RESUMES

Resumés of papers read at the Ecological Society Conference, 1975, are presented (except those presented in full elsewhere in this volume). For the complete programme of papers given at this Conference please refer to the Annual Report appearing on p. 140.

A PRELIMINARY ACCOUNT OF THE FOOD AND NUTRITION OF THE BRUSH-TAILED OPOSSUM

ALICE FITZGERALD

Ecology Division, DSIR, Lower Hutt.

The diet of a population of opossums in 4.4 ha of lowland evergreen forest in the Orongorongo Valley, east of Wellington was investigated from 1969-1973 by identifying plant remains in faeces. An index of digestion was used to correct the observed frequencies of leaf cuticle fragments in faeces; fragments of other foods were recorded by frequency of occurrence. A survey and routine phenological record of vegetation helped to interpret monthly faecal analyses.

Approximately 60% of the leaf diet was taken from two species of tree *Metrosideros robusta* and *Weinmannia racemosa* which were eaten in all months. Trees of these species are being defoliated and killed by the animals. Two lianes, *Ripogonum scandens* and *Metrosideros fulgens* together contributed about 15% but were eaten seasonally. About another 10 tree species were eaten regularly in small amounts while many tree and epiphtye species were seldom or never browsed by opossums.

Reasons for this selection of food species were sought in feeding trials with captive animals and chemical analyses of food and faeces. While being fed trial diets opossums were weighed daily and all intake and output measured Animals fed pelleted commercial herbivore food over eight weeks maintained or gained body weight. Animals fed leaves of single species or a mixed diet or leaves of three tree species over a period of three weeks lost considerable weight. On a diet of *Melicytus ramiflorus* leaves, intake was low and six out of ten opossums died before the end of the trial presumably of poisoning.

At monthly intervals over a year, the constituents in the leaves of two preferred *Metrosideros* species were analysed, and the leaves of six tree species were tested for leucoanthocyanins, saponins and alkaloids. Results showed that species with negative or mild reactions to the tests were eaten more commonly than species with strongly positive results. Opossums ate most *Metrosideros fulgens* when the leaves contained their highest amounts of lipid.

Both field and laboratory aspects of the study are continuing.

RODENT POPULATIONS IN THE ORONGORONGO VALLEY, WELLINGTON, 1971-1976

B. M. FITZGERALD AND B. J. KARL

Ecology Division, DSIR, Lower Hutt.

Some results from a 5-year study of populations of *Rattus rattus* and *Mus musculus* in forest in the Orongorongo Valley are presented. Results were derived from standardised snap-trapping carried out at 3-monthly intervals in mixed rata-podocarp-hardwood and lowland beech forest (1971-76) and in silver beech (1973-76). The method was considered fairly reliable in assessing rodent populations and showed the major trends in population fluctuations.

The number of rats remained fairly stable over the 5 years but the numbers of mice varied dramatically, being high in 1971-72 and in 1974-75. Both rats and mice bred in spring and summer but reproduction of mice was inhibited when they were at high densities. Estimates of the age of animals, based on tooth wear indicated that the mean age of rats varied very little over the 5 years. When mice increased dramatically in 1971-72 they formed a young even-aged population. The animals still surviving as the population declined to low densities again consisted of very old animals but in the 1974-75 peak the population declined to very low densities before the mice reached old age.

The high numbers of mice in late 1971 followed heavy seeding of hard beech *(Nothofagus truncata)* and high numbers of mice in silver beech *(N. menziesii)* in 1974 followed heavy seeding there. Moderate seeding of hard beech in 1974 was followed by an increase in the numbers of mice. Although the amount of beech seed produced had most influence on the numbers of mice, variations in the intensity and success of summer breeding by mice also influenced their numbers. The rat population did not appear to be influenced by the variations in beech seeding.

Rats were an important item in the diet of feral house cats in the Orongorongo Valley, being present in about 48% of 677 cat droppings examined. When mice were plentiful they occurred in up to 80% of the cat droppings and even when they were scarce were still found in about 10% of the cat droppings. It is considered that predation may be important in limiting the numbers of rats and may be an important influence on low-density house populations.

THE SUMMER DIET OF TAKAHE WITH PARTICULAR REFERENCE TO FOOD SELECTION IN RELATION TO NUTRIENT CONTENT AND POSSIBLE COMPETITION FROM RED DEER

J. A. MILLS[1] AND A. F. MARK[2]

The summer diet of takahe *(Notornis mantelli)* an endangered gallinule now confined to the Murchison Mountains of Fiordland was investigated in the alpine grasslands over a two year period by counting numbers of takahe droppings and amounts of feeding sign in permanent plots of each of the four main tussock dominants and by recording the feeding sign along line transects through their territories. A similar assessment was made of red deer *(Cervus elaphus)* preferences.

