

RESUMES OF CONFERENCE PAPERS

Resumes of papers read at the Ecological Society Conference, 1980, are presented (except for papers presented in full elsewhere in this volume). For the complete programme of papers given at the Conference please refer to the Annual Report at the back of the Journal.

STUDIES ON THE POPULATION DYNAMICS OF *TYPHA* AT LAKE PUKEPUKE

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INTRODUCTION

Harper (1977) has recently stressed the significance of the modular construction of plants. Plants respond to density not so much by changing the proportions of their parts, as by changing the number of basic modules of which they are composed. In the case of deciduous rhizomatous perennials, such as *Typha orientalis*, the basic module can be defined as a single above-ground shoot and its associated rhizome and adventitious roots. Although we may traditionally regard the expansion of clones of such species as being due to "vegetative reproduction" the process does not differ fundamentally from the growth of a new shoot on a tree; both are better regarded as the production of new modules - vegetative growth.

The shoot growth of stands of *Typha orientalis* was studied at Lake Pukepuke from 1968 to 1973. The lake is situated on coastal sand-dune country at approximate latitude 40°21' S, longitude 175° 16' E, in the Manawatu District of the North Island. It is currently managed as a Waterfowl Reserve by the Wildlife Service (Department of Internal Affairs) and monitored as a Representative Catchment by the hydrology section of the Ministry of Works and Development.

The studies summarised here comprised part of a research programme covering the history of the lake ecosystem and the changes in energy flow patterns occurring in *Typha* stands during hydrosereal development. These studies are being prepared for publication. This resume deals only with the population dynamics of the above-ground vegetative shoots of *Typha*.

METHODS

Eleven stands varying in area from 4 m² to 1 m²

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were selected for detailed monitoring. Using aerial photographs, field data on water depths and other observations, the stands were ranked chronologically from pioneer (< 5 years old) to mature (originating 1929-1942). In the case of five stands all the shoots were cut and above ground biomass removed prior to commencement. As the cut shoots began to resprout, and new shoots appeared, all were labelled with numbered aluminium tags attached with wire around the shoot bases. The remaining stands were uncut, but similarly labelled. The height growth and longevity of all individual shoots in each stand - a total of 1028 shoots - was recorded during frequent visits between November 1969 and April 1972. Different stands were monitored for different lengths of time, the shortest being for 13 months (18 visits) and the longest for 29 months (26 visits).

RESULTS

Overall average shoot density (based on 56 1 m² quadrats) was 14.3 ± 2.2 shoots m² (mean ± standard error). The maximum density was 58 (in a disturbed stand) and the minimum 7 shoots m². In cut stands shoot density tended to increase following cutting, while in "undisturbed" stands density declined.

The spring cohort of shoots commenced growth in June or July (when the shoots were still below the water surface). Most of these shoots survived for about ten months, senescing in the following March, April or May. A second (summer) cohort of shoots could also be recognised. Individuals of this cohort commenced growth during the first three months of the year and suffered heavier mortality than the first, but some survived the Winter to become the 'early starters' of the succeeding spring cohort.

Survivorship curves showing the proportion of the population living to any particular age were in general strongly convex (Deevey Type I; Deevey, 19<17), but approximately linear curves, albeit with steps, were recorded in the higher density cut stands. The effect of cutting on subsequent shoot survivorship was to spread the mortality risk more evenly through the growing season, and to allow some individuals to survive longer than occurred in undisturbed stands. In the latter, early mortality was generally increased at above average densities,

but at least sixty percent of the spring cohort survived for 9 or 10 months.

These studies indicate that:

1. shoot survivorship is reduced by increased density
2. there is considerable variation in shoot density and survivorship at anyone site from one year to the next, and
3. that variation between stands exists in the amount of early mortality and exceptional longevity.

However, both increased early mortality and potentiality greater longevity are associated with an earlier starting date. Thus, shoot density and the date upon which growth commences determine the subsequent survivorship characteristics of the annual cohort.

