Some Soils of the Tussock Grasslands

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This paper discusses soils of the fescue tussock grasslands and the snow tussock grasslands of the South Island. These cover the floors and mountain slopes of the dry inland basins, mountain valleys and adjoining mountains. I have chosen these grasslands because the question of their utilisation is quite important. The soils fall into three categories, namely, the Alexandra, Omarama and Kaikoura soils. They belong to a sequence in which the degree of weathering, which is the distinguishing character of the soils, increases from the Alexandra to the Kaikoura soils.

The Alexandra soils are present in the driest parts of the basins under rainfalls of 12in. to 17in., and support mainly desert plants, the original tussock cover having been destroyed by burning and grazing. These soils have progressed little further than the weathering of the rock. Minerals are fresh, grain size is large, the soil contains many large grains, and the mineral particles are almost free from colloid coatings. The colour of the sub-soil, therefore, approximates the colour of the broken rock, which is grey to brown grey.

The Omarama soils are present on the damper parts of the basins and the mountain slopes immediately above the Alexandra soils and under rainfalls of 17in. to 30in. These soils support a fescue tussock grassland in which introduced grasses are prominent and in which bare ground is exposed. These soils are more weathered than those of the Alexandra soils and the grain size is smaller with little coarse sand. They contain enough products of weathering to furnish a colloid coating for the mineral grains.

The Kaikoura soils support snow tussock grassland and are on the higher levels. They show a greater degree of weathering than do the Omarama soils. Enough products of weathering have accumulated in the profile to colour the sub-soil a yellow to brownish yellow and to impart a well defined crumb structure to the top-soil.

The factors which determine the zonation of the Omarama and Kaikoura soils probably determine the vegetation zonation also. It must be remembered that the present environment is only part of the story of soil formation. The Kaikoura soils have existed under a warmer and wetter climate than the present when forest grew on the wetter mountain sides and on the downlands of the coast.

It seems safe to assume that the mountain soils have persisted through at least two climatic cycles, namely, the dry cool grassland cycle that was terminated by the early settlers and a previous warm damp grassland cycle. If this view is correct it prompts the further reflection that soil evolution under the present climate, even under the most favourable circumstances, cannot replace the Kaikoura soils which have been lost through erosion. In addition, indications are that over a large area the snow tussock grasslands are relict grasslands which are in the process of extinction.

Before discussing the changes that have taken place in the soil it is desirable to summarise the demands which the plant makes on the soil that supports it. The plant demands (1) a stable environment for its roots, (2) an adequate supply of plant foods, (3) an adequate supply of water, (4) freedom from substances that inhibit plant growth. If any of these requirements is not met the plant ceases to grow. For each there is a critical level, but unfortunately we do not know what it is for any of the tussock plants. Therefore, we do not know how tolerant these plants are of changes in the soil mantle. It is possible that the present state of the soil mantle may in itself be a determining factor in the fate of the snow tussock grasslands, that is, once the surface is bared to the action of frost the amount of re-growth of the available plants on the disturbed soil is insufficient to stop the downward movement caused by freezing and thawing. This will continue until the end-point of scree is reached or the capacity of the soil to meet one of the other plant demands 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

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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