer Surplus

The first step in analysing the responses was to fit a model to the data which explained the proportion of respondents who would be willing to pay any nominated dollar amount. In view of the dichotomous nature of the questions a logit model was used to do this. The fitted model was (t - scores in parentheses):

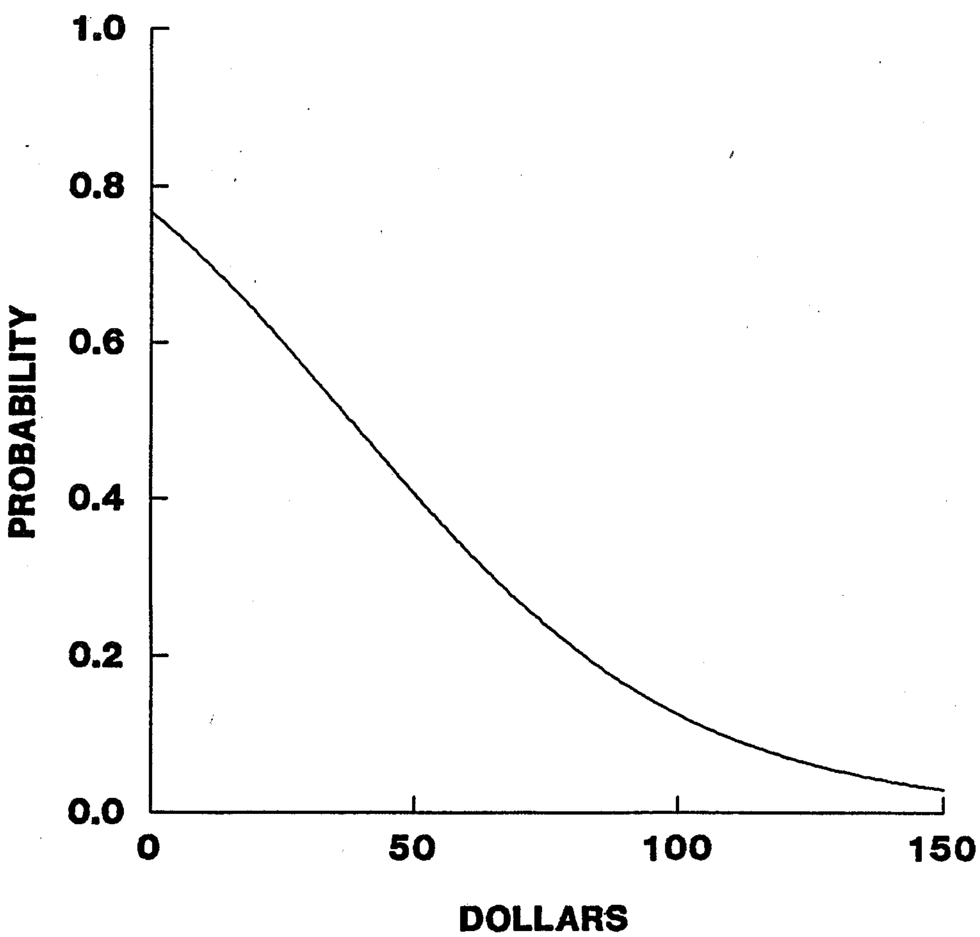
$$L_i = \underset{(12.99)}{1.191} - \underset{(-18.13)}{0.03141}\ DOLLARS_i \qquad N = 2332$$

where, $L_i = \log_e (P_i/(1-P_i))$

and, P_i = the probability that any randomly chosen individual will be willing to pay $DOLLARS_i$.

The function is illustrated below:

Figure 3: Graphical Presentation of Willingness to Pay for Research into Biological Control of *Clematis vitalba*



The benefit accruing to the average respondent if the research program is implemented, which is known as the mean consumer surplus, is found by integrating this function with respect to DOLLARS. The mean consumer surplus estimated from this function is $46.37, with an approximate 95 percent confidence interval of $40.65 - $53.03.

It should be noted that this is the estimated consumer surplus associated with the implementation of the research project itself. Respondents were told that the chances of successfully implementing a biological control project are relatively small and will have used this information in determining whether they were willing to pay the nominated amounts. It is most probable that the consumer surplus to be derived from the certain control of *Clematis vitalba* or a similar threat to native bush would be considerably higher.

The aggregate consumer surplus for all New Zealanders aged 18 years and over may be calculated by multiplying the individual consumer surplus by 2,401,000 which is the size of the adult New Zealand population (Key Statistics, December 1989). The estimated aggregate consumer surplus from research into the control of *Clematis vitalba* is $111.33 million.

