The Grazing Factor and the Maintenance of Catchment Values in the Australian Alps

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THE GRAZING FACTOR AND THE MAINTENANCE OF CATCHMENT VALUES IN THE AUSTRALIAN ALPS

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Summary

The major problems associated with summer grazing in the Australian Alps are analysed in relation to catchment values.

A few species are grazed very selectively. The intensity of this selective grazing appears to have increased during recent years, depite lower stock numbers, owing to the partial or virtual elimination of a number of palatable species which used to be more widespread. The problem of selective grazing is accentuated by the fact that the most widespread dominant herb, snow grass, *Poa caespitosa*, is not palatable at most stages; the minor herbs of the intertussock spaces provide most of the grazing.

Local stock concentrations result in extremely variable grazing intensities. Overall grazing intensities are low, but effective grazing intensities are very high. To place high country grazing on a sound basis, more uniform grazing would have to be achieved so that the large areas of snow grass could also be utilized.

It is concluded that present-day grazing is not compatible with the preservation and improvement of catchment values. The possibilities for making it so are limited to a small fraction of snow country mainly below about 4500 ft. Here grazing by cattle would in general be preferable to grazing by sheep.

The problem of finding alternative summer grazing for the livestock using the snow country could be solved by better utilization of underdeveloped freehold land.

I. Introduction

The phrase "rich snow grass pastures" has been used so often with reference to summer grazing in the snow country of the Australian Alps, that it has given rise to a quite erroneous conception of grazing conditions there. In point of fact, most of the several forms of snow grass, *Poa caespitosa*,† are among the least palatable mountain plants, except at certain stages, and it is this fact—that the dominant herb, which is a good catchment cover, is of low fodder value—that constitutes a problem so far never properly faced.

Apart from the problems arising from obvious physical difficulties—short grazing season due to snow conditions, frequent frosts, strong winds, difficult access, dingoes, etc.—the main problems of high country grazing can be enumerated as follows: What do livestock eat? What types of areas are grazed? What is the pattern of livestock distribution? What is the order of grazing intensities? What are the relative merits of sheep and cattle? What are the prospects of replacing existing snow grass pastures by an improved pasture sward, and what would be the consequences? What are the prospects of more intensive utilization of adjacent freehold land?

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† *Poa caespitosa* auctt. austral. (snow grass) = *Poa australis* R.Br. (white tussock grass).

Before attempting to examine these questions it is helpful to outline the main categories of land (land units) included under the term "snow country" (cf. Costin 1954, 1957*a*). The snow country proper, embracing more than 2000 square miles in New South Wales, Victoria, and the Australian Capital Territory (Fig. 1), is defined naturally as that situated above the winter snow-line. The lower limit of the winter snow-line, at 4500–5000 ft, coincides with the change from sclerophyll forest to subalpine woodland in which the snow gum (*Eucalyptus niphophila* Maiden & Blakely) is dominant.* Much of the upper forest country just below the winter snow-line is also grazed together with the snow country proper, however, and thus