Average maximum shoot heights ranged from 2.2 to 3.1 m in the eleven stands, with an overall mean \pm standard error of 259 ± 8 cm. The seasonal pattern of shoot production and height growth before cutting and in two subsequent seasons were compared for a pioneer and a mature stand. Following cutting (in November 1969) there was extensive resprouting of the cut shoots, so that the original density was rapidly re-established or surpassed. In both stands however, height growth terminated in January or February (as in uncut stands) when the shoots were generally about 1 m shorter than their uncut counterparts. In subsequent years the normal pattern of shoot production and height growth occurred in both stands, with the pioneer stand growing in height much faster than the mature stand (although both achieved similar final heights). Shoot height is known to be closely correlated with annual productivity (Ogden, unpubl.), thus the reduced height growth following cutting in the 1969-1970 season should have been associated with considerably reduced productivity. However, in the following year neither height growth rate nor shoot number were reduced; indeed, the latter showed a slight increase. I concluded that the reduced productivity must have caused a reduction of rhizome growth, an effect which might also explain the increased density of shoots following cutting. (Excavation of these stands at the conclusion of the study and measurement of the rhizome connections showed that the average length of the rhizomes connecting shoots of the 1969-70 season with those of the 1970-71 season was 12 ± 4 cm (95 % confidence limits) compared to 28 ± 6 cm for those connecting subsequent seasons).

Considerable variation existed between stands, and between years, in the date at which shoot growth commenced. Estimated commencement dates varied

from early May to late August, and were generally about 3 weeks earlier in 1971 than in 1970. Final average maximum shoot height was correlated with the date at which the earliest individuals in the stand commenced growth ($r' = -0.67$; " P " < 0.05). This relationship accounts for 45 % of the height variance: in general a delay of one month in starting growth reduces final height by about 14 cm and net production by about 0.1 kg.

CONCLUSIONS

Pioneer stands begin growth earlier in the year than those away from the water's edge. This allows them to achieve height sooner, and to have a higher productivity, more of which is accumulated in the rhizomes. Where rhizomes cannot spread into uncolonised spaces density increases. At densities above c. 14 shoots m^2 early shoot mortality also increases. Exceptionally high shoot densities arise only following disturbance (cutting, burning, trampling) and are in part a consequence of reduced net production limiting rhizome spread. In such stands the mortality risk throughout life increases so that the survivorship curve becomes flattened.

Individual shoots which are produced late in the season (the summer cohort) mostly die during April or May and thus contribute to juvenile mortality. However, a small proportion survive the winter to become the advance guard of the following spring cohort. The high risk involved in producing such potentially long-lived individuals late in the season is presumably offset against the disproportionately great contribution to net productivity which the survivors will make in the following year.

ACKNOWLEDGMENTS

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MODELLING THE EFFECT OF PORINA PHENOLOGY ON PASTURE DAMAGE

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Models in pest management are at their most effective when used to address specific, key questions which have arisen during an earlier stage in a systems approach. Applying this methodology to the problem of porina moth (*Wiseana* spp.) larvae in pasture, one of the key questions concerns the effect of pest phenology, as well as pest density, on pasture losses throughout the year. In particular, three markedly different patterns of moth flight have been observed (Carpenter and Wyeth, 1980). Do these significantly affect the temporal pattern of pasture damage? If phenology is important then it will be necessary to include a quite detailed treatment of the porina population in modelling the economic impact of the pest. If not, a simple time-dependent consumption function will suffice and the final model will thereby be rendered more tractable.

A model of the porina/pasture interaction, with a detailed consideration of the porina population, showed that different flight patterns had little effect on damage in the areas of hard North Island hill country under consideration. Rather, damage was dependent more on the seasonal dynamics of pasture growth than on pest phenology.

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NATURAL REGULATION OF A NON-HUNTED CHAMOIS POPULATION

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Chamois (*Rupicapra rupicapra*) were hunted in the Avoca River region from the mid 1930s to the late 1960s as part of an overall control programme to reduce their numbers. In 1967 hunting ceased and the animals were protected in order to allow studies of their behaviour when undisturbed.

Numbers subsequently increased, relative to population levels during the latter years of control, so that by 1973 chamois were present in moderate movements and range use of free-ranging chamois densities within the region ranging from 600-2050 m a.s.l., movements and range use of free-ranging chamois were commenced, with the aim of obtaining information relevant to the management of this species.

The main study area was the Basin Creek catchment, a 24 km² tributary of the Avoca River, situated 20 km south-west of Arthurs Pass. It is a mountainous region ranging from 600-2050 m a.s.l., with the average height of the ridges being 1950 m. The vegetation consists of grassland and herbfields interspersed between barren rock and scree in alpine areas, and mountain beech forest (*Nothofagus solandri* var. *cliffortioides*) from the valley floor to mid-slope.

Direct observations of chamois, many of which had been individually marked with self-attaching collars (Clarke and Henderson, 1978) were made on three to five days per month from 1973-1978. Census methods involved dawn to dusk total counts with a single sighting registered for every animal seen each day.

