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RESEARCH DIRECTIONS FOR CONSERVATION SCIENCE?

Five papers presented at the Science & Research Division Department of Conservation 1990

Compiled by

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Abstract: Selected papers from the 1990 Science and Research Division Seminar series include Late Pleistocene and Holocene Vegetation and Landscape Studies in New Zealand', by M.S. McGlone; ‘Current Research Issues in the Study of Moas and Moa-Hunting', by Atholl Anderson; ‘Review of the Mammals of New Zealand', by C.M. King; and ‘Changing Human Perceptions of the Natural Environment', by Geoff Park. There is a preface by B. McFadgen and P. Simpson, and a final appraisal by R.M.F.S. Sadleir. The papers concentrate on the connection between scientific research and conservation, and selected avenues of research are suggested and examined.

Keywords: Pleistocene, Holocene, vegetation, landscape, moas, introduced mammals, environmental perceptions, future research.

PREFACE

This publication comprises the five invited papers presented during the Science and Research Division 1990 Seminar Series. Four of the speakers were invited to talk on their special area of expertise. Three were chosen specifically because they were not part of the Department. All were chosen because of the breadth of their experience and the relevance of their discipline to the Department's responsibilities. The intention was to provide an historical perspective on the present day environment and protection issues.

The speakers covered diverse topics: Holocene vegetation changes; moas and moahunting in prehistoric New Zealand; the impact of animals introduced since European contact; and changes over time in perceptions of the New Zealand environment.

Each speaker was asked to review the current state of knowledge of the chosen topic, outline current problems, give ideas on management implications for the Department, and suggest what they perceived as the role of the Department's Science and Research Division in extending an understanding of the topic. In addition, we sought the comment of the Department in reply, and this was given by Dr R.S.Sadleir, Director of the Science and Research Division. Each paper fulfilled our expectations by providing a provocative assessment.

Dr McGlone outlined the effects of natural processes on the vegetation over the last 18 000 years and described the deforestation resulting from human settlement, beginning with the arrival of the first Polynesians about a thousand years ago. He challenged the Department to popularise historical information because greater public interest would help to clarify values and actions to protect our heritage.

Dr Anderson drew attention to the woefully inadequate data on which to base understanding of moas and moahunting. Management is only as good as the information it has to work with, and there is a lot of basic research still to be done. Dr Anderson maintained that this research is landscape-based and is perhaps better carried out by the Department's Science and Research Division than by the universities.

Dr King challenged conservationists to accept the ecological reality of introduced animals in most of New Zealand's ecosystems. She argued for a triage approach to three classes of land, with a concentrated effort to manage pests in those areas where effort will be rewarded with meaningful ecological success.

Dr Park noted that attitudes towards the New Zealand landscape have changed from seeing it as a "repulsive waste" to a "special place". He concluded that integrated studies are needed to chart this change and that the Department's Science and Research Division has a unique opportunity to achieve such a multidisciplinary approach.

Dr Sadleir examined the main conclusions from each paper with regard to a set of conservation principles. The principles underlie his comments on future research suggested by the other four seminar speakers. He noted that the department's research must give prior consideration to immediate management problems without, however, totally excluding strategic research. In his opinion, although the directions of research suggested by the other speakers are important to current conservation, he did not rank them highly in terms of current priorities.

The papers are intended to be provocative. Readers of this publication are invited to respond to the underlying issue - the nature and direction of research in conservation management.

Bruce McFadgen, Science & Research Division
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30 July 1991

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LATE PLEISTOCENE AND HOLOCENE VEGETATION AND LANDSCAPE STUDIES IN NEW ZEALAND

by

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1. INTRODUCTION

The Holocene, the most recent geological epoch and the one we live in, is defined as beginning 10 000 years ago. At that time global temperatures rose abruptly to present day levels and above, and the greatly expanded ice sheets of the Pleistocene (the last 2 million years) rapidly melted. Since that time the world has enjoyed temperatures much higher than the long-term Pleistocene average. Interglacial (Holocene-like) episodes make up only about 10% of Pleistocene time, and the Pleistocene average temperature is about 3°C cooler than the Holocene.

It is important to study the Holocene and the late Pleistocene cold period that immediately preceded it because it was during this 20 000 years that the biota and landscape of New Zealand assumed their present shapes. The forces which did this shaping are still operative and, by understanding them, we can gain insight into how these processes happen, and in what ways human intervention has altered their outcome. Study of these periods can also help us decide what value we should put on a particular part of our legacy from the past. For that reason, the study of the past should interest a government department whose major reason for existence is to preserve that legacy.

In this paper I first briefly review the vegetation history of New Zealand in the last 18 000 years and show how this history helps us understand the course of climate and environmental change. I then discuss how historical evidence can help our understanding of the effects of volcanism, erosion, extinctions, and human impact on the environment. Finally, I suggest priority areas for involvement by the Department of Conservation.

2. CLIMATIC CHANGE AND LANDSCAPE CHANGE DURING THE LATE PLEISTOCENE AND HOLOCENE

2.1 Vegetation Change

The vast, earth-shaping events of the late Pleistocene epoch transformed the New Zealand landscape. Colder temperatures (annual mean temperatures may have been as much as 5°C lower than now), less rainfall and stronger winds made the southern two-thirds of New Zealand inhospitable for plants. Scrub, grassland, and occasional patches of forest formed a monotonous vegetative cover stretching from the Hamilton Basin southwards. Glaciers filled the mountain valleys of the Southern Alps and flowed out onto the coastal plain in the south-west. Because the vegetation cover was sparse over much of southern New Zealand, frost, wind and rain eroded the soils of hill and mountain slopes. The products of the long period of glacial stripping of soils and carving of rock from the mountain ranges are now widespread in the lowlands as thick coverings of loess and as gravel outwash plains.

Some of the most convincing evidence as to the enormity of these events has come from the offshore cores drilled under the auspices of the Deep Sea Drilling Programme. A team led by Professor Campbell Nelson of Waikato University has shown that each time the glaciers advanced in the course of the Pleistocene, the predominant sediment type far off shore changed from carbonates, produced by animal and plant life in the water column, to terrigenous silicates as silt flowed into the sea from the eroding landmass (Fig. 1) (Nelson *et al.* 1985).

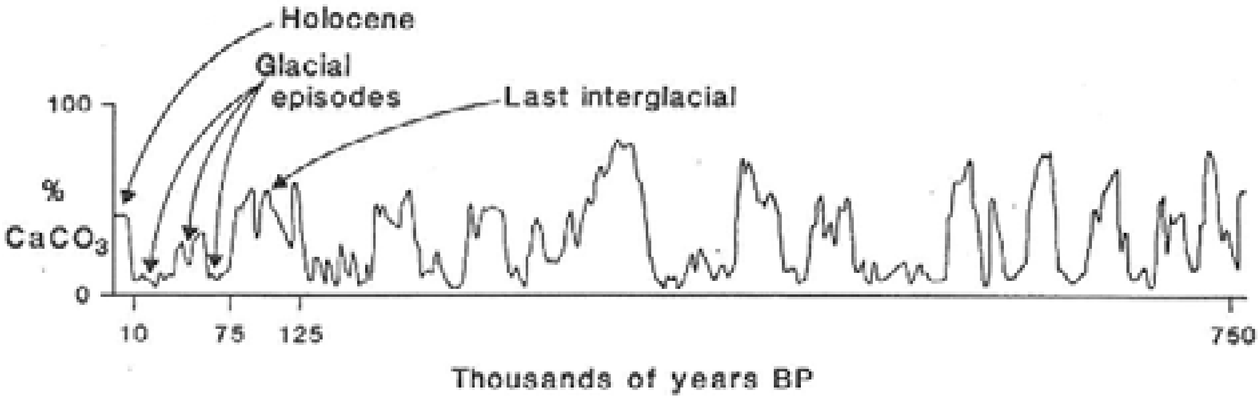

Figure 1. Carbonate cycles over the last 750 000 years from a deep sea core to the east of the South Island. High levels of carbonate indicate warm interglacial conditions. Low levels of carbonate correspond with high inputs of quartz eroded from mainland New Zealand, and match cold glacial periods. After Nelson *et al.* (1985).

The vegetation history of New Zealand since about 18 000 years ago is one of continuous change, with plant populations expanding and contracting in response to an always altering climate. At the height of the glacial period, around 18 000 years ago, most of the ice-free landscape south of Auckland was either bare ground, or under sparse `alpine' vegetation, tussockland, tall scrub or low forest. Recent research has confirmed a long-held belief that continuous tall forest dominated throughout the full glacial period in the Northland peninsula (Dodson *et al.* 1988). The present day distribution of frost- and cold-sensitive plants - especially woody species and ferns - in the far north had long been taken as evidence of a full glacial forest refugia in this area (Wardle 1963). A surprising feature of pollen diagrams from Northland is that they suggest full glacial forests in this region may have differed little from those of the present. Exactly why the northern tip of New Zealand should have differed so much from more southerly areas is not clear. It may be that there was a major ocean discontinuity at the latitude of Auckland and that north of there warmer ocean temperatures maintained an environment similar to that of the present.

From around 14 000 years ago the southern glaciers retreated, and by 12 000 years ago most were far back in their mountain valleys. At the same time, deposition of loess (windblown silt) which had accumulated on the lowlands in vast sheets during the height of the glacial period, slowed dramatically as the retreat of the glaciers and reclamation of the landscape by progressively denser vegetative cover reduced the source areas of silt.

Between 15 000 years ago and 7000 years ago, tall podocarp-dominated forest began to expand, and there is a step-like progression southwards of these communities, although it is not clear yet if there was any major change in the range of the species which make up these communities (Fig. 2). It seems most likely that patches of nearly every species that now grows in a region persisted there, in climatically favoured localities, through the glacial maximum. These small forest patches were therefore waiting ready to expand with the advent of warmer, moister climates (McGlone 1985). An alternative is that tall podocarp forest species may have spread from glacial refugia in Northland southwards. At present there is not enough evidence to confidently distinguish between the alternatives. However, regardless of whether the spread consisted of coalescence of pre-existing patches or of a southwards-moving wave of forest, it is clear that it proceeded very rapidly once it began.

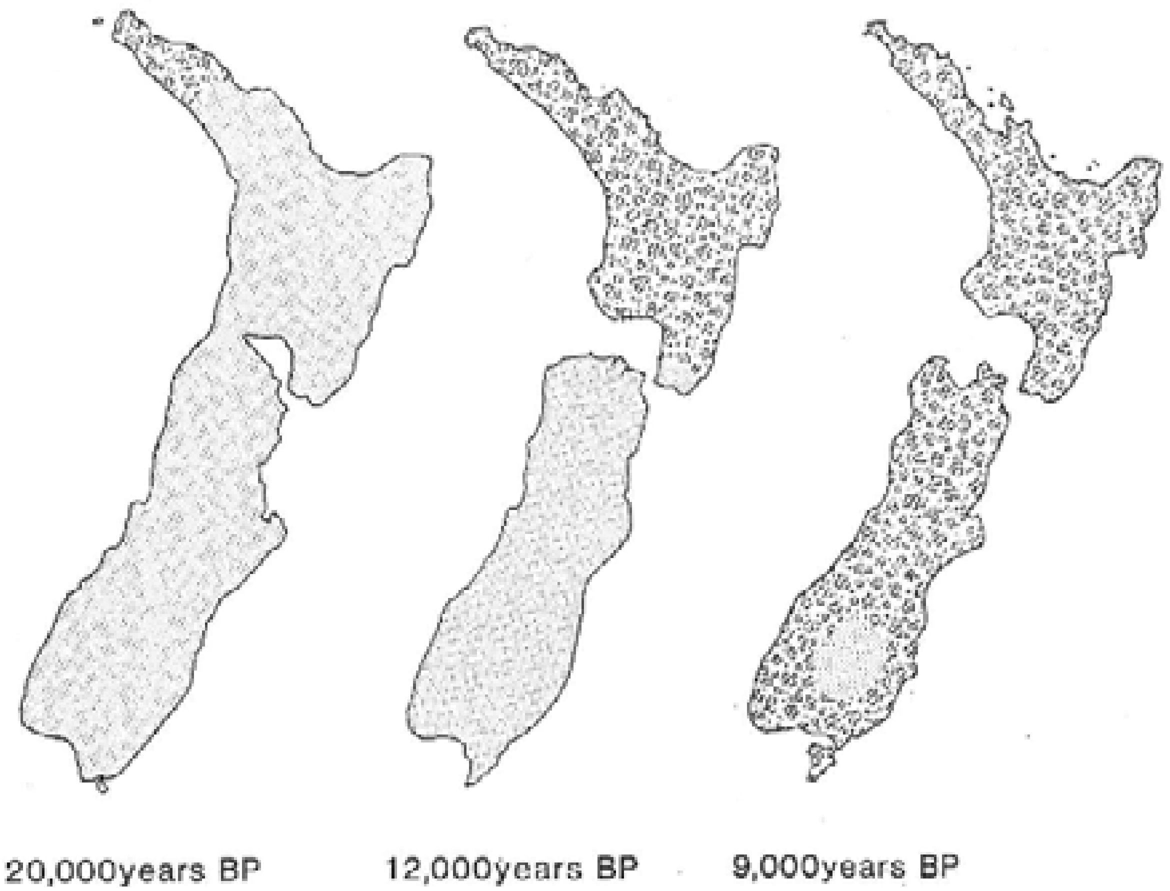

Figure 2. Spread of tall podocarp dominated forest since the glacial maximum. Changing outline of New Zealand is a result of the rise of sea level from its low of 120 m at the glacial maximum.

By 14 000 years ago all but the south-western sector of the North Island was covered in tall forest. By 12 000 years ago, Taranaki was reafforested, and low forest of rata and kamahi was prominent in coastal areas of the West Coast and Fiordland. At 9500 years ago, forest blanketed the lowlands except for Central Otago, which seems to have been the sole substantial area unaffected by the wave of podocarp colonisation. However, by 7500 years ago, it had a low forest cover as well.

The process of tall forest spread was almost certainly climatically controlled. The major steps (14 000, 12 000 and 10 000 years ago) in the spread coincide closely with rapid global warmings.

The great changes in vegetation, landscape and climate which accompanied the transition from the full glacial period to the Holocene, dwarf what follows. Glaciers have been at their minimum extent during in the Holocene, in particular between 9000 and 5000 years ago, and, although they have undergone a resurgence in the last 5000 years, they are still minuscule compared with those of 18 000 years ago.

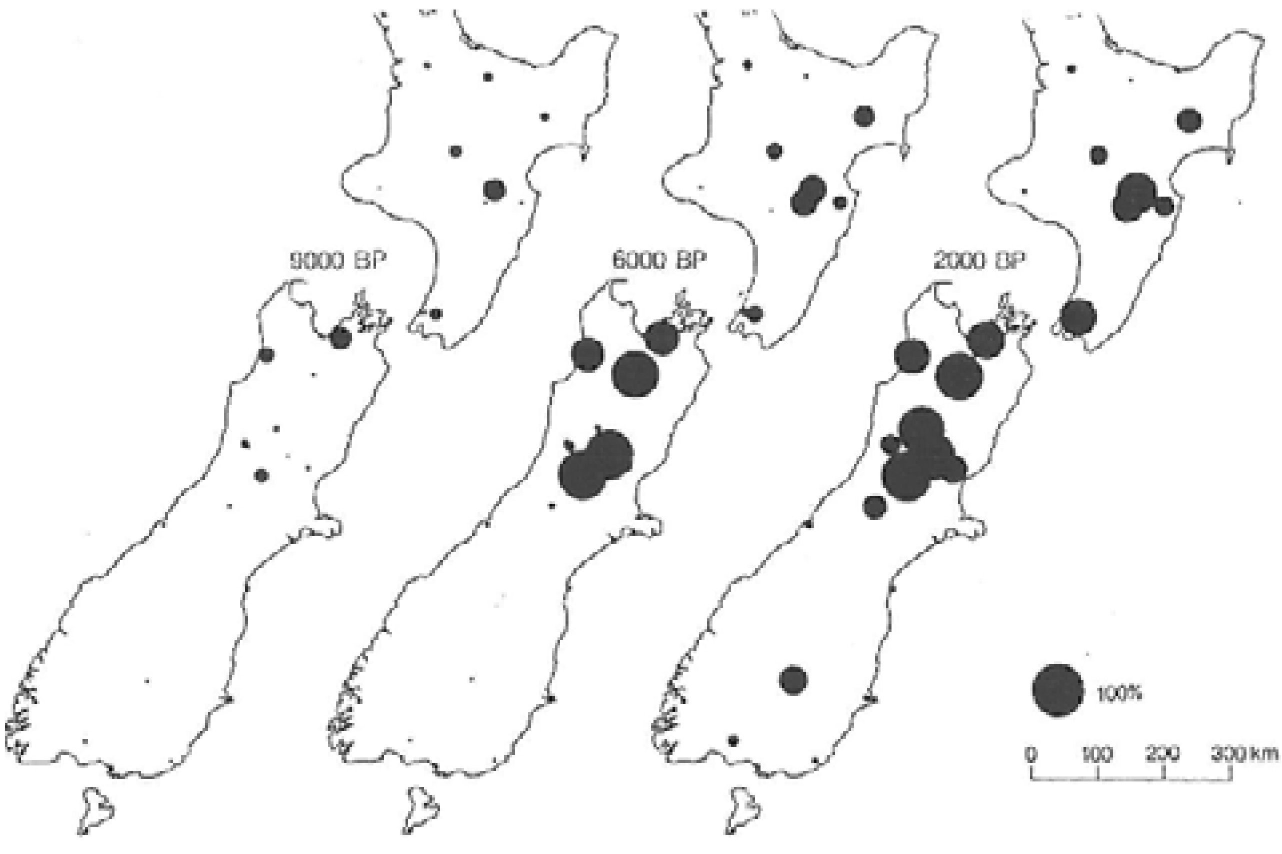

Figure 3. Holocene spread of beech. Circles are in proportion to the percentage of beech pollen recorded (from McGlone 1988).

Early Holocene vegetation (10 000 - 7000 years ago) showed marked variations from the present in lowland areas. Some abundant northern species were very restricted at this time: rewarewa and kauri, for instance, were nowhere abundant, spreading only in the late Holocene. *Ascarina*, now restricted to areas with light frosts and no drought, was widespread in all but the drier east coast regions. Tree ferns were more abundant than now in many localities.

Upland vegetation was also different. Beech forest, now dominant in most mountainous areas, was quite restricted. In its place a variety of low forest and shrubland communities seem to have been the main vegetation cover at near treeline, with *Phyllocladus*, cedar, mountain totara, bog pine and a range of upland shrubs prominent. In montane regions podocarp-hardwood forest with kamahi and rata was common. From about 7000 years ago, beech spread vigorously throughout most mountain areas (Fig. 3).

Peat bogs have also shown changes which give insights into Holocene climates. They are good indicators of a reliable water supply, either through groundwater or rain. Surprisingly, they are restricted in extent in the early Holocene. It is only since 7000 years ago that they became a widespread feature of lowland eastern landscapes, and before then they were uncommon in many upland areas. The spread of drought-resistant vegetation in the late Holocene therefore coincided with the spread or accelerated growth of bogs.

Central Otago, the driest region of the country, shows the contrast between the early and late Holocene most clearly. During the early Holocene there was no forest at all in this region, probably because of dry winter conditions and low annual rainfall overall. During the mid to late Holocene, bog growth accelerated in the upland ranges while scrub-forest spread throughout the region. About 2500 years ago, dry, windy summers led to huge fires destroying much of the lowland forest-tall scrub vegetation cover, while wet, snowy winters in the uplands maintained an extensive cover of bog and wetland.

There is thus an apparent contradiction in the various lines of evidence for Holocene climates. On one hand, the early Holocene forests had a predominance of plants which are characteristic of mild, moist climate, and yet tall beech forest was uncommon at treeline and peat bogs had a restricted distribution. On the other, the late Holocene saw the spread of drought- and frost-tolerant plants and deforestation by fire in central Otago, but beech forest dominated treeline communities and peat bogs spread rapidly. Rogers and McGlone (1989) have postulated that changes in the seasonality of rainfall and of the solar radiation regime may have been the driving force behind these alterations in vegetation and wetland distribution.

Changes in the Earth's orbit around the sun alter the seasonal distribution of sunlight. The early Holocene in the southern hemisphere had lower summer sunlight intensity (by about 6%) than at present. Changes in global climate may have affected atmospheric pressure fields in the south-west Pacific, thus altering the quantity and seasonality of precipitation. At present much of New Zealand has either a winter maximum or an almost aseasonal distribution of rainfall. If, as I have suggested, early Holocene summers were cloudy, wet and less sunny than now, and the winters mild and dry (McGlone 1989), there would have been marked changes in vegetation and wetland distribution. Winter rainfall saturates the soil, thus leading to permanent waterlogging in susceptible sites, which would promote formation of wetlands. On the other hand, the variable, dry summer weather which afflicts large areas of New Zealand, while forcing a temporary halt only to bog growth, can have very marked effects on the distribution of drought-resistant and drought-sensitive plants.

Cloudy and moist early Holocene summers and mild winters would encourage drought- and frost-intolerant vegetation in the lowlands, but only slow-growing, low-stature timberline vegetation would be able to deal with the stress which high respiration and low photosynthesis during the summer would impose. On the other hand, as the climatic system swung towards the present regime of overall cooler temperatures and wet, cloudy winters, and brighter drier summers, beech forest would have been competitively placed because of its ability to take advantage of the increased sunlight.

Late Pleistocene and Holocene vegetation change makes a fascinating study in its own right. I have been able to give here only a broad outline of the nature of the changes and the climatic controls. However, the complex interplay of climate, soil, tectonism, volcanism and vegetation when observed over long periods of time can give unique insights into how our present environment functions. There are a number of fields to which studies of vegetation and landscape history can make a significant contribution. Among these are climate change, volcanism, erosion studies, extinctions, and the whole question of human impact on the environment.

2.2 Climate Change

Palaeoclimatic studies, such as those based on interpretation of past vegetation change, have an important role in assisting our understanding of how the global climatic system functions. Increasingly palaeoclimatologists are moving away from these unidimensional characterisations of past climates in terms of temperature or precipitation alone, and are attempting to construct models of the entire climatic system. Palaeoclimatic evidence has been used along with computer models of the atmosphere to provide global scale interpretations of how the climatic system works (COHMAP Members 1988).

