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NATIVE SPECIES FOR SOIL CONSERVATION IN THE ALPS–NEW SOUTH WALES

BY

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Native Species for Soil Conservation in the Alps—New South Wales

P. A. Keane

A field study was made of the value of certain native species growing in the Alpine area of the Snowy Mountains of New South Wales for soil conservation purposes. The study was conducted during summer, January to March, 1972. *As well, limited observations were made in subsequent years. The ecology of the main colonizing species is outlined and their potential for soil conservation purposes is assessed.*

THE Summit Area Works Programme of the New South Wales Soil Conservation Service has been in operation since 1957. The programme was designed to protect, from erosion, the highest and most important parts of the catchment areas of the Snowy and Murray River systems. Reclamation of eroded areas has been undertaken mainly between Carruthers Peak and Mount Twynam. Some treated areas are also located in the Ramshead, Rawson Pass, Lake Albina and Granite Peaks areas.

The various structural and agronomic treatments have been carried out with the expectation that the native vegetation will re-establish over a period of time. The expectation has been borne out in some situations but not in others. When up to 0.5 metre of soil has been removed by erosion, native vegetation, or indeed any vegetation, has extreme difficulty in becoming established especially in this Alpine environment.

Native species colonize only slowly. However, the protection afforded to natives by sown exotic species, and the assistance of fertilizers has, in many cases, assisted the colonization by natives. These natives are better suited to the environment in the long term than exotic species and they do not require continued maintenance.

Not much is known about the ecology of the native species in the Alpine area, especially of those species which may be important for soil conservation purposes. Consequently, a survey to outline the ecology of some of the more important species in this regard was carried out during the summer, January to March, of 1972.

The native species considered in the Alpine environment were those capable of growing in colonizing situations. The more important in this regard were examined for habit, habitat, phenology and possible performance in a soil conservation programme. As the survey occupied only one growing season, assessments took account of the general ecological information available of the various species as well as the specific observations made.

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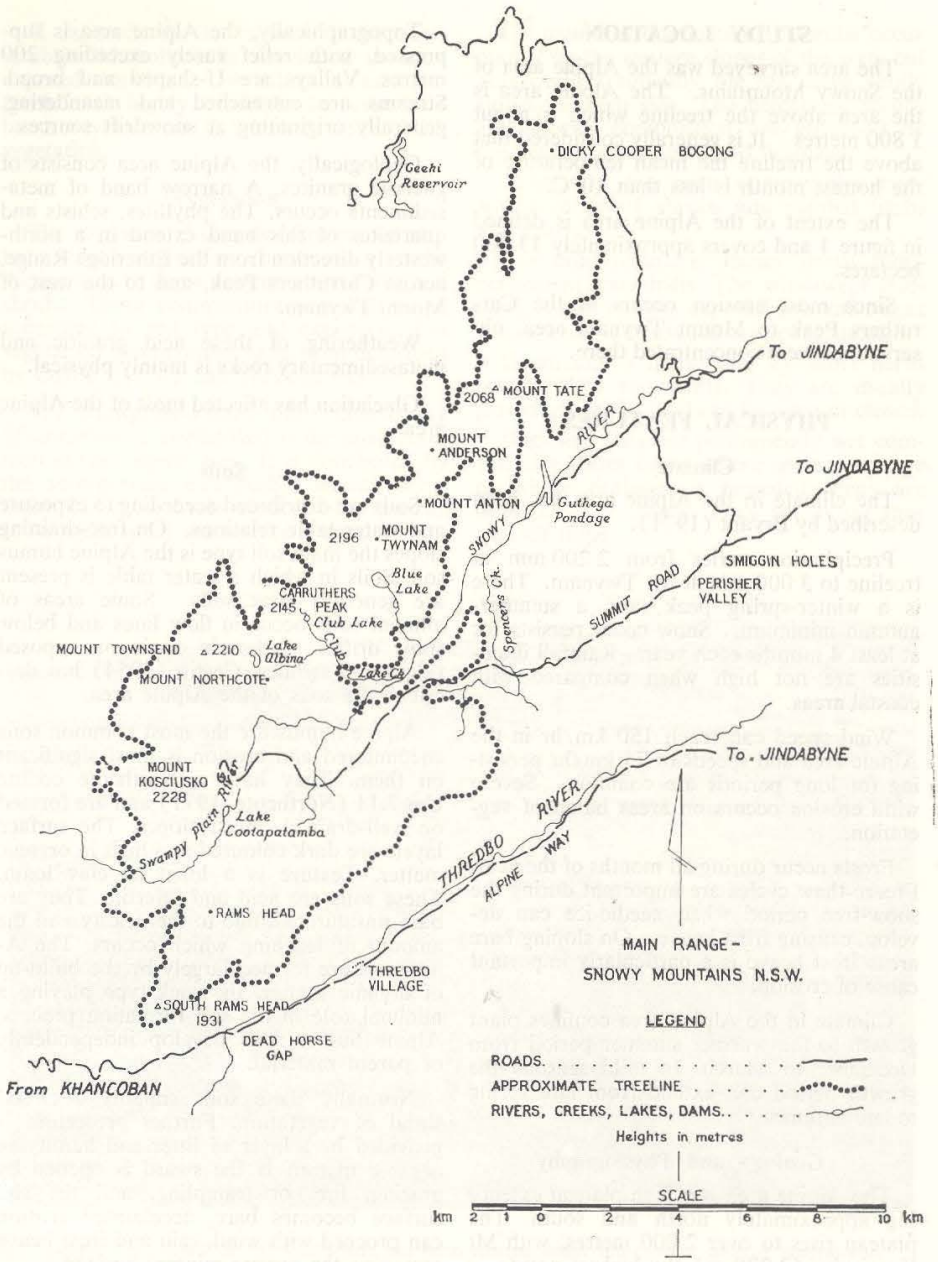

Figure 1—The map shows the area surveyed. The treeline approximates the area surveyed.