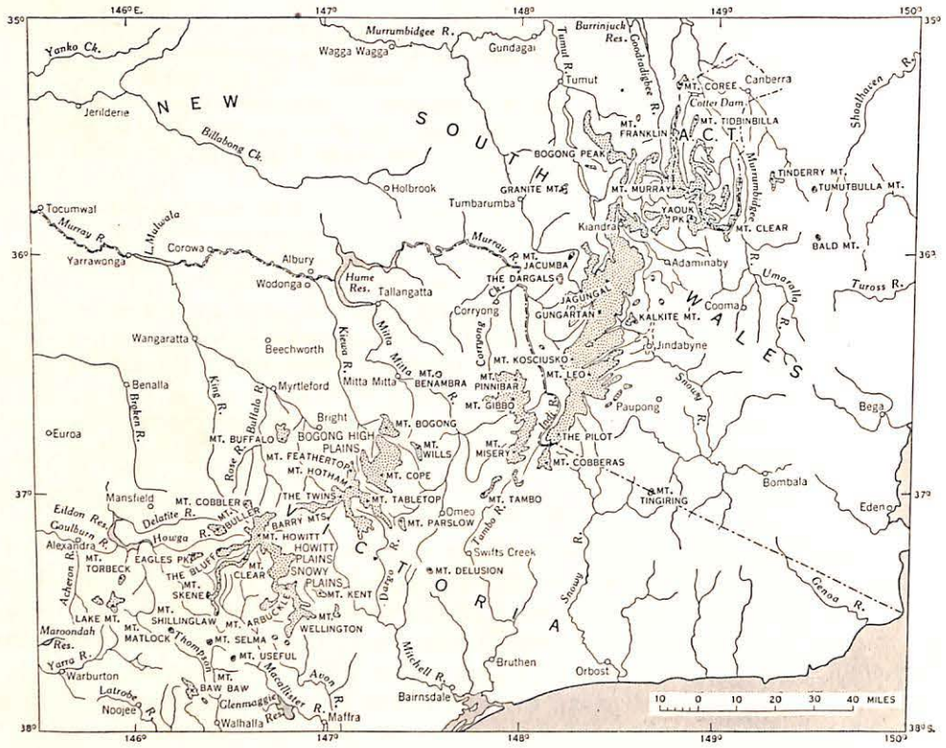

Fig. 1.—Map of Australian Alps, showing land above 4500 ft.

requires consideration. The snow gum belt is commonly broken by large, treeless sod tussock grasslands, attributed to temperature inversions or soil effects. At its upper limit at about 6000–6500 ft the snow gum gives way gradually to alpine herbfields, similar physiognomically to the grasslands but much enriched by the snow daisy (*Celmisia longifolia* Cass.) and other perennial herbs. Wet areas throughout the mountains are characterized by *Sphagnum* bogs and *Carex* fens, usually associated with wet heaths containing various epacrids, whilst rocky or otherwise exposed situations support dry heaths and other shrub-dominated vegetation.

* For locality details see Costin (1957*b*).

Grazing management consists in taking up sheep and cattle for most of the snow-free months, and bringing them down to lower freehold or leasehold country for the winter. In the Snowy Mountains area and on the Bogong High Plains the grazing season is restricted to the time between November 30 and May 31, stock numbers are regulated, and burning-off is now prohibited; grazing in some of the higher State Forests in Victoria is also subject to regulation; but in most other high mountain areas in New South Wales and Victoria there are few restrictions on the duration of the grazing season and the numbers of livestock grazed, and burning is permitted in spring and autumn. The Cotter Catchment in the Australian Capital Territory is the only large area which has been closed to livestock for an extended period (40 years). A recent decision by the New South Wales Cabinet will also eliminate grazing from the Snowy Mountains area above 4500 ft, as from the end of the grazing season in 1958. Salting is sometimes carried out during the summer, and if flies are unusually troublesome an occasional paddock muster may be made to crutch infected sheep. Apart from this, the livestock are left mainly to their own devices and range more or less where they like, without any shepherding such as is practiced overseas. Snow lease boundary fences are occasionally adequate, but for the most part they are not sufficiently maintained, are rarely stock-proof, and often do not exist; natural features and the distribution of shelter, water, and grazing-types are far more significant in livestock distribution than boundary fences. A few areas—notably the Snowy Mountains—have rangers who make inspections of the leases, and in some of the more valuable State Forests foresters are alert, but in general range management does not exist. This has now been the situation for more than 100 years, except that overall stock numbers, especially during drought years, used to be greater, and burning off almost universal.

The practice of burning off deserves additional comment. This became more common because graziers found that burnt areas were for some reason much more attractive to livestock. Thus autumn and, to a less extent, spring burning became accepted procedure. In theory a ground fire to sweep through the grass and shrub cover was all that was aimed at, but both in the snow gum and forest areas this frequently eveloped into a crown fire. Implicit in this practice is the knowledge that a large part of the native vegetation is unpalatable.

