the ratio of approximately 2.0-2.3 : 1.2-1.7, top soil to subsoil.

4. Between zones there appeared to be no marked change in the species comprising the population.

5. Variation from one sample site to another in any one location was greatest for bacteria and protozoa, whereas fungus and yeast isolations were remarkably similar.

6. With the exception of yeasts, the microbial population was studied over the three seasons of spring, summer and autumn. Species were relatively stable from season to season. However, numbers varied, there being a spring peak for bacteria, possibly correlated with moisture, protozoa showed a slight drop in summer, possibly due to a drying of the soil, while fungi showed a maximum in summer. This was correlated with temperature and a drying of the soil.

7. A species list has been drawn up of those micro-organisms which may possibly be regarded as being characteristic of these low tussock grassland soils. This list includes 15 fungi, 5 yeasts, 11 amoeboid and 17 ciliate protozoa. Bacteria have been grouped largely on a physiological basis and not sufficient is known of the taxonomy of soil bacteria to include them in such a list. The species are given in order of frequency of occurrence in Table 3.

Table 3. Common soil micro-organisms in order of frequency of occurrence.

FUNGI

Rhizoctonia sp., Cylindrocarpon didymum, Fusarium sp., Papulaspora sp., Trichoderma viride, Penicillium janthinellum, Zygorhynchus moelleri, Absidia glauca, Penicillium stoloniferum, Cladosporium herbarum, Penicillium cyclopium, Verticillium sp., Mertierella minutissima, M. alpina, M. elongata.

AMOEBOID PROTOZOA

Mayorella vespertilio, Trinema lineare, Difflugia constricta, Trichamoeba sp., Difflugia arcula, Euglypha rotunda, Trinema enchelys, Biomyxa vagans, Nuclearia simplex, Sphenoderia dentata, Cryptodifflugia oviformis.

CILIATE PROTOZOA

Enchelys sp., Keronopsis muscorum, Colpoda steinii, Oxytricha pellionella, Uroleptus mobilis, Gonostomum affine, Dileptus anguillula, Trichopelma sphagnetorum, Saprophilus muscorum, Colpoda inflata, Cinetochilum margaritaceum, Vorticella striata, Colpidium sp., Cyclidium glaucoma, Spathidium sp., Plagiopyla sp., Colpoda cucullus.

YEASTS

Cryptococcus diffluens, C. terreus, Candida curvata, Cryptococcus albidus, Candida humicola.

A Zoological Approach to the study of Ecosystems that include Tussock Grasslands and Browsing and Grazing Animals*

Thane Riney

To a student of vertebrate zoology tussock grassland is part of a much larger subject, that of animal-environment relations, a phase of ecosystem ecology. In the present paper the need for a synthesizing type of approach to the study of ecosystems is suggested and data, resulting from a trial of such an approach, are reviewed.

Vertebrate animals exist as part of complex interdependent system of components, such as rocks, climate, weather, soils, bacteria, plants and animals. When man is included as one of the components, human interests and activities may vary from minor modifications to changes capable of profoundly altering the dynamic balance of the ecosystem.

The basic question in this discussion is: to what extent do browsing and grazing animals contribute to deteriorating conservation values in a watershed? The immediate practical problem is: how can research be most effectively organized to answer this question?

The biggest practical limitation to any ecological approach to animals and tussock

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grasslands is that it is not humanly possible to learn everything about an ecosystem in time to use the information for comparative study purposes. However broad the approach, there remains the problem of selecting relevant material from a maze of detail. This is particularly important when the data gathered from different disciplines are to be combined. Thus a synthesizing approach is often appropriate. One such approach is to compare data drawn from several components of the ecosystem thus developing a series of cross checks. This approach may be useful in discovering questions pertinent to the understanding of an ecosystem in imbalance.

To illustrate this approach a research plan is presented which was devised for the Harper-Avoca area, a part of the Lake Coleridge catchment, Canterbury. The general plan of the project was to gather enough data from different portions of the ecosystem to define the nature of the imbalance suspected to exist. Data regarding ocurrence, utilization, and response were gathered from both the environmental and animal portions of the ecosystem. To facilitate comparison, the same major sampling techniques were used for several kinds of data.

For the occurrence aspect the relative numbers of each species present and the kind of habitat available to them were studied. The utilization study included the classes of vegetation consumed by animals, and the percentage of annual growth removed from shrubs or trees which were important for regeneration of the forest or as a major forage species. Among animal responses investigated were the sex and age ratios of deer and chamois. A technique for assessing the physical condition of deer and chamois was also developed. The environmental responses dealt with the nature and occurrence of accelerated erosion and the state of regeneration of the forest.