5.2 Sensitivity Analysis

5.2.1 Survey Non-response

A response rate of 46.1 percent, while not low for a survey of this kind, may give rise to doubts as to whether the results obtained are representative of the willingness-to-pay of the New Zealand population as a whole. Three possibilities exist:

Case 1: The views of the respondents are representative of the views of all adult New Zealanders.

Case 2: The respondent population is not representative of the New Zealand population as a whole. Non-respondents have less interest in the problem of *Clematis vitalba* and would not be prepared to fund research into its biological control.

Case 3: The respondent population is not representative of the New Zealand population as a whole. Non-respondents object to research into biological control and would require compensation to maintain their existing levels of welfare if such research was undertaken.

In Case 1, the survey results represent the mean benefit to every adult New Zealander of research into the biological control of Old Man's Beard. In Case 2 it must be assumed that non-respondents will not contribute to the research so the survey results must be weighted by the survey response rate to calculate the population mean. It is not possible to calculate the welfare impacts of researching the biological control of *Clematis vitalba* under the assumptions of Case 3 using the information obtained in this study. To do so would require a measure of welfare change for those opposed to research, and a means of comparing the welfare changes of those supporting and objecting to the research. The Potential Pareto Improvement criterion requires the subtraction of the compensation required by objectors from the willingness-to-pay of supporters to obtain the aggregate welfare change.

The consumer surpluses under the assumptions of Case 1 and Case 2 are shown in Table 3.

Table 3

Consumer Surplus - Case 1 and Case 2

	Mean Consumer Surplus	Approx. 95% Confidence Interval on the Mean	Aggregate Consumer Surplus
Case 1	$46.37	$40.65 - $53.03	$111.33m
Case 2	$18.36	$16.09 - $21.00	$ 44.08m

5.2.2 Item Non-response

A number of respondents were prepared to pay the lower amount asked in Question 7 but did not respond to the higher amount asked in Question 8. In the initial analysis these were treated as non-response. If, however, it is assumed that in fact this non-response was a rejection of the offer, the estimated model is:

$$L_i = \underset{(13.05)}{1.198} - \underset{(-18.41)}{0.03190} \text{ DOLLARS}$$

N = 2361
^{2} = 402
DOF = 1
p<.001

Mean consumer surplus is $45.82 with an approximate 95 percent confidence interval of $40.22-$52.35. The treatment of non-responses in Question 8 therefore makes little difference to the mean consumer surplus.

5.3 Factors Affecting Willingness-to-Pay

Respondents were questioned about a number of characteristics which were considered likely to affect their attitude to the problem of *Clematis vitalba*. These included the statistical area in which they lived, age, prior knowledge of the problem, frequency with which they visit native bush areas and the reasons for visiting native bush.

Expanded models were then estimated to test whether these characteristics were determinants of willingness to pay. Of the dependent variables tested, the respondents' age in years (AGE), their prior knowledge of the problems (KNOWLEDGE) and whether or not they had visited the bush during the last ten years (ACTIVE) were all significant at the 95 percent confidence level and all had the expected sign. When responses were categorised by statistical areas, which were accounted for by a series of dummy variables, none of the dummy variables was significant. This indicates that willingness-to-pay is similar throughout the country.

Although willingness-to-pay was shown to differ between those who had and those who had not visited native bush areas during the last ten years, neither the frequency of visits nor the purpose of the visits were shown to be significant.

When the three significant independent variables were included, the model shown in Table 4 was estimated. The dependent variable is the logit of the probability that an individual is willing to pay a specified amount.

Table 4

Model Incorporating Factors Affecting Willingness-To-Pay

Parameter	Estimate	Standard Error	t-statistics
CONSTANT	1.616	0.176	9.18
DOLLARS	-0.0329	0.00181	-18.25
AGE	-0.00935	0.00301	-3.11
KNOWLEDGE	0.234	0.109	2.14
ACTIVE	-1.140	0.196	-5.83

N = 2279, ^{2} = 459 DoF = 4 $p < .001$

All parameters are significant at the 95% confidence level, and of the expected sign. The greater is DOLLARS or AGE the lower is the probability that the individual will be prepared to pay a specified sum. Both prior knowledge of the problem of *Clematis vitalba* and having visited native bush within the last ten years increase the probability.