II. Fodder Plants, Types of Areas Grazed, and Patterns of Livestock Distribution

Distribution patterns of livestock in the main high mountain vegetation types are obviously irregular. Some of the reasons for these irregular distributions can be found by ascertaining what species and parts of plants sheep and cattle prefer to eat.

An appraisal of probable grazing conditions 50–100 years ago is illuminating, as at this time the country would have been in a more natural condition. The recollections of old residents and the character of relic stands of vegetation both indicate that adequate grazing was at first available without continual burning. If so, this presupposes that areas of palatable species were more widespread, or that palatable species now uncommon were more abundant, or both. There is no

question that the first supposition is true; the occurrence of relic bog and swamp communities, and of recently humified and humifying peats, indicates that the area of bog and fen has been reduced, at a conservative estimate, by at least 50 per cent., in many areas by much more. Field evidence also supports the second supposition. Most of the snow gum and forest country was originally fairly open with a well-developed herb layer and comparatively few shrubs. Periodic fires have since produced extensive development of scrub, reducing the total area available for grazing. In the case of certain individual species, documented evidence is also available. Thus McLuckie and Petrie (1927) recorded the palatable grass *Hemarthria uncinata* R.Br. as "common" in the alpine herbfields of the Kosciusko area. By 1946 (at the very latest) this plant had virtually disappeared (Costin 1954). Maiden (1898, 1899) comments on the commonness of the palatable grass *Danthonia frigida* J. Vickery, and Helms (1893) describes it as common and extensive enough to provide shelter for sheep on eastern slopes. The latter comment is particularly significant as the distribution of *D. frigida* is now largely of a relic nature in rocky situations and similar places of difficult access, especially on the steeper, western side of the Main Range.* There are also other palatable herbs, now found only as minor associates with snow grass, whose greater abundance in less accessible places likewise indicates they were once more widespread (e.g. grasses including *Agropyron velutinum* Nees, *Agrostis* spp., *Deyeuxia* spp., *Trisetum subspicatum* (L.) Beauv.; sedges including *Carex hebes* Nelmes and *C. breviculmis* R.Br.; *Luzula campestris* (L.) DC., *Ranunculus anemoneus* F. Muell., *Alchemilla novae-hollandiae* Rothm., *Aciphyllia glacialis* F. Muell. ex Benth., and various composites). Particularly noteworthy in this respect are the inaccessible herbfields at the base of the Mt. Cobbler cliffs in Victoria. In their luxuriance and richness in mesomorphic species (including the silky-leafed form of *Celmisia longifolia*, *Aciphylla glacialis*, *Uncinia flaccida* S. T. Blake, *Hierochloe redolens* R.Br. var. *submitica* F. Muell.) these cannot be matched in adjacent areas which have been grazed. It would thus appear that the original herbaceous vegetation provided more palatable grazing than the supposedly near-natural vegetation of today. From this it can also be inferred that early grazing was more uniform than at present, and that effective stocking rates were probably lower, even though overall livestock numbers were greater.

For some indeterminate but considerable time, therefore, the main dominant herbaceous plant available for grazing has been the snow grass which, however, is not attractive. This immediately presents a problem which high country grazing in most of Europe and North America does not have to face: namely, that the most abundant, dominant herb which is such a valuable catchment cover is not of much grazing value. In North America, for instance, high range management methods are based on maintaining the dominant herbs in as near climax condition as possible, but in the Australian Alps (and in New Zealand) range management, if it can be said to exist, consists in damaging the dominant herb as this produces more palatable

* Hartley and McTaggart, of the Division of Plant Industry, C.S.I.R.O., failed to find this grass during a collecting trip to Kosciusko in the mid 1930's (W. Hartley, personal communication). Following the exclusion of livestock from the summit area in 1944, small stands of the grass gradually reappeared and are now becoming more common along the road between Charlotte Pass and Mt. Kosciusko over which Hartley and McTaggart travelled.