Both takahe and deer prefer certain snow tussock species *(Chionochloa pallens* and *C. flavescens)* over others *(C. crassiuscula* and *C. teretifolia)* that are available. In November-December takahe prefer *C. flavescens* to *C. pallens* but thereafter until April *C. pallens* is preferred. The order of general consumption of leaf bases of the four tussock species by takahe (*C. pallens*>*C. flavescens*>*C. crassiuscula* >*C. teretifolia)* corresponds to the relative amounts of major nutrients and soluble sugars they contain. Another important food item, the leaf bases of *Celmisia petriei*, are particularly rich in calcium and sugars.

In addition to this selection between species, selection also occurred between plants of both *Chinochloa flavescens* and *C. pallens* in spring and early summer for the highest levels of phosphorus. Deer also show preference for snow tussocks with the highest nutrient levels. Competitive advantages of deer over takahe may explain recent elimination of takahe from areas west of the Murchison Mountains where the greatest modifications by deer to the alpine grasslands has occurred. Poor conditions of the beech forest understorey in the eastern Murchison Mountains, by affecting the overwintering of takahe has probably also contributed to their decline in this area. Rhizomes of the summer-green fern *Hypolepis millefolium* are shown to be an important winter food source for takahe in the forest.

[1]Wildlife Service, Department of Internal Affairs, Wellington.

[2]Department of Botany, University of Otago, Dunedin.

ASPECTS OF THE ECOLOGY OF POSSUMS IN PINE PLANTATIONS

M. N. CLOUT

Department of Zoology, University of Auckland, Auckland.

In July 1973, I began a study of the ecology of possums *(Trichosurus vulpecula)* in the *Pinus radiata* plantations of New Zealand Forest Products Limited, near Tokoroa in the central North Island.

Possums were live-trapped for two years in a young plantation (planted 1971) and adjacent cutover tawa/kamahi forest on the Mamaku Plateau (area A) and for 18 months in an older radiata stand (established 1960) closer to Tokoroa (area B).

Mark-recapture estimates indicated population densities of 2-3/ha. in both areas, with some evidence of a trend of increase in population A during the study period.

In both areas there was a pronounced autumn breeding season with a scatter of births throughout the winter and early spring. Most females bred once a year, with many breeding for the first time at one year old. In area B there were a few double breeders and one female gave birth to twins. Pouch young mortality was very low in both areas. Calculated growth curves showed that animals in area B grew to a larger size than those in area A.

Statistical analysis of home range overlap (Metzgar and Hill, 1971) revealed no significant departure from randomness in the degree of overlap of the trap-revealed ranges of adult female residents, but in both areas those of males overlapped less than expected on the basis of random occurrence. This was more marked in the relatively homogenous area B than in area A.

There appeared to be relatively few potential den sites in area B and radiotracking revealed that possums used fewer dens in this area than in area A, which contained many logs and dead trees and had abundant ground vegetation.

It was postulated that where there are few good dens these may become a limiting resource for some possum populations. Winter (1970) has shown that possums defend den sites and that females invariably dominate over males in agonistic encounters at dens. This suggests that where dens are limited in number females will tend to be more successful than males in competition for them, resulting in a sex ratio biased toward females.

In area B there was a significant excess of adult females. Similar sex ratio biases were recorded by Dunnet (1964) and How (1972) in low density Australian populations.

In direct contrast, the sex ratio in area A was biased towards males, although it showed a trend towards parity as the study progressed. The results of this and previous studies (Dunnet, 1964, How, 1972, Crawley, 1973, Jolly, 1976) strongly suggest that young males have a greater dispersal tendency than young females. It was therefore hypothesised that areas cleared of possums (e.g. by burning and poisoning, as in area A) would tend to be recolonised initially by young males, hence explaining the initial excess of males in area A. This idea was tested by depopulating area B by intensive cyanide poisoning in December 1974 and following recolonisation. By December 1975 the population density was half of that prior to depopulation. Most of the colonisers were young males and the sex ratio differed significantly from that in December 1974.

In July 1975 a standard airdrop of carrots treated with 1080 poison was carried out over area A, and approximately 80% of the population was destroyed. Subsequent livetrapping and a final depopulation using cyanide in September 1975 indicated that the 1080 had killed a higher proportion of males than females, although the resultant change in sex ratio was not statistically significant because of small sample sizes.

Assessment of fat reserves of individuals in monthly dead samples showed that males had lower reserves than females through the winter. Batcheler *et. al.*, (1967) and Bamford and Martin (1971) have demonstrated an inverse relationship at the population level between animal condition (i.e. fat reserves) and kill rate in aerial operations. Hence the lower winter fat reserves of males may explain the apparently higher kill of this sex in the July airdrop.