In recent years the palaeoclimatic history of the warmest periods of the Holocene has become of great interest as an analogue of the near future if global warming driven by increasing greenhouse gases occurs. The transition from glacial to our present interglacial climates occurred rapidly and was associated with a steep rise in methane and carbon dioxide concentrations. However, we have very little idea as to how and why these changes occurred. We are certain that changes in the seasonality of solar radiation are ultimately involved, but they happen too gradually and have too low an amplitude to explain the rather sudden and major climatic changes which have occurred during the Holocene. Abrupt changes in oceanic circulation are now regarded as perhaps the only way marked fluctuations in carbon dioxide could occur rapidly. It is rather unsettling to discover that very rapid global temperature changes can occur in association with rises in greenhouse gas concentrations, and the implication is that the global climate system is actually rather delicately poised. Because there is little land in our region, New Zealand's palaeoclimatic history forms an important part of a growing global effort to understand how these rapid changes come about.

2.3 Volcanism

Both andesitic and rhyolitic volcanoes, of which there are many in the central North Island, produce easily identifiable time horizons in the form of discrete tephra layers. Often the eruptions cause widespread destruction and disruption of the surrounding vegetation. We now have a very substantial and complete knowledge of the age, eruptive centre and size of New Zealand volcanic eruptions (Froggatt and Lowe 1990), and very detailed information about some of the larger eruptions, such as the Taupo Pumice.

Volcanoes give unparalleled opportunities for studying vegetation change on a time scale neoecologists can appreciate. Studies of the vegetation buried under volcanic deposits give a marvellous opportunity to look at a fully preserved slice of the past.

A number of detailed studies on the vegetation of Mount Taranaki and Mount Tarawera, two central North Island mountains affected by volcanic eruptions in the recent past, have been published. This work on recent changes has now been complemented by fossil pollen and macrofossil studies on the volcanic cones of Taranaki and Ruapehu and on more distant areas affected by volcanic airfall such as the Matawhango district, Pureora and the Bay of Plenty (McGlone 1981, Clarkson *et al.* 1986, McGlone *et al.* 1988, Rogers and McGlone 1989).

Clarkson *et al.* (1988) have produced a detailed study of a forest near Pureora which was buried by the Taupo Pumice (probably about 177 AD). The buried forest showed major differences from extant forests growing on similar sites in the districts, and most of the change could be ascribed to increased soil fertility after the eruption, and also to climatic deterioration since that time.

In the case of andesitic eruptions, the devastation of the forest is very close to the eruption site and is a direct result of hot volcanic debris overwhelming the forest and creating local fires. Andesitic volcanoes are an ineffective source of widespread forest fire, because the ash largely falls in a chilled state, and the volcanic cones themselves tend to have high rainfall. It is unfortunate that so great a proportion of the intact forests of andesitic districts is actually on the volcanoes. A major eruption by Mount Taranaki, for instance, could remove up to a fifth of the present forest cover on the mountain.

Rhyolitic eruptions spread their ash far more widely and may destroy forest over a very wide area, mostly through groundflow of hot debris. However, I have postulated that the rhyolitic eruptions also destroy distant forest by dumping toxic ash on their foliage (McGlone 1981). This weakens many trees, and in later years dead and dying trees act as ignition points for lightning strikes and fire.

Recovery of vegetation after volcanic eruptions is generally quick, no matter how widespread the devastation. Older ideas of volcanic eruptions leaving huge areas of the central North Island in scrub, fern, and grass are simply false. As we understand the process now, forest makes its way back in lowland areas at a rate determined by the growth of the individual forest species; there is no long lag time. The Taupo Pumice eruption destroyed forest by burying it under rhyolitic ash flows which spread over a roughly circular area of country up to 60 km from the eruption site in north-eastern Lake Taupo. Tall podocarp forest was again dominant within 250 years of the eruption, and the initial phase of the succession from bracken fernland to scrub and low forest was extremely rapid (Fig. 4). However, in exposed high altitude sites, the process can be slow, as Beverley and Bruce Clarkson have shown on Tarawera (Clarkson and Clarkson 1983).

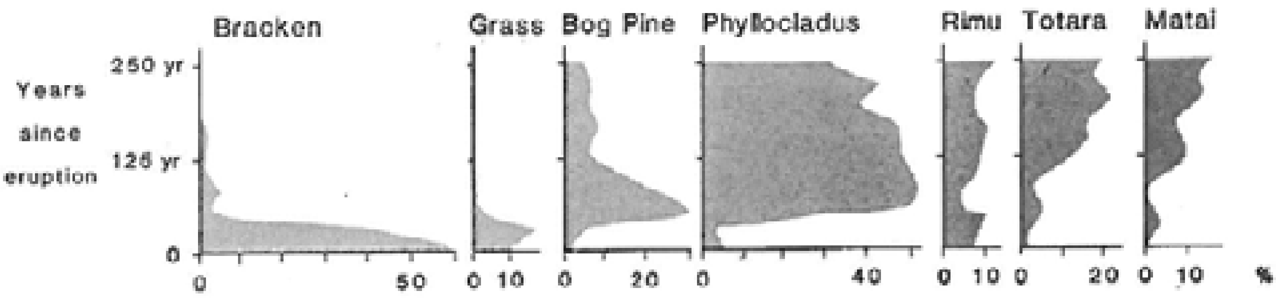

Figure 4. Pollen diagram showing recovery of forest since the Taupo Pumice eruption (c. 177 AD).

The species composition of the new forest after an eruption is often very different to the old. On Egmont, the forest has still not recovered its original composition after eruptions of about 400 years ago (McGlone *et al.* 1988). For instance, kamahi may have been quite uncommon until the two most recent eruptions, but now is very abundant. On the Kaimanawa Ranges, a series of eruptions may have restricted beech; after each eruption of nearby Ruapehu and Taupo Volcanic centres, beech became less common, and podocarps more abundant (Rogers and McGlone 1989).

The results from studies of volcanic eruption-induced plant successions reveal a great variety of successional paths, and these differ markedly from eruption to eruption. There are a great variety of responses to disturbance, intricately linked to the extent of disturbance, the nature of the newly created soil substrate, sources of propagules, and the state of the climatic regime at the time of disturbance. We cannot tell for certain why vegetation composition often changes after a major eruption, but we do have some strong clues. A new and fresher substrate seems a likely possible contributor, especially in the region around Lake Taupo. However, in the case of Egmont, it is more likely that the eruptions gave kamahi a head start over the slower growing podocarps, which it has yet to relinquish. Eruptions could also have the effect of accelerating vegetation adjustment to climatic change.

There are some implications for modern vegetation management. The first is confirmation of the enormous regenerative power of forest ecosystems that are left to their own devices. Even the Taupo Pumice, which destroyed forest almost totally over a radius of 60 km and left an inhospitable substrate of pumice sand and gravel, created only a very temporary clearing in the forest. If we were to abandon much of the marginal farmland in the North Island to forest regeneration, there is little doubt that immediate and unaided forest regrowth would occur. Fears that there would be prolonged dominance by woody weeds and secondary fire climax communities would probably not be realised. However, the massive forest destruction and alteration of the soils that have taken place since human settlement are unlikely to permit the same forest species to grow back in the same mixtures. As well, seral forest types will remain dominant into the foreseeable future. A second implication is that many forests which we may think of as being in equilibrium are probably in a highly dynamic state following on from disturbance. We can therefore expect continuing large vegetation change in many of our forests, even without further human interference. A less comforting implication is that even a modest coating of ash on forest foliage can lead to widespread tree death if the ash contains toxic substances. The next rhyolitic eruption in the North Island could thus lead to widespread forest death, and forest fire.

2.4 Erosion

There has been some controversy about the causes and the extent of erosion in New Zealand. A few decades ago, most erosion appeared to be attributed to the consequence of humans, and especially the European pastoralists, removing the natural vegetation through felling timber, burning and overgrazing (McCaskill 1973). Perhaps in a reaction to these exaggerated claims, some now hold that anthropogenic influence has been small: rainfall, cyclonic storms, relief and rock-type are claimed to be the main controls, not the presence or absence of vegetation cover (Grant 1985; McSaveney and Whitehouse 1989). Clearly, such a claim for the unimportance of vegetation cover has implications for current reafforestation, grazing and burning policies.

During the Holocene, under a dense forest cover, the lowland and rolling landscape has been unusually stable. In the lowlands it is usually only in the river valleys we see obvious evidence of erosion in the form of deep alluvial deposits on the flood plains, and terraces plastered against the valley sides. Most of the spectacular erosion has been occurring in the mountainous hinterlands and here, all the evidence is that rock type and rainfall are vastly more important than vegetation in determining rates of erosion. If anti-erosion policies are to be useful, a careful assessment of the long-term rates of erosion has to be made, and not hasty decisions based on some spectacular erosion features which may or may not be important in the larger scheme of things (Whitehouse 1984). However, changing land uses can result in order of magnitude increases in soil loss from the landscape, and we need to know just how our current and past land management is affecting soils and sedimentation in our lakes, rivers and estuaries.

Holocene research can be invaluable here in quantifying these long-term rates, and informative studies have been done elsewhere but, up until now, little detailed work has been carried out in New Zealand. A start has been made by using pollen analysis to provide both the chronology and nature of land use changes in estuaries (Hume and McGlone 1986). Current programmes are seeking to extend this work by looking at sediments in lakes.

2.5 Extinctions

Without the recovery of bird and reptile bone from swamps and caves, our concept of the New Zealand biota would be very different (Holdaway 1989). As it is, the full impact of the added dimension fossil work brings to our understanding of the fauna has yet to be felt.

Evidence from cave deposits from North-west Nelson and elsewhere have given us a valuable look at full glacial bird faunas (Worthy and Mildenhall 1989). Even in areas where forest was highly restricted and scrub and grassland were dominant, it seems that birds such as the kokako, which we now think of as solely tall-forest dwellers, were surviving. It may be that our concept of suitable habitat for many birds, based as it is on scattered and possibly atypical remnant populations, may be misleading.

Results from these full glacial environments suggest a rather restricted role for conventional island biogeography theory, which holds that the size of a contiguous land area is a major determinant of total species number. Over the last 18 000 years New Zealand's land area has shrunk from one large island, half again as big as the whole country is now, into the present archipelago of much smaller islands. At the same time the ratio of forested to non-forested land probably changed from something like 1:9 to 9:1. These major changes in size, shape and vegetation should, according to theory, have been accompanied by major extinctions as the biota adjusted to the new situation. In North America the majority opinion is that similar changes in vegetation and climate occurring at about the same time (12 000 years ago) led to the extinction of many large mammals. However, in New Zealand every bird identified from full glacial deposits turns up again in the Holocene. These results suggest that it is the range, not the number, of habitats which determines the number of species. As the total range of habitats was not reduced during the last glacial or the height of the Holocene, the total number of species in New Zealand remained static. It also suggests that certain habitats have now irrevocably vanished in New Zealand, with the possible exception of some offshore islands. This emphasises the spread of predators, rather than fragmentation of our forested areas, as the key to what is happening in our present-day landscape.

An interesting recent debate in the literature has hinged on the interpretation of fossil bird bone material. What is the primary habitat of the takahe: is it a subalpine bird, or is this simply a result of its extinction elsewhere? The Holocene and glacial evidence points to the takahe being primarily a bird of lowland habitats, and to it having been very widespread until its elimination by the Maori (Beauchamp and Worthy 1988). However, the evidence from its diet and mode of feeding suggest that it is a subalpine grassland-forest ecotone specialist which has become progressively rarer since the end of the Pleistocene and the spread of tall forest (Mills *et al.* 1984, 1988). The present population may therefore be but a specialised remnant or even subspecies of a much more diverse species with a broader niche. Or alternatively, we could be misled by the activities of birds accustomed to a subalpine diet and which, if given the right habitat, could thrive in lowland settings. Either way, without the Holocene fossil evidence, the question would hardly arise.

2.6 Human Influence

On-going work on peats and lake sediments has confirmed the general picture as to the late Holocene deforestation of New Zealand first outlined by Molloy *et al.* (1963). The early Maori used fire as their major landscape management tool, a tradition carried on by present farmers throughout New Zealand. The evidence for a major Maori effect on the natural vegetation is unequivocal. Between about 800 years ago and 300 years ago, probably between one-half and one-third of the lowland forests of New Zealand were destroyed.

I have discussed in some detail why the Maori used fire so extensively (McGlone 1983, 1989). In general, the closer the vegetation is to a seral state, the greater the proportion of its biomass is available for human consumption. Bracken and cabbage tree root were two staple foods, both only abundant in seral vegetation. Other foods, such as raupo pollen, tree fern piths and young foliage, and nikau palm hearts, are typical of regenerating or seral vegetation. Destruction of forest and subsequent increase in run-off of nutrients undoubtedly increased the primary productivity of swamps, lakes and streams. In the early stages of occupation, the destruction of forest may have also created more browse for game birds, and certainly there were a number of birds as equally at home in secondary scrub and fernland as in forest. Undisturbed forests did produce food, especially in the form of birds, and trees such as hinau and tawa provided fruit with carbohydrate-rich kernels. However, forest food resources tended to be seasonal, or scattered. All in all, a landscape with forest largely cleared and under bracken and scrub, and areas with better soils and microclimates under cultivation, would provide a much greater food resource than one totally in forest.

A further reason for forest clearance was probably the opening up of dense vegetation for travel. We know this happened over restricted areas, but it may have been a major motive for burning of the inland valleys of the Southern Alps. Finally, it is likely that the combination of dry forest and humans made it inevitable that accidental fire would reduce the extent of forest.

Pollen analysis, through its recognition of the outbreak of deforestation, does to an extent, provide a time horizon for permanent settlement of a district (Fig. 5). If forest was cleared, and repeatedly burnt, we can say that there was permanent use of the area. And there is a very good correlation between the dates for the earliest widespread settlements (between about 800 and 600 years ago) and deforestation. The assumption is that both were driven by the same underlying cause: rapid population growth. As the North and South Island were deforested at around the same time, we can assume that Maori populations were approximately of equivalent density during the early settlement period. It was only after 600 years ago that the massive expansion of population which was to create the Classic Maori civilisation occurred, and it occurred in the north.

Sutton (1987) has argued for a much earlier settlement of New Zealand, maybe as early as 1500 years ago, versus the more conventional 1000 years ago (Davidson 1984). The implications of an earlier settlement are intriguing, although they do not alter the basic story. An early settlement would imply a much slower rate of population growth, and this raises the problem of how a population could exist for such a long time with near invisibility in the historical record. I think Doug Sutton's evidence for a much earlier settlement is weak, and that until more convincing historical evidence in its favour comes to light we should stick to the 1000 year date.

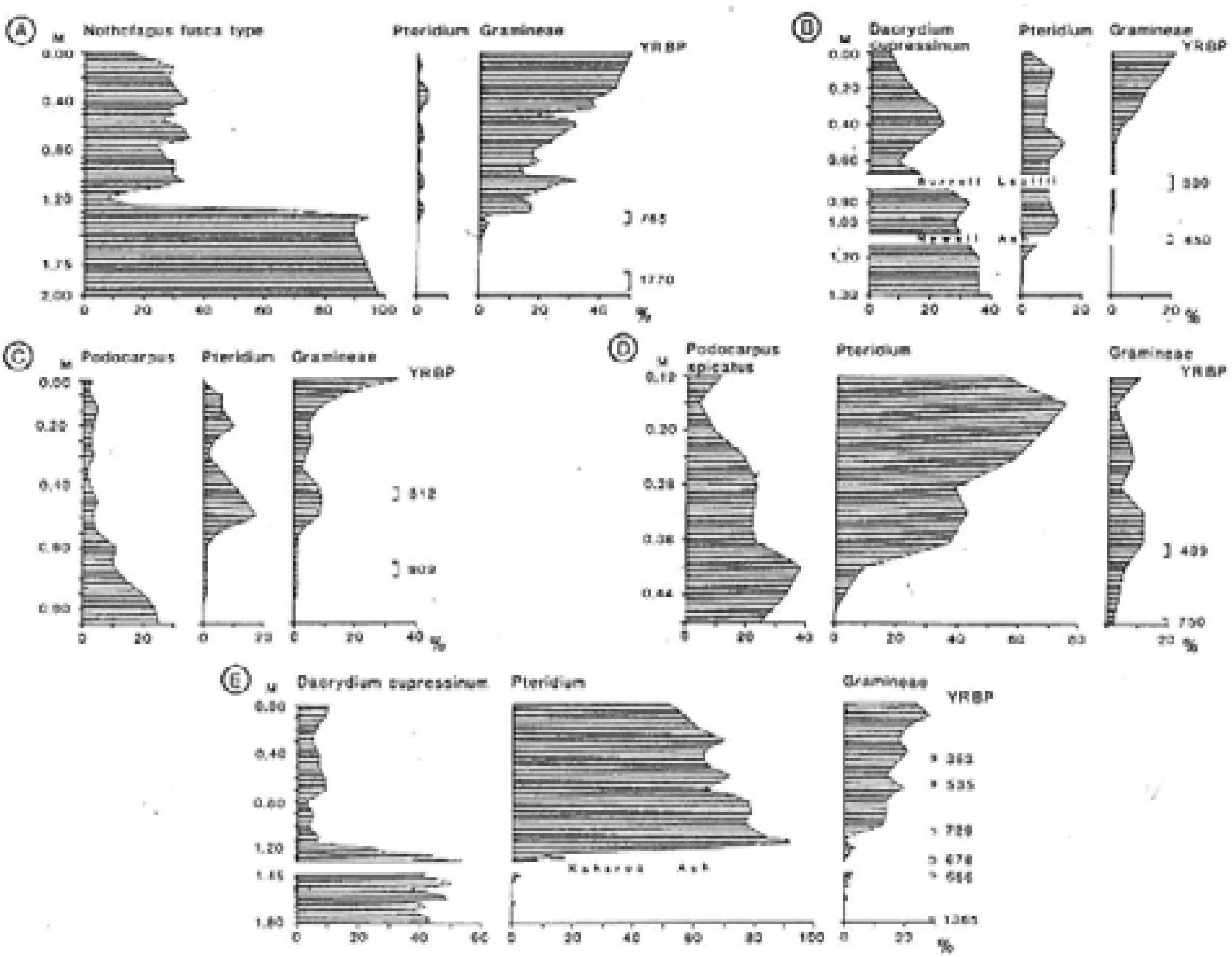

Figure 5. Typical deforestation pollen diagrams: A. inland Canterbury since 1770 yr BP; B. Mt Taranaki since c.500 yr BP; C. Southland since c.1000 yr BP; D. Taupo since 750 yr BP; E. lowland Bay of Plenty since 1365 yr BP.

The whole question of the Maori settlement of New Zealand has political overtones. Many who talk about the environmental destruction which has gone on for the last 150 years also paint a paradisiac picture of the pre-Cook Maori. They are depicted as pre-industrial Greens, conserving the biota, inflicting minimal damage on the environment, and treating all living things with great reverence. I would suggest that this is a caricature of the true situation, and one which neither advances our understanding of the past nor enhances the prestige of the tangata whenua. The story of the Maori settlement of New Zealand is one of skilful adaptation to an environment that was marginal for a people whose crops and animals were adapted to subtropical or tropical settings. In the same way that we used to take pride in the European settlement of New Zealand, I believe we can all take pride in the Maori settlement of Aotearoa. That it exacted a price in terms of a unique fauna and vegetation is undoubted, but this was an inevitable consequence of settlement. We should seek to understand the past, not project back our current concerns and anxieties. A mature nation does not need the myth of Golden Age, an Earthly Paradise when all was well, to accentuate its present plight.

3. FUTURE RESEARCH AND THE ROLE OF THE DEPARTMENT OFCONSERVATION

Maintenance of skills and resources in the area of historical research is difficult. Most historical research is time-intensive and relies both on expert knowledge of plant and animal fossils and well-maintained and comprehensive reference collections. It differs from most ecological work in that there is only a limited role for relatively unskilled labour or large team efforts. It is therefore expensive. There are also relatively few specialists in the area in New Zealand, and major aspects of our historical record are virtually unknown.

Despite the expense and the difficulty, it is important that some effort be maintained in this area. Historical studies give a much needed sense of perspective and extend, however imprecisely, the exceedingly limited range of our written historical record. Historical studies also give fresh insights which can interact profitably with understandings gained solely from studies of the present situation.

Most of the work I have described relies to a great extent on pollen analysis. Although there are now probably about 100 or so pollen studies of the Holocene, the coverage of the country is not complete, and the sites vary widely in quality. Until the network is complete at least at a regional level, we could be missing important parts of the picture. The situation with macrofossil studies is less rosy; few have ever taken this study up full time, and we lack basic reference collections, atlases, etc.

An immediate need is to establish a comprehensive New Zealand pollen and macrofossil database. At the moment our scattered and variable historical information is not adequate for the task of providing country-wide synopses of vegetation change over time, and of interpreting these changes in terms of environmental parameters (Norton *et al.* 1986). We also lack detailed studies, often called `high-resolution analysis', which can give ecological insights, especially into transient environmental disturbances such as wind throw, land instability, and fire. High-resolution techniques demand massive investments of time and should therefore be used judiciously in the New Zealand context.

There is also a need for more sophistication in our studies. There is now a wealth of conceptual models to follow from the United States and Europe, where historical studies have made enormous progress in applying rigorous statistical techniques to the analysis of the past. The Department of Conservation's role in promoting historical research is limited but not negligible:

Archaeological research needs the backup of full palaeoenvironmental studies of important sites. The information won from archaeological digs is hard come by and, by its very nature, woefully incomplete. If we are to ever understand the significance of what we are preserving in these, the most precious of all our historic places, we need a total environmental approach.

I believe that, if possible, pollen analysis should be used routinely. Intensive investigations of areas of high archaeological interest have yet to be done, and these could very likely yield interesting results regarding timing and nature of settlement patterns. If funds are available for historical research, this is the place they should go first.

Next to archaeology, environmental science stands most to gain from historical studies, as it needs long records of nearly everything to enable the big picture to emerge from a kaleidoscopic mass of data. Ecology is both an impressionistic science - far better at painting the big picture with a broad brush than providing quantifiable models of ecosystems -and also a science of detail, obsessed with the minutiae of what may be chance accumulations of species. Observing the past extends the range of situations in which complex ecosystems can be seen functioning and distinguishes the background buzz of random change from the broad sweep of environmental change, therefore helping our understanding. However, only a limited amount of this broad environmental research may have direct application.