grazing. In other words, existing grazing and catchment values are not directly related. This is not to say, however, that sheep and cattle will not eat snow grass. In drought years, for instance, sheep were known to have eaten down the tussocks almost to ground level, and it is generally accepted among graziers that stock will eat snow grass, or at least pull at it, if they are hungry; this is one of the signs that palatable herbage is scarce. Snow grass also includes several distinct forms (probably different species or subspecies) and whilst the most widespread form is the least attractive, some of the others which occur less frequently are grazed. Thus, the lax, upper montane and lower subalpine form is quite palatable and it is noteworthy that old graziers claim this form was once more widespread; its commonness in the ungrazed Treffle Park and Water Reserve near the old Kosciusko Hotel is significant in this regard. Occasionally the spiky-leafed swamp form and the hairy erosion form are also nibbled, and the broad-leafed swamp form, *P. caespitosa* var. *latifolia* Benth. is quite palatable. The seedheads, furthermore, are selectively grazed and young snow grass—whether shoots or seedlings—is also attractive.

Closer examination of mountain pastures shows that most of the grazing now takes place on the secondary communities of minor herbs which develop on the bare and half-bare spaces between the tussocks, and on the larger areas where more extensive tussock replacement has occurred (Plate 1, Fig. 2). The most widespread and palatable of these minor species is sorrel (*Rumex acetosella* L.), an early accidental introduction to the mountains which is now completely naturalized. A likely reason for this preference seems to be the sharp taste of the sorrel, as mountain livestock are notoriously salt-hungry and also nibble other sharp-tasting plants which seem to have nothing else to recommend them (e.g. *Restio australis* R.Br., *Hypolaena lateriflora* F. Muell.). Other palatable herbs of intertussock spaces include *Craspedia uniflora* Forst. f., *Leptorrhynchus squamatus* Less., *Cotula filicula* Hook. f. ex Benth., *Geranium pilosum* Forst. f., *G. sessiliflorum* Cav., and *Scaevola hookeri* F. Muell. ex Hook. f. *Themeda australis* (R.Br.) Stapf, species of *Danthonia*, and more locally white clover (*Trifolium repens* L.) are also common on some of the lower high plains.

In the snow gum country, within which or adjacent to which most of the grasslands are situated, sheep also show some strange preferences for certain apparently unpalatable woody species (e.g. *Cassinia aculeata* R.Br.). Young snow gum shoots are also attractive, and after fires the regenerating snow gum suckers are consistently nibbled back. Repeated over two or more seasons, this defoliation often results in the death of part or all of the burnt stand (Plate 2, Figs. 1 and 2).

The marked stock preference for the bogs and fens is due mainly to the presence of the sedge *Carex gaudichaudiana* Kunth., which occurs as a codominant in both communities (Plate 3, Fig. 2, and Plate 4, Figs. 1 and 2). Other palatable bog or fen plants include various other sedges, *Astelia alpina* R.Br. var. *novae-hollandiae* Skottsb., *A. psychrocharis* F. Muell., *Restio australis*, and *Hypolaena lateriflora*.

The snow patch areas (short alpine herbfields) include a large percentage of palatable species: *Montia australasica* Pax. & K. Hoffm., *Epilobium confertifolium* Hook. f., *Ranunculus inundatus* R.Br. ex DC., *Dioschiadium ranunculaceum* Domin,

and *Brachycome stolonifera* G. L. Davis. Grazing on these areas is relatively uniform, but because of their small size it is also heavy (Plate 3, Fig. 1).

Disturbed places such as watering points, salting areas, holding paddocks, and the environs of huts frequently include patches of palatable naturalized species, in particular white clover, Kentucky bluegrass (*Poa pratensis* L.), and brown top (*Agrostis tenuis* Sibth.). Such areas are always grazed hard to a smooth turf and are heavily dunged, which maintains the relative high soil nutrient level these species seem to require.