The population fluctuated in numbers within narrow limits; 40 to 72 chamois were seen each month, predominantly females and young. A primary peak in January coincided with the season of births, and a secondary peak in May and June coincided with the breeding season and an influx of males into the area. Recruitment of yearlings into the Basin population was low, and substantial losses of kids in one particular year were reflected in low yearling numbers in the next year. Losses of both kids and yearlings however, were offset by recruitment of additional breeding females from outside the Basin. Thus, although the population structure changed, its overall size remained much the same.

Patterns of behaviour within the Basin differed with sex; females were sedentary, while the males were migratory or transitory. Tagged juveniles surviving a minimum of 1-2 years illustrated this pattern well; most of the females remained within the Basin whereas almost all the males dispersed.

Resident females were dominant in the social hierarchy. Females of larger body size were at the top of the hierarchy, and appeared to benefit by having the largest share of range. The social behaviour of all chamois, however, required that they remain separate from others of incompatible rank, in order to prevent social disharmony. At the same time resident animals did not exclude others from their range, thus non-residents could enter and leave almost at will.

Home ranges were described by plotting the sightings of marked individuals. More than 30 localised home ranges were identified for females but only three for males. The availability of winter and summer habitat in Basin Creek allowed females to live in the same areas the year round. The home ranges for females were contained within three laterally adjacent areas, with little overlap. The animals in them were therefore recognised as separate sub-populations. Movement by transient chamois to and from these areas was primarily by way of ridges leading out of the study area.

The turnover rate of marked animals moving in and out of the Basin was high (c. 25% of the marked population per month). That figure, however, is clearly conservative, since most transient animals were never marked.

A high reproductive rate was evident from the early maturity of females - most breed first as yearlings - and in the 77% to 100% breeding success as judged from kids seen at foot in February. The lower figure is known to underscore fecundity as some newborn kids died prior to February.

Of all chamois found dead, 70 % were kids and yearlings. First-year losses were assessed from the proportion of live kids to breeding females sighted, which differed a lot between years; in 1976 only 25 % of the kids survived to 1 year of age. Bacterial pneumonia was suspected as the principal cause of death, its effect being most potent during cool wet weather in late summer and early autumn. This disease was probably also responsible for much of the yearling mortality. Though most adults were heavily infested with lungworm (*Muellerius* sp.) this did not appear to contribute significantly to adult mortality. Indeed, high survival was noted for animals surviving the first 2 years.

The exclusion of hunting from Basin Creek allowed chamois numbers to approach the limits of the food resource. Over 50 % of the alpine area was devoid of vegetation, and the geological instability, combined with over-grazing by herbivores severely limited the food resource available to chamois. The mechanism that regulated numbers appears to be population density operating through limited availability of food and living space within the separate sub-populations. During periods of heavy winter snow pack chamois suffered an acute shortage of food, which resulted in a visible decline in body condition. Disease and parasites probably aggravated the poor state of health of the adults.

The survival and recovery of most adults in the summer suggested that they had some immunity to repeated infection, but no such protection existed for the young.

In summary, chamois numbers were dynamically balanced by mortality and dispersal and these losses offset a high reproductive rate and recruitment of breeding females to the Basin. The population fluctuated in numbers according to the seasonal availability of food and the different spatial requirements of individuals within the separate sub-populations. This population has a well-documented history of resilience to intensive control measures (Batcheler and Logan, 1963; Douglas, 1971) and has subsequently become naturally controlled at densities around 1 chamois / 25 ha.

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DENDROCLIMATOLOGICAL STUDIES IN THE SOUTH ISLAND, SOME PRELIMINARY RESULTS

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Dendroclimatology is the study of climatically dependent annual variation in tree-ring widths, and was used in this study to investigate tree growth-climate relationships, with particular emphasis on the alpine timberline, and to reconstruct palaeoclimates.

Nothofagus solandri forest sites at the alpine timberline and on a montane bluff, in the Waimakariri River catchment, Canterbury, were sampled. Successful crossdating (the matching of similar ring width patterns between different trees) produced two site chronologies. The one from timberline spanned a 245 year period and the one from the bluff spanned 110 years.

At the bluff site, tree growth was significantly correlated with precipitation (positive) and temperature (negative) during the growing season. Low precipitation and high temperature cause low soil moisture levels which limit various plant physio

logical processes. Reduced tree growth is expressed in the formation of a narrow growth ring.