One of these applications is the determination of what was the original vegetation cover of an area, to help decide questions relating to most appropriate management, such as those relating to restoration or priority for preservation. For instance, many of the lowland wetlands are now totally remote from their original undisturbed shape. A large number have formed under the influence of human settlement and are therefore closer to human artefact than to pieces of old New Zealand. Effort put into preserving some of these monotonous associations of raupo and flax seems misguided in many cases, unless wildlife or Maori concerns take precedence. There are enough endangered wetlands of truly national importance, such as the upland bogs of the South Island, without looking for extra work. In other cases, pollen is useful in plotting the history of sedimentation of estuaries and lakes, and therefore can give estimates as to what are the background sedimentation rates. This information can be useful in determining what effects projected land uses may have.

The Department of Conservation could be more active as a populariser of historical information. It has a role as a provider of information about the lands it has under its stewardship, to give a background as to how and why it makes the decisions it does. Preservation of the natural and wild places of New Zealand depends above all on capturing the interest and sympathies of the population as a whole. If an area is of national importance, historical studies could also be seen as one way of both encouraging that interest and expanding our knowledge of the resource.

4. ACKNOWLEDGEMENT

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CURRENT RESEARCH ISSUES IN THE STUDY OF MOAS AND MOA-HUNTING

by

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1. INTRODUCTION

Perhaps I have been asked to lead this seminar because I have just had published a book called *Prodigious birds: Moas and moa-hunting in prehistoric New Zealand*, and it may be thought in consequence that I know a great deal about these topics. In one sense I do; I have followed in relentless detail the historical progress of the important issues up to the current state of knowledge. In another sense I do not, because this research demonstrated that 150 years of relatively intensive investigation have still left us short of satisfactory conclusions about the salient issues; short by little in some cases such as systematics perhaps, but in other matters, phylogenesis for example, as far from a satisfactory answer as we ever were.

It is a very broad topic since it encompasses the palaeobiology of New Zealand's `first family' of extinct avifauna as well as the archaeology of those who hunted them. I will comment briefly on a range of research issues, suggesting particular areas in which research is needed, and towards the end make some recommendations about management of sites.

2. MOAS: RESEARCH DIRECTIONS AND PROBLEMS

2.1 Systematics and Phylogenesis

In systematics, the simple question of how many species of moas there were in the late Holocene seems close to a resilient answer. Recent research (Worthy 1988a, pers. comm. 1990) suggests 11 species (Table 1). It is based on derived characters of morphological variation, that is landmarks of bone shape which are unique to specified taxa, and it is independent of variation in bone size, which was the main character used to define species in most earlier taxonomies. Worthy's taxonomy might prove definitive, but both the variations he contemplated in reaching it (and he has since shown (T.H. Worthy, pers. comm.) that *Euryapteryx* n.sp. of Scarlett can be securely synonymised with *E. geranoides*), as well as the history of the matter, certainly recommend caution. By 1885, the year by which remains of all the species known today had been discovered and published, Haast had listed 13 species; in 1891 Lydekker had described 23 and Hutton 26. Two years later Parker listed 20 and Hutton, 33 species. By 1900 Forbes had reduced the list to six, but Rothschild managed to expand it to 37 by 1907. Archey listed 18 modern species in 1941, and Oliver 28 in 1949. The Ornithological Society checklist recognised 24 species in 1970 but Cracraft synonymised these to 13 in 1976 (see Anderson 1989: Appendix A).

Table 1. Taxonomy of moas (after Worthy 1988a, pers.comm. 1990).

AVES: DINORNITHIFORMES

EMEIDAE [ANOMALOPTERYGIDAE]

Anomalopteryginae

*Anomalopteryx didiformis** *Megalapteryx didinus*† *Pachyornis mappini*††
P. australis†
P. elephantopus†

Emeinae

Emeus crassus† *Euryapteryx curtus*††
*E. geranoides**

DINORNITHIDAE

*Dinornis struthoides**
*D. novaezealandiae**
*D. giganteus**

* = both islands (11 spp.)
† = South Island only (9 spp.)
†† = North Island only (7 spp.)

The higher systematics of moas is also uncertain. Oliver's (1949) *Zelornis* complicated the modern division into six genera, as listed by Archey (1941) and Scarlett (1972), while Archey and Oliver's family Anomalopterygidae and its subfamilies (Emeinae and Anomalopteryginae) were dropped by Scarlett who returned to Owen's original proposal of a single family for all genera. Cracraft (1976) concurred, but retrieved Anomalopteryginae, and Worthy (1988a) returned to the two-family model (Table 1), which he still prefers (T.H. Worthy pers. comm. 1989). Clearly, it is unlikely that we have heard the last word on this matter.

There are various avenues of potential research on moa systematics. Reliance on derived morphological characters is, like many other methods, only as good as the comparative samples on which it is based. Many of these were collected 40 to 120 years ago and often have not been checked for accuracy of contemporary identifications, let alone revised in terms of subsequent synonymy, although Trevor Worthy is gradually working his way through the main museum collections. In addition to obvious tasks such as these, there are some rather more esoteric research opportunities. Tom Loy, who pioneered the identification of blood and other residues found adhering to prehistoric stone tools, has found that crystals grown from red blood cells are species-specific in form. Blood, probably of moas, does survive on stone tools from central Otago moa-hunting sites (as do feather fragments similar to others identified as being from moa), and it seems possible either to use such material or, better still, blood residues from identified bones, to test the separation of species postulated on other grounds (T. Loy, pers. comm. 1990).

Phylogenesis is another area where there is considerable optimism about the value of chemical methods, particularly those which establish comparative DNA signatures. So far, though, the results have not produced any clear answers to the major questions: are ratites monophyletic? Are moas and kiwis closely related? Are all moas descended from the same close-related stock? and so on. At present the arguments seem to me to be finely balanced between opposing hypotheses: that moas and most other modern ratites (probably excluding ostriches) descended from common flightless ancestors which inhabited Gondwanaland, and that ratites are polyphyletic, have acquired similarities through evolutionary convergence (notably by neoteny), and are mostly descended from ancestors which flew to the landmasses in which they were later discovered.

I favour the latter arguments (Anderson 1989) and consider not only that moas and kiwis are unrelated, but possibly also the two families of moas. I note here only three pieces of evidence. First, the fairly convincing evidence that ostriches are descended from small flying birds; second, that atrophy of wings and eventual flightlessness can be shown to have occurred very rapidly in other New Zealand birds (Worthy 1988b); and third, that no moa fossils are earlier than the late Tertiary. Neither, I agree, are there earlier tuatara fossils; however, moa bones are abundant and highly visible in Holocene terrestrial and freshwater sediments but apparently missing from early Tertiary lignites, including those in which bones of small birds are quite common, as for example in some Central Otago deposits (M. Pole, pers. comm. 1990).

There is an obvious opportunity for more field research here, since discovery of moa bones of modern taxa, or at least of large, manifestly-ancestral taxa, would clearly favour the Gondwanaland argument, not to mention their value in determining trajectories of moa speciation and morphological evolution. Alternatively, it might turn out that moa ancestors are actually lurking amongst the bones of the small birds. It is not only moas, of course, but kiwis, the enigmatic *Aptornis* and various other species for which we have very little fossil record, which might profit from more substantial research into these deposits.

2.2 Palaeoecology and Behaviour

A much greater field effort needs to be devoted, in my view, to the later natural sites as well. These include swamp sites mostly of Holocene age, cave sites which range into the upper Pleistocene, and open deposits, such as loess, which have a similar time span. They are the main source of information about moas and, indeed, most other extinct vertebrates (no doubt extinct invertebrates as well). Whichever issues we specify in the areas of moa morphological, ecological, or inferred behavioural variation, we can only profit if databases are geographically more diverse than those now and if they describe more remains. This is not simply an ad hoc assumption that more data lead to stronger conclusions, but rather a positive assertion based on what is happening in current research.

Take, for example, the recent re-assessment of moa ecology. One important line of advance has been made through the re-analysis of data already available. Arguments about the relative importance of shrubland and forest-fringe habitats have been perceptibly sharpened by systematic analysis of moa gizzard contents, collected years ago in most cases (Burrows *et al.* 1981), by locational analysis of long-known hunting sites (Anderson 1982), by looking at variations in beak form (Atkinson and Greenwood 1989), and by observing the crucial changes in accumulation of natural bone deposits.

At the Oparara Caves near Karamea, deposits spanning a geologically-long chronology were excavated with an archaeological precision that yielded important new insights. Secular changes in the lowland Buller environment were able to be matched against different suites of moa species (Worthy and Mildenhall 1989). In Pleistocene deposits dated to the last glacial maximum, at which time the upper forest limit was virtually at sea level in that district, the main species were *Pachyornis elephantopus* and *P. australis,* and *Megalapteryx didinus.* In Holocene deposits, however, these were replaced by *Dinornis torosus (struthoides)* and *Anomalopteryx didiformis*. It was always a reasonable hypothesis, of course, that different kinds of moas had different habitat preferences. Some conclusions along those lines were suggested by Millener (1981) in his dissertation on North Island Quaternary avifauna, but the Oparara Caves may be regarded as the first explicit and detailed case study.

Renewed examination of moa bones and their stratigraphic contexts from other caves in the North-west Nelson region, and of some of the major 19th century collections in terms of their probable environmental context, added weight to the conclusions. It is now possible to argue confidently that there are two broad assemblages of species which were distinguished by habitat preference towards either closed forest on the one hand, or a range of habitats extending from open forest through mosaics of seral stands and shrublands, to grasslands on the other. Within this primary distinction can be recognised some probable restrictions to their range by altitude: *Pachyornis australis* and *Megalapteryx didinus* seem to have been most abundant in subalpine vegetation, notably beech forest in the latter case, while *Dinornis maximus* and *Emeus crassus* were mainly on the coast, especially where grasslands remained during the Holocene.

Another result of the recent research which compares late Pleistocene with mid-Holocene collections showed that environmental changes were covariant with size-morph changes. Thus individuals of *Pachyornis*, an open-country genus, reached their greatest mean size irrespective of species during the last glacial era, but *P. mappini* showed clear dwarfing as its preferred habitats became restricted during the Holocene. In the South Island, reafforestation was less complete and had less impact on *Pachyornis elephantopus*. Similar effects have been observed in *Euryapteryx*. In addition, size variations in genera seemed to reflect the operation of Bergmann's Rule of an inverse correlation of body mass with ambient temperature.

These important results also bear significantly on other issues concerning moas, such as systematics, since it can be shown that various specimens once thought to represent different species are more probably the same species at greatly different times (Worthy 1987). Other results yet to be worked through concern moa home range size, niche overlap, biomass and so on.

A third result of recent research on natural deposits has been the recovery, only possible by using good excavation techniques, of new, fully-associated skeletons. Some of these have revealed additional features of anatomy which bear upon moa ecology. For example, the evidence that *Euryapteryx geranoides* had a particularly long tracheal loop, a feature often associated with enhanced vocal ability in birds, suggests that it may have been a more social species than others, and this, in turn, might account for its prominence in moa-hunters' catches (Worthy 1989).

Important as these new data and propositions are, they by no means exhaust the potential information available from natural sites. There are many things about moas for which our current evidence is frustratingly deficient. Only about 20 whole moa eggs exist, and very few of them can be traced to nests - so the clutch size of moas in general, and its variations between taxa are poorly known. I would expect the larger species laid relatively more eggs, or more often, since the size of eggs attributed to different species declines relatively with increasing body size (there is a scrap of evidence suggesting that in one case, but it is the only such instance). Similarly, we have very few examples of moa chick bone, and even fewer examples of immature bone than could have existed in the populations represented by the natural deposits. We have only a small number of instances of desiccated soft tissues, none of which include ventral surfaces, genitalia or any internal organs. As well, a surprisingly meagre inventory exists of moa feathers, and very few can be attributed to particular taxa.

We are lucky in fact to have what does exist of this kind of material, particularly when we compare it with the exceedingly scarce remains of other large birds which became extinct in recent times, such as the dodo and elephant birds. But continuing discoveries of moa soft tissues and of natural deposits in general, suggest that there is still much to be discovered. For instance, a thick deposit of preserved moa dung, a surprisingly rare commodity usually, has just been discovered in a site in the Cromwell Gorge. West Otago, the source of most dried remains, has never been systematically searched for dry sites, and we do not know the precise location of the famous Earnscleugh Cave.

Field research though is not all that is wanted - important and widely neglected though it is - we also need the development of new techniques to yield essential information from moa remains. If an understanding of moa demography is ever to be obtained, and I need hardly say how important that would be to all sorts of issues, including extinction, then it is vital to find ways of sexing and aging moa bone. The presence of medullary bone in females is a possibility, and citrate concentration in bone also seems to be gender-biassed, but neither indication has been tested on a large sample as yet. As for determining the age at death of individuals on the basis of long bones, I suspect that there is some incremental tissue accumulation correlated with it, but it is an area where there has been no research, so far as I know.

At this point I will leave research issues concerning moas, although there is much more to do than I have been able to suggest here, and turn to the archaeology of moa-hunting, a field in which I have been working, off and on, for about 12 years.

3. MOA-HUNTING ARCHAEOLOGY: CURRENT PROBLEMS

3.1 Scarcity of Evidence

Let me make it clear that the sites I am talking about are moa-hunters' sites in the literal, not the typological, sense - the sites and their faunal and artefactual contents represent hunting and processing moas. I do not include any other early sites or material culture which date to the era of moa-hunting, even though some might have been used by people who were moa-hunters at another season elsewhere. Let us also be clear that moa-hunters were exclusively Maori and were the ancestors of the modern Maori.

To date, about 300 moa-hunting sites have been recorded; 230 in the South Island and 75 in the North Island. Most of the records tell us nothing about moa-hunting other than the locality and the approximate significance of the site in terms of its extent, or the amount of moa-bone observed. Some additional data about moa bones are available in 42% of the sites; 40 sites in the North Island and 87 sites in the South Island, but quantitative data are even scarcer again and limited to about 50 sites in all (Anderson 1989).

They are, furthermore, a highly variable quality, and this can be illustrated by considering the sites in three broad categories. Category A has substantial sites rich in moa bone, with extensive (50 m^2+) excavation, competent recording and thorough analysis. Category B sites are those in which there has been competent and quite extensive (20 m^2+) archaeological investigation but where moa remains, though prominent, are not the major feature of the faunal array. Category C sites provide some quantitative faunal data from stratigraphically defined contexts, but most are sites where moa-bone was sparse and excavations limited.

Opinions will differ about which sites should be in each of these groups, but in my view there is only one category A site in the North Island -Kaupokonui - and only one in the South Island - Hawksburn, although another (Shag Mouth) is being analysed.

There are perhaps two category B sites in the North Island - Tairua and Foxton - and about eight in the South Island - Heaphy Mouth, Fyffe's, Warrington, Papatowai, Pounawea, Tiwai Point, Owen's Ferry and Coal Creek.

North Island sites in category C are Houhora, Sunde, Cross Creek, Opito, Sarah's Gully, Whakamoenga Cave, Tokoroa, Waingongoro and Paremata. In the South Island there are about twice as many, including Rotokura, Wairau Bar, the Redcliffs complex, Rakaia Mouth, Wakanui, Waitaki Mouth, Pleasant River, the Rockfall sites, Italian Creek, Dart Bridge, Minzion Burn and Old Neck (further data in Anderson 1989).

Several points should be noted here. First, archaeological evidence about moa-hunting, especially processing, rests substantially on remains from only two sites, or less than 1% of the total. Second, much of categories A and B evidence is very largely unpublished: Kaupokonui, Shag Mouth, Foxton, Fyffe's and Warrington; or partly published: Hawksburn, Papatowai, Tiwai Point, Coal Creek. Third, and very frustratingly, most of the largest and richest sites would barely make it into category C. Wairau Bar, particularly, was extensively excavated; the excavations were of variable quality, and the records are generally poor. Quantitative analysis was confined to samples taken from columns, and bones were identified only to family level. At the important Redcliffs complex, and at the huge Rakaia Mouth and Waitaki Mouth sites, as well as at extensive inland sites such as Woolshed Flat, only a few square metres at most have been excavated and analysed.

The first point that I want to make, then, is that the archaeology of moa-hunting rests on a very narrow empirical base, and that we are not likely to make much progress until that base is expanded significantly. It is important to appreciate this point, because there is a common belief that New Zealand's archaeology concentrated for decades, in fact for the greater part of its history, on moa-hunting sites and that it is time to get on with something else. In the sense that moa-hunting and the Archaic phase are synonymous, there is some truth in that, but in the literal sense of moa-hunting, or indeed hunting of any of the extinct avifauna, we know less than we do about sealing, fishing, horticulture, pa, houses or settlement patterns.

3.2 Taphonomy

Taphonomy and chronology provide two of the major areas of specific problems in moa-hunting research. Taphonomy is the study of death assemblages, that is of the processes which intervene between the initial deposition or discarding of cultural debris and the archaeological discovery of what remains of it. What archaeologists dig up, however skilfully, can only approximate in content and disposition what was originally deposited. To the estimation of sampling bias induced by partial excavation, then, we have to add estimation of the bias resulting from taphonomic processes.

Taphonomic problems are of various kinds. One is determining how much of the material in a site is of cultural origin. This is a problem in many coastal moa-hunting sites situated on sand dunes in which natural deposits of moa bone can become conflated, quite easily, with archaeological remains, and distinguishing cultural from natural moa bone is not always simple. In many South Island sites the problem is insignificant because while some moa bone may be natural, most of it is clearly from butchered birds.

In the North Island, however, where there are often just a few pieces of moa bone in a site, the question is whether it was a moa-hunting site at all. How can we tell? Burnt and broken bone usually indicates butchering, but (for example) subfossil bone was picked up and used for making fish hooks in the North Island as late as the 19th century, and scraps of it might have been discarded in the fireplace. Comparing radiocarbon dates of dog bone (obviously cultural) with moa bone (that might not be cultural) from the same context might let us see if the moa bones are older than the dog bones. But two accelerator dates cost $1600.00 and in many cases would provide inconclusive results. There are supposed to be indications if a bone was fresh when broken in so-called "greenstick" fractures and also in "spiral" fractures in bones broken to extract marrow. Some archaeologists profess to be able to distinguish the general appearance of cultural from subfossil bone, though their criteria are entirely subjective. Systematic testing of these indications has disclosed a significant margin of error in each. For North Island sites, in particular, we need a new methodology for distinguishing cultural bone; perhaps it might be found in changes of bone chemistry or microstructure between bone burnt fresh or old?

A second taphonomic problem is determining what happened to discarded moa remains. The proportion of particular bones represented, their dispersal in sites, and the ways in which they had been damaged, provide valuable evidence for inferring certain ways of hunting and processing. For example, the absence of moa head, neck and feet bones is generally taken to reflect discarding of the less meaty portions of carcasses when the kills were made at some distance from where the moa was cooked and eaten. However, the same effect might have been caused by those parts having been fed to dogs or left out for birds (including gulls and the now-extinct crows), or by weathering, which is more destructive of some bones than others.

The most worrying taphonomic problem of all is that the pattern of moa-hunting evidence throughout New Zealand may be shaped largely by regional variations in bone-weathering processes. It is a source of great concern to me that the density-distribution of moa-hunting sites, as well as the density or abundance of moa bone within sites, appears to correlate suspiciously well with environmental parameters. Moa-hunting sites are most numerous in the dry eastern region of the South Island, especially in the driest areas of it, and least numerous in the humid districts of the South Island and in the North Island as a whole. Where they do occur in these areas they are predominantly in sand dunes or similar soils. This seems to amount to the proposition that moa-hunting sites are mostly found in relatively free-draining, alkaline sediments, and seldom in humid and more acidic loams and clays. This, in turn, suggests that the nature of the soil environment is the basic determinative of site distribution and thus of their relative importance. Of course, the inherent difficulty here is that the actual density-distribution of living moa populations probably followed much the same pattern, so that we end up with two equally plausible explanations for the same phenomenon. There must be more research on this, for we need to be able to distinguish a cultural from a taphonomic pattern of site distribution at the regional or district level if we want to understand prehistoric settlement patterns that involve moa hunting.

Furthermore, moa-hunting sites in the eastern South Island are more visible not only because of their abundance of bones, but also because of their distinctive stone-blade technology. So distinctive is it, in fact, that this technology provides a reasonable indication of a moa-hunting site, and an almost certain one in the interior, even when moa bone is not observed. In the North Island, no such distinctive stone technology is associated with moa-hunting sites; they are not so obvious to the site recorder and, when bone is absent, their presence is unlikely to be suspected at all. Here again, a way of weighting the geographical incidence of moa-hunting evidence needs to be devised so that the differential regional probability of a moa-hunting site being recorded does not introduce a significant bias into the distribution pattern.

3.3 Chronology

The question of where moa-hunting sites are located, and why, goes hand in hand with the other major issue, chronology, because hypotheses about the regional dispersal of moa-hunting (Caughley 1988, Anderson and McGovern-Wilson 1990) and patterns of moa extinction, to take just two examples, are equally dependant on both. But I want to concentrate here on the more fundamental issue of the quality of the radiocarbon chronology. Leaving aside the standards of collection - the care with which the stratigraphical provenance is established and its chronological relationship to evidence of moa-hunting - the main question here is what kind of sample ought to be dated. Various reviews of the radiocarbon chronology of moa-hunting (McCulloch and Trotter 1975, McFadgen 1982, Caughley 1988 amongst others) have concluded that either or both moa bone collagen or marine shell are preferable to charcoal, mainly because many charcoal dates have an inbuilt age due to the samples being taken from old wood.

This is something of a non-sequitur, of course, since the problem lies in the nature of the charcoal sample rather than any inherent superiority of the other materials. In fact, it is my view that charcoal dates on short life-span samples are actually superior to dates on moa bone collagen. The latter material is unreliable on two grounds: first, that in experimental projects whole collagen gives dates significantly at variance with those obtained on its amino-acid constituents. Second, such data as I have been able to obtain from the Institute of Nuclear Sciences indicates that about half the moa bone samples which have been dated had $\delta^{13}C$ values higher than expected; that acid-insoluble mineral residues were also high (about 40% in the samples from Shag Mouth); that carbon content was relatively low, c. 1.5-3% in most cases (cf. 10% in fresh bone); and there is apparently no correlation with age (Dr H. Melhuish, pers. comm. 1990). These data suggest that moa bone of any age or context can be heavily leached, and then contaminated by the uptake of environmental carbon, carried in soil solutions, to a degree which renders the dating suspect (see also Anderson and McGovern-Wilson 1990).