III. Grazing Intensities

As shown above, grazing has now become increasingly patchy. Thus, in the forest country which now contains much scrub owing to continual fires, grazing occurs on a very small fraction of the total area. Recently burnt land provides some transitory grazing, but in about 2–5 years (depending on the site) it starts to revert to scrub and becomes almost useless until after the next burn. The natural wet meadows and sparsely wooded areas—and in some cases fire-induced clearings—provide most of the grazing, and livestock rarely move far afield from these favoured places. Such a distribution pattern was studied in a lease of 4 square miles at Sawpit near Kosciusko during the summer of 1955–56. Here a modified wet tussock grassland of about 5 acres supported approximately 100 sheep for most of the summer; only the immediately adjacent forest was also frequented to any extent and then mainly for shelter (Plate 1, Fig. 1).

In the snow gum and snow grass country, shrub-invaded places are again avoided, and grazing is concentrated on burnt areas, intertussock spaces, and more extensively damaged areas. Measurements of effective grazing intensities are instructive. In the case of a relatively uniform lease of about 2940 acres south-east of Daner's Gap in the Kosciusko area examined in detail in the summer of 1955–56 the maximum permitted stocking rate was approximately 2800 sheep-equivalents, representing an overall stocking rate just less than one sheep per acre. The approximate proportions of the main cover types in the lease as estimated by more than 3 miles of line transects were: snow gum with continuous snow grass sward 4 per cent.; continuous snow grass (mainly disclimax) 40 per cent.; shrubs 20 per cent.; and intertussock spaces and larger half-bare areas 30 per cent. and 6 per cent. respectively. It was this 36 per cent. of the lease which provided most of the grazing, at a stocking rate which now increases to about 2·6 sheep per acre. The composition of the intertussock spaces and half-bare areas was then estimated by means of quadrats: approximately 44 per cent. was bare ground, 26 per cent. was litter, and 30 per cent. was minor herbs. The last figure reduces the actual area which is mostly grazed to about 317 acres, increasing the effective stocking rate to almost 9 sheep per acre during the grazing season of 6 months.

A second lease of about 3790 acres north of Rennix Gap, with a maximum permissible stocking rate of about 1550 sheep-equivalents, was examined in a similar fashion. In this instance, most of the middle and northern sections of the lease fall away to the Snowy River and are too steep and rough to provide much grazing; in the summer of 1955–56 approximately 900 sheep spent most of the grazing season on the more uniform southern portion of about 600 acres towards Rennix Gap. The


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approximate composition of this 600-acre section was: snow gum with continuous snow grass 7 per cent.; snow gum with shrubs 11 per cent.; shrubs 14 per cent.; continuous snow grass (some disclimax) 30 per cent.; and snow grass with intertussock spaces, intertussock spaces, and larger half-bare areas 9, 27, and 2 per cent. As before, it was the latter 38 per cent. which provided most of the grazing, at an intensity of almost 4 sheep per acre. Quadrat measurements of these grazed areas gave their approximate composition as 41 per cent. bare ground, 21 per cent. litter, and 38 per cent. minor herbs. The minor herb component reduces the area actually grazed for most of the time to about 87 acres, which gives an effective stocking rate of approximately 10 sheep per acre for the season.

Seedling regeneration of the snow grass is effectively prevented by the high degree of utilization of seedheads (more than 90 per cent. eaten in the Daner's Gap area in the summer of 1955–56), by the selective grazing of the few seedlings which appear at the edge of the tussocks, and by the unfavourable microclimate of the intertussock spaces as regards extremes of temperature, wind, and humidity. In the case of many of the palatable minor herbs, on the other hand, their free-seeding habit or ability for rapid propagation enables them to persist almost until erosion has reached the underlying rotten rock. This fact—that grazing can still be obtained despite soil deterioration—is one of the main reasons for graziers' claims that grazing is not harming catchment values. Here the implicit assumption—often quite valid under lowland conditions—is that grazing and catchment values are directly related. On the Australian Alps, however, a condition of widespread moderate catchment deterioration is the one which, apart from an improved pasture, now most favours the grazier (Plate 1, Fig. 2 and Plate 2, Figs. 1 and 2).

