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VEGETATION OF HIGH MOUNTAINS IN AUSTRALIA IN RELATION TO LAND USE

by

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Introduction

Australia, although predominantly a country of low relief, low rainfall, and arid and semi-arid vegetation and soils, also contains considerable areas of elevated land which regularly receive heavy snowfalls and where the vegetation and soils are distinctly "high mountain" in character. The lower limit of this high mountain country is defined naturally by the winter snow line; this varies from about 5,500 to 5,000 feet in the Australian Capital Territory and New South Wales to about 4,500 feet in southern Victoria and 3,000 feet in Tasmania. The total area above the winter snow-line on the Australian mainland is about 2,000 square miles of which approximately 1,000 square miles are in New South Wales, 870 square miles in Victoria, and 140 square miles in the Australian Capital Territory. (Fig. 1). In Tasmania, the area of snow country aggregates about 2,500 square miles. Most of this discussion deals with mainland conditions as information on the Tasmanian high mountain vegetation is too incomplete to enable more than passing reference to be made at this stage.

In addition to the intrinsic interest of the Australian high mountains and their vegetation they are of great importance to the national economy on account of the large and reliable rivers which have their headwaters there. As seen from Fig. 1 these include the Cotter River in the Australian Capital Territory; the Goodradigbee, Upper Murrumbidgee, Upper Murray and Snowy-Eucumbene systems in N.S.W.; and the Upper Murray, Goulburn, Tambo, Mitchell, Macalister-Thomson-Latrobe, and Yarra River systems in Victoria. The great potential of these areas to supply water for irrigation and hydro-electric power and for domestic and industrial use is now being developed on an increasing scale.

The High Mountain Environment

The high mountain environment is naturally defined as that situated above the winter snowline where the ground is usually snow covered continuously for not less than one month of the year.


146° E.
147°
148°
149°
150°
35°
36°
37°
38°
38° S.
NEW SOUTH WALES
A.C.T.
VICTORIA
Murrumbidgee R.
Wagga Wagga
Gundagai
Burrinjuck Res.
Tumut R.
Tumut
Goodradigbee R.
Canberra
MT. COREE
Cotter Dam
MT. FRANKLIN
MT. TIDBINBILLA
Shoalhaven R.
Yanko Ck.
Jerilderie
Billabong Ck.
BOGONG PEAK
GRANITE MT.
MT. MURRAY
Murrumbidgee
TINDERRY MT.
TUMUTBULLA MT.
Holbrook
Tumbarumba
YAOUK PK.
MT. CLEAR
Kiandra
Tocumwal
Murray R.
L. Mulwala
Corowa
Yarrawonga
Albury
Wodonga
Hume Res.
Tallangatta
Murray R.
MT. JACUMBA
THE DARGALS
Corryong Ck.
Corryong
JAGUNGAL
GUNGARTAN
KALKITE MT.
Adaminaby
Cooma
Umaralla R.
BALD MT.
Tuross R.
Wangaratta
Beechworth
Kiewa R.
Mitta Mitta R.
Mitta Mitta
MT. BENAMBRA
MT. KOSCIUSKO
MT. LEO
MT. PINNIBAR
MT. GIBBO
Jindabyne
Snowy R.
Paupong
Benalla
Broken R.
King R.
Buffalo R.
Myrtleford
Bright
MT. BOGONG
BOGONG HIGH PLAINS
MT. BUFFALO
Rose R.
MT. FEATHERTOP
MT. HOTHAM
MT. COPE
MT. WILLS
MT. MISERY
Indi R.
THE PILOT
MT. COBBERAS
Bega
Euroa
Bombala
MT. TINGIRING
Eden
Mansfield
MT. COBBLER
Delatite R.
MT. BULLER
THE TWINS
MT. TABLETOP
MT. TAMBO
Omeo
Tambo R.
MT. PARSLOW
Eildon Res.
Goulburn R.
Howqa R.
BARRY MTS.
MT. HOWITT
HOWITT PLAINS
Alexandra
MT. TORBECK
EAGLES PK.
THE BLUFF
MT. CLEAR
SNOWY PLAINS
MT. SKENE
MT. KENT
Dargo R.
Swifts Creek
MT. DELUSION
Snowy R.
Genoa R.
Acheron R.
LAKE MT.
MT. SHILLINGLAW
MT. ARBUCKLE
MT. WELLINGTON
Maroondah Res.
MT. MATLOCK
Thompson
MT. SELMA
MT. USEFUL
Yarra R.
Warburton
MT. BAW BAW
Macallister R.
Avon R.
Mitchell R.
Bruthen
Orbost
Latrobe R.
Noojee
Glenmaggie Res.
Walhalla
Maffra
Bairnsdale
10 0 10 20 30 40 MILES

This environment includes two well-defined tracts, subalpine and alpine. The subalpine tract, extending from the lower level of the winter snow line to the treeline, is normally snow-covered continuously for about 1—4 months. The alpine tract, extending from the tree-line upwards, is snow-covered for longer periods, and locally in protected snowpatch situations for most of the year. Large areas of the Australian Alps were glaciated in Pleistocene times but today permanent ice- and snow-fields no longer exist. (Plates 1 and 2).

Often blowing with gale to hurricane force, the prevailing north westerly to south westerly winds, associated with cyclones originating in the Antarctic, bring most of the precipitation which falls mainly as snow with a relative winter incidence. In summer, heavy rainstorms are also common. In the sub-alpine tract the average annual precipitation varies from about 30 to 80 inches and the number of rain days from about 120 to 140. In the alpine tract precipitations range from about 70 to 120 inches per annum, with about 130 to 150 rain days. It is of interest to record that precipitations do not decrease at the higher levels as they commonly do on higher mountains overseas.

Mean monthly maximum temperatures rise to about 60—75° F. in midsummer in the subalpine tract and probably about 50—60° F. in the alps. The corresponding mean monthly minima fall to about 25—30° F. and to less than 25° F. in mid-winter, and do not exceed freezing point for about 6 and 6 to 8 months of the year respectively. During the snow free months, however, when there is often a regular alternation of warm days and freezing nights, daily temperature fluctuations are considerably higher and lower than the monthly means would indicate, the diurnal range not infrequently approaching 50° F. or more.

Geologically, the Australian high mountains show considerable variation, all of the main rock types such as acid granites, slates, basalt and limestone being represented. In contrast to Europe, however, the high mountain soils and vegetation are not strongly differentiated according to rock type, similar plant communities and soils being developed on quite different rocks. Thus, of the eight well-defined soil groups (COSTIN, 1954), alpine humus soils, lithosols, grey podsols, acid marsh soils, snow patch meadow soils, bog peats, poor fen peats and humified peats, the alpine humus soils develop as the climatic climax on all kinds of parent material. These soils, although strongly acid and base unsaturated, are neither peaty nor podsolised, and in contrast to the mountain soils of Britain and Scandinavia which are considered to be undergoing progressive base depletion leading to moor formation and further restriction of high mountain species, they appear to be stabilised against further leaching by a small but significant return of bases and mineral matter by decomposing herbs and earthworm activity

(COSTIN, HALLSWORTH & WOOF, 1952). Compared with the high mountains of Europe, moreover, where the surfaces are predominantly peaty or rocky, the Australian Alps are in the nature of soil mountains with soil and decomposing parent material often many feet in depth. This stronger soil development in Australia is related to the milder glacial history, the gentler slopes, the favourable climate for soil weathering and the unusually vigorous biological conditions in the soil. The association of these deep organo-mineral soils with summer storms of high intensity and wide daily temperature fluctuations capable of causing frost heave constitutes a high natural erosion hazard, necessitating great care in land use, if stability is to be maintained.