Whether marine shell might be a better material for dating is uncertain. However, since most of the current New Zealand dates seem to have been made on species that inhabit estuaries and lagoons (e.g. cockles and pipis), in waters which have old carbon or on species (e.g. mussels or paua) which may have been collected from limestone reefs, it is unlikely that they actually provide very reliable dates for much the same reason,
i.e. uptake of environmental carbon.

In defense of this position I offer the case of Shag Mouth, where a systematic radiocarbon dating programme, generously funded by the Division of Science and Research, was instituted to test this problem. So far we have the charcoal and moa bone collagen dates and most of the shell dates, and the results are instructive (Fig. 1). They indicate that the most consistent results are on charcoal of short lifespan, that the collagen dates are much less reliable, deviating wildly from the stratigraphical order, and that almost any subset of them would suggest a far greater span of occupancy than is indicated by the charcoal dates. The latter are in accord with other archaeological evidence, notably the settlement pattern arrangement, in suggesting that Shag Mouth was not a large site because it was repeatedly occupied, but rather because it was a village inhabited by a relatively large number of people for a fairly brief period.

This raises the fundamental issues underlying concern about chronology -how long, and in what manner was moa-hunting conducted and what do moa-hunting sites indicate about the initial colonisation of New Zealand? I am not going to tackle these here, beyond saying that the more reliable dates we get, the more it seems that moa-hunting was a remarkably brief and over-exploitative episode, and that if the first Polynesian settlers killed moas (and it seems perverse to imagine otherwise), then the developing chronology is dragging the initial colonisation period of New Zealand into the present millennium. However, we have almost to build the radiocarbon chronology of New Zealand's archaeology afresh, in the light of recent criticisms of it, and it will be some time before much more can be said (in fact, probably much longer than might have been predicted a year ago, now that the Institute of Nuclear Sciences has quadrupled its prices).

4. MANAGEMENT SUGGESTIONS

Management is not my business so I will be brief. Effective management is only as good as the data base it has to work with, and I have made it apparent, I hope, that a great deal of very basic research has still to be done in the present case. Our site records are deficient in various ways. For example, there has never been a systematic survey and record of all reported natural sites. Similarly, the field work has been haphazard and we have no secure base from which to predict how many sites, and of what kind, might yet remain to be recorded. Thinking still of natural sites, questions to ask are: do all alkaline swamps contain moa bones? And how many alkaline swamps are there? How common is moa bone in southern limestone caves? Or in the Waikato? and so on.

Basic recording leads into the kind of extensive landscape-based research issues that I have discussed such as, why are moa-hunting sites found where they are and not elsewhere? Is there regionally differential decay of faunal remains? and so on. These are very important questions which are not as easy to handle from a university base as they might be from the Division of Science and Research. You have already in one unit the variety of expertise needed to tackle them; archaeologists, soil scientists, botanists, and also access to a national network of field officers. The idea of landscape archaeology, palaeogeography, palaeohuman ecology, call it what you will, was, as I recall, a central research objective at the time the Division was set up, and I am still convinced that it is an approach to the past which has a great deal to offer in New Zealand.

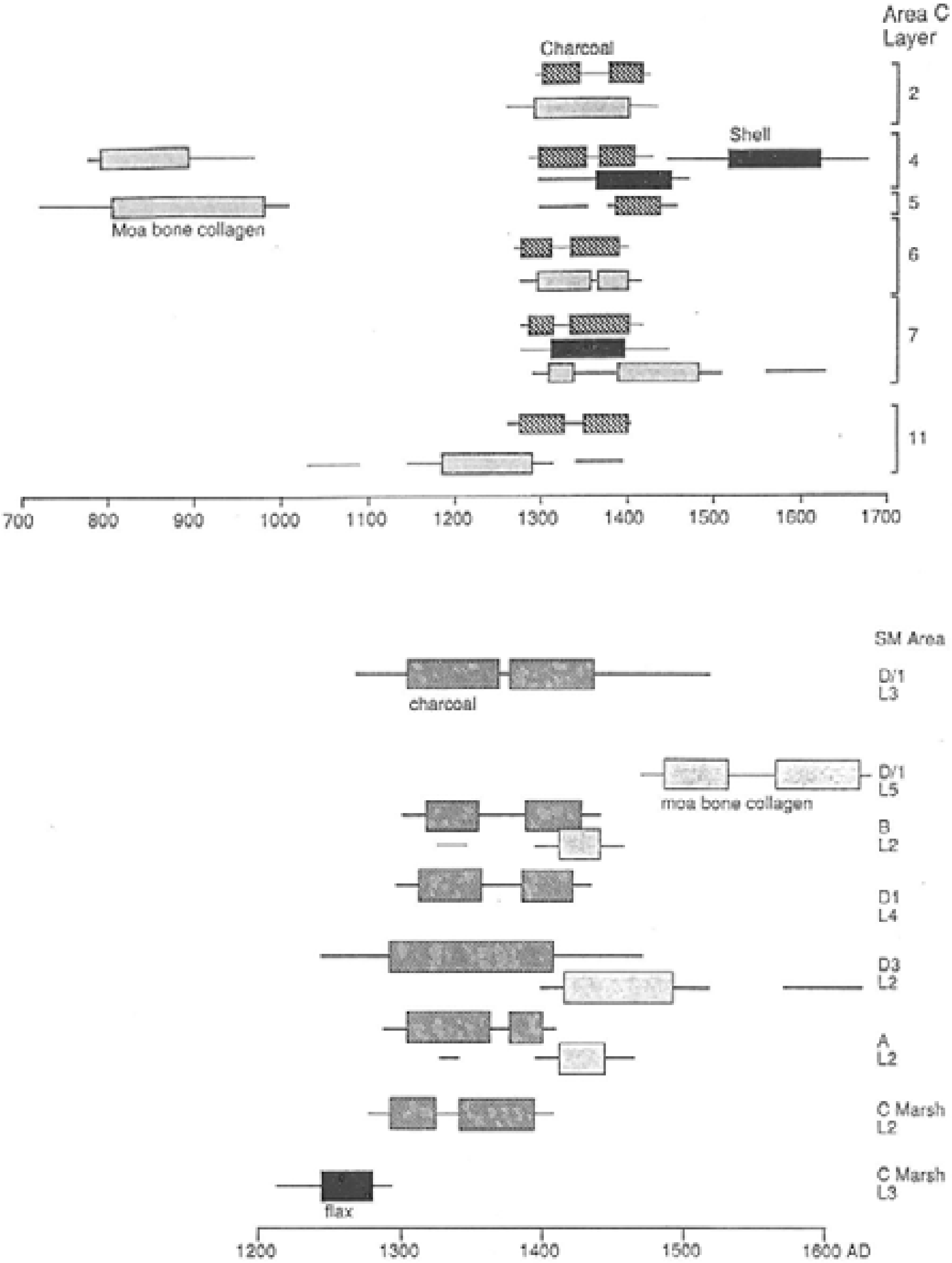

Figure 1. Radiocarbon dates (old half-life, A.D., conventional ages for charcoal, standardised moa bone collagen and shell dates) from the main excavation, area C (above) at Shag Mouth, and from excavations elsewhere on the site (areas A, B, C Marsh, D) below.

Lastly, there is the matter of protection. As yet, not much protection is afforded by law for sites containing remains of our extinct fauna, but even when there is, we probably need to think in terms of a register, perhaps of covenants, and the other mechanisms used to protect cultural sites. The evidence of moas and moa-hunting is important not only because it is the most distinctive and possibly instructive aspect of New Zealand's past, but because it is recognised internationally as the best example there is of the interaction of people with an extinct fauna.

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REVIEW OF THE MAMMALS OF NEW ZEALAND

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1. INTRODUCTION

Conservation policy in New Zealand has traditionally been hostile to the introduced mammals, and with good reason. All non-flying, non-marine mammals are imports here, and they have done enormous damage to a native flora and fauna that survived untouched until only a thousand years ago. With their human companions and a host of associated species, plus the huge scale of destruction of native vegetation necessary to turn natural forest into productive farms, the mammals introduced by the Europeans have transformed the landscape of New Zealand in less than 200 years. Before them, the Polynesian hunters and their rats and dogs did less spectacular but equally devastating damage to the pristine fauna and flora. The total effect has been to destroy many of the animals and plants that made New Zealand unique, and to replace them with imports that are mostly common elsewhere.

Attitudes to the introduced mammals among the human residents of New Zealand range from undisguised hostility to passionate admiration. At one extreme, many conservationists loathe them, and still grieve over the historic losses they caused to native fauna and flora, even those that were genuinely unavoidable. Some still regard all the introduced wild mammals as candidates for eradication, if only technology could provide the means. In national parks and some islands where more or less natural native communities survived longest and have been destroyed within living memory, the depth of this public hostility towards unpopular species such as the stoat can be quite startling (King 1984), and is easily extended to the researchers who work on them.

At the other extreme is the hunting lobby, whose members rejoice in the introduced game animals and in the freedom to hunt them in beautiful surroundings and with few restrictions. Such conditions seem unbelievable to envious European and American hunters, accustomed to tightly controlled open seasons and quotas. As individuals, hunters often appreciate the need to conserve native species and ecosystems; but pressure groups representing their interests, e.g. the New Zealand Deer Stalkers' Association, have been known to oppose policies proposed by DOC for management of native species that would reduce their opportunities to hunt game (Mills 1990).

The total numbers of conservationists and of hunters are substantial (well over 50,000 each) and the more active members of the two groups are not shy about voicing their very different opinions. Neither group can or should be dismissed by planners when future management options concerning mammals are being discussed; but equally, neither should be allowed to shout the other down.

On the middle ground are the great majority of people, who do not feel strongly one way or the other. Some (but fewer than one might expect) may recognise that mammals and their products are the source of much of the wealth of this country, both past and present. In the early days, fur seals and whales provided jobs for sailors, skinners and flensers, and huge profits for some shipowners and traders. Nowadays, sheep, cattle and deer provide jobs for farmers and hunters, and a host of employees in dozens of downstream industries, as well as a living for much of the rest of the human population. But, until recently, these and other introduced mammals have seldom been regarded as worth studying as species of interest in their own right. Almost all the extensive research that has been done on them in the past was planned with reference either to improving the productivity of the domesticated mammals or to alleviating some problem that wild or feral mammals were seen to cause; the intrinsic value of the rarer, "ancient" breeds of domesticated stock, now lost elsewhere in the world, was recognised only in 1976; there were no professional scientific associations to promote the study of mammals in New Zealand until the last few years; New Zealand museums continue to ignore all exotic species, even the ones that are rare or declining in their homelands.

These contradictions mean that the study of mammals on New Zealand is inescapably political. Attempts to define workable policies for the management of mammals on conservation lands cannot avoid disputes between those on the one side who want to see all introduced mammals controlled or, where possible eradicated, on all protected natural areas regardless of wildlife value, and those on the other side who are prepared to accept a more non-judgemental attitude to the past and a more tolerant attitude to the immigrants and their admirers. In addition, there is the hard economic fact that conservation funds are critically short these days; even some policies that are universally agreed upon cannot necessarily be implemented. The need to take into account such a wide range of views and circumstances is one of the reasons that the development of a rational conservation policy for mammals on conservation lands is so difficult. Like game management, although for different reasons, conservation biology has to be a synthesis of tradition, biology and politics (S.Briggs, pers. comm.).

My brief for this seminar was to provide a general review of the introduced mammals of New Zealand, their effects on the environment and their significance to conservation policy. This is a huge task, so I have relied heavily on other sources (see King 1990). My interpretation of the data remains my own, and my suggestions on policy are confined to the one group on which I have first-hand experience, the introduced predators. should point out that I approach the subject as an outsider, in two senses. First, I work outside DoC, and second, I am only a naturalised New Zealander, not a native one. My viewpoint is therefore more distant than is that of those who are actually involved in the questions I discuss. By way of compensation (I hope), my suggestions are independent, and might be seen as unfamiliar enough to stimulate fruitful discussion in the future.

2. A REVIEW OF THE MAMMAL FAUNA OF NEW ZEALAND

At the time that the infant New Zealand became separated from the rest of Gondwanaland, none of the modern mammals existed - not even the earliest mammals now extinct. All the species that came here must therefore have evolved in some other environment and colonised New Zealand across water. They came in three distinct waves. First came those which developed from terrestrial ancestors into marine or flying forms (bats, seals and sea lions); all eleven of their known descendants are counted as native species, and all arrived before human colonisation except for one bat that is recorded only as a single vagrant specimen. Much later, about 1000 years BP, came the Polynesian colonists and their two companions, the kiore and the kuri. All adapted well to New Zealand conditions, though not to the extent of becoming taxonomically distinct. Some people like to think that they qualify as "native", by length of residence if not by indigenous origin. This idea is appealing, but it conceals the massive impact that the earliest Polynesian immigrants, of all three species, had on the original fauna and flora of all the islands they visited - both in New Zealand and elsewhere in the Pacific. The kiore is popularly regarded as a harmless vegetarian, but only because the damage it did was long ago and undocumented. Evidence has been accumulating in recent years (Atkinson and Moller 1990) to show that, in its own way, the little kiore caused as much havoc among the smaller native birds, lizards, frogs and insects as the Polynesian hunters did among the larger and meatier moas, rails, and waterfowl.

Finally, from 1769 onwards, came the European colonists and the remaining 52 of the 65 mammal species recorded for the region. The pioneer farmers and 32 of the mammals settled down and proceeded to take over the country with extraordinary speed and thoroughness, even though it was not by any means empty at the time. This invasion was the last and clearest example of the processes of "ecological imperialism" (Crosby 1986), by which European influence had been expanding round the world during the previous 200 years. It worked because the European invaders arrived as an integrated community - the people, the mammals and all the associated crops, parasites and diseases with which they had evolved; they entered a land from which the dominant herbivores, the giant avifauna, had already been removed; and they met a remnant native community which, for geological reasons, had been insulated from any such onslaught before.

The land-breeding mammals known to have reached New Zealand at some time or another (Table 1) include 19 introductions that never became established in the wild. Among these are a number of species that could well have ranked among our first-order pests, including an unidentified Californian squirrel, the Indian grey mongoose and the North American raccoon. The mongoose is regarded as one of the nine most damaging mammals to have caused problems in other countries (Atkinson 1989). Other known troublemakers include the European mole, American grey squirrel, mink and red fox; all are regarded as pests elsewhere (Putman 1989) but no attempt has been made to bring them here. I think it is worth mentioning them in order to point out that we have cause to be grateful that we escaped the consequences that might have followed the colonisation of New Zealand by these species.

Table 1. The Mammal Fauna of New Zealand. (See Appendix 1 for scientific names.)[1] Arrived, but did not survive at least 25 years independently in the wild.

Widespread	Localised	Antarctic	Extinct	Not Established[1]
		Bats (4 spp.)		
-	Long-tailed Lesser short-tailed	-	Greater short-tailed	Little red flying fox
		Pinnipeds (7 spp.)		
-	NZ fur seal NZ sea lion Elephant seal	Weddell seal Leopard seal Crabeater seal Ross seal	-	-
		Marsupials (14 spp.)		
Brush-tail possum	Dama wallaby Bennett's wallaby Parma wallaby Brush-tailed rock wallaby Swamp wallaby	-	Black-striped wallaby (identification disputed)	Roan wallaby Unidentified wallaby Unidentified kangaroo Potoroo Marsupial cat Southern brown Bandicoot Ring-tailed possum
		Insectivores (1 sp.)		
Hedgehog	-	-	-	-
		Lagomorphs (2 spp.)		
Rabbit Brown hare	-	-	-	-
		Rodents (7 spp.)		
Ship rat Norway rat House mouse	Kiore	-	-	Gray chipmunk Brown California squirrel Guinea pig
		Fissipeds (7 spp.)		
Stoat Ferret Feral cat	Weasel	-	Kuri	Indian grey mongoose Raccoon
		Ungulates (23 spp.)		
Feral pig Chamois Feral goat Red deer	Feral horse Feral cattle Tahr Feral sheep Wapiti Sika deer Sambar Rusa deer Fallow deer White-tailed deer Moose	-	Axis deer	Bharal Gnu Llama Alpaca Mule deer South American deer Zebra
		GRAND TOTALS		
14	23	4	4	19

[1] Arrived, but did not survive at least 25 years independently in the wild

The remaining species include the native bats and pinnipeds plus 35 resident introduced species (residents are defined as those that established independent populations in the wild which survived for at least 25 years). The resulting fauna is unusual by world standards because (1) the introductions so vastly outnumber the natives; (2) the established residents comprise a mixture of wild species of both temperate and tropical origins plus several feral domesticated species which are now being exposed to natural selection for the first time in many generations; and (3) the colonising stocks entered an environment which was not only totally foreign to them, but which also, conversely, had hitherto been innocent of all terrestrial mammals but bats. The resulting interactions, within the mammal fauna and between the mammals and their environments, are not "natural", but together they make up a working, evolving community.

Of the resident exotic species, the kiore and the kuri were brought by the Polynesian colonists as food and as companions; the rest were brought by Europeans, some for the same but more for quite different reasons. All the marsupials, all the ungulates except those counted as farm stock, and even both the lagomorphs, were brought in to provide resources for sport hunters, fur trappers or game meat suppliers. The cat was a domestic pet. Only the three European rodents came uninvited, as stowaways among forage and packing materials on sailing vessels and distributed inland with almost every delivery of imported goods. The other three carnivores and the hedgehog were recruited to control those among the deliberate imports which had exceeded their brief to go forth and multiply.

The domination of New Zealand by European influences during the third wave of mammal arrivals in the nineteenth century helps to explain the disproportionate success of colonising mammals of European origin. Of 54 known introductions, 20 came from there, and all established successfully. They include all but one of the 14 species that are most common and widespread today. Next are the 14 of Australian origin, of which half established at least locally; one, the possum, is the only mammal that is now common and widespread on the mainland but which does not come from Europe. Of the rest, six came from Asia and 10 from North or South America, with mixed success; the two from Polynesia were both successful at first, but both were later displaced by equivalent European kinds. Two from Africa were liberated only among Sir George Grey's menagerie on Kawau Island. The bias towards species of larger body size brought to New Zealand, mostly Australian or European game animals, reflects the motives and influence of the acclimatisation societies (now known as Fish and Game Councils), the organisations responsible for most of the introductions. A similar pattern is typical among deliberate introductions elsewhere, e.g. on the Hawaiian archipelago (Tomich 1986) and on scores of other islands (Atkinson 1989).

Of the species that are or have been resident, only 14 are widespread on the main islands, and all are introduced (Table 1). None of the native species can now be counted as widespread, although most of them were so before human colonisation. This sad fact illustrates the familiar story of the effects of human colonisation on native species, especially on islands. Twenty-three of the residents are well established but localised, four are confined to the

Antarctic, and four are extinct. By comparison with islands of comparable size in the northern hemisphere, this is a small fauna of resident species, yet in the Orongorongo Valley the biomass of mammals is high by international standards (Brockie and Moeed 1986). Unfortunately, this high biomass has been gained at the expense of the native fauna; and 99% of the total biomass is accounted for by a dense population of possums, whose browsing has substantially altered the species composition of the original forest.

3. CONSERVATION SIGNIFICANCE OF THE INTRODUCED MAMMALS

The impact of possums on forest composition is clear, and it is easy to classify the possum as the single most damaging mammalian pest present in New Zealand today. But a general classification of the pest status of all the introduced mammals is more difficult, for three reasons. First, the labelling of a species as a pest presupposes a clear management policy for mammals in New Zealand, against which the impact of any given species can be compared; but no such policy exists. Second, the pest status or otherwise of a species depends on where it lives; it may be a pest in one place and not a pest in another place. Third, at different times and places, some species are either a pest or a valuable resource, and at some times and places they can be both at once. The conservation status of any given population of introduced mammals must therefore hinge on the conservation status of the land they occupy, not on any particular characteristics of their own.

Table 2. A possible classification of the present conservation significance of the 35 species of introduced mammals.

SIGNIFICANT DAMAGE			LITTLE DAMAGE	
Mainland plus islands	**Mainland only**	**Islands only**	**Still present**	**Now extinct**
Possum Ship rat Kiore* Rabbit* Norway rat* Feral cat* Feral pig* Feral goat* Stoat* Red deer* Mouse* Feral cattle* Feral sheep* Fallow deer White-tailed deer	Chamois* Tahr* Weasel* Ferret Bennett's wallaby Feral horse Sika deer Wapiti and red wapiti hybrids*	Dama wallaby Black-tailed rock wallaby	Parma wallaby Swamp wallaby Hedgehog Brown hare Sambar Rusa Moose	Black-striped wallaby Kuri Axis deer
15	8	2	7	3

*** = of greater significance in the past than at present**.

3.1 Past and Present Significance

Table 2 sets out a possible classification of the introduced mammals of New Zealand, according to the extent that they can be regarded as pests. A "pest" is here defined as an introduced mammal which has caused or is causing significant damage to native species or ecosystems, including both direct destruction of individuals and indirect degradation of their habitat. In other countries, the definition of a pest usually includes the idea of "damage ...of economic significance" (Putman 1989). This is possible on agricultural lands anywhere, but on conservation lands in New Zealand, it has until recently been regarded as impossible to put a monetary value on the native species damaged. Now, new techniques developed for the economic assessment of game mammals as a resource for hunters include concepts such as "option value", defined as the willingness to pay for a future opportunity to see wild individuals of the species concerned, and "existence value", defined as the willingness to pay simply for the knowledge that the species exists somewhere in the wild (M. Cause, pers. comm.). Cause emphasises "the need for economic principles to be used in "non market" wildlife resource management...so that these resources may be full partners at the bargaining table of land-use decisions". DOC should take note of this important point and set up a suitable research programme on it.

The introduced species fall into five groups. (The proposed allocation of species to these groups is highly debatable and not in itself important. put it forward only as a starting point for the discussion that follows.) Ten species have caused relatively little damage. The brown hare lives at naturally low population density; the kuri probably remained largely domesticated; the damage caused by the hedgehog is negligible, and that caused by the others is either slight, very localised, confined to strongly modified habitats, or is indistinguishable from that caused by other, more dominant pests with which they co-exist. Seven of this group are still resident in New Zealand, and three once were but are now extinct.

The other 25 species are or have been the cause of significant and widespread damage to native ecosystems; a 26th and even more important species is, of course, our own. Collectively, these are responsible for the total transformation of the natural environment of New Zealand within historic time; other factors, such as climatic change (Grant 1989) have compounded their effects.