Different combinations of the dummy variables KNOWLEDGE and ACTIVE result in four different models for consumers with different characteristics. The mean willingness to pay for each of these groups of consumers is shown in Table 5 (Note: AGE is set to the sample mean of 45 years).

Table 5

Willingness-to-Pay by Individual Characteristic

Individual Characteristics	Mean Willingness to Pay	Percent of Respondents With These Characteristics
Knew about problem & visited bush	$49.89	68.1
Knew about problem & had not visited bush	$25.72	5.3
Did not know about problem & had visited bush	$44.29	22.0
Did not know about problem & had not visited bush	$21.86	4.6

Individuals who knew about *Clematis vitalba* before receiving the questionnaire (73 percent of respondents) were prepared to pay (on average) $5 per year more than those who did not know about the problem. Those who had not visited native bush areas within the last ten years (10 percent of respondents) were prepared to pay approximately half as much as those who had done so.

5.4 Discussion and Conclusions

1) New Zealanders perceive the threat to our native bush from *Clematis vitalba* as a serious one and are prepared to pay significant amounts of money for a chance of controlling this weed. Two scenarios have been evaluated in this study. They are:

a) That the views of the survey respondents accurately reflect the views of the whole adult population. Under this assumption it is estimated that New Zealand society would be prepared to pay $111 million to fund research into the biological control of *Clematis vitalba.*

b) That all survey non-respondents were uninterested in the problem of *Clematis vitalba* (i.e. that only 39.6 percent of the population would be prepared to make any payment for this purpose). Under this assumption New Zealanders would be prepared to fund this research to the extent of $44 million dollars.

These results provide overwhelming evidence that research into the biological control of *Clematis vitalba*, estimated to cost approximately one to two million dollars over a period of six years, would be highly valued by New Zealand society.

A third possibility was also suggested, which was that a proportion of the non-respondents would actually require compensation if a research project aimed at introducing insects or diseases to New Zealand was to be implemented. However, while this possibility cannot be ruled out, it seems likely that individuals with strong adverse feelings about the introduction of new agents would have had as much motivation to respond to the survey as those who believe biological control of *Clematis vitalba* to be very desirable.

Concern over the host-specificity of biological control agents is frequently encountered by scientists working in this area when talking to the public about biological control. They point out that there have been no instances in New Zealand when an agent, introduced for the biological control of a weed, has damaged species other than the intended target. The screening procedures implemented before the release of such agents are extremely stringent and the chances of damage to other plant species, remote. (P Syrett pers.comm).

In fact only one percent of respondents declined to make a token payment on the grounds that they did not want new insects or diseases introduced, although a number expressed a willingness to pay and a desire for reassurance that the biological control agents would have no undesirable effects. Consequently, although the estimate of willingness to pay may require some reduction to allow for compensation to individuals opposed to the introduction of new insects and diseases, the most likely level of aggregate willingness to pay lies between the two estimates of $111 million and $44 million. Education of the public about biological control and the risks associated with it should be considered part of research projects of this type.

More frequently expressed by respondents to the survey, than concern over introduced species, was the desire to reduce the volume of chemicals introduced to the environment. Many expressed a preference for biological rather than chemical control. A surprisingly large number also noted that physical removal of *C.Vitalba* would be a good occupation for the unemployed.

2) The problem of *Clematis vitalba* is one that must be viewed from the national rather than the regional perspective. It is appropriate that funding for control of this weed and other agents causing serious damage to a resource such as native bush be undertaken at the national level. This is clearly indicated by the results of this

study. No significant regional differences could be detected in the willingness-to-pay of individuals surveyed. However, there were major differences in the incidence of the weed between regions. At present there is no known infestation of *Clematis vitalba* in Northland. Despite this, individuals in Northland are prepared to pay as much for research into its biological control as individuals in the Wellington region where there has been considerable effort to alert the public to the seriousness of the problem in the area. It is inequitable that the burden of paying for *Clematis vitalba* control falls on a few regional authorities when the destruction of native bush by this weed results in a loss to New Zealanders wherever they live.

3) It is clear that the resources currently devoted to the control of *Clematis vitalba* are considerably less than the value to New Zealanders of preventing its further destruction of native bush. It is acknowledged that the estimates of local body and DOC expenditure on *Clematis vitalba* control presented in Chapter 2 understate the true costs of control measures presently undertaken. They exclude the costs to landowners of complying with their legal requirement to destroy infestations on privately owned land in areas where *Clematis vitalba* has been declared a Class B target. They also omit the unrecorded costs incurred by local authorities and the voluntary efforts of such organisations as the Royal Forest and Bird Protection Society. Nevertheless the lower estimate of the value of research into biological control ($44 million) is many times greater than the estimated NPV of current control measures ($2.3 million). Control expenditure is markedly less than New Zealanders are prepared to pay for even a chance that biological control of *Clematis vitalba* may be achieved.

