# THE ECONOMICS OF RABBIT CONTROL IN CENTRAL OTAGO:

## A Preliminary Analysis

I.G.C. Kerr, E.J. Costello and K.L. Leathers
Centre for Resource Management

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**Discussion Paper**

Centre for Resource Management
University of Canterbury & Lincoln College, New Zealand

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ABSTRACT

This paper reports a preliminary examination of the economic efficiency and equity implications of recent rabbit control policies and programmes. The Alexandra Pest Destruction Board in Central Otago was used as a case study.

Public and private expenditure data on rabbit control were collected and analysed for the period 1974-75 through 1981-82. Control programme benefits were estimated using data obtained in a survey of runholders and from historical production records. Programme costs were developed from actual expenditure data on control operations and administration based on Board records. While the estimated benefits are much less precise in comparison to programme costs, the results of the cost-benefit analysis suggest that significant cost savings can be achieved in meeting the stated objectives of current pest management policies. In particular, the level of annual expenditure in recent years on those lands which can be regarded as good natural habitat for the feral rabbit does not appear to be warranted, since such land types have an inherently low productive capacity and could not sustain the present level of control input on a 'user pays' basis. Although certain public benefits (e.g., land and water conservation) were not estimated, such benefits would have to be quite large to justify recent levels of annual taxpayer input into APDB control operations. The incidence of programme costs under present policy shows that most of the burden is borne by the tax-paying public. The report concludes with some suggestions to appraise these implications more accurately for regional and national public policy.

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# CHAPTER 1

# INTRODUCTION

## 1.1 Background to the Problem

The introduction of rabbits (*Oryctolagus cunniculus*) into New Zealand during the early European settlement imposed major economic costs on the nation, in spite of considerable benefits from meat and skins for export and their value to sportsmen. The severity of damage to pastoral agriculture that can result from uncontrolled wild rabbit populations is well documented in the history of New Zealand's farm development. As early as the 1870s overgrazing of pastoral lands by rabbits was apparent. Now, after more than a century of efforts to control them, some areas of the country are still subject to periodic, and in some cases severe, depredation by the feral rabbit.

The first official recognition that rabbits had become a threat to the pastoral economy resulted in the inquiry by the 'Select Committee on the Rabbit Nuisance' (Otago Provincial Government, 1875). The following year the Rabbit Nuisance Act 1976 was enacted. While this Act and subsequent legislation initiated the establishment of rabbit control boards and terms of reference for control programmes, they were basically ineffectual in dealing with the problem. Following many amendments, that of 1947 legislated for the decommercialisation of the rabbit and for eradication (the "killer policy"). This proved to be the breakthrough in pest management thinking that was needed. During the following decade feral rabbit populations were reduced significantly, stimulating farm development of lands once thought 'too risky' because of the rabbit threat. Subsequently, the "killer policy" has undergone a metamorphosis, partly in recognition that eradication was a practical impossibility, but also because 'managing' rabbit numbers in certain problem areas made good economic sense. Pest control operations proved expensive, and, with a limited budget, it was imperative that these funds were used judiciously.

In several areas of the country, particularly the semi-arid regions of Central Otago, rabbit control remains an important element in land use

management and soil conservation. Because much of this area is a natural (in some ideal cases) habitat for the wild rabbit, effective controls are essential to manage rabbit numbers at tolerable levels to reduce the risk of a major outbreak. However, current control policies and programmes are costly to maintain, and there is recent evidence to suggest that more effective and cost-efficient controls are needed in the future (James *et al*, 1983.

The total costs of pest control in 1981-82 amounted to $11.5 million, comprised of rates paid by land owners ($4.4m), government grants to pest destruction boards ($6.5m), pest-related work on Crown and Maori land ($.1m) and funding of the Agricultural Pest Destruction Council ($.4m). In addition, there are costs of research and services provided by the Ministry of Agriculture and Fisheries (conservatively estimated at $.2m) and other public and private costs of administration of pest control programmes. Since the 1950s the level of expenditure on pest control has remained fairly stable in real terms. Much of this annual national commitment is aimed at rabbit control, particularly with respect to the proportion of expenditure in the South Island.

Table 1 summarises pest board expenditure and cost-sharing arrangements for selected regions in 1981-82. This comparison illustrates the relative importance of pest control in the South Island and Central Otago, and clearly demonstrates the equity issue in financing rabbit control programmes. Alexandra, recognised as a 'high risk' area in Central Otago, received an 86 percent subsidy for rabbit control operations, while the New Zealand average for tax-payer input is 60 percent. The government's interest in the matter is reflected in a shiftin the ratio of grants to rates paid to 50/50 in 1982/83 for the country as a whole.

TABLE 1

Pest Destruction Boards' Expenditure and Cost-Sharing Comparisons
1981 - 82

| Board or Region | Financed by: | | | |
|---|---|---|---|---|
| | Tax-payers[a] | | Land -owners | |
| | ($1,000) | (%) | ($1,000) | (%) |
| Alexandra | 409 | 87 | 58 | 13 |
| Central Otago | 1,541 | 83 | 316 | 17 |
| South Island | 4,617 | 67 | 2,280 | 33 |
| New Zealand | 6,537 | 60 | 4,442 | 40 |

[a] Government grants to pest destruction boards

Source: Agricultural Pest Destruction Council (1982)

Equity on cost-sharing, however, is difficult to judge without consideration of 'willingness-' and 'ability-to-pay' factors. In the Alexandra Pest Destruction Board district much of the hill and high country land is very suitable rabbit habitat, and has been classified as 'high' to 'extreme' for 'rabbit proneness'. 'Rabbit proneness' describes the suitability of land as rabbit habitat. The data in Table 2 suggests that almost 50 percent of the Board's area can be considered at risk, but these land types have an inherently low grazing productivity. Accordingly, while high levels of infestation can severely deplete pastures, create erosion problems and displace livestock, the land-holders' ability to pay rates is limited by low expected returns from these lands. Hence, it is important in evaluating pest management policies and options that both public and private benefits and costs are clearly understood.

TABLE 2

Preliminary Appraisal of 'Rabbit Proneness' and Stock Carrying Capacities
Alexandra Pest Destruction Board District

| 'Rabbit Proneness' Rating | Approximate Area | | Grazing Productivity[c] |
|---|---|---|---|
| | ha | % | su/ha |
| 'Extreme' | 45,893 | 26 | .2 |
| 'High' | 13,649 | 8 | 1 |
| 'High' ('low')[a] | 23,648 | 14 | 2 |
| 'Medium' | 46,248 | 26 | 3 |
| 'Low' | 42,713 | 24 | .2 |
| 'Nil'[b] | 2,687 | 2 | 0 |
| Total area | 174,838 | 100 | |

[a] Soils of 'high risk in an undeveloped state but now 'low' due to development via irrigation or cultivation.

[b] Areas of bare rock, dredge tailings, etc.

[c] Approximation of the dryland average stock carrying capacity per year.

## 1.2 Study Objectives and Scope

The basic aim of this investigation was to appraise the economic costs and benefits of present rabbit control programmes. The Alexandra Pest Destruction Board's area was used for detailed analysis. This area is considered to be representative of past and present rabbit control needs and control expenditures in Central Otago.

The specific objectives of the analysis were:

1. to estimate, on a preliminary basis, the probable cost-benefits of rabbit control in the case study area; and

2. on the basis of this estimate, to suggest future avenues of research that will lead to more cost-effective means of controlling rabbits.

In as much as the cost-effectiveness of present control measures is important in terms of current policy (and policy options), other important aspects of the problem that deserve the immediate attention of appropriate research agencies are highlighted in this study.

It is clear from previous research on the biological aspects of rabbit control that the efficiency of control measures depends, to a large degree, on the land types (or 'rabbit proneness') under consideration (Williams, 1977; Bell and Williams, 1981). An important implication of this is that while field operations vary widely in terms of cost-effectiveness, the overall net benefits of a control programme will hinge on an assessment of the risks associated with containing eruptions of the pest that could affect contiguous lands of higher productive value. Reliable data on the spread of rabbits under differing environmental conditions is not yet available (Fraser, Pers. Comm.).

## 1.3 Data Sources and Study Methods

Ideally, an efficiency analysis of public programmes should compare benefits and costs to whom -so-ever they accrue 'with and without' a given programme of policy change. Since suitable farm production data 'with and without' the presence of rabbits is not available, an alternative approach was necessary to estimate control benefits. Pest control benefits accrue at both private and public levels: private, mainly as income (productivity) protection; and public, largely as conservation or protection of land, water and other resources. Private benefits were estimated using the 'before and after' method: i.e., comparing production levels during a period of high rabbit infestation (the early 1950s) with production levels observed in recent years. An allowance was made for technological change during the period, and the residual change in productivity was considered a rough approximation of the private benefits attributable to rabbit control. Income generated from the added production achieved by rabbit control was calculated from gross margins per stock unit for a breeding ewe flock of productivity performance representative of high country flocks in the region (Kerr, 1983).

As with pest control benefits, the incidence of control costs are both public and private. Expenditure by the Alexandra Pest Destruction Board for the years considered in this study are well documented in annual reports and operations records. Estimates of private expenditures were obtained by a personal interview survey of a sample of eleven run-holders in the Alexandra Pest Destruction Board district.[1] In most cases detailed records had been kept (for tax purposes) of out-of-pocket expenditure on rabbit fencing, night shooting, roading (for access of APDB control operations), attendance at pest control meetings, etc. Land-holders were also asked to estimate the additional carrying capacity they could sustain in the absence of rabbits. These data, clearly 'guesstimates' in most cases, turned out to be generally consistent with the benefit estimates obtained with the 'before and after' method, adjusted for the development that occurred on these properties since the early 1950s.

At present the 'rabbit problem' appears to be centred mainly on the semi-arid soils of the brown-grey earth group which are common in Central Otago. In the undeveloped state all brown-grey earths, often with depleted vegetation, are good candidates for colonisation by large numbers of rabbits. The reason for this is the warm dry habitat on sunny aspects where, in spite of a short breeding season and low reproductive rates, the survival of young rabbits is quite high. In contrast to the drier soil types, moist or wet areas or lands that have been successfully developed through oversowing and cultivation are less suitable habitats. Following the land classification system developed by Bussieres and O'Connor, the high country runs surveyed were grouped according to soil characteristics and assessed for 'rabbit proneness'.

The survey concentrated on high country runs, since these account for the majority of the Alexandra Pest Destruction Board's district. While all land-holders, freehold and leasehold, pay a rate for pest destruction in the Alexandra PDB district (34c per hectare in 1981-82, 60c in 1982-83), it is the less intensively farmed high country that receives a major tax-payer subsidy for rabbit control.

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[1] The APDB district contains 17 high country runs. The runholders participating in this survey have been kept anonymous.

Conventional cost-benefit analysis methods were used for the economic appraisal (Pearce, 1975). The direct costs of control were estimated from actual records (APDB) for the period under examination. The direct benefits were estimated using two different methods: (1) by assessing 'before and after' production levels for the selected runs, adjusted for production increases due to technological change (Kerr, 1983; and Appendix 1); and (2) by asking the respondents to estimate income foregone attributed to rabbit infestation. The private costs of rabbit control (for example, rabbit-proof fences and roading to facilitate APDB operations) were added to the 'public' costs (APDB expenditures less rates paid by the land-holder) to arrive at the estimated total direct cost.