Between the late 1940s and the mid 1980s, natural processes plus advances in field techniques led to real reductions in the populations of many formerly rampant pests. Of the 25, no fewer than 15 were to some degree less damaging during that period than they had been before. Some have actually been eliminated, such as most of the mainland herds of feral farm stock. But extermination is seldom a feasible option. Perforce, the most striking examples of damage reduction involve sustained control of wild herbivores, such as the rabbit and the high-country ungulates. Postwar aerial poisoning campaigns, aided by the "decommercialisation" policy (Howard 1966) and by changes in farming practice and stocking rates unfavourable to rabbits, reduced the extent of rabbit damage on grasslands over most of the country, except in the semi-arid parts of the South Island that provide optimal conditions for rabbits. The development of new methods for aerial hunting, both for carcases and for live recovery, plus the change in regulations necessary to permit deer-farming, greatly reduced the numbers of deer, chamois and tahr in the high country. Commercial interests are a somewhat unreliable partner in animal control work, but their impact on the densities of previously inaccessible populations of game mammals during that era was very impressive; for example, they reduced the overall population of wild deer by 75-95% (Challies 1985). But this effect depended on constantly maintained effort, and could not in itself be permanent. During the last decade, and especially since 1987, changes in the organisation and funding of government-sponsored control work have greatly reduced the extent and impact of the routine operations against wild herbivores (rabbits and ungulates) that formerly worked so well. In addition, declining profits and collapsing markets (e.g. since the reunification of Germany) have inevitably brought the end of most commercial hunting. The surviving animals, given respite from hunting and surrounded by improved food supplies, are responding: already, tahr are increasing at about 18% per year (J.P. Parkes, pers.comm.).

The introduced predators (rodents and carnivores) entered native communities that still contained many defenceless species, unprepared to compensate for a drastically increased mortality rate. The effect was devastating at first, but since most native species that still survive are either less vulnerable or less abundant, the worst is now over. Of course some (e.g. kokako, kakapo) live on, in acute danger from various hazards including predation; but they are few compared with the number of mostly lesser-known species that have gone. Some of the invaders have followed their former prey to obscurity, and are as unlikely to return. The kiore, very damaging in Polynesian times, is now confined to offshore islands and to Fiordland; cats and mustelids (and native harrier hawks), that thrived on the huge populations of European rats, mice and rabbits typical of many parts of the country in the century between 1850 and 1950, are now relatively scarce. These historical reductions in damage done on the mainland by introduced predators, by contrast to the parallel declines in damage from rabbits and deer, are natural rather than imposed by management, and can be regarded as permanent.

On islands, the success of recent eradication campaigns against feral goats, pigs, cattle and sheep, plus wild cats, possums, and rodents has greatly reduced the number of places where these mammals pose a direct threat to populations of vulnerable native species. Provided DOC is able to monitor these "cleaned-up" islands and prevent new introductions, these improvements can probably be maintained long-term. In dealing with a depressing subject it is good to remember that much has been achieved, even though much remains to be done.

The difference between temporary and permanent reductions in damage by invading mammals depends on whether or not the mammals have reached a dynamic equilibrium with the native biota. Predator-prey systems involving efficient invading predators and extremely vulnerable native species tend to reach permanent equilibrium quickly. For "equilibrium" read "rapid exit" for the natives and "change in diet" for the invaders. Herbivore-vegetation systems are the same, because herbivores act like predators of vegetation. Once the individual birds, lizards, insects and plants that have been destroyed can no longer be replaced, many local extinctions amalgamate into one total extinction, whether the invaders later decline or not.

But if the adult prey/plants are long-lived and have some refuges or some defence, such as efficient dispersal of juveniles or vigorous regeneration, then permanent, stable equilibrium is less likely. The huge recovery potential of many common forest plants can be held down only so long as they are constantly depressed by browsing; conversely, individual adult kokako and canopy trees can survive for years after their populations have ceased to sustain themselves, so some vulnerable native species still hang on today. If the invaders are removed, the processes that brought about the damage may be put into reverse, and a new dynamic equilibrium maintained (at a cost) by deliberate management rather than by nature.

3.2 Distribution of Pest Mammals in New Zealand

It is difficult to give a precise listing of the distribution among the New Zealand islands of the mammals identified above as past, present or potential pests, since there is a continual turnover of new information from surveys and management operations. The following figures give an approximate summary, and up-to-date details can be obtained from the database on island distributions maintained by DOC.

Counting each island population of each species separately, the present total number of populations of pest mammals is at least 319. The North Island now has 18 of the 25 pests, the South Island has 20, and Stewart Island has seven. Within historic times the North Island had an additional one which is now extinct there, and Stewart Island had three. On the offshore and outlying islands the distributions are: Chatham group, 13 populations present, five gone (died out or exterminated); Kermadecs, four present, four gone; Subantarctic group, 18 present, 13 gone; inshore islands, 238 present, 73 gone. This might seem an alarming total, but in truth it could have been very much worse. Veitch and Bell (1990) list a number of heart-stopping "near misses", for example the pregnant female mouse found among stores being unloaded on Raoul Island. Actually, in 1954 mice actually escaped onto the island from stores, but they apparently did not survive. There have also been some lucky failures among the deliberate introductions. Veitch and Bell point out that "If all attempts to introduce animals to islands were documented we could well see that relatively few were successful."

4. TOWARDS A MANAGEMENT POLICY FOR INTRODUCED MAMMALS

As a start, I propose two guiding principles. The first is that a management plan for any given population of introduced mammals be decided from the conservation value of the land they occupy, not from any characteristics of the mammals themselves. To some extent, this is already being done, in the district management plans required by the Conservation Act for all DoC lands. The second is that no funds should be committed to any mammal control operation unless careful and realistic calculations have been made in advance as to the probability of success and the costs of the operation; every approved project should be monitored, its goals kept constant, and its results determined in terms of the benefit to the protected species or ecosystem at risk, not in terms of the number of pest mammals killed. Unless or until such benefit can be assured, the damage must either be minimised in some other way, or tolerated. The point is not that we should give up, but that we should be very very careful to use the funds we have only where they can do real good.

Note that these remarks apply only to conservation lands, and only to one aspect of the management of those lands, the question of introduced mammals. It should be remembered that there are many other principles involved in the design and maintenance of conservation lands (O'Connor *et al.* 1990), and there are times and places when these other considerations take a higher priority than do pest mammals.

A control operation aimed against several different species of mammals can also be a monitored experiment, not only to check on the impact of the control work on the target mammals, but also as a means of deciding which particular mammals should receive concentrated attention in the future. This approach is important when the protected value at risk is an extremely vulnerable species in very urgent need of help, such as the North Island kokako, and the mammals to be controlled are not precisely identified. Preliminary data show that the kokako are threatened both by competition for food from browsing mammals and by direct predation. In a current five-year Research-by-Management programme, different populations of kokako are being protected either from both browsers and predators, or from neither. Their responses are being closely monitored in comparison with a companion study on the relative number of nesting attempts and the causes of nesting failures (R.Hay, pers. comm.). The next 20-30 years will be the critical ones that decide whether or not the kokako will escape extinction on the mainland; the results of this programme will help to determine the management policy that will influence the course of events one way or the other.

The total area of protected lands in New Zealand at present (as at March 1989) is 5.49 million hectares, some 20% of the land area of the country (Department of Conservation 1989). A protected area can be defined as one in which "the preservation and protection of the natural environment is either the principal or a major objective of management" (Dingwall 1982). For each of the various classes of reserves, appropriate management objectives are set, mostly administered through DoC. However, the governing legislation has evolved over time, and some of it is rather ambiguous or even contradictory; and research on reserves is not and perhaps hardly ever could be sufficient (although it has come a long way since the days when Gibb (1970) could call it "only desultory"). There is also still widespread debate about the normal functioning of natural ecosystems in New Zealand, about the reference point to which management policies refer, about whether the consequences of human activities are to be regarded as part of "nature" or not, and about the different kinds of safeguards needed to secure the particular aspects of what remains of the original nature of New Zealand that we choose to defend. As Molloy (1989) points out, we long ago lost the biscuit, and are now reduced to disputing over the crumbs.

5. TRIAGE STRATEGY FOR INTRODUCED PREDATORS

The triage strategy was developed by military doctors, overwhelmed by the casualties of war, to ensure that their inadequate resources were spent where they could do most good. The wounded were classified into three groups: those who would certainly survive without immediate attention, those who were certain to die despite all possible attention, and those who had some chance of survival if attended immediately but not otherwise. Medical resources were concentrated on the third group, and later, if there were any left over, some went to the first group. The second group got comfort and painkillers, but no attempt was made to save them - not because the military medics lacked compassion, but because it was absolutely necessary to avoid spending precious resources on hopeless cases. This strategy was an effective practical response to the paramount requirement to make the most of limited medical manpower and supplies in a time of wartime crisis.

There are parallels between the present state of conservation in New Zealand and a wartime crisis; certainly the limitations on professional staff, money and supplies are just as tight and the need to concentrate on achievable goals just as urgent. I therefore suggest that we consider including the principles of triage in at least some aspects of our management strategy for conservation lands. As an example, I use the introduced predators, for two reasons. First, they are the only group with which I have first-hand field experience. Second, the troubles caused by predators and by other introduced mammals, such as possums and deer, are different; predators kill individual protected animals directly, whereas deer and possums kill them indirectly by degrading their habitats or removing their food. I agree there is a case for ranking all pest control proposals together (G. Hickling, pers. comm.), but that may not be easy within the existing administrative structure of DoC; so, for the moment, my proposals are addressed mainly to DoC's Protected Species Division.

Predator control is only one of the management tools available, and for some threatened species, it is not the most important. In addition, the idea of predator control includes two rather different strategies. The first, population control, means the permanent elimination or effective reduction in numbers of the predator to below the level sustainable from food supplies; the second, damage prevention, means merely the local and temporary reduction in numbers of predators, only when and where they could be a particular nuisance. Population control is very expensive, and is feasible only in relatively small and isolated areas and worthwhile only if it achieves eradication or is guaranteed to be sustained. Damage prevention is less expensive, and is possible in larger areas; its effects, though short-lived, are worth achieving provided (1) sufficient is known about the predator targeted, and (2) the hazard is only temporary and predictable in advance.

The medical conditions of the individual soldiers brought to a field hospital are variable, but experienced doctors can quickly place each in one of the three triage categories described above. Likewise, the environmental conditions encountered in individual reserves are variable, but I suggest it might be possible to define three parallel categories of conservation lands; those whose native fauna will probably survive without immediate attention, those whose native fauna cannot be improved despite all possible attention, and those whose native fauna has some chance of survival if attended immediately, but not otherwise. The allocation of a reserve to one of the three classes would depend on (1) the present or potential value of the habitat for native fauna and flora; (2) the presence or absence of threatened native species or communities; (3) the number, species, distribution and vulnerability to control measures of introduced predators and other mammals; (4) the relative health of the natural processes that would allow the future survival of the threatened species or community, and (5) the relative priorities of active conservation work and of other uses of the land. The problems and processes of allocation might be analogous to those encountered by Atkinson (1990) in classifying offshore islands into five functional management categories.

Our management strategy for each of the three triage categories might be summarised as follows:

> Class A: Conservation lands whose wildlife value is very high or restorable, and is (or could be) defensible in the long term, given adequate funds for active management programmes, including effective population control of predators. Conservation would always have the highest priority, and incompatible competing land uses would be rejected. Public access could if necessary be restricted or prohibited.
>
> Class B: Conservation lands whose wildlife value is medium to high, and which are too large to protect from predators by population control but which will probably continue to remain valuable with strong legal protection and various degrees of other kinds of management, including **temporary damage control operations against predators** when necessary. Conservation and other forms of non-consumptive land use (e.g. tourism) would be equally valid, and may have to compete for priority. Public access would be expected and encouraged, though it could if necessary be regulated.
>
> Class C: Conservation lands whose wildlife value is low to medium and cannot be restored by any form of predator control, but on which opportunities for other forms of conservation are still worth seizing even though they would have to take second priority to other types of land use. Free public access would be a high priority.

Unprotected lands outside the conservation estate are not included in this system, but most would fall into classes B or C.

The classes would not be rigidly fixed; a large area allocated to one class may contain enclaves of another, and future developments in management techniques should allow revision of the allocations from time to time. The translation of the various different classes of reserves in the existing conservation estate to the three triage classes can be done only by DOC management, so here I give only some examples.

5.1 Class A Lands

Certain well-defined areas of the mainland, plus many valuable offshore islands, belong in Class A. The underlying philosophy for their management is the longterm maintenance of their irreplaceable biological diversity and the preservation of currently threatened ecosystems or species. If necessary these policies can be pursued at the expense of excluding the public and any incompatible land use.

This management strategy deliberately sets out to prevent an otherwise probable transformation or extinction of a native species or association. It requires a set of management policies aimed at short-term rescue as well as long-term protection, which includes but is not confined to rigorous control of all mammals causing damage, predatory or not. Removing predators alone is usually not sufficient, especially where they are not the prime cause of the problem. The classic illustration of this principle is the early stages of the takahe programme in Fiordland. During the 3-4 yearly irruptions triggered by beech seedfalls, mice become very abundant, followed by stoats (King 1984). Early data suggested that takahe may be at particular risk of predation during these years, but these have not been confirmed by later results. Now "changes in predation pressure ... are not considered to have been [a] major contributor to the decline in takahe" (Mills *et al.* 1989). Instead, Mills' team has shown that the main culprit is the red deer. In the Murchison Mountains, red deer were reduced to low numbers by 1976, and are kept down by continued control work, but the previous overgrazing of the tussock was so severe that it took until 1983 before the takahe began to recover. The takahe work is a prime example of how urgently experimental research is needed to direct conservation funds to the right target - in this case, the primary concern is the control of deer, and only when that goal has been achieved is it worth while considering additional attention to stoats. The same experimental emphasis is built into the Research-by-Management programme for the kokako; on the blocks allocated for treatment by mammal control, predators and browsers are being removed, not because they limit the numbers of kokako, but to see whether they do. If the programme provides proof that removal of mammals benefits kokako, the future continuation of mammal control in kokako areas will become a decision for management, not a question for research.

Among the native biota surviving today are many that cannot co-exist with the contemporary range of introduced predators. In order to preserve the few that survive on the mainland, control of introduced predators and other mammals is fully justified to the limits of our present and future technical ability. Other sensitive species are already confined to offshore islands. Our need for suitably "clean" and safe islands increases with the need to establish replicate, independent populations of more and more threatened species. Extermination of mammals on islands is quite possible, and the maximum size of the islands that can be rehabilitated this way is increasing all the time, as experience and new techniques give field operators vital confidence in their work (Veitch and Bell 1990).

In this context, "control" includes not only removal of existing populations, but also the prevention of establishment of new populations and, if that fails, immediate action to exterminate colonists before any damage has been done. This can be achieved only if invasions are detected quickly. The importance of preventive vigilance has been known for years, but it has not been taken seriously enough in the past to avert several tragedies. For example, Richdale warned in 1946 of the danger and the consequences of ship rats reaching Big South Cape Island; twenty years later, they did (Taylor 1968). In 1966 Howard compiled a list of priorities for animal control measures, and at the top of the list was the problem of preventing red deer from invading Secretary Island; they arrived the next year (Mark 1989). Regular monitoring requires some expenditure, but a lot less than is needed for an extermination campaign. Sometimes such monitoring becomes a contentious public issue, e.g. during the confrontation between crayfishermen and conservation authorities over mooring rights at The Snares (Moors *et al*. 1989). Sometimes effective action is swift enough but the danger of repeat invasions cannot be eliminated, e.g. when a single pregnant stoat swam to Maud Island and apparently produced a litter of seven or eight young; all were caught, but the island remains within swimming distance for stoats (King 1984; Taylor and Tilley 1984), and a repeat invasion is only a matter of time. Still, perhaps we have learned enough from these episodes to assign a high priority to action that remains possible, e.g. to prevent deer and pigs from reaching Egmont National Park, goats from invading Urewera National Park, and tahr from extending their range in the Southern Alps (Parkes and McSweeney 1989).

The mammals whose presence threatens the survival of native species or ecosystems are easily recognised, but their classification is still geographical; it is only the ones that live in Class A lands of particularly high wildlife value that merit attention. The same species living on Class B or C land may be ignored. For example, the following list gives a few of the places where a threatened native species or ecosystem (named in parentheses) is to some extent damaged by predators or other mammals:

Murchison Mountains (takahe), Secretary Island,(vegetation) - stoats, red deer
Pureora SFP, Mapara etc (kokako) - deer, possums, goats, cats, rats, mustelids
Te Rere (hoiho), Mackenzie Basin (black stilts) -ferrets, Norway rats, cats
Rangitoto/Motutapu Island (vegetation) - possums, brush-tailed rock wallabies
North Block of Great Barrier Island (kokako) - pigs, goats, ship rats
Far Northland (vegetation, snails) - possums

For each of the reserves placed in this category, there will be a range of options depending on circumstances. On the islands, elimination is technically possible, given sufficient money and determination. Secretary Island was colonised by red deer only in 1967, and the vegetation there, while not now quite pristine, remains the least modified sample of any forest in Fiordland. Its original state and the processes of its response to the invasion of deer have been monitored (Mark 1989). Rangitoto Island (a young volcano, joined to Motutapu at low tide) is an internationally famous example of the colonisation by vegetation of a totally naked eruption site, and botanists fear that the presence of possums and brushtailed wallabies must be preventing the succession from following its natural course. It is a generally agreed aim to eradicate mammals from as many islands as possible, provided the need and the planning is sufficient (Veitch and Bell 1990) and the potential benefits carefully assessed (Atkinson 1989), but there are exceptions (Taylor 1968), and no one person can decide at any given time which of the many islands that support introduced mammals could or could not be cleared. The assessment depends on fine local knowledge, on the continual advance of technique, on the finance and labour available, and on DoC's own priorities for island rehabilitation. Ideally these decisions should be made after national consultatioo of interested parties, including co-ordination of non-DoC advice (Parkes 1990b). By contrast, permanent elimination of predators is impossible on any mainland area, so operations there inevitably must be planned to continue for years and budgeted for indefinitely (as at Mapara: Saunders 1990).

Management of Class A lands is very expensive because it involves the costly labour-intensive techniques required to control or eradicate introduced mammals. If implemented properly this work will obviously command the lion's share of the national conservation budget, even though the total area of Class A lands which can in practice be defended in the longterm is relatively small. Nevertheless, these techniques are available to be used, and are constantly being improved. Results recorded so far on Class A islands such as Little Barrier, Kapiti and Breaksea and others (Veitch and Bell 1990) are impressive, and more can be expected in the future. The achievements of DoC and its predecessor, the NZ Wildlife Service, with respect to critically endangered species such as the black robin and the takahe are, quite rightly, universally acclaimed, and in general the public hold this work in such high regard that they willingly accept the necessity for restricted access to Class A areas.

5.2 Class B Lands

The best of the large and important mainland reserves, such as all the national parks, are candidates for Class B. All the large mainland reserves clearly deserve a high status, because they are of enormous value as the most extensive reservoirs of contemporary biological diversity, but they are open to the public, which means that the interests of their biota and of the human visitors must somehow be balanced, and they are too big to manage intensively. In practice, our present resources and technology are insufficient to achieve long-term, effective population control of any of the introduced mammals in national parks, including the predators. The only possible exception is the tahr (see below). However, it may be possible to implement damage prevention programmes at critical times in the most sensitive areas. For example, in the Eglinton Valley, damage-prevention measures against stoats in order to protect yellowheads are needed only for a short period in spring and summer every 3-5 years, after a heavy beech seedfall, and these high-risk seasons are predictable at the time of the seedfall, six months in advance.

There is always the hope that we may achieve more effective ways to manage large areas in the future. However, all large-scale management involves huge cost, which must be well justified and balanced against other claims for the same funds. So in the queue for funds for predator control, proposals for temporary damage prevention in the large mainland reserves may have to stand behind long-term predator population control programmes in the smaller, more isolated Class A lands which need urgent and expensive attention right now, and where the irretrievable damage that will follow if they do not get it is actually preventable with present technology.

Prevention of damage by predators on Class B land is likely to be regarded as having a lower priority, and therefore less well funded, than population control of predators on Class A land. Most Class B reserves will support only the relatively hardy species that have co-existed with predators for many years, though the damage done by predators in the past is all too evident. Class B reserves may contain enclaves of Class A land, but these will amount to a relatively small proportion of the total. Yet, paradoxically, there is a real biological sense in which habitat protection for presently healthy species on Class B land is more important than active management of endangered species on Class A land. Failure to recognise this in the past has encouraged us to "lavish deserved attention on native plants and animals whilst paradoxically continuing to deprive them of suitable habitat" (Gibb 1970) - so ensuring that future generations of reserves managers will have endangered species to worry about after those on the present list are all extinct. In other words, short term, intensive preservation measures become necessary when long term, extensive protection policy has failed. The long list of species needing active management in our day reflects the lack of knowledge about conservation of a hundred years ago; and equally, those that we fail to protect today will make up the endangered species lists of tomorrow. Such protection work does not necessarily involve predator control. It is vital to ensure that the funds required for protection policies that have high and permanent conservation benefits are not wasted on poorly researched predator control programmes whose conservation benefits are negligible.

This suggestion sounds startling but is not particularly original. Norton (1989) allows that

> passive management is appropriate for our largely intact natural areas...here nature can be left to order events...the only cases where active management may be necessary ...are when specific species are threatened (e.g. takahe...in Fiordland National Park).

The shortage of funds within DoC has already forced enormous rationalisation of control effort, and passive management is often all that can be achieved anyway; this is a matter for regret and protest on lands of Class A, but not necessarily on those of Class B.

5.3 Class C Lands

Mainland reserves with no exceptionally high value for native biota should be placed into triage Class C. They are part of the continually evolving natural world; all their resident species including the introduced predators are in fact involved in an irreversible process of adaptation to each other; conditions for the native species that remain cannot be improved by any achievable level of predator control; the appropriate management policy for them is to provide the rigorous legal protection necessary to ensure the future continuation of the evolutionary change in which they are now locked. Examples of Class C lands include the ten

Recreational Hunting Areas, some of the State Forest Parks, most of the 1219 Scenic Reserves, and some of the large, multiple-use islands e.g. Great Barrier and Kawau.