Conditions in Tasmania differ in several main aspects from those on the mainland. Most of the Tasmanian snow country consists of a large central plateau of resistant dolerite, with the smaller Ben Lomond massif in the northeast. The climate is distinctly more oceanic, especially in summer, and the long dry spells broken by summer thunderstorm activity are not so marked. In drier sites, the soils are shallow and stoney, and in wetter situations, peaty with gleyed or podzolised mineral layers beneath. Thus, there is little or no development of the "soil mountains" found on the mainland. In general appearance, the Tasmanian mountains resemble parts of the British mountains more than the Australian Alps.

Flora and Fauna

The high mountain flora and fauna* differ greatly from those of the rest of the continent, not only in their ecology but also in their unique spectra of life-forms, geographical origin, and evolution.

Many of the high mountain plants show much the same adaptations to alpine conditions as are found in other countries, such as nanism (dwarfing), the rock-clinging habit, bright and conspicuous flowers, perenniality, the tussock habit, ericoid, divided and lanceolate leaves, spinescence, strong vascular development, pubescence, and physiological resistance to fluctuating high and freezing temperatures, intense insolation, fierce winds, periodic moisture stress, and burial by snow.

The geographical affinities of the flora are best considered in terms of the following main elements: Australian, South African, Zealandic, Andine, Palaeo-antarctic, Palaeotropic and Cosmopolitan (including the European element). The distribution of these elements in the high mountain tracts (alpine and subalpine) compared with their distribution in the lower montane and tableland areas is shown in the case of the Monaro Region of New South Wales, which

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* Detailed lists are given in COSTIN (1954).

Table I

Geographical elements of the flora of the Monaro Region

Tract	Geographical Elements														Total No. of Species
	Australian		South African		Zealandic		Andine		Palaeo-antarctic		Palaeo-tropic		Cosmopolitan		
	No. spp.	%	No. spp.	%	No. spp.	%	No. spp.	%	No. spp.	%	No. spp.	%	No. spp.	%	
Tableland (2,000-3,000 ft.)	193	50.2	9	2.3	4	1.0	7	1.8	2	0.5	34	8.8	136	35.4	385
Montane (3,000-5,000 ft.)	242	53.1	10	2.2	6	1.3	8	1.8	5	1.1	33	7.2	152	33.3	456
Subalpine (5,000-6,000 ft.)	93	35.6	11	4.2	10	3.8	5	1.9	11	4.2	6	2.3	125	48.0	261
Alpine (> 6,000 ft.)	58	30.6	5	2.6	15	7.9	7	3.7	15	7.9	2	1.1	88	46.2	190
Total Monaro	360	49.6	16	2.2	20	2.8	13	1.8	20	2.8	49	6.7	248	34.1	726

contains the largest and highest parts of high country on the mainland (Table I).

It will be seen that the total flora of the Monaro Region is composed largely of Australian and Cosmopolitan species but the relative proportions of these and the other elements change characteristically with increasing elevation. In the tableland and montane floras Palaeotropic species are prominent and species with southern affinities unimportant, in keeping with the relative mildness of the past and present climates of these lower tracts. In the subalpine and alpine floras, on the other hand, in which severe climatic conditions have operated, there is a marked increase in the proportions of the Zealandic, Andine, Palaeoantarctic and Cosmopolitan species at the expense of those with Australian and Palaeotropic affinities.

Analysis of the life-form composition of the flora (Table II) by the method of RAUNKIAER (1934) is also instructive. Developed in Northern Europe, this method assumes that the unfavourable winter season of the year limits plant distribution and that the extent of this limitation is expressed in the life-form composition of the flora, which can thus be used to define characteristic "plant climates". In the case of the Monaro Region, however, neither the tableland nor the montane floras have any counterpart among RAUNKIAER's characteristic plant climates of the Northern Hemisphere. This is not surprising in view of the milder climate, both past and present, which these areas have experienced. On the other

Table II

Biological spectra of the flora of the Monaro Region.

Flora	No. of Spp.	Percent Distribution of the Species among the Life-forms										
		MM	M	N	Ch	H	G	HH	Th	S	E	Pt.-Qt.
Tableland (2,000-3,000 ft.)	373	7	9	21	12	23	11	7	9	0	1	0.8
Montane (3,000-5,000 ft.)	439	6	8	24	14	20	12	10	5	0	1	1.0
Subalpine (5,000-6,000 ft.)	255	1	1	18	16	32	13	9	10	0	0	0.6
Alpine (> 6,000 ft.)	184	0	0	1	31	41	10	8	9	0	0	0.8
Total Monaro	703	5	7	21	16	23	11	8	8	0	1	0.8
Raunkiaer: Normal Spectrum	400	6	17	20	9	27	3	1	13	1	3	1.0

hand, the subalpine and alpine floras show spectra which can be matched with RAUNKIAER's, the subalpine spectrum approximating to his Hemicryptophyte and Chamaephyte Climate of the European Boreal Zone and of the European Alps at an elevation of about 6,000 feet, and the alpine spectrum to the Chamaephyte Climate of the Arctic Zone verging on the Arctic Nival Region. Thus, with increasing cold in the subalpine and alpine tracts, there is a characteristic increase in the proportions of cold-resistant hemicryptophyte and chamaephyte life-forms, as in Northern Europe.

In the absence of much palynological and radio-carbon data providing direct evidence bearing on the evolution of the flora and fauna, it is impossible to do more than suggest the most likely course of evolution, in the light of geological and bio-geographical evidence. During most of the Tertiary, south-eastern Australia experienced a tropical to subtropical climate which in the prolonged Early and Middle Miocene Stillstand produced virtually a peneplain surface with extensive laterisation. Apart from a minor uplift in the Late Miocene, these conditions persisted until the commencement of the Kosciusko Uplift in the Late Pliocene when extensive physiographic, climatic and biological differentiation began. Up to this time a high mountain flora and vegetation would not have been able to exist on the Australian mainland. During the Early Pleistocene an ice-cap formed on the Kosciusko Plateau and smaller glaciations affected considerable areas of the Victorian Alps. Under these conditions the winter snow-line is estimated to have descended as low as about 3,000 feet in the Kosciusko area (2,000 feet lower than at present); it would have been as low as 2,000 feet in parts of Victoria, and from 1,000 feet almost to sea level (near Port Davey) in Tasmania. As Tasmania was then connected to the mainland by recently-emerged land bridges which, being largely unvegetated, would provide suitable conditions for the invasion and spread of mountain plants, this large-scale lowering of the winter snowline would have provided virtually continuous "high mountain" conditions from the sub-antarctic extensions of Tasmania to Victoria and New South Wales. Under these conditions, the broad outlines of the plant communities as they occur in the high mountains today probably took shape. Glacial recessions and the re-development of smaller glaciations during the Pleistocene would have produced various range changes and discontinuities of vegetation, and the final glacial recession of Late Pleistocene-Earlier Recent Time would have produced the distribution patterns much as they occur today.