STUDY LOCATION

The area surveyed was the Alpine area of the Snowy Mountains. The Alpine area is the area above the treeline which is about 1 800 metres. It is generally considered that above the treeline the mean temperature of the hottest month is less than 10°C.

The extent of the Alpine area is defined in figure 1 and covers approximately 13 000 hectares.

Since most erosion occurs in the Carruthers Peak to Mount Twynam area, observations were concentrated there.

PHYSICAL FEATURES

Climate

The climate in the Alpine area has been described by Bryant (1971).

Precipitation varies from 2 200 mm at treeline to 3 000 mm at Mt Twynam. There is a winter-spring peak, and a summer-autumn minimum. Snow cover persists for at least 4 months each year. Rainfall intensities are not high when compared with coastal areas.

Wind speed can reach 150 km/hr in the Alpine area and speeds of 75 km/hr persisting for long periods are common. Severe wind erosion occurs on areas bared of vegetation.

Frosts occur during all months of the year. Freeze-thaw cycles are important during the snow-free period when needle-ice can develop, causing frost heave. On sloping bare areas frost heave is a particularly important cause of erosion.

Climate in the Alpine area confines plant growth to the warmer summer period from December to March. In mild seasons the growth period can extend from late spring to late autumn.

Geology and Physiography

The Alpine area is a high plateau extending approximately north and south. The plateau rises to over 2 000 metres, with Mt Kosciusko (2 228 m) the highest point.

Topographically, the Alpine area is suppressed, with relief rarely exceeding 200 metres. Valleys are U-shaped and broad. Streams are entrenched and meandering, generally originating at snowdrift sources.

Geologically, the Alpine area consists of gneissic granites. A narrow band of metasediments occurs. The phyllites, schists and quartzites of this band extend in a northwesterly direction from the Etheridge Range, across Carruthers Peak, and to the west of Mount Twynam.

Weathering of these acid granitic and metasedimentary rocks is mainly physical.

Glaciation has affected most of the Alpine area.

Soils

Soils are distributed according to exposure and water table relations. On free-draining slopes the main soil type is the Alpine humus soil. Soils in which a water table is present are generally peat soils. Some areas of alluvial soils occur in flow lines and below snow drifts. Lithosols occur on exposed ridges and saddles. Costin (1954) has described the soils of the Alpine area.

Alpine humus are the most common soils encountered and erosion is most significant on them. They have a Northcote coding Um 7.11 (Northcote, 1971) and are formed on well-drained, moist slopes. The surface layers are dark coloured and high in organic matter. Texture is a loam or clay loam. These soils are acid and infertile. They are base unsaturated, due to the acidity and the amount of leaching which occurs. The A-horizons are formed largely by the build-up of organic matter, the rock type playing a minimal role in the soil formation process. Alpine humus soils develop independently of parent material.

Normally these soils support a closed stand of vegetation. Further protection is provided by a layer of litter and humifying organic matter. If the sward is opened by grazing, fire, or trampling, and the soil surface becomes bare, accelerated erosion can proceed with wind, rain and frost heave removing the organo-mineral horizon.

If exposed, the lower A/C horizon resembles lithosolic soils developed in more exposed situations. The subsoil is acid, infertile and highly erodible. It presents a harsh environment in which to re-establish vegetation.

Vegetation

The extremes of climate imposed by altitude reduce vegetation communities in the Alpine area to those dominated by forbs and shrubs. These communities are distributed according to soil type and exposure. The vegetation communities have been described by Costin (1954) and McVean (1969).

The snowgrass—snow daisy community (*Poa-Celmesia asteliifolia*) is the most common in the Alpine area. It is dominated by the snowgrasses and herbs, mainly snow daisy, but other herbs such as billy buttons (*Craspedia* spp.) are locally common.

Communities dominated by shrubs occur mainly on the western slopes of the area, but also occur frequently on the more gently sloping eastern side. The heights of shrubs and species composition are governed by the degree of exposure and drainage.

Feldmarks are open communities consisting of dwarf shrubs and stunted herbs and grasses.

The cold feldmark occurs above semi-permanent snowdrifts. The windswept feldmark occurs on very exposed cols and ridges where wind is funnelled and concentrated.

Communities dominated by short herbs occur below snowdrifts. They are usually permanently wet, and can be open or closed.

Bogs and fens are permanently wet communities. Bogs occur where springs emerge or where drainage is impeded. Fens are dominated by sedges. They act as silt fans and silt traps.

Figure 2—A track on Mt Carruthers has been treated under the erosion control programme. Native species are vigorously recolonizing the track so that it is now difficult to see

The survey was concentrated mainly in the snowgrass—snow daisy community, but the smaller areas occupied by feldmarks and the communities below snowdrifts were also examined in detail.

The botanical nomenclature for Alpine species is under review. As a result, author citations where possible are given in the appendix and species names are those which appeared correct at the time of the survey. Billy buttons (*Craspedia uniflora* sens. lat), for example, refers to at least five different species in the Alpine area which are awaiting description and allocation of specific names.

Alpine Flora

The flora of the Alpine area consists of some 190 to 200 species.

Approximately thirty of these species occurred in colonizing situations.

All except three of the colonizing species observed are natives. The three are the naturalized sorrel (*Rumex acetosella*), Shepherds purse (*Capsella bursa-pastoris*) and barley grass (*Hordeum leporinum*).

Sorrel has been naturalized in the area for many years. Shepherds purse and barley grass have probably been introduced by livestock and with hay used in the reclamation treatment.

The latter two are annual species and were not observed to set seed and generally do not persist. The appendix contains a list of the native species found in colonizing situations.