Indirect or secondary costs and benefits are not included in the cost-benefit ratios presented in this report. Indirect benefits of rabbit control would include soil conservation and related 'downstream' benefits that would occur as an adjunct to improved productivity of the land base. Although such secondary impacts are difficult to measure (and therefore hard to appraise), it is likely that, because of their nature (gradual depletion of soil resources), their immediate relative importance is likely to be less than the immediate and direct effect on productivity brought about by effective rabbit control.

## 1.4 Organisation of the Report

The next chapter presents the results of the empirical analyses. The assumptions leading up to the comparative cost-benefit analyses for the time period under study are outlined, and the land-use aspects in control cost-effectiveness are highlighted. In Chapter 3 the main findings of the study are summarised, and the more important issues requiring further study are examined. These are discussed in the light of present needs and possible changes in public policy.

# CHAPTER 2

# THE EMPIRICAL ANALYSIS AND RESULTS

## 2.1 Review of Previous Studies

Concern about the economic implications of rabbit infestation in Otago was first expressed in the 'Report of the Select Committee into Rabbit Nuisance' (Otago Provincial Government, 1875). Many observations about the economic consequences of rabbit damage and the cost of control in Central Otago have been made since. Notable among them were those of Thomson (1922) who described thoroughly the introduction, colonisation and infestation throughout Otago and elsewhere. In quoting one James Begg, Thomson draws attention to the severity of the problem at the time: "sheep perished from starvation by hundreds and thousands ... immense areas of grazing land were abandoned ... the rocky hills around Alexandra may be taken as ideal country for rabbits ..." In commenting on the value of rabbit meat and skins exported (approximately £400,000 from Otago in 1921), Thomson considered this a "very little return for the damage they do". Wodzicki (1950), in a review of the effects of the rabbit on production in Otago, noted the markedly slow growth in pastoral production in the 1880s compared with Canterbury, which was "comparatively free" (of rabbits). Other records discussed by Wodzicki referred to the particularly high cost of control incurred by some pastoral runholders.

The first economic evaluation of rabbit destruction operations in Central Otago was carried out by Warner (1956). This study of 17 high country properties reported a marked increase in pastoral production (sheep + 17%, wool + 36%) between the 1948-49 and 1954-55 seasons, following the adoption of a "killer policy" by the reorganised rabbit boards. The magnitude of rabbit infestation at the time might also be gauged from the estimates of rabbit kills, approximately 750,000 in 1948-49, falling to about 100,000 in 1954-55. The report anticipated a "happy position" for Central Otago in "a few years", based on a continuing pest control expenditure of 25 cents per ha (1956 dollars). The rate-payers' contribution to total pest board expenditure at this time was about 40 percent. However, as suggested by Fennessy (1958), the key to the success of the new pest control policy was the fact that the

rabbit was decommercialised (Rabbit Nuisance Amendment Act, 1947).

The first questioning of the total eradication policy occurred when Howard (1958) predicted that the rabbit had become "entrenched" in certain areas of Central Otago. Later, Howard (1963) said that control to "a level where undue amount of damage no longer occurs" is a preferable policy to that of eradication. This view engendered vociferous reaction from the Rabbit Destruction Council (Baker, 1963; 1965), which argued that a few years earlier, rabbits had cost the country $20 to $40 million annually in losses in production, and that, for 1963, the estimated share of increased meat and wool production resulting from the work of rabbit boards was $67 million. In addition, Baker (1965) listed the special benefits arising from the work of rabbit boards as:

"(a) protection of our national heritage - the land;
(b) increased farm production;
(c) increased land values;
(d) increased revenue to the State;
(e) increased export earnings;
(f) increased servicing to handle increased production;
(g) checking and curing of soil erosion;
(h) water conservation for generation of electric power;
(i) preventing the spread of the pest to clean country."

Meanwhile in 1963, 'Civis', a correspondent for the Otago Daily Times, reported that "the Molyneux Rabbit Board employees appear to be fighting a losing battle in their efforts to halt a heavy rabbit infestation on part of the Board's 95,000 acre area near Alexandra."

While it is clear that the above listing of 'benefits' from rabbit control includes double counting and may overstate the case, it is also clear that the control benefits accrue to both the private runholder and the nation. It is important, therefore, that the public interest (primarily soil and water conservation) and the private interest (productivity and income) are both considered in assessing the economics of rabbit control. Further, it is important that the spatial distribution of the rabbit problem is understood as land systems and land use can

markedly affect control costs and benefits. Recent unpublished reports and a review by Kerr (1983) all attest to the serious nature of the economics and land management issues involved in the area. Studies on the population dynamics of rabbits in uncontrolled and controlled conditions (Gibb *et al*, 1978; Williams, 1978) have raised questions (Gibb, 1967; Bell, pers. comm.; Batcheler, 1980; Bell and Williams, 1981) which suggest moves to systems of integrated pest management for rabbits, utilising natural and strategic control techniques to their full advantage.

## 2.2 Land Systems and 'Rabbit Proneness'

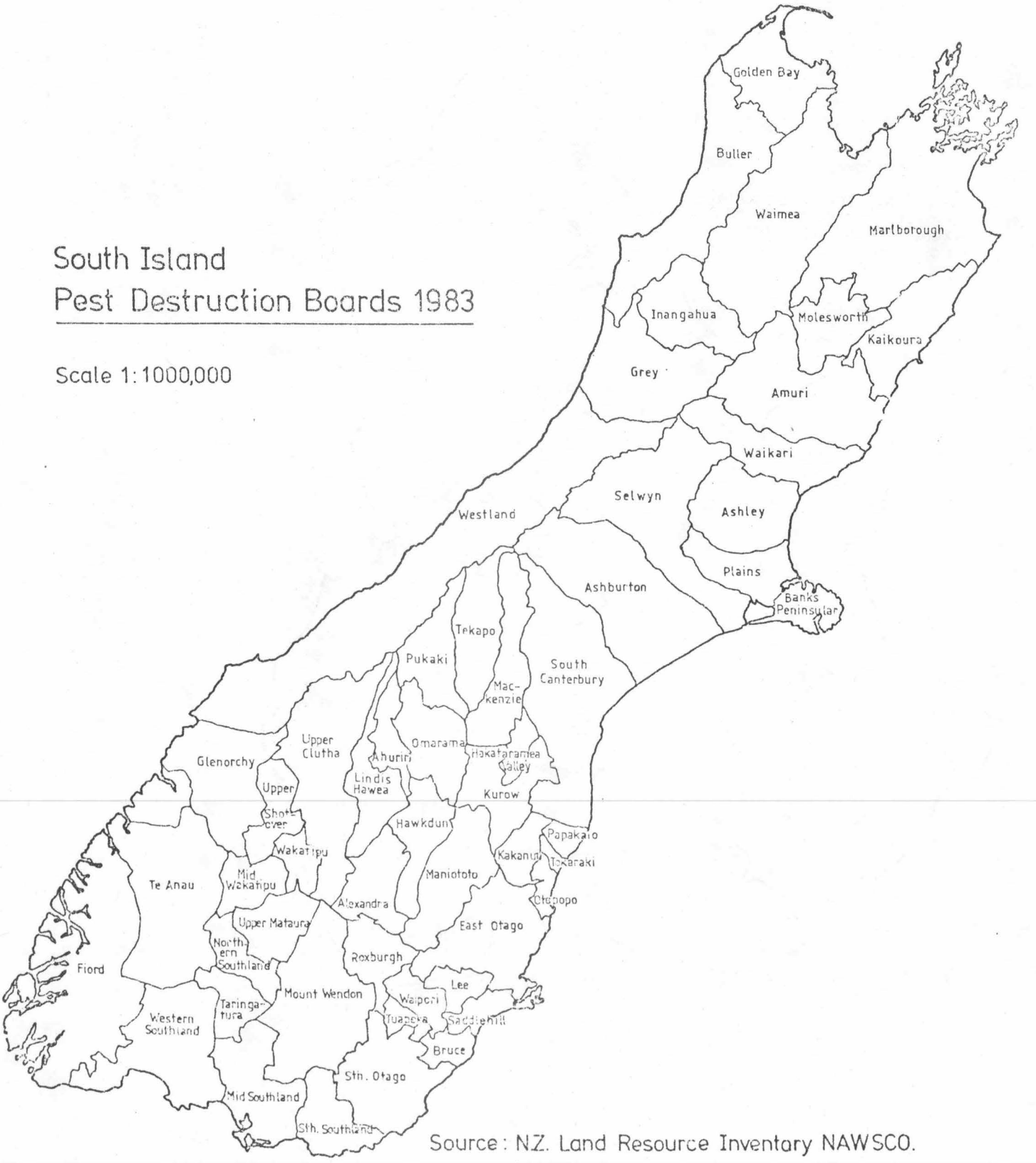
No study of the benefits and costs of rabbit control could be undertaken without reference to the nature and extent of 'rabbit prone' land. The 'rabbit problem' of today appears to be centred largely on the semi-arid soils of the brown-grey earths which are predominantly in Central Otago but are also found in the drier part of the Upper Waitaki. The total area of these soils amounts to about 230,000 ha, which is two percent of the rateable land of the South Island.

The land within the Alexandra Pest Destruction Board's district (refer to Figures 1 and 2) consists of fans, terraces, downs, hills and steeplands of a large intermontane basin of Central Otago. The parent rock is predominantly schist. Tertiary and Pleistocene deposits fill the major depressions. These deposits have been modified by the rivers into terraces and remnant hills. Pleistocene and recent fans have formed at the base of the mountains and terraces. Much of the hills, terraces and fans have been coated with loess.

The characteristic climate of Central Otago is one of warm, dry summers and cold winters, and high diurnal variation in temperature. Rainfall on the low hills, downs and valley floors is, on average, about 330mm, but varies widely between years. Higher hills and steeplands of the mountain ranges around the valley are substantially more humid.

The native vegetation was predominantly short tussock grassland in the valleys and low hills and tall tussock grassland on the higher hills and steepland. Introduced animals and plants have substantially modified

FIGURE 1




Source: N.Z. Land Resource Inventary NAWSCO.

