# Chapter 6
# soil values

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## Introduction

Soils are very complex physical, chemical and biological systems. They provide the life-sustaining pathways of air and water from the atmosphere, through the vegetation, into and through the ground below. In the reverse direction, soils transmit some of the air and water back into the atmosphere. Because soils are mostly out of sight beneath plants, their values tend to be overlooked among other natural values. Kosciuszko National Park differs greatly from other alpine areas in that deep organic soils dominate, whereas in most other alpine areas around the world soil formation is limited. This characteristic has led to the Australian Alps being described as 'mountains of soil' (Costin 1989). It also points to the area's sensitivity to disturbance.

The soils of Kosciuszko National Park are of great scientific interest in themselves. They have attracted international attention as outstanding examples of some of the great soil groups, both individually (the alpine humus soils) and in association with each other (e.g. the alpine sequence of lithosols, snow patch soils, alpine humus soils, bog and fen peats and silty bog soils), and for the associated studies of the pedogenic factors and processes controlling their formation and maintenance (Costin 1989, Good 1992). The scientific value is enhanced further by the large degree of 'naturalness' of the soils, which are relatively unaffected by the centuries of human occupation and associated uses of most mountains elsewhere in the world. Hence they are important natural 'standards', like above-ground reference areas of vegetation (Costin 1954, Costin et al. 2000).

In addition to their scientific interest, soils have vital 'service functions' such as the supply of clean water for domestic and industrial uses, irrigation, hydroelectric power and a wide range of recreational activities. The alpine and subalpine soils of Kosciuszko National Park receive, store, process and supply a larger quantity of high-quality water than any other group of soils on the continent. The soils of the surrounding mountain forests in the park also have valuable hydrological functions. Map 6.1 illustrates broad soil group distributions in the park.

### Basis for management

A major objective of the New South Wales (NSW) National Parks and Wildlife Act 1974 and the biodiversity strategy is the conservation of natural ecosystems, including (i) habitat, ecosystems and ecosystem processes and (ii) biological diversity at the community, species and genetic levels. Soils are an important part of most ecosystems, and are the medium through which many conservation management measures operate. Soils as part of ecological integrity are therefore well protected legally in national parks in NSW.

Because of the importance of the soils of Kosciuszko National Park for catchment protection and water yield, they are safeguarded further by the Soil Conservation Act 1938 and the Protection of the Environment Operations Act 1997. In fact, it was the soil conservation legislation that played an important role in the establishment of Kosciusko State Park in 1944, and in its subsequent protection and rehabilitation.

### Significance

In parallel with the wide representation of plant communities in Kosciuszko National Park, the soils vary characteristically on the semi-continental scale in response to the major pedogenic factors of climate, geology and physiography, down to local aspect and catenary levels (Costin 1954,1989, Costin et al. 1969, Good 1992). The recognition and understanding of these variations are facilitated in Kosciuszko National Park by its large size and persistence as a relatively undissected uplifted paleoplain, its wide altitudinal (225–2228 m) and climatic range, and the occurrence of soil parent materials as diverse as basic limestone and basalt, acid granites and metasediments.