4) This study has attempted to place a value on the benefits to the community of researching the possibility of biological control of *Clematis vitalba*. The method used to assess this value is relatively new and will, no doubt, be further refined in future. However, studies of this type provide a useful economic framework in which to assess the wider community's valuation of research projects. The results in this case show that allocation of research funds to the biological control of *Clematis vitalba* is fully justified.

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APPENDIX 1

INFORMATION RECEIVED FROM DISTRICT NOXIOUS PLANTS AUTHORITIES

The old DNPAs and other authorities who responded to the request for information on *Clematis vitalba* control are grouped below according to the Regional Council which now has responsibility for noxious weed control in that area.

Northland Regional Council

Hobson	No known sites - expenditure nil
Hokianga	" " " " "
Otamatea	" " " " "
Whangarei	" " " " "
Whangaroa	" " " " "

Auckland Regional Council

Franklin	No problem in district
Manukau City	1 small site only
Rodney	6 small sites - expenditure $250/year
Takapuna	No known sites - expenditure nil
Waiheke Island	No known sites - expenditure nil
West Auckland	4 small sites - expenditure $200/year. Publicity exercises carried out

Taranaki: Regional Council

Egmont	5 small sites $500/year for 5 years from 1988
Eltham	Expenditure virtually nil
Hawera	30 sites - expenditure low
New Plymouth City	A few pockets - expenditure $500/year

Otorohanga	3 small sites in past - expenditure in last five years nil
North Taranaki	A number of sites - expenditure nil
Patea	Expenditure virtually nil

<u>Bay of Plenty Regional Council</u>

Opotiki	15 sites (917ha) - expenditure = $1,000 over past 5 years
Taupo	1 site treated in 1989 - expenditure negligible
Tauranga	10 sites - $2,000 spent due to date, $3,000 in 1990 then $500/year
Thames/ Coromandel	No known sites - expenditure nil
Western Bay of Plenty	3 sites (expenditure combined with Tauranga)
Whakatane	No known sites - expenditure nil

<u>Gisborne Regional Council</u>

Cook	*C. vitalba* widespread. Gazetting refused. Expenditure nil
Gisborne City	*C. vitalba* widespread. Gazetting refused. Expenditure nil
Waiapu	No known sites - expenditure nil
Waikohu	8 sites - expenditure nil

<u>Waikato Regional Council</u>

Hauraki Plains	No known sites - expenditure nil
Matamata/Piako	5 known sites - monitoring continues
Ohinemuri	No known sites - expenditure nil
Otorohanga	3 small sites in past - expenditure in last five years nil
Waikato	3 known sites - expenditure $70/year
Waipa	4 sites - expenditure $300/year

Hawkes Bay Regional Council

Central Hawkes Bay	Widespread sites - expenditure not known
Hawkes Bay	A number of sites - not perceived as very serious. Small expenditure
Waipukurau	Widespread sites - expenditure not known
Wairoa	Several sites - 42 man weeks in 1987 and 8 man weeks in 1988 - no current expenditure

Manawatu/Wanganui Regional Council

Kiwitea	Very widespread - expenditure $5,000 to date
Manawatu	Nil expenditure
Palmerston North City	Widespread - expenditure $25,000/year
Pahiatua	Minimal expenditure
Pohangina	3-4 sites administered by DOC
Rangitikei	Nil expenditure
Tararua	Widespread. $14,000 in 1988/89, $7,400 in 1989/90
Taumarunui	Nil expenditure
Waimarino	28 sites (<4 ha) - expenditure not known
Wanganui	$3,000 in 1989

Wellington Regional Council

Data was received for the whole Wellington Region from the Regional Council.

OMB is widespread throughout the Wellington Region but is present in varying degrees of severity in different

Districts. The most concentrated areas of OMB exist in the Hutt Valley and in Wellington City. In all other areas OMB is present.