The impact of the native fauna on the development of the flora and vegetation appears to have been largely negative. The larger marsupials were only occasional summer influents, and grazing pressure from this source would have been very slight. With the advent of the white settler on the tablelands surrounding the mountains, however, new species and new practices of land use were superimposed. A considerable number of exotic plants and animals have now become naturalised, the latter, including the hare, rabbit, brumby (wild horse), fox and feral cat, now dominating the fauna and exerting a considerable influence on the vegetation. Apart from these "accidental" effects of white settlement, the major influence has been the practice of summer grazing of sheep, cattle and occasionally horses with the associated practice of "burning off" the high mountain vegetation to improve its palatability. The effects of these practices on the native vegetation and soils, and their compatibility with the now more important need to conserve water-supply, recreational and scientific values is discussed later.

Description of the Vegetation

As in other countries there is a distinct zonation of vegetation on the Australian Alps with increasing elevation. In most areas the zonation is masked at the lower levels by the fact that precipitations still remain high, but in certain localities, notably the Benambra-Omeo-Bogong area in Victoria and the Monaro Tableland-Snowy Mountains area in N.S.W., the lower tracts receive little precipitation and a full climatic sequence of soil and vegetation is developed. The best examples are found on the eastern slopes of the Snowy Mountains from the highest point at Mt. Kosciusko (7,328′) to the dry rain-shadow areas about 30 miles eastwards around Berridale and Dalgety (less than 3,000′). This sequence is depicted in Fig. 2. It will be seen that between the extremes of Berridale with an average annual precipitation of about 20″ and a mean annual temperature of about 54° F. and Mt. Kosciusko with an average annual precipitation of about 120″ and a mean annual temperature of about 36° F., the vegetation and soils range from dry tussock grassland with arid-climate soils resembling brown soils of light texture, progressively through open savannah woodland with slightly podzolised grey-brown podzolic soils, dry sclerophyll forest with distinctly podzolised iron podzols, wet sclerophyll forest with brown podzolic soils and transitional alpine humus soils (resembling acid brown forest soils), into the high mountain subalpine woodland with unpodzolised alpine humus soils giving way above the tree line to tall alpine herbfield on similar soils.

Within the sub-alpine and alpine tracts shown in Fig. 2 as dominated by sub-alpine woodlands and tall alpine herbfields, topographic and geological variation give rise to a large number of other high mountain communities including sod tussock grassland, heaths, bogs and fens (swamps), fjaeldmark (fell field vegetation), chomophyte communities (vegetation of cliffs, rock ledges, etc.), and snow patch vegetation (Plates 1 & 2). These communities are briefly described below.

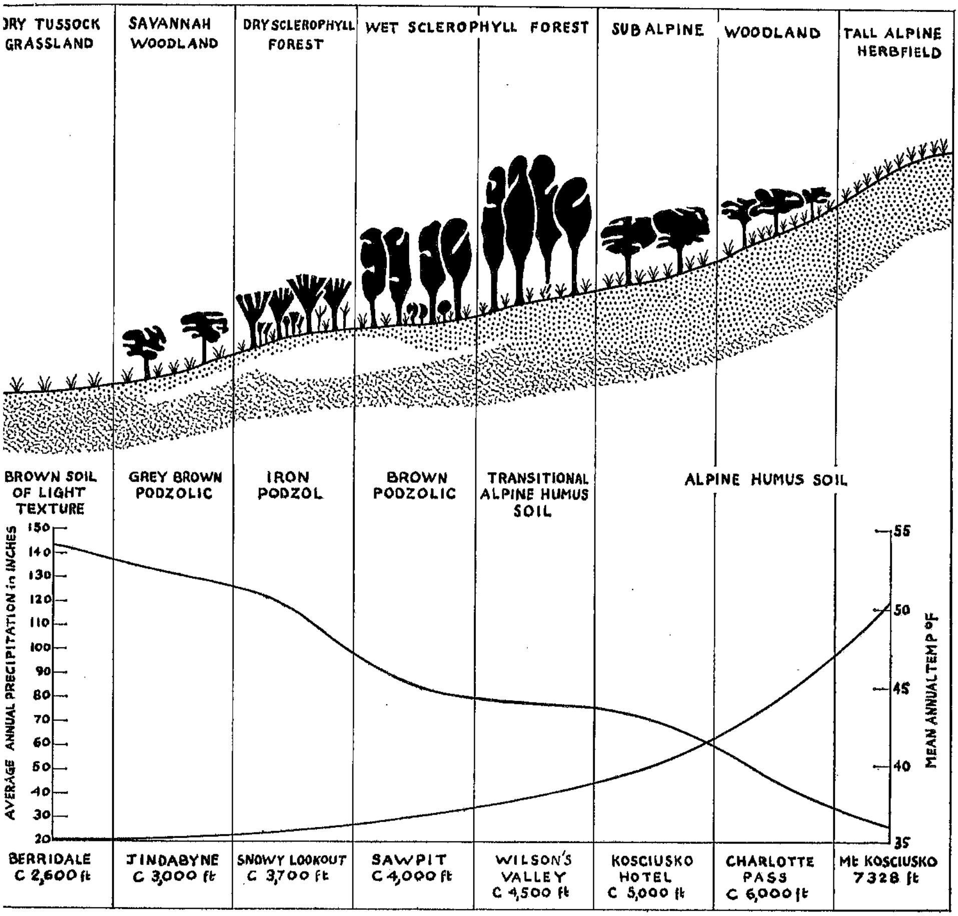

Fig. 2. Climatic sequence of vegetation and soils, Monaro Region of New South Wales.

Subalpine woodland: *Eucalyptus niphophila* alliance.

Subalpine woodlands of the *Eucalyptus niphophila* (snow gum) alliance are the climatic climax of the subalpine tract. They dominate the greater part of the high mountain country under discussion and form the tree-line vegetation in the highest areas. The upper limit of tree-growth varies between about 6,500 feet on Jagungal north of Mt. Kosciusko, to a little more than 6,000 feet on the Kosciusko Plateau, down to 5,750 and 5,500 feet on the more southern Victorian mountains of Bogong, Buller and Stirling. Exposed, isolated summits or their windward aspects are commonly bare of trees to considerably lower levels, as on Mt. Cobbler (5,342′) and Mt. Wellington (5,355′)

in Victoria. Another interesting latitudinal variation which appears in the southerly subalpine woodlands of the Baw Baw Plateau is the presence of myrtle beech (*Nothofagus cunninghamii* OERST.), a species which is entirely absent from New South Wales, and which elsewhere in southern Victoria occurs only under montane conditions. Its presence in the sub-alpine tract of the Baw Baws is related to the higher humidities and greater cloudiness of this area. It provides a strong link, together with an interesting group of Tasmanian species, with conditions in Tasmania, where the myrtle beech often ascends to the treeline as a scrubby rainforest in the moister subalpine environments, with scrubs of the endemic Tasmanian eucalypt *Eucalyptus coccifera* HOOK. f. in drier situations. In Tasmania endemic conifers (e.g. *Arthrotaxis cupressoides* DON.) may also be present as co-dominants and in pure stands giving the Tasmanian subalpine vegetation a quite different physiognomy from the subalpine woodlands of the mainland.

Mature communities of the *Eucalyptus niphophila* alliance are parklike in character with spreading single-boled snow gums underlain by a dense herbaceous stratum with relatively few shrubs except in locally more rocky situations where shrubs are more common. This original structure has been much modified by bush fires and intentional burning designed to improve the palatability of the native snowgrass. The addition of grazing influences complicates the picture further.