At the timberline a significant positive correlation between growing season temperature and ring width was related to dry matter production. Cool summer temperatures can result in less CO₂ fixation and less dry matter production and hence reduced growth with a narrow ring being formed. A significant negative correlation was also obtained between ring width and mean temperature of the preceding growing season. Two possible mechanisms could explain this correlation. Warm temperatures can result in increased food utilisation with little food being stored in winter, thus reducing the next year's growth. Secondly, warm temperatures can delay the Hardening of buds which then become subject to desiccation and frost damage over the winter. Less new photosynthetic tissue is then available for subsequent growth (c.f. Tranquillini, 1979).

Other factors also influence timberline tree growth, including the periodic flowering of *Nothofagus solandr*; and variations in the quality and quantity of sunlight. The complex nature of these interactions indicates the complex array of factors operating at timberline to limit tree growth. Detailed physiological studies of our timberline trees are needed to understand these patterns better.

Some palaeoclimatic patterns can be deduced from the longer timberline chronology. The temperature increase recorded at New Zealand stations for the last 80 years as described by Salinger (1979) is not apparent in the tree-ring data. A lot of significance has been placed on this apparent increase in biological and other studies (see Burrows and Greenland, 1979, for examples). Although it has recently been suggested (Hessell, 1980) that this increase in temperature is due to microclimate changes at the recording sites, the last 80 years appears to have been a period of rapid glacial recession and rising snowlines. If the supposed temperature increase is an artifact of the recording sites, it is legitimate to ask what has caused these events.

The timberline chronology indicates that the last 80 years has been a period of reduced climatic variability when compared with the preceding 150 years. This period of supposedly more equable climate may be causally related to glacial retreat and other similar phenomena. However, a return to a more variable climate could quickly occur.

Tree-ring chronologies such as those presented have important implications for interpreting the behaviour of biological systems and other natural phenomena, for the planning of public works (such as dams and roading), and for agriculture and

forestry. Planning for such enterprises utilises data on climatic norms for the last 80 years or less, but the timberline chronology presented indicates that this period has been atypical when seen against a longer perspective.

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EFFECT OF TAG LOSS ON ESTIMATION OF ANIMAL ABUNDANCE

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Tag loss is an ever present possibility and can, over a long period of time, reach substantial proportions. One method of assessing tag loss is the use of two distinguishable tags. For the simple Petersen model, exact formulae exist for correction for tag loss providing the tags are assumed to be independent (Seber and Felton, 1980). These corrected estimates have been shown to be moderately robust to tag dependence. By looking at the variance formulae it is seen that little is gained by using non-distinguishable tags.

In the more complicated Schnabel type census (see Seber, 1973) exact formulae for realistic sets of assumptions seem impossible since in practice there will be confusion over when in the past that a tag was lost and possibly whether a captured animal was previously tagged or not. However, Arnason and Mills (in press) have found useful approximate formulae for the situation of homogeneous tag retention by replacing random variables and their variances with their expectations assuming tag loss. Simulation has shown this approach to be adequate provided sufficient animals are recaptured. They found that the fully Jolly-Seber model is generally robust to tag loss as animals with lost tags act as

new recruits. For substantial tag losses the corrected full model estimates should be used. Under the Jolly-Seber death only model the population estimates can be badly biased (always upwards) whereas the estimates of survival rates are far less biased (always downwards).

Nelson, Anderson and Burnham (1980) used simulation to examine the effects of tag loss in the multi-sample single recapture model. They found that (i) there is only a slight negative bias in annual survival rates except, with severe tag loss, for long lived species, (ii) bias is virtually independent of numbers released annually, recovery rates and numbers of years banding and recovery, (iii) the estimated recovery rates are affected primarily by initial tag losses and (iv) these results applied generally to the more complicated multi-sample single recapture models.

Every effort should be made to minimise tag loss by using more permanent marks, as correction for tag loss can be done only approximately and the presence of tag loss results in a loss of precision.

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TOWARDS A NATIONAL CLASSIFICATION OF NEW ZEALAND VEGETATION AND LANDFORMS

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If ecological data are to assist in land use planning in New Zealand, there are advantages in devising a simple national classification with clearly defined categories for conveying information, and differentiating between vegetation types.

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To date there have been several approaches to the classification of New Zealand vegetation and various well-established conventions and terminologies are in use. However, our first studies of the literature on New Zealand's vegetation indicate a continuing propensity towards looseness, imprecision and inconsistency in nomenclature.