DESCRIPTION OF SPECIES

Fourteen native species, considered to be the most useful for soil conservation purposes in the Alpine area of New South Wales, are described and discussed in groups according to their general growth habit.

The ability of the plants to grow on eroded sites either without any treatment or with treatment such as ripping, bitumen and straw mulching and fertilizer addition is important (figure 2).

Mat-Formers

Alpine purslane (*Neopaxia australasica*)

Alpine purslane is a creeping perennial, preferring swampy or wet areas. It behaves as a perennial in these damp habitats but perenniality in drier sites is doubtful.

Plants are stoloniferous, but the stems may be partially buried under soil. Tufts of fibrous roots anchor this ground-hugging plant. Stems are reddish in colouration, especially near the growing points, and become brownish yellow and leafless further away. The stems can provide an interlaced mat, thus fully protecting the ground surface.

An individual plant can grow to 60 cm in diameter, but tends to die in the centre, leaving numerous interlaced colonies.

The plant grows best in moist habitats such as along or beside creek beds, overflow or boggy areas, and below snow drifts.

The plant also grows on patches of dead snowgrass. The mulch provided by the dead grass provides more moisture than usual. The rotting of the dead snowgrass roots probably provides some additional nutrient.

Alpine purslane also grows on treated and untreated erosion patches. This includes many areas which have been protected with bitumen and straw mulch. The mulch provides a suitable moisture regime. In addition there is a better nutrient supply. Fertilizer is applied before bare areas are mulched. In the natural habitat, snow melt below semipermanent snow patches provides a slow release of nutrient.

A factor common to almost all habitats in which Alpine purslane is found is a relative lack of competition from taller growing species. The only exception is on treated areas, where exotic, erect grasses occur.

The most critical factor appears to be moisture availability. The plant is severely affected by drought. Moisture stress occurs frequently in Alpine areas during the growing season due to high evapo-transpiration rates. Therefore Alpine purslane can be expected to do better in wetter years, and on

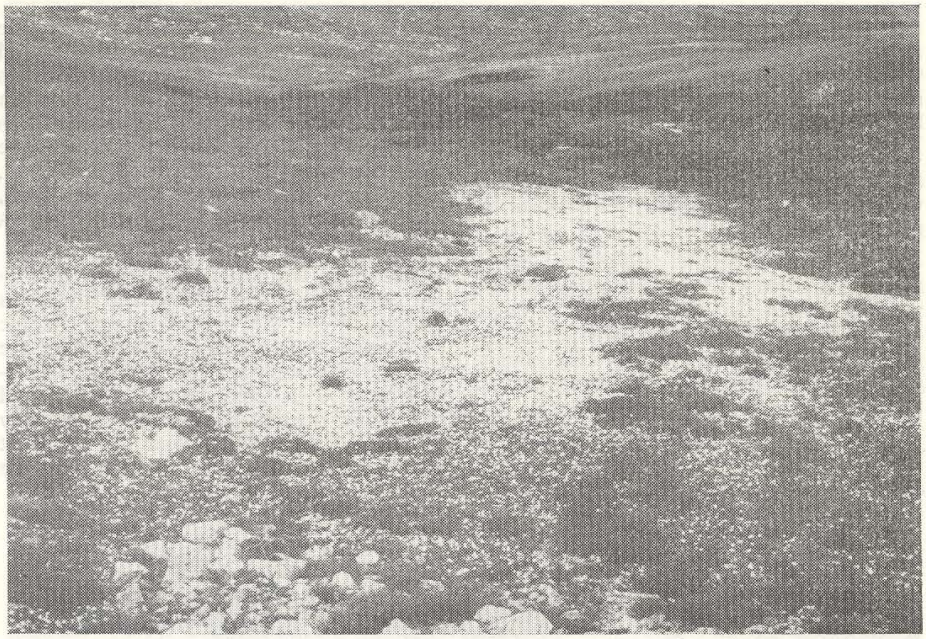

Figure 3—Alpine purslane (*Neopaxia australasica*) in flower and colonizing a bare area

sites with adequate soil moisture. Once established on dry habitats, survival depends on root reserves built up during the growing period and on the availability of soil moisture.

Alpine purslane is found mostly on level to gently sloping areas (5–15 per cent slope). The northerly (north and northeast) aspects, particularly on the metasediment belt, tend to be unfavourable. Plants on these aspects are the first to die back and seed as the combined effects of summer sun and northeast winds on these slopes can cause rapid depletion of soil moisture.

Flowering commences in early January and continues till the end of March, but by the middle of March, most plants have formed seed. Seed-setting commences about the end of February, beginning first in those plants in drier habitats. Collection of seed is not easy, due to the ground-hugging nature of the plant.

Vegetative propagation has been found to be the best way to increase and spread Alpine purslane.

Alpine purslane provides almost complete ground cover in its favoured habitats. When occurring as a colonizer, it can provide 50 per cent or more ground cover, depending on the size of individual plants or groups of plants. The interlacing of stems enables the plant to provide complete protection of the soil surface (figures 3, 4).

Alpine willowherb—*Epilobium tasmanicum*

This is a perennial herb forming circular mats which may be up to 30 cm or more in diameter, although most are smaller than this. Stems are reddish to green and creep out from the centre of the plant. The growing points turn upwards reaching a height of 5 to 8 cm above the ground-hugging mat. The plant is less strongly rooted away from the centre of the mat (figure 5).