FIGURE 2

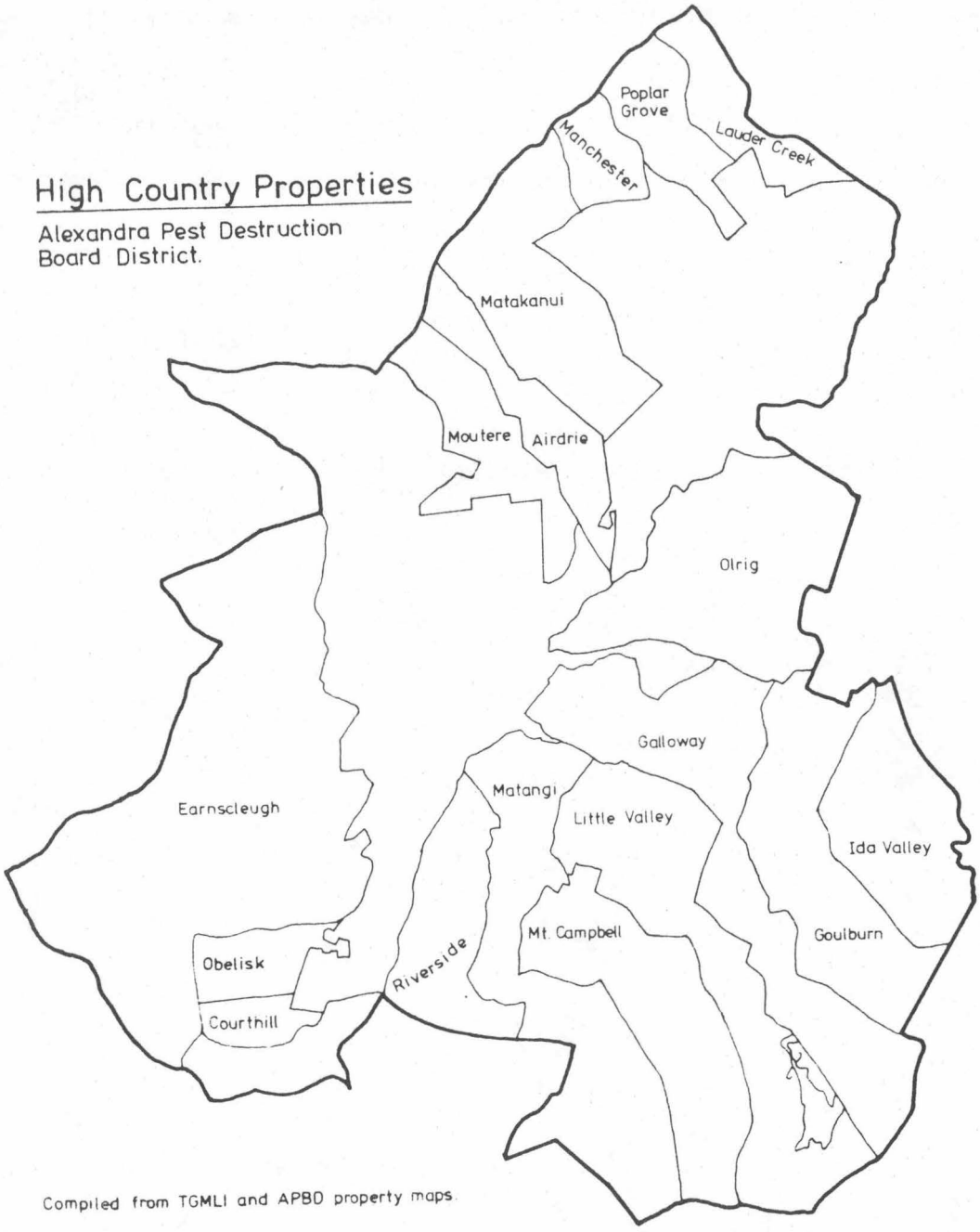

High Country Properties
Alexandra Pest Destruction Board District.
Poplar Grove
Manchester
Lauder Creek
Matakanui
Moutere
Airdrie
Olrig
Galloway
Matangi
Little Valley
Ida Valley
Earnscleugh
Mt. Campbell
Goulburn
Obelisk
Riverside
Courthill
Compiled from TGMLI and APBD property maps.

FIGURE 3

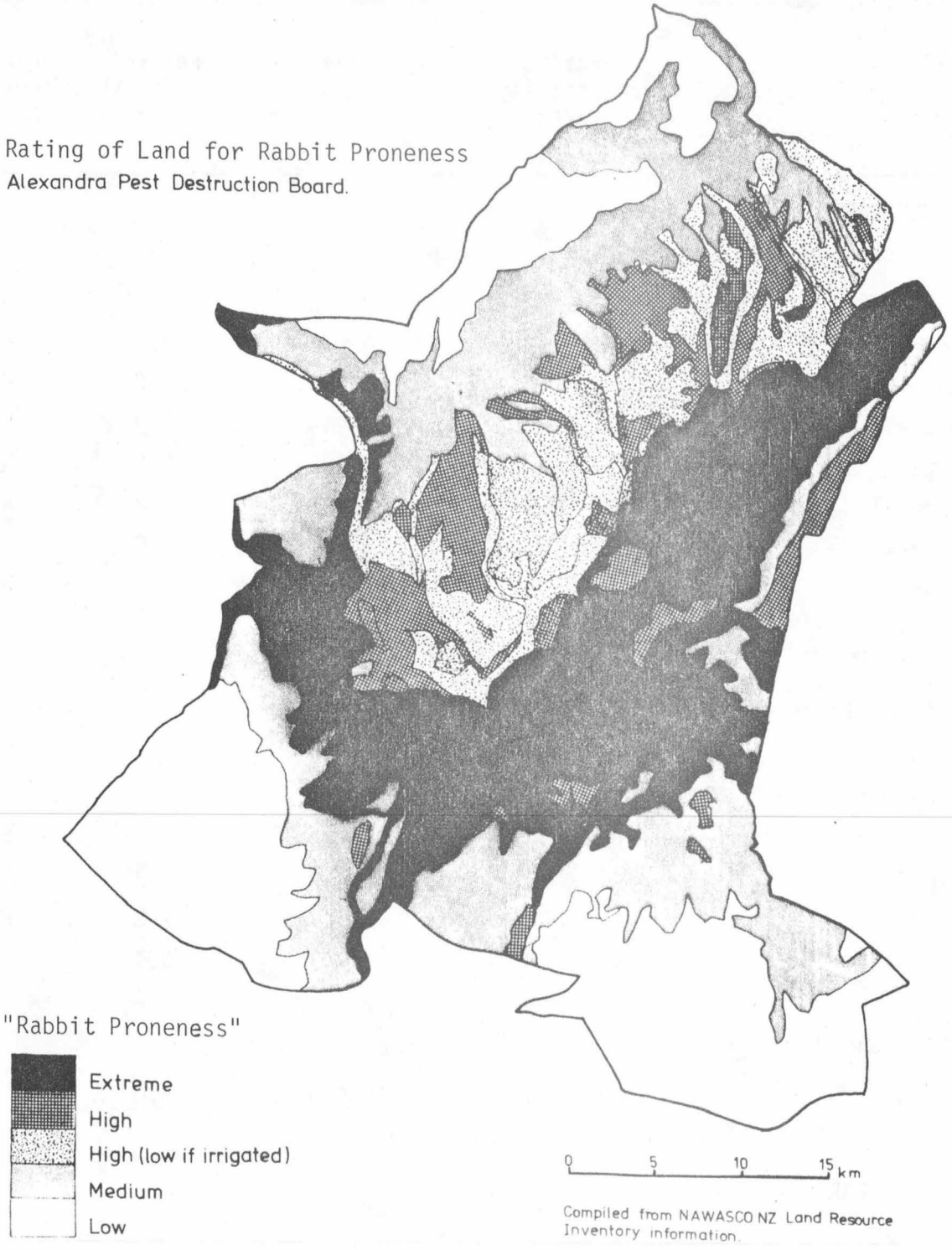

Rating of Land for Rabbit Proneness
Alexandra Pest Destruction Board.
"Rabbit Proneness"
Extreme
High
High (low if irrigated)
Medium
Low
0
5
10
15 km
Compiled from NAWASCO NZ Land Resource Inventory information.

TABLE 3

Alexandra Pest Destruction Board Area:
Soil Sets, Grazing Productivity and Rating of 'Rabbit Proneness'

| Soil Sets | Grazing Productivity (su/ha) (a) | (b) | Area (ha) | Percent of Total (%) | Rabbit Proneness Rating |
|---|---|---|---|---|---|
| BROWN-GREY EARTHS | | | | | |
| - on terrace lands and fans | | | | | |
| Lowburn | <0.1 | 5 | 2 893 | 1.7 | H |
| Drybread | 1 | 5(10) | 4 538 | 2.6 | H(L)* |
| Linnburn | 2 | 5(12) | 3 796 | 2.2 | H(L)* |
| Pigburn | 2 | 6(12) | 3 444 | 2.0 | H(L)* |
| Waenga | 1 | 2(10) | 1 396 | 0.8 | H(L)* |
| Ripponvale | 1 | 2(10) | 2 033 | 1.2 | H(L)* |
| Molyneux | <1 | 1(6) | 1 661 | 1.0 | H(L)* |
| Ranfurly | 2 | 4(10) | 550 | 0.3 | H(L)* |
| Cromwell | <1 | 1 | 261 | 0.1 | H |
| - on rolling lands and hills | | | | | |
| Conroy | <1 | 2 | 8 913 | 5.1 | X |
| Conroy Hill | <1 | <1 | 22 722 | 13.0 | X |
| Clyde | <1 | <1 | 304 | 0.2 | X |
| Clare | <1 | 1 | 5 639 | 3.2 | H |
| Becks | 1 | 4 | 4 107 | 2.3 | H |
| Becks Hill | 1 | 4 | 747 | 0.4 | H |
| - on steeplands | | | | | |
| Alexandra | <1 | <1 | 13 954 | 8.0 | X |
| YELLOW-GREY EARTHS (Dry sub-hygrous) | | | | | |
| - on terrace lands and fans | | | | | |
| Matakanui | 1 | 5 | 1 235 | 0.7 | M |

TABLE 3 continued

| | | | | | |
|---|---|---|---|---|---|
| - on rolling lands and hills | | | | | |
| Cluden | 2 | 8 | 3 888 | 2.2 | M |
| Tiroiti | 1 | 5 | 794 | 0.5 | M |
| Tiroiti Hill | <1 | 5 | 548 | 0.3 | M |
| Blackstone | <1 | 3 | 6 590 | 3.8 | M |
| Blackstone Hill | <1 | 5 | 14 278 | 8.2 | M |
| Matarae | <1 | 3 | 2 781 | 1.6 | M |
| - on steeplands | | | | | |
| Arrow | <1 | 4 | 16 134 | 9.2 | M |
| UPLAND AND HIGH COUNTRY YELLOW-BROWN EARTHS (Hygrous) | | | | | |
| - on rolling lands and hills | | | | | |
| Teviot | <1 | 3 | 12 084 | 6.9 | L |
| Teviot Hill | <1 | <1 | 5 306 | 3.0 | L |
| Carrick | <1 | <1 | 7 101 | 4.1 | L |
| Carrick Hill | <1 | <1 | 3 074 | 1.8 | L |
| Obelisk | <1 | <1 | 2 834 | 1.6 | L |
| - on steeplands | | | | | |
| Dunstan | <1 | <1 | 10 527 | 6.0 | L |
| ORGANIC SOILS | | | | | |
| - on uplands | | | | | |
| Kaherekoau | <1 | <1 | 391 | 0.2 | L |
| GLEY RECENT SOILS | | | | | |
| Paerau | 3 | 12 | 1 396 | 0.8 | L |
| RECENT SOILS | | | | | |
| Frazer | 2 | 6(12) | 4 673 | 2.7 | H(L)* |
| Eweburn | 2 | 5(10) | 1 557 | 0.9 | H(L)* |
| BARE ROCK, DREDGE TAILINGS, ETC. | | | | | |
| Total area | | | 2 687 | 1.5 | |
| | | | 174 836 | 100% | |

NB: a Productivity with little or no development.
b Potential without or with ( ) irrigation.
* Soils of 'high' risk in a dryland state but 'low' under irrigation.

the short tussock grassland. Much of this modification has occurred through over-grazing of susceptible sites by sheep and rabbits, by burning of tussock grassland, and by the spread of introduced species.