The aim of the current project is to attempt to reconcile the systems already in use, to produce a flexible hierarchical classification, and all acceptable set of terms for vegetation and landforms that:

- (i) are clearly defined so that we will all know what we mean when we use them.
- (ii) fit into a logical system that accommodates all possibilities at the levels of dominant and diagnostic species composition, vegetation structure, and landform elements.

It is hoped that the terms will be used as "accepted standards" in the legends of vegetation maps, and in the definition of vegetation and landforms in formal publications and reports.

Landform classes have been introduced as a major element in order to classify on an ecological basis.

The current project is being undertaken by the Working Group on Classification, one of four set up at the Biological Resources Workshop, convened by the Commission for the Environment in September 1979.

Two "Approximations to a National Vegetation/Landform Classification" have been circulated throughout New Zealand. An annotated bibliography has been made of all the known references to New Zealand vegetation up to 1980. It is proposed to publish this and a manual for a national vegetation/landform classification and terminology.

VEGETATION/LANDFORM CLASSIFICATION

The basic components of the classification proposed are:

1. *Altitudinal zonation*: These generally follow the zones first suggested by Cockayne (1928) and later by P. Wardle (1964). The terms, *Lowland coastal*, *Lowland inland*, *Montane*, *Subalpine*, *Low-alpine*, *High-alpine* and *Nival* zones are now generally accepted, although still subject to amendment. In defining terms, a sliding scale to account for zonation changes with increasing latitude (e.g. Zotov, 1939) is suggested.

2. *Vegetation composition and structure*: The structural system of Atkinson (1962) and modifications to it (Atkinson, pers. comm.) is simple and generally acceptable but further discussion of it is continuing. Usually only one growth form is used

for the structural name, e.g., shrubland. The naming of the major plant components of the vegetation likewise follow Atkinson's (1962) system. We recommend the use of these structural and compositional names, or acceptable modifications of them.

3. *Landforms*: The association of landform with vegetation is useful for a country as topographically diverse as New Zealand and with few broad classes of vegetation structure (e.g., forest). A simple system of landform elements and their modifiers (e.g., parent materials, drainage and slope) that can be readily understood and applied has been compiled.

CHECKLIST OF KNOWN VEGETATION TYPES

Some 250 references containing 2,300 vegetation types and their habitats have been searched and card indexed. Many of these types are similar and can be readily grouped. Different systems and inconsistency of naming vegetation were widely encountered.

The information on the card index is being stored using the DSIR computer network.

To help catalogue the information and expand its usefulness a sound biogeographic base is desirable. Cockayne's (1928) Botanical Districts have been traditionally used but these need to be refined to account for ecological diversity. The system and criteria of Ecological Districts as used by Nicholls (1977) in North Westland could provide this refinement.

Details of the proposed scheme are available from the authors at Botany Division, DSIR, Christchurch. Any comments would be welcome. We hope soon to finalise the system for general use.

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THE MARLBOROUGH TREE BROOMS: AN ECOLOGICAL ASSESSMENT

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New Zealand legumes (8 genera, approximately 50 species) constitute a small but ecologically and socially significant group of plants. All species but one are endemic, with an overall affinity with tropical Pacific floras, especially that of Australia. As evident throughout the family Papilionaceae, New Zealand legumes have an affinity for seasonally arid, pioneer sites, for which role the ability to fix atmospheric nitrogen and evolve mechanisms to withstand dry environments, are fundamental.

New Zealand brooms are small to large, generally leafless shrubs or small trees which reach their greatest diversity in the grasslands, shrublands and riparian sites of the eastern South Island. The so-called "tree brooms" constitute four species belonging to two endemic genera, the monotypic *Chordospartium* or weeping tree broom, and *Notospartium*. The tree brooms are found between the Wairau River in the north, and the Rangitata River in the south; they occupy an altitude range from nearly sea-level to over 1000 m, and a rainfall range from 600 mm to 1600 mm.

Chordospartium stevensonii occurs in several scattered populations: the Avon (a tributary of the Waihopai River) coastal bluffs at Clifford Bay, the Jordon (a tributary of the Awatere River), and tributaries of the lower Clarence River (the George, Swale and Jam). The species is classified as endangered (Given, 1979; Given, pers. comm. 1981, IUCN Red Data List), with only a few hundred individuals remaining. There is evidence that some of these populations may represent distinct varieties.

