Rehabilitation Guidelines for the Resort Areas of Kosciuszko National Park

August 2007

Department of **Environment & Climate Change** NSW

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Prepared for:

Parks and Wildlife Division
Department of Environment and Climate Change NSW
PO Box 2228
Jindabyne NSW 2627
Australia

By:

nghenvironmental
PO Box 4770
Bega NSW 2550
Australia

Published by:

Department of Environment and Climate Change NSW
59-61 Goulburn St
PO Box A290
Sydney South 1232
Australia

Ph: (02) 9995 5000 (switchboard)
Ph: 131 555 (environment information and publications requests)
Ph: 1300 361 967 (national parks information and publications requests)
Fax: (02) 9995 5999
TTy: (02) 9211 4723
Email: info@environment.nsw.gov.au
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Liz MacPhee (NPWS Rehabilitation Officer, Former Snowy Sites Scheme) provided significant information in regard to the planning of rehabilitation and relevant rehabilitation techniques that have been researched and applied in Victorian alpine resorts. This information in this document is the intellectual property of the Department of Environment and Conservation and is protected under copyright laws.

Amendments and Additions

The only controlled copy of the Rehabilitation Guidelines will be the version available at www.nationalparks.nsw.gov.au

Amendments are to be recorded in the table below.

When an amendment or addition is made to the Guidelines and advisory email will be sent to interested parties.

To be included on the distribution list of the advisory email please contact the NPWS Resorts Section Assessments Coordinator or (02) 6450 5543.

A summary of the amendments and additions will also be available on the internet.

Section reference	Amendment	Reason for amendment	Approved by	Date

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Part A

Introduction, Background and Objectives of Rehabilitation

A Introduction, Background and Objectives of Rehabilitation

A.1 Introduction

These *Rehabilitation Guidelines* ('the Guidelines') have been prepared to assist land managers, their staff and contractors in the ski resort areas of Kosciuszko National Park (KNP) plan and undertake rehabilitation of disturbed sites. The Guidelines provide a baseline for best practice rehabilitation, focussing on six 'keys' to success and efficiency. These are summarised below.

The Keys to Efficient and Successful Rehabilitation

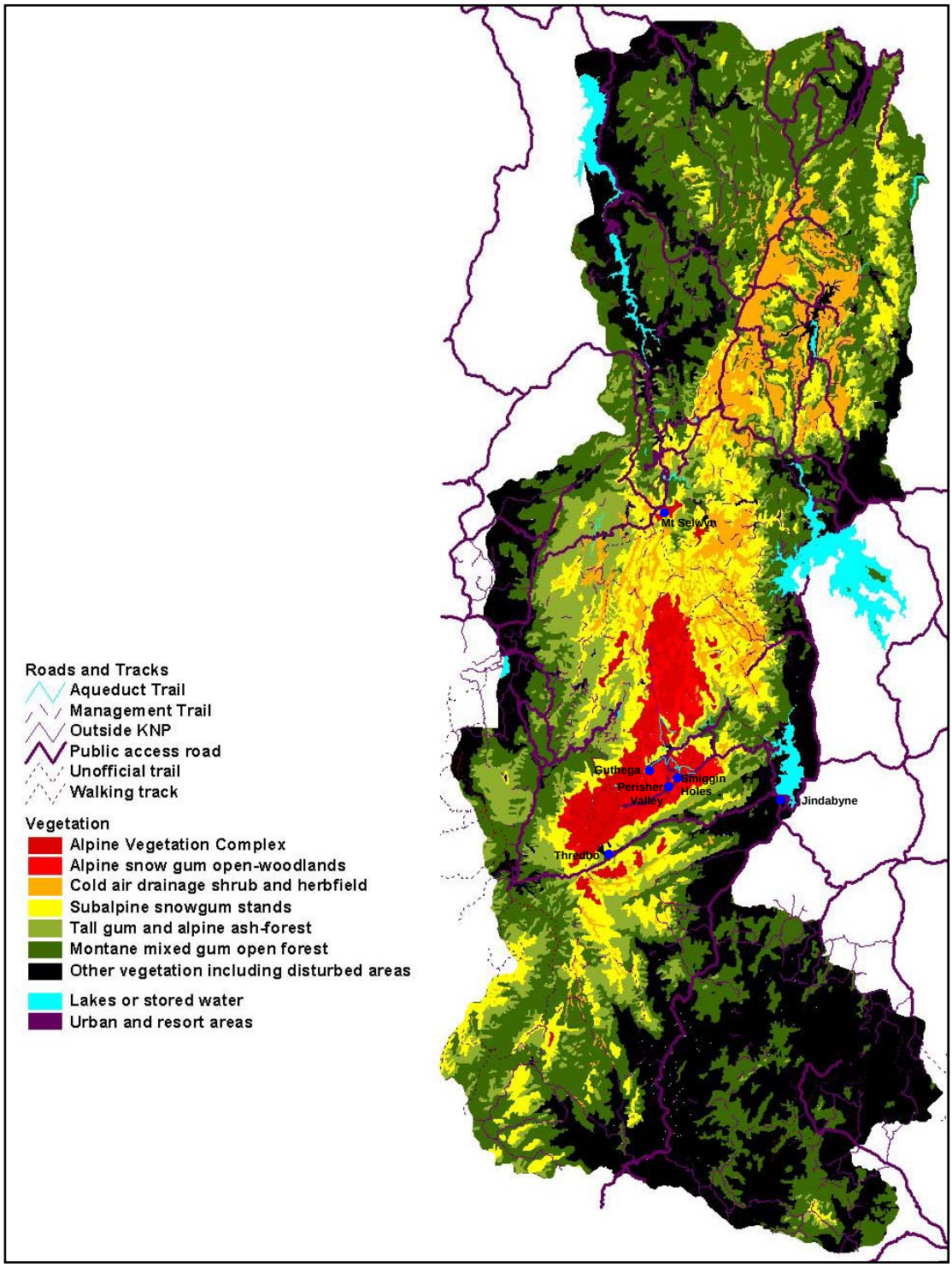
- **A site by site approach to rehabilitation**:- every site is different, so we need to understand the individual characteristics of each site to be able to plan rehabilitation in a way that maximises potential for success.
- **The use of indigenous species**[1]:- indigenous species are ideal for rehabilitation because:
  - They cover and protect soils much better than exotic species;
  - They are adapted to local climatic and soil conditions, so they generally require less fertilising and maintenance than exotics;
  - They strengthen the ecosystem so that it is better able to withstand disturbance, climate change and weed invasion;
  - They provide the right kind of food and shelter for native animals; and
  - They are beautiful!
- **Management continuity**:- Ideally, for rehabilitation to be efficient and successful, one person should be responsible for overseeing the entire process of planning, planting, maintaining and monitoring a particular site.
- **Skilled rehabilitation crews**:- well trained staff or contractors will be able to identify ways to use resources efficiently and ensure that rehabilitation is successful.
- **Consideration of timing constraints**:- Rehabilitation has to take into account natural rhythms such as seed availability, propagation times and the best seasons for planting. These constraints need to be considered and planned for from the early stages of development.
- **Monitoring**:- Rehabilitated sites need to be monitored for several years after planting to make sure that they are successful and allow lessons to be learned from experience.

[1] Indigenous species are defined as "species naturally distributed within a specific geographic area", eg, KNP or the Perisher Range (vs. *native species* which are species indigenous to Australia).

The Guidelines have been developed to meet the particular needs of ski resort managers. As a result, they focus on the characteristics and requirements of the resort areas of Thredbo, the Perisher Range Resorts (Perisher, Smiggin Holes and Guthega), Charlotte Pass and Mt Selwyn. The Guidelines would also be useful, however, to other land managers working in the montane, subalpine and/or alpine zones of KNP and the Australian Alps (e.g. Country Energy, Telstra, Snowy Hydro and government authorities).

The montane, sub-alpine and alpine zones of KNP are shown in Figure A.1.1.

Figure A.1.1 Montane, sub-alpine and alpine zones of KNP (red to green).



A.2 How to use these Guidelines

These Guidelines have been arranged in sections that can easily be extracted for particular tasks. Appendix 1 details what is contained in each section of the guidelines and intended users.

Under NPWS policy, these Guidelines will be updated regularly to ensure that they remain relevant and continue to reflect best practice. A recommended review period for each section is indicated in Appendix 1. Review should be undertaken by the NPWS with input from stakeholders involved in rehabilitation within KNP, particularly resort managers.

A.3 Alps in Context

The Australian Alps, including the Snowy Mountains and alpine regions of Victoria and Tasmania, are a unique and valuable part of Australia's natural environment. Alpine and sub-alpine areas occupy less than 0.15% of Australia's landmass (Costin 1979-2000) Not only are these areas unusual, but they are also culturally valuable, featuring regularly in the stories, history and aesthetic, emotional and recreational values that contribute to Australia's identity.

The Australian Alps are unusual because they have the most extensive soils of any mountains in the world, but large quantities of soil have been lost due to past land uses such as grazing, burning of vegetation and construction activities (Good 1992).

The Alps also represent one of Australia's largest catchment areas, receiving an estimate of almost one third of southeast Australia's rainfall. The peaty, organic soils of the mountains play a vital part in releasing these water resources slowly and continuously into the lowlands. Bogs act as natural reservoirs, holding onto vast amounts of water and slowly releasing it over dry periods to maintain a constant supply downstream (Good 1992, Costin et al. 1959 & 1960, Connell Wagner 2001). Loss of soil, vegetation and general degradation of bogs has, however, affected this valuable water resource. The damaged bogs and soils no longer retain as much water as they did in the past, so, instead of releasing it steadily over the year, water runs off quickly in springtime, causing erosion and siltation of downstream rivers and lakes (Good 1992, Costin et al. 1959 & 1960, Connell Wagner 2001). By summer and autumn, most water is likely to have left the mountains, causing much lower late season flows downstream than occurred in the past.

As well as their important role in water conservation, Australia's mountain soils also support numerous unusual plants and animals, many of which occur only in the mountainous regions. In these environments they form communities with other species that, like them, have evolved to survive snow and extreme cold, strong winds and nutrient-poor soils (ISC 2002, Costin 1979-2000). Many species are slow growing and, as a result, they can take a long time to recolonise an area once they have been removed, especially if the organic soils have also been washed or blown away from the site. When this occurs, areas become susceptible to weed invasion, which, along with loss of habitat, may reduce the competitive ability of native fauna (Costin 1979-2000).

Climate change is another factor likely to increase pressure on the native flora and fauna by reducing snow and rain fall, increasing temperatures and creating conditions that potentially favour the ingress of weeds, pests and diseases and more frequent fires (Hennessy et al. 2003, Pickering et al. 2004). Improving the condition of the Alps will make them more resistant to the potential long term impacts of climate change and other disturbance (Preston and Jones 2006, Pickering et al.

2004). Furthermore, well managed areas will also more truly reflect the aesthetic qualities that make the Alps unique and appealing to visitors, potentially contributing to their attractiveness as year round tourist destinations.

A.4 Central Concepts of Rehabilitation

A.4.1 Rehabilitation: revegetation or restoration?

According to the Macquarie Dictionary, the definition of rehabilitation is, *'to restore to a good condition, regenerate or alter to an improved form.'* In vegetation management literature, rehabilitation is generally understood to involve a process of introducing plants to a disturbed site with the aim of 'kick starting' natural processes so that eventually nature should be able to take over and the site will start to function again like a natural ecosystem. E.g.;

- the US EPA's *River Corridor and Wetland Restoration Program* define rehabilitation as, *'the manipulation of the physical, chemical, or biological characteristics of a site with the goal of reparing natural/historic functions (of degraded wetland).'* (ww.epa.gov/owow/wetlands/restore/defs.html)
- the US Plant Conservation Alliance defines rehabilitation as, *'altering a degraded environment in order to improve ecological function'*. (www.nps.gov/plants/restore/library/glossary.html)
- the US *Invaders of the Sonoran Desert Region* project of the Arizona-Sonora Desert Museum project defines rehabilitation as, *'the recovery of specific ecosystem services in a degraded ecosystem or habitat.'* (www.desertmuseum.org/invaders/invaders_glossary.php)

In deciding how to manage a disturbed site, the desired long term outcome needs to be considered; e.g. is the aim simply to protect soils from heavy or moderate usage, to provide aesthetic qualities to the site, or to restore the natural ecosystem?

Figure A.4.1 provides a schematic representation of the different approaches to rehabilitation and their relationships. Depending on the proposed use of the site, management options include:

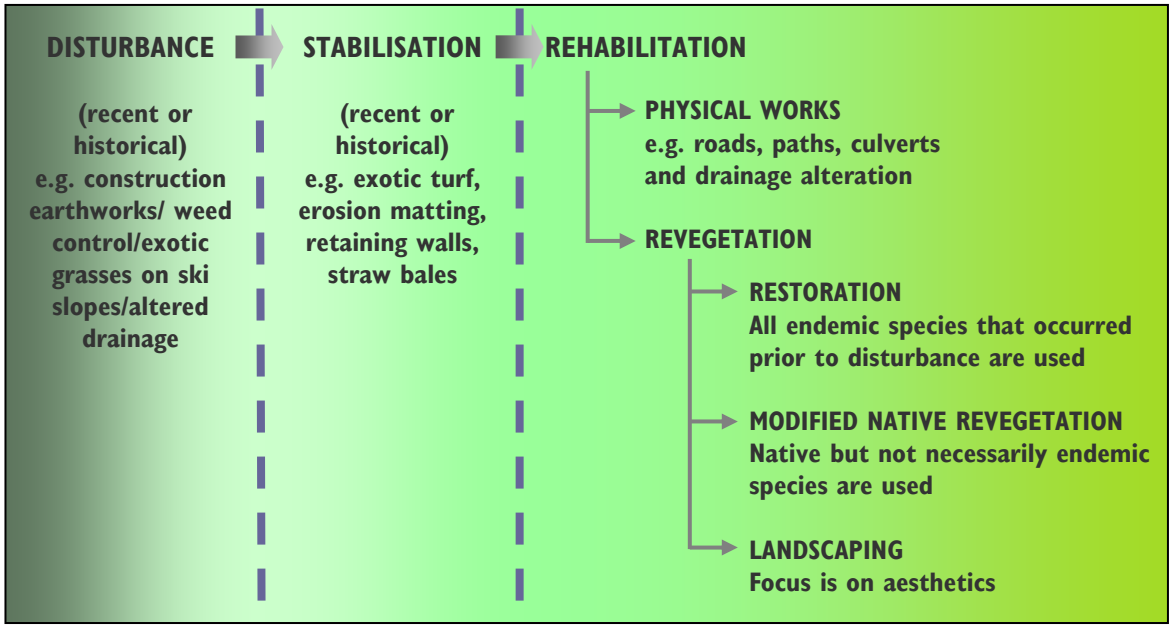
Stabilisation – generally a first stage in responding to a disturbed site, stabilisation involves implementing measures to prevent further environmental degradation such as soil erosion or colonisation by weeds. Stabilisation could include planting-out the site to create a protective groundcover, or use of other techniques such as paving or other materials.

Revegetation – focuses on site stabilisation and, in some cases, improving the appearance of the area by establishing vegetative cover. In revegetation, any kind of vegetation could be used, not necessarily indigenous species, however, where non-indigenous species are used the site will be more likely to require long term maintenance, the ecological benefits will be lower and the revegetation may contribute to the spread of weeds.

Restoration – restoration of the ecosystem of a site to a state resembling its original, pre-disturbance condition. Involves kick-starting natural processes, for which the use of indigenous[2] species is essential.

Landscaping – emphasis on aesthetics rather than ecosystem processes. May use indigenous or non-indigenous plants, however, where indigenous species are used these are generally selected to create a representative rather than a realistic ecosystem. Landscaped areas are likely to require high levels of ongoing maintenance; do not usually offer significant ecological advantages; and, like revegetated areas, may contribute to the spread of weeds.

Figure A.4.1 Relationship between different approaches to rehabilitation



This Guideline emphasises rehabilitation using indigenous species. As indicated in section A.3, the alpine regions, including the ski resort areas, are facing a number of significant environmental issues arising from exotic pest species, soil degradation, climate change and increased human visitation. The use of indigenous species in effective, high quality rehabilitation will help make the unique and significant natural ecological systems of the Australian Alps robust and self sustaining in the face of these pressures, as well as improving the overall appearance of the alpine landscape and their appeal to visitors. While planting programs you are planning may have the primary aim of stabilising soils, creating an aesthetically pleasing landscape or improving vegetative cover, by choosing to use indigenous species for these plantings, you will be improving the chances of the alpine landscape being able to sustain itself in the future and continue to attract visitors.

[2] Refer to section A.1 (Introduction) for a definition of indigenous.

A.5 Knowledge, Skills and Responsibilities

A.5.1 The Advantage of Having Skilled Staff

Skilled staff are essential for effective rehabilitation. With appropriate training and experience, they will understand the significance of rehabilitation and ensure that rehabilitation is effective and completed efficiently.

These Guidelines have been prepared to provide a resource for people undertaking rehabilitation planning and on-ground works, however, the Guidelines do not take the place of a practical working knowledge of rehabilitation issues. It is essential, therefore, that the guidelines are backed up by appropriate training and a concerted effort on the part of Kosciuszko land managers to develop a pool of trained and experienced workers and rehabilitation managers.

Rehabilitation issues must be part of the site induction process. All workers likely to be involved in on-ground works need to be aware of the factors influencing successful rehabilitation. This will also ensure that rehabilitation resources are used efficiently, an important consideration as rehabilitation can be a significant proportion of the budget for any project.

A.5.2 The Roles and Responsibilities of Rehabilitation Teams

The roles and responsibilities of people involved in rehabilitation generally fall into two groups: project management and on-ground workers. The respective roles of these two groups are as follows:

A.5.2.1 Project Managers

Rehabilitation project managers are essential to providing continuity and ownership through to the end of the project and making sure that the best possible job is completed.

For successful rehabilitation to be achieved, each resort or other land manager should have at least one person with the ability to manage a rehabilitation project. This person would be appropriately trained to prepare and manage the implementation of a rehabilitation plan, and they would be responsible for overseeing the rehabilitation process from beginning to end, to ensure that there is continuity and ownership in management.

Rehabilitation project managers should be involved in the development process as a whole, from initial planning to rehabilitation and follow-up work. This level of involvement will ensure that the project manager has an awareness of all aspects of site environmental management and planning and ensure that rehabilitation timing constraints are appropriately factored into development planning.

Tables A.5.1 and A.5.2 detail the knowledge, skills and responsibilities required for Project Managers.

A.5.2.2 Works Crew

Rehabilitation works crews are the on-ground workers who carry out the physical work of rehabilitation including site preparation, planting and maintenance. They may also be involved in seed or cutting collection and propagation. Works crews should have at least one person who has sufficient skills, experience and an understanding of the significance of rehabilitation and techniques used to protect the environment and undertake rehabilitation work.

Tables A.5.1 and A.5.2 detail the knowledge, skills and responsibilities required for works crews.

Table A.5.1 Knowledge and Skills for Best Practice Rehabilitation

KNOWLEDGE	PROJECT MANAGER		WORKS CREW	
	ESSENTIAL	DESIRABLE	ESSENTIAL	DESIRABLE
The aims and objectives of rehabilitation.	☑		☑	
What is a Site Assessment?	☑			☑
What is a Rehabilitation Plan?	☑			☑
SKILLS AND EXPERIENCE				
Soil conservation methods	☑		☑	
Site drainage	☑		☑	
Trenching techniques	☑		☑	
The ability to quality control tube stock and seed (if stock grown in-house); or The ability to recognise poor quality stock and manage growers.	☑		☑	
Knowledge and understanding of weed management techniques appropriate to most weeds occurring in Kosciuszko National Park.	☑		☑	

Table A.5.2 Rehabilitation Responsibilities

REHABILITATION PROJECT MANAGEMENT	
Best Practice	• Project manager has high level knowledge, skills and experience of all aspects of alpine rehabilitation. • Project manager is responsible for site rehabilitation including development of a rehabilitation plan to induction of works crew, implementation, maintenance and monitoring of the site. • Project manager acts on the outcomes of audit(s) carried out by an independent or third party auditor. • Project manager ensures a thorough handover occurs so that the site is appropriately maintained and monitored over the long term. • Project manager documents site characteristics, effectiveness of rehabilitation techniques applied, and makes documentation available for future reference.
Minimum Acceptable Standard	• Project manager has good basic knowledge, skills and experience in alpine rehabilitation. • Project manager has access to expert advice on alpine rehabilitation. • Project manager ensures responsibility has been delegated to ensure preparation of a rehabilitation plan, induction of works crews, implementation, maintenance, monitoring and handover of site. • Project manager understands the aims and objectives of the rehabilitation plans.
Poor Practice	• No one is identified as project manager; and/or • Responsibilities for rehabilitation have not been delegated; and/or • There is no induction or hand-over between each step in the rehabilitation process; and/or • No post-rehabilitation monitoring is undertaken; and/or • No site hand-over occurs.
REHABILITATION WORKS CREW	
Best Practice	All members of the rehabilitation works crew have a high level of knowledge, skills and experience in rehabilitation.
Minimum Acceptable Standard	Crew foreman has good basic knowledge, skills and experience in rehabilitation.
Poor Practice	No one in the works crew has adequate knowledge, understanding and experience of rehabilitation.

Part B

Planning For Rehabilitation

B Planning for Rehabilitation

B.1 Timing in the Planning Process

Rehabilitation is a long term activity that needs to be carefully planned around a variety of natural and operational time constraints.

Factors to consider for successful rehabilitation include:

Natural Factors:

- Identification of indigenous species on and surrounding the site: This is necessary so that the most suitable species for rehabilitation can be identified. In alpine environments an adequate site assessment can only be undertaken if the ground is not covered by snow and species that spend part of their life cycle below ground (annuals, bulbs etc.) are visible.
- Collection of material for propagation (seeds, cuttings or division): In the Kosciuszko alpine areas most seed ripens between late January and March. Cuttings are normally taken after seed production in March – April, when plants put their energy into new growth. Division can be undertaken over a broader period, generally January – March.
- Propagation of tubestock: This takes time and can vary from one species to another. Normally propagation is carried out over autumn and winter (after seed has ripened), which means that stock will generally be ready for planting the following spring or autumn (depending on how long it takes to propagate the species). If timing between the works and plant availability is poor, use of temporary cover crops and mulching will be required.
- Stock holding time: Tubestock (and some seed) needs to be planted when it is at its most viable, otherwise there are likely to be high rates of attrition and more follow-up planting will be required.
- Establishment time: Plants take time to establish once they have been planted out and will require monitoring and maintenance during this period.

Operational Factors:

- Budget cycles and work plans: These can impose significant constraints on the timing and ultimate success of rehabilitation. The inflexibility of natural cycles and how these constraints affect the project timeline need to be taken into account. This is why rehabilitation has to be an integral part of the planning process from the outset of any development.
- Overlap with other aspects of the development planning and approvals process: There are many areas where planning for rehabilitation overlaps with other aspects of the development planning and approvals process. For example:

- The environmental impact assessment (EIA/REF/SEE) for proposals include a thorough site assessment. Parts of this will be relevant to rehabilitation, e.g. assessment of soil and water, plant lists and details of threatened species.
- The (site) environmental management plan (EMP/SEMP) for the proposal covers all aspects of environmental management on the site. Some of the environmental safeguards that it will include are relevant to rehabilitation, e.g. vegetation and soil protection measures. There is scope for combining the Rehabilitation Plan with the SEMP (refer to section B.3.1.3).

Awareness of these areas of overlap can allow work projects to be planned and undertaken much more efficiently. In these Guidelines, an attempt has been made to highlight areas of overlap and show how efficiency can be improved.

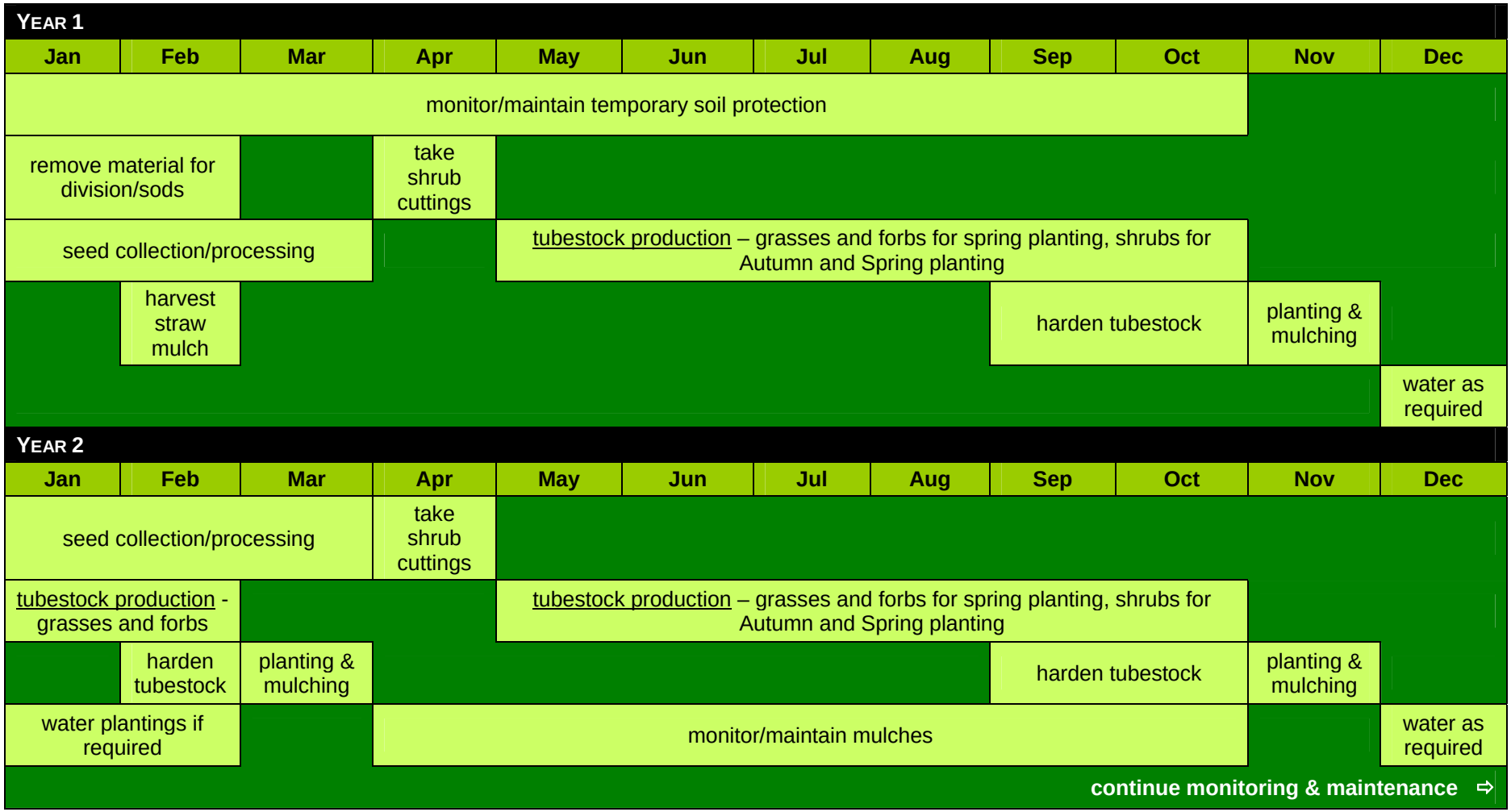
Table B.1.1 provides an indicative guide to the planning and timing of rehabilitation. Specific timing should however, consider the individual characteristics of the species to be used, seasonal variations, and the progress of any works.

Generally, propagation activities are centred on two main ‘seasons’:

- Late summer to early autumn: seed collection and propagation.
- Winter to early spring: Production of tubestock and planning for future production.

The best times for planting are around November and March, although October and April are also favourable for planting depending on seasonal snow falls. December to February are generally too dry for planting. If planting during summer is necessary, watering is likely to be required.

Table B.1.1 Indicative timing for rehabilitation



Source: adapted from a table provided by E. MacPhee, DECC, Tumut.

B.2 Site Assessment for Rehabilitation

In order for rehabilitation to be effective and efficient, a good understanding of the characteristics of the site is essential. Undertaking a site assessment as the first stage of rehabilitation allows data on the special features of the site to be gathered, so that species and techniques suited to the site can be identified. This section of the Guidelines describes factors that need to be considered in the site assessment.

Site characteristics should always be recorded. To avoid excessive documentation, this can be carried out during preparation of an SEE or REF. To assist in preparation of a site assessment, a proforma is included in Appendix 2.

B.2.1 Land Use

Identify past, current and likely future uses of the site.

Past and current uses are likely to influence the condition of the site and whether it will need any special treatment, e.g. If the site is subject to regular passage by heavy vehicles, soils may be compacted. Alternatively past use may contribute to nutrification or contamination.

Future use will influence the kind of rehabilitation that is suited to the site (refer to section A.5.1). For example, a site that is likely to be subject to heavy traffic or will have a landscaping/aesthetic function will need to be rehabilitated differently to a site where the aim is to restore it to an ecologically functional condition (refer to section A.4.1).

Photos of the site should be taken at this point, to record current use and condition. It is recommended that photos should be taken, if possible, from permanent sites that could be used as ongoing monitoring points (refer to Appendix 17 for further information on fixed point photo monitoring).

B.2.2 Altitude, Aspect and Exposure

Altitude, aspect and exposure to wind and snow all influence the microclimate of the site and the type of species suited to it. In planning for rehabilitation species that naturally occur in the type of environment occurring on the site should be identified.

Consider also how site development might alter the natural microclimate, e.g. by increasing the amount of time the site is in the shade, blocking wind or affecting snow accumulation. If development results in less snow and more shade than would occur naturally, the site is likely to become significantly colder than surrounding areas. As a result, plants that occur naturally on and around the site may no longer grow there. In this case, to find suitable species, look at nearby areas with characteristics similar to the altered site.

B.2.3 Soil

Assessment of soils should focus on two main aspects – suitability for plant growth and erodibility. Knowing whether the soil is easily eroded by wind or water and how fine or coarse the soil particles are, will help you determine what sort of erosion controls are necessary and the best methods for protecting it during and immediately after the works. Soil erodibility issues should be covered in the Site Environmental Management Plan (SEMP) for the works, however, you may want to carry out additional assessment. Basic soil tests can give you an indication of the suitability for plant growth of the soils on your site as well as its erodibility (refer below).

As shown in figures B.2.1 and B.2.2, most plant growth occurs in the topsoil, or uppermost layers of the soil, where there are sufficient nutrients, water and air. Because

of its value for supporting plant growth, every effort should be made to preserve topsoil. On many work sites, topsoil may be degraded or even absent. On these sites rehabilitation efforts need to focus on improving the soil as much as possible and establishing hardy plants that can tolerate poor soils. Once these plants have established, biological processes should begin to activate and the soil will slowly improve, possibly allowing other plants to establish later on.

Soil Testing

A good understanding of soils is essential for effective rehabilitation. Soil testing will help you determine the characteristics of soils on the site. This information will help you identify what species are best suited to the area, and what sort of other work might be necessary to prepare the soil for planting. Several basic tests have been included in the site assessment proforma in Appendix 2, with instructions in Appendix 13. Basic tests that should be undertaken include:

Depth of topsoil – is there enough topsoil for plants to grow, or is there just hard subsoil or rock?

Soil texture and infiltration rate – Is the soil compacted? How fast does water soak in/does it all run off the surface causing erosion?

Composition – is the soil high in organic matter/clay/sand? Composition will influence erodibility and other characteristics. For example, organic soils may be easily eroded by wind if exposed and dry. Different plants will be more or less suited to different soil types. Some prefer clay while others grow in peat.

pH – how acidic or alkaline is the soil? Soil pH affects nutrient availability and which species are suitable. Australian alpine/montane plants are adapted to a pH of 4.5 – 6.5. Bog plants can survive at a pH as low as 4.

Alpine and subalpine plants will not grow well in soil that has a pH greater than 6.5 – they need acid soils to persist. If your site has a high pH, it will need to be addressed[3].