	Actual		Forecast	
Expenditure	1985/86	$ 2,500	1990/91	$12,000
	1986/87	$ 2,500	1991/92	$ 8,000
	1987/88	$ 2,500	1992/93	$ 5,800
	1988/89	$ 2,500	1993/94	$ 2,200
	1989/90	$88,000	1994/95	$ 1,700

Nelson/Marlborough Regional Council

Golden Bay	30 sites - DOC expenditure only
Marlborough	Widespread - little expenditure, amount unknown
Nelson City	Widespread infestation - expenditure nil
Waimea	Widespread infestation, serious problem, expenditure nil

Canterbury Regional Council

Amuri) Cheviot) Hurunui)	Relatively widespread - little expenditure, not separately recorded
Ashburton) Banks Peninsula)	A number of sites - expenditure $3,500 in 88/89 and $8,000 in 1989/90 excluding wages and mileage
Paparua	103 sites (.77 ha) - expenditure confined to some time input by NPO.
Selwyn	Many sites - no special budget, but 6-8 weeks of NPO time/year
Strathallan	Widespread. Considerable publicity effort and advice. Direct control expenditure nil.
Waimairi	162 sites (Class I-15, Class II-94, Class III-35, Class IV-18). Expenditure $2,000 to date plus publicity work.

Waimate	51 sites at present. Considerable work done by PEP Schemes in the early 1980's. Expenditure ($1989) 1986 $2,400; 1987 $2,800; 1988 $1,028; 1989 $1,748; 1990 $1,028.

<u>West Coast Regional Council</u>

Buller	Control program in Buller River catchment funded by the Department of Lands & Survey and the Noxious Plants Council. Expenditure 1985-86 $65,430; 1986-87 $38,200; 1987-88 $79,072; 1988-89 $70,500; 1989-90 $50,000.
Inangahua	Expenditure nil.
Westland	Expenditure nil.

<u>Otago Regional Council</u>

Bruce	Approximately $1,000 per year
Clutha	Expenditure nil
Lakes	Expenditure has built up over past four years to $10,000 per annum.
Maniototo	Eight sites - expenditure minimal
Silverpeaks	Approximately 250 sites. Recently gazetted and presently being surveyed. Expenditure to date on education and surveying.
Tuapeka	Well established in Clutha River valley - expenditure nil.
Vincent	Expenditure $4,000 per annum over past four years
Waihemo	Thirteen sites - expenditure minimal
Waitaki	Expenditure nil

<u>Southland Regional Council</u>

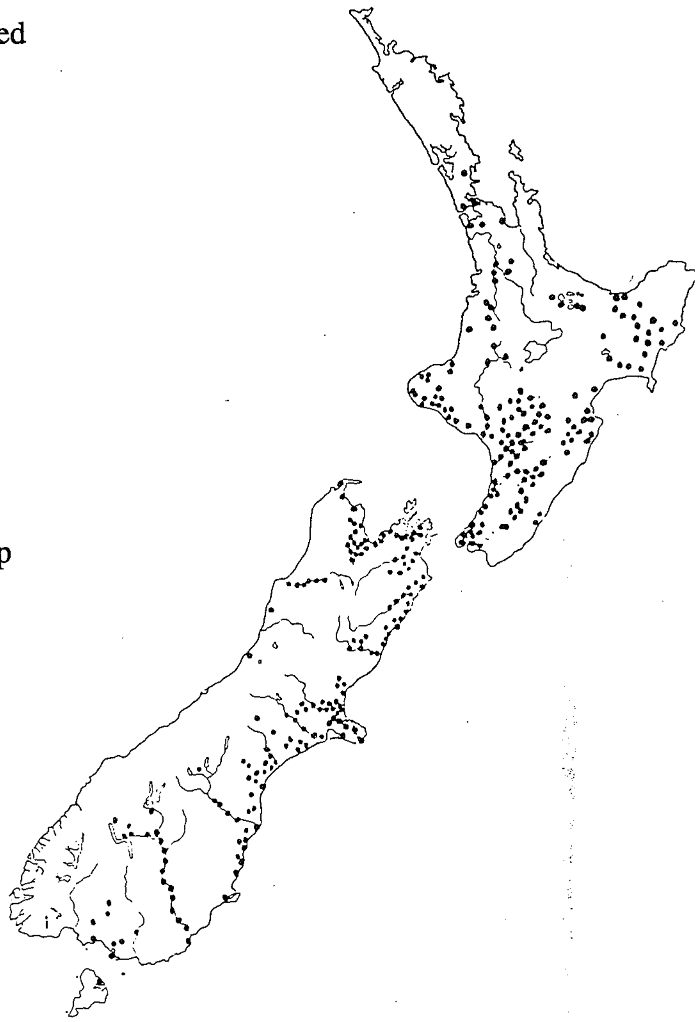
Southland) Wallace)	Expenditure $5,000 since 1985. Budgetted expenditure for 1990/91 = $1,500

APPENDIX 2

THE QUESTIONNAIRE

OLD MAN'S BEARD

Old Man's Beard is a weed which is invading New Zealand's native bush. It was brought here as a garden plant, but has escaped into the bush where it is killing even the largest trees. Now spread throughout much of New Zealand, Old Man's Beard is regarded as a very serious threat to our native forests. The map on this page shows the distribution of Old Man's Beard in 1987.