It so happens that sheeps (but not cattle) are fond of the new snow gum shoots and these are persistently nibbled back when a tree is attempting to make new growth after a fire or when a seedling is attempting to establish itself. If this defoliation is frequent enough the ligno-tuber fails to regenerate. In this way large areas of snow gum country have been made treeless and additional areas now regenerating with difficulty will soon become treeless if current grazing practice continues. Once snow gums in an area have been killed and the seed reserves exhausted, recovery takes place slowly and with difficulty. In initially difficult snowgum environments, furthermore, as near the treeline and next to frost hollows, it is problematical if natural regeneration can ever be achieved, as the removal of the woodland en masse creates more extreme climatic conditions as regards exposure to wind and frost which exceed the tolerance of the snowgum species.

Tall alpine herbfield: *Celmisia longifolia-Poa caespitosa* alliance.

At about 5,500 to 6,500 feet, depending on latitude, the subalpine woodlands give way to treeless communities of which the *Celmisia longifolia-Poa caespitosa* tall alpine herbfield alliance is the alpine climatic climax. Its most extensive development in Australia is

PLATE I

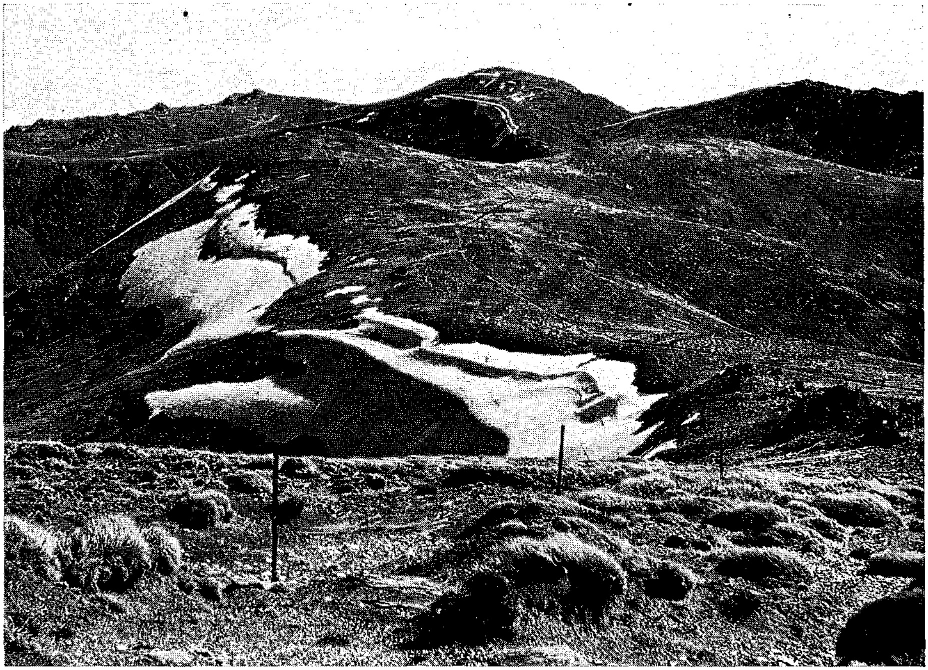

Plate 1. Alpine landscape, Kosciusko, showing typical distribution pattern of some of the vegetation. Climatic climax tall alpine herbfield has the widest occurrence: the community in the foreground has been seriously damaged following heavy grazing. Short alpine herbfield occurs below the snow patches, and fjaeldmark communities along the upper margins of the snowpatches and on the adjacent windswept cols. Chomophyte herbfield vegetation is abundant on the steep slopes of the rocky mountain shown on the right. Bogs, fens and grassland develop along the poorly drained valleys below the snow patches. Moraine and similar rocky environments (not shown) support heaths.

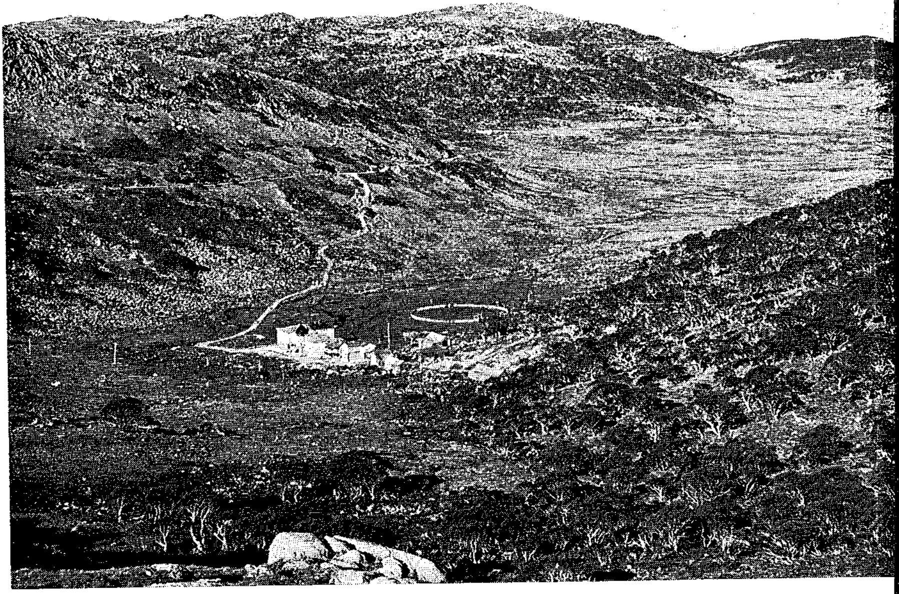

Plate 2. Typical subalpine landscape and vegetation pattern, Kosciusko. Subalpine woodland covers most of the slopes with heaths in rockier situations. Grassland, bogs, fen, and wet heath occupy the valley floor. A few of the surrounding peaks rise just above the tree-line into tall alpine herbfield.

in the Kosciusko area but it is also well developed in Victoria in the Bogong High Plains area, on Mts. Buller and Stirling, Pinnibar, Gibbo and the Cobberas, and on the leeward slopes of Mt. Speculation, the Crosscut Saw, Mt. Howitt, Mt. Magdala, Mt. Lovick and The Bluff. The occurrence of alpine herbfield as a climatic climax over a wide range of rocks from basalt to granite, sandstone and slate, means that the influence of parent material is relatively slight. This is in strong contrast to the corresponding herbfield vegetation of Europe which develops mostly in association with rocks or ground waters of adequate base status. Under the moist climatic conditions of the British and Scandinavian mountains, furthermore, progressive base depletion and mor formation are thought to be further restricting the already limited distribution of this type of vegetation. On the Australian mainland, on the other hand, the herbfield communities appear to be in stable equilibrium owing to the special soil stabilising processes of base and mineral circulation referred to previously.

Mature communities of this alliance usually consist of a continuous sward of herbs with associated minor chamaephytes; in summer time the massed flowering of *Celmisia longifolia* and similar flowering forbs (species of *Ranunculus, Gentiana, Euphrasia, Wahlenbergia, Brachycome, Craspedia, Erechtites, Podolepis, Helichrysum* and *Senecio*) presents pictures of striking colour, variety and beauty. Modification by grazing with occasional fires has virtually eliminated several palatable co-dominant herbs which old records show to have been important about the turn of the century, notably *Aciphylla glacialis* and *Danthonia frigida*. This stage of floristic modification has now proceeded in most areas towards structural change involving the opening up of the continuous sward with the appearance of minor herbs. Many of the most severely damaged and/or unfavourably situated areas have been eroded down to the underlying rock mantle as on parts of the Kosciusko Plateau, and the destruction is increasing each year. When such extensive depletion occurs, natural recovery may be impossible except over a long period of geological time.

Tall alpine herbfield: *Brachycome nivalis-Danthonia alpicola* alliance.