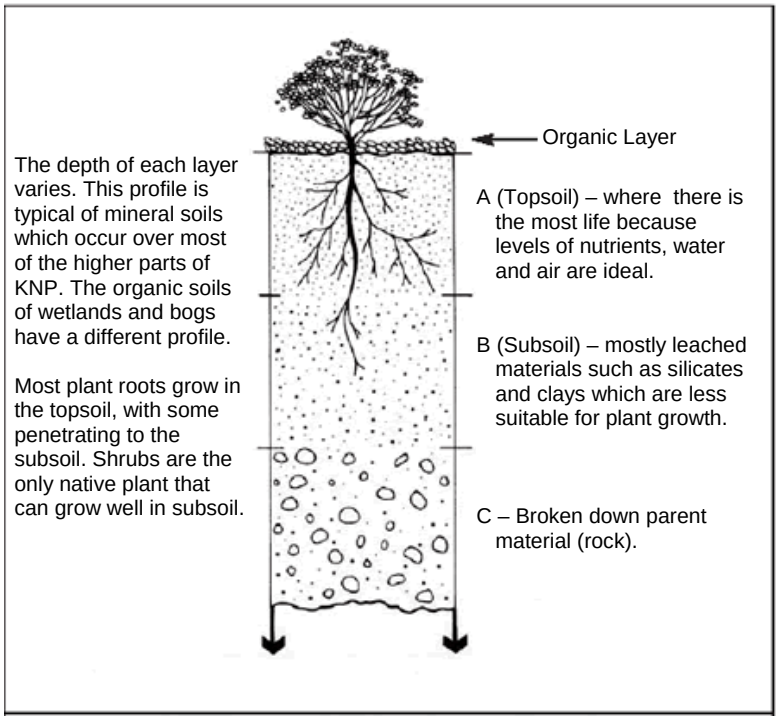
Alongside the basic tests outlined above and in Appendix 13, more detailed laboratory testing could also be considered. The better your understanding of soils is, the greater your chances of success with rehabilitation will be. Try to understand the characteristics of the soil both on your site and in the type of natural plant community that you are trying to reintroduce. Is the soil on the site suited to this type of community? If not, can it be improved or should you consider introducing different species that are more suited to the site?

[3] If soil in an alpine area has a high pH this likely to be due to contamination from building products, especially concrete. This is why it is important to protect soil from these products.

The best way to ameliorate a high pH is to add organic matter. Super phosphate and nitrogen (urea) can be used for a more rapid solution. These should be thoroughly mixed into the soil and rested for a few days before re-testing.

Figure B.2.1

Soil layers; most plant growth occurs in the topsoil.



Variation of diagram from Canadian CMHC website: http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_073.cfm

Figure B.2.2

Typical section of alpine humus – the most widespread soil type in the alpine sections of Kosciuszko National Park.

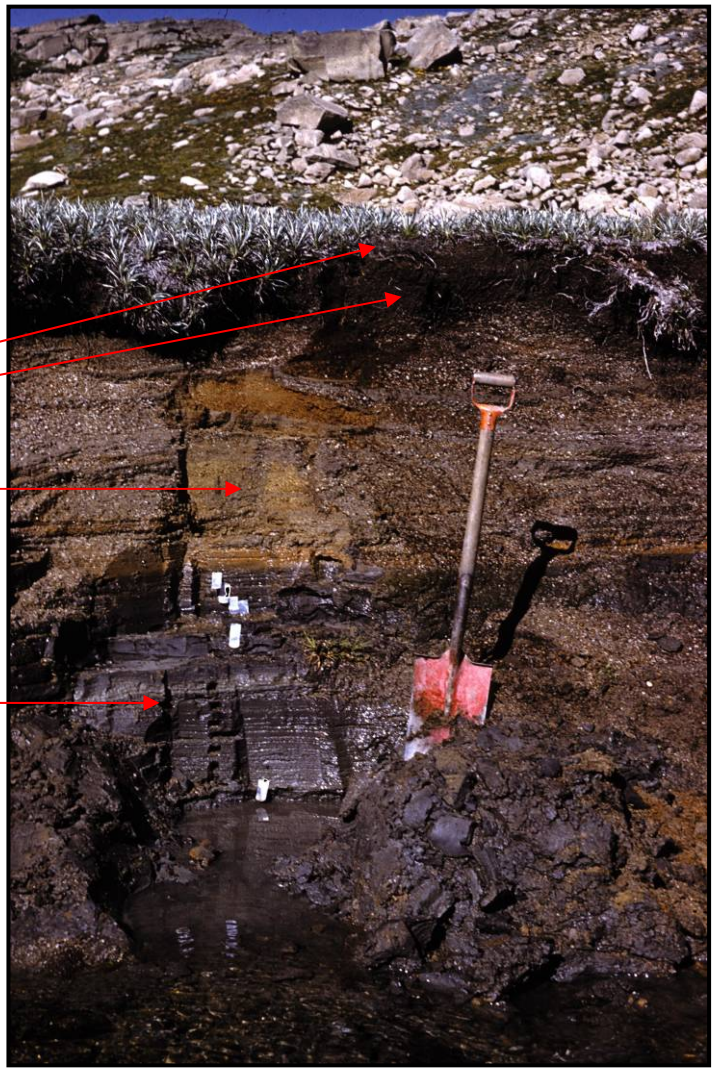


Photo: A. Costin

Topsoil is essential for good plant growth. Failure to protect soil is a major contributor to the failure of rehabilitation projects.

Very few plants can survive in sub-soil alone, so it is essential to protect soil from weed infestation, contamination and loss. The most common ways in which topsoil is lost are:

Wind erosion – when soil is exposed it dries out quickly and then is easily picked up and blown away by the wind.

Erosion by water – bare soil is also easily moved by water, especially if heavy rainfall occurs, causing water to run over the surface and carry away exposed soil.

Contamination and weed infestation also contribute to the loss of soil by making it unsuitable for the growth of plants. In order to protect soil it should be covered as soon as it is practicable. If it is being stockpiled, the area where the stockpile will be kept must be weed free and well protected from run-on and run-off.

Soil protection measures should be detailed in the SEMP for your project. Details of stockpile protection and basic soil treatment can be found in section C.1. of the Guidelines. For further information the 'Blue Book' *Managing Urban Stormwater: Soils & Construction*, by Landcom (2004) is an essential reference.

B.2.4 Slope and Drainage

Site drainage is influenced by a range of natural and disturbance-related features. Effective rehabilitation needs to consider the potential for an altered site to be returned to a condition resembling its natural state. This potential will be strongly influenced by changes that have been made to the type of soil and drainage on the site.

Slope and drainage have a strong influence on soil development and the range of species that are adapted to the site. This occurs through the impact of slope on water movement and microclimates, as discussed below.

Drainage, Infiltration and Erosion

- Steep slopes generally shed water quickly and are, therefore, usually drier than flatter areas;
- Because of the way water runs off a steep slope (and sometimes also because of exposure to wind and frost action) soil at the top of a steep slope is usually thinner and rockier than at the bottom of the slope.
- Soil and organic matter accumulates where water slows down, at the bottom of a slope and on flat areas. As a result, soils in flatter areas are generally relatively moist, thick and rich in organic matter.
- Soil that has developed naturally is usually relatively porous and open in structure, which allows water to infiltrate, so less runs off over the surface.
- Disturbed soils have usually lost their open structure and become compacted and dense, making it more difficult for water to infiltrate, as a result more water runs off over the surface. Also, because soil in disturbed areas has less organic matter and vegetation covering and protecting the surface, the surface flow of water is

likely to cause erosion. Different types of soils and surface landforms contribute to different forms of erosion;-

- Sheet erosion is where the surface is stripped away evenly; and
- Channelling occurs where water becomes more concentrated in certain areas, and gouges out a channel. The channel can eventually enlarge to form a 'gully'.

An understanding of these processes will assist you to identify how to manipulate drainage to remediate the soil on a particular site. It may be necessary to change the existing drainage patterns to improve conditions for the desired species. For example, improving soil texture will improve infiltration of water, which means that there will be less surface runoff and erosion, allowing constructed drains will perform better. This will improve potential for soils to be retained and recover and provide good growing conditions for plants that are adapted to these conditions. Alternatively, to rehabilitate a bog or wetland, the aim would be to slow the flow of water, block channels and encourage water to spread out so that it is retained longer on the site. This will produce conditions better suited to the establishment of bog and wetland species.

Microclimate

- Sites at the top of a slope are often more exposed to wind, and snow accumulates less. Without snow for insulation, these sites are, therefore, also subject to intense frost action, while in summer they are hot and dry.
- Mid-slopes are usually more sheltered, with a less extreme microclimate.
- Lower slopes are sheltered but often subject to heavy snow build-up, which, because there is also less sunlight, takes time to melt and reduces growing seasons. These areas can also be subject to cold air drainage and are colder than higher slopes.
- Flat, open areas are also often subject to cold air drainage, particularly at night, but they are sunnier than valleys, therefore they warm up more during the day. Also, where there are bogs or pools that retain water, this moderates temperatures.

Influence of Buildings and Other Infrastructure

To determine whether some parts of the site are likely to be wetter or cooler than others, it is necessary to consider whether surrounding structures are likely to shelter the area from rain or sunlight, channel wind, influence snow deposition or alter natural drainage. For example, where drainage pipes are installed around the edge of buildings or carparks they may significantly dry out adjacent soils. This influence would be enhanced if the building also shelters the area from rain. In such places, it will also be necessary to consider whether certain species are likely to block drains with their roots.

Good drainage will help to protect topsoil and create the conditions necessary for plant survival.

B.2.5 Vegetation Communities and Species

If an environmental assessment (REF/SEE) has been prepared for the proposal, it will include a list of the vegetation types (or communities) and species found on the site, which will save you time and money. If the site was not subject to development or the species list cannot be located, it will be necessary to visit the site and compile a list of species on and surrounding the site, and the type of communities represented (e.g. woodland, heath, bog, grassland etc.). This information is required to determine what type of community should be reinstated on the site and what species will be required.

When observing surrounding plant communities, think about whether any of these types of community are suited to the area you want to rehabilitate (depending on future use of the site and the new environmental conditions that have been created by development). If not, consider the species present and whether some of them may still be suitable for use on the site. Look for natural colonisers, fast growing species and species with rhizomatous roots that can be used to help stabilise soils and which spread out to cover large areas quickly.

If the site is an area where the visual appearance is an important concern, look for attractive local plants, but keep in mind that for species to be suitable for landscaping they also need to be easy to propagate and grow. These factors have been considered in the list of species in Appendices 9-11. Furthermore, where it is desirable to restore the ecosystem function of the site, as well as making it aesthetically pleasing, other less attractive species also play an important role, therefore a balance of different types of plants needs to be obtained.

B.2.6 Weeds

Failure to control weeds will significantly reduce the success of rehabilitation.

Weeds have several characteristics that allow them to quickly out-compete indigenous species and monopolise available space, water and nutrients. The characteristics that give them such an advantage include:

- Ease of dispersal,
- Rapid growth, and
- Ability to grow easily in all kinds of conditions, especially disturbed sites.

Construction and similar activities promote the growth of weeds because bare soil that is easily exploited by weed species is exposed. In addition, the movement of machinery and soils helps weeds to disperse, contributing to their spread. Once they appear, weeds quickly take over a site, making it very difficult for indigenous plants to become established. For rehabilitation to be effective, it is essential that weeds are controlled before and after planting.

During the initial site assessment, weed species that are present on the site should be recorded so that a weed management strategy can be developed as part of the rehabilitation plan.

Appendix 12 contains a guide to some of the more common weeds in the Kosciuszko area. Section C.1.3 and C.4 contain further information on strategies for the control of weeds, whilst specific issues relating to stockpiling of soils and use of sods are discussed in sections C.1.2 and C.1.4 respectively.

B.2.7 Bushfire Protection

Under the *Rural Fires Act*, development in resort areas is required to conform to bushfire safety requirements. This means that vegetation needs to be managed to ensure that the potential for bushfires to affect development is minimised. If the area to be rehabilitated is located near to development, it may need to be treated as an Asset Protection Zone (APZ). An APZ is an area of managed vegetation separating a development or other asset from unmanaged vegetation. Within the APZ, general vegetation management may include clearing away dead leaves, wood and other dry plant matter, ensuring that adequate separation between trees and buildings is maintained and ground cover is kept to a height of not more than 100mm.

Rehabilitation plans, particularly for areas adjacent to new buildings or other flammable structures need to consider APZ requirements in the choice of species used for rehabilitation and maintenance procedures. Generally the types of native species likely to be used in rehabilitation around the resort areas are fairly low growing, and, if appropriately used, are unlikely to contribute significantly to bushfire hazards. Guidelines on the management of vegetation and landscaped areas within APZs have been included in Appendix 14. Further references that may be useful where bushfire protection is considered in planning for rehabilitation are included in the Resource List, Appendix 19.

B.2.8 Threatened and Significant Species

In compiling a species list for the site you will need to note the presence and location of any threatened or significant species or communities. If an environmental assessment (REF/SEE) has been prepared for the proposal, it should contain this information, which will save you time and money.

Rehabilitation of areas that have significant species or communities may require specialist advice. If you intend to rehabilitate such areas, you should contact the DECC for advice.

Rehabilitation of threatened species or ecological communities is very difficult and expensive and should be regarded as a specialist activity. Disturbance of such areas should be avoided.

Threatened and significant species are listed under the following legislation and policies:

- Schedules 1 and 2 of the *Threatened Species Conservation Act 1995;*
- *Commonwealth Environmental Protection & Biodiversity Conservation Act 1999;*
- Schedule 1 (the 'Schedule of Significant Natural and Cultural Features') of the *Kosciuszko National Park Plan of Management 2006*.
- Certain species are also listed under the ROTAP system developed by the CSIRO and the JAMBA and CAMBA agreements on migratory birds.

Resources for Threatened Species and Communities

Comprehensive information on threatened species and communities is available on the DECC website:

http://www.threatenedspecies.environment.nsw.gov.au/index.aspx

Other useful information about threatened species, threat abatement plans and critical habitat can be found at the NPWS site:

http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Threatened+Species

Commonwealth information about threatened species and ecological communities, as well as key threatening processes, threat abatement plans and recovery plans can be found at the Commonwealth Department of Environment and Heritage site:

http://www.deh.gov.au/biodiversity/threatened/index.html

NSW recovery plans have been prepared for some Kosciuszko species including the Anemone Buttercup and the Southern Corroboree Frog. These can be found at:

http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Recovery+plans

Information on NSW Priority Action Statements is expected to be available at:

http://www.threatenedspecies.environment.nsw.gov.au/tsprofile/home_PAS.aspx

B.2.9 Other Special Features

Are there any other unique or special features about the site that would influence how it is rehabilitated? For example, does the site have cultural or scenic significance? How could rehabilitation protect or highlight this significance?

Recreational, scientific and other uses of the site should also be considered, for example, if the site forms part of a ski run, rehabilitation will have to take into account requirements such as creation of a ski-able surface, slope grooming activities etc. If the site is contaminated, how this may also influence rehabilitation and will need to be considered.

As well as threatened species, Schedule 1 of the KNP *Plan of Management* lists significant soil, rocks, landforms, wetlands, water features and cultural features that should be considered in the site assessment. Heritage items and sites are also listed in the Historic Heritage Information Management System (HHIMS) and Aboriginal Heritage Information Management System (AHIMS) maintained by the NPWS.

If an environmental assessment (REF/SEE) has been prepared for the proposal, it should contain information about significant features of the site that can help you identify these features and relevant stakeholders, as well as saving time and money.

B.3 The Rehabilitation Plan

The aim of a Rehabilitation Plan is to create a document that details all the issues that need to be considered during rehabilitation. The Plan also provides a useful record that can be used later, to help you compare different approaches or replicate past success elsewhere.

The majority of rehabilitation that takes place in the resort areas follows construction activities. As a result, this section of the Guidelines is arranged according to the logical sequence of planning development activities, i.e.

1. Pre-development planning:
    - site analysis
    - formulation of aims/objectives
    - overlap with SEMP
    - staging (sequencing and timing – acquisition of materials and equipment)
    - human resources, training and induction
2. Protection of resources and values during development
    - Site protection and preparation (i.e. weed management, shaping and grading, drainage, waste management, designated stockpiling, access and protection areas)
3. Rehabilitation
    - techniques, equipment and material required
    - extent of rehabilitation area
    - site preparation and protection of soils
    - planting requirements
    - protection of rehabilitation
4. Post-rehabilitation maintenance and follow-up
    - techniques, equipment and material required
    - monitoring and auditing
    - site handover

To assist with developing a Rehabilitation Plan, a proforma and checklist has been included in Appendix 3.

B.3.1 Pre-Development Planning

B.3.1.1 Site Assessment

Ensure that a site assessment has been completed (refer to section B.2).

B.3.1.2 Aims of Rehabilitation

The Rehabilitation Plan should clearly explain the aim of the rehabilitation. Refer to Section A.4.1 for a description of the different approaches to rehabilitation, including restoration, revegetation and landscaping. Each of these approaches will entail a different objective; for example, restoration implies attempting to recreate the natural characteristics that would have occurred on the site prior to disturbance or development.

On the other hand, landscaping has a primarily aesthetic objective. As a result, the alternative aims will govern the approach to site management and species selection.

You should also identify whether the site is part of an Asset Protection Zone, providing a development with protection from bushfires. If this is the case, a different approach to rehabilitation will also be necessary (refer to section B.2.7 and Appendix 14).

B.3.1.3 SEMP Formulation

Rehabilitation is part of best practice site environmental management.

A Rehabilitation Plan should be developed before the SEMP, so that overlapping requirements can be incorporated into the SEMP.

Protection of site resources and values is likely to overlap substantially with the Site Environmental Management Plans (SEMPs). SEMPs detail measures that are to be taken to protect the natural values of sites and their surrounding areas, including soil, water, flora, fauna and historic/archeological and cultural values (noise, aesthetics etc.). A Rehabilitation Plan addresses some aspects of the SEMP in greater detail, including how flora values will be treated, aspects of soil and water protection fauna values, aesthetics etc. It makes sense, therefore, for a Rehabilitation Plan to be prepared before or alongside the SEMP so that its requirements can be effectively incorporated into the SEMP, and to prevent unnecessary duplication of details.

Specific aspects of Rehabilitation Plans that often overlap with SEMPs include:

- staging (sequencing and timing)
- acquisition of materials and equipment
- induction and training
- site preparation
- soil and water protection and drainage
- stockpiling requirements
- monitoring, documentation and record-keeping
- maintenance and follow-up
- site hand-over.

B.3.1.4 Collection or Sourcing of Plant Material

It is essential that you clearly identify where you will source the plants you are going to need to rehabilitate the site. Options include:

- Use of sods stripped from the site prior to the works (refer to section C.1.4 for guidelines on sod storage and use);
- Collection of seed that will be sown directly on the site following the works; and
- Collection of seed, cuttings or other plant material that will be used for propagation of tubestock off-site.

If the use of seed or tubestock is intended, it will be necessary to identify the quantity of seed or tubestock required. Indicative planting rates for different species and different sites are included in the species list in Appendices 9-11. These can be used to help calculate quantities required.

A scientific licence under the National Parks and Wildlife Act and Regulations is required prior to:

- any seed collection within a national park; and/or
- collection of seed, cuttings or other vegetative stock for propagation from a protected native plant or any plant that is a threatened species of part of an endangered population or endangered ecological community.

To apply for a scientific licence prior to collection of plant stock for propagation, download an application form from

www.nationalparks.nsw.gov.au

and send to the NPWS Wildlife Licensing and Management Unit, Hurstville, NSW.

B.3.1.5 Staging (Sequencing and Timing)

Taking into consideration sourcing of materials and equipment, detail all stages of rehabilitation, including sequences of events and timing considerations such as weed treatment timing, seed collection, the length of time it will take to acquire stock, anticipated planting times and maintenance requirements. Refer to sections B.1 and C.2.1 for a general indication of the timing of major rehabilitation events, and the following sections for timing issues affecting specific rehabilitation tasks:

- C.2.2.1 – seed/propagation material collection
- C.2.2.2 – propagation
- C.3.2 – stock storage
- C.3.3 – planting

B.3.1.6 Human Resources, Training and Induction

Detail which staff and/or contractors will be employed on the project and what their respective roles will involve. Identify training and induction needs.

For further information on responsibilities, knowledge and skills required for rehabilitation, refer to section A.5.

Prior to commencing work on the site, all staff and/or contractors should be inducted so that they are aware of site specific issues.

B.3.2 Protection of Resources and Values during Development

B.3.2.1 Weed Management

Weed management needs to commence before any work on the site, to ensure that existing site weeds are not spread during works and to make follow-up control easier and more effective.

A plan for managing weeds should be prepared. It should include:

- pre-works control of existing weeds on the site and stockpile areas;
- implementation of safeguards to ensure that weeds are not spread either to, from or within the site; and
- follow-up weed control until plantings are well established and ground is covered, so there is limited opportunity for weed invasion.

Refer to sections C.1.3 and C.4 for further information about weed management.

Weeds with multiple reproductive methods (e.g. seed + roots) are the most difficult to control. They require long-term treatment.

Weed Management Resources

- NSW Agriculture: *Noxious and Environmental Weed Control Handbook* and website: http://www.agric.nsw.gov.au/reader/weeds
- CRC for Weed Management/DEH *Introductory Weed Management Manual*
- Australian Alps Liaison Committee: *Alps Invaders: Weeds of the High Country*
- Jackie Miles and Max Campbell: *Weeds of the Monaro – a guide to identification and control.*

Refer to Appendix 19 for full details of all of these references.

B.3.2.2 Protection of Natural and Cultural Values

Undertaking works, even where their ultimate aim is to protect environmental values, has the potential to impact on these values. For example, rehabilitation works could result in introduction of weeds or impact on surrounding areas through spreading of soil, rubbish or trampling. In order to minimise the potential for impact to occur, safeguards are necessary.

Normally the environmental impact assessment (SEE or REF) for the works will have identified natural and cultural values associated with the site and the potential impacts that might occur. From this information, safeguards would usually have been developed. These would be detailed in the environmental assessment and should be reiterated in the SEMP and Rehabilitation Plan. If safeguards for the rehabilitation stage have not been adequately covered, additional safeguards may need to be included in the Rehabilitation Plan.

B.3.2.3 Designated Access

To minimise the extent of the impact of the works, access routes for vehicles and machinery should be clearly defined. In particularly sensitive areas, foot access may also need to be delineated to ensure that potential impacts on vegetation are minimised.

The same access route should generally be used for rehabilitation as for other work. Normally access would be defined in the SEMP so reference can be made to this. If possible, disturbed areas should be used for access. In areas where there is no existing disturbed access route, a route should be chosen that avoids impacting on the most sensitive areas. Preference should be given to accessing the site via the following alternatives (in order of preference):

- Rocky, well drained, gently sloping ground;
- Areas dominated by grasses; or
- Herb fields or shrubby areas.

If access through sensitive areas cannot be avoided, use temporary bridges or crossings and/or equipment that can avoid or reduce impact.

Access through bogs, wet areas, snow patch areas, steep slopes and any other areas of fragile or sensitive vegetation should be avoided. These areas are expensive and difficult to rehabilitate.

B.3.2.4 Designated Storage/Stockpile Areas

The SEMP or rehabilitation plan for your project should delineate or cross reference areas suitable for storage or stockpiling of materials such as excavated soils, sods and materials that will be used in all stages of the works (e.g. plants, mulch, fibre matting etc.). The aim of using clearly defined stockpile areas is to minimise the spread of impacts resulting from the works and ensure that material isn't stockpiled in sensitive areas.

Generally, stockpile areas should make use of existing disturbed, weed free areas. If this is not possible, the principles for choosing access routes should be followed (refer to section B.3.2.3). It is important that stockpile areas are weed free, otherwise the materials that you store in the area will become contaminated.

Stockpiles should be placed on geotextile to prevent contamination. Stockpile areas should be bunded and covered (to reduce dehydration, loss of materials and impact on surrounding areas).

B.3.2.5 Earthworks

For efficiency and convenience, it is useful to detail in the SEMP or construction plans earthworks such as ripping, shaping, grading and drainage required for rehabilitation. Soil management such as separation of topsoil and subsoils and protection from contamination or erosion should also be included.

Including earthworks in the SEMP or construction plans allows such work to be completed during or immediately after construction, as appropriate, so that once construction is completed and most heavy machinery is removed from the site, it is immediately ready for mulching and planting.

B.3.2.6 Waste Management

The SEMP and/or Rehabilitation Plan should detail/cross reference how waste will be managed. Rehabilitation waste that will need to be appropriately disposed of includes (but is not limited to) excess soils, weeds, wrapping materials, plant pots/tubes, disused sediment and erosion control materials and plant protectors.

B.3.3 Rehabilitation

B.3.3.1 Materials and Equipment Required

The Rehabilitation Plan should include a schedule of all materials and equipment required for rehabilitation including (as necessary):

- fill, soil, compost
- mulch, matting, mulch anchoring materials
- seed and plants
- fertilizer, water saving granules
- plant protection materials
- earthmoving, ripping, shaping, drainage, auguring equipment
- hand tools
- water supplies
- storage provisions for materials, equipment, water supplies etc.

B.3.3.2 Extent of Rehabilitation Area

As well as designated access and stockpile sites (refer to sections B.3.2.3 and B.3.2.4), the Rehabilitation Plan should clearly define the area to be rehabilitated. The area requiring rehabilitation following development is likely to include stockpile sites, access routes, service trenches and the general footprint of the work.

B.3.3.3 Site Preparation and Protection of Soils

Prior to planting, the site must be prepared. Preparation is likely to involve a continuation of the earthworks and erosion and sediment control measures detailed in section B.3.2.5, however additional measures are likely to be required. These are detailed below.

Maintenance of Erosion and Sediment Controls

Erosion and Sediment Controls will have been installed during the development phase (as per the SEMP), however, however additional or different measures may be required during rehabilitation. Details of these should be included in the Rehabilitation Plan. Include a schedule of triggers for maintenance (e.g. heavy rainfall). Establish whose responsibility it will be to maintain erosion and sediment controls, and how long the controls will be retained.

Site Preparation

Detail additional (post development) work that will be required to prepare the site for planting, including weed control and breaking-up or cultivating the soil. If the site is contaminated, note any special measures that will be necessary to make it suitable for

planting. Does rubbish or other material need to be removed? You will also need to detail how this will be achieved and where the material will be transferred to.

Mulching and Management of Bare Ground

The site should be planted out as soon as possible after the works, or each stage of the works, so that soils are not left exposed for any longer than necessary. In order to achieve this, timing issues need to be carefully considered.

If it is not possible to plant out the site immediately after the works, bare ground will need to be protected or it will erode (e.g. this may occur when works need to be completed urgently, but are finished in late autumn, when plants will not establish). The soil should be protected by covering it immediately with mulch and ensuring that drainage, sediment traps and other erosion controls are in place and functional.

Detail what kind of mulch will be required, how much is needed and how it will be used. Also, note who will be responsible for sourcing mulch, and where and when will it be acquired.

Mulch must be weed free. The best mulch to use is material reserved following clearing of vegetation from the site or local native grasses, if these are available and weed free. If it is necessary to use straw mulch made from exotic grasses (e.g. rice straw), this should have less than 10 percent of the crop seed in it[4]. Generally, 1 bale of straw mulch is enough for approximately 20m^2, applied so that, if pressed down with a hand, it is about 2.5 cm (1 inch) thick.

If artificial mulch mats are used, these should be fine (less than 200-250g/m^2), to allow native grasses and seedlings to penetrate, e.g. *Jutemaster FM*™.

Contingencies for Weather Conditions

Weather conditions can have a range of effects on rehabilitation. These include:

- Loss of soil from the site due to heavy rainfall or dry temperatures and wind;
- Inclement weather may impact on the work schedule;
- The production of seed by plants can vary significantly from season to season – in poor seasons the availability of seed may be severely limited;
- Poor weather conditions (severe cold or hot, dry conditions) between the time of planting and establishment of new plants may kill plants or severely set back growth;
- Weather conditions may limit the capacity of nurseries to produce stock.

Because soil is easily lost but essential for the growth of plants, it must be protected from the elements at all times. During stockpiling soil needs to be protected from erosion. When topsoil has been re-spread, or the works are finished, all bare soil needs to be mulched, even if planting won't be done for some time. After planting, the soil still needs to be protected by re-applying mulch until it is well covered by plant growth.

[4] Refer to section C.1.7.1 for further information about mulch alternatives.

B.3.3.4 Planting Requirements

To ensure that enough plant material is available for successful rehabilitation of high altitude sites, you will usually need to start planning at least 12 months ahead of soil disturbance.

As well as listing species required for rehabilitation, estimates are needed of quantities of seed and/or tubestock required to provide rapid cover for the site. Indicative planting rates for tubestock and seed are provided in sections C.2.4.3 and C.2.4.4. As a general rule, however, you should plant more densely in sites located on steep slopes or very degraded or exposed sites. This is because there is a higher likelihood that plants will die on these sites, or seed and seedlings will wash away if heavy rain occurs.

Consider how planting will be undertaken, e.g. if Sterile Rye Corn is used to establish initial cover, it will need to be followed-up by over-planting with native tube stock. If planting is to be staged, specify this in the rehabilitation plan, including details of the quantities of species required during each stage and where the stock will be sourced.

Following rehabilitation, monitoring may indicate that follow-up planting is necessary, to fill in gaps where initial planting was not successful. You should try to factor in the likelihood that extra plants will be required and stagger the production of tubestock so that there will be some plants ready for later work (if the excess plants are not, in the end, required, they can probably be used to supplement planting elsewhere). A 10-20% failure rate is common with Tubestock, although this can be reduced with good follow-up maintenance of the planting (refer to section C.5.2).

Tubestock or Seed?

Both tubestock and seed offer advantages and disadvantages, detailed in Table B.3.1.

Table B.3.1 Advantages and Disadvantages of Tubestock vs. Seed

Tubestock		Seed	
Advantages	**Disadvantages**	**Advantages**	**Disadvantages**
Better survival, growth and regeneration rate than seed, especially on steep slopes.	More expensive, complicated and time consuming to prepare and plant than seed.	An ability to collect a large amount of plant material for propagation. The cost of this is potentially lower cost than rehabilitation with tubestock.	Can spend a lot of time and money collecting seed and yet have poor results in rehabilitation, especially in high altitude sites.
	Can only be used where soil is deeper that the pot. May have to source more soils or plant substrate.	May be useful on sites where soil depth is not great enough for tubestock to be planted.	Requires very good ground preparation to provide a suitable seed bed.
		If successful, seed produces a more natural effect than tubestock.	Not suited to steep sites as seed is likely to wash off. Seedlings are also vulnerable to being un-rooted by frost heave.

In general, it is recommended that the most reliable and effective approach is to use a combination of both seed and tubestock. For example, a temporary grass cover crop such as Sterile Rye Corn can be used for initial soil stabilisation and weed control. Once this dies down, it provides a good mulch and the site can be planted out with tubestock of dominant native species. Weed control and mulching should be continued for one to two years, following which the site can be re-seeded with understorey species to achieve a more stable and natural effect. This technique provides a good solution for planting steep, high altitude sites.

A case study providing further information on the use of Sterile Rye Corn has been included in Appendix 5.

B.3.3.5 Protection of Rehabilitation

New plantings may be vulnerable to grazing from both native and introduced animals, so they need to be protected. Specify how this will be achieved in the Rehabilitation Plan. A variety of techniques and materials are available, including tree guards, capsicum spray and electric fences.

If newly planted seedlings are not protected from grazing, rehabilitation will usually fail.

B.3.4 Post Rehabilitation

B.3.4.1 Maintenance of Rehabilitation

Maintenance is an essential component of rehabilitation.

To ensure that rehabilitation is successful and avoid expensive follow-up work, ongoing maintenance is essential. Maintenance should continue until all plants are well established and there is good ground cover. The Rehabilitation Plan should include a maintenance schedule incorporating details of:

- watering;
- weeding;
- replacement of plants that have failed to establish;
- maintenance of erosion and sediment controls and plant protection, including mulch, and repair, replacement or removal of controls/protection as required.

Details of who is responsible for maintenance, and for how long, should be included in the Rehabilitation Plan.

Once the vegetation has established, excess erosion and sediment control materials should be removed from the site as many of these, particularly synthetics, can take a long time to break down and may be hazardous to fauna. If possible, minimise the use of synthetics which will need to be cleaned up later by using natural materials that will break down over an appropriate period of time.

B.3.4.2 Monitoring of Rehabilitation

As well as maintenance, rehabilitation should also be monitored on an ongoing basis. Monitoring helps you to appraise the relative success or failure of the work. It can be achieved relatively quickly and easily and will pay for itself through providing potential to benefit from experience.

The Rehabilitation Plan should note who will be responsible for ongoing monitoring and include a schedule for this, and it should detail what kind of monitoring is to be undertaken. Monitoring using photo points is recommended, as this technique is very quick, simple and effective. Details are provided in Appendix 17.