Old Man's Beard climbs existing vegetation, smothering and eventually killing the trees and all other plants below it. Old Man's Beard replaces the bush. Photograph A on the next page, shows native bush which has no Old Man's Beard. Photograph B Shows bush with Old Man's Beard.

At present the Department of Conservation and a number of local councils are attempting to control Old Man's Beard using chemicals such as Roundup and by hand-cutting and pulling. However the weed is still spreading in many areas. These measures are costly to taxpayers and ratepayers and must be carried out every year.

It may be possible to find, and introduce to New Zealand, insects or diseases which would control Old Man's Beard without the need for these expensive short-term measures. This would reduce the amount of chemicals put into the environment and may be effective in remote or densely forested areas where chemical control is too difficult.

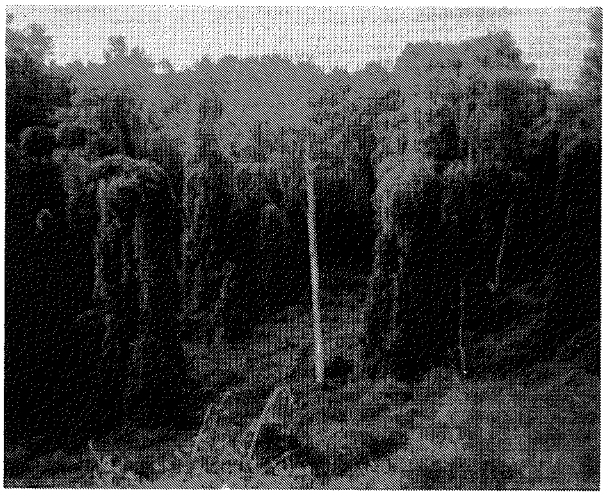
Although the benefits from controlling Old Man's Beard in this way may be great the chances of doing so are relatively small. If this could be done, it would be several years before enough insects could be bred to control the weed throughout New Zealand although a disease might spread more rapidly. Conventional control measures would be continued during that time.

Research to find insects or diseases to control Old Man's Beard would require funding by the taxpayer.

PHOTOGRAPH A
Native Bush Without
Old Man's Beard

Q.E. II Trust

PHOTOGRAPH B
Native Bush Damaged by Old
Man's Beard



C. West DSIR

Now, would you please answer the questions which follow? Most of them require only a tick in the box beside the answer that is correct for you.

1. Did you know about the problems caused by Old Man's Beard in native bush before you received this questionnaire?

Yes ☐
No ☐

2. How often have you spent time in native bush areas such as national parks, reserves etc., during the last ten years?

1. Never ☐
2. Once ☐
3. Once a year or less ☐
4. More than once a year ☐

3. When you have visited native bush areas, which activities have you taken part in?

1. Haven't visited native bush during the last ten years ☐
2. Tramping ☐
3. Fishing ☐
4. Hunting ☐
5. Watersports (such as white water rafting) ☐
6. Just enjoying the scenery ☐
7. Other (..................) ☐

4. What is your present age in years? ☐

5. Would you be willing to pay a little extra tax next year (say $1) to pay for research with the aim of finding insects or diseases which would control Old Man's Beard. This would be a "once-only" payment and would not be repeated in future years.

Yes ☐

No ☐

6. If you answered "No", why not?

....

....

....

7. Would you be willing to pay $☐ extra tax during next year only to pay for research with the aim of finding insects or diseases which would control Old Man's Beard?

Yes ☐

No ☐

8. Would you be willing to pay $☐ extra tax during next year only to pay for this research?

Yes ☐

No ☐

9. If you have any general comments about Old Man's Beard and its control we would be interested to read them.

....

....

....

Thank you very much for taking the time to answer this questionnaire. We would be very grateful if you could now put it in the envelope provided and send it back as soon as possible.

RESEARCH REPORT

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