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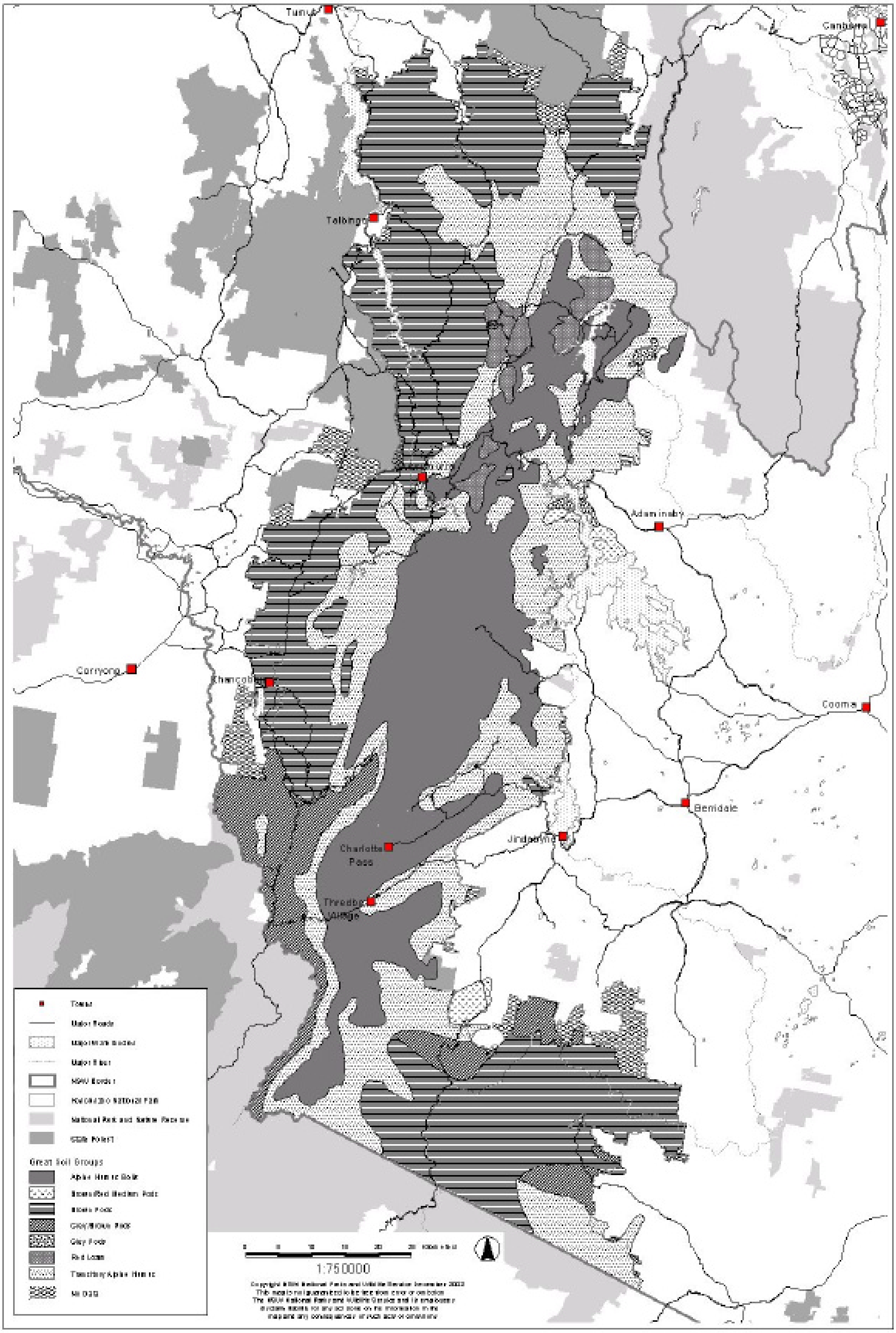
## Map 6.1 Broad Soil Group Distribution in Kosciuszko National Park



Thus, the dominance of the alpine and subalpine climate on soil formation is seen in the development of one and the same soil group, the alpine humus soils, on all parent materials, in contrast to the increasing dominance of parent material on soil formation at lower levels. On a given parent material over a wide range of altitude, characteristic sequences of soils are developed: for example, alpine humus soils and various podsolics on granites and metasediments; alpine humus soils, krasnozems and chocolate soils (not in Kosciuszko National Park) on basalt; and alpine humus soils, rendzinas and terra rossas on limestone (Costin 1954, 1989).

The importance of the topographic factor (through drainage) also varies with altitude and parent material as expressed in soil catenas: in the alpine–subalpine environment, the lower–catenary soils (bog peats) are the most acid and oligotrophic, whereas at lower elevations the lower–catenary soils (meadow soils) are relatively eutrophic, reflecting the accumulation, rather than dilution and loss, of nutrients. Whilst many native plant species in Kosciuszko National Park are not particularly sensitive to soil nutrient levels, other species, and even whole communities, are nutrient-sensitive, a fact not fully appreciated in park management.

In Kosciuszko National Park the alpine humus soils of the alpine and subalpine tracts are particularly well developed. Important soil processes that have been studied, albeit inadequately, include weathering, soil moisture movement, colloid and nutrient cycling, solifluction, aeolian deposition, soil faunal and mycorrhizal activity and various types of soil erosion and remediation techniques (Costin 1954; Costin et al. 1959, 1960, 1961, 1964; Walker and Costin 1971; Johnston and Ryan 2000).