Notospartium torulosum occupies a few riparian gorge sites along the Canterbury foothills, and is also classified as endangered. *Notospartium carmichaeliae* is more widespread but is threatened by agricultural practices and survives as less than 2000 individuals in riparian populations along the Awatere and Waihopai Rivers (particularly the Grey and Spray Rivers which are juxtaposed across the Main Divide). *Notospartium glabrescens* is much more common, with several thousand individuals in numerous populations along tributaries draining the Inland and Seaward Kaikoura Ranges as far south as the Kowhai River.

The Marlborough Tree Brooms are part of a distinctive bluff flora which includes such important New Zealand plants as *Hebe hulkeana*, *Pachystegia* and *Senecio monroi*. Together, these and other

species define the North-eastern Botanical district (Martin, 1932). A graceful form, the large size, and spectacular flowering provide the Marlborough Tree tirooms with high landscaping value, which is enhanced by their rarity.

Their uncommon occurrence relates both to natural and human factors. Although naturally associated with hardwood forest species (e.g. lancewood, broadleaf and kanuka), they are limited to discontinuous open sites, most notably bluffs. Erosion of these sites is continual and flooding may have restricted *Chordospartium*. Natural, Maori and European fires have probably been significant, particularly the last. Cattle and sheep browsing restrict the establishment of seedlings to protected sites. Most recently, aerial spraying for noxious weeds has significantly reduced populations along the Waihopai and Awatere Rivers. With the exception of *N. glabrescens*, all species appear to be declining in numbers.

Individual populations, however, indicate a strong ability to regenerate on sites protected from fire and grazing. For instance, the Jordon River *Chordospartium* population contains adults surrounded by juveniles. It is evident therefore that these species will survive if adequately protected. The necessary steps for this include:

- (1) Immediate preservation of known key populations, involving fencing, weed control and protection from fire.
- (2) Survey to determine the distribution of each species and the status of disjunct populations, followed by reservation where appropriate. Queen Elizabeth II National Trust covenants would suitably reserve some populations on private land, but full Reserve status is essential for key sites.
- (3) Propagation of seedlings from endangered populations, and subsequent enrichment and protection of these and perhaps adjacent sites. Representatives of different populations should be widely cultivated in Botanic and private gardens.
- (4) Taxonomic investigations to determine intra-specific variation, and to resolve the question as to whether *N. carmichaeliae* and *N. glabrescens* are distinct species or not. The writer believes they are.
- (5) Investigation of ecological characteristics, including insect fauna, phenology, pollination, and ecological anatomy. A research project for a Doctoral dissertation would be appropriate.
- (6) An education programme to maximise awareness as to the value of these species (and others which

occupy similar sites in Marlborough and Canterbury) and to minimise the danger of accidental destruction through fire, spraying, tracking and grazing. Education of those not committed to nature conservation, but yet who control local natural resources management, is most important.

As a result of publicity generated by recent spraying incidents, a survey to determine potential reserves is currently being undertaken by Botany Division, DSIR, and preliminary steps have been taken by the Department of Lands and Survey, Blenheim, to reserve populations of *N. carmichaeliae* in the Spray River (Simpson, 1979). A Botany Division report on the unique Clifford Bay *Chordospartium* population has been prepared for the Department of Lands and Survey, Blenheim, and Reserve status recommended. The plight of the brooms presents a striking example of the need for conservation and productive land use to be more integrated so that important genetic resources are not lost forever.

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ANIMAL BIOMASS IN NATIVE FOREST OF THE ORONGORONGO VALLEY, WELLINGTON

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As part of a continuing ecosystem study, a succession of workers has measured the abundance of several animal groups in podocarp-broadleaf

forest of the Orongorongo Valley. Annual litterfall was also measured and estimates made of above-ground plant biomass.

Our forest produces more litter than most European deciduous forests and the fall of litter is more evenly distributed throughout the year. Most tropical rainforests produce more litter than the Orongorongo forest. European oak forests and the local podocarp-broadleaf forests contain about equal above-ground biomass.

Results of studies on animal abundance were converted to kg body weight per hectare (Table 1).

TABLE 1. *Animal biomass in podocarp-broadleaf forest, Orongorongo Valley.*

| Taxonomic group | Date | Mean biomass (kg/ha) |
|----------------------------|----------------------|-------------------------|
| Earthworms | 1980 | 332.0 |
| Arthropods ¹ | 1975 - | 145.7 |
| Reptiles and amphibians | - | infinitesimal |
| Birds | 1969-70 | 0.583 |
| Brush-tail possums | 1980 | 18.6 |
| Goats | 1966-76 ² | 14.8 |
| Ship rats | 1966-68 | 0.225 |
| Mice | 1977-78 | 0.026 |
| Cats | 1970--73 | 0.026 |
| Stoats | 1970 -75 | 0.005 |
| Total mammals ³ | | 33.7 |

Notes:

¹ Includes Collembola, beetles, mites, spiders, centipedes, millipedes, isopods and amphipods only. Only ground dwelling species have been sampled.