Since the destruction of females carrying young is important for effective control it was suggested that the composition of kills should be considered in addition to % reduction in density when assessing operations.

REFERENCES

BATCHELER, C. L.; DARWIN, J. H.; PRACY, L. T. (1967). Estimation of opossum (*Trichosurus vulpecula*) populations and results of poison trials from trapping data. *New Zealand Journal of Science* 10: 97-114.

BAMFORD, J. M.; MARTIN, J. T. (1971). A method for predicting success of aerial poisoning campaigns against opossums. *New Zealand Journal of Science* 14: 313-321.

CRAWLEY, M. C. (1973). A live-trapping study of Australian brush-tailed possums, *Trichosurus vulpecula* (Kerr), in the Orongorongo Valley, Wellington, New Zealand. *Australian Journal of Zoology* 21: 75-90.

DUNNET, G. M. (1964). A field study of local populations of the brush-tailed possum *Trichosurus vulpecula* in eastern Australia. *Proceedings of the Zoological Society of London* 142: 665-695.

HOW, R. A. (1972). The ecology and management of *Trichosurus* species (Marsupialia) in New South Wales. Ph.D. thesis, University of New England, Armidale, New South Wales.

JOLLY, J. T. (1976). Habitat use, movements and social behaviour of the opossum *(Trichosurus vulpecula)* in a pastoral habitat on Banks Peninsula. M.Sc. thesis, University of Canterbury, New Zealand.

METZGAR, L. H.; HILL, R. (1971). The measurement of dispersion in small mammal populations. *Journal of Mammalogy* 52: 12-20.

WINTER, J. W. (1970). Social interactions in relation to dispersion of the brush-tailed possum (*Trichosurus vulpecula*). *Australian Mammal Society* Bulletin 2: 205 (abstract).

ASPECTS OF THE ECOLOGY OF KIORE *(Rattus exulans)* ON TIRITIRI MATANGI ISLAND

H. MOLLER AND J. L. CRAIG

Department of Zoology, University of Auckland, Auckland.

Tiritiri Matangi Island lies 5 km off the Whangaparaoa Peninsula about 30 km north of Auckland. It has a total area of 220 ha and with the exception of a 20 ha Lighthouse Reserve forms part of the Hauraki Gulf Maritime Park.

Following the removal of sheep and cattle in 1972 the majority of the island has become covered by rank grass and bracken and there has been a dramatic increase in the kiore *(Rattus exulans)* populations.

Snap-trapping since December 1974 and mark-recapture population estimates from two live-trapping grids since February 1975 indicate that kiore on Tiritiri undergo marked annual fluctuations of density. In an area of forest dominated by *Leptospermum*, kohekohe, mahoe and pohutukawa, minimum number alive estimates reached a peak in autumn 1976 of 69 kiore/ha but Jolly-Seber mark-recapture estimates reached 96 kiore/ha. On a live-trapping grid in an area of grass dominated by Prairie Grass *(Bromus unioloides)* and Cocksfoot *(Dactylis glomerata)* minimum number alive estimates reached 99 kiore/ha while Jolly-Seber estimates reached 125 kiore/ha. Low densities of 11 kiore/ha (minimum number alive) were reached for both bush and grass grids in spring of 1975. Even Jolly-Seber population estimates are believed to seriously underestimate kiore density, particularly on the grass grid where differential trappability is a problem. However, even these minimum density estimates are considerably higher than so far recorded for rodents in New Zealand.

Annual fluctuations in density result from a restricted breeding season of only 3-4 months which produce a large influx of young animals of trappable age in January, February and March. This restricted breeding season forms part of a trend of increasing seasonality in reproductive rates of *Rattus exulans* with increasing latitude.

Similarly the very high mean of 7.0 embryos per pregnancy on Tiritiri is part of a statistically significant trend of increasing litter size at higher latitudes. Since most females have only 2 or 3 litters per breeding season the annual production per mature female is not extreme and there is no significant correlation of published estimates of annual production with latitude in kiore populations.

An ecological study of kiore on Little Barrier Island by Watson (1956) also suggested a marked population fluctuation related to a restricted breeding season. However, he trapped pregnant females in March and it seems from his data that females may have bred in the same season in which they were born whereas on Tiritiri young do not mature sexually until the following season. On Little Barrier mean litter size was only 4.7. There is a danger, then, in considering the results obtained in our study as being representative of the New Zealand situation rather than being related to specific ecological conditions on Tiritiri.

The study is continuing.

REFERENCES

WATSON, J. S. (1956). The present distribution of *Rattus exulans* (Peale) in New Zealand. *N.Z. Journal of Science and Technology* B37: 560-70.