The soils of the area, being brown-grey earths in the semi-arid region, yellow-grey earths in the dry, subhygrous area, and yellow-brown earths in the humid region, strongly reflect the influence of the climate. In the undeveloped state, all the brown-grey earths, with often depleted vegetation, are predisposed to high rabbit infestation because of the warm dry habitat offered. Without irrigation, these soils are often a high risk for dryland pastoral development. Some of these soils, because of their predominantly rocky and sparse vegetative cover, are particularly rabbit-prone. The high rabbit populations are due to the high rate of survival of young rabbits in this favourable environment, even though Central Otago has a short breeding season and a low reproductive rate (Counterpest, 1980). Conversely, rabbits are usually much less a problem on developed moist or wet areas.

From the Soil Surveys of the Central Otago region (Leamy and Wilde, 1971; Orbell, 1971) and the NWASCO land resource inventory mapping system, the preliminary assessment of the incidence of rabbit-proneness (referred to in Table 2, p.3) in Central Otago was derived. These results are reported in Table 3 and illustrated in Figure 3. The classification method resulted in four proneness ratings: low, medium, high and extreme, according to the likely suitability of the respective soil types as rabbit habitat. A further group of soils was rated 'high' (or 'low') depending on the degree of development.

The results indicate that the Alexandra Pest Destruction Board district comprises approximately 44 percent of the soils with an 'extreme' or 'high' rating of rabbit proneness in the South Island and that almost 50% of the Alexandra Pest Destruction Board's district is in this category. Also, the 'rabbit problem' is clearly one centred on semi-arid soils of low productivity. In effect, this means that the potential benefits of controlling rabbits in their preferred habitats would be expected to be <u>small</u> in terms of the extra production that could be achieved in their absence. Accordingly, to achieve "net benefits" (i.e.,

an excess of estimated control benefits over estimated control costs), the costs of control would have to be fairly low or the public benefits (such as soil conservation) would have to be fairly large.

## 2.3 The Benefit-Cost Framework

For the purposes of this preliminary assessment, the authors distinguish between direct and indirect benefits and costs and between public and private accounting methods (Pearce, 1975). The accepted approach to measuring costs and benefits "with" and "without" the rabbit control programme, however, requires data that are not presently available. Consequently the procedures used provide indicative estimates only, and the results should be regarded as such until more detailed study is completed.

### 2.3.1 Control costs

The New Zealand pest destruction boards' system of administration allows a sharing of direct costs between the land occupier (private costs) and the nation (public costs). The private costs borne directly by the farm owner or leaseholder include:

1. rates paid to the Alexandra Pest Destruction Board;
2. erection and maintenance of rabbit-proof fences;
3. time spent at pest destruction board meetings and inspections;
4. costs of tracking to provide access for board operations;
5. time and materials spent on night shooting; and
6. pasture restoration after rabbit depredations.

The public costs (to the nation) of pest control in the Alexandra Pest Destruction Board area consist of:

1. grants by Government (the tax-paying public) to assist the board in its operations;
2. other expenditure by the Agricultural Pest Destruction Council and the Ministry of Agriculture and Fisheries on monitoring and administration of the board's operations;
3. administration, advisory and public costs of land rehabilitation borne by other agencies, either directly or indirectly caused by rabbit infestation;

4. expenditure on research which has relevance to pest control in Central Otago in general and the Alexandra Pest Destruction Board area in particular;
5. possible environmental damage caused by control operations; and
6. other public expenditure on investigation, liaison and administration arising from the incidence of severe rabbit infestation within the Alexandra Pest Destruction Board area.

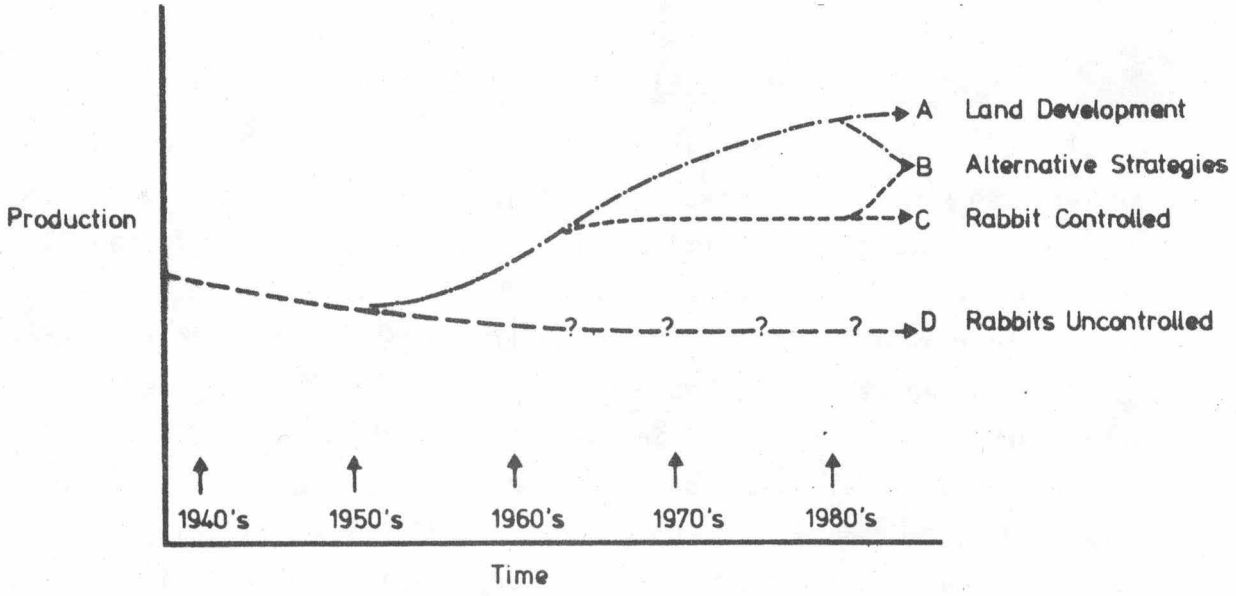
2.3.2 Control benefits and economic efficiency

The benefits to the land occupier (private benefits) are measured by the market value of increased production that occurs as a direct result of rabbit control, with total or potential benefits being the restoration of productivity under complete eradication. Benefits to the public would include the private benefits plus any additional positive effects such as increased foreign exchange earnings and/or reduced risk of soil erosion, to whomsoever they accrue. The efficiency of rabbit control is determined by comparing net benefits and costs with and without control programmes. Hence, an efficient control programme would be one in which the last dollar of public and private expenditure (or incremental cost) is equal to the savings in production losses (or incremental benefit) which is attributed to the control. Likewise an inefficient control programme would have costs exceeding benefits. A control measure is said to be cost-effective if it is more efficient or less inefficient in comparison with an alternative control method or methods.

At present suitable data is not available to estimate accurately the benefits of rabbit control, particularly in the sense of 'incremental benefits' as required in cost-benefit analysis. Consequently, an alternative approach - the 'before and after' method - was used in this study. This approach can be used successfully in analysing historical data provided that other influences on production levels, besides rabbit damage, can be identified and excluded from the observed time trend. The stylized diagram (Figure 4) represents possible levels of production over recent years from rabbit prone land in Central Otago. The diagram is intended to provide a framework for an understanding of aspects considered in this study.

FIGURE 4

Production from Rabbit Prone Land
(Diagrammatic Representation)




The 1940s are seen as the most recent period of severe depradation by rabbits, with pastoral production at a minimum. It is conceived that without control, production would have fallen to an uncertain lower level ('D'). In the 1950s, with the advent of rabbit boards, the 'killer policy' of control was initiated. Increases in production from the undeveloped land to a level 'C' took place through regeneration of depleted vegetation and oversowing. The difference between levels 'C' and 'D' are the production benefits directly attributable to the destruction of rabbits. There is, however, a continuing private and public (social) cost of maintaining rabbit populations at an acceptable level, hence this difference cannot be construed as 'net' control benefits.

Secure from re-infestation, and with the availability of finance and new technology, farmers began land development in the 1960s. Production increased to level 'A'. Where this development has proved successful, the resulting change in habitat appears to have been at least a partial barrier to re-infestation. On areas where the nature of the

land precludes successful land development for pastoral purposes, some alternative land uses or control strategies seem necessary to avoid the continued high level of expenditure on rabbit control as currently practised. This may result in production 'B', which may be greater or less than at present.

## 2.4 Information Sources and Estimation Procedures

The empirical data used in this analysis were obtained from both primary and secondary sources. In the Alexandra Pest Destruction Board district there are 17 properties, all of which are included in the 308 high country runs which comprise the TGMLI High Country Production Survey (Kerr *et al*, 1983). Ten of the 17 runs within the district are included in the Otago 'dry' zone of property classification used in the TGMLI survey, while the remaining seven are in the Otago 'moist' zone. The 17 runs also fall into three categories in the land classification system devised by Bussieres and O'Connor (1983). This system may assist in characterising properties according to their potential for rabbit infestation. Eleven properties (within the 17), for which long run production information was available, were selected for study of the benefits and costs of rabbit control.

Cash flows for the benefits to runholders from the control of rabbits were derived from an assessment of the added production directly attributable to the control of rabbits since the 1948-1952 period when infestation was generally at a peak and records of sheep numbers were available. The change in productivity from then until 1981-82, the year of the most recent TGMLI High Country Production Survey (Kerr *et al*, 1983), was analysed and adjustments made for changes in unit production and the amount of development undertaken since the early 1950s. Income generated from the added production due to rabbit control was calculated from gross margins per stock unit for a breeding ewe flock of productive performance representative of high country flocks in the region. The period selected for time series analysis was 1974-75 to 1981-82.

The direct benefits of rabbit control over the eight years studied

was made with reference to:

1. the productivity and livestock performances in 1981/82 of the properties studied (from TGMLI High Country Production Survey);

2. the added productivity due to oversowing and topdressing and other land development (from TGMLI High Country Production Survey);

3. the number of livestock carried on the property in 1948-1952 (from Annual Sheep Returns).

The costs of initial removal of a rabbit infestation preceeding land development by oversowing and topdressing and enabling the development to take place is considered to be part of the costs of land development. Continuing rabbit control costs are considered to be part of the maintenance costs of developed land.

An example of the estimation of the direct benefits attributable to continuing rabbit control operations on a high country property is:

| | |
|---|---|
| 1981/82 productivity | 5 000 s.u. |
| Less: | |
| (a) land development: | |
| oversowing and topdressing | 1 500 s.u. |
| irrigation | 1 000 s.u. |
| (b) productivity with rabbit infestation: | |
| 1948-52 productivity | 2 000 s.u. |
| Balance (assessed rabbit effect) | 500 s.u. |

While such assessments may be conservative they are never-the-less consistent with the information obtained in interviews with affected farmers.

Cash flows of private costs (to each land occupier) for the same period were assembled from data collected from personal interviews. This information included the cost of losses of production due to rabbits (the amount of income foregone directly attributable to

rabbits) and cost of rabbit control such as rabbit-proof fences, shooting, administration, and rates paid to APDB. The survey form used is reproduced in Appendix A.

Cash flows of the cost of the APDB's activities have been calculated for each of the selected 11 high country farms for the years 1974-75 (the first year of the APDB's operation as an amalgamated board) until 1981/82 (the last year of available comparative data). The control costs were derived from information in APDB annual accounts, rating classifications, reports and records, and Agricultural Pest Destruction Council reports and records.