More rigorous monitoring techniques could also be used. Landscape Function Analysis (LFA), is recommended as this technique is easy to learn and apply, and provides clear indicators of the progress of rehabilitation work. It also enables comparison between sites. LFA would be particularly useful where firm evidence of the progress of your rehabilitation work is required. Further information about LFA has been provided in Appendix 18.

B.3.4.3 Auditing

Auditing of completed rehabilitation is essential to ensure that rehabilitation has been completed in accordance with the procedures detailed in the Rehabilitation Plan. Auditing will also trigger the need for further work, if required.

Auditing of rehabilitation can be combined with auditing of all site environmental management and the SEMP. If possible, auditing should be completed by, either, the person responsible for the project, or, an auditor from outside the group of people immediately responsible for the work.

B.3.4.4 Site Handover

The Rehabilitation Plan should detail when (at what point) the site will be handed over and the parties involved. During the handover, the developer/contractor should ensure that the receiving party is aware of any ongoing management or maintenance requirements.

B.4 Examples of Completed Site Assessment and Rehabilitation Plans

To help you understand what a Site Assessment and Rehabilitation Plan should contain, the Guidelines contain examples of:

- a completed Site Assessment - Appendix 2.
- a completed Rehabilitation Plan - Appendix 3.

While the Site Assessment and Rehabilitation Plan have been split up to clarify the purpose of each of these aspects of planning for rehabilitation, in practice they are often combined into the one report, or may integrated with the Statement of Environmental Effects (SEE), Review of Environmental Factors (REF) or Site Environmental Management Plan (SEMP). Respectively, the two sample documents included in Appendices 2 and 3 have been adapted from a combined Site Assessment/Rehabilitation Plan for Hotham Chalet, Victoria (Alpine Flora, 2004).

Note that the example of a Rehabilitation Plan included in Appendix 3 lacks the timing schedule recommended in these Guidelines. A sample schedule is, however, included in the restoration strategy for Mt Feathertop walking track, Appendix 7.

Part C

Rehabilitation Techniques

C Rehabilitation Techniques

C.1 Soil Management

C.1.1 Topsoil Separation

Topsoil is a distinct layer in the soil profile (refer to B.2.3). It is essential for most normal plant growth and must be carefully protected during all ground disturbing works. Topsoil needs to be protected from:

- wind or water erosion,
- contamination by weeds, pathogens, rubbish or chemical substances, and
- mixing with other soil layers, particularly subsoils.

Separation of the different soil horizons during excavation will prevent mixing and offer some protection from contamination. Separation will also make it easier to replace the soil in its natural sequence, with the topsoil at the top.

Figure C.1.1 shows how soils can be managed to ensure that the different layers are not mixed and can be replaced in the right order quickly and efficiently.

Figure C.1.2 gives a more detailed example of how to manage soil separation during trench excavations, and includes use of sods (refer to C.1.4). This technique has been used successfully by the Department of Commerce to protect relatively undisturbed areas along road sides.

Figure C.1.1 Basic separation of topsoil and sub-soils. To back-fill the excavation, first pull back the subsoil then place the topsoil over this.

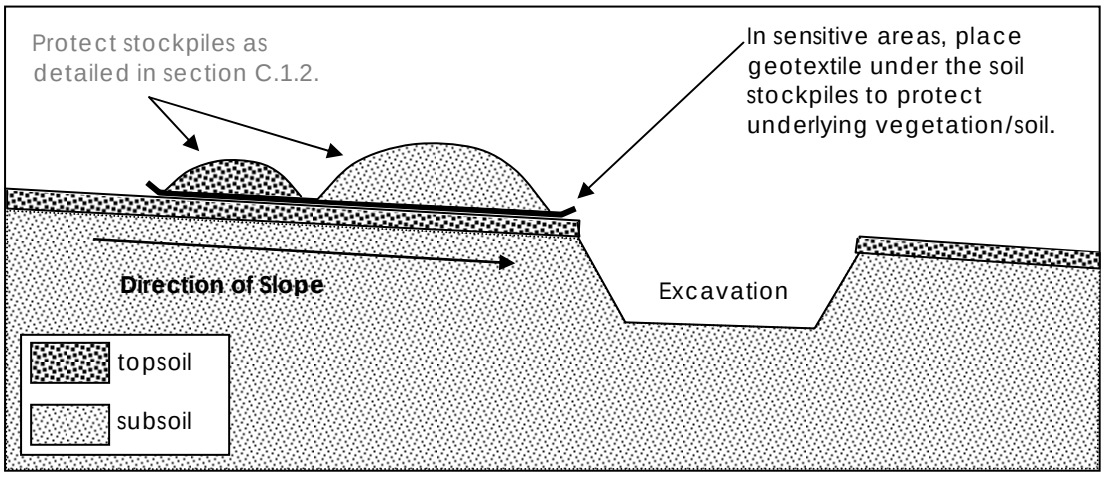
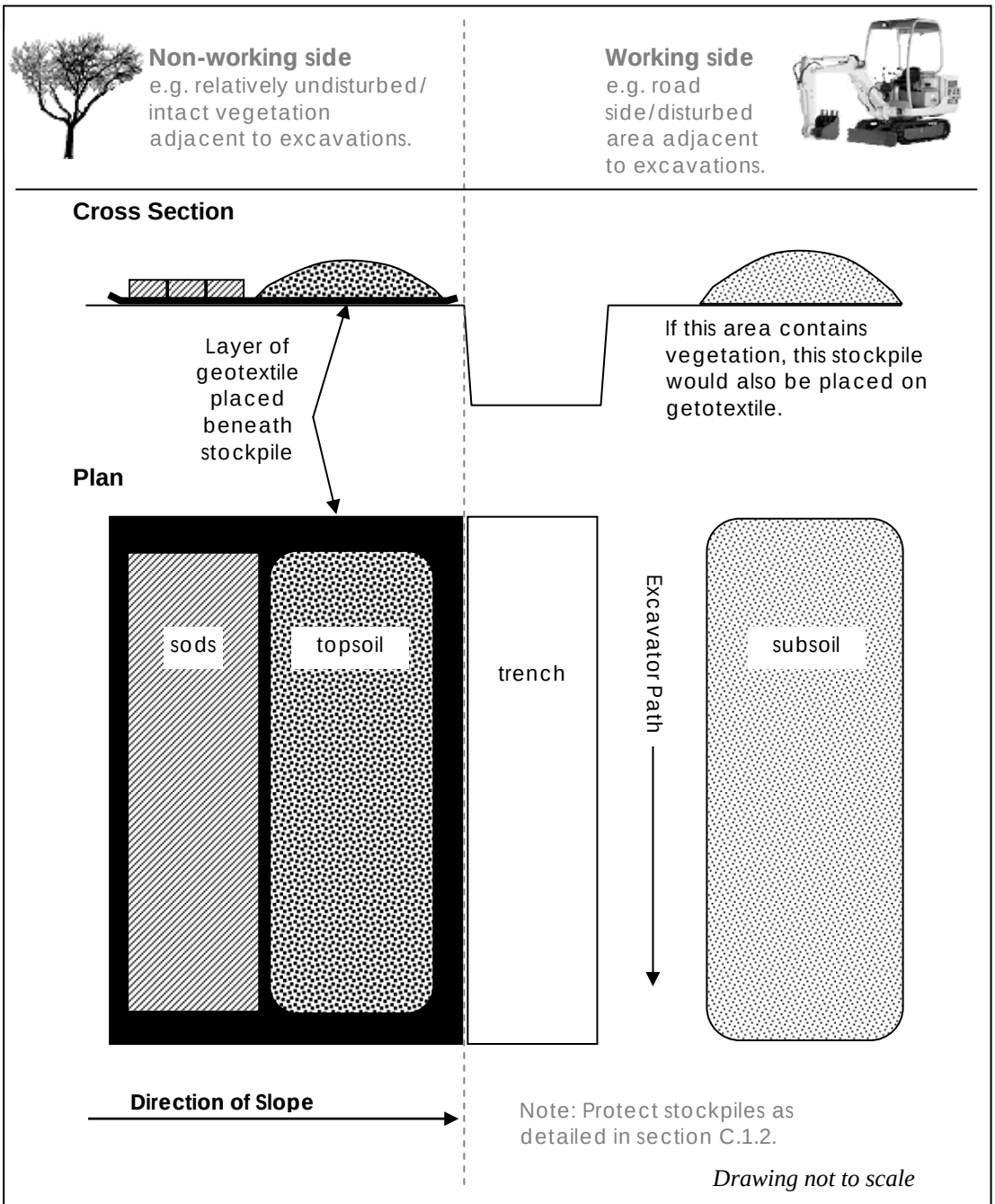


Figure C.1.2 Soil and Sod Separation during Trench Excavations



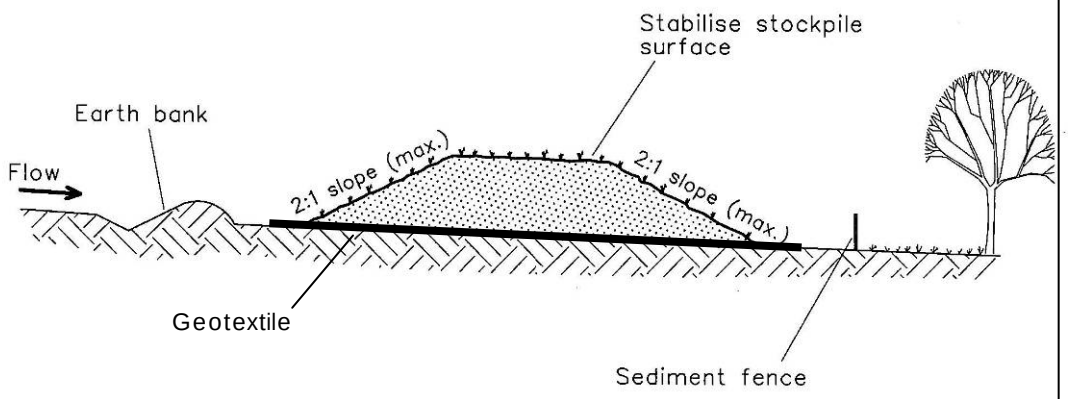
CONSTRUCTION NOTES

1. Suitable for working on up to 50 m sections of trench. Lay out section length of geotextile along the non-working side of the trench.
2. Excavate trench as follows:
   - Cut sods and place furthest from the trench on geotextile.
   - Strip off topsoil and place on the geotextile, between the trench and the sods.
   - Excavate subsoil, placing it on the disturbed side of the trench.
3. Lay pipes in trench.
4. Backfill trench as follows:
   - Replace subsoil.
   - With care not to catch up the geotextile, pull back topsoil. Finishing may need to be done by hand.
   - Replace sods and top-dress lightly with any left-over topsoil.
5. Roll up geotextile and move along to the next section. Repeat the process.

C.1.2 Stockpile Management

Once soil has been excavated, it may need to be stockpiled for some time before it can be re-spread. During this period the stockpile will need to be protected to ensure that soil does not blow or wash away. Figure C.1.3 shows how a soil stockpile should be formed and protected.

Figure C.1.3 Protection of Soil Stockpiles.



CONSTRUCTION NOTES

1. Choice of stockpile area: locate stockpiles at least 2 (preferably 5) metres from vegetation, concentrated water flows or natural water bodies, roads or hazard areas. A disturbed but weed free area should be chosen if possible
2. Preparation of stockpile area: control weeds, lay down geotextile beneath the stockpile and bund the area to control run-on/run-off.
3. Construct the stockpile as a low, flat mound (less than 2 metres high), elongated along the contour.
4. If the stockpile is to be in place for more than a day, or if strong wind or rain occurs, protect it by covering with geotextile that is well anchored down.
5. If the stockpile is to be in place for more than 3 days or if there is a possibility of rain, construct earth banks on the upslope to divert water around the pile and sediment barriers 1 to 2 metres downslope.

Adapted from Landcom 2004

C.1.3 Dealing with Weeds in Topsoil

The presence of weeds in topsoil is a serious problem. Generally it is recommended that if the areas from which topsoil is removed contain more than 50 percent weed coverage, consideration should be given to removal and disposal of the soil or treatment to destroy the weeds prior to re-using the soil, if possible. This is because, where there is a high-level presence of weeds, rehabilitation is very likely to fail due to out-competition of the native species by the weeds. In reality, however, topsoil is a limited and valuable resource, therefore re-use of weed infested soil may be necessary. If this is the case, committed, on-going weed control will be essential if rehabilitation is to be successful.

Treatments to destroy weeds in soil have generally taken one of two approaches; chemical treatment (e.g. with appropriate herbicides to effectively kill the type of weeds occurring and their propagules); or non-chemical treatment which generally involves 'cooking' the soil to kill weeds and their propagules (e.g. in an oven/steaming small quantities, composting, or covering with black or clear plastic that traps solar heat). The disadvantage of both approaches is that they are likely to also destroy beneficial soil organisms and thereby reduce soil health. Mixing with untreated soil or weed and pathogen free compost may assist in returning beneficial organisms to the soil.

C.1.4 Use and Management of Sods

Sodding offers distinct benefits but it should not be seen as a rehabilitation technique in its own right.

'Sodding' refers to a technique used for saving the vegetation on a site and replanting it once the works have been completed. It is often seen as a form of transplanting where, rather than digging up material from one area and replanting it somewhere else, the plants would be reserved until they can be replanted back on the original site. Unfortunately many native species, particularly woody species, do not tolerate transplanting. As a result, sodding in its own right should not be seen as a rehabilitation method.

Sodding does, however, offer distinct benefits. These include preservation of:

- intact topsoil, including most organic matter;
- soil organisms;
- some plant propagules, including seed and vegetative matter, which will contribute to species diversity and the density of regrowth on the site; and
- some potential to reduce the cost of rehabilitation through saving viable plant matter.

Organic matter and soil organisms are important components of healthy soil that is capable of supporting new plant growth. Furthermore, while most plants (particularly woody species such as shrubs and heath) do not generally tolerate sodding, there is a possibility that, if sods are used, some viable plant material will survive. This is most likely with grasses and some forbs.

Because of the potential benefits of using sods, the technique, is generally recommended. Sods must be treated carefully to maximise the survival rate of plants, protect the soil and minimise the need for over planting and follow-up work. Details of how to use sods effectively are provided below.

Sods will fail if they are poorly selected or cut, or inadequately stored, replaced or maintained.

Choice of sodding material

- Indigenous forbs and grasses are most suitable for sod replacement.
- Material which contains noxious weeds and invasive pastoral grasses should be excluded and disposed of outside the Park.
- Sods with over 50% weed load are not generally suitable for use in rehabilitation, unless the weeds can be effectively controlled. If they are not controlled, rehabilitation is likely to fail due to out-competition by weeds.
- Transplanting of woody species with a main stem diameter more than 2 cm is generally not successful, however, in these areas it is still recommended that you use sods to preserve essential components of the soil that will help tubestock to grow later. Any woody material on the sods should be chopped off and used as thatch or mulch to protect the site.

Cutting sods

- Soil should be moist prior to cutting sods. If it is dry, water enough to moisten the soil, do not water so heavily that the soil becomes waterlogged.
- Cut sods to a size of about 30cm^2, so that they can be handled easily, without falling apart.
- Each sod should be cut to a depth that incorporates the topsoil and most plant roots, normally 10-20cm. As a general rule, the thickness of the soil should equal the height of the vegetation.

Some examples of well prepared sods are included in Figures C.1.4 and C.1.5.

Figure C.1.4 Although these sods contain some shrubby vegetation, they are dominated by grasses, which have a good chance of surviving. The sods have been cut deep enough to minimise disturbance to most of the root system of the plants.

Photo: E. MacPhee

Figure C.1.5 The size of this sod is not too large – it can be handled reasonably easily without the sod breaking apart. Placing the sod on geotextile helps to protect it from contamination, drying out and soil loss, as well as making it easier to handle.

Photo: E. MacPhee

Sod Storage

If sods dry out at any stage, or are not replaced properly, sod replacement will fail to produce regrowth.

- Store sods for the minimum period possible. The success of using sods is likely to diminish with longer storage, therefore they should be used as soon as possible.
- If the sods will not be replanted on the same working day and conditions are dry, water them lightly to prevent drying out.
- If the sods are to be stored for more than 2 working days,
    - place them on weed mat with weed free straw bales butted up close to the sods to prevent drying out.
    - Also place shade-cloth over the sods (it can be folded under the straw bales for securing).
    - Water occasionally if conditions are dry.

Note: Sods can be piled on top of each other if they are to be stored for only two to three weeks, however, for longer storage, they should be placed in a single layer with no space between them.

Replacement or planting of sods

- Replace sods at the same level as the surrounding landscape.
- It is best to replace sods carefully by hand, with some hoeing of the area for individual sods to be replaced so that they fit tightly.

- Once replaced, push the sods up hard against one another so that erosion channels do not form. Use any extra topsoil to back-fill between sods or spread lightly over the top of the replanted sods to fill any holes that may have formed during storage and transport.
- In most plant communities you will need to over-sow the sods with seed and/or tubestock to ensure that enough viable plants are present to successfully recolonise the site.

Maintenance of areas rehabilitated using sodding

- Water sods in well directly after planting
- Continue watering daily for the following week, unless there is rainfall.
- If the season remains dry, continue watering regularly.
- Areas that have been rehabilitated using sodding should be maintained as described in section C.5.2 for up to 5 years sub-alpine areas and up to 10 years in alpine areas.

C.1.5 Drainage, Erosion and Sediment Control

Failure to provide adequate erosion and sediment controls and drainage on site is a major contributor to the failure of rehabilitation projects.

Until vegetation becomes established on the site it will be very vulnerable to erosion. Good drainage and installation of erosion controls are essential to ensure that soil on the site is protected and vegetation has the best chance of survival.

Drainage, erosion and sediment control issues and techniques specific to the site should have been identified and addressed in the environmental assessment and SEMP. These will need to be implemented and continually maintained during the whole rehabilitation period.

A range of resources containing detailed notes and drawings on erosion and sediment control and drainage are listed overleaf.

C.1.5.1 Cross Drainage and Sediment Barriers

Table C.1.1 details recommended spacing for drains or sediment barriers on slopes of different gradients.

Table C.1.1 Recommended spacing for cross drains and sediment barriers.

Slope	Drain/barrier
5% - 10%	15 - 20 metres
10% - 15%	10 - 15 metres
15% - 25%	8 - 10 metres
> 25%	5-8 metres

Adapted from Parr-Smith and Polley (1998).

Resources for Drainage, Erosion and Sediment Control

- Landcom (2004) ***Managing Urban Stormwater: Soils & Construction*** ("The Blue Book") – this is the standard reference on erosion and sediment control. The publication includes a useful 'hip pocket handbook' containing construction drawings of key erosion control structures. Can be obtained at:

  www.landcom.com.au/bluebook.aspx

- Parr-Smith, G. and Polley, V. (1998) ***Working Draft Alpine Rehabilitation Manual for Alpine and Sub-alpine Environments in the Australian Alps***. This publication contains detailed notes on drainage, erosion and sediment control, including recommended sediment barrier and cross drain spacing for different slopes, as shown in table C.1.1.

Two publications relating to walking and cycling track management, that also contain useful information and specifications relating to erosion control in highland areas:

- Davies, P., Loxham, J. and Guggon G. (1996) ***Repairing Upland Path Erosion*** – a British publication.
- Parks and Wildlife Service (PWS) (2001) ***Walking Track Management Manual*** – contains detailed design drawings for drainage construction.

All of the above references are held in the NPWS Jindabyne resource collection. Refer to Appendix 19 for full details.

C.1.6 Preparing Soil for Planting

Prior to planting, sites should be prepared to ensure that appropriate conditions for plant growth are provided. Site preparation should involve:

- Retaining and re-spreading soils so that their natural order is reflected (i.e. subsoils at the bottom and topsoil at the top).
- Raking the surface so that big clods are broken up, the surface is even and the soil is easy to handle during planting. Some lumps, rocks, chunks of wood etc. can be left as these provide valuable microclimates for the establishment of different species.
- Ensuring that soil is not overly dry and powdery. It should be slightly damp but not sodden and muddy or the soil structure will be damaged. If it is very dry, watering it the day before planting is recommended.

The lack of available weed and pathogen free soil material is a common limiting factor to restoration and revegetation works in alpine areas. A minimum depth of 200 mm of soil material is generally required to sustain plant growth for most species. As a result, protection of the existing soil material on and around work sites is essential for successful restoration works.

C.1.6.1 Severely Depleted Soils

On sites where soils are severely depleted, measures need to be taken to:

- Protect the soil from further erosion; and
- Kick-start soil formation processes so that nature starts to improve the quality of the soil.

On severely disturbed or degraded sites, where there is little soil or the soil is very compact and nutrient depleted, additional steps may need to be taken to improve the soil. These include:

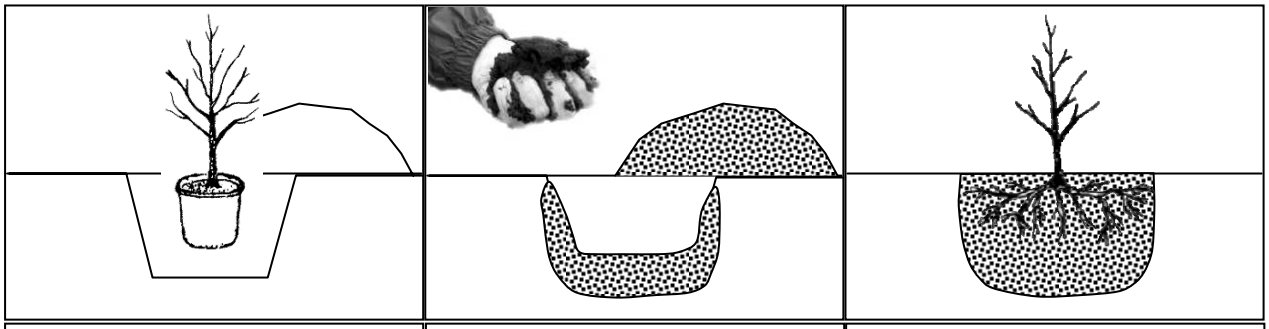
- Improving drainage through construction of drains (refer to section C.1.5) and improving potential for infiltration by:
    - o Cultivating the soil to reduce compaction; and
    - o Adding organic matter and micro-organisms to improve fertility and enhance the capacity of the soil to recover.
- Adding fertilizer (nutrients) to improve potential for plants to establish.

The addition of weed free compost is helpful because it introduces essential organic matter, micro-organisms and nutrients. Where there has been significant soil loss it may be necessary to work organic matter or compost into the subsoil to create a medium more suited to soil growth. Three techniques that have been used with some success are detailed below.

1. Inclusion of Sterile Copra Peat

Sterile copra peat (coconut fibre) has been used in Victoria to assist growth of shrubs in areas where topsoil has been severely disturbed or lost. The method of achieving this is illustrated in Figure C.1.6.

Figure C.1.6 Use of Copra Peat to Improve Depleted Soil



1. Dig a planting hole 2-3 times bigger than the pot.	2. Incorporate copra peat (and fertiliser) into the soil that has been removed and also rummage it into the edges of the hole.	3. Turn the plant out and spread out its roots as you replant it in the hole, using the copra peat-soil mix you have prepared.
How much Copra Peat? For an average 3 inch pot - one handful of peat. For bigger plants, increase the amount of peat in proportion to the size of the pot, e.g. for a 6 inch pot, use two handfuls of peat.		

2. Manufacture of 'Soil' from Sawdust and Woodchips

For large scale rehabilitation projects where no local soil is available, artificial media can be created from sawdust and woodchips. The following process should be followed:

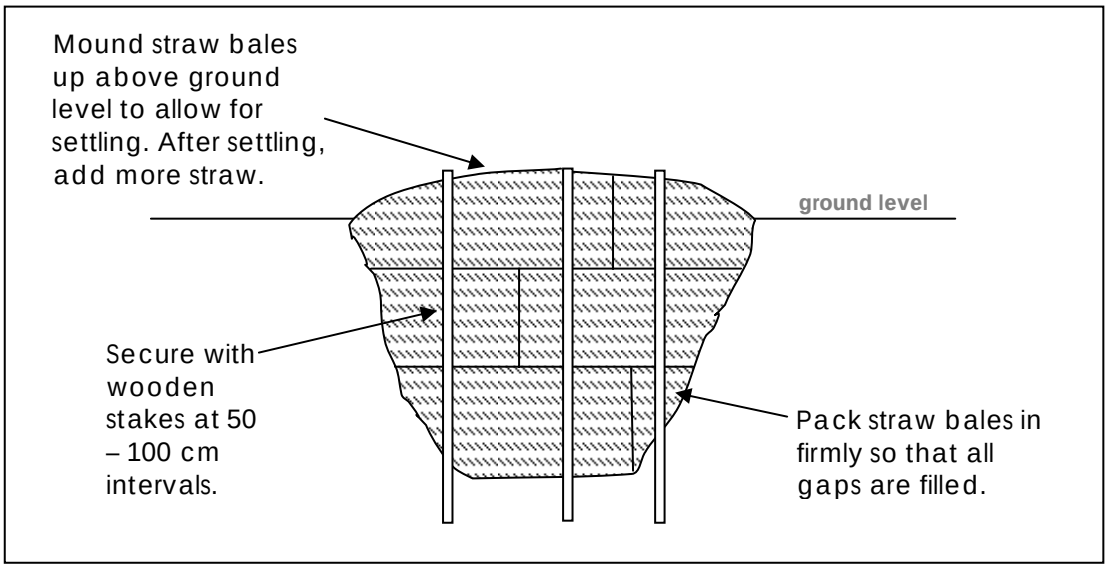
- Use a ratio of sawdust to woodchips of 4:1.
- Add dolomite and urea, each at a rate of 1kg/m^3 of sawdust plus woodchips.
- Mound the mixture into a stockpile, which should be treated as described in section C.1.2. Ensure that the pile is stored in a weed free area. A normal pile would be about 3m wide by 2m high.
- Leave the pile to compost, turning regularly to prevent overheating and spontaneous combustion. A three month breakdown process is required after the pile has reached 50^{o}C.

3. Straw-bale Mock Peat

Straw bales have been used to create a peat-like 'soil' in which some plants are able to establish. In particular, this technique has been used in bog rehabilitation, and also on sections of walking track which have been badly eroded, forming a deep trench. The technique is illustrated in Figures C.1.7 to C.1.8

Figure C.1.7 Section of former walking track (to the right of new track) that has been filled with straw bales. As the bales break down they settle and compact. As a result, further applications of straw will be necessary, until a level equal to the surrounding ground is maintained. Note that, although this area was not planted out, it can be seen that some species from the surrounding area have started to colonise the straw. As they build-up biomass they will also contribute to raising the ground level.

Figure C.1.8 Use of straw bales to replace soil in badly eroded areas.



C.1.7 Mulching

Mulch Essentials

- Mulch must be weed free.
- To maximise potential for local indigenous species to colonise rehabilitated areas, it is essential to use light-weight mulch mats or thinly applied natural mulch.
- Mulch must be maintained. It needs to be replaced as it breaks down, and, if any synthetic netting becomes exposed, this should be removed to protect fauna.

Numerous different mulches are available, however many have significant limitations when used in alpine environments. For example, many mulch mats are too heavy for fine alpine grasses and other plants to penetrate. Others, whilst ostensibly made of natural, biodegradable materials, often have synthetic components that remain once the rest has degraded. This can become a hazard for fauna such as skinks, which become entangled in the fine netting. Natural products such as straw can contain weed seeds or diseases which are likely to flourish and out compete the species you have planted.

C.1.7.1 Preferred Mulches for Alpine Areas

Using indigenous material can significantly improve rehabilitation success rates. All weed free indigenous organic material on the site should be regarded as a valuable resource that can be reused as mulch.

Straw from native grasses:- Straw from native grasses is often a bi-product of seed collection and makes an ideal mulch as it should normally be local to the area it is being used in, and contains extra seed.

Fine, light weight jute or coconut fibre matting:- For soil stabilisation, light weight matting with an open structure may provide protection and allow for adequate plant establishment, however, this is best used with tubestock rather than when direct seeding, as many alpine seedlings have difficulty penetrating such matting. Experimentation and/or communication with other alpine management authorities about their experience with different forms of matting may be worthwhile. Matting with a synthetic core should be avoided because of the potential threat it poses to fauna.

Shredded plant material removed from the local area:- Where works take place in shrubby areas, such as heath or woodland, there is likely to be abundant material available for reuse as mulch. Care should be taken, however, to only reserve weed free material.

The local plant material should be shredded when it is first cut, and allowed to decompose a little while the works are carried out. It should be stockpiled as described in section C.1.2, in a weed free area.

Mulch can also be applied more thickly, up to about 4 cm deep, in areas that will be rehabilitated with woody species such as shrubs or trees. Generally the lower altitude sites where this kind of mulch is likely to be obtained and used should be fairly sheltered, therefore the need to bind the mulch will be lower. Larger pieces of wood, such as branches, and rocks reserved from the site can be laid on top of the mulch to weigh it down. These will provide some habitat value.

Sterile straw:- If native grass straw is unavailable, guaranteed weed-free straw may be an alternative. It can be difficult, however, to find straw that is completely weed free. In order to minimise the chances of importing weeds:

- Identify and use a reliable producer of good quality, weed free straw;
- If it is necessary to obtain straw from an area that could contain weeds, try to source it from somewhere where the type of weeds the straw is likely to contain are species that won't persist in alpine or subalpine areas.

Introduction of weeds in straw bales can be a major contributor to weed infestation in KNP. These weeds can significantly reduce the potential for successful rehabilitation.

C.1.7.2 Application of mulch

Straw

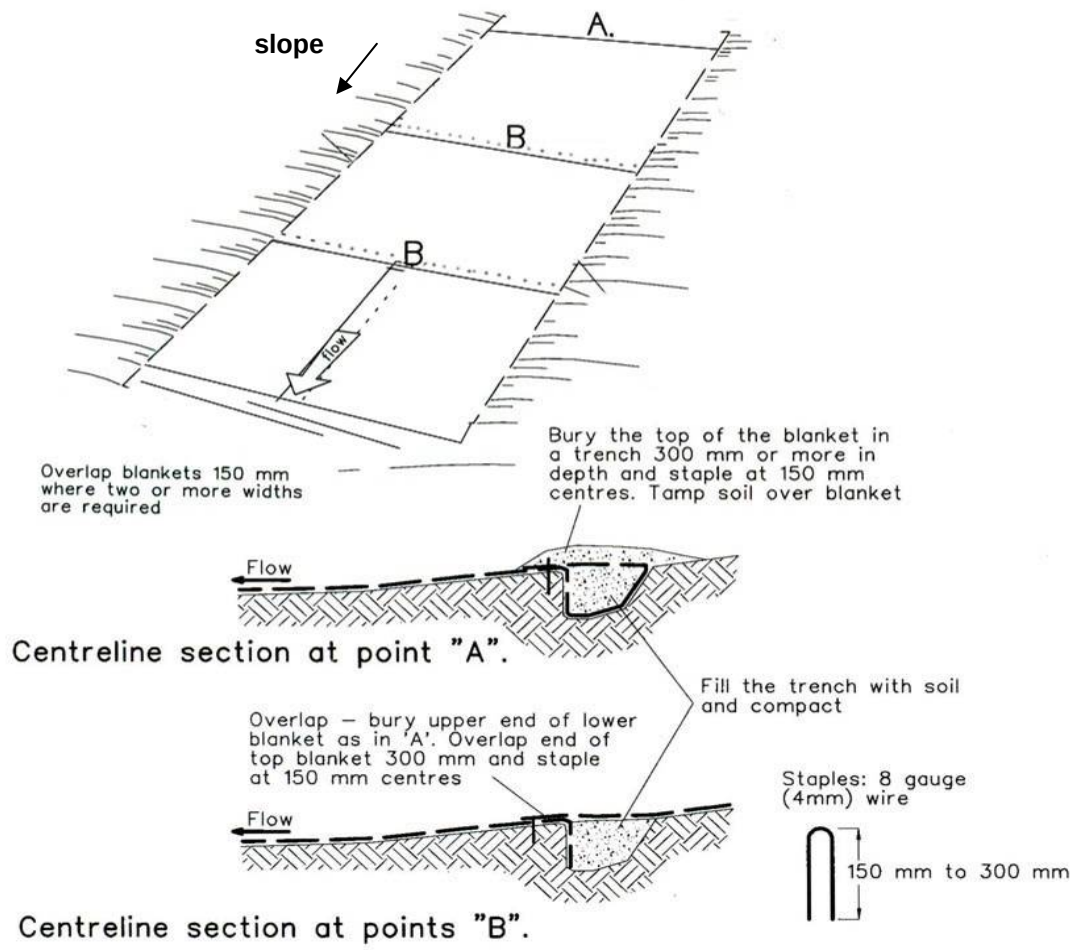
Both indigenous and non-indigenous straw should be applied lightly, so that the surface is covered but easily accessible with a light rummage with the fingertips. It should never be applied in thick wads because these will pack down into an impenetrable mat. Preferably the straw should not be shredded or cut into short lengths, as this is more likely to pack down and/or blow away. Longer lengths tend to weave themselves together into a more open but stable matting.