In crevices, rock ledges and similar steep rocky situations the closed herbfield communities of the *Celmisia longifolia-Poa caespitosa* alliance give way to chomophyte vegetation of the *Brachycome nivalis-Danthonia alpicola* alliance. These communities usually have a fragmentary distribution, often forming small colonies of a single species. They occur through the alpine areas of the Australian Alps but particularly on the steeper mountains such as Bogong and

Feathertop where the chomophyte habitat is well developed. The relative inaccessibility of these communities has protected many of them from grazing influences.

Short alpine herbfield: *Plantago muelleri-Montia australasica* alliance.

On leeward aspects on the highest mountains of the alpine tract where the snow drifts heavily and persists for at least eight months of the year other distinctively alpine communities develop: the lower snowpatch situations irrigated by the melt waters from the snow patch support a short carpet-like vegetation of the *Plantago muelleri-Montia australasica* short alpine herbfield alliance and the drier rocky snow patch margins an open fjaeldmark vegetation of the *Coprosma pumila-Colobanthus benthamianus* alliance.

The short alpine herbfields attain their best development in the Kosciusko area and are not uncommon in the Victorian Alps on Mt. Bogong, the Bogong High Plains, Mt. Hotham, Mt. Feathertop, Mt. Stirling and Mt. Buller. Mature communities usually consist of a single continuous herbaceous stratum closely appressed to the soil surface in a mat-like fashion. Physiognomically, they are very similar to the more familiar snowpatch vegetation of Europe but differ in the comparative absence of dwarf woody chamaephytes such as the dwarf willows, and in the greater importance of flowering plants rather than mosses and liverworts.

These snowpatch communities are subject to heavy pressure even under natural conditions by virtue of the fact that they act as stabilising outwash aprons for the meltwaters from the snow patches. Once the surface mat is broken by livestock-trampling, however, and the evenly distributed surface flow from the snowpatch is channelised, gully erosion and drying out of the snowpatch vegetation advance rapidly often down to the underlying rock.

Fjaeldmark: *Coprosma pumila-Colobanthus benthamianus* alliance.

The upper snowpatch margins which rapidly dry out on becoming free of snow and for the remainder of the short snow-free season are exposed to drought and considerable daily temperature changes, support a very open fjaeldmark vegetation in which the mat plants *Coprosma pumila* and *Colobanthus benthamianus* are the characteristic dominants. The Kosciusko area is the only place on the mainland where this vegetation occurs. In other countries homologous communities ascend higher than any others to the level of permanent ice and snow; their presence in Australia is thus of considerable historical value. An interesting feature of the Australian fjaeldmark vegetation is the absence of cushion plants of the type found in Tasmania, New Zealand and the sub-Antarctic Islands. It seems unlikely, in the light of other phytogeographical evidence, that such plants failed to reach the mainland; post-glacial climatic changes towards drier summers, leading to the elimination of the cushion plants, is a more likely cause.

Fjaeldmark: *Epacris petrophila-Veronica densifolia* alliance.

Another fjaeldmark alliance, in this case characterised by *Epacris petrophila* and *Veronica densifolia,* also develops in the Kosciusko area, on the most wind-exposed alpine cols and summits. Unlike the fjaeldmark of the previous alliance, this community often exhibits a characteristic pattern of coseral development in which the vegetation is being renewed and destroyed simultaneously on the leeward and windward sides. This continuous process of destruction by wind and wind blast, and renewal, results in a slow migration of the community in the direction of the prevailing winds. In this way a given area of ground becomes successively bare and covered by fjaeldmark vegetation in its various upgrade and downgrade stages. The *Rhacomitrium* "heaths" of the British mountain tops show a similar pattern.

The Australian fjaeldmark communities are not attractive to livestock and have not undergone much modification.

Sod tussock grassland: *Poa caespitosa-Danthonia nudiflora* alliance.

The sod tussock grasslands of the *Poa caespitosa-Danthonia nudiflora* alliance are naturally closed communities dominated by the snowgrass and other perennial herbs. They occur both in the sub-alpine and alpine tracts mainly in the level and undulating situations of broad valleys and plateaux. In some cases excessive soil wetness is the limiting factor preventing the invasion by sub-alpine woodland or alpine herbfield but in most cases cold air drainage into broad valleys producing frosts lethal to the establishment of trees appears to be the main cause. Where cold air drainage is pronounced, as in the headwater region of the Murrumbidgee River, the lower limit of this alliance is depressed by as much as 1,000 feet below the normal sub-alpine level. Widespread in the Snowy Mountains, particularly in the Murrumbidgee headwaters and the Kiandra area, these communities also occur extensively in Victoria as on the Bogong High Plains, Dargo High Plains, Howitt Plains, Snowy Plains and similar areas further south. An interesting outlier of this alliance, apparently the northernmost of any size, occurs on the Barrington Tops of New South Wales.

Under natural conditions bare ground is rarely exposed in sod tussock grassland and when it is the bare area is of a small enough size to be overhung and protected by the leaves of adjacent tussocks.

This protection seems to be essential for the early ececis of the snowgrass which, though hardy in the adult stage, is extremely tender and susceptible to disturbance as a seedling. As in the snow gum and alpine herbfield country, fires and grazing have produced a general opening up of the tussocks with the development of inter-tussock spaces and more extensive areas of minor herbs, and shrubs. It is the area of minor herbs which now provide most of the palatable grazing.

Heath: *Oxylobium ellipticum-Podocarpus alpinus* alliance.

Locally exposed areas in the subalpine tract and very rocky environments both in the subalpine and alpine tracts such as rock outcrops, stream banks and glacial moraine support heaths of the *Oxylobium ellipticum-Podocarpus alpinus* alliance. The dominants of this alliance usually grow as dense shrubberies which under more extreme conditions of exposure to wind and cold frequently assume a rock clinging habit or become prostrate. The massed flowering of these communities in summer is one of the most spectacular sights in the mountains. Like the associated subalpine woodlands, the heathlands have been burnt frequently to secure more palatable grazing, resulting is a greater proportion of fire-favoured species. Where the fires have been frequent and combined with grazing, disclimax herbaceous communities have been produced and accelerated soil erosion has frequently followed. Closely related heath vegetation is also widespread in the high country of Tasmania where the rockier soils provide an ideal environment.

Heath: *Epacris serpyllifolia-Kunzea muelleri* alliance.

The heath communities of the *Epacris serpyllifolia-Kunzea muelleri* alliance, unlike those described above, are found on poorly aerated but not necessarily wet soils of level to gently sloping situations both in the alpine and subalpine tracts. The dominants themselves usually grow less densely so that a subordinate grassy herbaceous stratum often develops. Unlike the *Oxylobium-Podocarpus* heaths the *Epacris-Kunzea* heaths are not particularly fire-resistant and consequently they may be largely eliminated by frequent fires. On the other hand, deterioration of climax grassland communities in the vicinity with resultant exposure of bare soil commonly leads to invasion by *Kunzea muelleri*.

Bogs: *Epacris paludosa-Sphagnum cristatum* alliance; *Carex gaudichaudiana-Sphagnum cristatum* alliance.