One main sampling technique used was the station line. Lines were located in typical sections of the drainage and normally extended along a compass bearing up and across the hillside from its base to its ridge. For comparative study several sets of data were taken from mil-acre stations located every 20 paces along these lines. Data derived from the station lines included: (1) proportion of the line containing grass, shrubs or trees: (2) the distribution and density of the faecal droppings of deer, chamois, opossum, hare and sheep: (3) average percentage ground covered with vegetation or bare: (4) the frequency of occurrence of arbitrarily defined ratings of stability for each line. The following results exemplify the synthesizing approach and contribute to a perspective of the vertebrate animal in an ecosystem including tussock grassland.

The relations between the numbers of droppings and the proportion of grasses and forbs on the lines differ between species. Deer, for example, are most numerous where the proportion of grass is small compared to shrubs and trees. The opposite is true of sheep and hare, while numbers of chamois and opossum droppings do not correlate with the frequency of occurrence of grasses and forbs. From these observations it was concluded that in the Avoca drainage, where both introduced wild and domestic animals are present, it is inaccurate to speak of the tussock grassland as a self-contained research subject: tussock grassland is part of a watershed used by several species and each species is related to the grassland in a different way. Thus the distribution and numbers of vertebrates are most appropriately studied in terms of the entire watershed rather than restricting observations to vertebrates and tussock grassland alone.

Comparison of average percentage ground cover with number of droppings shows that greatest numbers of deer and smallest numbers of sheep and hare were found on those lines with the greatest percentage of ground cover, while differences in numbers of chamois and opossum were apparently unrelated to the amount of cover.

Comparison of stability ratings with broad vegetative classification showed that the most unstable lines were those with a majority of grasses and forbs and few or no trees present, and, on the four most stable lines, grasses and forbs were represented on 25% or less and trees and/or shrubs on 35% or more of the stations.

When faecal droppings per 100 stations are compared with stability ratings it is apparent that: (1) lines with the highest numbers of deer droppings contained the lowest percentage of stations rated unstable: (2) there was no relation between opossum and chamois numbers and either stable or unstable areas: (3) the most unstable areas were those in which the highest numbers of sheep and hare occurred.

Although this does not represent the complete picture, it should be apparent from the above discussion that a clearer definition of the present state of imbalance in this particular drainage is needed and that the "practical conservation problem" is not simply due to the presence of deer and chamois as was supposed in the initial stages of this study. Future research may explore the extent to which hare and sheep contribute to the state of imbalance existing in this watershed, and the extent to which each of the several species competes with the others for living requirements. The foregoing discussion emphasizes the need to define the problem areas in relation to an ecological situation which includes human interests. As shown, the synthesizing approach using data from several components of the ecosystem may facilitate such a definition.

Insects Attacking Tussock

J. M. Kelsey

Tussock is defined as any tussock species on which the insects recorded were known to feed, but unless otherwise stated, the tussocks referred to are *Festuca novaezelandiae*, *Poa caespitosa*, and *P. colensoi*, at altitudes ranging from 1,500-4,500 feet. Data are confined strictly to tussock itself, and do not include inter-tussock vegetation.

Earlier literature indicated that only 9 insects—all larvae of Lepidoptera—were known to feed on tussock; in addition the adults of 22 further species of Lepidoptera were recorded as being common on tussock, and a further 47 species were found on native grasses in tussock areas. The term "native grasses" has been used apparently in many cases as a general name to include the above three tussock species. In 1940 the list of insects definitely attacking tussock was extended to include a species of *Odontria* feeding on roots, and the caterpillars of the three moths *Persectania ewingi*, *Leucania toroneura* and *L. acontistis*. In 1945 grass grubs were recorded as damaging tussock. There are records of only 13 species of insects that definitely eat one or more of the three tussock species mentioned above, and an almost unlimited number of tussock-zone moths whose larvae may be able to eat tussock.

The following insects were actually seen to feed on tussock, or contained tussock fragments on dissection; they have been divided into Leaf-eating insects, of which 23 species were recorded, and Root-feeders, comprising 10 species.

1. LEAF-EATING INSECTS:

Argyrophenga antipodum Dbld. (Nymphalidae)
Crambus simplex Butl. (Pyralidae)
Crambus flexuosellus Dbld. ,,
Crambus spp. (2)
Persectania ewingi Westwd. (Noctuidae)
Persectania disjungens, Walk. ,,
Leucania acontistis Meyr. ,,
Leucania phaula Meyr. ,,
Leucania semivittata Walk. ,,
Agrotis ypsilon Rott. ,,
Oxycanus spp. (2) (Hepialidae)
Orophora unicolor Butl. (Psychidae)
Locusta migratoroides Reich. (Oedipodinae)
Phaulacridium marginale Walk. (Acridiinae)
Brachaspis collinus Hutt. ,,
Mealybug (1) (Margarodinae)
Thrips (2)
Dictyotus caenosus
Hudsona anceps
Mysius huttoni
Odontria sp.
Pyronota sp.

2. ROOT-FEEDERS:

Costelytra zealandica White (Melolonthidae)
Chlorochiton convexa Given ,,
Pyronota ,,
Odontria striata White ,,
Odontria spp. (5)
Weevils (2)
Elaterids (3)
Tipulids (3)