As straw is light weight and liable to blow away, it should be fixed down, preferably with an open weave jute mesh such as Treemax Soil Saver™, that is pinned down with non galvanised pins or weighted with rocks. A method for laying jute mesh is described in figure C.1.9. This method is also illustrated in figures C.1.10 and C.1.11.

Fibre Mats

Fibre matting should be laid as described above for jute mesh, and in figure C.1.9. Care should be taken not to overlap layers of matting more than 150mm, to minimise the overall area where mulch is double thickness.

Figure C.1.9 Method for Laying Fibre-Mat Mulch or Jute Mesh



INSTALLATION PROCEDURE

Ground and earth preparation

The slope should have an even surface. Soil should be raked evenly over the surface then the prescribed mix of seed should be broadcast. If straw mulch is to be used, this should be distributed over the surface before the mesh is laid down.

Fixing techniques

Construct a trench as per the drawing above on the upslope perimeter of the matting and place the matting into this trench as per the diagram above. Roll matting down the prepared slope. If more than one width is to be used, overlap each strip by 150 mm. Peg the extremities of the matting at 150 mm centres. 2-3 staples are required for every square metre.

Monitoring and maintenance

Following installation, the site will require monitoring. It should be inspected after any severe storm event or other management activity that might result in disturbance of the site (such as slope grooming), so that if the matting is moved it can be replaced and re-secured in a manner that should prevent further disturbance. As mulch breaks down, it should be replaced until adequate revegetation has occurred and exposure of soil is minimal.

Adapted from Landcom 2004 and manufacturer's guidelines.

Figure C.1.10 (right)

Use of jute mesh to secure straw mulch – 1. Straw is being laid and a trench has been excavated at the top of a batter. The jute mesh, (like cargo net, shown rolled up at the top of the batter) will then be secured by placing the top of it in the trench and weighing it down with rocks. The rest of the mesh will be unrolled carefully over the straw to cover the batter and secure both the soil and straw mulch.

Figure C.1.11 (below)

The completed batter with jute mesh laid over straw and tubestock planted through it. Note how the mesh has been weighed down with rocks placed along drainage lines.

Photos: E. MacPhee

C.2 Preparation of Plants for Rehabilitation

C.2.1 Timing Issues

Timing is critical in preparing plants for rehabilitation. The success of rehabilitation is extremely dependent on stock being available and ready for planting during short, seasonal windows of opportunity.

Seasonal constraints and timing factors need to be considered in preparing plants for rehabilitation. Opportunities for seed collection and planting, and an indication of the length of time it will take to propagate stock are detailed in sections C.2.2.1 and C.2.2.2 below (respectively). C.3.2 provides an indication of how long stock can be held before planting, and C.3.4 discusses optimal timing for planting.

Working backwards from expected completion of construction/rehabilitation dates may be useful to identify opportunities for seed/cutting collection and optimal timing of propagation, ensuring that good sized, healthy plants are ready for use when rehabilitation takes place.

C.2.2 Plant Production

C.2.2.1 Seed/Cutting Collection

There are three main ways to collect plant material for propagation: seed collection, cuttings and division. Each of these methods is described below.

Seed Collection

Many forbs and grasses are suited to collection in large quantities that will enable direct seeding, however, seed can also be collected for propagation of tubestock. Use of seed where possible, will ensure that genetic diversity and integrity are maintained, thus the limitations of using cuttings or division, which result in production of clones, can be avoided.

To ensure the genetic integrity of the area to be rehabilitated, seed should be sourced as close as possible to the rehabilitation site. To ensure sufficient volumes are available for direct seeding, however, it may also be necessary to source seed from other nearby areas. To ensure that seed is ripe, weed free and likely to be viable, it is recommended that collection should be carried out by a suitably trained and experienced person.

Some general guidelines on seed collection are contained in Table C.2.1.

Table C.2.1 General seed collection and storage guidelines

Before Collection
• Obtain permission to collect seed within KNP (if required, refer to section B.3.1.2). • Ensure you can correctly identify the species to be collected.
Timing of Seed Collection
• Most alpine and sub-alpine species only produce seed between mid-February and mid-April. • Grasses come into season early, generally in the last two weeks of February. • Most forbs can be harvested in March, as well as many pod bearing plants such as *Bossia, Podolobium* and *Acacia*. • *Eucalyptus pauciflora* (Snowgum) seed is generally available all year round but may vary from site to site.
Collection of Seed
• Try to collect seed from as many well spaced plants as possible to ensure genetic diversity. Likewise, do not remove more than 20% of the seed from any one plant so that some remains for natural regeneration and as a food source for fauna species. • Take care not to damage plants when collecting seed. Think about what other species (including fauna) you are impacting on to gain access to the seed plants. • Seed that is suitable for collection should be ripe and not affected by pests or disease. Indicators of ripeness vary from species to species, but generally, when a species is ripe, the seed will easily detach from the parent plant, for example, daisies will start to become fluffy and break apart. Eucalypts and other species with woody capsules are ripe when the capsule becomes dry and brown. Grasses and sedges often undergo a colour change and the seed becomes noticeably larger and harder when it is ripe. It will often fall off when you run your hand up the flower head. Soft fruits also change colour but become softer rather than harder. Seeds of leguminous plants (enclosed in pods) are ripe when the pod becomes brittle and begins to split. Many of these species however, shed ripe seed explosively in hot weather, which can make it difficult to collect the seed. • Various methods can be used to harvest seed, including: - Cutting off seed heads using secateurs or a scythe (cut off any leaves to minimise moisture build-up during transport and storage). The cutting instrument you use should be sterilised by wiping with methylated spirits between plants; - Running your hand up the seed head to loosen and collect grass seed or pulling off whole pods by hand; - Placing a tarpaulin under the plant and shaking it so that all the seed is caught in the tarpaulin.
Transport, Drying and Storage of Seed
• After collecting seed, it is best to store it in calico or paper bags. Plastic ‘sweats’ the seeds and can cause fungal diseases. Label each collection with the date and place of collection and the species. It is also good practice to record the number of plants sampled. • Once collected, seed should be dried in a warm, dry place. Grasses and sedges can be laid out on a tarpaulin to dry. Small quantities of other seeds can be left in their collection bag if they are not too tightly packed. Occasional shaking of the bag will help

the seed dry evenly.

- Pods should be kept in their bag until they burst, releasing the seed, after which the pod can be discarded.
- Many seeds can be extracted by giving them a good shake. Papery seed covers may need to be rubbed off – rubbing them over a coarse sieve may be effective. The seed coating can be gently blown off.
- Soft fruits should be fermented for a few days before rubbing off the flesh. Placing them in water can be useful to help wash away the pulp.
- When the seed is completely dry[5], it can be stored in airtight containers, jars or plastic bags. Bags are useful because you can easily eradicate as much air as possible. Transfer the information from the original label to the new container.

Store the seed in a cool, dark, dry location.

Collection of Cuttings

The use of cuttings is particularly recommended for species where enough seed cannot be collected, or when propagation of the particular species using seeds is difficult. It is preferred for many shrubs, which are excellent for rehabilitation but are difficult to grow from seed.

The best time to collect cuttings is generally in autumn. The cuttings should be stored in a plastic bag with some moisture but not overly wet. The right amount of moisture can be added by breathing into the bag to create a layer of mist, or dipping the cuttings briefly into water. The bag should then be sealed and stored in a cool place, such as an esky. It should be taken to the nursery as soon as possible.

Division

Division involves digging up a plant or part of a plant and dividing it up so that each part has some roots. These sections are then potted up and grown on to a good size. The technique is best suited to species that form clumps, such as grasses and rushes, or those which trail over the ground, putting down roots where the stems touch the ground (e.g. *Violas*). Because division involves ground disturbance and sometimes removal of whole plants, the method is not preferred, however, it may be appropriate where sodding is being carried out. Sods with good quality plants would be removed from the site and propagated at a nursery.

Material for division should be dealt with immediately. For transport, the sod should be placed in a plastic bag and watered to field capacity (i.e. damp but not sodden). The plastic bag should then be placed in a polyester sack and delivered to a nursery as soon as possible.

[5] Moisture content should be measured if possible to ensure that seed is completely dry, otherwise there is a risk that it will become spoiled.

C.2.2.2 Plant Propagation and Culture

Effective plant propagation involves a great deal of skill, knowledge and experience. As a result, it is strongly recommended that you establish a working relationship with a reliable nursery.

Propagation and culture of native plants is a specialist field. It is generally recommended that this is carried out by a suitably qualified and experienced person or contractor. You should try to identify a good nursery, cultivate a working relationship with them, and audit their stock regularly to ensure that standards remain high.

Note that, for alpine species, round pots are generally preferable to forestry tubes, as most alpine species have a fibrous root system as opposed to a tap root.

Some introductory notes on plant production have been included in Appendix 15.

Consideration of the period of time required to produce tubestock is important to ensure that healthy, good sized stock is ready for planting according to schedule. The time it takes to produce tubestock varies widely, depending on species, whether cuttings or seed are used, and nursery conditions. For example, to reach plantable size;

- Many grasses and forbs take 3-4 months,
- *Celmisia* takes 9-10 months,
- *Olearia* takes about 6 months,
- *Grevillea australis* and *Prostanthera cuneata* take 10-12 months.

Drawing on the experience of nursery operators is invaluable in trying to determine how long it will take to acquire good sized plants.

C.3 Plant Management and Planting

C.3.1 Quality Control

Strong and healthy tubestock is essential for rehabilitation to be successful in the severe Kosciuszko environment.

Prior to planting all plants should generally have been grown on to 7.5 cm pots, although 5 cm pots may be adequate for forbs, sedges and grasses. Plants in pots of these sizes are recommended as they are physiologically dynamic, small enough to plant, but large enough to cope with transplant shock. Smaller pots may, however, be more appropriate for sites that have minimal or shallow soil, or for remote sites, to which they are easier to transport.

All plants should have sufficient, healthy, root and shoot growth. Plants that are small, diseased or pot bound generally will not succeed when planted in an alpine landscape.

Appendix 16 contains a checklist to help with quality control of tubestock.

C.3.2 Transport and Storage of Plants

Transport

Plants should be transported carefully to minimise potential damage. They should be kept cool and the time it takes to transport them should be minimised to reduce potential for dehydration.

Storage

All tubestock has a time when their roots and shoots are at optimal size and vigour for planting out.
Planting tubestock when it is in optimum condition will greatly enhance rehabilitation success.

Different species also vary widely in how long they will tolerate remaining in a pot between attaining plantable size and planting. In general, however, the longer plants are held in pots, the more their vigour will be reduced, making them progressively less likely to survive planting.

Generally;-

- Grasses can tolerate longer periods in pots because their fibrous roots are better able to survive disturbance such as pruning before they are planted.
- Some shrubs such as *Ozothamnus alpinus* need to be planted as soon as the have reached optimal size and vigour.

- Holding some stock (e.g. *Grevillea australis*) can reduce growth rates and allow them to be stored longer before planting.

Hardening Off

Prior to planting, tubestock should be stored for a period to 'harden off'. This will allow them to adapt to the more natural conditions likely to prevail at their ultimate destination, reducing the chance that they will die of shock after leaving the more ideal conditions created in a nursery. Ideally plants should be hardened off at a location with similar temperatures, light conditions etc., to their ultimate location. In some cases it might be necessary to stage hardening off so that it occurs in progressively more stressful conditions. This is most likely to be necessary if plants are moved from a nursery with very mild conditions to a cold, exposed alpine location. To avoid the need for this, it is preferable to cultivate stock close to KNP, if possible.

Hardening off should involve at least two weeks of exposure to the elements at the at the source nursery, and a further two weeks in a suitable location that will allow them to become accustomed to the conditions of their intended location. They will need to be watered regularly during the hardening-off period but less than in the production phase.

C.3.3 Windows of Opportunity for Planting

Rehabilitation Plans should consider the need to time planting for a period when conditions are suitable for the rapid establishment of plants. Issues that need to be considered when developing a planting schedule include:

- Temperature: Consider whether the temperature range during the period when planting is being planned are likely to be conducive to the survival and growth of the plant stock. If it is too hot, plants may wilt or become burnt and die. Alternatively, if it is likely to be frosty, this may also delay plant establishment or even kill more sensitive young plants.
- Moisture availability/rainfall: Soil moisture is important; if it is too dry plants won't survive. Adequate soil moisture and rainfall will help plants establish quickly and will also make it easier to dig holes for planting. If it is too wet however, plants may become waterlogged and soils are also more likely to be damaged during access, planting, or by temporary exposure during heavy rain.

The planting of tubestock in high altitude areas after April will often fail because the soil is too cold for the plants to establish.

Optimal periods for planting Tubestock are:

- late spring
- early autumn

If sites can be irrigated, planting can be carried out any time between November and April. It may also be possible to stretch the planting period a little if plants are in optimal condition for planting. For example, if plants have been well hardened off for

a long period in conditions similar to the rehabilitation site, they will probably be better able to withstand planting earlier in the season, while temperatures are cold.

Generally, healthy plants are better able to adapt to conditions once they are planted than unhealthy stock, which, if absolutely required, should be planted only when optimum conditions prevail.

C.3.4 Plant Hygiene

The production of alpine tubestock that is pathogen free is crucial.

The introduction of any new or different pathogen, pest or weed into the vulnerable and unique Kosciuszko environment would, potentially, be disastrous for indigenous alpine flora.

Plants are sensitive to a range of diseases such as *Phytophthera* (Die-back) and pests, including nematode worms and other micro-organisms. A good nursery will have strict hygiene procedures to minimise the chance of infection, however, once plants are removed from the nursery, hygiene protocols should continue to be observed. To minimise the chance that disease will be transferred, all equipment used during planting, including tools, vehicles and clothing should be clean. Further details on plant hygiene practices are included in section C.4 (weed control).

C.3.5 Site Preparation Prior to Planting

Refer to section C.1 for information about treatment and preparation of the site prior to planting. Good site preparation will ensure that soil is protected and soil condition is optimal for plant establishment.

C.3.6 Planting

C.3.6.1 Tubestock

Preparation of Tubestock

Tubestock should be in good condition prior to planting. 7.5 cm round pots are the preferred container for shrubs and forbs as this ensures a sizeable root mass to increase survival rates. Five centimetre round pots are the preferred container for grasses.

V93 Hiko cells or similar small cells used for propagation of grasses may be suitable for planting subalpine sites with good soil, moisture and shelter. Sites with poor soil or difficult growing conditions (dry, exposed etc.) should, however, be planted out with larger tubestock. Plants grown in Hiko cells will not have enough carbohydrate stores to successfully establish in a marginal site.

No matter what sized pots are used, plants should not be overgrown or root-bound. Prior to planting, it is advisable to remove any flowers or fruits/seeds as this will help encourage vegetative growth to help the plants establish. With excessively ‘leggy’ or elongated plants, pruning may reduce the risk of damage during transport, prevents excessive transpiration that results in the plant drying out quickly, and encourages more bushy growth.

Planting

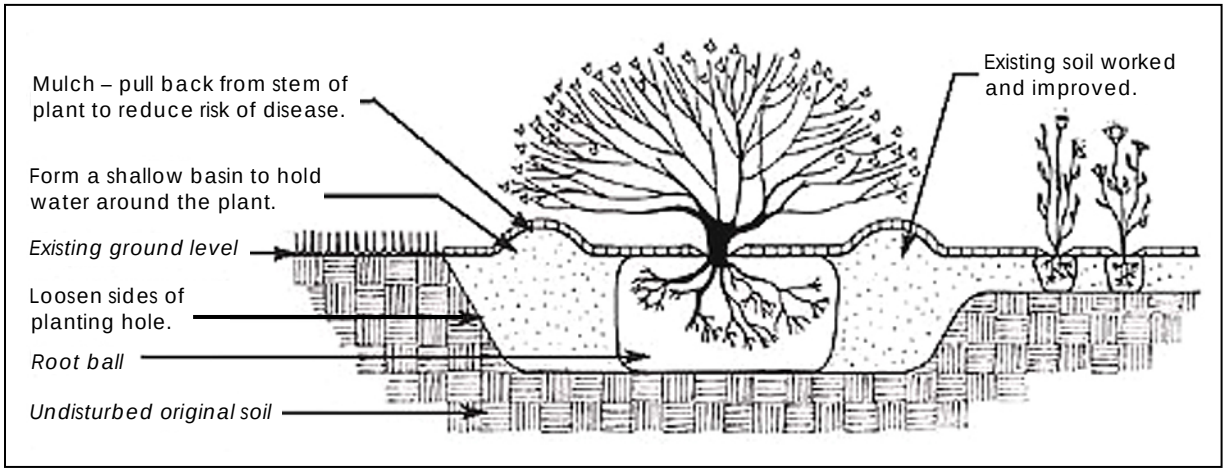
Just prior to planting, tubestock should be watered to field capacity (completely wet but not dripping or sodden). They should then be upturned and planted at a depth that ensures that the surface of the potting medium is in line with or only very slightly below the surrounding soil surface, as shown in figure C.3.1. This ensures that the stem is not buried, but may allow for a small hollow where water can penetrate rather than running off. The plant should then be firmed down, but not too hard, so that natural soil texture is maintained (e.g. porous but not too loose or too compact).

Generally tubestock will be planted into soil that has already been mulched, therefore, you will need to clear a patch of mulch away so that a hole for the plant can be excavated. Once the plant is in place and the soil has been backfilled, pull back the mulch, but, as shown in figure C.3.1, do not mound it up around the stem of the plant. (Refer to figure C.1.11 for an example of where this technique has been carried out in an area mulched with straw).

Following planting, the site should be watered to field capacity. As a general guide 100 tubestock plants require a minimum of 20 litres of water during planting. Watering should continue afterwards, as part of the maintenance schedule for the site (refer to section C.5).

Note that over-watering should be avoided at all times as this may be detrimental to root development and soil structure, and excessive watering may also contribute to erosion.

Figure C.3.1 How to plant tubestock.



Source - Canadian CMHC website: http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_073.cfm

Planting Rates

Planting rates will depend on the species used (size when mature and rate of growth), the health of stock, site conditions (steep, exposed, dry etc.), and the likely conditions for growth (e.g. difficult sites where frequent watering cannot be achieved may need higher densities to make up for the likely death of some plants).

In general, planting rates should be relatively dense to ensure the success of restoration works. As a general guide,

- Shrubs should be planted at a rate of 3 plants per m^2; and
- Forbs and grasses should be planted at rates of:

- 7-10 plants/m^2 in alpine areas, or
- 5-7 plants/m^2 in sub-alpine areas.

C.3.6.2 Direct Seeding

Sowing seed directly onto the rehabilitation site can be an efficient alternative to nursery grown tubestock, however, not all species are suited to this technique. Indigenous species are relatively slow to grow from seed, therefore they take a long time to cover and protect bare ground. As a result, it is preferable to use tubestock interspersed with seed.

For effective rehabilitation using direct seeding, you should consider the following points:

- Direct seeding generally works best for grasses and some forbs, especially those for which large quantities of seed can be gathered very efficiently. To ensure that you will be able to get an even germination and good, quick cover, you need to know how viable the seed is (to know how heavily to spread it) and ensure that any innate dormancy is broken prior to seeding.
- Soil in areas to be seeded must be well prepared and weed free. Seed should be well integrated into the soil so that it is not carried away by water, wind or fauna.
- Direct seeding works best on small (<1500m^2) areas of relatively flat ground which have good erosion and sediment controls in place and are mulched appropriately directly after seed is spread (refer to section C.1.7 for further information on mulch application).
- Direct seeding of native grasses on steep slopes will fail unless you use matting to stabilise the slope (e.g. *Terramat*™) or intersperse the seed with tubestock as described in section B.3.3.4.
- In general, using a combination of seed and tubestock is more effective than using seed alone (refer to section B.3.3.4). This is probably because the tubestock provides some protection of seedlings by helping to stabilise the soil, protects them from grazing animals, and reduces the impact of freeze-thaw action on the soil. Also, the tubestock will start to cover the soil much faster than the seed.

Sterile Rye Corn

Direct seeding of Sterile Rye Corn offers some advantages for alpine rehabilitation, however, use of Sterile Rye Corn on its own does not amount to rehabilitation. This is because Sterile Rye Corn is an annual plant, so it only lives for one year, and as it is sterile, it will not self-regenerate. As a result, when the grass dies down it will need to be replaced with other plants to provide permanent ground cover.

In order to effectively rehabilitate a site using Sterile Rye Corn, it needs to be over-planted with native seed and tubestock that can establish once the Rye Corn dies down.

The main advantages of Sterile Rye Corn are:

- When planted in conjunction with native species, it produces a fast growing cover that stabilises the soil and suppresses weeds by acting as a mulch and releasing plant inhibiting chemicals (allelopathy). This allows slower growing natives to establish.
- The thatch produced by the crop provides a good weed free mulch for the site later on, as the original mulch begins to break down.

Further information on the use of Sterile Rye Corn has been included in Appendix 5.

Selection and Treatment of Seeds

Seed used in direct seeding should be of good quality. Appropriate treatments (e.g. heat or cold treatment/scarification) should be carried out prior to seeding, if required.

Seeding Rates

It is important to distribute seed at appropriate rates. If seeding densities are too high, not only is this inefficient and potentially expensive, it may also lead to too much competition between seedlings, resulting in weak plants and, potentially, the onset of disease.

Generally, on reasonably flat slopes 15-20g/m^2 of seed would be appropriate, using mulch mat (e.g. *Terramat*™/*Jutemaster FM*™) or straw mulch secured with jute mesh e.g. *TreeMax*™ to protect the seed and soil. Much higher rates would be required on steeper slopes; seed in these areas will need good protection to prevent it from washing away.

Care of Seeds Prior to and After Germination

Watering should be carried out immediately after seeding and daily (unless there is good rainfall) until germination occurs. Before germination grass should be watered with a fine spray until the topsoil is moistened to its full depth. Water should not be applied so heavily or frequently that waterlogging occurs. The surface should be damp and the topsoil moist.

Once seed has germinated, regular watering should be continued until a dense, continuous sward, with an even colour and height has developed.

C.3.6.3 Use of Sods and Transplanting

Refer to section C.1.4 for information on planting sods or material that is to be directly transplanted from one part of the site to another.

C.3.7 Fertilizer Application

Fertilizer use can be of great benefit in helping the establishment of rehabilitation, however, it should be used with some restraint, particularly in weedy areas and near waterways or wet areas. This is because:

- Most weed species love fertile ground and quickly take over areas where fertiliser has been used, limiting opportunities for native species to establish.
- Fertiliser is soluble in water and is, therefore, easily transferred away from the site in groundwater. The groundwater then flows into alpine wetlands and rivers and can cause algae blooms and eutrophication due to the increase in nutrients (alpine water is naturally very low in nutrients).
- Using more fertiliser than plants can take up is wasteful because excess fertiliser will be transported away from the site by water, potentially impacting on weeds and waterways downslope.

Due to these issues fertiliser should be applied with restraint, especially in weedy areas, near wet patches, or in drainage lines of all sizes. Generally, broadcasting should be avoided in favour of spreading fertiliser more directly around the root area of individual plants.

During planting of tubestock, rather than broadcasting fertiliser, it is best to sprinkle 5 to 10 grams of fertiliser (e.g. *Osmocote*™ native plant formula) directly into the planting hole.

For direct-seeded areas, *Dynamic Lifter* broadcast over treated sites has been used effectively in non-weedy alpine areas. When direct seeding in potentially weedy areas, however, it is recommended that you withhold the application of fertiliser until the second year after the initial works. This allows any weed invasion to be controlled prior to the application of fertiliser. Fertiliser can then be broadcast at 100-150 grams/m^2, or added directly to the root zone of plants.

C.4 Weed Control

The Kosciuszko area contains numerous weed species. It is important for rehabilitation workers to be able to identify these. To help with weed identification and provide information on control, a guide to the main weeds within the Park has been included in Appendix 12. Listed below are eight of the most significant weeds in the Kosciuszko ski resort areas.

Significant Weeds of Kosciuszko Ski Resorts

Yarrow (Milfoil) *Achillea millefolium*	**Browntop Bent Grass** *Agrostis capillaris*
Sweet Vernal Grass *Anthoxantheum odoratum*	**Wintercress** *Barbarea verna*
Cocksfoot *Dactylis glomerata*	**Vipers Bugloss** *Echium vulgare*
St Johns Wort *Hypericum perforatum*	**Soft Rush** *Juncus effusus*

Weeds are plants that are easily spread from site to site. This may be on clothing, machinery, or by natural means, however, once they arrive, weeds generally establish quickly and out-compete other species. As a result, the most useful weed control methods focus on preventing the spread of weeds and controlling existing weeds. A number of excellent guides to weed control are available. As a result, these Guidelines only contain a brief introduction to weed control, focussing mainly on ways to prevent the spread of weeds. Further information can be found in the references listed in section B.3.2.1 and in the resource list in Appendix 19.

C.4.1 Preventing Spread of Weeds

Weed control begins with preventing their spread. Ensure that rehabilitation works do not contribute to the distribution of weeds by:

- Limiting the area of soil disturbed to minimise the exposure of bare ground;
- Using mulches and establishing plant growth as quickly as possible to protect bare ground;
- Avoiding the importation or movement of soils or plant matter that could contain weed seeds, such as straw mulch (do not use straw that comes from sites where weeds such as Vipers Bugloss, St Johns Wort and Milfoil occur);
- Avoid re-using weed infested topsoils if possible (refer to section C.1.3);
- If you are using rock, pressure wash it prior to importation;
- Ensure that seed collected for rehabilitation is weed free (seed collection, processing and storage should be undertaken by people who are able to recognise weeds);
- Ensure that all materials and equipment are clean and weed free. This may mean that equipment needs to be washed when it is moved from one site to

another, and even between different parts of one site when weeds grow in just one part of the site. This is particularly important for trenching operations, to ensure weeds are not spread along the length of the trench; and

- Use fertilisers conservatively to avoid creating the conditions for weed establishment by over-fertilising.

C.4.2 Controlling Weeds on Site

> **"A weed is a plant that grows fast, is aggressive and throws out zillions of seeds. Bare ground is easily colonised by weed plant species." (Jill Dawson, Australian Alpine Nursery)**

If weeds are found to be present in a worksite before or after works, they need to be controlled. Weed control methods include:

- Encouraging workers to recognise weed species and effect weed control (including simply pulling weeds out by hand) as they undertake work and/or during monitoring/reconnaissance surveys;
- Monitoring the site before and after the works to identify weed control requirements and allow rapid action to be taken to implement control works;
- Undertaking weed control as appropriate to the species targeted.

Weed control within KNP is carried out in accordance with the Snowy Mountains Region *Pest Management Strategy 2007-2010 (draft)* and relevant legislation. All works crews operating within KNP should include staff who are adequately trained to be able to make appropriate decisions about weed management and identify the process required to allow weeds to be managed effectively. All weed control staff should have appropriate prescribed qualifications as per the Pesticides Regulation 1995. Supervisors or staff involved in planning works should have AQF (Australian Qualifications Framework) level 5 certification.

Chemical herbicide is usually administered at two levels:

- Only registered herbicides should be used on those weeds listed on the herbicide label, and in accordance with the information provided on the label;
- In some circumstances a herbicide may be used that has not been registered for a particular plant or for a particular situation, however a permit for off-label use must be acquired before such use is allowed.

The Commonwealth's Australian Pesticides and Veterinary Medicines Authority is responsible for herbicide registration and issuing permits for off-label use. The DECC Environment Protection Authority (EPA) is responsible for regulating the appropriate storage and use of herbicides.

In regard to the use of herbicides, note that:

- Herbicide is most effective when applied at a time when the plant is actively growing and not limited by cold, drought etc.;
- Herbicide should be applied using the most appropriate method for the plant species;

- Non-chemical alternatives to herbicide should be considered, eg, steam application may be effective on hard surfaces. For small infestations, hand pulling or digging up the plants, combined with secure transport and disposal of the plants can be the most effective solution.
- Legislation introduced on 1 February 2007 requires specific notification of the public prior to undertaking a pesticide/herbicide program. Contact NPWS Resorts Section on 6450 5616 if unsure of requirements.

C.5 Protection and Maintenance of Rehabilitation

C.5.1 Plant Protection

New plantings may need to be surrounded with guards to protect them from pests. Tree guards can also provide temporary protection from frost and wind damage. If tree guards are used, however, care should be taken during installation not to damage plants. They should also be maintained during the period they are needed, and removed when outgrown.

If long term protection is required, consideration could be given to fencing the whole site. In general, options for protection of plants include:

- Tree guards for woody species,
- Electric fences for larger areas,
- If fencing is not an option, feral animal control needs to be considered, therefore you need to contact the DECC.

Plants also need to be protected from weeds, pests or disease. Ongoing monitoring should also look for evidence of any of these problems and action should be taken to control them if necessary. (Refer to section C.4 for further information on weed management).

C.5.2 Maintenance of Rehabilitation

Maintenance is essential for rehabilitation to be successful. Core maintenance tasks are detailed in table C.5.1. A maintenance routine must be included in rehabilitation plans.

How long do sites need to be maintained?

- Montane and sub-alpine areas – up to 5 years
- Alpine areas – up to 10 years

Table C.5.1 Essential maintenance requirements for successful rehabilitation

Watering	Watering is only required when there is little or no rainfall, so the amount of watering you need to do will depend on the season. Watering is a short term requirement that only needs to be continued until the plants become established (i.e. generally for the first year). Improving the water holding capacity of the soil through the addition of organic matter or, in some cases, water holding crystals, and using mulch (refer to section C.1.7), can reduce the amount of watering needed.
Weed control	Control weeds biannually for the first three years, then annually.
Mulch	Replace mulch where this has broken down or is lost at least annually, until the plants are producing their own biomass.
Sediment controls	Repair or replace sediment controls until the ground is well covered and there is no sediment movement. Remove sediment controls with minimal ground disturbance once they are no longer needed.
Drainage	Culverts, sediment basins and rock flumes need a maintenance plan to ensure they are regularly cleared over the long term.
Plant replacement	Replant any plant losses over the first few years, until the plants are well established.
Plant protection	Plants need to be observed for signs of grazing and, if necessary, plant protection should be repaired or upgraded. Once plants have grown sufficiently to survive on their own, or have outgrown their guards, the protection should be removed.