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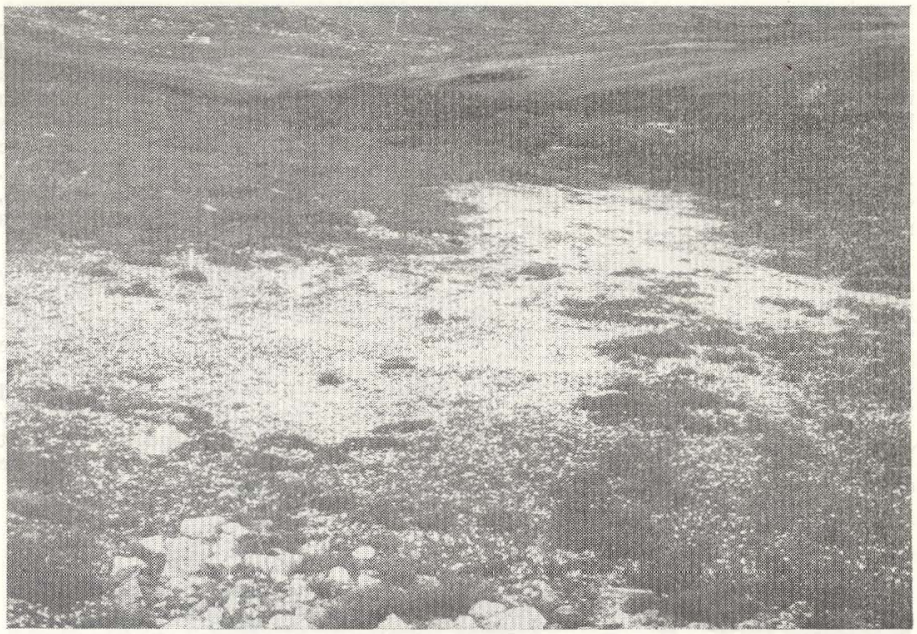

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Alpine willowherb prefers stony, bare areas and can occur on level to steeply sloping sites. Its main natural occurrence is in the cold feldmark which provides a very harsh habitat.

Many of the erosion pavements present a similar habitat after treatment and Alpine willowherb has successfully established in many of them.

These plants are small and inconspicuous at first, and can be mistaken for Alpine purslane when in the vegetative stage, especially when the two plants occur together. However, they are readily distinguished by their smaller, more ovate leaves, and long capsules when fruit matures.

Alpine willowherb can withstand dessication better than Alpine purslane. Consequently, it is more in evidence late in the season and in drought years. It may require protection in its early stages. In the cold feldmark, late snow cover provides this shelter, while on treated areas (erosion pavements) the bitumen-straw mulch helps the plant establish. Once established, the plant no longer needs as much protection. Snow melt may provide some nutrients, while on treated areas fertilizer provides a growth stimulus.

The cold feldmark is characterized by few competing plants. On treated areas this is not always the case, although Alpine willowherb usually occurs where there are few taller growing species. Alpine willowherb was seen colonizing few untreated erosion pavements. The reason for this may be lack of seed source and the fact that Alpine willowherb occurs naturally on the upper leeward (wind-sheltered) slopes.

Figure 4—Alpine purslane in flower

Figure 5—Alpine willowherb (*Epilobium tasmanicum*) colonizing bare soil

Seedlings grow in the protection of the parent plant which provides shelter. They can also be expected to establish where rocks provide shelter.

Alpine willowherb flowers after the snowdrifts melt. The main flowering occurs in February and fruits form from the end of February reaching a peak towards the middle and end of March.

The upright red fruits, containing small seeds, are relatively easy to harvest. Vegetative propagation is possible, and the plant has been successfully transplanted.

Alpine willowherb will not provide complete cover on bare areas, but it can be used as a complementary colonizer with other species, especially in the more exposed, drier sites.

Alpine cudweed (*Gnaphalium collinum*)

This plant is a mat-forming to tufted plant, covering areas of up to 10 cm in diameter, but usually less. It is a perennial species and has a greyish appearance at the growing points. The plant appears brown to black away from the growth apices.

Alpine cudweed occurs as a colonizer of bare areas, but it is not common. It is mainly seen on blowout areas of the snow grass-snow daisy community, and also in the wind-swept feldmark. It occurs in open plant communities.

The plant can provide discontinuous cover over large bare areas, and for this reason can be considered a useful colonizer. However, in common with most mat-forming species it cannot withstand intense competition from taller growing species.

Vegetative propagation is possible. Its restricted occurrence in the Alpine area reduces its value. It is a slower growing species than Alpine purslane or alpine woodrush. However, it can grow successfully in dry habitats, and provides more permanent cover.

Australian edelweiss (*Ewartia nubigena*)

This is a perennial species very similar in appearance to Alpine cudweed. It is a mat-forming plant, often covering areas of 20 cm or more in diameter. The slender woody branches radiate from a central butt, parallel and close to the ground. The plant has a silvery-green appearance.

Australian edelweiss has a restricted distribution in the Alpine area. It occurs mainly on the wind-swept feldmark, where it can be one of the dominant species. Blow-out areas in the snowgrass-snow daisy community are often colonized by the plant. Eroded areas are a favoured habitat. The range of this plant has probably been extended because of the erosion which has occurred. However, it is only found at high elevations. The plant occurs mainly in open communities.

It provides good ground cover but the cover tends to be discontinuous. The plant dies off towards the butt.

Australian edelweiss is a primary colonizer of eroded areas. It is also a successful species in this regard. It can survive very well in dry, exposed situations, due to its woody nature but is a slow grower.

Propagation is by vegetative methods. It can be used as a complementary colonizer on the more wind-exposed eroded sites.