In the alpine herbfields most of the grazing also occurs on damaged areas and in snow patch situations. The badly damaged Gungartan area north of Kosciusko, and Mts. Hotham and Feathertop near the Bogong High Plains, are good examples (Plate 3, Fig. 1).

The bogs and fens, apart from very wet ones dangerous to stock, are almost always overgrazed, the more so the smaller their percentage in a given area. This varies from less than 1 per cent. in drier forest country to more than 10 per cent. on some of the wetter subalpine and alpine plateaux. The summit area of Mt. Kosciusko, supposedly closed to livestock since 1944, exemplifies how selective this grazing of bog- and fen-land can be. Although this area is now legally closed to grazing, the lack of protective fencing and adequate policing results in the return of at least a few head of cattle every year. In the summer of 1955–56, about 30 head were present.* In terms of the snow patch areas, bogs, and fens, even this number of livestock is high. These cattle stayed during virtually all of the fine weather on, or in the neighbourhood of, about 5 acres of fen south-west of Mt. Kosciusko. Of this area, about 2 acres have been eroded away, so that most of the grazing came from about 3 acres. This intensity of 10 head of cattle per acre seems almost impossibly high, but locally it is not unusual. Most of these favoured areas are deteriorating even though much of the surrounding country may remain in reasonable condition (Plate 3, Fig. 2, and Plate 4, Figs. 1 and 2).

* The previous year several hundred head were present.

Thus, it is obviously unrealistic to assess stocking rates in terms of total area of lease, as only a fraction of the lease is actually being grazed. It is also clear that the small fraction of country supplying the grazing is often being grazed at high intensities, in many cases higher ones than highly improved pastures would be able to sustain without damage. Consequently, many of these heavily grazed areas are deteriorating to the detriment of catchment values. The paradoxical situation has developed where the areas least able to stand grazing are being heavily grazed, whilst the more extensive sound areas better able to stand grazing are supporting very few stock. This is one of the key problems in any attempt to place high country grazing on a permanent basis.

IV. Choice of Livestock

Choice of livestock has been regarded as much less of a problem in the Australian Alps than in many high mountains overseas. No serious attempt has been made to evaluate the relative suitability of sheep and cattle for the various grazing types, choice of livestock in general having been determined by natural hazards. Thus, the more remote or rugged mountains, where dingoes are usually a problem, support cattle, whilst the more easily accessible mountains support sheep.

On the other hand, it is assumed on the basis of the serious damage caused by the very heavy sheep concentrations during drought years that grazing by sheep is more harmful to catchment values than grazing by cattle. The elimination of sheep from the Bogong High Plains area is partly due to this assumption.

An examination of conditions in the field shows that whether sheep or cattle are more harmful depends largely on the nature of the grazing type. Considering the snow gum and snow grass country as a whole, sheep are more harmful than cattle, because of their closer grazing of the intertussock spaces. Similarly, grazing by cattle would be less harmful on some of the lower high plains below 4500 ft which, because of their uniformity and low elevation, might be capable of limited grazing use without damage. Here cattle would provide better utilization of the coarser, taller type of pasture necessary for maximum detention and infiltration of water into the catchment area.

On the other hand, soft wet places such as bogs, fens, and the snow patch areas, and very steep sidlings, are more seriously damaged by trampling, which is more severe with cattle than sheep.

V. Pasture Improvement and its Consequences

The problem of localized grazing can at this stage be resolved into two main issues. If grazing is to become more efficient it must first be made more uniform so that most of the total area is being utilized. This introduces the second issue—more uniform grazing will require that the widespread unpalatable snow grass be made palatable or that it be replaced by an improved pasture. Experience in the Australian Alps now indicates that the establishment of pastures of recognized grazing value offers the greater possibilities. There is no doubt from several accidental and intentional trials that, given suitable conditions including an adequate soil nutrient level, a considerable number of species can establish and persist (e.g.