Glossary

Including Acronyms and Abbreviations

APZ	Asset Protection Zone – a *buffer zone* between assets (buildings etc.) and natural vegetation, where vegetation and other potential fuels are managed to minimise the risk of a bushfire affecting the asset.
Biodiversity	The variety of living organisms, the genes they contain and the ecosystems they form.
Buffer Zone	An area adjacent to or adjoining a natural area or other asset, that minimises or absorbs the affect of activities outside that area/asset.
Corridor	A linear area of vegetation linking other larger remnants of vegetation. It forms a link for the movement mainly of animals, but also a relatively natural area for plants to establish or re-establish. Corridors, therefore, form a vital part of the ecosystem in highly disturbed areas.
Cuttings	Used as a means of propagation, parts of the parent plant are cut away and re-planted, generally after dipping in plant hormones to encourage roots to develop. Once roots have formed the plant is said to have 'struck' and growth of the upper parts will follow. Once the cutting has struck and is growing well, it is ready to plant out.
DECC	NSW Department of Environment and Climate Change
Direct Seeding	The practice of sowing seed directly onto the soil. This technique is mostly used for grasses, however, other species that produce seed prolifically may also be suited to direct seeding, particularly many of the alpine forbs.
Division	In clump-forming species, division is sometimes used as a means of propagation. It involves dividing up the clump, or cutting part of it off with roots intact, and replanting this (also referred to as 'clump separation').
Earth Bank	A mounded up bank of earth designed to reduce erosion by slowing the down-slope flow of water.
Ecosystem	Term used to describe the network of processes and interactions that occur between plants, animals and other elements of a given community, population or geographic area.
Ecotone	A transitional zone or marginal area between two plant communities. Often very rich in plant and animal species.
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EP&A Act	Environmental Planning and Assessment Act, NSW 1979
EPA	NSW Environment Protection Authority (division of DECC)
EPBC Act	Environment Protection and Biodiversity Conservation Act, Australia, 1999
Field Capacity	Soil is said to have been watered to 'field capacity' when it has absorbed the maximum amount it can before excess water begins to move or drain away. When this begins to occur, the soil will have a sodden, soggy appearance, with water oozing out and the soil itself will be less resistant to deformation or compaction. Soils that are sodden should never be worked as this will destroy their natural structure so that they become compact and poorly aerated.
Habitat	The place or environment where a species naturally occurs.
Harden off	The process of storing plants in conditions similar to the final planting location to allow them to acclimatise. Allowing plants to harden off reduces the chance that they will die of shock due to the sudden contrast between the ideal conditions produced in a nursery situation and more natural conditions.
Indigenous	Species naturally distributed within a specific geographic area, eg, KNP or the Perisher Range (vs. *native species*).
ISC	Independent Scientific Committee
JAMBA	Japan - Australia Migratory Bird Agreement
KNP	Kosciuszko National Park
KT	Kosciusko Thredbo Ltd.
LALC	Local Aboriginal Land Council
Landscaping	Can be a type of rehabilitation, where the focus is on aesthetics rather than ecosystem

	processes. Indigenous or non-indigenous plants may be used, however, when indigenous species are used these are often confined to the creation of a representative rather than a realistic ecosystem.
Native Species	Term normally applied to any species that naturally occurs, or is *indigenous* to Australia (refer also to *indigenous*).
NPW Act	National Parks and Wildlife Act, NSW 1974
NPWS	National Parks and Wildlife Service, a division of the NSW Department of Environment and Climate Change.
OH&S	Occupational Health and Safety
PoM	Plan of Management (NPWS)
Pore Spaces	Small air spaces occurring naturally in soil with a good structure. A compact soil will not have sufficient pore spaces for air and water to penetrate.
Propagule	Any part of a plant that is capable of growing independently from the parent plant, e.g., a seed, cutting, sections divided from a clump forming plant etc.
REF	Review of Environmental Factors - a type of environmental impact assessment.
Rehabilitation	According to the Macquarie Dictionary, the definition of rehabilitation is, *'to restore to a good condition, regenerate or alter to an improved form.'* In vegetation management literature, rehabilitation is generally understood to involve a process of introducing plants to a disturbed site with the aim of 'kick starting' natural processes so that eventually the nature should be able to take over and the site will start to function again like a natural ecosystem. E.g.; • the US EPA's *River Corridor and Wetland Restoration Program* define rehabilitation as, *'the manipulation of the physical, chemical, or biological characteristics of a site with the goal of reparing natural/historic functions (of degraded wetland).'* (ww.epa.gov/owow/wetlands/restore/defs.html) • the US Plant Conservation Alliance defines rehabilitation as, *'altering a degraded environment in order to improve ecological function'*. (www.nps.gov/plants/restore/library/glossary.html) • the US *Invaders of the Sonoran Desert Region* project of the Arizona-Sonora Desert Museum project defines rehabilitation as, *'the recovery of specific ecosystem services in a degraded ecosystem or habitat.'* (www.desertmuseum.org/invaders/invaders_glossary.php)
Restoration	A type of rehabilitation where the aim is to try and restore the area to its original, pre-disturbance, condition. In highly disturbed sites, restoration may not be possible, therefore the aim would generally be to rehabilitate the site using indigenous species, to allow natural processes to re-establish and return the site to a more natural type of environment, although not exactly what it would originally have been.
Revegetation	To stabilise a site using vegetation.
Sediment Fence	Term used to describe a fence-like structure designed to prevent the downslope movement of sediment.
Sediment Trap	Normally a pit or basin-like structure designed to catch run-off from a site and slow the movement of water enough for suspended sediment to settle.
SEE	Statement of Environmental Effects - a type of environmental impact assessment.
SEMP	Site Environmental Management Plan – a document detailing environmental safeguards to be used to protect a site during and after development.
Sod/Sodding	The term sod is applied to a square or chunk of material that is stripped from a site with vegetation, soil and roots all intact. Theoretically this material can be stored and later replanted on the site or transplanted to another location. In practice, however, it may be difficult to get native vegetation to re-establish from sods therefore special care is required to maximise the chances of success with this technique.
SRC	Sterile Rye Corn
SSNCF	Schedule 3 of the KNP Plan of Management – the Schedule of Significant Natural and Cultural Features
Stabilisation	Strategies designed to prevent a site from degrading, eg, using mulch, plants and other erosion and sediment controls to protect soil and prevent erosion and sedimentation.
TSC Act	Threatened Species Conservation Act, NSW 1995
Guidelines	This document.

Appendices

Appendix 1

Schedule of Contents, Intended Users and Review

SECTION	CONTENTS	INTENDED USER		REVIEW
		MANAGERS	WORKERS	
Part A	**Introduction, Background & Objectives**			
A.1	An introduction to the guidelines: Summarises the 'Keys to Successful Rehabilitation' and contains information about intended users and the area covered by the Guidelines.	☑	☑	Every 5 years
A.2	General information for managers on How to use the Guidelines – links closely with this appendix.	☑	☑	Every 5 years
A.3	*Alps in Context* - A short summary of the significance of Kosciuszko National Park and the reasons why rehabilitation is necessary.	☑	☑	Every 5 years
A.4	*Central Concepts of Rehabilitation* – Contains definitions of some of the central concepts of rehabilitation, including restoration, revegetation and landscaping, and suggests when each of these different approaches might be appropriate.	☑	☑	Every 5 years
A.5	*Knowledge, Skills and Responsibilities* – Details the skills and training requirements of rehabilitation managers and workers.	☑	☑	Every 5 years
Part B	**Planning for Rehabilitation**			
B.1	*Timing in the Rehabilitation Process* – Describes how timing, in particular natural time constraints, needs to be considered in planning for rehabilitation. Contains an indicative schedule of when different activities need to be undertaken for use in planning.	☑		Every 5 years
B.2	*Site Assessment for Rehabilitation* – Details the environmental factors that need to be considered in order to make judgements about rehabilitation techniques and species suited to the site.	☑		Every 5 years
B.3	*Rehabilitation Plan* – Details the issues that need to be considered in developing a rehabilitation plan.	☑		Every 5 years
Part C	**Rehabilitation Techniques**			
C.1	*Soil Management* – details techniques for managing soils to preserve fertility and prevent erosion.		☑	Every 5 years
C.2	*Preparing Plants for Rehabilitation* – provides information about acquisition of material for propagation (seed, cuttings etc.) and propagation – i.e. how to acquire material for rehabilitation.		☑	Every 5 years
C.3	*Plant Management and Planting* – information about quality control, transport and storage of plants, timing of planting, plant hygiene, planting and fertilizer application.		☑	Every 5 years
C.4	*Weed Control* – information about weed management with references to other weed management guidelines and resources.		☑	Every 5 years
C.5	*Protection and Maintenance of Rehabilitation* – details of tasks that need to be carried out after planting to ensure that rehabilitation is successful.		☑	Every 5 years
Glossary	Contains definitions of some of the main terminology used in rehabilitation.	☑	☑	Every 5 years

APPENDICES				
APPENDIX	CONTENTS	INTENDED USER		REVIEW
		MANAGERS	WORKERS	
1	Details contents, intended users and recommended review interval for Guidelines.	☑ DECC		When any sections altered
2 & 3	Proformas for use in preparing Site Assessments and Rehabilitation Plans and an example of a completed Site Assessment/Rehabilitation Plan.	☑		Every 5 years
4 - 8	A selection of case studies and more detailed discussions outlining examples of good rehabilitation. Includes: • Rehabilitation of Ski Runs • Use of Sterile Rye Corn • Rehabilitation in the Resort Villages • Walking Track Rehabilitation • Alpine Nursery Operation	☑	☑	Every 2-3 years to include updated case studies, information and experiences.
9 - 11	*Species Lists* - Lists of species indigenous to KNP which are recommended for rehabilitation at each of the resort areas. [Lists for the Perisher Range Resorts (App. 19), Thredbo/Bullocks Flat (App. 10) and Mt Selwyn (App. 11)]. Contains information on natural occurrence, propagation and use in rehabilitation.	☑	☑	Every 5 years - update based on monitoring and experience.
12	*Weed Information* - Information about key weed species affecting KNP.	☑	☑	Every 2-3 years
13 - 18	*Technical Specifications* – a collection of specifications detailing how to carry out some of the basic techniques of rehabilitation and soil preservation, including: • Simple soil testing procedures • Rehabilitation in Asset Protection Zones • Basic propagation methods • Checklist for quality control of tubestock • Monitoring techniques – photo points and LFA	☑	☑	Every 5 years
19	*Resource List* – a list of other resources that may be useful for rehabilitation.	☑	☑	Annually

Appendix 2

Site Assessment Proforma

Numbers in this text style refer to relevant sections of the *Guidelines*.

1. NAME OF SITE: _____

2. LOCATION: _____

_____

3. DATE OF ASSESSMENT: _____

4. ASSESSMENT COMPLETED BY (name): _____

5. LAND USE (section B.2.1)

5.1 Describe the current use of the site: _____

_____

5.2 What is the proposed/likely future use of the site? _____

_____

6. SITE CHARACTERISTICS (section B.2.2)

Attach a map/sketch of the site.

6.1 Altitude: _____

6.2 Aspect

What directions do different parts of the site face? Are they likely to be shadowed/windy/subject to snow build-up?

_____

6.3 Soil (section B.2.3, Appendix 13)

6.3.1 Depth/Condition of Topsoil (A13.2)**:** _____

6.3.2 Composition/Type (A13.3.I)**:** _____

6.3.3 Dispersibility (A13.3.II)**:** _____

6.3.4 Compaction (A13.3.III)**:** _____

6.3.5 Infiltration (A13.3.IV)**:** _____

6.3.6 pH (A13.3.V)**:** _____

6.3.7 Other features of the soil: _____

6.4 Slope angle: (measure with an inclinometer if possible, s. B.2.4)_____

6.5 Drainage (section B.2.4)

Describe drainage on the site – is it boggy/dry? Where does water run/accumulate?

_____

_____

6.6 Vegetation (section B.2.5)

6.6.1 General Vegetation Type/variations over the site: _____

_____

_____

6.6.2 Species List

Species	Abundance*

*Estimate number/proportion of site covered by the main species.

6.6.3 List of Weed Species Present*(section B.2.6)

Species	Abundance*

*Estimate number/proportion of site covered by the main species.

6.7 Is the site adjacent to a building or other asset vulnerable to bushfire? (s. B.2.7)

_____

6.8 Note threatened species or significant species: (section B.2.8)

_____

_____

6.9 Are there any other special features of the site? (section B.2.9)

Consider the visibility of the site, its historic or cultural significance etc.

_____

_____

_____

_____

_____

_____

_____

7. ATTACHMENTS

Attach photos and plans of the site, illustrating characteristics described, such as drainage, proximity to special features, existing/historical condition.

Sample Site Assessment

SITE ASSESSMENT - HOTHAM CHALET

Lot 1 Higgi Drive, Mt Hotham Alpine Resort - November 2004

1. Land Use

The Hotham Chalet is located on the corners of Higgi Drive and Lawlers Lane in the Mount Hotham Alpine Resort. It is a high profile, freehold site which is highly prominent when you drive through the Mount Hotham Alpine Resort. Improvements in both the infra-structure and the landscape of this site will add to the aesthetic and commercial value of both the Hotham Chalet proposed apartments and the Mount Hotham Alpine Resort.

Figure A Current condition – Hotham Chalet, November 2004.

2. Altitude, Aspect and Exposure

The site is located at an altitude of approximately 1820 metres above sea level. In general it has a northerly exposure, however the Chalet casts a shadow over the southern parts of the site, and the western side is also sheltered by a cutting. In general, the site is cold and exposed, however the northern part of the site would be somewhat warmer and dryer than other sides. Snow would be most likely to build up and persist on the southern and western sides of the site which are cool, shady and relatively sheltered from wind.

3. Soil

The current landscape condition of this site is poor. It has only a few remnant indigenous alpine shrubs to the rear of the building, which have managed to survive in rocky shale and little obvious soil. From a close observation of this site, it is apparent that there have been many disturbances to the soil in the past. All of the natural landscape qualities of this site have been lost.

4. Slope and Drainage

There is currently a drainage problem to the rear of the building resulting in pooling of water. If this site is to be rehabilitated successfully then the drainage problem must be ameliorated. A vehicular track to the rear of the Chalet contributes to drainage problems and needs to be closed for rehabilitation to be successful.

5. Vegetation Communities

The only indigenous vegetation present on site is located on a small slope to the rear of the Chalet. This is illustrated in figure B. These plants have probably colonised from a remnant local seed bank. They include one plant of the *Hovea* species, one *Ozothamnus* and one small Snow Gum.

Figure B Indigenous vegetation on a small slope to the south east of the Chalet.

Towards the front of the site, adjacent to the Lodge's rubbish hatch, is a small stand of Snow Gums on land is managed by the Mount Hotham Alpine Resort. They provide an example of the type of vegetation likely to have formerly existed on the Chalet site.

Vegetation on the site is highly disturbed and species currently present on this site are predominantly weeds. These are described below. Only about 5% of vegetation on the site is indigenous, including the following species:

- *Eucalyptus pauciflora* – Snow Gum
- *Grevillea australis* – Alpine Grevillea
- *Hovea montana* – Rusty Pods
- *Olearia phloggopappa var. flavescens* – Dusty Daisy Bush
- *Poa fawcettiae* – Snow Grass
- *Poa hothamensis* – Ledge Grass
- *Ozothamnus alpinus* – Alpine Everlasting

6. Weeds

As much as 95% of the site is covered with exotic species, including:

- *Achillea millifolium* – Milfoil
- *Agrostis capillaris* – Brown Top Bent Grass
- *Dactylis glomerata* – Cocksfoot
- *Holcus lanatus* – Yorkshire Fog
- *Hypocheris radicata* – Cats Ears
- *Phleum pratense* – Timothy Grass
- *Rumex acetosella* – Sheep Sorrell
- *Trifolium repens* subsp. *repens* –White Clover

7. Bushfire Protection Issues

The site is located adjacent to the Chalet, therefore bushfire protection needs to be considered in rehabilitation.

8. Threatened and Significant Features

The Hotham Chalet site is very close to Mount Higginbotham, which is a listed (EPBC Act 1999 and FFG Act 1988) *Burramys parvus* – Mountain Pygmy Possum habitat. This area is also known as habitat for Broad-toothed Rat and, possibly, the Alpine She-oak Skink. The Hotham Chalet site has no suitable habitat for these species but by rehabilitating this area with indigenous provenance based alpine plants, this area may eventually provide a small, habitable buffer zone between Mt Higginbotham and Higgi Drive.

9. Other Special Features

As this site is so prominent in the Mount Hotham Alpine Resort, it is important that it is rehabilitated with indigenous alpine species and attention to the aesthetic aspect of the site.

Appendix 3

Rehabilitation Plan Proforma and Checklist

Numbers in this text style refer to relevant sections of the *Guidelines*.

1. NAME OF SITE: _____

2. LOCATION: _____

_____

3. DATE OF PREPARATION:_____

4. PREPARED BY (name): _____

5. PRE-DEVELOPMENT PLANNING (section B.3.1)

5.1 Has a site assessment been completed?

Detail reference and where to acquire document (section B.2 & Appendix 2)

_____

_____

5.2 Has a Site Environmental Management Plan (SEMP) been completed?

Detail reference and where to acquire document (section B.3.1.3)

_____

_____

5.3 Describe the aim/objective of the rehabilitation: (section B.3.1.2)

_____

_____

_____

_____

_____

5.4 Detail staging of rehabilitation, including sequencing and timing of major events:

(section B.3.1.5)_____

_____

_____

_____

_____

5.5 Source of Material for Rehabilitation

5.5.1 List plants required for rehabilitation (section B.3.1.4)

Species	Sowing/Planting Rate	Quantity Required	Supplier	Collection/other details

5.5.2 List other materials required for rehabilitation (section B.3.3.1)

Include mulch, landscaping materials, tools, fencing etc.

Item	Quantity Required	Supplier	Collection/other details

5.6 Staff and Induction Matters (section B.3.1.6)

5.6.1 List human resources required for rehabilitation, their role and training requirements/experience:

Position	Role	Number of people	Training Requirements

5.6.2 Note matters that will covered during site induction for all people entering the site:

_____

_____

_____

_____

_____

_____

_____

_____

_____

6. PROTECTION OF RESOURCES AND VALUES DURING DEVELOPMENT (s B.3.2)

6.1 Weed Management (section B.3.2.1)

6.1.1 Does the site contain weeds that need to be managed prior to the works? If so, describe what species are present and how they will be managed:

_____

_____

_____

_____

_____

_____

_____

6.1.2 Describe measures that will be taken during the works to minimise potential for the transport of weeds or pathogens:

_____

_____

_____

_____

_____

_____

_____

6.2 Protection of Natural and Cultural Values (section B.3.2.2)

6.2.1 What natural/cultural values need to be protected at the site?

_____

_____

_____

6.2.2 How will these values be protected?

_____

_____

_____

6.3 Designated access and stockpiling arrangements (section B.3.2.3 & B.3.2.4)

If no SEMP has been prepared, or the SEMP does not adequately cover rehabilitation stage arrangements including stockpiling and access, attach a sketch of the site showing designated access and stockpile areas.

6.4 Earthworks (section B.3.2.5)

Detail any earthworks required for Rehabilitation or attach plans that show these works.

_____

_____

_____

6.5 Waste Management (section B.3.2.6)

Detail all waste that will be produced during rehabilitation and how it will be managed.

_____

_____

_____

_____

_____

_____

_____

_____

7. REHABILITATION (section B.3.3)

7.1 Extent of rehabilitation area (section B.3.3.2)

Attach a map/sketch of the site showing all areas requiring rehabilitation, proposed treatments and where sediment and erosion controls would be located (or refer to SEMP).

7.2 Site Preparation and Protection of Soils (section B.3.3.3)

7.2.1 How will the site be prepared for planting?

_____

_____

_____

_____

7.2.2 How will sediment and erosion controls be maintained?

Note who is responsible for maintenance and how often routine checks will take place.

_____

_____

7.2.3 How will bare ground be protected?

Include contingencies for extreme weather conditions/emergencies.

_____

_____

_____

7.2.4 What sort of mulch will be used?

Describe how the mulch is to be handled to ensure that it remains in place, and measures that will be taken to ensure that the mulch does not contribute to the introduction of weeds. Include a sketch if necessary

_____

_____

_____

_____

7.3 Planting (section B.3.3.4)

7.3.1 Layout and density of planting

Attach a map/sketch of the site showing where different species will be planted and indicating the density of planting (may be included in 6.1)

7.3.2 Use of Fertilisers

Will fertilizers be required? If so, detail what sort and how they will be applied.

_____

_____

7.4 Protection of the site (section B.3.3.5)

Detail how the site will be protected from grazing or other disturbance (wind, frost etc.) once planting has been completed.

_____

_____

8. POST- REHABILITATION (section B.3.4)

8.1 Maintenance of Rehabilitation (section B.3.4.1)

8.1.1 Who is responsible for maintaining the site?

_____

8.1.2 Maintenance tasks and frequency

Detail what will be checked during maintenance visits, required actions and frequency of visits

Task	Frequency

8.1.3 How long will maintenance be continued? _____

8.2 Monitoring (section B.3.4.2)

8.2.1 Monitoring tasks and frequency

Detail monitoring technique(s) used, responsibility and monitoring interval (frequency)

Task	Responsibility	Frequency

8.3 Auditing (section B.3.4.3)

8.3.1 Will the rehabilitation work be audited on completion? Yes No *(circle)*

8.3.2 Who is responsible for auditing? _____

8.4 Site Handover (section B.3.4.4)

8.4.1 Will handover be required? Yes No *(circle)*

8.4.2 Who will the site be handed-over to?

_____

8.4.2 When will handover occur?

_____

8.4.2 Detail matters that need to be considered in handover

_____

_____

_____

_____

Checklist

Does your Rehabilitation Plan contain the following essentials?

Has a site assessment been completed and consulted? ..... Yes No *(circle/strike out)*
Has a SEMP been completed and consulted? ..... Yes No
Are aims/objectives of rehabilitation stated? ..... Yes No
Is staging detailed, including sequencing and timing of main activities? ..... Yes No
Are details of required site preparation included, i.e.;

- Weed management ..... Yes No
- Designated storage, access and protection areas ..... Yes No
- Earthworks (ripping, shaping and grading, drainage) ..... Yes No
- Waste removal ..... Yes No

Are all required materials and equipment detailed and sourced, including;

- Fill, soil, compost ..... Yes No
- Plants/seed ..... Yes No
- Mulch/matting/mesh ..... Yes No
- Fertilizer/water saving granules ..... Yes No
- Plant protection ..... Yes No
- Earthmoving/ripping/shaping/drainage/auguring equipment ..... Yes No
- Hand tools ..... Yes No
- Water supply ..... Yes No
- Storage for equipment/materials/water supplies ..... Yes No

Is maintenance detailed? ..... Yes No
Is monitoring detailed? ..... Yes No
Are handover provisions detailed? ..... Yes No

Sample Rehabilitation Plan

REHABILITATION PLAN – HOTHAM CHALET

Lot 1 Higgi Drive, Mt Hotham Alpine Resort - November 2004

1 PRE-DEVELOPMENT PLANNING

1.1 Existing Documentation

A Site Assessment has been prepared for this project: SITE ASSESSMENT - HOTHAM CHALET, November 2004, located in Appendix 2

A SEMP has been prepared: XXX NAME & LOCATION XXX

1.2 Aims of Rehabilitation

Rehabilitation of this prominent site within Mt Hotham Village, will aim to use indigenous alpine species, while also creating an attractive landscape feature. The type of community appropriate to this site is a short alpine herbfield to the front and sides of the building, and a closed heath design on the small slope at the rear of the site. These will create an attractive feature as well as achieving effective rehabilitation of the site. The following photographs will give some idea as to what can be represented.

Figure A Short Alpine Herbfield – Bogong High Plains

Figure B Alpine Heathland – Mt Hotham

The site is located adjacent to Hotham Chalet, therefore it is important that it is rehabilitated in a way that will not contribute to a bushfire hazard. The use of low growing alpine species and grasses, which can be mown to maintain a low height and fuel loading close to the chalet, is appropriate for this site.

1.3 Staging

Redevelopment of the Hotham Chalet will not be completed before early April 2004. The rehabilitation needs to be completed by late April. The planting of tubestock in high altitude areas after April will often fail due to low soil temperatures. This site could be planted during spring as long as the soil is well protected over the winter and early spring period.

Maintenance will be carried out for at least 2 years from the completion of rehabilitation.

1.4 Sourcing of Plant Material

The tubestock used in this project needs to be grown from plant material that has been sourced from the Mt Hotham area. It needs to be grown by a reputable indigenous alpine plant producer and be of sufficient size and quality to successfully establish. A supplier should be contacted as soon as possible to allow time for material for propagation to be collected and cultivated. A list of potential supplies is provided below:

XXXXXXXX LIST DELETED FOR USE IN THIS EXAMPLE XXXXXXXX

All plants need to be grown in at least 7.5 cm pots with sufficient root and shoot growth. Plants that are small, diseased or pot bound will not succeed when planted in an alpine landscape. Plants in this size pot are recommended as they are physiologically dynamic, small enough to plant, but large enough to cope with transplant shock.

Recommended Species:

Forbs

- *Bracteantha subundulata* – Orange Everlasting
- *Celmisia pugioniformis* - Dagger Leaf Snow Daisy
- *Craspedia lamicola* – Billy Buttons
- *Craspedia maxgreyii* - Grey Leaf Craspedia
- *Cotula alpina* - Alpine Cotula
- *Helichrysum rutidolepis* - Pale Everlasting
- *Microseris lanceolata* - Native Dandelion
- *Leptorhynchus squamatus* – Scaly Buttons
- *Podolepis robusta* – Alpine Podolepis
- *Scleranthus biflorus* - Two flowered Knawel
- *Senecio pinnatifolius* – Alpine Groundsel
- *Stelleria pungens* - Prickly Starwort

Grasses

- *Poa fawcettiae* - Snow Grass
- *Poa hiemata* - Soft Snow Grass
- *Poa hothamensis* - Ledge Grass

Shrubs

- *Grevillea australis* – Alpine Grevillea
- *Grevillea victoriae* – Royal Grevillea
- *Hovea montana* – Rusty Pods
- *Olearia frostii* - Alpine Daisy Bush
- *Olearia phloggopappa var. flavescens* - Dusty Daisy Bush
- *Podocarpus lawrencei* - Mountain Plum Pine
- *Prostanthera cuneata* - Alpine Mint Bush
- *Tasmannia xerophila* - Alpine Pepper Bush

1.5 Other Material and Equipment Required

Other material and equipment required includes:

- Rakes, spades and trowels – three of each to be provided by contractor.
- XX bales of mulch, 1 roll each Jute mesh and geotextile, XX mesh anchoring pins, XXkg Osmacote, XX kg Dynamic Lifter – sourced from XXX.
- Electric fencing materials – sourced from XXX if there is evidence of grazing after planting completed.
- Water will be provided by existing hoses from the exterior of Hotham Chalet.

1.6 Human Resources

Table A details the roles and responsibilities of the works crew and project managers.

Table A Project Roles and Responsibilities

Task	Project Manager	Works Crew	Project Auditor
Oversee rehabilitation project; ensure that all works are completed as detailed in the Rehabilitation Plan.	Y		
Source seed and tubestock.	Y		
Quality control rehabilitation materials including plant stock.	Y		
Induct works crew.	Y		
Maintain erosion and sediment controls as per SEMP.		Y	
Prepare site for planting, including weed control.		Y	
Undertake planting.		Y	
Carry out follow-up maintenance including watering, weed control and maintenance of mulch and plant protection.		Y	
Replace failed plants if necessary.		Y	
Oversee ongoing maintenance and monitoring, including collecting and filing site information.	Y		
Audit rehabilitation 3 months after completion.			Y
Provide audit results to project manager.			Y
Act on audit outcomes.	Y		

1.7 Induction of Staff and Contractors

Prior to commencing work on the site, all staff and contractors must participate in induction. This will be co-ordinated by the Project Manager. Induction should include a discussion of all issues detailed in this Rehabilitation Plan.

2 PROTECTION OF RESOURCES AND VALUES DURING DEVELOPMENT

2.1 Weed Management

Prior to any rehabilitation of the surrounds of the Hotham Chalet site, the weeds must be managed. For successful establishment of indigenous alpine tubestock, weeds must be sprayed and/or removed. This should be carried out prior to construction on areas of the site where the soil will be removed, however, where the soil is not disturbed, it is recommended that weed control should be held back until the rehabilitation process can begin. This is because the weeds will offer some protection to the soil during construction. Care will need to be taken, however, to avoid spreading the weeds from this area back onto the site. Location of stockpiles in un-treated areas should be avoided.

When the new development is near to completion, then the site can be sprayed with herbicide. It is of particular importance to eradicate the *Achillea* and *Agrostis* species as these genera are highly rhizomatous and will colonise well after disturbance. A combination of glyphosate (e.g. Roundup™) and a wide spectrum broad leaf herbicide (such as Banvel™ or Amicide™) will give the best result for weed removal on this site.

2.2 Protection of Natural and Cultural Values

Recommended locations for erosion and sediment controls are designated in the project SEMP. Once the footprint of the new development has been established, access pathways have been designated and weeds have been controlled, then any remaining areas of bare soil should be mulched. Weed free straw is the recommended mulch for this site.

2.3 Designated Access

Vehicular access to the site should be confined to existing roads, including the drive way and carpark shown on the attached site plan, figure C.

Pedestrian access to all parts of the site to allow rehabilitation work to be completed is acceptable, however, preference should be given to walking over gravel or other hardened areas where this is possible. This will help to protect the soil from compaction.

After the work has been completed, pedestrian access should be confined to defined pathways.

2.4 Designated Stockpile/Storage Areas

Soil, mulch, plant stock and other materials should be stockpiled in the carpark area, shown on the attached site plan, figure C.

2.5 Earthworks

The extent and type of earthworks required are detailed in the construction plans, XXXLOCATIONXXX.

2.6 Waste Management

All soil will be reused on the site. No woody weeds require removal.

No rubbish is to be disposed of on site. All planting/construction waste is to be deposited in the rubbish skips located on site for removal to XX Waste Transfer Station.

3 REHABILITATION

3.1 Extent of Rehabilitation Area

The area to be rehabilitated is shown on the attached site plan, figure C. All disturbance must be confined to this area and designated access and stockpiling areas.

3.2 Site Preparation and Protection of Soils

3.2.1 Site Preparation

Prior to planting, the following steps are to be taken to prepare the site :

- Weeds are to be controlled:
- The site should be cultivated to break up compacted soil, particularly in areas that have been subject to regular vehicular and/or pedestrian traffic.
- Measures to improve drainage should be installed in wet areas, particularly the flat area at the back of the Chalet.
- Mulch should be spread over the site to protect the soil.

3.2.2 Maintenance of Erosion and Sediment Controls

All erosion and sediment controls should be regularly inspected to ensure that they are in effective working condition. Inspections should particularly be carried out after heavy rain or storms so that sediment traps can be cleared if necessary and damaged barriers can be repaired or replaced.

3.2.3 Management of Bare Ground

Once weeds have been eradicated, then all bare soil areas must be mulched as soon as possible. It is of particular importance, even if the site is not planted before the winter, that the area is mulched.

3.2.4 Mulch

Mulch will protect the soil from erosive processes, inhibit weed seed germination and will help improve the soil for planting in the following spring. If the site can be planted before the winter, it must be planted prior to April 30th as, after this time, the soil is liable to freeze and planted seedlings will not be able to establish.

3.2.5 Contingencies for Weather Conditions

Geotextile or sediment control fabric may be used for temporary protection of areas of bare ground, and stockpiles if required however, over the long term, the use of mulch is preferred as this helps to maintain soil health and fertility, whereas long-term use of geotextile may be messy and inhibit natural processes.

3.3 Planting Requirements

3.3.1 Layout and Density of Planting

To have a dramatic landscape effect, the flowering species need to be mass planted. The desired effect would be to have swathes of the same species planted in an area which merge into another species of a slightly different shade or height. The flowering species can be inter-planted with either Snow Grass or Soft Snow Grass. In time, the grasses will provide mulch to the planted areas and will soften the effect of the many flowering plants. A planting density of 5 to 7 seedlings per square metre of a mixture of grasses and forbs is required to achieve an immediate landscape effect.

Please refer to the landscape plan for the layout (Figure C).

The rear slope that peters down to a flat area needs to be heavily planted with shrubs to rehabilitate the slope. A combination of the shrub species listed is recommended for the sloped area. This can merge down into grasses on the flat section to the rear of the site. The grass species, *Poa fawcettiae* (Snow Grass) and *Poa hothamensis* (Ledge Grass) would be suitable. Shrub species should be planted at 3 plants per square metre and grasses at 5 plants per square metre.

As the area around Hotham Chalet will be accessed in non-snow times, it is important that properly constructed pathways are installed as part of the landscape design. 'Soft' paving materials are recommended, such as 'Lilydale' toppings or fine scoria rock. These can be rolled and compacted so that they are stable. These types of paving materials are more suited to an alpine area than a hard paving surface such as bricks because of frost heave. Soft pavers cope better with soil movement than hard pavers. The edge of the pathways should be contained using close growing vegetation. Using a definite edge looks harsh, is difficult to keep neat and will probably not stay defined after a winter. A mixture of *Poa* and forb species (particularly *Cotula alpina* and *Helichrysum rutidolepis*) are suitable for this purpose.

3.3.2 Fertilizer

As this site will have a proportion of its topsoil removed, it is recommended that a nutritional planting additive be used in the planting holes for each seedling. This will improve initial establishment and promote vigorous plant growth. Slow release fertilisers, such as Dynamic Lifter and 9 month – Osmocote, mixed in with the planting soil is recommended.

3.4 Protection of Rehabilitation

Initial monitoring is required. Once the site has been planted out, should there be evidence of grazing a low, two strand 12 volt electric fence will be used to protect the seedlings. This fencing would be maintained until plants are well established.

4 POST REHABILITATION

4.1 Maintenance of Rehabilitation

Once the rehabilitation/landscaping of Hotham Chalet site has been completed, it is important that the work is maintained. It is inevitable that some level of mortality will occur with the planted seedlings. Follow-up work should include:

- Regular watering during dry periods;
- A replacement planting follow-up program, about a year after the initial planting;
- Follow-up weed control; if invasive weeds such as Milfoil are allowed to re-establish the landscape work will fail. Weed species can be sprayed with herbicide if not too near the planted seedlings, but otherwise, they will need to be hand removed. After a few years of diligent maintenance, native plants should be able to out-compete the weed species and this area can become a relatively sustainable landscape that is sympathetic to its surrounds.
- Re-mulching of any bare areas is also recommended on an annual basis.