Even where the remaining habitats are only semi-natural, these areas can still be of great interest (Molloy 1989). Some native species can survive in highly modified habitat (O'Donnell and Patrick 1989), and relatively cheap and simple measures can be well worth implementing whenever opportunity arises. Moreover, environmental education is an enormously important component of planning for the future; youngsters who have learned respect for wild nature through free access to outdoor pursuits today may be among the DoC administrators of tomorrow. All these aims can be achieved without any expenditure on predator control, and conversely, no form of predator control can assist them.

5.4 Unprotected Lands Outside the DOC Estate

Relatively few lands set aside for agriculture, commercial forestry or other economic gain are included within the DoC estate. But those unprotected lands support many predators, plus the two most controversial mammalian pests in New Zealand today - the possum and the rabbit. Dealing with them is largely the responsibility of other agencies, whose decisions could affect DoC's interests. For example, the predators that now live on rabbits presumably cannot be kept out of adjacent DoC lands, and if most rabbits were suddenly removed by, say, the introduction of myxomatosis (legally or illegally), there could be a temporary increase in predation on native species. The possum is a pest of much greater national importance; the possum/TB/forest protection problem is now arguably the most serious in the entire range of past and present nightmares presented to New Zealand by introduced mammals. The two usual methods of controlling possums, poisoning and trapping, both produce large amounts of carrion, and regular campaigns against possums can help to maintain many predators in the forests that might survive on scavenging supplemented with native birds. There is no obvious solution to this dilemma.

5.5 Advantages and Disadvantages of the Triage Strategy

The main advantage of the triage strategy is that it is practical. It takes into account, not only the different aims of the various kinds of reserves that make up the DoC estate, but also the biological realities out there in the field. It accepts that, since we simply do not have enough money to implement all the management programmes that are needed,the best we can do is to place the money we do have into the policies that will actually do the most good. This means that management of introduced predators on conservation lands should be restricted to operations on Class A lands that recognise the crucial distinction between the means (removing predators) from the end (protection of the native biota), and that this aim may take priority over public use. It also recognises the strength of the temptation to mistake the means for the end, to continue to remove the pest whether or not any protection is achieved (Parkes 1990a). Under the triage system, managers would have to begin to set real and achievable ends for every campaign, thereby exposing the difference between effective and ineffective projects. In practice this means that only effective projects will be funded, and then only on Class A lands. Surely, this principle is not arguable. The debate begins when we try to define which projects are effective and which lands should be placed in which class.

It might be objected that the triage strategy allows only two variations on the "do something" option, whereas others are possible. For example, J.P.Parkes has developed a list of nine policies for dealing with mammal pests (mainly herbivores) in descending order of benefit to conservation values:

- Limit the introduction of new species
- Halt colonisation of new areas
- Eradication
- One-off operation (e.g. biological control or habitat manipulation)
- Site-specific sustained control
- Recreational hunting
- Commercial hunting
- Occasional government control
- Do nothing.

Parkes' scheme is different because it is based on the actions to be taken against the mammals themselves rather than on the conservation values of the land they occupy. The two schemes can be put together well, at least to the extent that the actions suggested are appropriate for predators. The first five points are alternative means of achieving population control on Class A lands, the next three could achieve damage prevention on Class B lands if implemented at the right time and place, and the last applies to Class C lands.

The disadvantage of the triage strategy is that it invites controversy. The impacts of introduced predators have been so great and so distressing, especially in the past, that it will certainly be seen as simple heresy to propose a policy of abandoning all attempts to control them even on conservation lands of lesser value. For example, if the triage principle is accepted, then the management policy for predators on Class B lands, which would include many large mainland reserves, would be downgraded: all attempts to control the populations of predators with present technology would be abandoned in these areas, despite what the legislation says. (Obviously, any new and really effective advance in control methods, comparable with the advent of helicopter hunting, would cause an immediate reappraisal of policy. The idea is not to avoid control work, but to avoid wasting money.) This proposal may sound shocking, and no wonder. There is no doubt at all that predators have eliminated many species in the past. The processes of change have been observed and documented in many places, as summarised in King (1990). It would seem like betrayal to cease to fight against them. Even where the prospects are hopeless, it is still considered by many to be important to go on trying.

Such an opinion is, of course, a value judgement, although it is one widely accepted among conservationists. However, the decision about what to do about the damage does not have to be a value judgement. It can and should be based on a hard-headed assessment of the costs of a control operation and the benefits that might be expected.

If the equation is unfavourable, then it should be up to those who favour taking action anyway to prove that the work is still worth doing for other reasons.

Unfortunately, in these times conservation has to be selective, so we have to be sure we channel our efforts into the defence of those values which we want to maintain (Molloy 1989) and which are actually defensible in the long term. Change is inevitable; we must accept that the concept of "protection in perpetuity" for extensive conservation lands can refer only to their legal status, not to their biological condition. Large-scale, slow changes in all ecosystems are continuous and unstoppable, and are caused both by natural forces (e.g. shifts in climate) and also by the consequences (intentional or not) of human activities. In the long term, most reserves can therefore be protected only with reference to the future, not to any past date or state. This is true in all countries, not only New Zealand; the only real difference here is in the speed and recent date of human intervention. We are among the few nations who can still catch a glimpse of the contrast between our present landscape and its pre-human past.

In practice, the overpowering argument for abandoning all pretence at population control of predators on Class B and C land is the quite simple one that, at present, we have no choice. The reason is that any really successful programme for preservation of the native species and ecosystems placed in Class A will require such a huge investment as to exhaust nearly all the conservation resources available.

5.6 Auditing Proposals for Control Operations

The definition of effective projects can, in principle, be quite straightforward. But it is usually avoided, at least in part because the setting of rational goals for control work assumes a clear understanding of the dynamics of the problem which few managers can achieve. Caughley's (1977) trenchant criticism of government-funded control operations that proceed without rational planning or monitoring has produced few improvements over the last 15 years.

The planning process may involve some substantial preliminary work, to which some managers object on the grounds that it uses up funds that could better be spent on getting on with the control work itself. This objection is rooted in the simplistic gung-ho approach that has wasted millions of dollars on ill-conceived campaigns in the past. It is not tolerable now. As Caughley (1989) points out, "Management options [for any given pest] must be stated in concrete form and anchored in ecological and geographic fact if they are to be anything more than wishful fancy." The only problem is that, whenever sufficiently detailed planning has been done, the requirements for a successful campaign turn out to be so restrictive that they simply do not apply in most areas or to most pest species. If these requirements are unknown or not met, a campaign intended to eradicate a population degenerates into a harvest, which can be counterproductive and eventually more expensive. If administrators try to short-change the programme or work a compromise, then it simply amounts to "money down the drain" (Caughley 1989).

Eradication is a far better option than control, if is possible; it leads to a stable outcome, and in the long term it is a far more economic use of funds. But in the short term, the immediate costs of eradication work are astronomical. The few campaigns whose costs have been systematically tallied and published have produced some hair-raising figures. For example, the coypu occupied only some 6000 km^2 of East Anglia in 1962. Control work was favoured by the facts that the coypu is relatively easily trapped, had a limited distribution on flat, accessible land, and is susceptible to severe winters. Yet the final effort, from the decision to go all-out for eradication 1981 to success in 1987, preceded by years of trials and population modelling, still cost £2.75 million (Gosling and Baker 1987, 1989 and unpubl.)

Few pests in New Zealand are as vulnerable to deliberate eradication as was the coypu, and certainly none of the predators are. About the only candidate is the tahr. Parkes (1989) estimated that eradication would be possible within 10 years at the barest minimum cost of $10.5 million, but the assumptions used in his model were rather optimistic. An alternative estimate is $24 million over 2.5 years (Caughley 1989). (Since then, the tahr have been protected from hunting, and are increasing again.) Neither estimate included the cost of the follow-up surveys, so the real costs would be much more even for tahr, and out of sight for stoats or cats. Such a level of commitment seems unlikely in present times, even if the hunters' objections to eradication were over-ruled, so it looks as if even the tahr, the only mainland pest mammal that might be permanently removed from the list, is safe for the time being.

Where eradication is impossible, **sustained control** work should be justified in terms of the benefit to the native biota at risk, not the number of predators killed. Every campaign removes as many pests as it can; what is important is to determine whether the real aim, protection of the valued resource, has been achieved. Campaigns may be reported as "successful" when a satisfactory number of stoats has been killed per 100 trapnights, but in fact it takes a lot more information than this to gauge whether the campaign has had any effect either on the stoats or on the native fauna at risk.

For example, after a beech seedfall year when stoats become very numerous, there is probably a temporary increase in the level of predation on bush birds (King 1984, 1990), although hard evidence is so far limited to the yellowhead (Elliott 1990). But experimental trapping of stoats in Fiordland suggests that it is probably impossible to kill more than about half the stoats present at one time, and this is insufficient to induce any general increase in the numbers of common bush birds. This conclusion is readily explicable from the population biology of the predators. Since stoats in that area are naturally short-lived (>80% mortality in the first year class, the bulk of the population), and those removed can be rapidly replaced from more than 20 km away, there is little hope that control measures there can be more than briefly effective, because they cannot even replace natural mortality; the most that can be achieved is to bring forward the normal autumn (post-breeding) decline. However, more recent work in Pureora Forest Park told a different story. Preliminary (unconfirmed) data suggest that the natural mortality of first-year stoats there is under 50%. If the kill rate is still over 50%, the control programme could be locally effective; if it is, the number of stoats killed per 100 trapnights should decline. The number of stoats caught there was indeed lower in

1984-86 than in the first year of trapping, 1983. The only trouble is, stoats at Pureora are much scarcer than in Fiordland, so that trappers tend to become discouraged when they have to put in such huge effort and then catch so few. Furthermore, the most numerous predators in that habitat are not mustelids but rats, which are very resistant to control.

A serious difficulty with control work is that it is effective only when sustained. Effective control, after all, depends not only on achieving the desired reduction in numbers of the target species but also in preventing a recovery. But proposals for predator control work have to compete for funds with other DoC priorities, and cannot always win. When they do not, the pressure relaxes. Since most predators can make good enormous losses within a year or less, all previous benefit achieved can be wiped out within a few breeding seasons, and the inevitable result is frustration for the field workers and criminal waste of funds by administrators.

The third option is to **do nothing**. However much we long to eradicate predators from all conservation lands, it is futile to deny that, at present, it is impossible. On all but a few of the highest-priority reserves, we have no choice but to learn to live with them and accept the consequences. Parkes (1990a) concludes that the strategy of "doing nothing" may have undesirable results, but it is likely to be the one most widely adopted; at present DoC can afford to treat only about 30% of the land occupied by feral goats, and that with varying degrees of success. However, it is possible to identify areas where is worth attempting at least two variations on "doing something" about predators - population control or damage prevention - and, equally important, other areas where "doing nothing" will at least have the positive result of channelling funds towards attainable goals.

6. THE OTHER SIDE OF THE COIN

On protected lands that still support both threatened native species and introduced mammals, there is seldom any difficulty in deciding which should survive, whether or not the mammals have any intrinsic value of their own. The decision is sometimes complicated by politics, as in the celebrated case of the goats on Arapawa Island (Rudge 1978, 1990), and is often difficult to decide from existing, insufficient data, but the principle is usually clear. The few remaining samples of the past, the ancient endemics and the remnants of the world they inhabited, need and will certainly get our fiercest protection, by whatever means we can afford.

On the rest of the main islands, that ancient world has been replaced by a new world, which includes both modified native ecosystems and a huge range of resident exotics. A remarkable number of native species have adapted to these new conditions and are now pursuing new evolutionary pathways. Evolution did not stop when the colonists arrived, and however much we regret them, the processes of change cannot be made to run backwards.

There is a real case for the idea that, in these places, all introduced mammals be adopted as a naturalised part of the fauna - indeed, to some extent this idea is already accepted. For example, the hunting lobby has argued for years that game animals are a resource, not a pest. In direct contravention of the conservation policy of the time, they advocated active management of wapiti in Fiordland National Park (Mills 1990), and protested against the reduction of deer, chamois and tahr by commercial hunting. In recent years their concerns have been met by the development of Recreational Hunting Areas. Provided there is no likely conflict between soil and water values and hunting, the aim of their management is to enhance hunting, usually of fallow and other deer, and commercial operations are excluded (Fraser 1989). Here at last we see the beginnings of the change in attitudes for which Howard pleaded in 1966: "In the future we must learn to tolerate [mammals] in some areas while at the same time controlling them more effectively in others". But such a change, involving the abandonment of years of effort to protect the vegetation by eradication of browsing mammals, was not acceptable at the time Howard was writing, and indeed could hardly have been predicted then, commented Miers (1985) with astonishment. In fact, by 1985 the change of policy had gone so far as to include deliberate, official restocking of forests with deer, as was done with fallow in Lismore SF, although this was apparently an isolated incident (G. Nugent, pers.comm.). Nevertheless, the view of the hunting lobby must be considered, and it may lead to other changes in conservation policy in the future.

A special case of the hunting-versus-conservation problem concerns feral pigs on Maori land. Pigs played no part in pre-European Maori culture, but they were among the arrivals most gladly welcomed by the meat-hungry Maori people in the late 18th century. Ever since, pigs and pighunting have been important to the Maori, sometimes more so than the less tangible idea of wildlife conservation. For example, the North Block of Great Barrier Island is a semi-isolated area of considerable wildlife importance (Towns 1988), in which eradication of goats and pigs is very desirable and probably feasible. But the campaign against the goats was obstructed by the desire of some Maori landowners to protect the pigs (Parkes 1990a). The same attitudes would also inhibit plans to eradicate pigs on other islands (Rudge 1990).

Whether or not a mammal species has a history of causing damage to native flora or fauna, those that become resident seem to establish thereby a precedent for staying. Hence there is a surprisingly large group of mammals which have developed a near-preservation status in their own right. The kiore is perceived to be worth preserving because it has unique osteological features and is considered to be "part of our scene" (J. Davidson, pers. comm.). The probable disappearance of the axis deer and the moose are regarded with regret, and the potentially possible extermination of tahr and sambar would be resisted by hunters (indeed, when tahr and sambar declined too far, both were protected by hunting bans). People who witness an encounter between a rabbit and a stoat usually intervene on behalf of the rabbit, even though rabbits have done incalculable damage in the past. This conservative attitude even contributed to the survival of a threatened species, the parma wallaby, "rediscovered" on Kawau Island after it was believed extinct in Australia (actually, wild populations have now been found there too: Warburton and Sadleir 1990).

For some species, we have found new solutions (or sometimes, merely new attitudes) to old problems. These often involve the discovery, driven by independent changes in the outside world, of new scientific or commercial value in formerly "useless" species. The transformation of red deer from pest to valuable farm asset (Caughley 1983) was probably the most dramatic example, but there are others. Certain isolated strains of feral domesticated mammals (goats, sheep, cattle and rabbits) have acquired new significance as representatives of rare or ancient breeds that have died out elsewhere in the world (Rudge 1990).

Accepting that introduced mammals have their own intrinsic value need not conflict with traditional interpretations of conservation policy. Provided we first safeguard the values for which the reserve concerned was created, it is possible to allow some introduced mammals shared use of it. The mammals have a conditional status, clearly secondary to that of the indigenous biota but still valid at suitable times and places. For example, Rudge (1990) lists 14 offshore islands on which 20 populations of feral mammals now exist. Some must certainly be removed, and the sooner the better, but at least half could remain without jeopardising any conservation interests. Nor is this argument particularly original, or even confined to mammals. As Molloy (1989: 69) remarked:

> Few people will question the responsibility we have to safeguard our indigenous and highly endemic flora and fauna, but many people seem to have developed an extraordinary Antipodean attitude towards naturalised plants and animals which some claim is emotional, parochial, illogical and unscientific. Speaking strictly about plants, why not adopt a more mature outlook and accept that we now have a new flora, about equal to the native, which is here to stay. Rather than enshrine these plants in protected area legislation as undesirable aliens to be eradicated where possible, why not acknowledge their virtues and the contribution they can make to the enhancement of our vegetation and flora, especially in semi-natural areas.

And, indeed, why not extend the same ideas to mammals? Other countries, e.g. UK, have had their share of the troubles caused by introduced mammal pests (Thompson 1985) without developing the degree of xenophobia common in New Zealand - and even here, policies based on that attitude, though understandable, are at least a hundred years too late (Williams 1979). Outside the highest-priority reserves, there is much to be said for the definition of conservation proposed by Elton (1958), from long familiarity with the profoundly humanised landscape of Britain: "...some wise principle of co-existence between man and nature, even if it has to be a modified kind of man and a modified kind of nature."

Application of this idea to mammals would have benefits both for New Zealand and for mammal science generally. The introduced mammals have adapted to their new environment in ways that are now detectable and often quite surprising (Table 3). These adaptations, of identifiable stock of (usually) known source and date, are among the clearest in the world, and are of considerable interest to mammalogists overseas. Yet the main New Zealand museums, all established over a hundred years ago and with outstanding collections of native fauna and flora, and well-earned international reputations for research on them, all studiously ignore the introduced mammals. The best examples of mammalian adaptation in historic time have gone unrecorded and undocumented by proper collections. Perhaps the continued evolution of conservation policy in New Zealand will eventually allow social and scientific acceptance of introduced mammals as equal partners in the mainland fauna, at least on lands not occupied by any threatened native species, and then perhaps the museums will be allowed to study our mammals for their own sakes. If the study of historical places is already provided for in the legislation, why not also the study of historical changes in the introduced mammals? The advantage of accepting the introduced mammals as de facto members of the contemporary fauna, at least in areas where they are not in contact with any threatened native fauna, is that these changes might be documented, and the positive value and scientific interest of the introduced mammals might be more appreciated.

Table 3. Ecological or evolutionary adaptation among mammals in New Zealand.
For full details and references, see King (1990).

Observed Change	Species
Residence in habitats occupied by competitors elsewhere	House mouse, brown hare, ship rat
Substantial increase in population density	
Classic irruptions during colonisation phase	Rabbit, red deer, tahr
In predictable cycles	Beechmast mouse/stoat interaction
Generally higher in NZ	Possum, hedgehog
Significant change in body size	
In accordance with Bergmann's Rule	Possum, brown hare, kiore
In relation to habitat	Stoat
Population dynamics unaffected by disease damaging to original stock	Hedgehog, chamois, rabbit
Healthy populations established from few colonists	Bennett's wallaby, Rusa deer
Freedom from domestication	Ferret, feral farm stock
Adaptations in reproduction	
Breeding starts at earlier age	Red deer, feral goat, brown hare
Breeding season longer	Rabbit

7. CONCLUSIONS

The study of mammals in New Zealand is not a simple academic discipline; it is full of disputes, and is in practice inseparable from politics. These disputes are basically about the philosophy of how we as New Zealanders view our country, our heritage and ourselves.

Rational management goals are hard to set, in part because our society's perceptions of mammals as pests, resources or neither are becoming increasingly confused - a problem also encountered by environmental managers in Australia (D. Choquenot, pers. comm.). The only certain fact is that, at least on the mainland, the resident introduced mammals and the remnants of the native fauna and flora must, over the years, evolve together into a new and dynamic community. Both the native and the exotic elements in this partnership have changed or are in the process of changing in response to the new conditions. Whether or not those changes are welcome, they are inevitable and, indeed, are in themselves of interest to science. As McGlone (1989) put it: "...management of areas set aside to preserve natural values must be based on an understanding of their history and likely future. Even when they are protected, there will inevitably be changes in biotic composition and structure." These changes are an inescapable part of the future of large mainland conservation lands in New Zealand. The only debatable part of the process is exactly how it will proceed in any given place, and how we choose to react to it. The only way to prevent it, and then only locally and at huge expense, is by preserving representative examples of the original fauna in the few remaining defensible fortresses.

The traditional reaction to all this is to take the view that all changes induced by human activities are detrimental, and that at least on all conservation lands we should continually resist them. On this view, conservation decisions involving exotic fauna are simple and unarguable -no introduced species can be perceived as having any value, and all must automatically be controlled to the limit of our technical and financial ability.

This blanket policy is becoming less and less acceptable. It argues from one position only, and ignores other values and opinions. But the contemporary legislation is required not only to facilitate conservation, but also to promote recreational hunting. The Government simply has no funds to support or finance expensive eradication schemes against predators or any other mammals, except of course on certain clearly defined lands such as those I have labelled Class A. There, conservation rightly takes highest priority; elsewhere, the conservation lobby is one among others, and must bargain with them on equal footing. Where eradication is not possible, the hard-line attitude to control of mammals is of course still a valid position, but then so are others. In the future DoC will have to find some reasonable way of resolving the conflicts when planning management policies concerning mammals, preferably by demanding realistic cost-benefit analyses before funding any project.

Of course no-one could or would deny for a moment the disastrous consequences that have followed most of the introductions, nor the supreme importance of defending the defensible remnants. But I would point out that, at least on the mainland, much of the damage was inevitable as New Zealand became what it is, an advanced Western nation with a high standard of living and a relatively small but significant place in world affairs. We must accept that the process inevitably though unintentionally caused substantial dislocation of the sensitive native fauna which evolved in a largely forested environment entirely different from the largely grassland one established now. We could save ourselves much unnecessary grief if we could learn to distinguish the losses that were genuinely unavoidable. They are real and sad, but they are not relevant to contemporary policy, so the best thing to do is accept them and leave them out of contention. "Regretting the past, and the human role in it, is really only useful as a basis for doing better in the next cycle of interference which we call `management'"(Rudge 1989). Unfortunately, management of protected natural areas is not an exact branch of science, and we have to proceed by trial and error. There is nothing wrong with that so long as we learn from, and swiftly eliminate, the errors.

Learning from the errors of the past leaves our energies free to assault the problems that are potentially soluble, and to appreciate the positive side of the changes. On the one hand, we do have the advantage of a large number of offshore islands (more than 228 larger than 5 ha) that provide sanctuary for native refugees from the mainland. These need and deserve the security of isolation, guaranteed by our most dedicated managers and our fiercest legislation. On the other hand, on the mainland where such action is far too late, our sense of loss can and should be diminished by the knowledge that there are few other places in the world where the processes of evolution can be observed so directly. Natural processes are replacing some of our lost bird species by unassisted immigration (10 species have been self-introduced since 1840, as listed by King 1984). Of course these imports are no substitute for the ones that have gone, which were unique to New Zealand; if there were anything we could do to reverse the trade we surely would, but there is not. But the new arrivals are still beautiful in their own way, and are much appreciated residents of the farmlands and gardens of modern New Zealand. Likewise, on lands such as the Recreational Hunting Areas it is possible to appreciate the introduced mammals for themselves.