A notable feature of the alpine humus soils in Kosciuszko National Park is the absence of the podsolisation process normally found in cold wet climates on acid rocks with low-nutrient vegetation. In fact, the reverse situation occurs, with accumulation of soil colloids and nutrients in the surface soil. These soil-building processes involve recycling by the deep-rooted snow grasses and other major herbs, possibly in association with soil mycorrhiza (Johnston and Ryan 2000), accretion of windblown dusts, and vigorous decomposition and redistribution of plant remains by soil organisms, particularly invertebrates, including the mountain earthworm (affin. Megascolex sp) (Costin 1954, Good 1992). One of the main conditions under which these organisms can operate is the deep continuous cover of winter–spring snow insulating the underlying soil and its inhabitants. The below-snow surface soil is thus maintained at favourable soil moisture levels at temperatures above freezing. These conditions are not found in mountain areas with colder autumns and early winters and/or subsequent light snow cover (Costin et al. 1969).

The abundant alpine–subalpine insect fauna in Kosciuszko National Park of some 850 recorded species (Good 1992) may also depend on these soil conditions, because eggs, larvae and pupae can overwinter without damage, with an almost explosive emergence of adults soon after the spring thaw.

Kosciuszko National Park encompasses the foremost water catchments in Australia. Historically, appreciation of this significance by the first Soil Conservation Commissioner, Commissioner Clayton, and Premier McKell led to the establishment of Kosciusko State Park in 1944, and appreciation of the importance of nature conservation in the park has continued.

The significance for catchment performance of soil conditions, including surface cover, cannot be overestimated. Surface soil conditions have a controlling role in the balance between non-erosive infiltration of precipitation and erosive surface run-off. Depending on site conditions, surface cover of 70–100% at rates of at least 10 tonnes per hectare (oven dry weight) is necessary for soil protection from frost, wind and storm rains (Costin et al. 1960, Costin 1980, Good 1976). Reduction of surface cover below these levels by former burning practices and livestock grazing led to widespread catchment erosion, especially in the alpine and subalpine tracts. Subsequent protection from these practices has been followed by recovery of ground cover and soil stability in most areas, although some erosion 'hot spots' remain (see below). In the lower elevation sclerophyll forests, current prescribed burning programs frequently reduce cover to below these limits, as well as preventing forest successions from proceeding towards old-growth stages. More attention should be given to a fundamental conservation equation: fuel = catchment cover = habitat.

Along drainage lines within a catchment, groundwater soils have a further controlling role in spreading and filtering catchment run-off before it enters streams. The groundwater soils have to carry a heavy 'water load'; they can function successfully only if they retain their almost level even surface. Incision by gullying and deeper entrenchment impairs these functions, a situation still present in parts of Kosciuszko National Park even though there has been general catchment improvement.

### Dependence

Kosciuszko National Park is the only part of southeast Australia that protects such a wide range of mountain soils still in their largely natural condition and in one and the same geographic location. This applies particularly to the snow patch soils, alpine humus soils, bog and fen peats and silty bog soils of the alpine and subalpine areas. They are represented in high mountain parks in Victoria but are still subject to livestock disturbance and erosion there.

### Condition and trend in condition

Surveys of the snow leases and permissive occupancies in Kosciusko State Park, carried out in the 1940s and 1950s by the Soil Conservation Service of NSW, documented widespread soil erosion attributed to the destruction of soil cover by fires and grazing (Costin 1954; Durham 1956; Morland 1949, 1951, 1958ab, 1959, 1960; Newman 1953, 1954abc, 1955abc; Taylor 1956, 1957, 1958ab). Improved fire management and progressive removal of grazing from 1944 to 1958 have been followed by natural stabilisation of most soils in the park, associated with an increase in the soil surface cover on a catchment scale to the previously mentioned levels of 70–100% in amounts of at least 10 tonnes per hectare. Other associated soil measurements in some subalpine areas over a 20-year period show a reduction in the bulk density (ie increased porosity and infiltration of moisture) and an increase in soil organic matter (Costin et al. 1959, 1960,1961; Wimbush and Costin 1979a). In general, the recovery trend of the last 40–50 years has reached a plateau of relative stability, but not always in the original condition. Near-original conditions have been achieved where sufficient organomineral topsoil remained, but not where topsoil loss proceeded to the residual stony erosion–pavement stage (Johnston and Ryan 2000, Wimbush and Costin 1979abc). This stage will persist for a long time, probably centuries; fortunately shrub regeneration on these stony sites is stabilising most of them. In the alpine zone these stone pavements have reached stability as 'erosion' feldmarks (Good 1976, 1992).

On the Kosciuszko Main Range, and Gungartan and Bulls peaks area to the north, some of these erosion 'hot spots' involved losses of up to half a metre of organomineral topsoil over a total area of about 1500 hectares (Good 1976, 1992). Soil losses from the Main Range between Mount Kosciuszko and Mount Twynam were recorded by the Soil Conservation Service of NSW to be in the order of 1.2 million tonnes. Patient, hands-on soil reclamation work by the Soil Conservation Service between 1954 and 1980 eventually stabilised most sites, but there remain eroding edges and run-off/run-on erosion problems requiring future attention.