Following the land classification system developed by Bussieres and O'Connor (1983), the high country runs included in the interview survey were grouped according to the following soil characteristics:

Group A (5 runs): Those with a high proportion (30 percent) of terraces and fans of dry brown-grey earths (BGEs), a moderate proportion of yellow-grey earths (YGEs) and a small proportion (10 percent) of high country yellow-brown earths (YBEs). The properties occur in the semi-arid basins and are highly prone to rabbit infestation.

Group B (4 runs): Those with an appreciable proportion (10-30 percent) of BGEs and YGEs associated with a substantial proportion (20 percent) of YBEs. These properties occur on the margins of basins, have dry valley bottoms and are marginally less rabbit prone than Class A.

Group C (no runs sampled): Those with a small proportion of BGEs and a preponderance of YGE hills and steeplands and a lesser proportion of high country YGEs on steeplands. These properties occur on the flanks of the moister valleys and are less rabbit prone than Class B.

Group D (2 runs): Those with a very high proportion (50 percent) of steepland YBEs and a small proportion (10 percent) BGEs. These properties occur from the margin of the lakes to Central Otago proper and are the least prone to rabbit infestation.

## 2.5 Summary of Empirical Results

The results of the analysis are reported in three sections. First, the APDB expenditure since 1974-75 is described. This discussion is supplemented with additional data on control operations and itemised costs which are reported in Appendix B. Second, the private costs to the runholder, including perceived losses in productivity resulting from the presence of rabbits on their properties, are examined. Finally, the cost-benefit ratios from the public and private view-points are estimated and assessed.

### 2.5.1 Pest Board expenditures

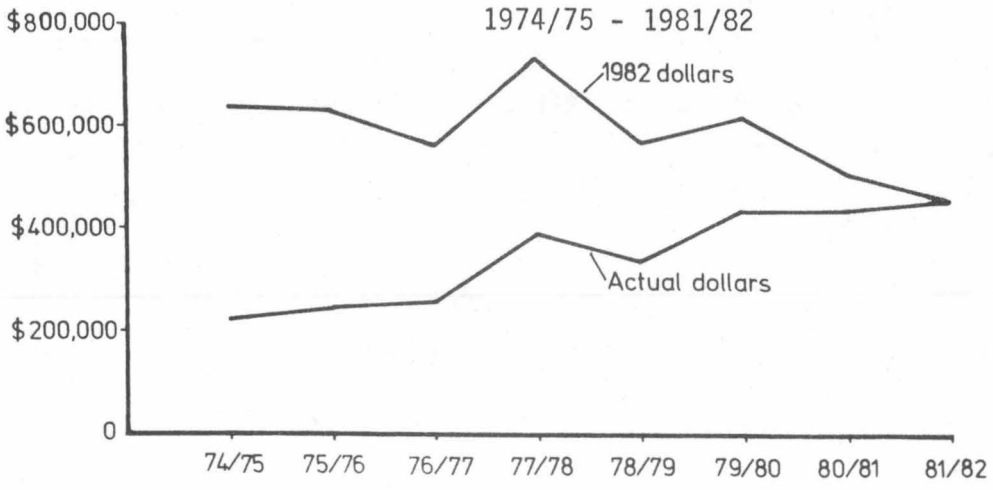
Total annual expenditure by the APDB is summarised in Figure 5. As discussed in Section 2.3.1, the total public costs of rabbit control should include related expenditures by other agencies for administration, research, etc. Only the operating and administration costs of the APDB have been estimated, hence the APDB expenditure reflects a lower limit on the "true" taxpayer contribution to pest control in the board's area. The Board's expenditure does, however, include rates collected from local taxpayers. The results show that while actual expenditures (in actual dollars) have increased since 1974-75, annual expenditures adjusted for inflation (in real dollars) has actually declined during this period.

FIGURE 5

Total Expenditure

Alexandra Pest Destruction Board

1974/75 - 1981/82




* Compiled from annual accounts of Alexandra Pest Destruction Board

Several methods for assessing the distribution of APDB expenditure were explored. The method chosen was to relate the board's total costs to the labour (in man days) involved in the respective field operations. The costs per property were computed from a specially developed programme by the MAF Rabbit Research Group (Broad, pers. comm., 1983). Average field operation costs per man day (including materials) were estimated from information contained in the board's annual accounts and supervisors' reports, and APDC reports and records. The details of these estimates are reported in Appendix B. The estimated average cost per man day of $128 for 'other field expenses' (other than the major poisoning operations)[2] is substantially greater than that often used by many boards in estimating the unit costs of control operations. This finding confirms the earlier results reported by Williams (pers. comm.). The total man days of field staff employed by the board has remained fairly constant over the last seven years, but this is, apparently, less than in previous years.

The rates collected by the APDB were $58,368 in 1981-82, or 13 percent of the board's expenditure. Grants from Government made up virtually all other income of the board and this pattern has not changed greatly over the eight years studied. For 1982-83, the rates expected to be collected are $104,781, or 15 percent of expenditure, but this ratio of cost sharing is considerably short of the Agricultural Pest Destruction Council's objective of reducing Government funding to 30 percent of total cost. (APDC Circulars 1982/18 and 1983/18). The average rate paid by the 17 high country properties and by all ratepayers in 1981/82 and in 1982/83 is compared in Table 4.

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[2] These 'other' field expenses are attributed primarily to night shooting (see Appendix B).

TABLE 4
Average Rates Collected by the APDB
High Country vs Total Rated Area Properties

1981-82 and 1982-83

| Year | High Country | All Ratepayers |
|---|---|---|
| 1981-82 | $2,139 ($0.30/ha) | $148 ($0.34/ha) |
| 1982-83 | $4,304 ($0.60/ha) | $263 ($0.60/ha) |

The Board's 1982-83 rating policy has been to apply a uniform $0.60 per hectare rate over all of the rateable area irrespective of rabbit proneness or cost of rabbit control. The total rates paid in 1981-82 by the 17 high country farmers were $36,368, or 62 percent of all rates paid to the Board. This amount was approximately 15 percent of the total expenditure on the 17 properties concerned. By comparison, all other properties in the Board's district contributed $22,290, which was only 9 percent of the estimated expenditure on the non-high country properties. Hence, the high country farmers were making a significantly larger contribution to rabbit control costs than were other farmers in the Board's district. When the average amount of rates paid by each of the eleven high country runs was expressed in 1982 dollars, a 30 percent decline in average "real" rates paid was found for the years studied.

2.5.2 Runholder expenditures and production losses

The private costs to runholders, including direct out-of-pocket expenditures for prevention and repair of damage, rates paid to the APDB and their perceived loss of productive capacity, are summarised in Table 5. These data are reported by classification of rabbit proneness, and are compared with APDB costs on a per hectare basis of total run area.

Even with the substantial control inputs by the Pest Destruction Board, runholders in groups A and B estimated that productivity savings of $.84 to $1.51 per hectare could be realised with better control. This is perhaps optimistic because several of the runs included in the survey

had particularly acute rabbit problems and previous control treatments had not been very successful.

TABLE 5

Summary of Public and Private Pest Control Costs by Land Type
APDB District, 1981-82
(in 1982 Dollars per Hectare)

| Classification of Rabbit Proneness | Private Costs | | | Public Costs (Grants)[a] | Total Costs |
|---|---|---|---|---|---|
| | Rates | Prevention | Productivity Loss | | |
| | $/ha | $/ha | $/ha | $/ha | $/ha |
| Group A (n=5) | .30 | .91 | 1.51 | 1.55 | 4.27 |
| Group B (n=4) | .30 | .10 | .84 | 2.48 | 3.72 |
| Group D (n=2) | .30 | nil | nil | nil | .30 |
| Group average (11 runs) | .30 | .43 | 1.07 | 1.95 | 3.75 |

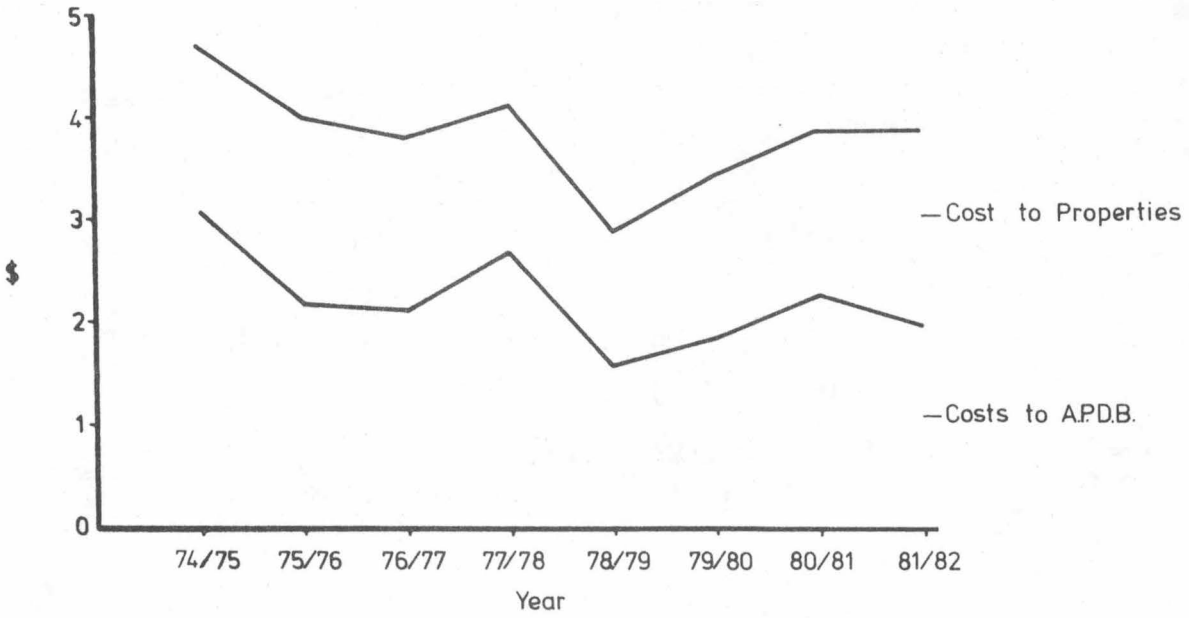
[a] APDB expenditures less rates paid by runholders.

Even with the substantial control inputs by the Pest Destruction Board, runholders in groups A and B estimated that productivity savings of $.84 to $1.51 per hectare could be realised with better control. This is perhaps optimistic because several of the runs included in the survey had particularly acute rabbit problems and previous control treatments had not been very successful.

For the 11 high country properties as a whole the trend in per hectare private and APDB control expenditures is illustrated in Figure 6. While the trend is generally downward since 1974-75, the periodic outbreak of rabbit numbers is apparent from the annual increases per hectare costs observed in 1977-78 and in 1980-81. Expressed on a per stock unit basis, the annual costs for these two periods are compared in Table 6. As with per hectare costs, costs 'per stock unit' strongly reflect the extent of rabbit prone land within the group classifications.

FIGURE 6

Cost of Rabbit Control per Hectare (1982 Dollars)
11 High Country Properties
APDB District 1974/75 - 1981/82




It is important to point out, however, that since control expenditures are concentrated on areas of 'extreme' or 'high' rabbit proneness, the actual cost per stock unit will be much higher for these areas because of the low carrying capacity. (This aspect is discussed further in the following section.) Even so, these per unit costs for the high country properties are substantially greater than those estimated by Bell and Williams (1981) and further emphasise the local nature of the rabbit problem.