NITROGEN FIXATION IN MANGROVES

B. J. HICKS, W. B. SILVESTER AND F. J. TAYLOR

Department of Botany, University of Auckland, Auckland.

Nitrogen fixation associated with two Auckland forests of the mangrove *Avicennia resinifera* (Forst.) was studied using the acetylene reduction and $^{15}N_2$ fixation techniques. Nitrogenase activity, the enzyme associated with nitrogen fixation, was found in three distinct nitrogen fixing systems.

Within the first 10 mm of the surface sediments an aerobic nitrogenase system was found. Sediments from this region reduced acetylene at a rate of 1.1 to 2.2μ mol C_2H_4 $h^{-1}g^{-1}$ (dry-weight) when incubated under air and 0.1 atmos acetylene, derived from a nitrogenase activity of 9.1 to 17.1μ mol C_2H_4 $h^{-1}m^{-2}$ for maximum summer rates. Sampling over a two year period indicated that rates averaged over an annual cycle were somewhat lower than this, estimated at 4 to 7μ mol C_2H_4 $h^{-1}m^{-2}$. Depression of nitrogenase activity was seen under anaerobic incubation, and no stimulation of activity in surface sediments was caused by light. Activity in this zone was highly correlated with finely divided organic material, apparently of leaf origin.

A second nitrogenase system was found extending from immediately below the top 10 mm to a depth of about 100 mm. Nitrogenase activity was dependent on anaerobic conditions, being depressed by incubation under air. Sediments taken from this zone and incubated anaerobically with 0.1 atmos. acetylene yielded acetylene reduction rate varying from 0.5 to 0.7μ mol C_2H_4 $h^{-1}g^{-1}$ dry-weight.

Measurement of nitrogenase activity in *in situ* anaerobic sediments was precluded however by the overlying aerobic sediments, and the rate of passage of N_2 gas to this zone in natural conditions is still uncertain. The role of the mangrove rhizosphere in nitrogenase activity in both aerobic and anaerobic sediments was apparently minimal.

Blue-green algae epiphytic on pneumatophores, the above ground breathing organs of the mangrove root system, constituted a third nitrogenase system. The blue-green algae, primarily a *Calothrix* species, reduced acetylene at a highly variable rate, though in summer this was often between 100 and 300μ mol $C_2H_4h^{-1}$ pneumatophore^{-1}. The variability appeared to be caused by showers of rain during low tide which greatly reduced nitrogenase activity temporarily. Random sampling showed that pneumatophores occurred at an average density of 219 to 271 m^{-2}, and thus total pneumatophore activity was estimated at between 22 and 81μ mol C_2H_4 $h^{-1}m^{-2}$.

A tentative estimate of the total nitrogen fixation associated with these mangrove forests can now be made, excluding the anaerobic zone because of the uncertainty of its function *in situ*, and making other assumptions. Rates for pneumatophores were multiplied by 150 days instead of 365 to compensate for the lower rates that occurred during winter. Many previous experiments by other workers have shown that a molar ratio of acetylene reduction to nitrogen fixation of 3 : 1 holds well for blue-green algae, and this ration was assumed for the epiphytic algal fixation. From the rates quoted above, blue-green algae on pneumatophores which gives a N_2 (C_2H_2) fixation of 7 to 27 kg N $ha^{-1}yr^{-1}$, nitrogen fixation was estimated directly on decaying organic matter by use of $^{15}N_2$ and on an area basis was estimated at 2-4 kg N $ha^{-1}yr^{-1}$. Thus known sites of nitrogenase in mangrove forest may contribute from 9 to 31 kg N $ha^{-1}yr^{-1}$. Although the fate of this fixed nitrogen is not yet known, mangrove-associated nitrogen fixation may well make a significant contribution to nitrogen budgets of Northern New Zealand harbours and estuaries.

ACCUMULATION OF PLASTIC PELLETS ON NEW ZEALAND BEACHES

MURRAY R. GREGORY

Department of Geology, University of Auckland, Auckland.

Small plastic pellets, of the kinds commonly being recorded as contaminants on beaches, and in coastal as well as oceanic waters along the eastern seaboard of North America and elsewhere are now known to be widely distributed on the beaches of New Zealand.

Several pellet shapes can be recognised—ovoids, spherules, beads, rods, discs and cylinders 2-5 mm across are common. Rhombohedroidal chips in varying sizes and larger button-like fragments are less frequently encountered. The pellets are mostly colourless.

These rounded plastic pellets are identified as the imported feedstock (raw materials if one likes) of the plastics industry in New Zealand. Unlike the North Atlantic, where polystyrene beads are dominant, most of the rounded granules accumulating on New Zealand beaches appear to be virgin polyethylene and polypropylene. The chips, which are invariably coloured, may well represent recycled material of local derivation.