Trifolium repens, *T. fragiferum* L., *Poa pratensis*, *Agrostis tenuis*, *Anthoxanthum odoratum* L., *Dactylis glomerata* L., *Festuca rubra* L., *Holcus lanatus* L., *Lolium perenne* L., and *Phleum pratense* L.).

Costs of pasture establishment and management would, however, be high. At least 30*s*. per annum would be required for the purchase, transport, and spreading of superphosphate at the low rate, under mountain conditions, of one hundredweight per acre. The erection and maintenance of adequate protective and subdivisional fencing to exclude the vulnerable bogs, fens, springs, soaks, snow patch areas, very steep places, damaged sections, and other critical areas as regards catchment values would also be costly. In the case of the Bogong High Plains of Victoria (which are rather more uniform than most of the Australian Alps) an area of approximately 55½ square miles would require an estimated 300 miles of fencing.* If it is assumed that fences last about 20 years, this represents an annual fencing cost of about 5*s*. per acre which heavy maintenance under snow conditions would probably increase to about 10*s*. Additional expenses would include initial pasture establishment, rabbit control, improved access, and permanent buildings. Extensive batter stabilization trials by the Snowy Mountains Authority have confirmed that conventional methods of pasture improvement would have to be modified so that the soil surface and seedlings were protected against frost-heave which is unusually severe on the Australian Alps. This would mean establishment under the protection of a mulch, either of straw or through sod seeding or spot-sowing between tussocks. Under conditions of improved pasture, rabbit control would also be necessary, at least below 5000 ft, for rabbits, like domestic livestock, do not find the native snow grass pastures palatable and become well established only in areas which have been damaged or disturbed in such a way that the snow grass is replaced by minor herbs. Essentially the same conclusions have been reached independently by Dr. W. Howard of the University of California, who has been studying the rabbit problem in New Zealand.

On the basis of these figures, considerably more than £2 per acre per annum would be required for the development of typical high mountain country as improved pasture. Opposed to this, present and potential values of grazing from these areas vary between only 5*s*. and 20*s*. per acre per annum (according to whether the estimate is made on a current rate-of-agistment basis or on the gross value of production of wool and meat). This represents as little as 0·1–0·3 per cent. of the value of production of wool and sheep and cattle meats in Victoria and New South Wales (approximately £335,000,000 in 1954–55) (Australian Academy of Science 1957).

According to Taylor (1956) the grazing industry in approximately 1,000,000 acres of the Snowy Mountains area would have to produce wool and meat to the value of more than £29 4*s*. 0*d*. per acre per annum to compete with the estimated value of water in terms of hydro-electric power and irrigation products. Further analysis of this problem (Australian Academy of Science 1957) indicates that this value should be almost doubled, and it could be increased still further if the enormous indirect values of irrigation water and hydro-electric power are also considered. Against these values, the estimates of 5*s*. to 20*s*. per acre per annum for grazing values represent a very small fraction. A corollary of this is that if grazing reduces the

* Estimate based on vegetation boundaries (Costin 1957*a*, Fig. 2).

potential value of water by as little as 1–3 per cent. it is not an economic proposition, apart from the fact that grazing itself might be economically unsound. Although precise figures on this problem cannot be given in the absence of detailed stream flow and soil loss data for early years, field evidence is widespread that grazing has reduced catchment values by far more than this small amount (cf. Costin 1954, 1957*a*). Furthermore, extensive pasture improvement, even if economic, would mean that the thick coarse sward of snow grass tussock would be replaced by a much shorter one. This replacement would be significant as regards water yield since surface detention of water, a function of surface roughness, is directly correlated with infiltration rate, and is thus important for ground water recharge and sustained stream flow. Measurements now in progress (Costin, unpublished data) to ascertain the relative value of snow grass and short-grazed improved pasture in this regard, show that overland flow is uncommon with a dense cover of snow grass but it is quite common on an improved pasture sward. Thus, extensive replacement of snow grass by a shorter sward could hardly be justified, unless increased grazing returns more than offset the soil and water losses due to more erratic stream flow.