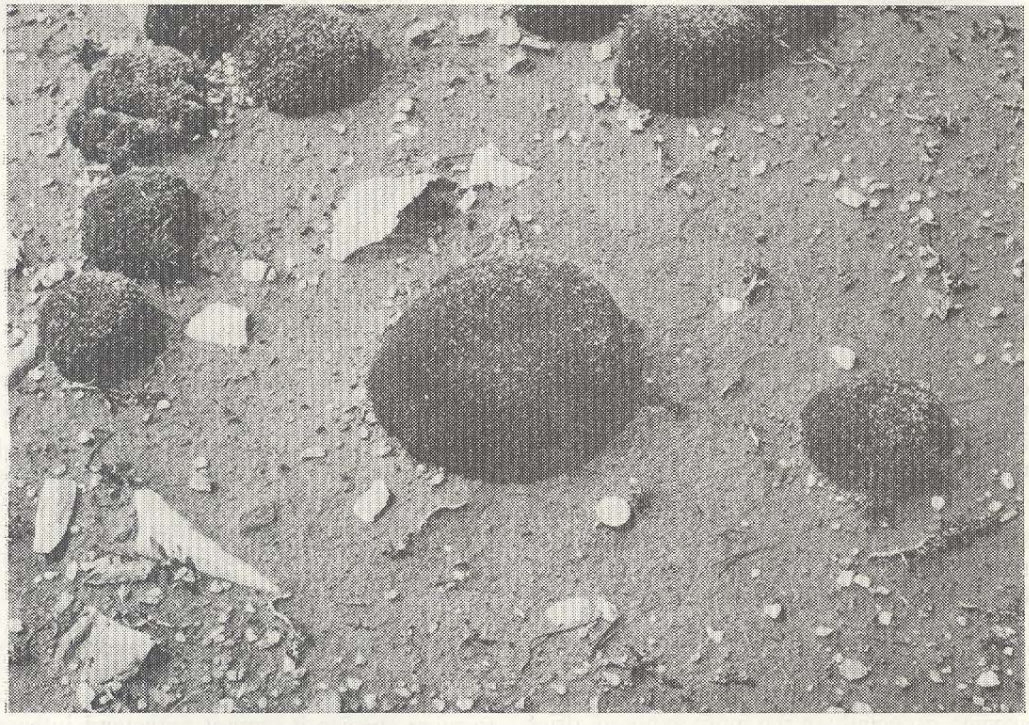

Figure 6—Alpine colobanthus (*Colobanthus benthamianus*) colonizing bare ground

Alpine colobanthus

(*Colobanthus benthamianus*)

Alpine colobanthus is a densely tufted perennial plant, growing in a semispherical moss-like form, much like a cushion. Individual plants are usually less than ten centimetres in diameter (figure 6).

This plant grows on bare, exposed areas. It is not widespread through the Alpine area. Its chief natural occurrences are on the wind-swept and cold feldmarks but it is also found on blowout areas in the snowgrass-snow daisy community.

The species prefers bare, stony areas that have few competing species. It is found only at high altitudes.

Alpine colobanthus is a colonizer of eroded areas, where it may occur with mat-forming or with erect species. Invariably it occurs in open plant communities.

The plant flowers in January and February with seed set by the end of February. Collections of seeds is difficult, because the seed is set within the dense cushion. Propagation is from seed and by vegetative means.

Each plant generally covers from 5 to 8 cm in diameter of ground surface. However, it has a discontinuous occurrence on bare areas, and overall does not provide a great deal of ground cover. Once a sward of taller growing species forms, colobanthus cannot compete, even though the basal ground cover may be far from complete.

But Alpine colobanthus is an initial colonizer of eroded areas, and can be considered a successful species in this regard. The ground cover it provides makes it a good complementary species to the mat-formers, especially on the more exposed sites.

Rosette Types

Billy Buttons (*Craspedia uniflora*)

Billy buttons comprise at least five species in the Alpine area presently included under the same specific epithet. Several of these species are far more common than the rest, and the common ones can be seen in colonizing situations (figure 7).

Figure 7—Billy buttons (*Craspedia uniflora*) growing in bare areas between tussocks of snowgrass

Billy buttons are perennial herbs, with a rozette of basal leaves and an upright flowering stalk. Several plants can occur together, apparently derived from the previous season's roots.

The species of interest occur in well drained, generally unexposed sites. They colonize areas of dead snowgrass. In these situations they may be the only species present, or they may occur with other colonizers.

Billy buttons can also occur on both treated and untreated eroded areas. Plants in these situations are often stunted due to exposure.

Young plants are often found in sheltered spots around the edges of erosion patches and they occupy sites relatively free from competition from the tufted herbs and grasses.

Billy buttons flower mainly in late-January to mid-February. Flowering commences earlier at lower altitudes. Flowering continues in isolated plants to about mid-March, when seeding reaches its peak.

Collection of seed is easy and involves picking off the compound seed head. The seed germinates well in sheltered spots.

As individual plants have basal rosette leaves, each does not cover much ground surface but when billy buttons are locally common, they can cover sixty to seventy per cent of an area.

Figure 8—Alpine woodrush (*Luzula oldfieldii*) colonizing an erosion pavement

Billy buttons are mainly secondary colonizers of bare areas and follow the mat-formers, but they do provide some ground cover in the initial colonizing stages.

On areas of dead snowgrass, billy buttons often behave as primary colonizers. In the snowgrass-snow daisy community, billy buttons are often locally common in patches.

Muellers buttercup (*Ranunculus muelleri*)

This buttercup is a small tufted plant with a basal rosette of leaves.

The plant occurs in nearly all the plant communities in the Alpine area, usually as isolated plants. It is sometimes locally common.

Muellers buttercup is a primary colonizer in blowout areas, and eroded areas. The plant does not tolerate much competition.

It is a useful complementary colonizer of eroded areas.

Loose Basal Rosette Types

Native yam (*Microseris scapigera*)

Native yam is a soft perennial herb, with basal leaves.

The plant occurs mainly in the snowgrass-snow daisy community. It is locally common. It is seen as a primary colonizer in patches of dead snowgrass.

Similarly to *Trisetum spicatum,* yam is a useful colonizing species on treated mulched areas, because of its ability to colonize on dead snowgrass.

Native yam flowers late in the season.