The problem of incising and eroding peats and other groundwater soils elsewhere in Kosciuszko National Park also requires attention. Measurements over a 20-year period show continuing erosion of stream-bank and stream-bed profiles in subalpine valleys, even though the initial disturbing agents are no longer present. Where incision is less severe, simple water-spreading measures in valley headwaters may halt further degradation. Where there has been only minor incision, a slow upward trend is apparent (Wimbush and Costin 1979c, 1983).

As well as the already mentioned disturbances and trends in the catchment soils of Kosciuszko National Park as a whole, localised soil damage has occurred in many areas, such as that arising from former engineering operations of the Snowy Mountains Hydro-Electric Authority (SMHEA); along transmission lines, roads and management tracks, four-wheel drive tracks, horse riding route pads and walking tracks; and in development sites such as resort areas. Much of the former damage has been repaired, but continuous maintenance work will be required.

### Pressures

The most widespread pressure on the soils in Kosciuszko National Park is that of fire, as it destroys or reduces the protective ground cover, thereby mobilising surface soil and nutrients, and potentially leading to erosion (Brown 1972, Good 1973).

During the last 50 years, there has been a reduction in the number and extent of wildfires, and in recent years there has been a reduction in the number and area of prescribed fires, with a subsequent improvement in cover and soil stability. A policy of no burning now applies in the alpine zone, much of the subalpine zone and the lower Snowy rain shadow area, where the protection of severely eroded soils on steep slopes requires the further build-up and maintenance of ground cover. In most of the remaining forest areas 'hazard reduction' or 'prescribed' burning is part of their management, but widespread prescribed burning is not practised. Wildfires are less frequent, but they have the potential to initiate extensive soil damage if the burnt areas are subject to fire of high intensity (Brown 1972, Good 1973).

On the assumption that prescribed burning will minimise the risk of future wildfires, there is a perceived need for the periodic reduction of ground cover to below 10 tonnes per hectare. However, this is not necessarily consistent with the needs of catchment protection or nature conservation. Frequent prescribed burning in the 'safe' winter period increases the potential for soil nutrient losses, as fire-mobilised nutrients are exposed to several months of erosion and leaching until there is sufficient recovery of vegetation to reabsorb them during the following summer. Such losses are likely to be cumulative and are always downhill. Fire managers in Kosciuszko National Park have a difficult task to get the balance right (see Chapter 12).

Recreational activities present significant, if localised, pressures on soils. As well as soil erosion, surface compaction may result from slope grooming and the use of vehicles on a shallow snow pack. Where pore space in soils is related to many years of previous soil development - as in alpine humus soils - compaction effects may last for a long time. Then there is the problem of slow 'nutrient leakage', as of calcium from paved tracks made with concrete or concrete blocks, onto nutrient-susceptible bogs and peats. Such leakage is associated with an increase in less oligotrophic native species and an invasion by weeds. Alternatives to paved tracks are raised walkways, provided any steel that is used is ungalvanised and hence free from toxic zinc that may remain in soils for years (Johnston and Good 1995).

The ability of soils to absorb nutrients and sediment to the benefit of catchment water supply does not necessarily benefit other park values. Nutrients in human urine and faeces, especially phosphorus, can persist for years in recipient soils, as around the many huts in Kosciuszko National Park and on long-abandoned SMHEA campsites, which are now unidentifiable except for their persistent populations of thistles and other eutrophic weeds. Even where there is tertiary treatment of sewage from resort areas, the discharge of the effluent is likely to cause localised soil fixation and subsequent remobilisation of nutrients, with the potential for changes in the natural ecosystems affected. There is an ecological case for the complete removal of sewage wastes from Kosciuszko National Park.

There are also problems of localised soil disturbance and erosion from the activities of feral animals. In the less elevated cold air plains, such as Snowy Plains, rabbit control is an ongoing requirement. Rooting by pigs, with partial destruction of native vegetation and mobilisation of soil nutrients, facilitates weed invasion. The several thousand wild horses in Kosciuszko National

Park, apart from their selective grazing effects on native vegetation, selectively frequent mountain valleys that are sensitive to trampling because meadow soils and bog peats are easily incised and gullied. Such effects are seen in the south of Kosciuszko National Park in the Ingegoodbee headwaters. With wild horses there is an obvious conflict between the conservation of natural and recently identified cultural values.