There are compelling reasons for taking seriously the view that, except in certain important and well-defined areas, the native fauna and the introduced mammals should be treated as resident species of equal status in the scientific sense. This does not, of course, necessarily mean that they are equal in the conservation sense or that they have equal claim to scarce conservation funds; but it does imply that DoC must think through the consequences of having responsibility to protect both the remnants of the past and the dynamic foundations of the future. It means that there is a strong case for recognising the introduced mammals as part of the fauna of New Zealand, with an intrinsic interest and value of their own -certainly secondary to that of the native fauna, but still real and worth attention. The potential conflicts between the two can be avoided by good management.

8. RECOMMENDATIONS

DoC should debate, within itself and with outside advisors, the implications of accepting:

- the inclusion of the introduced mammals into the fauna of New Zealand, to be controlled where conservation benefit can be expected but otherwise tolerated;

- the idea of native wildlife as having an "existence value" defined in monetary terms, which would then allow

- a stricter cost-benefit assessment of all proposed mammal control work on high priority conservation lands;

- the idea of a triage strategy, at least as applied to management of introduced predators, which recommends population control of predators in the highest-priority reserves, damage control in middle-priority ones, and no action in all the rest.

If these concepts are accepted, all management plans for protected natural areas should be reviewed in these terms, and some effort should be made to educate the public about these plans and the philosophies behind them.

Legislation affecting the work of DOC should be reviewed, simplified and clarified, with especial attention to defining the biological terms it uses.

DOC should commission a set of field manuals documenting known techniques for monitoring and control of the introduced mammals regarded as pests on high-priority conservation lands. (The first of these, for mustelids, is now in preparation, but others are needed.) That DOC should commission more research on the technology of pest control, including adaptations of new ideas being developed by pest agencies overseas.

DOC should encourage or commission research on the co-evolution of native and introduced species in the New Zealand of the future.

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Appendix 1: Scientific names of mammals mentioned in text.
Note: This is not a species list for New Zealand.

Alpaca *Llama pacos*
Bandicoot, Southern brown *Isoodon obesulus*
Bat, greater NZ short-tailed *Mystacina robusta*
lesser NZ short-tailed *Mystacina tuberculata*
NZ long-tailed *Chalinolobus tuberculatus*
Bharal *Pseudois nayaur*
Cat, house or feral *Felis catus*
marsupial *Dasyurus* sp.
Cattle, feral *Bos taurus*
Chamois *Rupicapra r. rupicapra*
Chipmunk, gray *Tamias striatus*
Coypu *Myocastor coypus*
Deer, axis *Axis axis*
fallow *Dama d. dama*
mule *Odocoileus hemionus*
red *Cervus elaphus scoticus*
rusa *Cervus timorensis*
sambar *Cervus u. unicolor*
sika *Cervus nippon*
white-tailed *Odocoileus virginianus borealis*
Dog *Canis familiaris*
Ferret *Mustela furo*
Fox, red *Vulpes vulpes*
Gnu *Connochaetes gnou*
Goat, feral *Capra hircus*
Hare, brown *Lepus europaeus occidentalis*
Hedgehog, West European *Erinaceus europaeus occidentalis*
Horse, feral *Equus caballus*
Kiore *Rattus exulans*
Kuri *Canis familiaris*
Little red flying fox *Pteropus scapulatus*
Llama *Lama glama*
Mink *Mustela vison*
Mole, European *Talpa europaea*
Mongoose, Indian grey *Herpestes edwardsi*
Moose *Alces a. andersoni*
Mouse, house *Mus musculus*
Pig, feral *Sus scrofa*
guinea *Cavia porcellus*
Possum, brushtail *Trichosurus vulpecula*
ring-tailed *Pseudocheirus peregrinus*
Potoroo *Potorous tridactylus*
Rabbit, European *Oryctolagus c. cuniculus*
Raccoon *Procyon lotor*
Rat, Norway *Rattus norvegicus*
Polynesian *Rattus exulans*
ship *Rattus rattus*
Seal, crabeater *Lobodon carcinophagus*
leopard *Hydrurga leptonyx*
NZ fur *Arctocephalus forsteri*
Ross *Ommatophoca rossi*
southern elephant *Mirounga leonina*
Weddell *Leptonychotes weddelli*
Sea lion, NZ *Phocarctos hookeri*
Sheep, feral *Ovis aries*
Squirrel, "brown California" unknown
grey *Sciurus carolinensis*
Stoat *Mustela erminea*
Tahr, Himalayan *Hemitragus jemlahicus*
Wallaby, Bennett's *Macropus r. rufogriseus*
black-striped *Macropus dorsalis*
brushtailed rock *Petrogale p. penicillata*
dama *Macropus eugenii*
parma *Macropus parma*
roan *Macropus robustus*
swamp *Wallabia bicolor*
Wapiti *Cervus elaphus nelsoni*
Weasel, common *Mustela nivalis vulgaris*
Zebra *Equus zebra*

CHANGING HUMAN PERCEPTIONS OF THE NATURAL ENVIRONMENT

by

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> The scenery we admire in England is often the costly coat of arms rather than the primaeval dress of nature. As regards polish of cultivation, the garden's glories, the plough's court robes, New Zealand is much in the state that Britain was when Caesar landed; and if Caesar's Britain could now be shown to us, many a bright champaign [flat and open] country which we call beautiful, would vanish to reveal the gloomy forest and repulsive waste.
> Charles Hursthouse (1857: vol. 1, p. 97)

> ... a special place in [a] special situation. Here were islands that seemed to remain unchanged from the dawn of time as fantastic bird sanctuaries.... Thought sternly mountainous, volcanic in places ... it was a kind of an antediluvian Eden, already archaic long before the myths and parables of Genesis were assembled. Men arrived here later than anywhere else on Earth.
> J. B. Priestley (1974: 38)

1. SETTING THE SCENE

From "a repulsive waste" to a "special place", the nature of New Zealand as perceived by the European culture has changed dramatically in the brief time it has been in this country. And it will continue to change. What distinguishes the two statements is the social perception of the state of nature in New Zealand.

Both statements are part of our history, part of our landscape, part of us. We ignore at our peril the relevance of both to the business of conservation. Both refer to the principle of the New Zealand landscape that has become one of the fundamentals of conservation. What is unique and distinctive about nature here evolved without people and is characterised by their absence.

In our work in conservation research we take it for granted that New Zealand is a special place. We can feel pleased that a wordsmith of the stature of J.B. Priestley thought so, but what he said about our archaic biota and the brevity of the human presence is nothing new to us. From our perspective, it is Charles Hursthouse's words that seem so strange and out of place alongside our contemporary wisdom of the nature of New Zealand. His ideas seem as archaic as his language. But it would be a mistake to believe that the difference between Priestley and Hursthouse is simply a product of history. We forget that few see New Zealand as we do.

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[1] **The comments in this paper on the state of conservation, and its history, in New Zealand reflect the opinions of the author. They should not be read as the official view of the Department of Conservation.**

People came here to use nature and make it like some place else. Many still far prefer that altered state to the indigenous nature of the country. New Zealand is not only a country renowned for the quality of its protected wilderness. Most of its inhabitants live in what have become, biologically, some of the most altered landscapes on earth.

Recently I was asked to help draw up a set of criteria by which the new Forest Heritage Trust Fund could evaluate bids for land purchases for new protected areas. I also saw the pile of applications that came in from Department of Conservation offices around the country. What struck me was the way the applications used the modern language of conservation ecology: *ecological representativeness*, *diversity*, *sustainability*, as well as concepts of rarity and scenic value. It is common these days to hear people involved in conservation talk in terms of an ecologically representative network of reserves in each district. And increasingly, since the Department of Conservation began, a new theme, biculturalism some call it, is creeping into the conservation language.

Go back to when the government began setting aside bits of the natural landscapes as reserves, however, and you are in another world of language and ideas, the colonial world of the perfect scene, the picturesque lake, the sublime waterfall and ruins of the Maori pa. Behind it all was the tiny gentleman's club of the social Darwinists, men like S. Percy Smith and Walter Buller who - at the turn of the century - were as active in the beginnings of the Polynesian Society and in presenting the scientific case that the Maori were a doomed and dying inferior race as they were in the creation of offshore island bird sanctuaries and scenic reserves. What today we call the conservation estate was started by them. Its foundations are their ideas, not those of modern conservation biology. They rescued many beautiful places from certain destruction, but in the process - by means of the Public Works Act - many auspicious Maori places became spots for the colonial bush picnic.

The ideas that have shaped my own conservation consciousness have come largely from the enquiry of *identity* and the need to protect somewhere the true vernacular character of each New Zealander's landscape; places that can assist the enquiry - who am I, what is this country I live in, what was it like before me, what has happened to it, why did it happen?

You can see this enquiry running through the beginnings of the conservation movement just as you can see it in New Zealand literature. And when you enquire, the landscape becomes the palimpsest, or the slate of a society whose mood about its environment has been radically changing.

I will illustrate what I mean with the landscape I know best. If there has been a symbol of the line of approach of the modern conservation movement, the research activity that has accompanied it, and the land that has been set aside because of it, it is lowland kahikatea forest. This ecosystem, widespread in the New Zealand James Cook and the missionaries saw, is now exceedingly rare. Kahikatea forest symbolises the plight of nature in the New Zealand lowlands. Probably more than any other kind of forest, it has driven the campaigns of the modern conservation movement that eventually led to the setting aside of the last of the great lowland forests, in the late 1970s and 1980s.

I have been working in conservation research for only a brief 15 years, long enough to have seen the destruction of some valuable natural landscapes. Some of them, if they had survived until today, would be identified as crucial and precious. Certainly their destruction would never have been subsidised by Government today. Photographs I took in the mid-1970s of Kongahu Swamp, in North-west Nelson, record the last intact coastal swamp surviving outside South Westland. But its drainage subsidies were committed by the time we tried to save its kahikatea with a bit of conservation science and today it is more pasture than natural habitat.

In 1947, just after I was born, this appeared in the Annual Report of the Forest Service:

> These forests stood in the main on swampy lowlands or good rich land which has now been converted into dairy-farms ... The problem is a simple one, therefore. It is merely dairy-farming versus white-pine forestry; and there can be no doubt about the decision. Dairy-farming demands such land in the national interests, and commercial kahikatea forests are therefore impossible ...
>
> New Zealand Forest Service 1947: 31

The report used the past tense because that is the sense in which the official world saw kahikatea swamp forest. I wondered how it had happened that way. Who had been involved? And eventually, tracking back through the files of concern at the diminishing supply of the tree as the dairy industry here and in Australia took all that could be supplied, I found this:

> ... no forest land, except it be required for the special purposes of a climatic or a scenic reserve and which is suitable for farm land, should be permitted to remain under forest if it can be occupied and resided upon ...
>
> Royal Commission on Forestry 1913: xxiv

You would not hear that kind of language, those ideas, coming out of a Royal Commission today. But one of the authors of the report was one of ecology's few heroes from those times, Leonard Cockayne. Cockayne was the father of ecology in New Zealand. He wrote about keeping the sanctuaries of natural New Zealand "intact".

The Royal Commission of Forestry was charged with determining what could be done to conserve the diminishing supplies of white pine timber. Their responses were unanimous:

> As is well known, the soil of the white-pine swamps, when drained and the trees removed, forms one of the richest of agricultural land, which when grassed is extremely useful for dairy farms.... Since no land is more suitable for occupation than that of the white-pine swamps, when drained, their value in this regard is a strong plea in favour of the removal of the trees forthwith. (p. xxiii)

It was about the same time as the ethnologist Elsdon Best was expressing ideas like this in the *Transactions of the New Zealand Institute*:

> The forest is conservative, repressive, making not for culture or advancement. None of the higher types of civilisation of antiquity originated in forest lands. Primitive man remains primitive in sylvan solitudes. Some day a civilised tribe, from open lands, happens along, and hews down the forest. Then the Children of Tane, human and arboreal, alike disappear, and the places knows[sic] them never again.
>
> (Best 1908: 200)

Leonard Cockayne and Elsdon Best were influential men. The ideas they sometimes expressed, strange and tragic to us today, were commonplace 75 years ago when the foundation of the conservation estate was built.

Some conservation administrators may have had reason to look back to last century through the files on each protected area, but I known very few scientists who have done so. Certainly I had not until only recently when a need to understand the *context* in which the reserves containing some of the last kinds of lowland kahikatea forest were established revealed to me the world of conservation's history.

These files reveal more than the changing ideas about land, people and nature and the changing issues of conservation. There was a trickle of entries through the early decades of the century, a few entries preoccupied with boundary problems and survey. For many long-protected areas the files are so sparse that in the 1940s and 1950s, the areas almost seem to have become forgotten in the Department of Lands and Survey's preoccupation with land settlement. Then suddenly, in the early 1970s, they explode in volume. Pakeha New Zealanders had begun to forge their quest for identity with the need to protect twhat remained of the indiegnous nature of their country.

Conservation, as we use the word while employed by the taxpayer to carry out the research that underpins it, is a completely different subject of concern today than it has been.

I want to talk about the changing human perception of the natural environment keeping this record of official conservation in mind. It is after all Department of Conservation's genealogical record, our inheritance and our legacy. But from the few files I have followed back down the decades to the early 1900s, often finding the pencilled notes in the margins as revealing as a document itself, some important principles have emerged that we in conservation research cannot ignore.

The way people and institutions act on the landscape is driven by how they perceive it. These perceptions are cultural constructions. They can change dramatically in time, and they can differ considerably at any one time between different cultural groups.

We talk at length about the "intrinsic" values of the natural world, for example. But we neglect the fact that the way we use the word to reinforce the protection of nature is a cultural construct. In the sense that it is expressed in the new environmental legislation, it conveys the belief that humankind is a state outside nature, that nature can exist in the state of wellbeing only if people are excluded from it. When Maori talk about the intrinsic state of nature, however, they include themselves in it.

We rarely examine the perceptions behind even the most elementary concepts with which we relate to the natural world.

When Edward Goldsmith, the editor of The Ecologist, spoke at the Gaia Conference at Auckland University in 1989, he did so to an anxious murmur from the audience every time he linked the "Gaia consciousness" to the Greek goddess it derives its name from and the corollary that he was keen to make, that the new consciousness was essentially a maternal one. Eventually the more obvious corollary, his *paternalism,* got more than some of the audience could bear; as part of an organised reaction to his language, one woman, now a member of the new Conservation Authority, stood up, begged him to stop and re-appraise his sexism.

Words convey how we perceive and understand nature. The literature on New Zealand's forests is, like the way people commonly talk about the forest, littered with references to the virgin forest. But a few years ago I came across a passage from the writer, Ettie Rout that showed how gender affects the perception of nature. She is travelling from Christchurch along the Taramakau, in Westland for the first time:

> Tall straight-stemmed trees with feathery boughs rising out of a tangled billowy ocean of moss and fern and creeper - everywhere a wealth of lush foliage, a reckless fecundity appealing alike to sense and passion as the quintessence of wild and untrammelled virility ...
>
> (Rout 1909)

Like there is no absolute use of words in describing nature, there is no use pretending that there is anything absolute about conservation; that the landscape contains values a few of us know are precious, but that the rest of the population will one day come around to appreciating. Conservation is about values, about the eternal human conflict to use nature or not to use it. As Wendell Berry, the American landscape writer, wrote, no one is exempt:

> I cannot think of anyone whom I know or have heard of, who is not contributing in some way to destruction; the reason is simple.
>
> (Berry 1988)

The reason is that we live in an economy that is overwhelmingly destructive. To live un-destructively within it is virtually impossible.

2. THE BEGINNINGS OF STATE PROTECTION

Perhaps the most illuminating way of seeing the historic relationship between official conservation and changing social perceptions of the landscape is the category of protected land that is still today the most common and widespread, the scenic reserve.

Someone involved in conservation policy asked me recently why it is that highway reconstruction inevitably affects a scenic reserve. The reason lies in the way protected areas were designated beside the winding roads to have pieces of beautiful bush as part of the traveller's scene. The pressures of modern transport require the bends to be straightened out.

The influence of people like ourselves - biologists in the main - who spend much of our time gathering information to make the case for conservation, is a feature of only the late 20th century. Whatever the range of ecological diversity in our protected area system, and whatever the value biologists may put on it, it is not a product of biologists lobbying to get those areas protected. The areas that are the backbone of our conservation estate in the lowlands are still today known as "scenic reserves", the term they were given when they were protected almost a century ago. Small and fragmentary, they will continue to give conservation management some of its greatest headaches in long-term care of nature and its processes. They were not really set aside to protect nature's processes in the first place. Their setting was thought to be aesthetically pleasing, and a reformist government was persuaded that - as beauty spots - they could earn the country more in tourist revenue than if their forest was cleared with the rest.

The "scenic reserve" is the survivor of a Victorian sensibility, the cult of the picturesque. It links modern conservation directly with the late nineteenth century and a tradition of seeing and painting a landscape that is fused with the act of possessing it. And the link can be taken further back, to the 1770s and the initial projection on the European imagination of New Zealand's beauty as something unfamiliar but romantic and elemental.

The first people who began systematically protecting the natural landscape, the Scenery Preservation Commission (1903-1908), had very different intentions to what we have today. One of the first places they sought was a lake in the Horowhenua. It was owned by a wealthy European who was modelling his country seat on the landscaped estates he had seen in England. The mansion overlooking the view had not yet been built, but some of the wooded shore had been cleared and planted with ornamental trees. Maori canoes and a carved pataka had been installed, to

> ... embellish its picturesque shores to the water's edge ... furnishing a good illustration of the expressed opinions of the Commission that cleared areas with dwellings thereon in good order in bush country fronting rivers and lakes vastly improves the scenery.
>
> (Scenery Preservation Commission 1906)

For the nature of New Zealand to become beautiful, a New Zealand Pastoral had to be created.

Since the early 1880s government surveyors had been instructed to leave intact places of scenic beauty. Just months before the Scenery Preservation Commission was established in 1903, Harry Ell, MP, wrote to the Minister of Lands complaining bitterly of the vast blocks of forest like the 40 Mile Bush in southern Hawkes Bay that had been cleared without an acre being reserved:

> My only object in urging you to set aside, out of the large areas of native forest country, small reserves at short intervals of distance, is that I believe in so doing I am urging you to do what the people and members of the House desire. I have for the last three years urged upon your Department to make small reserves of native forest every 3 or 4 miles, in addition to the large forest reserves; small patches of bush ... here and there would make a countryside more beautiful to travel through and be a source of pleasure to the residents of the district so treated, for all time ...

Ell's letter was circulated to all North Island Commissioners of Crown Lands with the request, "Will you please take this matter into consideration?"

Initially, the scenic reserve was conceived as complementing the settler's farm rather than competing with it for precious land. But in the end, in quite isolation, it followed a different destiny; any sense that lands left in forest provided, as they do, a benchmark against which loss could be measured, was ignored by the utilitarian pursuit of rural land management.

The intention of the government's Scenery Preservation Commission was revealed in its first recommendation: "a small piece of land near all scenic reserves especially bush, acquired by Government to be cleared to enable picnickers and tourists to camp thereon." In the increasingly populated lowlands of the country, nature's only protection from the settlers' fires was under the mantle of scenic beauty, as something that might attract tourists and as an antidote to the land as solely a site of trade and rural work.

Nature became the object of an excursion, a means of enjoying a change of scene. The rural worker's experience did not matter. What did were the town dweller's and the tourist's. Both require a landscape that appears unspoiled by man's use, the momentary idyll that satisfies the nostalgia that is so persistently recurrent in our culture, the nostalgia that is so persistently recurrent in our culture, the nostalgia for a "golden age".

Today, a deep division persists between a primarily scientific understanding of nature conservation and the fundamentally aesthetic appreciation of the landscape with which the business of protecting it began. The men who lobbied to safeguard the remnant pockets of wildness we still call "scenic reserves" from the ravages of land clearance were not ecologists. They were men like Percy Smith the one-time bush surveyor who created the myth of the Great Fleet to explain the peopling of Aotearoa from the tropical Pacific, and who believed Maori at the turn of the 19th century were dying out. Percy Smith, said at his death to have had "above all an eye for the picturesque ... and human interest", was the chairman of the original Scenery Preservation Commission.

Beautiful natural scenery also improved the mind, Percy Smith told "a deputation of representative gentlemen" from Taranaki soon after the Commission began work, was primarily:

> ... in the interests of young people, though large sums were now annually spent in New Zealand by visiting tourists. Beautiful scenery exercises an elevating and refining influence on the minds of youth, and we should do our utmost to educate and give pleasure to young people.
> Scenery Preservation Commission 1904

But it was also about the possession and control of land by those who now ruled. From the very beginning Percy Smith had his eyes on Maori land. He wrote to Joseph Ward, the Prime Minister, seeking amendments that would make the Scenery Preservation Act "more satisfactory" in that regard:

> There are in the hands of the Natives ... many forest-clad ranges, etc., which have been from time immemorial preserved by them for the purpose of snaring birds. Such lands being called Pua-tahere. They are usually just such places as the Commission would wish to see reserved in order to preserve the forests and scenic features of the country.

3. CHANGES TO COME

New Zealand is a country settled by cultures with deeply differing relationships with nature. We who work in conservation need to get used to the idea that the concepts and legal structures on which official conservation is based still flow essentially from only one relationship. Official conservation - its management philosophies, its personnel (in research, especially) and its expression in the countryside, in the myriad of "scenic reserves" - reflects, almost exclusively, the European interests in the landscape.

Percy Smith's influence on the conservation of the landscape was driven by the belief that the Maori relationship with it was over. A retired government surveyor from the era when survey maps carried legends such as "Lands in the hands of the Natives over which the Native Title has not been extinguished", it was inevitable that he gave the official protection of nature the mantle of land dispossession. While we can only thank him for the vigorous effort he put into securing the protection of the landscape, he placed it firmly within the mindset of total European control that prevailed in government at the turn of the century. It was a mindset that divided society into colonisers and colonised, as its surveyors' lines divided the landscape itself.

Only a century later, as the Treaty of Waitangi makes its presence felt in New Zealand society with a vigour not seen since the 1860s, are we beginning to realise the extent to which the contemporary issue of indigenous land rights derive from the actions of the surveyors and land administrators of the late nineteenth century.