4.2 Monitoring of Rehabilitation

Since the site would be planted in April, it is recommended that monitoring of the site is carried out within one week of planting, and thereafter, on an annual basis. This will ensure that, if required, follow-up work will be identified and completed, and the long term success of the rehabilitation work will be better assured.

4.3 Auditing

It is recommended that the Management of Hotham Chalet audit the rehabilitation work twice: once on completion of the initial planting and mulching, and a second time one year later, to ensure that follow-up work has been adequately completed.

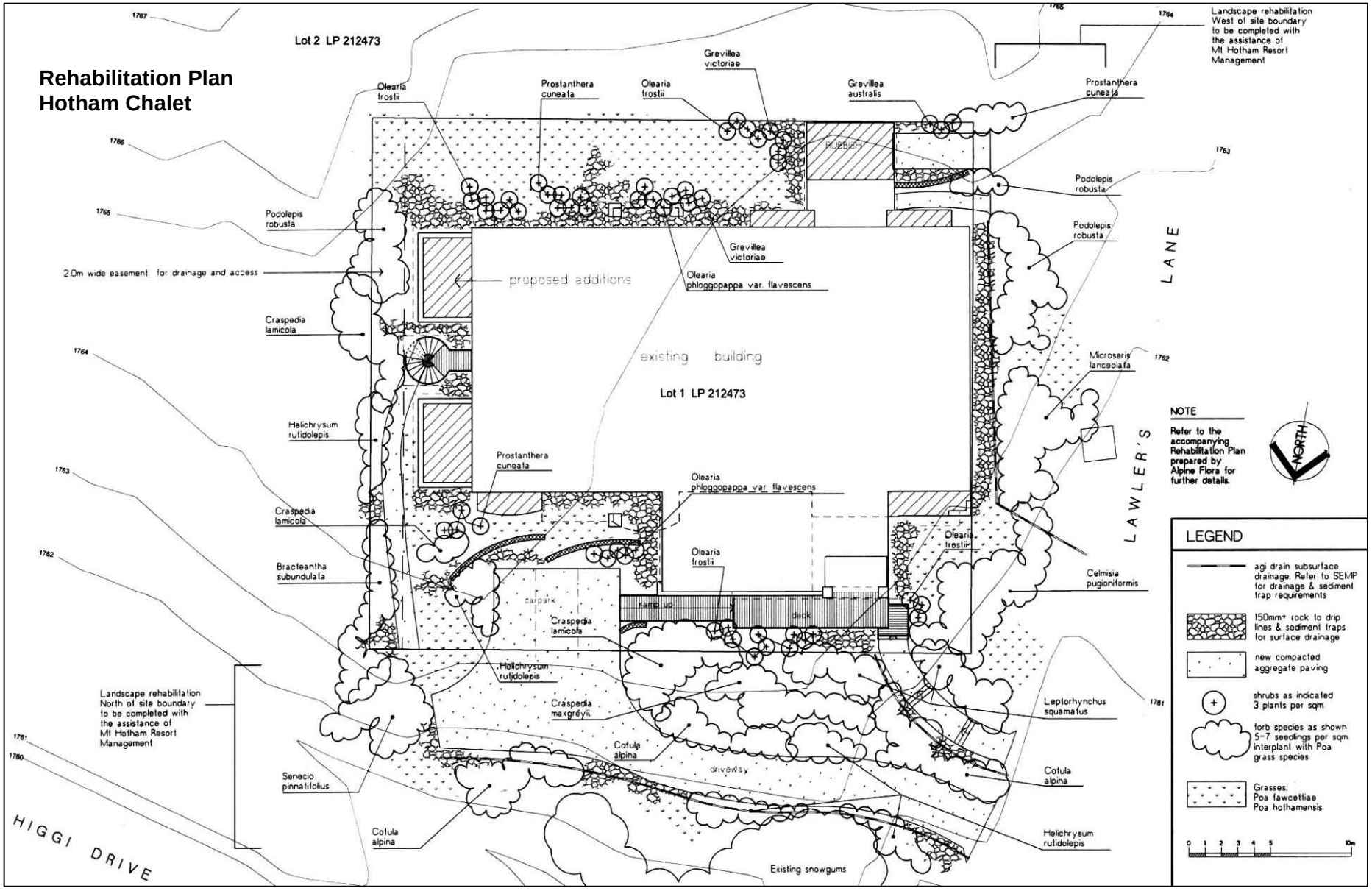
If the rehabilitation of the site is inadequate then a contingency plan needs to be provided to resort management. Failure to effectively rehabilitate may contravene lease compliance.

4.4 Handover

Site handover will take place once planting is completed. Hothan Chalet management will be responsible for maintenance and monitoring. They will be made aware of the relevant requirements of this Rehabilitation Plan.

Photos in this section courtesy E. MacPhee.

Figure C Site plan



Appendix 4
Rehabilitation of Ski Runs

A4.1 Introduction

Management of ski slopes is a major component of the rehabilitation work that has been undertaken in the resort areas. Various methods have been trialled for rehabilitation of ski slopes including use of different species of exotic grasses, native grasses and native shrubs. An overview of the main issues concerning these different approaches, based on experience within the resort areas, is presented below.

A4.2 Use of exotic vs. indigenous grasses

A trial of the use of Chewings Fescue vs Poa was undertaken on the Rollercoaster ski run at Perisher Blue was undertaken during the 1990s. In March 1993 the middle and bottom sections of the Rollercoaster were sown with *Poa* at 15g/m^2 (over re-spread topsoil), while the lower section was sown with Chewings Fescue. Coverage by the Fescue was poor and, in 1994 the area was dug up and re-sown, again with Fescue. The two areas are compared in Figures A4.2.1 and A4.2.2. Figure A4.2.3 shows the area sown with *Poa* more recently, while Figure A4.2.4 shows a site on the Accelerator ski run that was sown with Fescue about 4 years ago.

Figure A4.2.1 Planting of Chewings Fescue, showing low biomass levels, on the lower section of the Rollercoaster.

Photo: Wawick Papst

Figure A4.2.2 Section of the Rollercoaster rehabilitated with Poa. Note the much higher level of biomass in the *Poa*, compared with the Fescue, which provides robust protection of soil.

Photo: Wawick Papst

Figure A4.2.3 A recent photo of the section of the Rollercoaster rehabilitated with *Poa*. Note the level of regeneration of native shrubs which help to provide robust, permanent cover while being low growing enough not to impact on the quality of the ski slope.

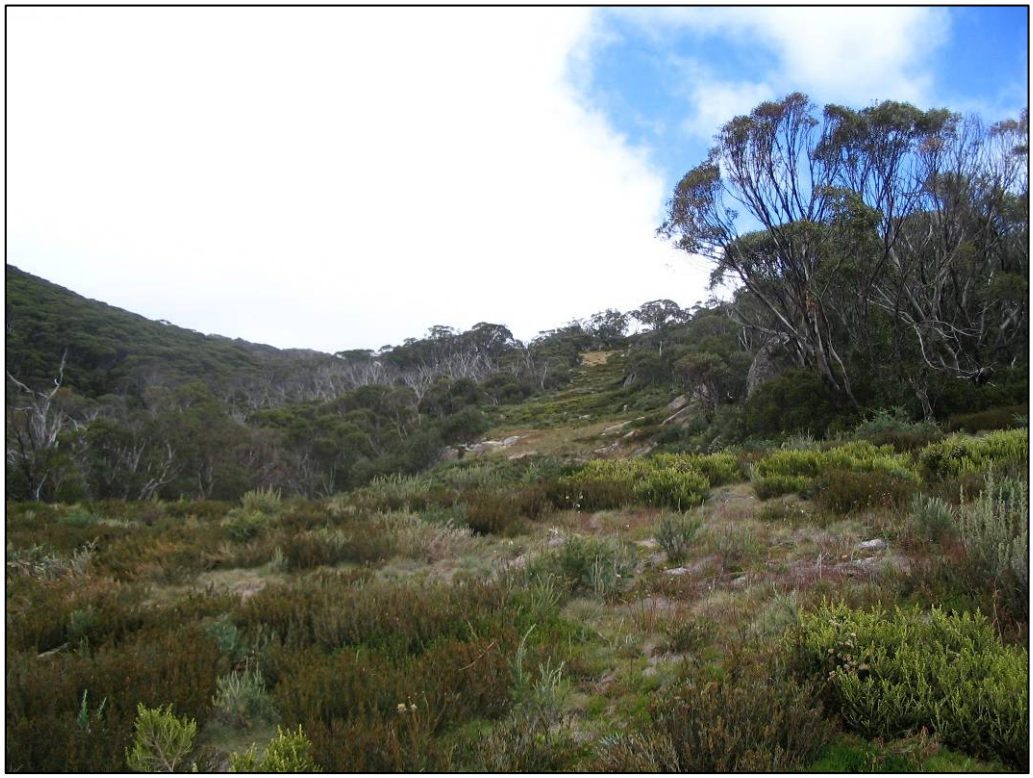


Photo: Elizabeth MacPhee

Figure A4.2.4 Accelerator ski run – a site sown with Fescue in c. 2003. Again the relatively poor coverage of the ground and low levels of biomass are obvious when compared with the sites sown with *Poa*.

Photo: Elizabeth MacPhee

From the above photos it is clear that the amount of biomass generated by *Poa,* is much greater than occurs in areas sown with Fescue, providing much better protection of soil and potential for regeneration of shrubs. It also appears that areas rehabilitated with native species are much more resilient and long lasting than areas where exotic grass has been used.

A4.3 Use of shrubs on ski slopes

Many native shrubs are low growing, tough and wiry, and have strong root systems that bind soils and contribute to the health of micro-organisms. A shrub layer more than 20 centimetres high also provides valuable habitat for native fauna such as Mountain Pygmy Possums and Broad-toothed Rats. These species benefit from the shelter offered by the shrubs, which allow them greater freedom of movement across ski runs.

Shrubs (and also native grasses) can also help retain snow cover by creating a layer of air between the soil and snow. This helps maintain constant temperatures and protect the snow from meltwater. Without the air layer, the meltwater would have a higher latent heat than the snow, thus it would hasten thawing. The constant temperatures created by the trapped air layer also contribute to the health of the soil.

Generally the tough, low growing alpine shrubs are considered hardy enough to withstand ski slope management activities without interfering with the effectiveness of slope management. Figure A4.3.1 is another recent photo of the area regenerated with *Poa* on the Rollercoaster which highlights the range and density of shrubs that have successfully colonised the area rehabilitated with *Poa.* It is clear that this area should pose no problems for slope management.

Figure A4.3.1 Recent photo of shrub colonisation of the section of the Rollercoaster rehabilitated with *Poa*.

Photo: Elizabeth MacPhee

Appendix 5
Use of Sterile Rye Corn

A5.1 Introduction

Interest in the use of Sterile Rye Corn (SRC) as a substitute for more invasive species such as Chewings Fescue has increased over recent years. Although the use of SRC is a new and developing technique, some of the possible advantages of SRC include the following:

i) SRC is capable of rapidly producing a good cover crop with a large amount of biomass above and below ground, which is valuable in protecting soils from erosion. It is a very effective soil stabiliser.

ii) It germinates readily in a range of conditions.

iii) SRC is thought to be allelopathic to many weeds and appears to reduce the potential for weeds (particularly grasses) to become established on sites where it has been used.

iv) SRC is an annual species, so it dies back after a year, reducing the possibility of it becoming invasive, whilst leaving large quantities of weed-free mulch to protect the soil and encourage micro-organism activity.

v) The majority of plants are sterile, so they don't produce seed, reducing the potential that the species would become invasive.

Like Fescue, the biomass and effectiveness of SRC diminishes over time, therefore, use of SRC should be seen as a two stage process. In the first stage, planting the SRC provides rapid cover and stabilises the soil. In the second stage, as the SRC starts to die down, native plants need to be established for permanent rehabilitation. As few serious trials of SRC have been carried out to date, little information about the use of SRC in the alpine areas is currently available, however, several trial which should be watched are described below, followed by best practice guidelines on the use of SRC, as currently understood.

A5.2 Trials of Sterile Rye Corn in Kosciuszko National Park

SRC is a new and developing technique. Recently a number of trials have been carried out in different locations within KNP. These should be monitored over the longer term in order to allow key issues to be identified and lessons to be learned on the use of SRC. Trial sites that should be monitored include:

i. Excelerator Ski Run: Perisher Blue have trialled the use of SRC on Excelerator over the last year. Four monitoring sites have been established on at the site, from which further information should be available in the future. At present, concerns have been raised that the SRC did not did not last long enough to allow natives to establish, therefore follow-up planting may be required.

ii. Tube Town: Tube Town is located at the base of Mt Piper and has also been the site of recent SRC trials carried out by Perisher Blue. This site is less steep than the Excelerator ski run and trials currently look more promising.

iii. Former Snowy Hydro sites: Trials undertaken at Former Snowy Significant Sites (FSSS) at Yarrangobilly, Tantangara spoil dump and T2 Dogleg were carried out by the DEC on highly disturbed sites. Most sites were located on poor soil or rock spoil. The altitude at the sites ranged up to 1400m.

    The trials resulted in a high rate of germination of SRC, occurring between 3 to 5 days after planting. Germination also occurred on rock spoil, although this was not as robust as on soil. The SRC appeared to suppress weed growth, particularly grasses, although

Bokhara clover occurred at one site. It is possible that hard seeded weed species like clover are less affected by the allelopathic effects of SRC.

Now that the SRC has senesced (matured and died back), the thick cover continues to stabilise the slopes (refer to Figures A5.2.1 and A5.2.3). It is planned that over-planting with natives will be undertaken during April.

Figure A5.2.1 Sterile Rye Corn on the T2 Dogleg former Snowy site – Early February 2006. Foreground areas were located on thin soil, rear areas on rock spoil.

Figure A5.2.2 Sterile Rye Corn at the Dogleg site – after senescence, April 2006.

It is recommended that longer term monitoring of the trials outlined above should be undertaken to build up a knowledge base about the potential application of SRC within the park.

A5.3 Best Practice use of Sterile Rye Corn

Based on current experience with the use of Sterile Rye Corn in alpine areas, the following points have been assembled to give an indication of current best practice in the use of SRC in KNP.

i) SRC needs to be used in conjunction with native seed and tubestock so that, once it dies down, the native plants will be able to provide permanent cover. After the first year or two, the site should be over-seeded with understorey species to achieve a more natural and stable effect.

ii) Care needs to be exercised in selecting appropriate native species for use with SRC. Preference should be given to strong growing, dominant species.

iii) Weed control and mulching should be continued for one to two years after the SRC dies down.

Appendix 6

Rehabilitation in the Resort Villages

A6.1 Introduction

Two examples of rehabilitation within Victorian alpine resort villages have been included in these Guidelines. These include:

- proposed additions to Hotham Chalet, at Mt Hotham (included as an example in Appendices 2 and 3); and
- rehabilitation associated with construction of new apartments at Ropers Apartments, in Pretty Valley (attached to this Appendix).

Although each project was a little different, several key stages of the works at both sites are relevant to similar projects within other resort areas. These are described below, followed by a summary of some of the typical characteristics of rehabilitation sites within resort villages.

Many resort areas, particularly the Perisher Range resorts, are located within valleys and in close proximity to areas of bog or wetland. Bogs are sensitive ecosystems that are easily damaged and very difficult to rehabilitate effectively. As a result, it is strongly recommended that development proposals avoid impacting on bogs. Large areas of bog within KNP have, however, already been disturbed. The results of disturbance generally include loss of vegetation diversity and altered hydrology. Typically disturbance leads to more rapid run-off and channelling of water, causing bogs to dry out and downstream flows to become more seasonal (refer to section A.3 for more information about the important role of bogs in acting as reservoirs for south-eastern Australia).

Because of the hydrological and biological significance of bogs and the frequent occurrence of disturbed bogs in the resort areas, there may be occasions when bog restoration can be included in rehabilitation proposals. The Ropers Appartments case study includes a plan for rehabilitation of an area of bog. Significant aspects of this have also been highlighted as a general guideline below. It is strongly recommended, however, that, if bog rehabilitation is proposed, specialist advice should be sought.

A6.2 Key aspects of work undertaken at Hotham Chalet and Ropers Appartments

Key aspects of rehabilitation work undertaken at Hotham Chalet and Ropers Appartments included:

vi) Weed control: Resort areas are often weedy. Weed control at both sites was commenced prior to the construction works commencing and followed-up during and following rehabilitation. Important aspects of weed control included:

- Removal of the top 10 cm of soil in particularly weedy areas (refer below to comments regarding soil quality);
- Not commencing weed control in areas where construction-related disturbance would not occur, until after construction was completed. This was to maintain some vegetation cover to protect the soil during construction. Care would, however, need to be taken with this technique, to ensure that potential for the weeds to disperse back onto the site or elsewhere, was minimised; and
- Particular emphasis was placed on control of rhizomatous species such as *Achillea* (Yarrow) and *Agrostis* (Bent Grass), as these spread rapidly after disturbance.

vii) Soils were protected during construction and rehabilitation, according to prescriptions detailed in SEMPs for each site. Important aspects of soil management included:

- Storage of soil stockpiles in weed-free, protected locations.
- Mulching of all bare soil.
- At both sites soils had been disturbed previously and were compact and lacking in structure and topsoil availability. Generally construction activity would result in ripping up and re-spreading of soil, however, in areas that were not ripped, cultivation would be necessary.
- Where removal of topsoil was recommended, the addition of fertiliser and organic matter (e.g. Copra Peat) to the planting hole was recommended.

viii) Installation of appropriate drainage was recommended.

ix) Construction of formal pathways, was recommended, were required.

x) With regard to planting, emphasis was placed on:

- Sourcing plants and quality control of tube-stock;
- Use of indigenous species;
- Preference for hardy, fast-growing species, where appropriate, to provide rapid cover;
- Use of species that would give a pleasing visual effect (including mass planting of species to produce swathes of colour);
- Inter-planting of flowering forbs and grasses, planted at a high density (5-7 plants per square metre) to achieve an immediate landscape effect); and
- Planting at higher densities on slopes.

xi) Ongoing post-rehabilitation maintenance of sites was recommended, including watering, weed control, re-mulching and protecting sites until rehabilitation was well established and self-supporting.

A6.3 Typical charactaristics of rehabilitation sites within resort villages

As highlighted in the Ropers Apartments and Hotham Chalet case studies, a range of factors typical of resort areas need to be considered when planning rehabilitation in these areas. Some of the major factors that need to be considered are listed below:

- Areas requiring rehabilitation are typically very disturbed, with disturbance including poor soil (topsoil is often either absent or mixed with other soil layers), little indigenous vegetation and the presence of weeds.
- Many of the resort areas are adjacent to bogs or other sensitive areas that need to be protected.
- Areas adjacent to buildings are often subject to heavy use. Rehabilitation or landscape planning should attempt to identify routes that are likely to be used for access to the building or service points around the building and provide appropriate surfaces. For heavily used routes hardened surfaces would be required, while for occasional access to services grassed areas would be reasonably resilient and provide space for equipment to be laid down if necessary.
- Areas adjacent to hardened surfaces, below cuttings and adjacent to buildings are often poorly drained, while other areas may be very dry. Rehabilitation planning needs to take into consideration these areas and improve drainage, where possible, or ensure that species that can tolerate these areas are used.
- Bushfire protection is an important consideration in carrying out rehabilitation adjacent to lodges, public buildings and other important assets.
- Aesthetics are also an important consideration, therefore a landscaping approach may be more relevant than attempting to rehabilitate or restore the native character of the vegetation. Landscaping should, however, consider the use of locally indigenous

species that reflect an appropriate type of community (i.e. a community that will be able to survive on the site and, preferably, reflects the kind of community that would naturally occur at the site).

- Opportunities to create fauna habitat could be considered, e.g. use of rock and heath species near waterways or wet areas may create Broad-toothed Rat habitat.

A6.4 Special aspects of bog rehabilitation at Ropers Appartments

An important aspect of the Ropers Apartments case study was the inclusion of an adjacent area of bog in the rehabilitation plan. It should be noted that this area of bog was degraded prior to any works taking place, not degraded due to the works themselves. The bog restoration could, therefore, be seen as an offset for other impacts resulting from the works.

Specialist advice should be sought if bog rehabilitation is to be attempted, however, because opportunities for bog rehabilitation around the resort areas may arise, some of the key aspects of bog rehabilitation at Ropers Apartments are described below.

Key aspects of bog rehabilitation include:

- A long term commitment and on-going maintenance;
- Ensuring that hydrology is correct; flows need to be slow moving, steady and spread out over the area of the bog (not channelled);

- Bogs are vulnerable to weed infestation; weed species need to be filtered from water and managed continually during the entire period it will take for the bog to re-establish;
- Many bog plants are difficult to propagate and very slow growing, therefore preparation of stock has to commence well in advance. Specialist nursery assistance is likely to be required.

Note: It is generally recommended that any kind of impact on bogs is avoided due to the level of commitment and complexities involved in bog rehabilitation.

Attachment A6 Rehabilitation Plan for Ropers Appartments

Ropers Apartments
at Pretty Valley Lodge

Site 39 Slalom Street
Falls Creek

Site Rehabilitation Plan - Spring 2004

This rehabilitation plan is comprehensive to the Pretty Valley lodge site and only includes the development of Buildings A and B. It is highly likely, however, that Buildings C, D, E and F will be constructed in the future. A separate rehabilitation plan will be done for the area that these buildings will affect when required.

Introduction

Ropers Apartments at Pretty Valley have been in conceptual form for some years. In 2001, environmental assessments were done on the site by various contractors, including a vegetation assessment by Ecology Australia, a landscape concept report by Mexted Rimmer Associates and a waterway management plan by Neil M Craigie Pty Ltd. All these documents will be presented with the rehabilitation plan as appendices.

The aim of this plan is to incorporate all of the above documents to produce a meaningful and prescriptive plan, which can be followed by the architect, the construction team and the landscape team.

Landscape Features

The area adjacent to the Pretty Valley Lodge is highly disturbed with about half remnant native vegetation present. The remaining vegetation is composed of a variety of mostly invasive, woody and herbaceous weeds. (See Vegetation Assessment for Pretty Valley Lodge Redevelopment – Ecology Australia 2001)

The most important feature associated with this site is the alpine moss-bed on the western side of the site. This type of ecological community is protected in the *Flora and Fauna Guarantee Act* 1988 and must not be disturbed or built upon in the future. It is currently in a degraded state and this development is an excellent opportunity to improve its condition and eventually restore it to a functional moss-bed with Sphagnum moss hummocks present.

Another important feature of this site is the presence of mature Snow Gums (*Eucalyptus pauciflora ssp. hedraia*). This subspecies is listed as vulnerable and is localised to the Bogong High Plains. It has much to offer aesthetically in landscape quality with both form and attractive coloured bark. It is vital that as many of these trees are retained and protected from development as they are very slow to grow and seedlings of these plants do not provide the same effect as mature trees.

The single plant of Snow Speedwell *(Derwentia nivea*) is another important feature of this site. This is a declared rare plant nationally and must be protected. If this plant is to be disturbed during the development it must be relocated by a professional horticulturist and nurtured until re-established.

Site Condition 2004

The Pretty Valley site had a thorough vegetation assessment done in 2001 by Ecology Australia. (See attached documentation). The site in 2004 is in a very similar condition as this assessment, however some aspects are altered. Barry Jones, the leasee has planted in excess of 100 Snow Gum seedlings around the site in 2002/03. Some have been planted where the new buildings are to be constructed and need to be transplanted. In time these will add to the landscape features of the site.

Of particular note at this site is the presence of woody weeds, namely *Cytisus scoparius* (English Broom) and *Salix cinera* (Grey Willow). Both of these species have invaded the surrounding Alpine National Park and have the potential to become monocultural in the Park, particularly after the 2003 fires. A large amount of money and time is being spent by Parks Victoria to control these weeds. It is absolutely essential that any individuals of these species are completely removed from the site. *Juncus effusus* (Soft Rush) is a significant weed of alpine moss-beds, with the potential to invade and dominate wetlands. This weed must also be eradicated.

In general, this site does have a very large amount of weed seed present in the soil. The control of weeds will be an ongoing process well after the development and rehabilitation is complete. It is important that follow up weed control is done on this site for at least five years so that indigenous vegetation can re-establish.

Pre-Development Requirements

Before a single sod has been dug for this development a number of documents have to be approved by the relevant authorities and then followed by the contracted developers. There are a Site Environmental Management Plan (SEMP) which should have a project description, management and induction guidelines, monitoring requirements, site environmental values, construction impact management, including storm-water, surface treatments, native vegetation management and so on. Some of the information that is required for the completion in the SEMP is in this document and should be referred to where relevant.

The other important document is this one, the Site Rehabilitation Plan. This plan will divide the site into sections with species identified and a prescription for rehabilitation formulated for each section.

As the construction of the new buildings is proposed to begin in spring 2004, it would be sound practice to also begin the weed eradication program in spring 2004. All woody weeds need to be physically removed. Herbaceous weeds can

be sprayed with glyphosate and a surfactant. If herbaceous weeds are intermingled with indigenous species, an attempt should be made to remove the native plants and either replant them in an area that will not be further disturbed or alternatively potted up and stored under nursery conditions until required for replanting. Soft Rush (*Juncus effusus*) in the bog system can be sprayed with BioActive Roundup. All spraying must be done by a person trained in herbicide use, with good plant identification skills. Once weeds have senesced, mulching with a weed free material is recommended.

Alpine Bog Rehabilitation Requirements

The report by Ecology Australia 2001 deems that bog restoration is impossible. I dispute this statement. If the hydrology of the bog system is correct, that is, if water flows are maintained, weed seed filtered out of water flows and the water is slowed and spread to support indigenous vegetation, then restoration is feasible. Other important issues in restoring this moss-bed are the thorough removal of all the weed species and the replanting of a variety of indigenous moss bed species. Long term maintenance will be required as well as support from the FCRMB to ensure that this bog system will be restored.

Hydrological Aspects

Once the hydrology of an alpine moss-bed is altered and free running water is in the system it will continue to degrade until this aspect is altered. This is the basic hydrological problem with the Pretty Valley site bog system. The report by Neil M. Craigie, Waterway Management Consultants produced in 2001, lists the physical condition of the bog system and is still relevant in 2004. I will list the issues the report identifies and recommend solutions.

- Problem(s)

Significant erosion problems at the Slalom Street end due to high velocity water exiting and dropping from the road culvert causing incised channels.
Extensive sediment deposition at the Slalom Street end and further downstream into the bog system.

- Solution(s)

The water discharge from the culvert has to be slowed and filtered to enter the Pretty Valley site. This is primarily the responsibility of the FCRMB. Where the culvert discharges from the road onto this site, a cleanable sediment basin with multiple dispersal pipes into the soil profile would be suitable. A series of gross pollutant traps should also be part of this system, which capture large amounts of sediment, rubbish and weed seed. The water can then be filtered through a series of rock pits. This is the best way to slow, disperse and clean culvert discharges.
Once the water being introduced into the site has been slowed and modified, the repair of the incised channels is relatively simple. The incised channels need to have weirs installed at the points where the water has the most erosive energy. This takes a trained person (such as myself) who understands the morphology of the landscape The weirs need to be closer together where the ground is steep and the depth of the weirs will vary according to the entrenchment. Weirs can be made from local rock and silt mat or from rolled

hessian bags wrapped in silt matting and then pinned in. This effectively collects the fines that are dispersed from the drainage line, fills in the channelling and provides a substrate for indigenous wetland species to re-establish.

- Problem(s)

Erosion occurring at the end of the bog system due to earthworks and drainage construction immediately downstream in the carpark. Erosion is also occurring at an artificial drain cut as the outlet under the vehicle track at the rear of the Rubbish Collection building. This drain links into the drainage line above the carpark adding to the overall erosion problems on the lower part of the site.

- Solution(s)

Initially the site needs to be thoroughly inspected after the sediment basin has been installed below the Slalom Street culvert to see if the high water flows have diminished through the system. Concurrently the drainage construction of the carpark needs to be assessed to see whether any earthworks can be done to correct the effects of the lower drain. The placement of weirs above this drain should help in reducing the water flows and decrease erosive processes. The outflows from the drain near the Rubbish Collection building will either need one or two small sediment basins installed and large and small rocks spread at the outflow zone to disperse the waters energy. This should address the erosivity of the water and in time some native plants such as *Carex appressa* can re-establish.

- Problem

The easterly and westerly edge of the bog system have been artificially confined by earthworks and building construction. Spoil from the construction of the Pretty Valley Lodge is spread along the edges of the bog. These margins also have evidence of scouring from concentrated water flows.

- Solution

If the flows into this bog system are slowed and spread (see the first solution), then much of the scouring from high water flows will not occur. The placement of weirs in strategic positions throughout the bog system will also stop scouring. Water from the bog system is currently spreading into the Snow Gum woodland area and needs to be diverted back into the wetland system. The placement of weirs in appropriate places will address this problem.

The placement of building spoils along the edge of the bog system was very bad practice and must not occur again. Not only does it create a distinctive barrier to for the flow of water in and around the bog, building spoils are commonly of a basic pH. Alpine bog systems are strongly acidic, with indigenous wetland species requiring a pH of around 4.5 to 5. If the pH is altered enough this will further encourage the growth of weedy exotic species. The edges of the bog system on this site must be less defined where the different types of plant communities merge into one another. Earthworks may be required, manually or with a small bob-cat to either remove these building spoils or ameliorate them into the landscape.

To ensure that the construction works on the site do not affect the bog system further, the area will be fenced off in October 2004 with a silt mat fence that is partially dug into the soil profile to protect it from further degradation.

Other hydrological impacts, such as to the existing lodge, for this development are tabled in the Neil M. Craigie 2001 report and should be included in the SEMP.

Plant Management – Alpine Bog System

This plan recommends that the removal of weeds from the bog system begins in the summer of 2004. Hopefully this will be concurrent with the installation of the sediment basin on Slalom Street so that weed seed infiltration is reduced. Once the weeds have been removed and or sprayed a more thorough assessment of the placement of weirs and the extent of planting required will be done. It is important that a weed management program is followed throughout the site, but particularly for the bog system if it is to be restored to a healthy state.
As stated by the Ecology Australia 2001 report, the bog predominantly needs the structural dominants re-introduced, such as *Baeckea gunnianna, Epacris paludosa* and *Callistemon pityoides*. Other species that may be useful as they have the ability to behave like natural weirs in time are *Carex appressa* and *Carex guadichaudiaina*. Shrubs will need to be intensively planted at about 3 per square metre. The *Carex* spp can be heavily planted behind artificial weirs at about 10 per square metre.

Adjacent to the bog directly up from the rubbish collection building, the planting of *Acacia obliquinervia* (Hickory Wattle) is recommended along that service road. This will hide the industrial look of the Oversnow and rubbish collection buildings.

The propagation of the woody species of the moss-bed has been initiated by Liz MacPhee of Alpine Flora. Due to the difficulties and slow growth rates associated with producing these species, they will not be available for planting until spring 2005. Other species required for the bog restoration work will be scheduled so that the planting can be done at the one time.

Once the hydrology, weeds, and sediment in-flows have been corrected, part of the management of this bog will be to re-introduce Sphagnum moss. This will only be possible once the woody dominants are established, to provide both support and shade for moss growth.

Ultimately, in time with comprehensive rehabilitation, and a thorough maintenance program the moss- bed will be effectively restored to a healthy ecological community.

Site Rehabilitation Prescription

Outside of the bog community, the rest of this site needs a prescriptive rehabilitation program that will identify sections of the site and what needs to be done to achieve successful rehabilitation.

Mexted Rimmer has generated a conceptual landscape plan (see Appendices) which this plan will generally follow in regard to species. However, this plan will also provide a process by which the rehabilitation and/or landscaping can be done.

As previously mentioned a person trained in herbicide application, with good knowledge of indigenous and weed species needs to do a thorough spray of weeds in the spring of 2004. This will by no means solve the weed problem of this site, but will enable the rehabilitation needs of the site to become clearer. Without suitable weed control, any disturbance of the soil which is inevitable when constructing buildings, will only further promote the spread of weeds. Weeds and the loss of topsoil are the greatest difficulties in achieving rehabilitation/landscaping outcomes using indigenous species.
The removal of any existing exotic mature trees is also highly recommended. Two large Lodgepole Pines (*Pinus contorta*) grow adjacent to the existing lodge. Whilst these trees have some landscape quality, the fact that they are trees from a northern European landscape and detract from the aesthetic beauty of Snow Gums and the overall effect that this landscaping/rehabilitation plan would like to achieve. From an environmental point of view, Lodgepole Pines are an invasive woody weed that has been targeted by Parks Victoria for removal in the surrounding Alpine National Park.