Tufted Herbs

Alpine woodrush (*Luzula oldfieldii*)

Alpine woodrush is a tufted erect perennial with a somewhat bulbous base (figure 8). It can grow 30 to 40 cm high but most plants are up to 20 cm high. Several plants may be clumped together, growing from the original rootstock and forming a compact colony.

Alpine woodrush is usually confined to the more exposed situations where it is a successful species. These situations are typically the feldmarks, particularly the cold feldmark. Vegetation cover is usually discontinuous.

The plant is a colonizer of bare exposed eroded areas, but is generally more successful on treated areas. In latter sites, Alpine woodrush, together with Alpine colobanthus (*Colobanthus* sp.) can form an almost closed sward. This is in direct contrast to the more open situations in which it occurs naturally.

Flowering is at a peak during February, with seeding in mid to late-March. Seed collection involves clipping seed heads off the plants. Propagation can be either vegatative or from seed.

Because of its erect, tufted habit, individual plants of Alpine woodrush cover areas of 2 to 4 cm in diameter at the base, with aerial cover being 4 to 8 cm. Where clumps occur together the area covered is larger.

Alpine woodrush is a successful colonizer of the more exposed situations.

Snow Daisy (*Celmisia asteliifolia*)

Snow daisy is a perennial herb, with tufted radical leaves. It propagates by strong rhizomes and can occupy extensive areas, the new plants being interconnected by the rhizomes. Each colony or clone is easily recognized as belonging to a particular rhizome, and plants become gradually smaller towards the growing end.

Snow daisy prefers deep soil on uneroded sites and occurs extensively on the better drained slopes. It is the most common of all herbaceous species in the Alpine area but avoids exposed sites, wet areas and frost pockets.

Rhizomes generally extend to the edges of the erosion or natural pavements but do not colonize the pavements.

Some erosion pavements have sharp, often actively eroding scarps. If these scarps are shaped, snow daisy will grow to the edges of the pavement and stabilize the scarps. Rhizomes can also be transplanted into these shaped scarps to help stabilize them.

Snow daisy has been observed to grow on eroded areas only after they have been ripped.

Erosion of a stable snow daisy community leads to exposure of the rhizomes of snow daisy, followed by death of the plant after frosts.

Snow daisy is mainly confined to its natural habitat, where it is very successful. It competes well in its habitat, occupying most of an area, and allowing little or no room for other species.

Flowering commences in early-January and builds up to a peak by late-January-mid-February. Like most Alpine species, flowering commences first at the lower elevations and proceeds higher as the season progresses.

Seed begins to mature by the end of February and is nearly all mature by mid-March. Seed heads can be readily harvested by hand.

Snow daisy is rarely seen growing naturally from seedlings, and although it seeds prolifically, seed setting appears to be more successful in some years than in others. Insect damage to seed heads is common.

The plant has achieved its success largely by vegetative propagation. Its spreading rhizomes occupy most of the suitable habitats.

Snow daisy slowly invades areas of dead snow grass. These areas are colonized initially by seedling growth of herb species such as Alpine purslane, billy buttons and native yam. Snow daisy then gradually covers these areas from the edges.

The complete swards of snow daisy provide excellent cover, with no areas of soil being exposed to erosive forces.

Erect or Ascending Stemmed Herbs

Variable groundsel (*Senecio lautus*)

Variable groundsel is an erect perennial herb, with a tendency to a spreading habit as the plants grow. It grows from seedlings and spreads by rhizomes. Plants are generally smaller on bare sites (figure 9).

Groundsel can be observed in most habitats except those that are constantly wet, and those that have exposed westerly aspects. Its most usual habitat is the cold feldmark.

It is a colonizer of bare sites, noticeable because it may often be the only tall species in these areas. It can be observed on both treated and untreated eroded sites, and can be considered a successful colonizer of them. It is more common on treated areas.

Flowering reaches a peak from the middle to the end of February, and seeding from the middle to the end of March. Seed collection is easy, by plucking the seed heads.

Mature plants of variable groundsel can provide cover over areas of 30 to 40 cm in diameter. On bare ground, individual plants cover areas up to 20 cm in diameter.

Variable groundsel, although very noticeable where it has no competition, can also be found in closed swards of snowgrass. It can behave as a primary colonizer on bare areas but will also persist as the vegetative sward achieves complete ground cover. It can also colonize areas of dead snowgrass.

Sorrel (*Rumex angiocarpa*, syn *R. acetosella*)

Sorrel is a slender, erect perennial herb. The plant is usually very noticeable because of its red colouration. It can grow up to 50 cm high, but most plants in the Alpine area are up to 20 cm high. The plant spreads by an extensive slender rhizome system.

Sorrel is ubiquitous, occurring throughout the Alpine area in the snowgrass-snow daisy community and bare areas but is not common in very exposed areas.

The plant flowers over most of the season, at lower altitudes first. Seed forms by March and collection is relatively easy due to the upright nature of the plant. Propagation is from rhizomes.

Sorrel provides relatively poor ground cover. On bare eroded areas, whether treated or untreated, ground cover provided by the plant is poor. During the middle of the growing season sorrel can provide 40 to 50 per cent cover, but only for a short period. Sorrel appears to perform better during drier growing seasons. This is possibly because of less active competition.

However, sorrel is a very successful primary colonizer. Its extensive rhizome system gives the plant soil binding characteristics.

There seems to be little need to help this naturalized species spread into reclaimed eroded areas. The plant is usually there first, or is introduced in the hay mulch. Fertilizer encourages its growth, since the rhizome system gives plants already present a start and grasses used in the reclamation treatment are slower to germinate than sorrel.

Eyebrights (*Euphrasia* species)

The eyebrights are erect herbaceous plants, growing in clumps. The small purple-flowered plant on the windswept feldmarks (*E. alsa*) grows to about 10 cm, while the other species (*E.* aff. *glacialis*) grows to 20 cm or more. These latter plants occur mainly in the snowgrass-snow daisy community in clumps. The clumps can be up to 30 cm in diameter.