Two bog alliances have been studied in the Australian Alps: the

Epacris paludosa-Sphagnum cristatum raised bog alliance and the *Carex gaudichaudiana-Sphagnum cristatum* valley bog alliance. In their active condition the raised bogs consist of alternating moss hummocks and hollows associated respectively with acidopholus shrubs and with helophytes and hydrophytes. The valley bogs lack this well marked hollow-hummock pattern, consisting instead of a series of low moss hummock banks without shrubs, inclosing shallow pools containing helophytes. These communities have an interesting distribution in south-east Australia, the northernmost apparently being on the New England Plateau and on the Barrington Tops. It is also of interest to record the increasing relative importance of bog with increasing humidity and cloudiness, especially in summer, from north to south; for example there is an estimated 5% of bog above the winter snowline on the Bogong High Plains and about 10% above the corresponding level on the Baw Baw Plateau further south.

The bogs contain some very palatable herbs, especially *Carex gaudichaudiana*, and are selectively overgrazed, particularly by cattle. The resultant trampling, together with associated fires, leads to rapid deterioration of the bog with the breakdown of moss hummocks and banks and the resultant initiation of drainage lines through the bog. Entrenchment, gullying and drying out of the peat soon follow. Already an estimated 50% of the bogs of the Australian Alps as a whole have undergone fairly advanced deterioration; in many areas this deterioration is almost complete.

Fen: *Carex gaudichaudiana* alliance.

The fens of the *Carex gaudichaudiana* alliance also develop on wet soils, but under slightly higher (though still low) conditions of base status than the bogs. In the natural condition these communities have a rather sparse cover of *Carex* sometimes with associated helophytes. Typically, they occupy permanently wet basin situations, but they can also develop even on gentle slopes on account of the surface water retaining properties of the peats. The compactness of the peat enables the water table to be raised locally several feet above the general level of the water table, and there is abundant evidence in the form of deep uniform deposits of peat that this has been happening in many places for a long time. Once the surface drainage of the fen is destroyed, however, enabling water which was formerly pooled on the broadly concave fen surface to run off, this building up process is stopped and often reversed until, even within a few years after disturbance, the fen is eroded down to the underlying gravel or rock. Selective overgrazing of the fens, mainly on account of the palatable *Carex*, has produced widespread trampling damage, drying out and erosion.

Community interrelationships

The interrelationships of the high mountain communities can now be summarised as follows:

Under alpine conditions of climate, tall alpine herbfield of the *Celmisia longifolia-Poa caespitosa* alliance forms the climatic climax and under subalpine conditions, subalpine woodland of the *Eucalyptus niphophila* alliance.

Physiographically determined climaxes which replace the alpine climatic climax are the localised tall alpine herbfields of the *Brachycome nivalis-Danthonia alpicola* alliance in crevices, on rock ledges and other relatively protected rock faces; the short alpine herbfields of the *Plantago muelleri-Montia australasica* alliance in moist, snowpatch environments, on wet gravelly areas and along associated streams; fjaeldmark of the *Coprosma pumila-Colobanthus benthamianus* alliance in adjacent relatively dry and exposed snowpatch situations; and fjaeldmark of the *Epacris petrophila-Veronica densifolia* alliance on the most wind-exposed alpine plateaux and cols.

On imperfectly aerated though rarely waterlogged soils in the alpine and sub-alpine tracts and under conditions of cold air drainage in the subalpine tract the alpine and subalpine climatic climaxes are replaced by sod tussock grasslands of the *Poa caespitosa-Danthonia nudiflora* alliance. On somewhat drier soils the grasslands grade into heaths of the *Epacris serpyllifolia-Kunzea muelleri* alliance.

In contrast to the above conditions producing sod tussock grassland or *Epacris-Kunzea* heath, relatively rocky and freely drained situations support heaths of the *Oxylobium ellipticum-Podocarpus alpinus* alliance both in the alpine and sub-alpine tracts. In the alpine tract the shorter duration of snow cover as determined by local physiography also appears to be important.

In permanently wet situations, under conditions of increasing acidity and base deficiency the above communities are replaced respectively by fen (*Carex gaudichaudiana* alliance), valley bog (*Carex gaudichaudiana-Sphagnum cristatum* alliance) and raised bog (*Epacris paludosa-Sphagnum cristatum* alliance) developing as physiographic climaxes.

In most parts of the Australian alps the relationships indicated above and the relationships within the alliances themselves have been much modified by land use, largely the summer grazing of sheep and cattle associated with recurrent fires and more locally by engineering and tourist operations. The nature of this modification is now considered in greater detail.

Land Use and Economic Importance

The high mountains of Australia, all removed from the main centres of population, remained for many years largely unknown except to a handful of scientists, miners, graziers and timber cutters, and occasional hikers and skiers for whom these areas had some special attraction. This situation still remains substantially the same in much of the Victorian Alps and in Tasmania, although it has now altered in those parts of the Snowy Mountains and Bogong High Plains in which engineering works for the development of hydro-electric power and the storage and diversion of water for irrigation are in progress.

An inevitable result of this disinterestedness has been that the various forms of land use in the mountains have remained of a pioneering nature in which the individual with no other resources but his own has employed exploitative means to force quick returns without care or knowledge of the long-term consequences. The basic philosophy of conservation — that for each natural resource the methods of use must maintain and, if possible, increase the permanent productive capacity of that resource — has never been fully recognised. This philosophy of productive use without detriment to the resource being used implies that priorities according to land use capability should be established. Management for one purpose may be incompatible with permanent management for the type of production for which the resource is most suitable, even if this most suitable use still remains to be applied. This is the essence of the ecological approach to land use which insists that whilst the incidence of factors influencing the soil-vegetation system may change, the overall stability of the system must be maintained. A given form of land use should be capable of maintaining this stability if it is to have justification, even before economic criteria are applied.

Before the coming of the white settler to the lower country surrounding the mountains little more than 100 to 125 years ago, the impact of the native fauna including the Australian aboriginal on the high mountain soils and vegetation seems to have been very slight. The early settlers with their sheep and cattle found themselves surrounded by open grassy forests leading up to the high mountains in which palatable grazing was immediately available. From this it may be assumed that the palatability of the natural mountain vegetation was greater than that of supposedly natural vegetation of today, in which burning is considered by many to be necessary to encourage new and palatable growth. There is little doubt that this was so: the bogs and fens contain a number of very palatable plants, particularly the sedge *Carex gaudichaudiana*, and field surveys indicate that these palatable areas have been reduced by at least 50% over the last few decades. There is also good evidence that certain palatable native species (e.g. *Hemarthria uncinata*, *Danthonia frigida*, *Aciphylla glacialis*, etc.) recorded as common by earlier botanists have now become infrequent and in some cases have virtually disappeared leaving a sward more predominantly composed of one of the various forms of the snow grass *Poa caespitosa*. This presents a problem which high country grazing in most of Europe and North America does not have to face, namely, that the main dominant herbaceous plant available for grazing is not attractive, except at the seedling and seed head stages. In the U.S.A., 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) present range management, if it can be said to exist, consists in damaging the dominant herb as this somehow produces more palatable grazing. The effect of this damage, as shown earlier, is to produce bare areas on which palatable secondary herbs develop, and it is these bare areas which provide most of the grazing. Thus it can be seen that at present a condition of widespread, moderate soil and vegetation deterioration is the one which, apart from an artificial improved pasture, most favours the grazier, and the paradoxial situation has arisen 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 for which a solution would need to be found before the continuation of high country grazing would be placed on an ecologically sound, permanently productive basis.