² Most goats shot out in 1976.

³ Excludes deer and pigs, which occur only in low numbers.

Earthworms constitute by far the largest biomass in the community and would once have been exploited as a food source by kiwis, wekas and robins. With the loss of these species from the Orongorongo forest, this food source remains almost unexploited by vertebrates, with the exception of introduced blackbirds and song thrushes. The ground-dwelling arthropod fauna is substantial and diverse and carries a greater biomass in the lowland podocarp-broadleaf forest of the Orongorongo Valley than in several tropical rain forests of the world.

The biomass of birds in the Valley is similar to that found in podocarp-broadleaf forests of the South and Stewart Islands and in several Japanese and United States forests, but it does not approach the average 1.5 kg/ha found in many European

forests, nor the biomass of forest birds on Kapiti Island which is calculated to be 4-10 times greater. Mammalian predators probably hold the Orongorongo Valley birds to such low numbers.

The biomass of mammals is high by world standards; indeed, it is difficult to find any other forest supporting such a biomass of leaf-eating mammals. The biomass of brush-tailed possums, both in the Orongorongo Valley and in other similar forests, is cause for alarm. The forest cannot support this biomass of possums without its floristic composition and structure being transformed.

FERAL PIGS - UNGULATE PREDATORS

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There is circumstantial evidence that the feral pig (*Sus scrota*) is responsible for the decline in numbers of mammals and birds in some parts of the United States and Australia, but there are no published reports of pigs feeding upon another ungulate.

In the Tennessee Great Smoky Mountains National Park. Forestry Department staff have presumed (pers. comm.) that feral pigs were preying on white-tailed deer (*Odocoileus virginianus*) fawns. In the higher altitudes of some Hawaiian National Parks, feral pigs may be responsible for reducing recruitment in Hawaiian goose (*Branta sandvicensis*) populations (Director of Hawaiian National Park Research Unit, pers. comm.). In Australia, circumstantial evidence of predation on lambs of merino sheep (*Ovis aries*) has been available for many years. Pullar (1950) considered lamb predation the most serious source of economic loss caused by feral pigs. Amongst the farming community this subject still causes controversy, as there have been few witnessed instances of feral pigs actually killing healthy lambs.

A study by Pavlov and Hone (unpubl.) is the first attempt to quantify the impact of pig predation on lambs. Observations were carried out in the spring and autumn of 1978 and 1979. On moonlit nights, 7 x 50 binoculars were adequate for observations. At other times, a first generation Night Viewing Device (N.V.D.) (Javelin Model 220, Apollo Lasers, Los Angeles, California) was used with a 7.5 cm diameter viewing attachment. The N.V.D. was attached to a tripod during prolonged use. The flock was approached downwind and the observer stationed within 100 m of the flock, depending on

prevailing conditions. Observations were continuous for up to eight hours.

Most contacts between feral pigs and lambing flocks occurred between 1700 and 2400 hours E.S.T. There were many unsuccessful attacks on individual lambs, occasionally involving chases of 80 m. Some pigs harrassed the flock for up to 2 hours and left without killing any lambs. Ten kills were witnessed. All were by lone animals and all involved chases of less than 20 m. When the pigs were within 10 m of the flock they rushed at the nearest ewes and lambs. If a lamb was overtaken, it was knocked off balance and killed with a bite to the thorax.

The feeding sequence of the feral pig follows a typical pattern (see Figs. 1 and 2). The entrails are removed; the backbone and ribs are eaten; the muscle on the upper legs is eaten after the legs are pulled "inside out"; the skull is crushed and the brain removed; the skin and leg bones are eaten last. No feral pig was seen to leave a carcass before the entrails were eaten but they may leave at any other stage. It appears that when predatory behaviour has been aroused by one kill, the sight of the lambing flock nearby may initiate another kill perhaps before the first kill is fully eaten.