The pellets float. They wash ashore and are concentrated in a narrow zone along the drift line or spread across the back-bench and wash-over flat.

A survey has recently been completed of over 300 beaches around New Zealand. This has shown that whilst the number of pellets accumulating varies regionally (Fig 1), it is greater near the important

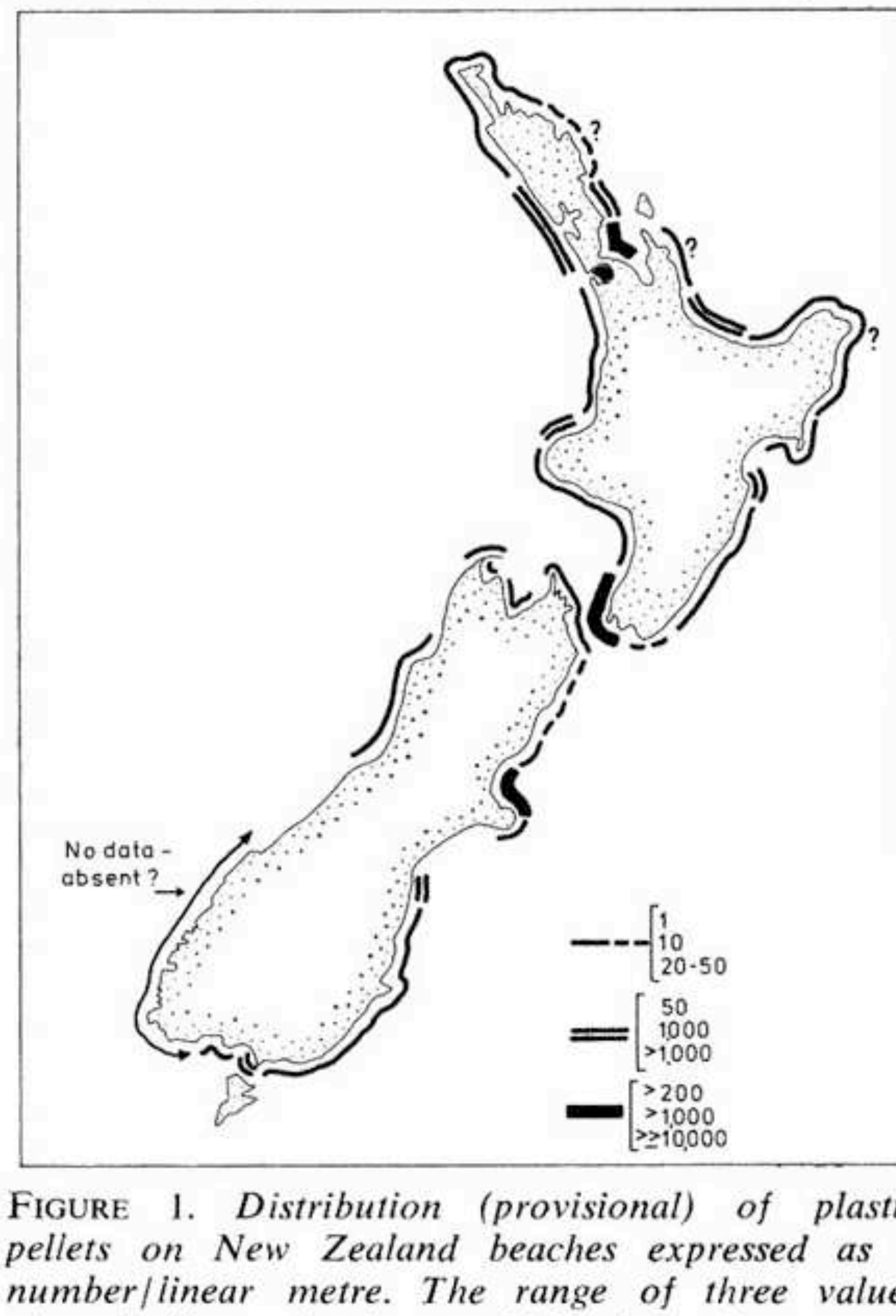

FIGURE 1. *Distribution (provisional) of plastic pellets on New Zealand beaches expressed as a number/linear metre. The range of three values given indicates levels at which the pellets are i) reasonably consistent, ii) quite commonly encountered, and iii) locally concentrated.*

industrial centres of Auckland, Wellington and Christchurch. Even so, on beaches one would imagine as remote from possible contaminants of metropolitan origin, significant numbers of pellets are to be found. The quantity of these pellets on the New Zealand coast today probably exceeds 1000 tonnes.

These pellets cannot be considered litter in the usually accepted sense. The principal source is likely to be accidental spillage at the major ports. Pellets may also make their way into coastal waters via streams and storm-water drainage, following spills during transport to or handling at inland procsesing plants.