It is concluded, therefore, that present-day grazing in the Australian Alps is not compatible with the preservation and improvement of catchment values, and that the requirements of properly adjusted grazing would be so costly in most areas as to make it uneconomic under existing conditions. In the small minority of areas possibly capable of economic development as a sound catchment–grazing proposition (i.e. some of the lower, more uniform high plains below 4500 ft) catchment deterioration would first need to be arrested. Even then the changed hydrological conditions resulting from large scale pasture improvement would most likely detract from catchment values.

VI. Related Problems on Freehold Land

It would be unrealistic to assume that the management of the snow country primarily as a catchment area, by removal of livestock from most of it, would impose no hardships on a number of run-holders and snow-lessees. At the same time, it is now forgotten that the snow country was first intended to serve primarily for drought relief, and not as a regular yearly supplement to lower freehold land. One effect of this changed emphasis from an intermittent to an annual demand is that a small minority of graziers has now become economically dependent on the snow country to the extent that their freehold land, at least in its present condition, does not in itself constitute a living area. More generally snow country grazing has tended to discourage the full development of lower areas, many of which are therefore in a comparatively neglected condition. This is particularly evident in the Monaro Region of New South Wales.

It will be accepted by all that economic dependence on short-term leasehold land is most undesirable both for the grazier and for the community. No grazier can be expected to invest money in permanent improvements on country for which there is little or no security of tenure. Hence land use is exploitative, being based on short-term management policies such as periodic burning designed to obtain immediate if transitory returns. With its much shorter history of settlement, however, Australia is more fortunate than longer-settled countries like Italy, Spain, Switzerland, and even North America, where over the centuries a considerable population has become economically dependent on high mountain grazing, to the extent that fully effective remedial action cannot be taken by the governments concerned. In Australia, high country grazing could easily be terminated without affecting the grazing industry as a whole. In the case of the small minority of graziers for whom economic difficulty would result, suitable readjustments could be made, largely through the application of scientific farm planning methods to freehold land. This aspect of the problem calls rather for more adequate extension services than for further research.

VII. Acknowledgments

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Explanation of Plates 1–4

Plate 1

Fig. 1.—Natural forest meadow, near Sawpit, Kosciusko, showing heavy local overgrazing. The adjacent forest is relatively ungrazed.

Fig. 2.—Damaged snow grass pasture, near Daner's Gap, Kosciusko, showing the distribution of the snow grass tussocks (largely ungrazed) and the heavily grazed intertussock spaces carrying sorrel. Regeneration of snow gums after fire has been prevented by selective grazing by sheep.

Plate 2

Fig. 1.—Selective grazing by sheep of snow gum shoots regenerating from the crown of a recently burnt tree, near Prussian Creek, Kosciusko.

Fig. 2.—The whole area shown was burnt by the bushfires of 1939. The area to the left (part of the Hotel Kosciusko Water Reserve) was fenced off from grazing immediately after the fire, and good vegetative regeneration has taken place. On the adjacent area since grazed by sheep, tree regeneration is largely absent.

PLATE 3

Fig. 1.—Typical alpine grazing country on the Kerries, north of Mt. Kosciusko, showing selective grazing of snow patch area (marked by *Montia australasica* in flower).

Fig. 2.—Damaged fen near the Kerries, showing locally heavy overgrazing. The attractive plant is *Carex gaudichaudiana*.

PLATE 4

Fig. 1.—*Sphagnum* bog damaged by heavy selective grazing by cattle. Feathertop Razorback, Vic.

Fig. 2.—Part of a bog near Smiggin's Holes, Kosciusko, showing selective grazing of *Carex gaudichaudiana* growing through the *Sphagnum* moss. The adjacent snow grass is ungrazed.