### Knowledge gaps

As stated earlier, the soils of Kosciuszko National Park have been little studied compared with most other natural features. As one of the starting points for future work, detailed soil mapping could be considered. Among the attributes mapped would be soil cover, depth, and moisture characteristics, including infiltration capacity. Knowledge of these attributes is relevant to the management of vegetation, fauna and other ecosystem components, and would assist fire planning and resort area management.

Further research is required on the relationship of soils, vegetation and ground cover at different altitudes and aspects of erosion potential (see Chapter 12).

There is a knowledge gap in terms of appreciation and quantification of the thresholds between acceptable and unacceptable levels of vegetation and soil degradation in high-use recreational areas.

### Opportunities

Although much has been achieved in the control and management of soil erosion in Kosciuszko National Park, the erosion control programs started many years ago must be continued and accepted as a part of routine resource maintenance works. Specific achievable objectives include the further stabilisation of erosion 'hot spots' on the Main Range and control of their accelerated run-off effects; the rehabilitation of eroding groundwater areas, especially valley bogs, in the alpine and subalpine zones; and the control of soil degradation and erosion in all infrastructure development projects. In view of the rapidly increasing use of walking tracks, especially in the alpine area, the effects of different track systems on associated soils and vegetation should be reviewed and the most appropriate systems more widely applied.

### Indicators and monitoring

The long-term vegetation transects in the alpine and subalpine zones should be continued not only for the information they provide on vegetation trends but also for information on the soils. These have been documented by Roger Good and by the Alps Liaison Committee (R Good, National Parks and Wildlife Service, pers. comm., 2002) and a selection of transects for further monitoring could be made.

There are also various photographic records of soil conditions made many years ago by former officers of the Soil Conservation Service of NSW (e.g. Morland 1949, Newman 1953, Taylor 1957). These records should be located, some of the sites should be identified in the field and repeat photographs should be taken at regular intervals (e.g. Main Range, Kiandra, along roads and around construction sites). There is a good case for a professional 'ecological archivist' on the park's staff to coordinate such work.

## Addendum on fossil soils

Kosciuszko National Park also contains fossil soils and remnants of fossil soils. Their persistence in parts of the park reflects its relatively subdued terrain and the limited glacial and other types of natural erosion activity. Some of the older soil materials have been able to persist, with present-day soils developed within or over them. They are of high scientific value and practical importance (Costin 1972, 1989).

At the scientific level, the ages of various fossil soils contribute to the evidence of general contemporaniety of Ice Age and subsequent climatic changes at Kosciuszko and mountains in other parts of the world. Certain fossil soil features, notably the non-sorted steps, are among the best examples of their kind; their study has also shown how alpine humus soils developed (Costin et al. 1967, 1969). At the practical level, the depth and extent of slope deposits enhance catchment storage of water, but they present construction problems for engineers and are erosion hazards if disturbed.

The oldest features are topsoil remnants in extensive slope deposits formed by solifluction during previous periglacial conditions. They occur on gentle to moderate slopes on both sides of the mountains, as in the upper Murray Valley between Geehi and Tom Groggin, along the Thredbo Valley and the Snowy Valley at Munyang and below Island Bend. On sites steeper than the angle of repose of unconsolidated materials, slope materials would also have moved downhill but could not accumulate. The age of the buried topsoils, about 30 000 years, indicates when the Ice Age cooling off started (Costin and Polach 1971, Costin 1972).

At higher altitudes in the Snowy headwaters, the age of the fossil peats and sediments overlying surfaces that would have been covered by ice and snow during the Ice Age indicates that this long cold period was on the wane by 15 000 years ago. Identification of pollen grains in the peats and sediments reveals how the vegetation has changed during postglacial time to the present day (Martin 1986ab, 1999).

Solifluction terraces and non-sorted steps record more recent changes in climate, including a cold phase between about 3000 and 1500 years ago (Costin et al. 1967). The stratigraphy and surface soil and vegetation patterns of the steps also show how alpine humus soils at Kosciuszko have originated and developed, including rates of formation of various soil properties.

The peats beneath long lasting snow patches preserve remains of the specialised plants that formed them, together with varying amounts of dust blown in from the west (Walker and Costin 1971, Johnston 2001). Their further study could provide an 'aridity index' for inland Australia during the last several thousand years.

Many of these fossil features are in the Kosciuszko summit area that is now attracting increasing numbers of walkers. Some re-siting of tracks and/or replacement by raised walkways may be needed to minimise trampling damage.