TABLE 6

Cost of Rabbit Control per Stock Unit
11 High Country Properties Grouped According to Rabbit Proneness
1976-78 and 1981-82
(In 1982 Dollars)

| Classification of Rabbit Proneness | Private Costs | | APDB Costs | | Total Costs | |
|---|---|---|---|---|---|---|
| | 76/78[a] $/su | 81/82 $/su | 76/78 $/su | 81/82 $/su | 76/78 $/su | 81/82 $/su |
| Group A(n=5) | 2.73 | 2.73 | 3.03 | 1.43 | 5.76 | 4.16 |
| Group B(n=4) | 2.89 | 1.89 | 3.47 | 4.08 | 6.36 | 5.97 |
| Group D(n=2) | 0.16 | 0.05 | 1.38 | 0 | 1.54 | 0.05 |
| All groups | 2.03 | 2.09 | 3.28 | 2.28 | 5.31 | 4.37 |

[a] Aggregated TGMLI data for the survey years 1976-77 and 1977-78

2.5.3 Control efficiency since 1974-75

Ratios of benefits and costs were estimated annually since 1974-75. Present value (discounted) benefit and cost streams were not used as a basis of the analysis, since the effectiveness of control operations at one point in time could not be related to expenditures or benefits in subsequent time periods. Although present value estimates are preferred for benefit-cost analysis where time series data are concerned, the method used is apparently satisfactory given the nature of the data under examination.

The benefit-cost ratios were calculated for each year, following the definitions explained in Section 2.3, using two accounting view-points:

1. a private accounting method, where the estimated savings in production attributed to rabbit control (the private benefit) is divided by the runholder's direct expenditures plus his perceived remaining productivity loss (the private costs); and
2. a public accounting method, where the private benefit is divided by the private cost plus the Government's share (taxpayer contribution) of APDB expenditure.

Secondary, or flow-on effects, are not included, which will understate the local (and possibly regional) benefits of rabbit control, nor are any national benefits that might be attributed to water and soil protection included. It is possible that in the absence of effective control operations in the future they could become significant factors in policy assessment at the national level. Similarly, "public" costs, as estimated by the authors, actually understate the true social costs, since spending by other agencies and organisations on rabbit-related control programmes have been excluded in the cost estimates for the study area. Such expenditures in recent years, as reported in Section 1.1, do appear significant however, and warrant more detailed analyses.

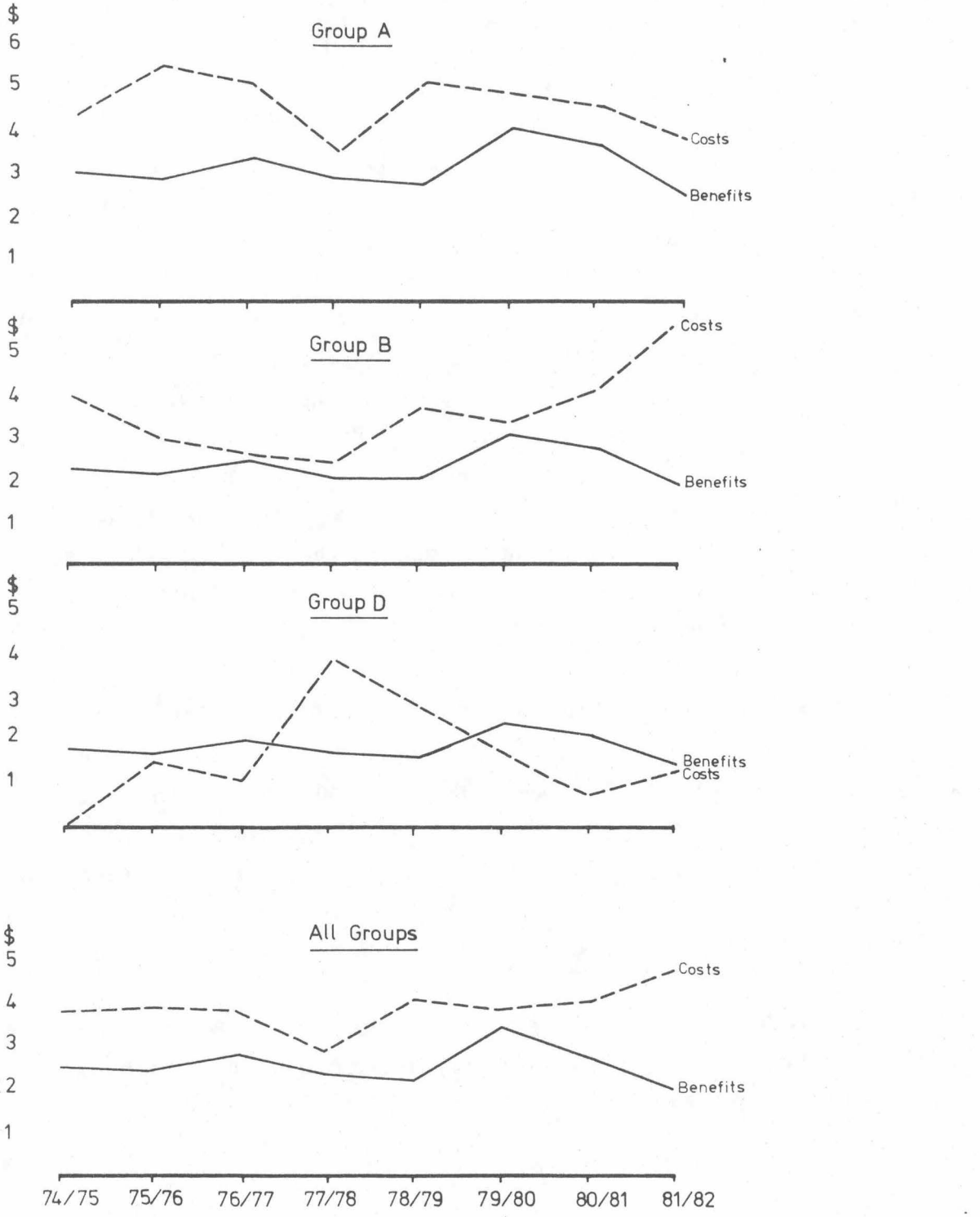
In general, over the eight years to 1981-82, the 'public' costs (Board and farmer) of pest destruction were greater than the 'private' benefits (Figure 7). This is particularly so for those runs with a large area of 'extreme' or 'high' rabbit prone land. Group A, comprising the runs with the drier valley bottoms, and Group B, much the same as Group A, except with some moist tops, clearly illustrate the problem areas where control costs apparently exceeded benefits during the years for which data are available. Group D, which are more productive soils, illustrate an improved cost-effectiveness in rabbit control.

The results summarised in Table 7 show the ratios of benefits to costs (B/C) of rabbit control for 11 individual properties and compare efficiencies of control from both the private and public viewpoint. The ratios are the average benefit received per dollar of control cost over the 1974/75 to 1981/82 period. For example, a B/C ratio of 0.40 means that on average, for every dollar spent on rabbit control, only 40 cents were received in added productivity as losses in productivity ascended.

As expected, because of the high taxpayer input to the Board operations, the private B/C ratios are typically greater than one, while the public B/C ratios are less than one.

FIGURE 7

Benefits and Costs of Rabbit Control per Hectare
11 High Country Properties
APDB, 1974/75 - 1981/82 (in 1982 Dollars)




---- Total costs per hectare ——— Private benefits per hectare

TABLE 7

Average Ratios of Benefits to Costs for Rabbit Control Programmes
11 High Country Runs
APDB 1974-75 to 1981-82

| Rabbit Proneness Classification | B/C Ratios Private Viewpoint | Public Viewpoint |
|---|---|---|
| Group A | | |
| Run 1 | 1.05 | 0.40 |
| 2 | 0.53 | 0.32 |
| 3 | 1.12 | 0.63 |
| 4 | 7.80 | 2.09 |
| 5 | 3.40 | 0.69 |
| Group A average[a] | 1.54 | 0.68 |
| Group B | | |
| Run 6 | 1.01 | 0.65 |
| 7 | 1.04 | 0.64 |
| 8 | 2.61 | 0.74 |
| 9 | 5.31 | 0.48 |
| Group B average[a] | 1.60 | 0.64 |
| Group D | | |
| Run 10 | 4.27 | 0.64 |
| 11 | 4.70 | 1.78 |
| Group D average[a] | 4.45 | 1.12 |

[a] Weighted average of benefits and costs for each group based on run size in hectares.

For those properties without significant areas of 'extreme' or 'high' rabbit proneness, the benefits of control have apparently exceeded the costs, and in some cases, by a wide margin. Given the incidence of control expenditures and programme benefits illustrated in the individual run data (Table 7), it is clear that ample scope exists to rationalise better the total programme expenditure within the control district. The key to improved cost-effectiveness would appear to lie in better identi-

fication of the land systems in terms of both rabbit proneness and pastoral productivity. The potential importance of this observation is best illustrated with an example.

In Table 8 the amount of annual net revenue expected from 'extreme' or 'high' rabbit prone land without any rabbits (i.e., total eradication) is compared with the cost of control. Both values are expressed in dollars per hectare of affected area. The area actually receiving treatment, being of inherently low productivity, has a much more marked effect on the benefit-cost ratio than when costs and benefits are considered for the properties as a whole. Nelson (pers. comm.) estimated the costs per actual hectare treated at $18.00 (excluding labour and overheads). The total costs are thus about $23 per hectare (authors' estimate). Lands typically classified 'extreme' in rabbit proneness can only generate, on average, about one fourth this amount in annual net income. Annual carrying capacity varies between 0 su/ha for some rocky sites to more than 3 su/ha for the more favourable sites (NWASCO Land Resource Inventory). An average for much of the grazed area is approximately 0.2 su.ha and may decline well below this with increased rabbit populations.

As the control interval is extended to several years or more, per hectare costs drop until annual costs and benefits are about equal at a four-year treatment interval. If production declines at all as a result of spacing treatments, it becomes unlikely that benefits will ever equal or exceed costs. In recent years the pattern of annual expenditure on many district properties has remained about the same, suggesting that spelling these lands may not have been considered a viable option. It is clear that unless means are found to increase the productivity of the land, annual returns (even in the complete absence of the rabbit risk) cannot sustain the level of costs now incurred under present control technology and practise.

TABLE 8

Expected Net Revenue and Costs of Control
On Soils of 'Extreme' or 'High' Rabbit Proneness
A Sensitivity Analysis

| Control Interval (Years Between Poisons) | Net Revenue (gm=$27.24/su) $ | | Control Costs ($23/ha)[c] $ |
|---|---|---|---|
| | a | b | |
| 1 | 5.45 | | 23 |
| 2 | 5.45 | 4.77 | 11.50 |
| 3 | 5.45 | 4.08 | 7.67 |
| 4 | 5.45 | 3.40 | 5.75 |
| 5 | 5.45 | 2.72 | 4.60 |

[a] Gross margin based on an average carrying capacity of 0.2 su/ha per year.

[b] Carrying capacity is assumed to decline to 0.1 su/ha with a five-year control interval.

[c] Authors' estimate.

## 2.6 Conclusions and Limitations

In summary, the main findings of the study can be stated as follows:

1. There has been a slight reduction in the overall cost (in 1982 dollars) of pest destruction in New Zealand since 1974-75 (see Fig. 5, p.21).

2. In relation to other districts of the country, there is a large area (44 percent) of land of 'extreme' or 'high' rabbit proneness within the Alexandra Pest Destruction Board district (see Fig. 3 and Table 2, also refer to Section 2.2).