The larger species occur mainly in the intertussock spaces where they perform a useful function in providing ground cover.

Eyebrights are not commonly seen as primary colonizers of eroded areas.

Tufted Grasses

Trisetum spicatum

Trisetum is a tufted perennial grass, growing to about twenty centimetres in height. The plant has a rusty appearance

Figure 9—Variable groundsel (*Senecio lautus*) colonizing an erosion pavement

due to a general pubescence. Spikelets are reddish, becoming yellow as florets open.

This plant occurs in the snowgrass-snow daisy community. It is prominent because of its tall, tufted appearance. The plant is only common locally.

Trisetum is sometimes seen as a primary colonizer of patches of dead snowgrass but it does not occur on eroded areas.

However, it may be a successful species on eroded sites. The artificial mulch used to treat eroded areas is similar to the mulch left by patches of dead snowgrass. With fertilizer, the plant may be useful as a primary colonizer and stabilizing species.

Propagation is by seed which matures late in the season. Collection is relatively easy.

GERMINATION AND GROWTH OF ALPINE SPECIES

Growth of most Alpine species begins before snow thaw. Some germinations also occur in the protection of the snow, despite low air temperatures.

Young seedlings are protected from frost and dessication by litter and snow early in the season. Due to the high altitude, the soil surface dries very quickly.

Seedlings in the Alpine area occur either under snow drifts before complete snow melt, or more commonly in very sheltered spots, under older plants and litter, well after snow melt.

Under natural conditions, regeneration and growth from seedlings on bare areas is rare. Colonization by young plants therefore depends upon the site being protected.

The generally prolific seed production of alpine herbs ensures successful germination in the following summer even if seed viability is poor. Observations indicate that adequate germination does occur but seedling survival is a critical factor determining whether plants persist. The more protected the site, the better the chance of survival.

Untreated, eroded sites do not have much ground cover. As well, this cover can deteriorate in years with abnormal weather, particularly drought years. The reason for this poor cover is the high mortality of seedlings due to exposure.

Recolonization of eroded areas by germination and growth of native species is therefore a slow process, with many false starts.

RECOLONIZATION OF ERODED AREAS BY NATIVE SPECIES

Untreated

Minor to moderately sheet eroded areas are generally recolonized naturally by such species as sorrel, Alpine purslane, Alpine willowherb, variable groundsel, Australian edelweiss and Alpine woodrush. Other species which can occur as primary colonizers are listed in the appendix.

Overall, the ground cover on these areas is 30 per cent. That is, 70 per cent of the soil surface is still exposed. Most of these areas also have minor to moderately eroding edges.

Colonization does not appear to have proceeded naturally to any great extent, nor does the process appear to have speeded up in recent years. The evidence suggests that recolonization is an extremely slow process. There are very few minor to moderately sheet eroded areas that have 70 per cent or more ground cover.

While these areas generally have poor vegetative ground cover, there is not much evidence of soil loss. But much soil is bared to the forces of erosion; raindrop, hail, frost heave and wind. As well, and perhaps more importantly, these areas of bare soil provide areas of rapid runoff, which cause localized flooding, and deleterious effects on stable vegetation.

On areas of severe sheet erosion and also areas of rilling and gullying, there is little or no evidence of colonization by native species.

Treated

Treatment of the bare eroded areas involves seeding and fertilizing, protection with a bitumen-straw mulch and sometimes disturbing the soil surface by ripping.

Recolonization on most treated areas is good. The Carruthers Peak area, one of the first restored, has an overall ground cover estimated at 90 per cent of which native species contribute half.

Other areas more recently treated show varying amounts of colonization by native plants.

COLONIZATION AND SUCCESSION ON BARE AREAS

The best primary colonizers of the less exposed sites are Alpine purslane, Alpine willowherb, sorrel, and variable groundsel.

The more exposed sites are best colonized by Alpine woodrush, Alpine colobanthus and Australian edelweiss, as well as Alpine willowherb and to a lesser extent Alpine purslane.

Most of these species occur in similar situations over their natural range. That is, the habitat on the eroded areas is essentially similar to their natural habitat. So, rather than consider them as primary colonizers, they could be achieving the status of stable communities on these bare areas. However, invasion by elements of the snowgrass-snow daisy community might be expected. This would depend on the degree of exposure of bare area. Litter and soil build-up, if occurring on these areas, would also encourage this invasion.

On less exposed sites almost complete cover can be provided by the colonizers while on exposed areas they tend to be discontinuous both in distribution and total ground cover provided.

It is difficult to distinguish any succession on bare areas. Increase or decrease in abundance of native species over time will determine if a succession is occurring.

GROUND COVER AND NATIVE SPECIES

Ground cover has been considered for the more important species.

Evaluation of native species for ground cover purposes varies according to their growth habits. The species can be broadly divided into—

(1) Mat-formers.
(2) Hummock or cushion plants.
(3) Rosette types.
(4) Loose basal rosette types.
(5) Tufted herbs.
(6) Erect or ascending stemmed herbs.
(7) Tufted grasses.

Each habit type provides colonizing species. Not all of the species discussed here were described under earlier headings.

(1) Mat-formers

Generally, the mat-forming species provide the best ground cover, especially in colonizing situations. These include Alpine purslane, Alpine willowherb, Alpine cudweed and Australian edelweiss. This is because of their ground-hugging, spreading nature, covering for the most part all of the ground surface on which the plant occurs. However, in more exposed situations they are subject to windblasting, and by themselves do not constitute the best cover.

Also included in this category are the shrubby *Pimelea alpina, Epacris microphylla* and *Pentachondra* species. They are observed in exposed situations, and sometimes on blowouts, but are not common. They could provide cover in exposed sites, but are difficult to establish.