This problem can be resolved into two main issues. If grazing were to become more efficient it would first need to be made more uniform so that most of the total area — not just a small fraction of it — were being utilized for stock feed. This introduces the second issue — that if more uniform grazing were to be achieved either the widespread unpalatable snow grass would need to be made palatable or replaced by an improved pasture sward. Experience in the Australian Alps now indicates that the establishment of pastures of recognised grazing value would offer greater possibilities and there is no doubt from several accidental and intentional trials that a considerable number of species could be established and persist. Costs of pasture establishment and management would, however, be very high: approximately 30/— per acre per annum for topdressing and another 10/— for the erection and maintenance of the fencing required. Opposed to this minimum estimate of £ 2 per acre per annum for typical high mountain country, is the low present and potential value of grazing from these areas: this varies from about 5/— to 20/— per acre per annum and represents little more thans 0.1 % of the value of production from sheep and cattle in Victoria and New South Wales (approximately £ 335,000,000 in 1954—55). Clearly, pasture improvement under these conditions would be uneconomic, except perhaps in some of the lower, more uniform areas where economies might be effected.

Land use, in the conservation sense, should have more than economic justification, however, before it can lay claim to a particular land resource. More important, it should not reduce the productive capacity of actually or potentially more important forms of land use by more than it itself is producing. Thus, the case for grazing involving either the maintenance of the vegetation in a deteriorated condition or its replacement by improved pastures should also be examined in relation to management requirements for the supply of water for domestic, irrigation and industrial needs, hydro-electric power, mountain recreation areas and nature reserves.

The use of water as such and in the production of hydro-electric power involves storage in dams and reticulation in race lines, pipes or tunnels. There are few other countries where the efficient use of water for these purpose is as important as in Australia; here water is recognised as one of the main factors limiting present and future production and maintaining and increasing the standard of living. Furthermore, suitable storage sites are comparatively few and mainly restricted to the mountain areas themselves. This means that storages should have their lives extended as much as possible towards an indefinite life, the purely economic criterion being insufficient since there may be no other suitable storage sites. There is little need to pursue the argument that the condition of high mountain vegetation should be managed in such a way that any works for storage and diversion of water should have maximum protection from sedimentation.

Considering the use of water as water, priorities of use would probably be given to domestic use, then primary industry and industrial purposes. In the first instance the water should be as pure as possible. This means that maximum infiltration of precipitation on the catchment should be achieved. The Federal Capital, Canberra, derives almost all of its domestic water supply from the high mountain section of the Cotter catchment, whilst in Victoria the rapidly growing towns of the Latrobe Valley and the city of Melbourne itself are largely or partly dependent on the high mountains for their domestic supplies. With its many uses for drinking, household, sanitary and garden purposes, and its relation to health and illness in the community, it is almost impossible to put a true monetary value on high quality domestic water beyond stating that it is indispensable.

Water is also an absolute necessity in industry, very large amounts being required for many industrial purposes, and for the removal of wastes at a rate sufficient to prevent obnoxious pollution. In the rapidly growing industrial areas of the Latrobe Valley in Victoria where brown coal is being mined on an increasing scale for gasification and electrification purposes, and where secondary industries are developing around the sources of power, not to mention the many factories processing primary products of this rich rural area, including paper pulp and dairy products, good quality water will be needed in greatly increased amounts and the southern areas of the Victorian Alps provide the only suitable sources. In these cases, therefore, management for domestic and industrial uses should take priority over management as high country grazing land and even for electric power for which there are several more suitable alternatives.

One of the greatest developments in Australian primary industries has been that of irrigation in the dry, formerly unproductive areas of inland New South Wales, Victoria and South Australia. The water now supplied by the Australian Alps for irrigation has an estimated production value of about £ 20,000,000 in N.S.W., and £ 30,000,000 in Victoria. This total* of £ 50,000,000 will be increased to about £ 80,000,000 by the diversion works of the Snowy Mountains Project. On the basis that the 1,875 square miles of high mountain country in N.S.W. and Victoria supply about half of this water, it can be seen that present value for water exceeds £ 20 per acre and the expected value is more than £ 33. The full utilization of the waters of the Victorian Alps would increase this value still further. (f. Australian Academy of Science, 1957).

Other values which should be added to these are taxation revenue (about 20% of the above production values), and the decentralization of population and industry. Finally, not only is the water of the high mountains of great value for irrigation and out of all proportion to its value for mountain grazing, but these mountains are the major source of irrigation water in southern Australia, for which there are no other alternatives.

In the case of hydro-electric power in New South Wales and Victoria, the Snowy Mountains, Kiewa, Eildon and Hume generating systems will produce power valued at more than £ 30,000,000 per annum, representing an annual return of more than £ 12 per acre of high country. This amount can be increased by further development in Victoria. In these instances, however, the contribution of hydro-electric power to total power will be considerably less than in the case of water for use as water, representing less than 20% of the total power output in these States. The situation in Tasmania is a little different. Here the value of hydro-electric power is expected to be about £ 20,000,000, representing a return exceeding £ 20 per acre per annum of high country. This power is indispensable to the Tasmanian economy as there are no suitable sources of coal, which means that the management of the Tasmanian mountains for power production is more necessary than on the mainland.

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* Figures for South Australia are not available.

In the case of recreational values assignable to the high mountains, the economic criterion is almost impossible to apply. In this instance the role these areas do and will play in providing outdoor relaxation of a special kind, and the lack of alternative areas for obtaining such recreation, are probably the main criteria for attributing priorities.

Visiting scientists who have seen the unique flora and vegetation of the Australian Alps are among the strongest supporters of the move to preserve these unique features for their intrinsic value as a special kind of high mountain vegetation and for future study. This particularly applies to the smaller areas above the treeline where a diverse and unique alpine vegetation and flora are preserved. In this instance there are absolutely no alternatives, and the need for preservation as a primitive area can stand on its own merits.

Against this background information of actual and potential value of the high mountain areas for various purposes, the case is strongest for the use of water as such for domestic, irrigation and industrial needs in view both of its greater economic value for these purposes, and the virtual lack of alternative catchments from which water can be obtained. The use of water for hydro-electric power is also very important economically, but except in Tasmania where there are as yet no suitable alternative sources of power, the needs of hydro-electric power production should be second to those of water use as such. Recreational and scientific needs are almost impossible to estimate in economic terms, but most would agree in view of the lack of alternative areas that they should be given far greater emphasis than at present, probably third to water and power in most areas and second to water use as such at least in the unique alpine areas above the treeline. Grazing, though historically first in the field, can claim only lowest priority.

In ascertaining which types of vegetation best meet the requirements of these various needs in the priorities mentioned, it can be stated at the outset that only the natural vegetation is acceptable for scientific purposes and that this also ensures highest values for recreation. It is also clear that a deteriorated native cover or a highly improved pasture would be most desirable for grazing purposes but this would be incompatible with preservation for scientific and recreational needs. Optimum management for water supply purposes will of course be governed by the hydrological properties of the various cover types which either exist or might be produced in the mountains. The more important of these properties are soil stability (conversely, erosion), surface infiltration (conversely, run off), and evapo-transpiration, including the more special aspects of snow storage and cloud and fog drip. Final answers to all of these problems cannot be given until research has been carried further, but a good deal of preliminary information is now at hand to provide a reasonable understanding of present and longterm management needs.

Hydrological Research

The most important hydrological property of the vegetation as regards catchment values, namely the rate of soil loss with the associated property of surface run-off, is being studied by means of numerous small experimental plots on which the effects of natural and artificial rains and snowfalls are being regularly measured. The cover types include all of the important ones found naturally and under current grazing management and also include the type of improved pasture which intensive development for grazing might hope to produce. Table III, based on about 50 individual plots and 14 individual rains, gives comparative soil loss and surface runoff incides for the various cover types:

Table III.