3. There has been a consistently high proportion of Government grants (87 percent) to rates (13 percent) in the total operating

expenditure of the APDB since it was formed (Table 1, also see Fig. 5 and Appendix B).

4. There has been a generally constant level of expenditure per hectare (in 1982 dollars) on rabbit control by the APDB for the eight years to 1981-82 on the 11 high country runs surveyed (Fig. 5, and also see Table 6, Appendix B).

5. There has been a steady fall in the average amount of rates paid (in 1982 dollars) by the 11 high country runs surveyed (see Appendix B, Table 6).

6. There has been a general rise in costs (in 1982 dollars) incurred by the affected farmers, in addition to rates, as a consequence of rabbit damage on the high country runs prone to rabbit infestation (Appendix B, Table 6).

7. In general, over the eight years to 1981/82 the public costs of pest destruction substantially outweigh the private benefits to the occupiers of the high country runs surveyed. This is particularly so for runs with a large area of 'extreme' or 'high' rabbit prone land (see Figure 7).

Questions which arise from these conclusions include:

1. Are the public benefits of pest control in the Board's district (not measured in this study) sufficient to justify the maintenance of the existing pattern of expenditure?

2. Is the high cost of pest control unique to this Board, to Central Otago, or does it also apply to other areas?

3. How can the resources of the Board be better directed to areas of greatest need or of greater cost-effectiveness?

4. Would alternative strategies for control and/or uses of the rabbit prone land be any more cost-effective than the present methods employed by this Board and others?

These questions have not been addressed in this study but have a major bearing on future pest control policy. To answer these questions and related issues accurately, a closer examination of the management options is required. Greater precision is needed in estimating private and public costs and benefits, particularly where a restructuring of Government policy concerns 'user pay' and equitable cost-sharing principles. Further, the biological and ecological basis for formulating more efficient management strategies and for assessing the associated risks of alternative approaches is not adequately understood. In the concluding chapter we outline some of the policy options which stem from this preliminary analysis, and suggest areas of research that should help to overcome present limitations in understanding the pest management problem.

# CHAPTER 3

# IMPLICATIONS FOR POLICY AND RESEARCH

Faced with a problem of the costs of rabbit control exceeding the benefits, there are comparatively few options open to land occupiers, Boards and Government except to change present policy and control methods. In the absence of a more successful approach than that currently employed on highly rabbit prone land, the demand for high levels of Government assistance will continue. The productivity of the affected land cannot sustain the present level of pest control inputs (the 'user pays' criterion). While the earlier APDC 'killer' (eradication) policy (along with land development) reduced rabbit populations significantly, eradication was and still is a technically unachievable objective. It seems that a threshold has been reached in control effectiveness, where 'eradication' is being replaced by 'management' as the basis of pest control policy. The next step would be to consider the rabbit problem within the larger context of land and related resources management.

## 3.1 Possible Strategies for the Future

For the land in the Alexandra Pest Destruction Board's area which is in the category of 'extreme' rabbit proneness, there may be a need for alternative strategies for rabbit control, or alternative land use to reduce the high costs of existing control operations. Some management options that deserve consideration include:

1. Continue existing methods of control, with emphasis on general 'belt-tightening' measures to improve overall cost-effectiveness. (This option implies reducing overheads and possibly cutting back on such activities as night shooting, which are less cost-effective than aerial poisoning.)

2. Retire those blocks of land that are rabbit prone and too expensive to maintain for pastoral purposes. (This implies that 'ideal' wild rabbit habitat should be recognised as such and managed to its best advantage, possibly as a recreational resource

and, under proper administrative controls, as a commercial enterprise[3].)

3. Modify habitat for concentrated rabbit control through predators, toxins or biological means such as myxomatosis. (Essentially this strategy would require zoning of lands for designated uses at certain times, implying strict compliance with control schedules, fencing standards and stock management practices. Some possible consequences of introducing myxomatosis are discussed by White (1983).

4. Under the authority provided by the Agricultural Pest Destruction Act 1967, S56(b), the APDB can institute control operations irrespective of existing land use. (While this option presently exists, it is seen as only an emergency measure for cases of major pest outbreaks. However, the fact that it is an option, and could be implemented more frequently than in the past, gives the Board latitude in the search for more effective control measures. The consequences for landholders, given the uncertainty of when and how such powers were applied, would make pastoral use of the affected lands fortuitous.)

5. Examine possible changes in land use, from extensive grazing to more intensive production including herbs, shrubs, trees and related enterprises such as goats, game birds (recreation) and others. (This option focuses on alternative land uses of rabbit prone areas, and raises some interesting possibilities. Alternative use may not only compete with rabbits[4], but generate

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3 The commercial value of meat and skins was not included as a social cost (an opportunity foregone) in the authors' benefit-cost calculations. Given the historical evidence on export revenues from Central Otago, rabbit 'farming' could conceivably prove a viable land use option in many areas within the district.

4 An example is the encroachment of wild thyme (an introduced plant) on rabbit prone lands in the Alexandra area. Thyme is potentially a high value exportable product and is not a palatable herbage for either sheep or rabbits.

better economic returns than the conventional merino wool/ mutton production system.)

## 3.2 Recommendations for Future Research

Several extensions of the present study appear worthwhile in the light of the preliminary findings and possible future strategies. In particular a closer examination of the cost-effectiveness of alternative pest control options for selected sites is considered vital. Thus far the results suggest that 'rabbit proneness' of the land may be the key to the design of optimal control strategies. Accordingly, a second phase of research is proposed, which would logically address the needs of the Board in exploring the range of alternatives that could lead to a more practical, cost-effective means of pest management. The following issues have been highlighted as worthy of immediate attention in near-term research:

1. An evaluative framework that encompasses local, regional and national perspectives in pest management. This would bring the local and regional issues into a clearer focus and facilitate a broader consideration of the problem and alternative solutions.

2. A careful examination of the relationship between rabbit proneness and the spatial incidence of control expenditure. This analysis would be directed at the identification of possible 'management units', and the control options that may be best suited for each type of management unit, to include: alternative methods of control, the timing of control operations, and the implications for pastoral and other (alternative) land uses.

3. The identification of ecological, social and economic implications. This would involve a detailed assessment of costs and benefits over the range of options from "do nothing" to fully integrated strategies involving a mix of control measures.

4. An assessment of the long term economic efficiency implications of responding more effectively to epidemic situations, requiring perhaps the creation of contingency funds set aside to finance strategic control

programmes. Essentially, this is a study of risk management and, in particular, the evaluation of expected social costs and benefits with regard to land and water conservation.

5. A careful examination of the equity implications of a 'user pay' approach to funding pest management programmes. While focussing on 'ability to pay' for private benefits received, this aspect of the analysis would also clarify the nature of 'public' benefits at the local, regional and national levels.

6. An extension of the analysis of 'rabbit proneness' and 'pest management' to broader issues in land use and resource management. Under the principle of 'best use', can alternatives to sheep husbandry be identified that would yield a higher long term benefit from these rabbit prone areas? If so, how can pest management be integrated with general land use planning?

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# APPENDIX A

C O N F I D E N T I A L

## QUESTIONS ON SOME OF THE COSTS OF RABBIT CONTROL

RUN: DATE:

How much money, other than pest destruction board rates, have you spent each year since 1973 on?

| | 81/82 | 80/81 | 79/80 | 78/79 | 77/78 | 76/77 | 75/76 | 74/75 | 73/74 |
|---|---|---|---|---|---|---|---|---|---|
| (a) rabbit proof fences (construction, repair, ....) | | | | | | | | | |
| (b) attending meetings, inspection etc ... | | | | | | | | | |
| (c) other (rabbit destruction, renewing pastures, ...) | | | | | | | | | |

NOTES: ? = don't know, 0 = none

What do you estimate the losses in total production to have been that were directly caused by rabbits?

| | 81/82 | 80/81 | 79/80 | 78/79 | 77/78 | 76/77 | 75/76 | 74/75 | 73/74 |
|---|---|---|---|---|---|---|---|---|---|
| (a) sheep (stock units) | | | | | | | | | |
| (b) cattle (stock units) | | | | | | | | | |
| (c) other | | | | | | | | | |

NOTES: ? = don't know, 0 = none

# APPENDIX B

## SUPPLEMENTAL COST DATA, APDB CONTROL OPERATIONS 1974-75 to 1981-82

The cost (including overheads) of the Board's main control methods was estimated each year since 1974-75. The results for 1981-82 are summarised in Table 1 (the entire time series is reported in Table 4).

TABLE 1

Estimated Total Cost of Rabbit Control Methods, 1981/82

| Item | Costs $ | Percent % |
|---|---|---|
| Aerial carrots | 61 908 | 14 |
| Ground carrots | 2 628 | <1 |
| Aerial oats | 57 778 | 13 |
| Ground oats | 128 386 | 29 |
| Other field operations (basically night shooting) | 199 547 | 44 |

From the Board's records it has been possible to make comparisons between only two control techniques - vehicle and motorcycle night shooting. For eleven high country properties on which night shooting was carried out, motorcycle night shooting was half as costly as vehicle based night shooting. While this observation confirms those of Williams (1979), it cannot be said that either method is cost efficient when compared with the apparent efficiency of successful aerial poisoning operations.

Several methods were explored for comparing the amount of funds

required for different controls, and the one chosen was to relate the Board's total costs to the labour (as man days) involved in the respective field operations. The costs per property were computed from a specially developed programme by the MAF Rabbit Research Group (Broad, pers. comm.). The cost per man day (in nominal dollars) and the Board's manpower utilisation since 1974-75 are reported in Tables 2 and 3.

TABLE 2

Estimated Field Operational Costs
In $ Per Man Day, 1974/75 - 1981/82 (Actual Dollars)

| Item | 74/75 | 75/76 | 76/77 | 77/78 | 78/79* | 79/80 | 80/81 | 81/82 |
|---|---|---|---|---|---|---|---|---|
| Aerial carrots | 175.46 | 231.35 | 272.65 | 338.84 | 325.30 | 398.27 | 411.77 | 460.11 |
| Ground carrots | 115.90 | 150.00 | 190.88 | 210.04 | 207.76 | 265.63 | 230.08 | 273.46 |
| Aerial oats | 112.97 | 109.05 | 134.94 | 193.78 | 178.21 | 260.52 | 312.31 | 374.76 |
| Ground oats | 69.40 | 81.21 | 94.36 | 135.51 | 112.05 | 167.27 | 176.95 | 208.32 |
| Aerial pellets | - | - | - | - | - | - | 1067.80 | - |
| All other field expenses | 45.81 | 54.16 | 59.84 | 91.23 | 65.51 | 102.45 | 107.95 | 127.64 |

* Costs offset by large sale of capital assets

TABLE 3

APDB Manpower Utilisation in Field Operations
1974-75 to 1981-82

| Item | 74/75 | 75/76 | 76/77 | 77/78 | 78/79 | 79/80 | 80/81 | 81/82 |
|---|---|---|---|---|---|---|---|---|
| Field operations: | | | | | | | | |
| - Days | 3,934 | 3,042 | 2,748 | 2,831 | 2,614 | 2,881 | 2,491 | 2,478 |
| - Percent | 73 | 74 | 70 | 69 | 69 | 69 | 68 | 62 |
| Total man days | 5,496 | 4,137 | 3,941 | 4,074 | 3,789 | 4,118 | 3,649 | 4,005 |

