mands falls below a critical value and the vegetation is killed out.

Both the Alexandra and Omarama soils have sub-soils with almost as much natural fertility as the topsoils. Consequently when the topsoil is lost as the result of erosion, plants can settle down to a new life on them without too much upset.

The sub-soils of the Kaikoura soils on the other hand are much more leached and much more infertile than the topsoils. The loss of topsoil could be a determining factor in the regrowth of the snow tussock. How important this is we do not know. Possibly it is only of academic importance because this stage is transient owing to the rapid solifluction, but one would expect it to be a negative factor rather than a positive one in the plant-soil relationship.

The effect of a bare surface on the water regime of a soil will be obvious. Evaporation is greatly increased and water that would percolate into soil if filtered slowly through the foliage of the tussocks now runs off the bare surface rapidly, eroding the surface as it goes. As far as our limited observations go it appears that the changes in the moisture status are greatest in the Alexandra soils and least in the Kaikoura soils, but the water requirements of the snow tussocks may be great enough for the induced drought of the Kaikoura soils to have as adverse an effect on its capacity to survive as the more extreme drought of the Alexandra soils on the fescue tussocks. It must also be remembered that the snow tussock is a relict grassland that has survived from an earlier and damper climate cycle. If it was a climax plant in that cycle, it may have survived into the later cool dry cycle because of the buffering effect of luxuriant foliage and the thick peaty litter, both effective insulating agents. If this is so the drought induced by baring the surface must have been doubly catastrophic. It could be that this factor alone is sufficient to determine whether the snow tussocks survive or not, and since the snow tussock grasslands of the Kaikoura soils have been burnt many times it could be argued that the present cycle of accelerated erosion is irreversible.

In applying our knowledge of the soils to the immediate practical problems of soil conservation probably the most important consideration is the excessive instability of the Kaikoura soils. The native vegetation, the snow tussocks, formed a closed cover, and the tussocks grew to a height of up to six feet. The soil was thus well insulated against frost. A prerequisite of a plant introduction programme must therefore be a knowledge of the minimum mass of foliage required to insulate the Kaikoura soils against solifluction. Any attempt to establish plants providing less than this protection is likely to be unsuccessful. Account must also be taken of the physical disturbance the plant roots would suffer in the early stages of establishment.

Microbiology of Tussock Grassland Soils

Dr. R. H. Thornton, Dr. J. D. Stout and M. di Menna

An investigation of aspects of the microbiology of tussock grassland soils was carried out in the 1953-1954 season and was an attempt at a team approach to soil microbiological studies. The investigation sought to determine the influence of vegetation, soil type, climate and season on several groups of micro-organisms existing in a relatively stable environment under near natural conditions. Five groups of organisms—fungi, yeasts, amoeboid and ciliate protozoa and bacteria, have been studied jointly in soils under low tussock grassland cover dominated largely by *Festuca novae-zelandiae.*

The investigation has included the isolation of different organisms with various and appropriate techniques, in some cases comparing standard with newly developed methods and comparing the effects of differently constituted isolating media. The organisms have been identified taxonomically and their frequency of occurrence determined. In some cases information has been obtained of features of the physiological activity of some of these organisms.

Three locations were chosen for study, one in the North Island near Waiouru, another close to Bealey near Arthur Pass in Canterbury, and the third on the Old Man Range near Alexandra. The three locations were at an altitude between 2500-3000 ft, on W-N/W slopes.

ENVIRONMENT

A summarised account of the environmental features at the three locations is given below.

1. *Vegetation.* A vegetational survey was carried out by Mr. A. P. Druce at three locations and the following table is from his data.

Table 1. Distribution of physiognomically important plants.

Common to three locations:

Festuca novae-zelandiae
Agropyron scabrum
Crepis capillaris

Mainly at Waiouru and Bealey:

Anthoxanthum odoratum
Danthonia pilosa
Linum catharticum
Hypochaeris radicata
Trifolium dubium } less common at Bealey
Holcus lanatus }

Confined to Bealey:

Pteridium aquilinum var *esculentum*
Agrostis tenuis

Mainly at Bealey and Alexandra:

Poa caespitosa

Mainly at Alexandra:

Raoulia lutescens
Poa pratensis
Cirsium arvense
Aira caryophyllea
Vulpia bromoides (v. *dertonensis*)
Rumex acetosella

Thus broadly Waiouru and Bealey were similar floristically, whereas Alexandra differed somewhat markedly.

2. *Soil type.* The locations were on the following soil types which are given, together with some analytical details, in Table 2.

These soils showed some marked differences.

3. *Sampling.* Samples were taken from 5-10 different sample sites in each location and at each site soil samples were taken from each of three zones, i.e.

1. 2in. deep between spaced tussock plants

2. 2in. deep beneath tussock plants

3. 13in. deep in the B horizon.

4. *Season.* Observations were carried out in the spring, summer and autumn seasons of 1953-1954.

Table 2. Soil types with some analytical details.

Soil type	*Waiouru* Taupo light sandy loam	*Bealey* Tekoa silt loam	*Alexandra* — stony sandy loam, slightly gleyed. (Omarama set)
pH	5.6	5.2	6.2
Organic carbon %	6.8	5.3	3.1
C/N ratio	12	16	11
Base saturation %	50	39	94

GENERAL RESULTS

The results from this investigation are presented as a generalisation of the picture to fulfil the spirit and purposes of the symposium. When the results are examined in detail there are many variations from this broad picture, so the following remarks are made with caution and reservation.

1. Generally, in the three locations, there is a similarity in the isolated species for the different groups of organisms. Vegetation, therefore, would appear to set the general limits on the species able to develop in these locations. This is probably correlated with the supply of food materials by plant leaves and roots. Local differences in the vegetation, soil type and climate in each of the three locations appear to modify the basic pattern of this microbiological fauna and flora.

2. Whereas the Bealey and Waiouru locations have a similar population for each of the five groups, Alexandra shows a distinct yeast and ciliate protozoan population. This difference is probably attributed to vegetation and soil type differences in the latter location.

3. Microbial activity, as judged by numbers of micro-organisms, appears to be greatest in the top few inches and decreases with depth. However, the decrease in fungal numbers is less than expected being in

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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