As anyone designing the strategies of survival for threatened birds knows, conservation is about the long-term. It is about planning for an uncertain future. By 2025, demographers tell us, the Polynesian population will amount to over 30% of the New Zealand people. As the Polynesian component of the population continues to grow, the national conservation estate will come increasingly under the influence of very different perceptions than prevail today. Certainly they will represent a different world from the picturesque aesthetics of social Darwinists like Percy Smith who gave the estate its foundation in the ideology that Maori were a dying race.

The social historian Jock Phillips concluded a recent address to the New Zealand Institute of Landscape Architects with some relevant, but uncompromising words: "If you have to design for the new society New Zealand has become, you must first recognise that we are now a divided society" (Swaffield 1990). He based this on an analysis of social trends -the Maori renaissance and a reorientation of New Zealand from the Britain of the South to Aotearoa. He portrayed the new order as a series of conflicts - the tensions between the individuality of place and the conforming pressures of global markets, the social values implicit within landscape, and the legacy of history between traditional connections to place and the new economy of Pakeha greed that alienates people from place. Phillips, don't forget, was not talking about the racial conflict in public health, justice and education. He was talking about the landscape.

We in the field of conservation research need to be able to find an understanding of the way these tensions in society impact on the landscape, or live with the consequences of not resolving them. But the attitudes and perceptions within conservation research itself need to change to accommodate the great changes going on in the multiracial society in which we live. I will quote a couple of viewpoints from two people who are thinking of conservation in this regard.

One, a manager who has recently joined the Department of Conservation:

> The main gain for myself in joining Department of Conservation has been the struggle within the Maori perspective and the realisation that the essence of their grief has to do with an essential loss of CONNECTEDNESS to the land and hence to one another. Nature has been the currency of their cultural connectedness. "God" has been the currency of ours and it is the liberalisation of our interpretation that fragmentation of Western culture, and land, has come about. The business of conservation facilities a strange confluence of biculturalism. After 150 years of confusion and misunderstandings our two cultures are inevitably drawn together as differences in perception, and Westerners illusions of choice, are transcended by the common imperative - conservation as a necessity.
>
> (Clive Anstey, personal communication)

The other, a biologist working with Maori knowledge about the natural biota:

> The collision of cultures instigates debate. The tribal councils will decided what records of spiritual practice should be published. What response will New Zealand scientists make to these records?
>
> Both cultures can appreciate that prohibitions on human action are inserted at certain points in the chain of being to prevent harm being done in the natural and social worlds. The omen of death that the sighting of a green gecko implies, asserts the existence of spiritual power. If the omens and tapu are left out, the natural world will be unprotected by Maori values. Also, if New Zealand scientists fail to play their part and deride maori metaphors and Maori respect for spiritual qualities, Maori control of the landscape will be displaced by pakeha control, as it has been by the appointment of pakeha wildlife and conservation officers. If Maori spiritual values get pushed aside, we have not constructed a bicultural society. On the other hand, the elders deeply appreciate scientific validation of their inherited knowledge. Both sides can proceed through critical appreciation of the other's perspective.
>
> (Wendy Pond, personal communication)

The presence of the Treaty of Waitangi in the Conservation Act is not just about future things. It also requires us to consider the past, not just treat it as something long gone and irrelevant to us. We might want to distance ourselves from the official attitudes towards land, nature and Maori that prevailed a century ago. But a way forward can only be made with a sound knowledge of the influence that they had on shaping the landscape we live in and the conservation estate for which we are stewards.

There is a myriad of protected areas out there whose files and gazette notices proclaiming their status as government reserves tie official conservation inextricably to the compulsory taking of *waahi tapu* and other ancestral land. We only fool ourselves is we think of DoC as a new organisation, as though its history stretches back no further than April 1987.

The point I want to make is that if the Department of Conservation is going to be an advocate for conservation, that task of advocacy places it in confrontation with the developmental ethos that has traditionally characterised the role of Government in the management of land in New Zealand. To be an advocate it is vital that you understand the society you are up against.

There are few securities for a conservation ornithologist studying offshore island or at-risk birds. But at least there is a century-old tradition of legislation to help you. If you are Maori concerned about the care of ancient, ancestral waahi tapu, or an ecologist concerned about the plight of forest remnants or wetlands surrounded with fertile farms and market gardens, history is against you. From colonial times until only very recently, the weight of both public opinion and the developmental ethos that has dictated the role of Government in using land or leaving it in its wild state has always been against you. The cultural traditions that connect Pakeha with Europe, and Maori with tropical Polynesia, are as powerful as they are ancient and ingrained.

As more and more people believe that we have been using the earth's resources unsustainably, perceptions on the natural environment are changing, more radically in our times than perhaps ever before. But public attitudes on nature and its values are one of the Department of Conservation's great unknowns. We have remarkably little sound social information on which to base our advocacy programme. I think it would be enormously valuable for conservation advocacy to have a few more pointers on public opinion, such as the recent Heylen Poll carried out for Greenpeace and which showed that 92% of New Zealanders wanted an end to all exploitation of whales in New Zealand waters.

How we best care for a place depends not only on what we know of the vulnerabilities and limits of its indigenous animals and plants, or the nature and significance of its archaeological information. There is another whole layer of knowledge that concerns what the place has meant to people, how that meaning has made the place what it is, how those values have changed, how some have been suppressed by the selective readings of history that are always going on in a country such as ours with more than one culture tied economically to the land.

Many Pakeha now dissociate themselves from the colonial mentality of what Monty Holcroft called "the campaign against nature" and the way it invaded and destroyed the Maori landscape. They regret that the campaign was so rapacious that in the parts of the country where most of us live, we have had no chance to learn from the way Maori related to the land.

One of the strengths of conservation is that some of its ideas - like landscape, ecology and a sense of place - have the potential for a convergence of Maori and Pakeha values that needs to be put forward in creating a new New Zealand identity. A good example in the Department of Conservation is the way the Coastal Policy statement (DoC 1990) integrated the biological and human aspects in identifying the life-supporting capacity of the coast as a primary element of policy:

In identify in the life-supporting capacity, matters to be considered shall include:
spiritual relationships with the coast;
mauri;
wairua;
the life-giving qualities of water;
the contribution of oceans and seas to the global environment;
the contribution of oceans and seas to the global food chain.

Thinking of conservation in terms of life forces - as allowing the life forces of nature and culture to continue to go on expressing themselves - we see the conservation estate in very different terms than founders like Percy Smith did.

The landscape history of the country's most precious and vulnerable forest remnants in the coastal lowlands reveals that these are far from the remnants of the original primeval forest we might image them to be, that scientific surveys in the 1970s and 1980s have identified them to be. They have survived because they were important areas to Maori: inhabited, resource-rich areas, burial forests and so on.

We have a large body of scientific survey knowledge telling us what the conservation estate comprises in terms of bird species, rare plants and vegetation types. But it is not very good at informing us what these places have been like before us.

In a recent DOC Science & Research seminar Peter de Lange used the phrase "determining what a landscape has been doing". To get this perspective we need to re-appraise the way we approach conservation research and the way we approach the landscape. While there is a prevailing mood that looks askance at conservation science - as though in these hard-pressed times, it is an expendable resource - the very foundation of conservation is the scientific knowledge of the country's indigenous biota and its past. The everyday jargon of conservation -words like representativeness, for example - reflect research efforts that are no more than 10-15 years old.

By its very nature most conservation research is not very visible. Conservation's research is not like its policy formation and advoacy. The results that bring about change and improved conservation management are produced not at the timescale of the month or the year but at the scale of the decade. We need better ways of telling others that conservation research needs a long-term commitment.

When the Department of Conservation began in April, 1987, Philip Simpson and I gave a seminar here on landscape ecology. We identified the coming together, for the first time in the history of science in New Zealand, of biologists and archaeologists as an opportunity to be grasped. At that early stage, the other important component for "landscape" research - social science - had not yet happened. Our advocacy of landscape ecology was its potential for interdisciplinary research integrating expertise in natural ecosystems and human ecology.

I was pleased to hear Atholl Anderson in another seminar in this review series refer to "landscape ecology" as a way to the future for this organisation. In my opinion our biggest weakness is in the dimension of the landscape - where human affairs and nature intersect.

From the era of inventories and surveys we have some insight now into what ecosystems, what species, what archaeological sites are most at-risk. But we have an exceptionally poor understanding of their natural dynamics -how the things we are so anxious to protect actually work - and how the natural processes that make these things what they are, are coping with the actions of people.

In the terms of landscape dynamics, our window into knowledge of the conservation estate is remarkably tiny. We are surrounded by the problems of ever-increasing human encroachment on the nature of New Zealand and constant deterioration in the state of nature. There is plenty to find out that is vital to the task of handing the conservation estate on to future generations. I found that when I integrated history and the oral and traditional knowledge of Maori with my plant ecology, my whole understanding of the landscapes I had once professed to know well was transformed onto a different plane.

The combination of disciplines that has been brought together in this division is an opportunity for integrated research possessed by no other land research organisation in New Zealand. It still lacks some of the skills -ethnobotany, palynology, Maori history for example - that are needed to unravel the conservation landscape, but unless we take up that opportunity of integration and harness our own diversity, we are neglecting one of the real advantages we have.

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PROPOSALS AND PRINCIPLES (PERHAPS?)

by

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The four speakers reviewed our current understanding of the biological history of New Zealand and discussed it as a basis for further research on the environment and ecosystems of these islands. Each started at a different point in time and approached history through their own discipline, but all emphasised the changes that have occurred since the start of human occupation.

Matt McGlone outlined the history of vegetation change over the past 10,000 years and described pre-human changes due to climate and volcanism. He discussed the influence of Maori fires on vegetation patterns and noted how the Maori adapted to a habitat and climate that was marginal for a culture which had originated in a warmer tropical island climate.

Atholl Anderson reviewed current knowledge of moa ecology and noted that the current location of moa fossils is probably not a good indication of moa habitats. He discussed what is known of moa hunting and strongly emphasised that only a very few sites of moa hunters have been properly investigated. He felt that the history of the relationships between Maori and moa in New Zealand was especially important internationally, as it is the most recent record of the extinction of an indigenous fauna through human activity.

Carolyn King considered the most recent events covered in the series - the introduction of exotic mammals and their effects on the New Zealand biota. She described several examples of considerable changes in appreciation of the values of such species. (For example, red deer have been considered a valuable game species, forest herbivore pest, a resource for venison and antler export industry.) She went on to suggest that the emotionally-based demand that all exotic animals should be eradicated was not only impracticable but ignored the useful opportunities for studying their recent evolution in a new environment. She suggested that exotic species would be better managed in the future if they were now considered as an integral part of the present biota.

Geoff Park documented the gradual changes in European New Zealanders' perception of their relationship with the natural environment. The early colonists considered that the land was to be subdued and utilised, but social attitudes have since changed. He described how our understanding has moved to thinking of the human race as a part of nature, depending on, and relating to, the processes of the ecosystems which surround us. He concluded by commenting on the increasing confluence of European landscape concepts, as a sense of place related to the history of the land, with the long-held Maori views which totally integrate the land with the people.

Each author has referred, either explicitly or implicitly, to the major need for studying and understanding past events - biological and social - which have led to the present status of the New Zealand biota. They have suggested that such understanding was essential to form a basis for future research and management and have made suggestions as to what research should be carried out to further these ends. The purpose of this paper is for me, as Director of Science and Research for DoC, to respond and comment on those suggestions.

How are we to judge what research is necessary to underpin conservation management? The Department of Conservation has a very wide series of management mandates and must relate those mandates to the expectations, values and needs of the diverse culture which constitutes New Zealand society. Circumstances during the first four years of operation have not been conducive to the establishment of a clear set of management objectives placed in priority order. This has made it difficult to clearly identify which research is necessary to assist managers in fulfilling those objectives. There has, however, been considerable progress in early 1991 towards such priority setting. It has also become apparent to me that the absence of a departmental `philosophy of conservation', either an ethics or a principles statement, has made it hard for managers to establish priorities for various objectives.

This also applies to scientific research that supports management. Without a statement of principles of conservation, it is necessary for science managers to assess the needs expressed by other conservation managers, or by interested observers such as three of the four seminar speakers. Understanding well that "Fools rush in where angels fear to tread", I now take the first tentative step by describing my own personal views as to what those principles should be. These views will then underlie my comments on the suggested future directions of research outlined in the seminars.

The principles start from the premise that the human occupation of New Zealand was the result of dispersal movements of our species round the globe and, as such, is part of a normal ecological process of population dynamics. We are sentient and have come to understand these processes. As a species, we can comprehend and imagine the ecological situation prior to those invasions. I consider that ecological change is essentially a dynamic, responsive process; it can only be successfully managed by our recognising and using such dynamism. I feel that attempts to reverse the New Zealand biota to its pre-human condition fail to take into account the essential irreversibility of the processes concerned. Nevertheless, the principles expressed below recognise that, because we understand the inevitable process of extinction, we should attempt to delay it, either for our own selfish benefit or for some concept of trans-specific morality. Like any theistic belief, conservation is only a product of human thought and should be recognised as such in the derivation of the principles that direct its actions.

In the principles which follow I use `species diversity' in its expanded sense, including not only the number of species (species richness) but also as measured by weighting each species by numerical abundance in the ecosystem. The FAO Working Group on Biological Diversity distinguished in 1990 between *in situ* conservation - "the maintenance of reproducing organisms in the area where they have developed their distinctive properties" - and *ex situ* conservation, "the maintenance of organisms or genetic material away from the areas where they have developed their distinctive properties." New Zealand is an isolated group of islands which contributes to the world's species diversity largely by its high level of endemism. I consider therefore that conservation management in this country should only develop *ex situ* conservation where it does not conflict with *in situ* conservation.

PRINCIPLES OF CONSERVATION IN NEW ZEALAND - A personal view

- The natural and historic resources of these islands are the heritage of all the people of New Zealand. They were handed down to the present generation, who must act as kaitiaki, for the benefit of future generations.

- The natural and historic resources now available greatly influence our mode of life; they can be used as reference points for us to evaluate our individual positions in the natural world and in the diverse histories of our people.

- There is international recognition that New Zealand contains a vitally important indigenous assemblage of plants, animals and geospheric features which are culturally and scientifically important to conserve.

- The features are present because the islands separated from a continental land mass some seventy million years ago; they result from very active geological processes of change; an especial biota developed, closely reminiscent to that of Gondwanaland; and humans arrived in Aotearoa only a short time ago. It is therefore a national responsibility for the people of New Zealand to conserve our heritage as guardians for the world community.

- The main principle of **biological resource conservation** is to sustain and, where possible, enhance the diversity of organisms in New Zealand. Such conservation should recognise the history of natural and human introductions and manage both indigenous and introduced biota to preserve their diversity. In situations where the introduced biota are diminishing indigenous diversity, preference should be given towards the sustenance of the pre-human biota.

Many consider that the main principle of biological conservation in New Zealand should be to preserve, or recreate, the special character of biotic assemblages which were present before humans arrived. I consider that natural introductions since that time and the effects of humans and the species they introduced are part of an ongoing process of species dispersal. Because of this, I feel that maintenance of the diversity which has resulted should be the main principle. This approach is not inconsistent with the recognition that humans have rapidly increased the rate of species arrival and should, knowing this, act to reduce the resulting alteration of ecosystems and attempt to decrease the consequent rate of extinction of indigenous species.

- The main principle of **earth science conservation** is to ensure the survival of the best representative examples of New Zealand's diverse geologic features, landforms, soil sites and active physical processes, so that we can appreciate the unique geological history of this country and the development of its landforms. Preservation of such features and processes is essential for future understanding and education.

- The main principle of historic resource conservation, recognising that such resources are the physical entities of the spiritual and cultural values of the people of New Zealand, is to preserve historic sites and artefacts so that we can understand the processes of our social evolution. Historic resources should be managed for public presentation and education wherever this is compatible with their long-term preservation.

- The preservation of species diversity requires maintenance of the peculiar selective processes that led to the present state. Species, habitats and communities are components of ecosystems; the ecological processes within such ecosystems have led to the diversity in the biota. A major aim of conservation, to conserve species diversity, is achieved by sustaining the ecological and physical processes which act within ecosystems. The physical conservation of ecosystems and their components will result if such processes can continue to act.

- Biological and physical processes in New Zealand are dynamic. The biological situation is altering slowly in human time spans but rapidly in the sense of geological time. Physical processes are very slow in human time frames but some can be altered dramatically by human interference. Conservation must recognise the dynamic nature of physical environments and ecosystems and manage both to sustain diversity while change is taking place.

- Conservation is a social concept which arises and is modified at different stages in the development of a society's culture. The level of support for the concept will vary with the degree of public understanding and appreciation, and the economic situation of the time. However, to implement the principles described above requires management with a time base of decades or centuries.

- A main principle should be to inform our society that immediate circumstances should interfere as little as possible with management designed to achieve the long-term goals of conservation. It is an important corollary to ascertain public aspirations with regard to conservation as their appreciation of the concept will alter with time and circumstances.

- Conservation should not be done *for* the people of New Zealand but *by* the people, *with* their active involvement. The principle here should be to encourage and support the participation of local, regional and national groups and individuals in the direct conservation of their resources.

- Participation in conservation and effective advocacy for conservation cannot be separated from public enjoyment and utilisation of the conservation estate. It should be a principle to encourage and facilitate use of conservation lands by all the peoples of New Zealand wherever and whenever that use is compatible with the principles outlined above.

RECOMMENDATIONS FOR RESEARCH - An overview

Matt McGlone made a strong case for historical studies of vegetation change by pollen and macrofossil investigations while noting, I suspect with tongue in cheek, that "No self-respecting ecologist would admit that historical studies have added much to their understanding of the present...." He also promoted the very interesting idea of the value of routinely using pollen studies at archaeological sites to interrelate the state of vegetation at the time the sites were used to the pattern of site development. I agree with his conclusion that historical vegetation studies *per se* cannot, at the present level of funding, be considered to be directly important to the Department of Conservation. Nevertheless, DoC must always be concerned that this type of research, whether it be considered basic or strategic, is being carried out in order to support operational research of considerable importance to DoC managers. The principle above, relating to understanding our historic past, should include the pre-human past of these islands. In order for DoC to fully advocate and educate the people of New Zealand on the importance of our present flora and fauna, and how it came to be what it is today, it is necessary to understand both its pre-human and human history.

Atholl Anderson's research recommendations involved more detailed and extensive site surveys of moa-hunter sites, studies of regional and site characteristic differences in decay rates of moa bones, and the integration of human paleoecology to physical and biotic changes in the overall landscape. There is no doubt in my mind about the relevance of these proposals to a better understanding of Archaic Maori relationships to the environment of early New Zealand. However, I feel that DoC cannot support such research directly but must advocate the importance of such basic and strategic studies to the Foundation for Research, Science and Technology, as such research is clearly in the public good.

Geoff Park made no direct recommendations for research but implicit throughout his talk was the need for historical and social research: to know "what the place has meant to people, how that meaning has made the place what it is, how those values have changed, [and] how some have been suppressed by the selective readings of history...." I agree with his suggestion that conservation research should continue to bear in mind that most of the ideas of conservation and much of its present "jargon" are less than two decades old. He notes a convergence arising between Maori and European values of the sense of place and the ideas of life forces. To me, these are similar to the scientific principles of diversity and ecological processes. I feel that the spiritual concepts of "place" and "life force" relate closely to the scientific concepts of "habitat", as a part of ecosystem, and "ecological process". It is difficult to envisage research to investigate such parallels, but I feel it important for scientists to develop and remain aware of such cultural bias while proposing and conducting research investigations.

Carolyn King's research recommendations were largely nested in her interesting suggestions on altering management policy and adopting a triage approach to three classes of land. Some of her comments cover research and management activities which are already underway: Research by management at Mapara, where herbivore and predator control of a patch of bush as an "island" has already shown an increase in conservation values; research on predator control and hole-nesting bird response in the Eglinton Valley has shown the possibilities (and difficulties!) of stoat control during the peak of that species eruption. Ian Atkinson's classification of islands for their conservation management (Atkinson 1990) could counter some of her concern about an *ad hoc* approach. A new approach, that of controlling possums on a peninsula and erecting an electric fence barrier to prevent reinvasion is currently being attempted for the Mohau area on Coromandel. She discussed the management of introduced species in class B lands (wildlife value medium to low, will probably continue to remain so without active management) at some length. The reason for control of herbivores or predators must not be simply to get their numbers down but to reduce the effects they are having on conservation values. I have suggested that for herbivores the pattern of control must be determined by the maximum level of acceptable change in the vegetation which is being altered by the species involved (Sadleir 1988). Thus, the success of herbivore control must be judged by vegetation response, not by indexes of herbivore numbers.

Finally, she noted that the evolution of introduced species in New Zealand gives an excellent opportunity to study the relationships of such species in "foreign" environments and their rate of change. I agree that this is a largely ignored field. The attitude has been "Get rid of them. Don't study them for their own sake!" The question could be slightly altered to studying introduced species, so as to properly understand not only their own changes, but the effects of such changes upon their relationships with indigenous species. Unfortunately, such studies are of rather low priority to the present state of conservation. It may be that they are best proposed for funding to the Foundation for Research, Science and Technology. There has been, to my knowledge, no research upon the effect of natural bird introductions (there have been at least five species over the past century) upon the indigenous birds of New Zealand.

You will now be aware that in each case I have noted that the directions of research proposed is important to understand current conservation but that I have not ranked them highly in current priorities. This is not meant to be a negative statement. DoC's research must be heavily biased towards answering immediate management problems. This bias must never exclude support for strategic research which of necessity underpins urgent operational research. A recent survey of senior conservancy staff in DoC (Chris Collins, pers.comm.) indicated support for about 20% of S&R's effort going into strategic research. As the FoRST funding system develops, the universities become participants, and the new Crown Research Institutes get underway, it will become appropriate for S&R to look into joint research proposals with FoRST to study some of the topics suggested above. I see a clear relationship between such bio-historical research and DoC's advocacy and interpretation roles.

The principles that I proposed clearly indicate my overall belief that we must consider ourselves to be an inherent part of the ecosystems around us; unless we destroy the systems' component processes, we can best manage them for our benefit by seeing the ecological changes which drive them as an ongoing process. We can redirect the bed of a stream, we can dam it, we can remove water from it, but inevitably it is the ongoing processes of hydrological change which will eventually control the stream's direction and flow. Thus, it is with ecological processes; we can influence them temporarily, we are dependent on them continually, but in the long term, they will continue to dynamically alter the biota of New Zealand unless we destroy so many parts of the systems involved that the processes are themselves inhibited.

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