Top soil that is dug up during construction must be stored in a suitable area either close to, or on the site. A reasonably flat area with weed free straw or weed mat covering the area to store the soil is recommended. Any obvious weed species should be removed from sods or soil manually if possible.

There is a small outlet pipe on the eastern side of the site, which emerges from the decking around the pool. The out flow is straight onto vegetation with no attempt to incorporate the water into the soil profile. There is also a lot of *Juncus effusus* (Soft Rush) established in the out flow area. This is probably a direct result of the high amount water in this area. The pipe either needs to be extended further down the slope and put underground, or this water redirected into a proper storm-water out flow system.

Another important factor in achieving successful rehabilitation is the designation of pathways for both vehicle and pedestrian access. The SEMP discusses this issue and needs to be followed. Auditing of the site by a relevant authority is recommended once the construction of Buildings A and B has commenced.

Planting Details

As this site has someone in residence most of the year and watering of tube-stock can be done over the summer, planting times are not so critical. Generally, though, planting of alpine areas is the most successful from the middle of October to the middle of December or from the middle of March until the end of April. Planting in May is not advisable as the ground can freeze at this time of the year and tube-stock will not establish.

Tube-stock to be planted will need to be hardened off at high altitude. This can be done on-site if the plants can be watered every two to three days.

The use of a small amount of pelletised chicken manure and slow release fertiliser mixed with the planting soil can help plants establish. It is important that the fertilisers are not placed directly upon the roots at planting and that weeds have been eradicated. The use of fertilisers to improve planting success is not recommended where large amounts of weeds occur as the weeds will preferentially take up the fertiliser over the native species.

The planting density varies according to the numbers of plants available, the types of plants to be planted and the site requirements. Generally though, trees can be planted at one per square metre, shrubs at two to three per square metre and grasses and herbs at five plants per square metre.

Section 1

Please refer to the site map to locate sections.

This section is at the front of the existing lodge and is not in the development footprint. Some native species are present and the leasee Barry Jones planted some Snow Gum seedlings in 2003/03 which are growing well. This part of the site is ideal for the planting of indigenous shrubs on the edge of the site which is against the wall that separates the lodge from the road. The planting of lower herbaceous flowering plants interspersed with indigenous grasses is recommended. This would create an attractive area that is looked out at from the dining area of the Pretty Valley Lodge and will add aesthetic value to the existing lodge. Attractive shrub species such as *Grevillea victoriae* (Royal Grevillea and *Prostenthera cuneata* (Alpine Mint Bush) are recommended. Forbs that would do well in this section are *Helichrysum rutidolepis*, *Craspedia spp.*, (Billy Buttons*), Bractenatha subundulata* (Orange Everlasting), *Leptorhychus squamatus* (Scaly Buttons), *Rodanthe anthemoides* (White Everlasting) and *Brachyscome* species (Rock Daisies). These species interspersed with the blue form of *Poa fawcettiae* (Snow Grass) would create a very attractive representative alpine landscape and provide a good example to other lease holders of the potential for site improvement using native species.

Section 2

This section has a very deep trench running through it from the water that is dispersed from the road culvert. It would of originally have been part of the bog system that is present adjacent to this site. The water flows and entrenchment will have to be fixed as part of the rehabilitation of the site (as for the alpine bog recovery section). This will be done in conjunction with the Falls Creek Resort Management Board. Water is currently flowing out of the trench and towards the dry land vegetation. This must be fixed as part of the bog recovery work. Apart from this problem, this area has a large Lodgepole Pine which is recommended for removal. The leasee has also planted a number of Blue

Gums which are about ten years old. Whilst this gum is not a species that occurs in sub-alpine landscapes, at this point they can be retained. However, in the future, when the planted Snow Gums have exceeded 2 metres in height, removal of these trees is desirable.
Once the bog system is repaired, the batter of this section can be planted heavily with indigenous shrub species. *Grevillea victoriae, Prostanthera cuneata, Olearia frostii, Olearia phloggopappa var. flavescens* and *Derwentia derwentia* are the species I recommend for this part of section 2. Aside from the stream/bog area in this section, lower growing herbaceous species and grasses as for section 1 are recommended on the flatter ground up to the existing building.

Section 3

See the Landscape Plan produced by Mexted Rimmer for the outline of Section 3. Basically Section 3 is the area surrounding Building B. It is the area in which new spa baths are to be installed, adjacent to the raised walkway, the alpine bog and in between the two new buildings. The abstract drawing of the planting design by Mexted Rimmer is suitable. The list of species as outlined on the landscape plan is appropriate. However, from past experience, the placement of properly constructed drip-lines must be clearly marked on the plan to avoid confusion at planting. Generally, leaving one to two metres away from the building is recommended. The steeper the site, the wider the drip line area needs to be. The planting of grasses and tough herbaceous species is also recommended between 500mm and 1000mm away from the drip line as these areas tend to get a lot of water flow and some pedestrian access. The grasses that I recommend are *Poa fawcettiae* (Snow grass) and *Poa hiemata (*Soft Snow grass*)*. The herbaceous species recommended are*: Scleranthus biflorus* (Two –flowered Knawel*), Cotula alpinus* (Alpine Cotula*)*and *Helicrysum rutidolepis (*Pale Everlasting*)*. Other herbaceous species recommended for planting, that would help further the biodiversity of this site are *Bracteantha subundulata (Orange Everlasting), Bracyscome* species (Rock Daisies) and *Podolepis robusta* (Mountain Lettuce*)*.

Section 4

This section is the area surrounding Building B. This area will be under the most pressure from vehicles, building materials and foot traffic. Raised walkways would be ideal for protecting existing vegetation and soil. If this is not possible, then a protective material such as old carpet or silt matting would be acceptable. Any weed free native vegetation must be protected, especially mature shrubs and trees. Indigenous alpine plants are slow to grow and often difficult to produce. The more native species that can be saved through fencing or transplanting will reduce the cost of rehabilitation in the long run.
Once the snow has melted, the new buildings marked out and high conservation vegetation has been identified, then the pathways can be marked

out. This will be done as soon as possible in the spring of 2004, prior to any earth being disturbed. Induction of the builders into the importance of this is highly recommended.
The planting guide as laid out by Mexted Rimmer is suitable and can be followed.

Section 5

This section is the rest of the site that should not be overly disturbed by the construction of Buildings A and B. In the future, these areas may be developed, but as far as this plan is concerned, the rest of the site will be managed as having vegetation only. This plan recommends that this section has a thorough weed control program carried out and a clean up of debris. The lower part of the site, which is most of Section 5 would benefit from more Snow Gums. This would hide the road and the sewerage farm below the road and add aesthetic value to the site. However, until Buildings C, D and E have been decided upon and what the FCRMB would like to do with this area, no planting is recommended.

Post Development Requirements

It is very important in successful rehabilitation of high altitude sites that follow up maintenance and planting is done. This is not just for one year after the development has been done, but five.

This is particularly pertinent for the bog system. This area has been severely altered hydrologically, ecologically and floristically. This development is a real opportunity to restore a listed, protected community and to provide a prototype for restoring alpine bog systems within a ski resort.
The other more general areas that need rehabilitating have had many years of weed seed deposited in the soil profile and large weed load. This will be the most difficult aspect to achieving successful rehabilitation. It is very important to do very thorough initial weed control, use weed free mulch and do follow up weed control and re-mulching. This will be most intensive the first year after planting, but can become phased out over 5 years. In this time, planted indigenous species should be large enough to out-compete weed species.

From a rehabilitation perspective, the survival of 50 % of planted tube-stock is acceptable. However, this site can be maintained with watering and weed control as required. A survival rate of up to 80 % would be more acceptable and will be aimed for. Barry Jones, the leasee, has already showed his commitment in caring for seedlings by keeping more than 80 % of the Snow Gun seedlings alive that were put in just before the 2003 fires. Replanting of any lost plants can be done in the spring of 2006.

Timeline – Rehabilitation Works

Oct/Nov 2004

Site marked out.
Access tracks designated.

Alpine bog system delineated and marked as a no-go area.
Endemic *Derwentia nivea* transplanted and/or protected.
Snow Gum seedlings in development area transplanted.
Weed eradication program commences.
Woody alpine species cuttings taken, cuttings to be ready by spring 2005.

Dec/Jan 2004/05

Follow up weed control (removal and spraying)
Mulching of areas that weed control has been successful.
In conjunction with FCRMB, a solution to the road culvert on Slalom Street to be formulated.
Access tracks monitored.
Areas for topsoil, building supplies etc to be clearly marked.

Jan/March 2005

Installation of a cleanable sediment basin at the culvert from Slalom Street (dependent upon cooperation with FCRMB).
Seed/cuttings collected from indigenous herbaceous plants on site.
Carpark end drainage problems addressed (see detail in this plan).
Sowing of herbaceous species for spring planting.
Propagation of herbaceous alpine bog species.

Feb/April 2005

Installation of weirs in alpine bog system (dependent on culvert works).
Re-spraying of any emerging weeds, in and out of bog system.

May/June 2005

Completion (or near completion) of Buildings A and B.
Removal of scaffolding, building materials etc for the winter
Mulching of pathways and any remaining bare ground.

Oct/Nov 2005

Assessment of the success of the culvert works.
Major landscaping and rehabilitation works, with planting and design plans followed. Re-mulching where required.

Feb/Mar 2006

Landscape assessment. Replanting of dead tube-stock, follow up weed control.
Planting of the alpine bog, both woody and herbaceous species.

Nov 2006

Auditing of site landscaping/rehabilitation. More planting if required.
Continued weed control and re-mulching.
Assessment of the restoration of the alpine bog system.

Nov 2007-2009

Follow up maintenance as required.

Conclusion

The Falls Creek Ski Resort is currently proposing a large modern development in Slalom Plaza, which is adjacent to the Pretty Valley/Ropers site. This development could be the catalyst for the re-emergence of Falls Creek as the ultimate family alpine destination. The completion of Buildings A and B for the Ropers/Pretty Valley development and the successful rehabilitation of the land around these buildings will be in keeping with the vision that the Falls Creek management team has for their resort. It is also very important that there is full cooperation between the Falls Creek management and the lease holder of the Pretty Valley site so that the culvert repair and bog restoration are achieved.

The rehabilitation of any high altitude site is difficult and it is important that the limitations of these projects are understood. There needs to be a strong commitment to protect and improve the vegetation quality of the site not only by the lease holder, but by the construction team, the landscape team and the resort management if this work is to be successful.

This rehabilitation plan is a guide on how to best manage the existing indigenous vegetation as well as the removal of introduced plants and their replacement with indigenous species. Should any on-site environmental issues occur before, during or after the development, Alpine Flora – Liz MacPhee will provide guidelines on how to best deal with the problems.

Appendix 7
Walking Track Rehabilitation

A7.1 Introduction

Restoration of vegetation on degraded walking track sections at Mt Feathertop, Victoria, was undertaken following development of a Restoration Plan in January 2000. A copy of the Restoration Plan is included in an attachment to this appendix.

The section of track focussed on in the restoration project runs along a ridge leading to the summit of the mountain, at an altitude of 1740-1922 metres. This section of track was badly degraded with vegetation and soil disturbance rated as moderate to severe. The damage included:

- braiding, where multiple, criss-crossing tracks had developed;
- widened sections of track (1.5 – 2.7 metres wide);
- deeply scoured sections of track that had become redundant;
- deeply scoured sections that were still in use; and
- very steep, rocky sections, where the track alignment was poorly defined (leading to walker impacts becoming more spread out).

Due to the severity of impacts occurring on the Mt Feathertop ridge, a track management plan was developed, which included realignment and upgrading of the track, as well as closure and restoration of redundant sections of track and damaged verges.

A7.2 Description of work undertaken on Mt Feathertop

Work undertaken to address walking track impacts on Mt Feathertop included:

xii) collecting seed and preparing hardy indigenous tubestock for planting;
xiii) identifying and hardening a preferred track alignment;
xiv) installing appropriate drainage;
xv) preparing the soil or substrate on redundant sections of track and track verges for planting;
xvi) mulching and planting restoration areas,
xvii) watering, protecting and maintaining sites until rehabilitation was well established and self-supporting.

A7.3 Key considerations in walking track rehabilitation

Key issues that need to be considered in walking track rehabilitation are detailed below.

iv) Timing issues need to be considered from the outset to allow the works and plant preparation to be scheduled appropriately.
v) The preferred track location needs to be identified, taking into consideration the vulnerability of environments passed through (particularly gradient, drainage, soil and vegetation type), opportunities to confine the track to areas that are already degraded, and scenic opportunities. By locating the track in areas less vulnerable to degradation and constructing it to best practice standards, the repetition of the existing problems could be avoided.
vi) Plants suitable for rehabilitation need to be identified from the indigenous plants occurring at each site. Variations between each site need to be considered in choosing which species to use in specific areas; however, more significant

considerations involve identifying species that can be propagated easily and are hardy enough to survive in poor soil and exposed conditions.

vii) Once appropriate species for rehabilitiation have been identified, seed collection and propagation need to be commenced, taking into consideration the timing of the works and when tubestock will be required.

viii) Soil loss is likely to be a major limiting factor for rehabilitation. Where topsoil is absent, options could include, potential to import soil, creation of an organic soil substitute, and use of additives such as copra peat to build-up subsoil enough for the most hardy species to establish.

ix) Improving drainage and appropriately grading sites should be emphasised, to reduce potential for further soil loss and create adequate conditions for plants to establish.

x) Weed control is an important consideration, particularly as there is high potential for weeds to be introduced by walkers, as well as on work materials and machinery. Once introduced, weeds are likely to take advantage of exposed soils and disturbance. The Feathertop site was relatively low in weeds, therefore, control of existing weeds was a relatively minor consideration, however, strong emphasis was placed on ensuring that rehabilitation and track construction did not contribute to the introduction of new weeds.

xi) Classifying walking track impacts into 5 classes, as detailed in section A5.5.1 allows rehabilitation treatments to be tailored to the type of track degradation that had occurred, as well as specific environmental attributes of each site.

Attachment A7 Mt Feathertop Walking Track, Strategy for Vegetation Restoration

Example of a walking track rehabilitation project

MOUNT FEATHERTOP WALKING TRACK STRATEGY FOR VEGETATION RESTORATION

CONTENTS

LIST OF TABLES

Summary

This strategy refers to those degraded sections of the Mount Feathertop walking track from grid reference 118164 to grid reference 124170 (Map - Bogong Alpine Area, Outdoor Leisure Series). It provides general principles and guidelines for activities associated with the proposed works. It is anticipated that finer details, ie specific site plans, for the vegetation restoration will evolve as work progresses.

The height above sea level for these sections ranges from 1740 metres to 1922 metres. Generally the track follows an exposed narrow ridge over a series of knobs and saddles terminating at North Peak. The overall aspect of the track is south southwest, with the grade ranging from 5% to greater than 100%.

Vegetation of the surrounding area is predominantly low open heathland, dominated by the shrub *Grevillea australis* up to 1780 metres replaced by *Kunzea muelleri* from 1780 metres up to 1820 metres. From 1880 to 1920 metres the vegetation is predominantly exposed grassland/herbfield. The route of the walking track, being on the spur, also carries a complex array of alpine forbs, grasses and herbs.

NB Populations of the rare plant species *Ranunculus eichlerianus* have been described "in saddles along the ridge running up to the summit of Mt. Feathertop" and "in the vicinity of the Federation Hut camping area" (ANP Management Statement Special protection Zone 13). These populations will be located and all workers on site will be made aware of these locations and the need to protect them.

According to the Natural Resources and Environment Flora information system, a number of other plant species listed as Victorian Rare or Threatened Species and/or Australian Rare or Threatened Species may occur in the vicinity of the track. A thorough botanical search of the track and surrounding area is necessary to map the locations of significant flora.

Those plant species observed during a site assessment on 21 December 1999, in close proximity to the track or as remnant "islands", and which may be useful for restoration works are described in Table 6 - Species list, propagation and establishment methods (page 14).

Current track conditions.

Disturbance to soils and vegetation on the various track alignments ranges from moderate too severe. The disturbed sections have been categorised in to 5 groups according to depth of entrenchment, width, disturbance level and future use. There are obvious links from one group to another.

1. Braided/traversing redundant sections.

This group consists of separate routes around knolls that lead to the same destination, or new routes traversing severely disturbed areas. Entrenchment of these sections is from 10mm. to 150mm. The slope is gentle, ranging from 0% to 20%. The width varies from 300 to 800mm. There appears to be reasonable depths of soil material/rock fines for plant growth. These sections are to be closed, reducing numerous tracks to a single route. This will obviously increase traffic on the remaining track and hardening of the remaining alignment will be necessary to limit future disturbance.

2. Widened single-track sections.

This group encompasses a large area of disturbed track alignment. Entrenchment in these sections ranges between 100 and 300mm.. The slope varies from 30% to 60%. The width ranges from 1500 to 2700mm.. The vegetation has been reduced to small areas of remnant islands. Soil material is limited, consisting mostly of loose large stones and rock fines. The track will continue to follow this route.

3. Deeply scoured redundant section

This group describes a single section of the track that is to become redundant. Entrenchment is severe ranging from 400 to 600mm. The slope is generally steep from 40% to greater than 100%. The width ranges from 1200 to 1700mm. Vegetation and soil material have been removed completely, with washing occurring down to bedrock.

4. Very deeply scoured sections.

Disturbance in this group is severe, but is largely limited to a single site. Entrenchment ranges from 500 to 1000mm. The slope varies from 50% to 70%. The width varies from 2900mm. to 4200mm. Small islands of vegetation, from slumping edges, exist beside bedrock. Apart from vegetation islands soil material has been washed away down to bedrock. The stabilised track will continue to follow the current alignment through this section.

5. Very steep rises

This group is generally limited to areas on the final steep rises to Mount Feathertop and North Peak. The track alignment at these sites is poorly defined. Walkers appear to gain footing wherever it is possible. The slope is generally greater than 100%. The various routes are very rocky and there is little soil material. Restoration of these areas will be very difficult.

Proposed treatments.

Table 1 below describes the proposed treatments for each group.

Table 1 - Proposed treatments.

Group	Approximate area	Proposed treatment
1.Braided/traversing redundant sections.	380m²	• Harden favoured alignment. • Close and secure redundant alignment. • Loosen soil material with pick to ≈ 200mm. • Install invert drains as required. • Plant tube-stock – add sterile copra peat to in-situ soil material. • Direct seed. • Mulch. • Water as required.
2.Widened single-track sections	450m²	• Install invert drains at minimum intervals of 5 metres. • Excavate for rock pitching/track stabilisation. • Stockpile/protect soil material. • Import soil (pending research) • Construct terracettes where appropriate. • Plant tube-stock • Direct seed • Mulch • Water as required
3.Deeply scoured redundant sections	60m²	• Harden favoured alignment • Install drainage to protect site from run-off. • Install rock terracettes & percolating drainage • Import soil (pending research) • Plant tube stock • Direct seed • Mulch • Water as required

Table 1 – Proposed treatments continued…

Group	Approximate area	Proposed treatment
4. Very deeply scoured sections	80m²	• Excavate for retaining walls • Stockpile/protect soil material • Import soil (pending research) • Plant tube stock • Direct seed • Mulch • Water as required
5. Very steep rises	80m²	• To be advised

Principles for track stabilisation works.

This strategy does not address all the requirements of the track stabilisation works. However the following principles should be adhered to.

- All works should be confined to disturbed areas of the walking track alignment.
- Vegetation adjacent to working areas should be protected as required.
- Materials delivery sites should be confined to the disturbed areas of the walking track alignment.
- Initial works should provide adequate drainage to all the sections of the walking track to be treated, to assist natural colonisation by vegetation to occur.
- Drainage works should ensure no outflows from invert drains impinge on biological values.
- Drainage works should encourage percolation of water through the regolith, and not concentrate water flows. Invert drains should be installed at no greater than 5 metre intervals and should not exceed a grade of 1%.
- All exposed or stockpiled soil material should be protected from loss by wind and water.

Material for vegetation restoration.

Seed

For timing of seed collection see Table 2 - Indicative seed collection calender (page 8).

Direct seeding

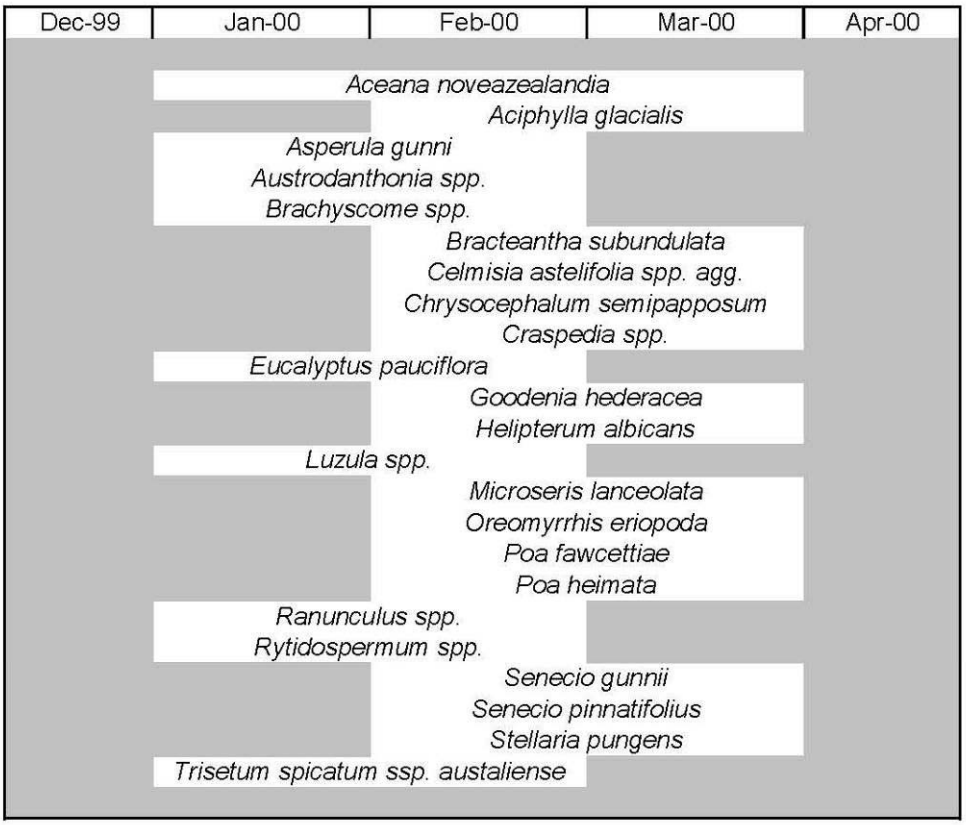
To ensure the genetic integrity of the area seed should be sourced as much as possible from the environs of the track. However it will be necessary to source seed from close by areas to ensure sufficient volumes of seed are collected to enable successful direct seeding. The Mount Hotham Resort Area has consistently produced reasonable volumes of indigenous seed. "High Knob" and "Twin Knobs" are at similar elevations to the works area. These areas should be investigated as suitable locations for seed collection.

Seed for Tube-stock

All tube-stock should be raised from seed collected from the environs of the track. Seed collection should commence as soon as possible in January 2000 and continue through to April 2000. Further seed collection will be necessary in subsequent years. It will be necessary to coordinate seed collection activities with the movements of the helicopter ferrying in stonemasons and their materials.

Seed should be stored appropriately.

Table 2 - Indicative seed collection calender.



Material for Division

Experimentation with the removal and replacement of sod material has occurred at Mount Hotham. This technique has had very limited success. The risk of loosing a valuable resource far outweighs the possible benefits. Every effort should be made to ensure that existing vegetation remains undisturbed. If it is absolutely unavoidable to disturb remnant islands of vegetation in the track alignment all such material should be removed to a suitable location to enable tube-stock or similar to be produced from vegetative division.

Close coordination with stonemasons and strict staging of stabilisation works will be necessary to ensure material for division is removed and delivered to a suitable location in prime condition. Storage of material is not acceptable. Constraints on helicopter flying time due to weather, fires etc. must be thoroughly investigated

Material for division should be placed in plastic bags and watered to field capacity. These should in turn, be placed in polyester sacks. The material should then be flown to Bright and delivered as soon as possible to a suitable location (preferably Ovens Research Station).

Cutting material

Some plant species eg *Grevillea australis* can only be raised from cutting material. All cutting material will be sourced from the environs of the track.

Planting and seeding Rates

Final selection of species and volumes for restoration works will be dependent on seed availability and viability. Only persons with a thorough knowledge of alpine restoration works should be employed for seed collection.

Planting rates

Dense planting rates will be necessary to ensure the success of restoration works. 3" round pots should be the preferred container for shrubs and forbs as this ensures a sizeable root mass to assist in survival rates. 2" round pots should be the preferred container for grasses. See table 3 for indicative planting rates and species numbers.

Tube-stock will need to be hardened to field conditions at lower altitudes for a minimum of 2 weeks. They should then be transported to a suitable location, at a similar altitude to the walking track, for a period of at least 2 weeks prior to planting. Mount Hotham Resort Area is the preferred location for hardening at altitude. Tube-stock will need to be stored beneath shade-cloth (30%-50%) and watered regularly during hardening off and storage prior to planting.

Seeding rates

Aceana noveazealandia and *Senecio pinnatifolius* have proven to be very effective in direct seeding at disturbed sites at Mount Hotham. *Poa hothamensis* has proven to be an excellent species for direct seeding in many disturbed sites. It appears that at high elevations *Poa hothamensis* may act as a nurse crop to other species but may not persist. I was unable to locate *Poa hothamensis* on 21 December 1999 but assume it will be present, especially where *Eucalyptus pauciflora* woodland joins the track from the western edge of the spur. *Craspedia spp.* has been used successfully in direct seeding of disturbed sites at Mount Hotham. Other species to add to the seed mix will be dependent on seed availability. See Table 4 for indicative seeding rates and volumes required

Table 3 - Indicative planting rates and plant numbers.

Section	Approx. Area/m²	Shrubs				Grasses						Forbs						Total Plants/m²
		Grevillea australis		*Kunzea muelleri*		*Poa fawcettiae Poa heimata*		*Rytidosperma spp*		*Trisetum spp.*		*Craspedia spp.*		*Celmisia astelifolia*		*Leptorhynchus squamatus*		
		/m²	Total	/m²	Total	/m²	Total	/m²	Total	/m²	Total	/m²	Total	/m²	Total	/m²	Total	
1.Braided/traversing redundant sections.	380	3	1140		0	2	760		0	1	380	0.5	190	0.5	190	1	380	8
2.Widened single-track sections	450	1	450	2	900	2	900	1	450	1	450	0.5	225	1	450	0.5	225	9
3.Deeply scoured redundant sections	60	2	120	1	60	1	60	1	60	1	60	1	60	1	60	1	60	9
4.Very deeply scoured sections	70	3	210		0	2	140	1	70	2	140	1	70	1	70	1	70	11
5.Very steep rises	80		0		0	3	240	3	240	2	160		0	1	80		0	9
TOTALS	1040		1920		960		2100		820		1190		545		850		735	

Table 4 - Indicative seeding rates and volumes

Section	Approx. Area/m²	*Senecio pinnatifolius*		*Poa hothamensis*		*Poa fawcettiae Poa heimata*		*Rytidosperma spp*		*Trisetum spicatum*		*Craspedia spp.*		*Luzula spp.*		*Aceana novea-zealandia*		*Oreomyrhiss eriopoda*	
		g/m²	Total	g/m²	Total	g/m²	Total	g/m²	Total	g/m²	Total	g/m²	Total	g/m²	Total	g/m²	Total	g/m²	Total
1.Braided/traversing redundant sections.	380	1	380		0	4	1520	0.5	190	0.5	190	0.5	190	0.5	190	4	1520	0.5	190
2.Widened single-track sections	450	1	450		0	4	1800	0.5	225	0.5	225	0.5	225	0.5	225	4	1800	1	450
3.Deeply scoured redundant sections	60	1	60		0	4	240	0.5	30	0.5	30	1	60	0.5	30	4	240	0.5	30
4.Very deeply scoured sections	70	1	70	6	420	4	280	1	70	1	70	1	70	0.5	35	6	420	1	70
5.Very steep rises	80		0		0	4	320	4	320	2	160		0	2	160	2	160	2	160
TOTALS	1040		960		420		4160		835		675		545		640		4140		900

Soil additives/fertilisers.

The lack of available sterile soil material is a common limiting factor to restoration and revegetation works in alpine areas. A minimum depth of 200 mm. of soil material is required to sustain plant growth The requirement for, and the volumes of, sterile soil required for restoration of the Mount Feathertop walking track will be determined as work progresses. There is no doubt that significant quantities of sterile soil will be required. Protection of the existing soil material on the walking track is essential for successful restoration works.

The inclusion of sterile copra peat has been used on the 'Pinch Pit' at Rocky Valley Dam to assist growth of shrubs in poor soil conditions. This method of improving soil conditions for plant growth should be employed in sections where soil loss has not been severe.

'Dynamic lifter' broadcast over treated sites has been used effectively to encourage vigour in restoration and revegetation works at many sites in alpine areas. However this may encourage the growth of weed species. For this reason it is recommended that application of dynamic lifter be withheld until the second year after initial works, when any weed invasion has been controlled. Then it should be broadcast at 100-150 grams/m^2.

'Osmocote' applied directly to tube-stock planting has also been used effectively to encourage vigour. 5 to 10 grams of osmocote should be incorporated into the soil, close to the root-zone of each plant.

There are many disturbed alpine sites requiring revegetation and restoration works, on private and public land, and leased areas. The availability of suitable sterile soil material is a key to success at Mount Feathertop and a large number of similar sites. Parks Victoria is strongly encouraged to contribute to a research project to commence this year. Which will provide techniques and costs for the production of suitable sterile soil material for restoration and revegetation works.

Mulch

Numerous materials are marketed for mulching of revegetation and restoration works. Recent trials and works conclude that currently the only effective mulch material is weed free, fine fescue straw secured with open weave jute-mesh ("soil saver"). Terry Murphy in Mansfield is a very cooperative fellow who strives to produce suitable weed and seed free straw for such works. Close liaison with Terry and inspection of straw prior to delivery to the works area is extremely important. Methods to sterilise straw should be investigated.

For temporary soil stabilisation works coconut fibre matting is light weight, weed free and effective. The most stable of these products is light grade 'fibremulch'. Unfortunately indigenous vegetation has difficulty penetrating this material. It is possible to have this material manufactured to a desired width. The Mount Hotham Resort Management Board has undertaken trials with a less dense 'fibremulch'. No results are available as yet.

Water

Tube-stock requires watering to field capacity immediately prior to planting, then watering in once planted. As a guide 100 plants require a minimum of 20 litres of water during planting.

The requirement for water after initial treatment will be dictated by:

- Timing of planting/seeding
- Seasonal conditions

- Microclimates
- Aspect
- Quality and depth of soil material
- Mulches

Consideration and manipulation of the above factors will reduce the requirement for watering after initial planting and seeding. However treated areas should be watered on a regular basis for the first year after establishment in the absence of adequate rainfall.

There are 2 sources of water in the vicinity of the works area – the water tank at Federation Hut and a spring on the northwest spur track. If necessary water will need to be flown in by helicopter.

Weed control

Weed control has been considered throughout this strategy. The following points serve to emphasise areas where the threat of weed invasion can be reduced.

The only weed species observed on 21 December 1999 were scattered *Hypocheris radicata* (Cat's Ear) and numerous *Acetosella vulgaris* (Sheep Sorrel). Weed invasion of the area is very low. Every effort needs to be taken to ensure this remains the case.