Whilst a continual increase in the number of these pellets is predictable because of their generally accepted virtual indestructability, my observations indicate some degradation is occurring. Furthermore, although the potential environmental effects of the pellets are not yet aesthetically offensive, the biologic hazards, if any, of these materials and their invisible degradation products remains uncertain and should be investigated.

A POSSIBLE BASIS FOR ECONOMIC RABBIT CONTROL

J. MORGAN WILLIAMS

Research Division, Ministry of Agriculture and Fisheries, P.O. Box 31-011, Christchurch

Over the last 15 years several workers (Howard, 1963; Gibb, 1969) have stressed the need to grade land according to its potential for rabbit population increase. That is its' rabbit proneness or risk of reinfestation. Very few Pest Destruction Boards appear to have done so with the result that a considerable amount of control work is not really related to need. Similarly the rates levied on landholders to provide the money to carry out rabbit control are seldom related to the risk of reinfestation and frequently landholders expect control simply because rates are paid and not because they have a rabbit problem.

The rapidly rising costs of rabbit control make it essential, and possible now that the aim of eradication of the rabbit is no longer official policy, that some relatively simple method of grading land according to its rabbit proneness be developed. This has been attempted as one facet of a broad study aimed at assessing the impact (and costs) of control operations on rabbit numbers in the Waikari Pest Destruction Board in North Canterbury.

Topographical, soil plus parent material, and to a limited degree, rainfall data were used to divide the Waikari Board into a number of areas that simply grouped like soils and topography together. These areas constituted, for the rabbit population, a number of habitat types. The potential for rabbit population growth in each of these areas was assessed using kill tallies obtained from Pest Board work records, while the effect of land development, on rabbit numbers in each area, was assessed by using the number of stock units per hectare as a measure of the lands' general productivity.

Topographical Areas

Nine areas within the Waikari Board were delineated (Table 1).

Kill returns as a Measure of Rabbit Proneness

Animal kill returns have been used as an indication of population trends in numerous studies probably because they are a relatively easy statistic to gather from any type of hunting operation. Batcheler and Logan (1963) assessed the effectiveness of control operations on deer and chamois, using several parameters. They concluded that the number of these animals killed per man day was one of the more sensitive indicators of the trend of a heavily shot population.

In the Waikari Board during the years 1967-1973 the pattern of work varied little from year to year with most of the control effort being devoted to night shooting (39%) and daylight hunting with dogs and a gun (36%). Poisoning, for which kill returns are not possible, only amounted to 8% of all work. During 1974 there was a change in board management and therefore in work distribution and methods used. Control by poisoning was widespread, totalling 39% and 56% of all work during 1974 and 1975 respectively.

As control during the years 1967-1973 was primarily by methods that yielded kill tallies it seemed reasonable to assume that they would provide data that would indicate population trends.

Provided food is adequate rabbit survival rates are usually considerably higher under dry rather than wet conditions; therefore if kill tallies are to indicate areas that favour rabbit survival it would be an advantage to be able to use data from dry or drought years. The year 1969-1973 were ideal for the purposes of this study. Rainfall in the Waikari Board was 25% below average.

Night shooting (N.S.) and gun and dog hunting (G.D.) kills per man hour were assessed as indicators of population trends. Kills/man/hour, by these two control methods, were calculated for every property

TABLE 1. *Topographical Areas in the Waikari Pest Board*

AREA	PARENT MATERIAL	TOPOGRAPHY	RAINFALL
1. Weka Pass/Scargill Scarp	Predominantly limestone and greywacke.	Rolling to moderately steep.	600–700 mm
2. Waipara/Omihi Flats	Greywacke and sandstone alluviums and loess.	Flat to gentle rolling.	600–700 mm
3. Weka Pass/Doctors Hills	Greywacke and hard limestones	Steep to very steep plus limited rolling country.	600–750 mm
4. Mt Virginia/Lakes	Greywacke and talus patches of loess.	Steep to very steep at heights of 150–1400 m.	1000–1300 mm
5. Waikari/Hawarden Flats	Alluvium and loess from limestone and greywacke.	Flat to low rolling.	650–750 mm
6. Coastal Hills Waipara to Hurunui river	Sandstones and limestones	Rolling.	800–1000 mm
7. Chiltern Hills to Hurunui River	Greywacke, alluvium and loess plus some calcareous sandstones	Flat low lying to steep at heights of 150–500 m.	800–1000 mm
8. Castle Hill/Ben Lomond	Greywacke and hard limestone.	Mostly steep 150–700 m, rocky outcrops.	600–700 mm
6. Scargill valley	Greywacke and sandstone alluviums and loess.	Flat to low rolling.	650–750 mm

worked in each of the years. The resultant figures for each property, in each of the topographical areas, were then summed to provide a yearly mean of kills per man hour with confidence limits.