Soil loss and surface runoff indices for high mountain cover types, Kosciusko

Cover Type	Soil Loss Index	Surface Runoff Index
Subalpine woodland		
– Mature: Parklike with dense snowgrass sward	0	2
– Regrowth, about 30 years after fire, with shrubs and grass.	0	1
– Shrubs, about 15 years after fire	1.5	13
– Bare Soil, 3 years after fire	1300	56
Sod tussock grassland		
– Mature: Continuous coarse sward	0	3
– Damaged: Bare spaces between tussocks	110	42
– Improved Pasture: Short-grazed continuous sward	1	22

These results show clearly the value of the native vegetation, especially a dense herbaceous layer of coarse snow grass, in reducing soil losses and surface runoffs: i.e., of producing water which is low in sediment and sustained in yield. Any deterioration in the cover type involving exposure of the surface soil produces accelerated soil losses and increased overland flows. A short grazed improved pasture sward also minimises soil loss but results in appreciably greater surface runoff which may cause erosion in valleys lower down; this also means less infiltration and hence less sustained stream flow.

The programme of soil moisture measurement is not yet sufficiently advanced to enable many comparisons to be made except that the tree and shrub types use more water than the purely herbaceous communities. The greater water use by the trees, however, appears to be more than offset by the greater amounts of snow which they accumulate and by the considerably slower melting of this snow under the protection of the trees. The presence of trees in snow country thus contributes to more sustained and probably greater stream flows. Snow-melt rates are also slower under the forest and in the small clearings sheltered by trees than in the open where insolation and wind are greater*. (Fig. 3). Preliminary experiments also show that the trees strain out appreciable amounts of water from clouds when, as frequently happens in the mountains, the cloudlayer descends to ground level.

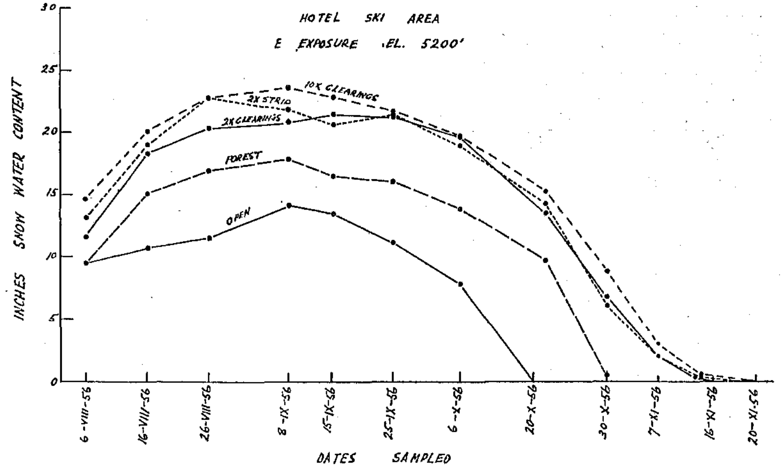

Fig. 3. Relation between size of clearing and snow-water content in dense subalpine woodland (sheltered aspect), Kosciusko.

These hydrological measurements have also been supplemented by measurements of water flow and water use in *Sphagnum* bogs** through which a large part of the water flows which eventually enters the mountain streams. These measurements have been carried out by keeping a continual record of the input of water into selected small bogs from springs and precipitation, and the output of water from the bog. It is apparent from these measurements that the bog plays a part in regulating stream flow. During the snow-free months the yield from a given precipitation is spread over one or more days in the case of a single bog and probably over considerably longer periods when a whole downslope series of inter-connected bogs is considered. During the winter the bogs make a continuous con-

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* Snow survey data obtained by Mr. L. GAY, American Fullbright Scholar working in Kosciusko area in 1956.

** Bog experiments conducted by Mr. G. LLOYD, American Fullbright Scholar working in Kosciusko area in 1957.

tribution to stream flow, by slowly melting the overlying snow, due to the thermal properties of moving ground waters near the bog surface. In non-ground-water areas, there is little snow-melt until spring. On the other hand, evapotranspiration losses are obviously considerable during the drier summer months, when potential evapotranspiration exceeds precipitation, so that the regulating function of the bogs is probably achieved at the price of total yield. However, as sediment content and regulated flow are given priority over gross yield, the bogs are desirable catchment assets.

With this framework of hydrological data and more coming to hand all the time, it is now possible to cross-check and supplement the large amount of interpretative field data accumulated over the years with more precise quantitative information. The results outlined above show that the existence of a continuous, coarse growing herbaceous vegetation to induce maximum infiltration with resultant sustained yield of pure water is far superior to bare or partly bare ground, shortgrazed improved pasture, or shrubs. The snow survey data also show that the presence or absence of trees has a considerable effect on the accumulation and subsequent maturing and persistence of snow to the extent that a high-mountain catchment with trees produces a more sustained and probably greater total flow of water than a deforested catchment. It would seem, however, that a fairly low density of trees or clumps of trees would produce more water than a densely forested catchment where interception and transpiration losses would be greater, the optimum diameter of the clearing between clumps of trees being approximately five times the height of the trees on exposed aspects and up to ten times their height on sheltered aspects. Quality and continuity of yield are further improved by the presence of bogs and swamps.

Management Requirements

These hydrological data show that the natural or near-natural vegetation is the most desirable of the several economically possible cover types which might be developed for the production of water, although in the more densely timbered subalpine woodland areas judicious light group selection felling might be expected to show some increase in water yield. By and large, the optimum vegetation requirements for water production are the same as those for recreation and scientific purposes, but they conflict with the present and possible future requirements of grazing.

The most important management procedure for the development of a near-natural vegetation over the bulk of the mountains would be the removal of domestic livestock and complete protection from fires. This policy already exists in the Australian Capital Territory, and from 1958 it will also operate in New South Wales.

These management methods, which are cheap and easy to apply, could be expected to restore the vegetation over most of the high mountain catchments within the next 30—50 years. In more severely damaged or critically exposed situations, however, artificial conservation measures involving re-seeding under a protective mulch, control of runoff water by diversion banks and stone-pitched drains, and the construction of snow fences, have been initiated by the Soil Conservation Service of N.S.W. Experimental re-afforestation is also visualised for extensively deforested areas where natural regeneration has so far failed. The control of stream bank erosion by water spreading and gully control structures will also be necessary in many areas. These measures to restore the catchment as a whole are also being accompanied by increasing attention to the more localised but often severe erosion connected with engineering works, and to the compatability of hydro-electric and national park values which so far have received little consideration. It is also becoming clear that a much more precise definition of responsibilities with co-ordinated control is essential among the many government and semi-government organisations concerned in these areas, if the scientific and technical knowledge available is to be effectively applied.

From being remote, little known, of small interest, and divorced from the realities of the day, the high mountains of Australia and their vegetation are becoming recognised as of vital importance to the nation and its inhabitants. Every man, woman and child of the ten million population already contributes more than £ 2 per annum to national works in these areas and it is apparent that the security of this huge investment depends largely on preserving a vegetation able to stabilise the soil. Lovers of the outdoors are now discovering the uniqueness of the Australian Alps and their vegetation, in a continent otherwise lacking in these resources. Scientists also realise the intrinsic interest of the unique plant communities and of the fauna which depends on them. Thus, the case is extremely strong for the preservation of the high mountain vegetation largely in its natural condition, of readjusting land use so that this near-natural condition can redevelop, and in cases of more severe soil-vegetation deterioration of implementing active soil conservation measures.

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