Bitumen-straw mulch provides shelter during the initial establishment and spreading stages. Taller growing species are necessary for protection of subsequent growth. The taller growth reduces wind velocity at ground level, and so reduces blasting by loose soil and gravel.

Mat-forming species are potentially better species for use in erosion reclamation treatments because of their spreading habit. They could be expected to gradually cover large amounts of bare ground.

(2) Hummock or Cushion Plants

The small hummock-forming species such as Alpine colobanthus and *Scleranthus* also provide complete ground cover on the area on which they occur. However, the area they cover is not large compared with the mat-formers, nor do they spread to any great degree. They are not so subject to windblasting, due to their cushion-like shape.

Overall the cushion-type plants are not so suitable for treated areas unless complete swards can be established. However, they would provide cover in more exposed situations, where swards are difficult to establish.

(3) Rosette types

The rosette-forming species include the billy buttons, Muellers buttercup and *Brachycome aculeata.* These all have relatively strong taproots.

The billy buttons usually provide the best cover of the rosette types, as several plants tend to grow together from the previous year's rootstocks. Clumps of billy buttons can be observed covering areas up to 1 metre in diameter. With their tallgrowing, stout flowering stems they also provide height to the vegetation, reducing wind velocity at ground level.

The rosette types are potentially useful as complementary species to the mat-formers in colonizing situations.

(4) Loose Basal Rosette types

Native yam is the only species considered here. Perenneating by its tuberous taproot, the rosette forms during the season to provide a discontinuous cover at ground level. There is not a continual cover over the season.

It could play a complementary role as a colonizer, although not providing much ground cover.

(5) Tufted Herbs

The tufted herbs are Alpine woodrush, snow daisy and Australian gentian (*Gentianella dimensis*). They are perennial, well-rooted species. Snow daisy is strongly rhizomatous.

Woodrush provides only limited cover in the more exposed situations.

Snow daisy occurs in dense swards. It affords good permanent ground cover over wide areas. However, its use is limited to areas with at least 5 to 10 cm depth of soil. In these situations snow daisy can provide better cover than most other Alpine species.

Australian gentian provides complete ground cover for the area it grows on. Clumps can be 20 to 30 cm in diameter. But it does not commonly occur as a colonizer of bare areas.

(6) Erect or Ascending Stemmed Herbs

These species are generally tall-growing, providing good to fair ground cover. They include variable groundsel and the eyebrights.

The eyebrights provide only fair ground cover. They are of limited value, occurring mainly in intertussock spaces (*Euphrasia* aff. *glacialis*) or in very exposed areas (*E. alsa*).

Variable groundsel can cover ground areas of 30 to 40 cm in diameter. Plants are usually smaller in exposed situations, and cover may be discontinuous.

Because groundsel provides height, and can grow in exposed areas it is a good complementary species together with the mat-formers.

(7) Tufted Grasses

The tufted grasses, *Trisetum spicatum* and *Agrostis muelleriana* do not provide much cover. The small *Agrostis* provides basal cover of only about 1 or 2 cm, while *Trisetum* provides basal cover of up to 5 cm.

Agrostis may play a role as a complementary colonizer. *Trisetum* may be a potential cover species in later successional stages.

NATIVE SPECIES AND FERTILIZER

It is difficult to distinguish between the effect of fertilizer and the effect of protection afforded by the bitumen straw mulch and cover species, plus the improved moisture relationships which also result from the mulch.

The combination of fertilizer, protection, and improved moisture conditions all combine to produce better ground cover on treated as opposed to untreated eroded sites.

However, evidence indicates that Alpine purslane, variable groundsel and sorrel and Alpine willowherb all respond positively to fertilizer.

The rate of reclamation in treated areas is probably increased by the use of fertilizer.

Additional applications of fertilizer in following seasons could be expected to assist colonization.

CONCLUSIONS

Treated eroded areas are reclaiming faster than untreated eroded areas. On the latter, native species are not nearly as common or as successful. The relative success of natives on treated areas is due to the initial protection given by the mulch and cover species, as well as the stimulus of fertilizer.

The continuation of reclamation techniques is essential to provide a rapid recovery from erosion in the alpine area.

The most successful native species in colonizing situations are the mat-forming plants, typified by Alpine purslane and Alpine willowherb.

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APPENDIX

SPECIES IN COLONIZING SITUATIONS

Neopaxia australasica (Hook. f.) Ö. Nilss (*syn Montia australasica*) (J. D. Hook) Pax et Hoofm.
Epilobium tasmanicum Hausskn.
Senecio lautus Forst. f. ex. Willd. sens. lat.
Colobanthus benthamianus Fenzl.
Luzula oldfieldii Hook. f. ssp. Dura Edgar.
Gnaphalium collinum Labill.
Ewartia nubigena (F. Muell) Beauverd.
Scleranthus sp.
Euphrasia alsa F. Muell.
Euphrasia aff *glacialis* Wettst.
Oreomyrris sp.
Rumex angiocarpa Murb. (syn. *R. acetosella LL*).
Capsella bursa-pastoris (L) Medic.
Craspedia Forst. f. var. Alpina Ewart.
Craspedia uniflora Forst. f. sens lat.
Trisetum spicatum L. Richter.
Ranunculus muelleri Benth.
Brachychome aculeata (Labill) Less.
Agrostis muelleriana J. Vickery.
Epacris aff *petrophila* Hook. f.
Pentachondra sp.
Microseris scapigera (Sol. ex Acunn) Schultz-Bip.
Pimelea alpina F. Muell. ex Meissn.
Aciphylla glacialis (F. Muell). Benth.
Celmisia asteliifolia Hook. f. (*syn. C. longifolia*) Coss.—under revision.
Gentianella dimensis (Griseb) J. H. Willis.
Helipterum albicans (A. Cunn) D.C. ssp. alpinum (F. Muell) Wils.