In the years 1967-1970 all but one of the areas had N.S. kill rates between one and three per man hour, while between 1970 and 1973 kills rose, in three areas, to as high as seven per man hour while remaining at the levels of previous years in other areas (Figure 1). This rise in N.S. kill rates during the latter years of the drought period was not paralleled by G.D. kill rates and revealed that G.D. kill rates are insensitive to changes in rabbit populations as indicated by night shooting (Figue 1). This is not surprising since rabbits, a burrowing and essentially nocturnal species, were being hunted during daylight.

The significant rises in kills between 1970 and 1973, in areas one, three and eight ($p<0.01$ in all cases Table 1 and Figure 1) contrasts markedly with the other areas where no such increases occurred. Clearly these areas, under the drought conditions that prevailed, have a higher potential for population increase and from a rabbit control view point could be considered high risk or rabbit prone. However this conclusion is only valid if it can be shown that hunting pressure per unit area was relatively constant over the years. Hunting pressure was assessed by relating the time spent on each property each year to the property area, and then handling these data in the same manner as kill data. The resultant annual mean for each topographical area was expressed as minutes hunting per hectare. Using this measure of hunting pressure, which is an approximation because the accessability of properties varies, nevertheless indicates that there was no significant change in effort in areas one, three and eight between 1970 and 1973 (Figure 1). A similar level of hunting pressure also prevailed in areas where there was no change in kills per hour.

Stock Densities as a Measure of Land Development

It has been suggested (Bull, 1956 and Howard, 1963) that improvement of pastures, reduction of cover and general improvement in land productivity via fertilisers, effectively limits rabbit numbers. While this observation certainly appears correct there does not seem to be any instance where such a correlation has been shown to exist over a large area of pastoral and arable land at different levels of development. If such a correlation could be established using readily available data (i.e. the number of stock units per hectare as a measure of land development be used in conjunction with kill tallies), then it could also be used in grading land according to its rabbit proneness.

The mean number of stock units per hectare, for years 1967 to 1974, were computed for eight of the nine areas. This statistic was plotted against the mean number of rabbits N.S. per hour for years