Fifteen fresh Iamb carcasses were positively identified as being killed by feral pigs. Three were within a 100 m² area and presumably were killed by the same feral pig. On two occasions, a second kill by the same pig was witnessed within fifteen minutes of the first. Identification of a pig-killed lamb was based on a number of features. These included: worn membranes of the foot, indicating that the



FIGURE 1. Feral pig that was readily recognised as a regular predator of lambs in spring 1978. The pig was harrassing the flock in late afternoon,



FIGURE 2. Lamb carcass partially eaten by a feral pig in October 1979. One of three carcasses found in a 100 m² area, presumably killed by the same pig. The first lamb was entirely eaten except for the skin and leg bones. This lamb was partly eaten. The third had only its entrails removed.

lamb had been born alive and had walked after birth; blood on the outside of the skin, indicating that the lamb was alive just before being eaten; blood and bone fragments trampled into the grass, as has been found to occur in 'untidy' feral pig feeding; the presence of legs with the bone exposed to the stifle joint and the muscle of the upper leg removed, typical of feral pig feeds if the carcass is abandoned within 25 minutes.

The feral pig is an opportunist omnivore. It is basically herbivorous but carrion or invertebrates are eaten when available. In a lambing paddock there are unusually good opportunities for a feral pig to ingest afterbirth and Iamb carrion at various stages of decomposition. The behaviour of some feral pigs in lambing flocks indicates that they can act as predators, actively selecting, running down and eating part or all of their prey. It is quite possible that the young or eggs of ground nesting birds could also become regular dietary items of feral pigs.

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ASPECTS OF AVIAN ISLAND
BIOGEOGRAPHY IN NEW ZEALAND

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Native land and freshwater birds, lizards and some groups of insects on New Zealand's offshore and outlying islands conform in their area / species-number relationship to Preston's (1962) equation $N = CA^2$. A distance/species-number relationship also exists for birds but the correlation co-efficient of the regression is not significant.

As far as birds are concerned at least, islands are not at equilibrium in the sense of MacArthur and Wilson (1967) (with an appreciable immigration rate balanced by a corresponding extinction rate and with a marked turnover of species). Instead, on unmodified islands, species complements are stable and turnover rates very low.

Habitats and niches remain unfilled because of the limited number and range of propagules available from the mainland islands. Furthermore, many of the exotic species established by European man on the mainland islands have become self-established on offshore and outlying islands, including the least modified and the most remote.

The three main reasons for some birds being absent from islands (aside from that of having perhaps once been present but now extinct or of not making a landfall under favourable circumstances) are:

- (i) Some species are physically incapable of crossing the water gaps.
- (ii) Others are psychologically incapable of committing themselves to such a crossing.
- (iii) Islands are ecologically unsuitable for some species.

Among endemics, the longer a form has been present in New Zealand (or the higher its taxonomic status), the more restricted is its distribution, and this applies to birds even when allowance is made for those which are flightless. The generalisation may also apply at least to lizards, freshwater fish and some groups of insects. However, this tentative extension of it needs to be critically checked.

Changes wrought by man, particularly European man, are sufficient to account for most, if not all, of the extinctions of native species which have occurred in recent times.

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BREEDING BIOLOGY OF GREY TEAL
(*ANAS GIBBERIFRONS*) IN NEST BOXES

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In 1975 Ducks Unlimited, an organisation of individuals, began erecting nest boxes for grey teal (*Anas gibberifrons*) on wetlands throughout New Zealand, and to date have erected over 1000 boxes. Their belief was that a lack of suitable nesting sites in swampland trees was limiting their numbers.

In July 1979 the Wildlife Service began inspecting boxes at Mangatawhiri in the Waikato, where 150 boxes had been erected. It was hoped that this would provide information on breeding biology, determine the best type and orientation of nest box, and if in fact nest boxes would increase the teal population.

From July to December 1979 visits were made every 3 days when a quarter of 108 boxes were inspected so that anyone box was visited each 12 days. On the first visit in July all 108 boxes were inspected and 30 % were being used by teal, a rate of use that varied little until November when only 1 box was used and that ended the breeding season. This abrupt stop was probably due to a combination of the boxes being used by starlings (*Sturnus vulgaris*) in October-November, and mynas (*Acridotheres tristis*) in December-January, and the drying up of the Whangamarino Swamp by October.

Because this nest box situation is artificial it was thought that unnatural behaviour would occur and this is suggested by the high average clutch size. In Australia the average of 54 'wild' clutches was 7.9 compared to 10.9 for 115 laid at Mangatawhiri, and is probably due to an increase in the dumping of eggs.

In 1980 the monitoring of boxes will be modified in an attempt to accurately gauge dumping, and attempts will be made to recapture tagged chicks to obtain some information on survival.

This bird is extremely difficult to study in its natural environment - so that any information obtained, even from nest boxes, is worthwhile.