TABLE 4

ESTIMATED COST OF FIELD OPERATIONS

ALEXANDRA PEST DESTRUCTION BOARD

1974/75 - 1981/82

| | 81/82 | 80/81 | 79/80 | 78/79 | 77/78 | 76/77 | 75/76 | 74/75 |
|---|---|---|---|---|---|---|---|---|
| LABOUR | | | | | | | | |
| Wages | 182581 | 167244 | 140607 | 113655 | 105609 | 89000 | 83901 | 91185 |
| Materials | 4828 | 265 | 239 | 9010 | 9924 | 9920 | 6497 | 3696 |
| Other field expenses | 50166 | 49783 | 42910 | 38342 | 36362 | 28135 | 28750 | 28577 |
| Administration | 27471 | 23802 | 17673 | 15505 | 14049 | 11881 | 9905 | 9224 |
| Accommodation | 15575 | 13798 | 12439 | 16406 | 9067 | 7149 | 5948 | 5651 |
| Loan charges | 2674 | 2627 | 2484 | 2484 | 2484 | 2484 | 2206 | 1247 |
| Miscellaneous | 3964 | 529 | 286 | - | 113 | 704 | 236 | 1414 |
| Capital (net) | 29040 | 10844 | 75444 | 24151 | 80660 | 15181 | 27304 | 39236 |
| TOTAL | 316299 | 268892 | 292082 | 171251 | 258268 | 164454 | 164747 | 180230 |
| Man days | 2478 | 2491 | 2851 | 2614 | 2831 | 2748 | 3042 | 3934 |
| Avg cost per man day | 127.64 | 107.95 | 102.45 | 65.51 | 91.23 | 59.84 | 54.16 | 45.81 |
| CARROTS | | | | | | | | |
| Carrots | 13305 | 21935 | 24204 | 17119 | 16147 | 20018 | 8229 | 4725 |
| Poisons | 1823 | 2336 | 4426 | 2716 | 960 | 3999 | 1182 | 306 |
| Freight | 5900 | 12759 | 12686 | 8288 | 5063 | 9871 | 4859 | 1740 |
| SUB-TOTAL | 21028 | 37030 | 41316 | 28123 | 22170 | 33888 | 14270 | 6771 |
| Aerial hire | 25122 | 52707 | 32936 | 21620 | 23248 | 18373 | 9291 | 2573 |
| TOTAL | 46150 | 89737 | 74252 | 49743 | 45418 | 52261 | 23561 | 9344 |
| Days (a) ground carrots | 9.6 | 13.1 | 4.9 | 13.6 | 6.1 | 33.9 | 34.7 | 53.4 |
| (b) aerial carrots | 134.6 | 290.1 | 248.3 | 184.1 | 180.5 | 224.7 | 114.2 | 43.2 |
| Avg cost per day (a) | 273.46 | 230.08 | 265.63 | 207.76 | 210.04 | 190.88 | 150.00 | 115.90 |
| Avg cost per day (b) | 460.11 | 411.77 | 398.27 | 325.20 | 338.84 | 272.65 | 231.35 | 175.46 |
| OATS | | | | | | | | |
| Oats | 50551 | 38506 | 37629 | 31885 | 48020 | 25749 | 27150 | 22582 |
| Poisons | 5494 | 3962 | 6927 | 6618 | 3468 | 4907 | 5054 | 1824 |
| Freight | 2337 | 2748 | 2597 | 2602 | 2411 | 61 | 2739 | 1365 |
| Oat cooking costs | 3779 | 3123 | 1986 | 1357 | 2114 | 1074 | 2291 | 250 |
| SUB-TOTAL | 62161 | 48339 | 49139 | 42462 | 56013 | 31791 | 37234 | 26021 |
| Aerial hire | 25665 | 12102 | 12785 | 12862 | 10541 | 6460 | 8591 | 4374 |
| TOTAL | 87826 | 60441 | 61924 | 55324 | 66554 | 38251 | 45825 | 30395 |
| Days (a) ground oats | 616.3 | 611.2 | 621.0 | 718.0 | 1084.0 | 761.7 | 1068.0 | 1002.5 |
| (b) aerial oats | 154.2 | 89.4 | 137.1 | 194.4 | 180.9 | 159.2 | 308.6 | 100.4 |
| Avg cost per day (a) | 208.32 | 176.95 | 167.27 | 112.05 | 135.51 | 94.36 | 81.21 | 69.40 |
| Avg cost per day (b) | 374.76 | 312.31 | 260.52 | 178.21 | 193.78 | 134.94 | 109.05 | 112.97 |
| PELLETS | | | | | | | | |
| Pellets | - | 5018 | - | - | - | - | - | - |
| Poisons | - | 337 | - | - | - | - | - | - |
| Freight | - | 455 | - | - | - | - | - | - |
| Aerial hire | - | 525 | - | - | - | - | - | - |
| TOTAL | - | 6335 | - | - | - | - | - | - |
| Man days | - | 6.6 | - | - | - | - | - | - |
| Avg cost per day | - | 1067.80 | - | - | - | - | - | - |

TABLE 5

Income and Expenditure: Alexandra Pest Destruction Board
1974/75 to 1981/82

| | 81/82 | 80/81 | 79/80 | 78/79 | 77/78 | 76/77 | 75/76 | 74/75 |
|---|---|---|---|---|---|---|---|---|
| INCOME: | | | | | | | | |
| Rates | 58 368 | 50 837 | 46 283 | 43 961 | 38 063 | 38 091 | 27 725 | 27 594 |
| Grant | 408 920 | 369 605 | 323 792 | 278 147 | 298 358 | 240 537 | 178 982 | 171 017 |
| Miscellaneous | 17 688 | 11 283 | 7 761 | 9 863 | 8 238 | 7 984 | 4 660 | 4 807 |
| Capital | 8 259 | 8 290 | 6 121 | 60 839 | 20 973 | 2 703 | 12 404 | 1 676 |
| Balance | 0 | 0 | 50 428 | 0 | 25 581 | 0 | 22 767 | 16 551 |
| TOTAL | 493 234 | 440 015 | 383 957 | 392 810 | 391 213 | 289 315 | 246 538 | 221 645 |
| 1982$ | 493 234 | 513 787 | 545 848 | 673 351 | 732 698 | 628 163 | 628 425 | 636 948 |
| EXPENDITURE: | | | | | | | | |
| Wages | 182 581 | 167 244 | 140 607 | 113 655 | 105 609 | 89 000 | 83 901 | 91 185 |
| Materials | 76 002 | 72 360 | 73 425 | 67 348 | 78 520 | 64 592 | 48 113 | 33 133 |
| Other field expenses | 112 969 | 134 201 | 105 906 | 85 070 | 79 739 | 63 973 | 56 521 | 38 880 |
| Administration | 27 471 | 23 802 | 17 673 | 15 505 | 14 049 | 11 881 | 9 905 | 9 224 |
| Accommodation | 15 575 | 13 798 | 12 439 | 16 406 | 9 067 | 7 149 | 5 948 | 5 651 |
| Loan charges | 2 674 | 2 627 | 2 484 | 2 484 | 2 484 | 2 484 | 2 206 | 1 247 |
| Miscellaneous | 3 964 | 529 | 286 | 0 | 112 | 704 | 236 | 1 414 |
| Capital | 37 300 | 19 134 | 81 565 | 36 688 | 101 633 | 17 882 | 39 708 | 40 911 |
| Balance | 34 698 | 6 320 | 0 | 55 654 | 0 | 31 650 | 0 | 0 |
| TOTAL | 493 234 | 440 015 | 434 385 | 392 810 | 391 213 | 289 315 | 246 538 | 221 645 |
| 1982$ | 493 234 | 513 787 | 617 538 | 673 351 | 732 698 | 628 163 | 628 425 | 636 948 |

SOURCE: Annual accounts, Alexandra Pest Destruction Board.

TABLE 6

Costs of Pest Control on 11 High Country Properties, Alexandra Pest Destruction Board, 1974/75 - 1981/82 ($ 1982)

(i): Public costs per hectare ($ 1982)

| | 1981/82 $ | 1980/81 $ | 1979/80 $ | 1978/79 $ | 1977/78 $ | 1976/77 $ | 1975/76 $ | 1974/75 $ |
|---|---|---|---|---|---|---|---|---|
| Group A n=5 | 1.55 | 3.18 | 3.28 | 2.01 | 3.24 | 2.92 | 2.23 | 1.65 |
| Group B n=4 | 2.48 | 1.64 | 0.81 | 1.09 | 2.29 | 1.56 | 2.35 | 4.41 |
| Group D n=2 | -0.32 | 1.17 | 0.73 | 3.45 | 2.54 | 1.25 | 0.34 | 0.81 |
| All Groups n=11 | 1.95 | 2.26 | 1.83 | 1.59 | 2.70 | 2.11 | 2.20 | 3.08 |

(ii): Total costs (public and private) per hectare ($ 1982)

| | 1981/82 $ | 1980/81 $ | 1979/80 $ | 1978/79 $ | 1977/78 $ | 1976/77 $ | 1975/76 $ | 1974/75 $ |
|---|---|---|---|---|---|---|---|---|
| Group A n=5 | 4.29 | 5.37 | 5.00 | 3.40 | 4.99 | 4.80 | 4.47 | 3.72 |
| Group B n=4 | 3.85 | 2.93 | 2.49 | 2.42 | 3.57 | 3.28 | 3.97 | 5.71 |
| Group D n=2 | 0.11 | 1.50 | 1.09 | 3.87 | 2.93 | 1.71 | 0.82 | 1.28 |
| All Groups n=11 | 3.84 | 3.86 | 3.45 | 2.90 | 4.12 | 3.83 | 4.02 | 4.68 |

TABLE 6 contd.

(iii): Rates paid to APDB per hectare ($ 1982)

| | 1981/82 | 1980/81 | 1979/80 | 1978/79 | 1977/78 | 1976/77 | 1975/76 | 1974/75 |
|---|---|---|---|---|---|---|---|---|
| | $ | $ | $ | $ | $ | $ | $ | $ |
| Group A n=5 | 0.31 | 0.31 | 0.35 | 0.40 | 0.37 | 0.43 | 0.45 | 0.45 |
| Group B n=4 | 0.28 | 0.29 | 0.32 | 0.37 | 0.35 | 0.41 | 0.43 | 0.43 |
| Group D n=2 | 0.32 | 0.33 | 0.36 | 0.42 | 0.38 | 0.46 | 0.48 | 0.47 |
| All Groups n=11 | 0.30 | 0.30 | 0.33 | 0.38 | 0.36 | 0.42 | 0.44 | 0.44 |

(iv): Other private costs per hectare (not including rates) ($ 1982)

| | 1981/82 | 1980/81 | 1979/80 | 1978/79 | 1977/78 | 1976/77 | 1975/76 | 1974/75 |
|---|---|---|---|---|---|---|---|---|
| | $ | $ | $ | $ | $ | $ | $ | $ |
| Group A n=5 | 2.43 | 1.88 | 1.37 | 0.99 | 1.38 | 1.45 | 1.79 | 1.62 |
| Group B n=4 | 0.95 | 1.00 | 1.36 | 0.96 | 0.93 | 1.31 | 1.19 | 0.87 |
| Group D n=2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| All Groups n=11 | 1.59 | 1.30 | 1.29 | 0.93 | 1.06 | 1.30 | 1.38 | 1.16 |