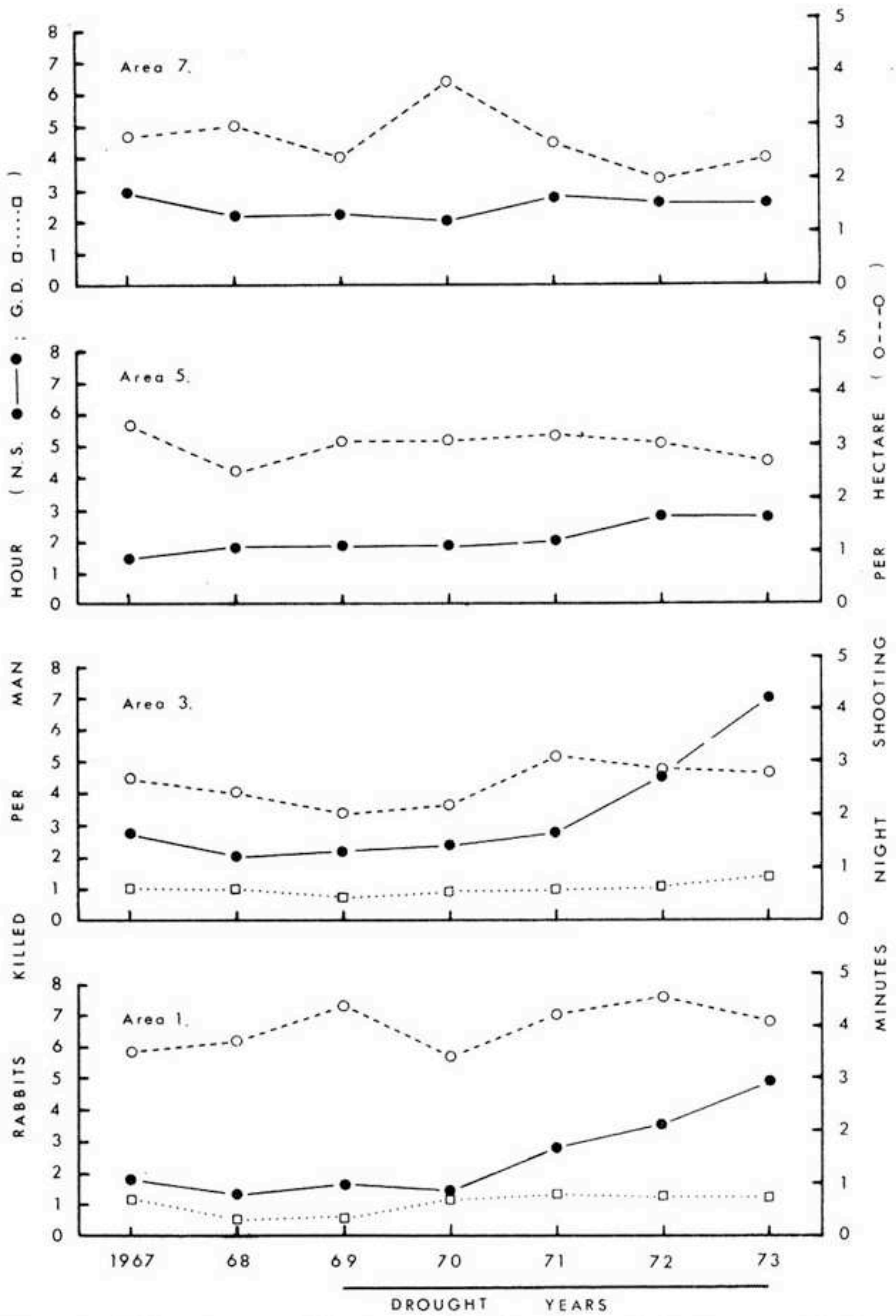

FIGURE 1. *Kill returns and hunting effort for four of the topographical areas.*

1967-1973. A regression line fitted through the resulting eight points indicated a significant relationship between stock units and rabbit kills ($r=0.7809$, $p<0.02$). Thus the areas carrying the highest numbers of stock units (i.e., eight—nine per hectare) had the lowest kills per man hour while areas with only three stock units per hectare had higher kill rates.

In general this result confirms the observation that rabbit numbers are usually higher on poorer more drought prone soils. Such soils are not confined to the apparently rabbit prone areas of one, three and eight, however. The topography in these areas makes them much more difficult to develop and this lack of development is reflected in stock densities.

DISCUSSION

It is evident, from N.S. kills per man hour, that three of the areas in the Waikari Pest Board are rabbit prone and that this becomes very apparent during a succession of dry years. The three regions contain the type of terrain and vegetation that has harboured relatively high rabbit densities for many years. Similar soils and terrain exist in other parts of the board, for example in areas four and seven. However the average rainfall is higher in both, which in conjunction with the high altitude of much of area four, and the higher level of farm development in area seven, appears to effectively help restrict increases in rabbit numbers.

While the relationship between rabbit numbers and stock densities may be of limited value when it comes to assessing the rabbit proneness of an area it does nevertheless confirm a widely held belief among rabbit researchers and many engaged in control It is to be hoped that this correlation might help allay the fears, held by some farmers, of rabbit resurgences in areas where rabbit numbers were high in the past but are now, after a lapse of 20-30 years and extensive development, at very low levels.

The relationship between development and rabbit numbers does not allow the conclusion that development was more important than control in the past; the two clearly went together. However, in view of the low rabbit densities that exist on the most developed country today it seems reasonable to conclude that the level of farming activity plays a significant rabbit control role.

Under the weather and rabbit control circumstances that prevailed in the Waikari Board between 1967 and 1973 it seems reasonable to conclude that N.S. kill tallies, derived from work records, provide in association with topography, and to a limited extent rainfall and stocking densities, a reasonable basis for classifying the board into areas of high and lower risk. Even such a relatively crude classification provides a basis for a more objective approach to striking differential Pest Board rates and possibly may encourage large Boards, with one rate over their whole area, to classify into various levels of risk and thus rates charged. Such an approach, with refinements that will be provided by current research, will have to be more widely adopted if farmer resistance to higher rate levels, in areas where rabbit numbers are low, is not to increase.

The use of kills per unit effort can clearly only be applied to boards where a high proportion of the control effort is devoted to methods that provide such tallies. This nevertheless leaves plenty of scope since the majority of North Island Boards use vehicle night shooting as their major method of control.

REFERENCES

BATCHELER, C. L. and LOGAN, P. C. 1963. Assessment of an animal-control campaign in the Harper-Avoca catchment. *New Zealand Forestry Research Notes*, No. 27, 26 pp.

BULL, P. C. 1956. Some facts and theories on the ecology of the wild rabbit. *New Zealand Science Review* 14 (5): 51-57.

GIBB, J. A.; WARD, G. D. and WARD, P. C. 1969. An experiment in the control of a sparse population of wild rabbits (*Oryctolagus cuniculus* L.) in New Zealand. *New Zealand Journal Science*, 12: 509-534.

HOWARD, W. E. 1963. Improving rabbit control in New Zealand. *New Zealand Farmer* 83 (38): 10-11.