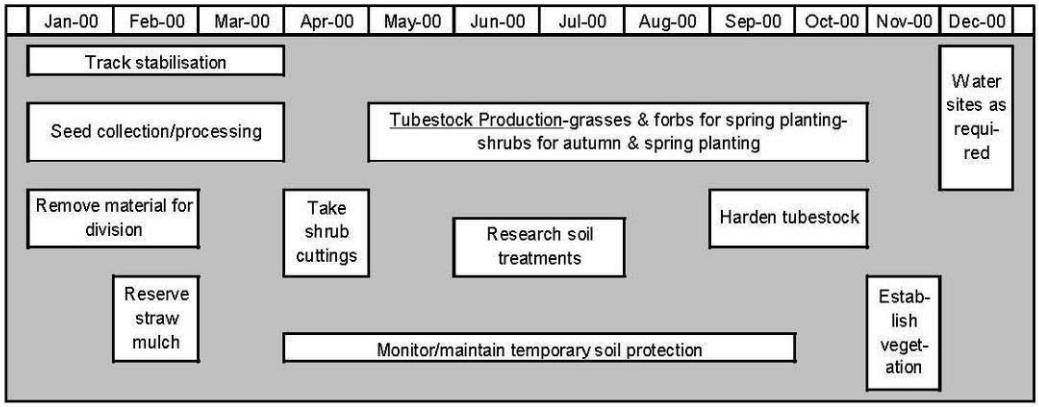
- Imported rock for stabilisation works will be pressure washed prior to delivery (pers. comm. Dayle Beatson – Project Manager).
- Workers at the site should be briefed on weed species and encouraged to effect weed control works (by hand) as the stabilisation occurs.
- Mulches will be weed free.
- Improvement to soil conditions may encourage weed invasion. Fertiliser use should be conservative until weed incursion is understood and controlled.
- Monitoring works should identify weed control requirements and rapid action should be taken to implement control works.
- Persons with appropriate knowledge and experience should undertake seed collection, processing, and storage.
- Workers at the site should be briefed on the need to ensure weed seed is not transported to the site from the camping area at Federation Hut, or from the spring on northwest spur track.
- Weed control works should be undertaken at Federation Hut and the spring on northwest spur track to ensure that walkers do not transport weed seed to the works area.

Timing

The timing of vegetation establishment will be dependant on the progress of track stabilisation works and seasonal rainfall.

Below is an indicative guide to vegetation restoration works timing.

Table 5 - Indicative restoration works timing.



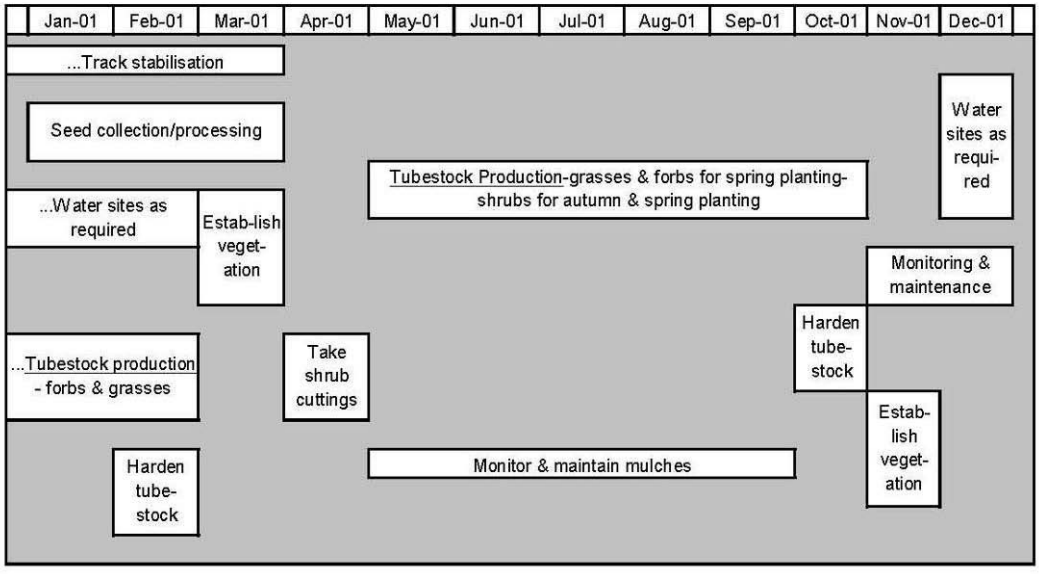


Table 6 – Species list, propagation and establishment methods.

Species		Propagation technique			Establishment technique		Comments
Proper Name	Common Name	Seed	Cuttings	Division	Tubestock	Direct seed	
Aceana noveazealandia	Bidgee-widgee					✔	Grows readily from direct seeding. May collect significant volumes of seed. Is colonising sections where soil is collecting.
Aciphylla glacialis	Snow Aciphyll					✔	Little horticultural knowledge. Seed generally not predated.
Asperula gunni	Mountain woodruff		✔	✔	✔		Is colonising areas in saddles where soil is collecting.
Austrodanthonia spp.	Wallaby-grass	✔		✔	✔	✔	Widespread on track at all elevations. Unknown horticulture. Growing on remnant islands.
Brachyscome spp.	Daisy	✔		✔	✔	✔	Abundant species adjacent to track to forming dense areas. Not a vigorous spp.
Bracteantha subundulata	Orange everlasting	✔			✔	✔	Scattered occurrence at lower elevations.
Celmisia astelifolia spp. agg.	Silver Daisy	✔		✔	✔	✔	Currently flowering abundantly. Widespread at all elevations. Seed often heavily predated.
Chrysocephalum semipapposum	Clustered Everlasting	✔			✔	✔	Scattered occurrence to ≈1800m. Vigorous seeder moderately predated.
Craspedia spp.	Billy-buttons	✔		✔	✔	✔	Very useful for direct seeding and tubestock. Seed often heavily predated.
Eucalyptus pauciflora	Snow gum	✔			✔		Isolated groups on western side of ridge. Low numbers of tubestock would be useful.
Goodenia hederacea	Ivy Goodenia			✔	✔		Colonising species. Can be grown from division.
Grevillea australis	Alpine Grevillea		✔		✔		Dominant shrub to ≈ 1800m. Hardy tubestock species.
Helipterum albicans	Hoary Sunray	✔		✔	✔	✔	May colonise rocky sites.

Table 6 continued

Species		Propagation technique			Establishment technique		Comments
Proper Name	Common Name	Seed	Cuttings	Division	Tubestock	Direct seed	
Kunzea muelleri	Yellow Kunzea		✔	✔	✔		Dominant shrub from ≈ 1780m. to ≈1820m. Little known as tubestock.
Luzula spp.	Woodrush	✔			✔	✔	Scattered/common at all elevations. Important component at higher elevations. Occurs as "self recruit" in disturbed sites at Mount Hotham.
Microseris lanceolata	Yam Daisy	✔			✔	✔	Scattered occurrence. Occurs as "self recruit" in disturbed sites at Mount Hotham.
Olearia phlogopappa var. flavescens	Dusty Daisy bush		✔		✔		Very low abundance. Has been found useful at other sites e.g. Mount Hotham.
Oreomyrrhis eriopoda	Australian Carraway	✔		✔	✔	✔	Scattered occurrence at all elevations. Seed rarely predated.
Poa fawcettiae	Horny Snow-grass	✔		✔	✔	✔	Abundant grass at all elevations. May produce moderate seed crop this season. Seed often of low viability.
Poa heimata	Soft Snowgrass	✔		✔	✔	✔	Abundant grass at all elevations.
Ranunculus spp.	Buttercups	✔		✔	✔	✔	*Ranunculus eichlerianus* has been recorded adjacent to the track and is listed as a threatened species.(see ANP Management Statement-Special Protection Zone 13.)
Rytidospermum spp.	Wallaby-grass	✔		✔	✔	✔	Abundant grass in remnant islands on track. Dominant at higher elevations.
Scleranthus spp..	Knawels			✔	✔		
Senecio gunnii	Mountain Fireweed	✔			✔	✔	Scattered individuals along track. Useful colonising species.
Senecio pinnatifolius	Variable Groundsel	✔			✔	✔	Excellent colonising species for direct seeding if sufficient seed available. Scattered individuals to ≈ 1850m.
Stellaria pungens	Prickly Starwort	✔	✔	✔	✔	✔	Good colonising species. Scattered individuals to ≈ 1800m.
Trisetum spicatum ssp. austaliense	Bristle-grass	✔		✔	✔	✔	Common and widespread on track at all elevations. Tends to be strongly rhizomatous. Indications of good seed crop.

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Pers. Comm.:Dayle Beatson, Project Manager. Parks Victoria, BRIGHT.

Pers. Comm.: Warwick Papst. Latrobe University.

Pers. Comm.: Daryl Burns, Ranger. Parks Victoria. Mount Beauty.

Appendix 8

Alpine Resort Nursery Operation

A8.1 Introduction

High quality stock is essential to successful, efficient rehabilitation. Tubestock that is healthy, vigorous and at optimum size for planting will have a much higher rate of surviving transplanting and a higher growth rate than poor quality stock. Sourcing quality tubestock when it is required can, however, be very difficult for resorts. This is partially due to difficulties in planning ahead with regard to alpine developments, and also because operation of a nursery to provide material for ski resorts is a specialised area of plant production. Alpine growth cycles, conditions and species are quite different from lowland areas, particularly with regard to extreme environments such as wetlands and very high altitude areas.

At Mt Hotham, in Victoria, some of these difficulties are being surmounted by the operation of a non-profit nursery. The Mt Hotham nursery was established to meet the planting needs of all the ski resorts in Victoria. It operates as part of the infrastructure supporting alpine resort management and, because it is regarded as part of the resorts infrastructure, the nursery is able to operate in accord with the planning process. Early in the process, resorts are able to inform the nursery of what types of plants are needed so that preparation of stock can commence well in advance of ground disturbance and plants are in peak condition for planting when they are required. Furthermore, through its staff, the nursery is able to provide on-site, specialist advice on rehabilitation to the resorts.

A8.2 Essentials of Alpine Nursery Operation

The following notes outline the key points that are essential to successful operation of an alpine nursery, based on experiences from the Mt Hotham nursery.

1. An alpine nursery needs to be operated by a suitable person who has both nursery and alpine ecology training. There is little available information about the specific needs of alpine plants, therefore experience, the ability to source what information is available, and an experimental approach would be very valuable characteristics in a nursery operator. Key issues the propagator needs to be aware of include:
    - When seed will be available for harvesting and appropriate seed harvesting methodologies;
    - Suitable times for taking cuttings or division, and appropriate methodologies;
    - The soil micro-organism needs of plants (i.e. some species are reliant on soil micro-organisms to aid in the uptake of nitrogen. To provide the appropriate suite of micro-organisms, these plants require the addition of soil to potting media);
    - The sensitivities of different species to different types of potting media, fertilizers and watering regimes;
    - The period of time it takes for different species to reach an optimal size for planting;
    - How tell when a plant has reached optimal condition (i.e. when the plant has enough biomass to cope with transplant shock but is not yet overgrown).
2. An alpine nursery should be located at a low altitude (below 500 metres) so that conditions are warm enough for plants to be grown throughout the year.
3. A suitable location(s) for hardening off at higher altitude are also necessary. Hardening off areas should be easy to access and to maintain in clean (non-

pathogenic) condition and be set-up to allow watering to be carried out easily, as required.

4. For an alpine nursery to be successful, it also requires a large enough market so that it can be set up to cater specifically for alpine requirements. Operation of a commercial alpine nursery has generally not been found to viable and has resulted in poorer quality stock due to pressure to compromise on growing conditions and species selection.

Appendix 9
Rehabilitation Species List: Perisher Range Resorts
Perisher Valley, Smiggin Holes, Guthega, Mt Blue Cow & Charlotte Pass

This appendix provides a list of species known to be successful in rehabilitation, and which would be suited to the Kosciuszko resorts. It does not provide a definitive list of species found in each resort.

Form	Species	Common Name	Community	Propagation and Seed Collection Notes	Direct Seeding
Forbs					
	Acaena novae-zelandiae	Bidgee-widgee	TAHa, H, STG	Seed (easy to collect large volumes).	Y
	Asperula gunnii	Mountain Woodruff	TAHa, STG, H	Cuttings or division.	
	Brachyscome spathulata	Spoon Daisy	TAHab, H	Seed	Y
	Celmisia pugioniformis	Dagger-leaf Celmisia	TAHa, STG	Seed needs 1-6 weeks cold treatment, length of time depending on altitude. Keep plants cool. Susceptible to root rot. Best direct seeded.	Y
	Celmisia tormentella	Snow Daisy		Seed needs 1-6 weeks cold treatment, length of time depending on altitude. Keep plants cool. Susceptible to root rot. Best direct seeded.	Y
	Craspedia lamicola	Shiny-leaf Billy-button	TAHa, STG	Seed or division	Y
	Craspedia maxgrayi	Woolly Billy-button	TAHa, STG	Seed or division	Y
	Helichrysum rutidolepis	Pale Everlasting	H, W	Seed	Y
	Leptorhynchos squamatus	Scaly Buttons	STG, TAHa, FMa	Seed	
	Microseris lanceolata	Native Dandelion	TAHa, STG	Seed	Y
	Oreomyrrhis eriopoda	Australian Caraway	TAHa, H	Seed	
	Ranunculus gunnianus	Gunn's Alpine Buttercup	TAHa, STG	1-6 weeks cold treatment, length of time depending on altitude. Division.	Y
	Scleranthus biflorus	Twin-flower Knawel	TAHa, STG	Seed or division	
	Senecio gunnii	Gunn's Groundsel	TAHa	Seed	Y
	Senecio pinnatifolius	Highland Groundsel	TAHa, STG	Seed	Y
	Stellaria pungens	Starwort	TAH	Seed, cuttings or division	Y
	Stylidium graminifolium	GrassTrigger-plant	TAHa, STG, H, B, W, SAH, SG	Seed	
Grasses, rushes					
	Austrodanthonia penicillata	Crag Wallaby-grass	TAHb	Seed or division	Y
	Carex breviculmis	Common Grass Sedge	B	Seed	Y
	Carex gaudichaudiana	Tufted Sedge	F, B, STG	Seed	Y
	Deyeuxia monticola var.	Mountain Bent-grass	STG, TAHa	Seed or division	Y
	Luzula novae-cambriae	Coarse Woodrush	W, H	Seed	Y
	Poa costiniana	Prickly Snow-grass	STG, F, B, TAHa, H, SAH	Seed or division	Y
	Poa ensiformis		W, SAH, SR	Seed or division	Y
	Poa fawcettiae	Smooth-blue Snow-grass	TAHa, STG	Seed or division	Y
	Poa hiemata	Soft Snow-grass	TAHa, SG	Seed or division	Y
	Uncinia flaccida	Compact Hook-sedge	TAHa, STG	Division	
Shrubs					
	Baeckea gunniana	Alpine Baeckea	B, H	Cuttings	
	Bossiaea foliosa	Small Leaved Bossiaea	SAH, W	Seed (collected in March)	
	Grevillea australis	Alpine Grevillea	H, SAH	Tip cutting	
	Hovea montana	Alpine Hovea	H, SAH, W	Seed	

	Leucopogon montanus	Snow Beard-heath	H	Spring cutting, takes 2 years to reach plantable size.	
	Olearia algida		H, SAH, W		
	Olearia phlogopappa	Dusty Daisy-bush	H, SAH, W	Seed or spring cutting. Roots quickly.	
	Ozothamnus alpinus	Alpine Everlasting	B, H	Tip cutting	
	Ozothamnus secundiflorus	Cascade Everlasting	B, H	Tip cutting	
	Ozothamnus hookeri	Kerosene Bush	H	Tip cutting	
	Podocarpus lawrencei	Mountain Plum-pine	H	Cuttings	
	Podolobium alpestre	Alpine Podolobium	H	Seed (collected in March)	
	Prostanthera cuneata	Alpine Mint-bush	H, SAH, W	Cuttings	
	Tasmannia xerophila	Alpine Pepper	H, SAH, W	Cuttings – slow to develop	
Trees					
	Eucalyptus pauciflora	Snow Gum	W	Seed (available all year). 3 weeks cold treatment at 4^{o} recommended.	Y

Key to Communities:

TAHa	Tall Alpine Herbfield *Celmisia –Poa* alliance	H	Heath (alpine)
TAHb	Tall Alpine Herbfield *Brachyscome-Austrodanthonia* alliance	F	Fen
SAH	Short Alpine Herbfield	B	Bog
FMa	Feldmark *Epacris-Chionohebe* alliance	STG	Sod Tussock Grassland
FMb	Feldmark *Coprosma – Colobanthus* alliance	W	Woodland
		SAH	Sub-alpine heath
		SR	Subalpine Riparian and wet areas
		SG	Subalpine Grassland and dry, treeless areas

Appendix 10
Rehabilitation Species List: Thredbo & Bullocks Flat

This appendix provides a list of species known to be successful in rehabilitation, and which would be suited to the Kosciuszko resorts. It does not provide a definitive list of species found in each resort.

Form	Species	Common Name	Community	Propagation and Seed Collection Notes	Direct Seeding
Forbs					
	Craspedia jamesii	James's Billy-button	TAHa, STG	Seed or division	Y
	Craspedia lamicola	Shiny-leaf Billy-button	TAHa, STG	Seed or division	Y
	Craspedia leucantha	Pale Billy-button	SAH, TAHa	Seed or division	Y
	Craspedia maxgrayi	Woolly Billy-button	TAHa, STG	Seed or division	Y
	Helichrysum scorpioides	Button Everlasting	TAHa, W	Seed	Y
	Podolepis robusta	Alpine Podolepis	TAHa, STG	Seed	Y
	Senecio linearifolius	Fireweed Groundsel	SAH, W, SR	Seed	Y
	Stylidium graminifolium	AlpineTrigger-plant	TAHa, STG, H, B, W, SAH, SG	Seed	Y
Grasses, rushes					
	Carex hebes	Dryland Sedge	TAHa, STG	Seed or division	Y
	Poa costiniana	Prickly Snow-grass	STG, F, B, TAHa, H, SAH	Seed or division	Y
	Poa ensiformis	Sword Tussock-grass	W, SAH, SR	Seed or division	Y
	Poa fawcettiae	Smooth-blue Snow-grass	TAHa, STG	Seed or division	Y
	Poa hiemata	Soft Snow-grass	TAHa, SG	Seed or division	Y
Shrubs					
	Acacia obliquinervia	Mountain Hickory Wattle	SAH	Seed (collect in March)	Y
	Cassinia monticola	Cassinia	W, SG		
	Grevillea australis	Royal Grevillea	H, SAH	Tip cutting	
	Hakea microcarpa	Small-fruit Hakea	SAH, W		Y
	Ozothamnus ellipticum	Kerosene Bush	B, H	Soft cutting	
	Ozothamnus secundiflorus	Cascade Everlasting	H, SAH	Soft cutting	
	Podolobium alpestre	Alpine Shaggy-pea	H	Seed (collected in March)	
		Prostanthera cuneata	Alpine Mint-bush	H	Cuttings
Trees					
	Eucalyptus dalrympleana	Mountain Gum	W	Seed	Y
	Eucalyptus delegatensis	Alpine Ash	W	Seed	Y
	Eucalyptus pauciflora	Snow Gum	W	Seed (available all year). 3 weeks cold treatment at 4^{o} recommended.	Y
	Eucalyptus stellulata	Black Sally	W	Seed (available all year). 3 weeks cold treatment at 4^{o} recommended.	Y

Key to Communities:

TAHa	Tall Alpine Herbfield *Celmisia –Poa* alliance	H	Heath (alpine)
TAHb	Tall Alpine Herbfield *Brachyscome-Austrodanthonia* alliance	F	Fen
SAH	Short Alpine Herbfield	B	Bog
FMa	Feldmark *Epacris-Chionohebe* alliance	STG	Sod Tussock Grassland
FMb	Feldmark *Coprosma – Colobanthus* alliance	W	Woodland
		SAH	Sub-alpine heath
		SR	Subalpine Riparian and wet areas
		SG	Subalpine Grassland and dry, treeless areas

Appendix 11
Rehabilitation Species List for Mt Selwyn

This appendix provides a list of species known to be successful in rehabilitation, and which would be suited to the Kosciuszko resorts. It does not provide a definitive list of species found in each resort.

Form	Species	Common Name	Community	Propagation and Seed Collection Notes	Direct Seeding
Forbs					
	Craspedia costiniana	Hairy Billy-button	TAHa, STG	Seed or division	Y
	Craspedia crocata	Crimson Billy-button	TAHab, SG	Seed or division	Y
	Craspedia jamesii	James's Billy-button	TAHa, STG	Seed or division	Y
	Derwentia derwentiana	Derwentia	SAH, W	Seed	Y
	Helichrysum scorpioides	Button Everlasting	TAHa, W	Seed	Y
	Podolepis heiracioides	Long Podolepis	TAHa, STG	Seed	Y
	Senecio linearifolius	Fireweed Groundsel	SAH, W, SR	Seed	Y
	Stylidium graminifolium	Grass Trigger-plant	TAHa, STG, H, B, W, SAH, SG	Seed	Y
Grasses, rushes					
	Carex hebes	Dryland Sedge	TAHa, STG	Seed or division	
	Poa costiniana	Prickly Snow-grass	STG, F, B, TAHa, H, SAH	Seed or division	Y
	Poa ensiformis		W, SAH, SR	Seed or division	Y
	Poa sieberiana	Snow grass	SAH, W	Seed or division	Y
Shrubs					
	Acacia obliquinervia	Mountain Hickory Wattle	SG, W	Seed (collect in March)	Y
	Bossiaea foliosa	Small Leaved Bossiaea	SAH, W	Seed (collected in March)	
	Grevillea australis	Alpine Grevillea	H, SAH	Tip cutting	Y
	Hakea microcarpa	Small-fruit Hakea	SAH, W	Seed	Y
	Ozothamnus secundiflorus	Cascade Everlasting	B, H	Tip cutting	
	Ozothamnus hookeri	Kerosene Bush	H	Tip cutting	
	Podolobium alpestre	Alpine Shaggy-pea	H	Seed (collected in March)	
	Prostanthera cuneata	Alpine Mint-bush	H, SAH, W	Cuttings	
Trees					
	Eucalyptus pauciflora	Snow Gum	W	Seed (available all year). 3 weeks cold treatment at 4^{o} recommended.	Y
	Eucalyptus stellulata	Black Sally	W	Seed (available all year). 3 weeks cold treatment at 4^{o} recommended.	Y

Key to Communities:

TAHa	Tall Alpine Herbfield *Celmisia –Poa* alliance	H	Heath (alpine)
TAHb	Tall Alpine Herbfield *Brachyscome-Austrodanthonia* alliance	F	Fen
SAH	Short Alpine Herbfield	B	Bog
FMa	Feldmark *Epacris-Chionohebe* alliance	STG	Sod Tussock Grassland
FMb	Feldmark *Coprosma – Colobanthus* alliance	W	Woodland
		SAH	Sub-alpine heath
		SR	Subalpine Riparian and wet areas
		SG	Subalpine Grassland and dry, treeless areas

Appendix 12

Weeds of the Kosciuszko Region

A12.1 Significant Weeds of Koscuiszko Ski Resort Areas

Yarrow (Milfoil)

Achillea millefolium

Description: A small creeping plant with finely dissected, feathery leaves. Flower shoots are taller, producing clusters of tiny white or pink flowers.

Occurrence: Common in all disturbed areas around the resorts, as well as on roadsides and track edges.

Dispersal: Individual plants spread by underground runners (rhizomes). Easily spreads to new sites when chopped up rhizomes are moved in soil and on machinery. Also spreads by windblown seed.

Control: Do not reuse soil that contains rhizomes or straw from areas where Yarrow occurs. Ensure earth moving equipment is clean when moving from site to site or between infested and non-infested parts of the site. Dig or spot spray prior to seeding. All rhizomes must be removed if dug-up. A long term program is necessary for control.

Left
Top, entire plant
Bottom, leaves

Right
Top, flower, white form
Bottom, flower, pink form

Browntop Bent
Agrostis capillaris

Description: Mat forming grass with strong above and underground runners. Leaves 1-5 mm wide, branching seed heads up to 20 cm long. Reddish-purple seed heads are initially tightly packed, close to the stem then spread out to become feathery as seed matures.

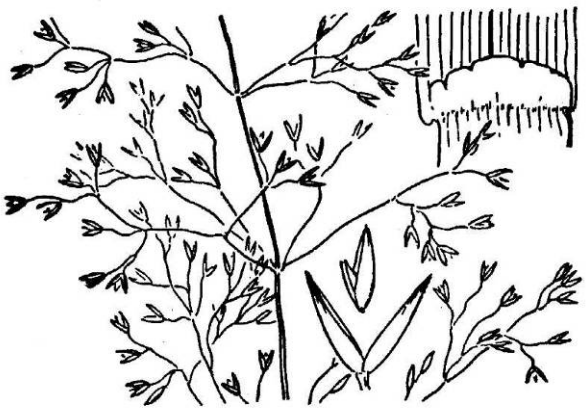
Other Species: Other *Agrostis* species that are also weeds in KNP include *A. gigantea* and *A.stolonifera.*

Occurrence: Common in all disturbed areas around the resorts, where it has been planted for soil stabilisation. Invades native vegetation by spreading out from disturbed areas.

Dispersal: Individual plants spread by underground and above ground runners. Easily spreads to new sites when chopped up rhizomes are moved in soil and on machinery. Possibly also spread in the gut of grazing animals.

Control: Do not reuse soil that contains rhizomes. Ensure earth moving equipment is clean when moving from site to site or between infested and non-infested parts of the site. Spot spray in spring.

***Left**, Developing seed heads*
***Right**, Sketch showing mature seed head and ligule inside leaf joint*



Source: Hitchcock/Chase (1950)

Sweet Vernal Grass

Anthoxanthum odoratum

Description: Tufted grass with unbranched seed heads (like foxes tails) 1-9 cm long. Seed heads on a long, bare stem and are green-greyish, drying to gold. Leaves 2-5 mm wide. The whole plant has a new mown hay smell.

Some Wallaby Grasses (*Austrodanthonia* spp.) appear similar but mostly have hairy seeds and a fluffy looking seed head that does not turn golden. The native species also lack the distinctive hay smell.

Occurrence: Commonly associated with Montane vegetation, preferring wetter areas. Often on roadsides and track edges, as well as other disturbed areas.

Dispersal: Seed spread by wind, water, animals and slashing. Also in contaminated soil and machinery.

Control: Dig out or spot spray before seeding.

***Left**, leaves*
***Middle**, mature seed head*
***Right**, flower head*

Early Wintercress

Barbarea verna

Description: Care must be taken to distinguish this species from native species. NPWS should be notified. Belongs to the cabbage and mustard (Brassicaceae) family. Yellow flowers and rocket like leaves. Flowers early in the season.

Occurrence: Occurs around all the resort areas, particularly Perisher Range and Charlotte Pass.

Dispersal: Prolific seed production. Mainly spread through movement of soil and slashing.

Control: In most cases can be hand pulled. NPWS have been trialling a combination of hand pulling and herbicide application.

***Left**, Plant*

Right
Top, flower
Bottom, basal leaf

Cocksfoot

Dactylis glomerata

Description: Grass that forms dense tussocks with wide leaf blades (to c. 14mm) that tend to fold so that the upper half bends downwards. Membranous ligule and boat-shaped leaf tip. Compact, blunt-ended seed heads.

Occurrence: All the resort areas.

Dispersal: Spreads from roots and seed. Dispersed by wind, water, slashing and contaminated soil.

Control: Do not reuse soil that contains rhizomes. Ensure earth moving equipment is clean when moving from site to site or between infested and non-infested parts of the site. Spot spray in spring.

***Right**, immature seed head*

Vipers Bugloss

Echium vulgare

Description: Bright green, fleshy herb growing to about 50 cm high. Bright blue-purple flowers similar to Patterson's Curse, but more coarse, prickly hairs. Normally one main flower stem whereas Patterson's Curse is usually more branching.

Occurrence: Occurs in disturbed areas including roadsides and around resort areas and Snowy Hydro sites. Also along river beds.

Dispersal: Spread by slashing, vehicles and in contaminated soil and straw. Sticky seed can also be spread on fur or clothes. Benefits from fertiliser application.

Control: This is a Noxious Weed so control is mandatory.

Avoid over fertilising or broad scale fertiliser application in rehabilitation areas where Vipers Bugloss occurs. Ensure that straw mulch, machinery and other equipment is weed free. Do not use straw from an area where Vipers Bugloss occurs. Work and move from non-infested to infested areas rather than the reverse to avoid spreading seed to the weed free areas.

***Left**, flower*
***Right**, basal leaf rosette*

St John's Wort

Hypericum perforatum

Description: Branching herb up to around 60 cm high with small pale bluish green leaves. When held up to the light, numerous tiny oil dots can be seen in the leaves. Yellow flowers similar in form to briar roses but smaller. Flowers occur in summer, followed by tiny seed held in papery brown capsules.

Dies down in late Autumn and sprouts anew in Spring.

Occurrence: Common in disturbed areas all over KNP, especially dry areas where there is not much other vegetation.

Dispersal: Spreads in contaminated soil and on machinery, and in straw. Seeds stick to fur and clothes. Also produces underground runners by which the plant can be spread.

Control: This is a Noxious Weed so control is mandatory.

Small infestations can be hand dug and disposed of carefully, however, all underground runners must be removed. Otherwise spray and cultivate, taking care not to spread root fragments on machinery.

Do not use straw from an area where *Hypericum* occurs. Work and move from non-infested to infested areas rather than the reverse to avoid spreading seed to the weed free areas.

Does not tolerate strong competition from healthy vegetation so effective rehabilitation of disturbed areas may help exclude the species from some sites.

***Left**, flower*

***Middle**, plant*

***Right**, seed head*

Soft Rush
Juncus effusus

Description: Tussock forming rush occurring in wet places. Tubular round leaves filled with white pith that is dense and uniform.

Looks very similar to native *Juncus* rushes, however the stem of Soft Rush is very easy to compress between the fingers and white stem pith is continuous (in native *Juncus* the pith is often interrupted by air spaces).

Occurrence: Established in the Victorian Alps and starting to appear in KNP.

Dispersal: Fine seed is spread by wind and water. Also in contaminated soil and on boots and machinery.

Control: Notify the National Parks office in Jindabyne if you discover an infestation. Get the plants identified properly to ensure that it is not a native species. Prevent seeding by removing flowers and seed heads and destroying them. Clumps can be dug out or careful spot spraying can be carried out, using a wetting agent. Note that herbicide use is restricted near watercourses.

Right
Flower head
Below
Several plants

Photos in this section courtesy of Jackie Miles, except where otherwise credited.

A12.2 Other Common and Important Weeds Occurring in Kosciuszko National Park

Black or Spear Thistle (*Cirsium vulgare)* - Produces large quantities of seed that are dispersed by wind, water, and on the fur of animals, as well as on contaminated machinery, soil and straw. Many thistles are Noxious Weeds so control is mandatory.

Cotoneaster (*Cotoneaster* spp.) – Heavy seeder and invasive woody weed that requires persistent control. Commonly planted in the past around lodges and in former townships.

Broom (*Cytisus scoparius*) – 1-4 metre tall shrub with yellow pea flowers (sometimes with red or purple markings). Common along the Guthega Road, around Snowy Hydro Sites and in lower parts of the park. A Noxious Weed, therefore control is mandatory. Spreads in contaminated soil and on machinery so do not move or reuse soil from areas infested with Broom. Seed can last for 100 years in the soil so an ongoing control program is essential. Fire and disturbance may stimulate germination but it must be followed-up with comprehensive control to avoid creating a greater problem. Smaller plants can be dug or pulled out. Infestations are cut and painted or sprayed with herbicide.

Patterson's Curse (*Echium plantagineum)* – Spread by slashing, vehicles and in contaminated soil and straw. Sticky seed can also be spread on fur or clothes. Benefits from fertiliser application, therefore broad-scale spreading should be avoided in areas where this species occurs. Patterson's Curse is a Noxious Weed so control is mandatory.

Hawkweed (*Hieracium aurantiacum*) – Like an orange dandelion with hairy leaves and stem. Has become a significant weed in New Zealand, North America and is now spreading through the Australian Alps. Appeared in Kosciuszko in 2003. New infestations, if discovered, need to be controlled immediately. It is a Noxious Weed. Notify the National Parks office in Jindabyne immediately if you discover an infestation. Get the plants identified properly and removed from the site as quickly as possible. Prevent seeding by removing flowers and seed heads and destroying them.

Yorkshire Fog Grass (*Holcus lanatus*) - Prefers wetter areas with acid soils, including bogs. Often on roadsides and in drains but spreads insidiously into undisturbed areas.

Bird's-foot Trefoil (*Lotus* spp.) – Invades disturbed wet sites including drains and waterways. Very hard to control with herbicide.

Lupin (*Lupinus* spp.) – Colourful flower spikes and distinctive leaves arranged in a whorl of 9 or more, like a fan. Hairy bean like seed pods. Common around Cabramurra. Potentially very invasive in forest and wetter subalpine woodlands. Spread is most likely through contaminated soil. Plants can be chipped or spot sprayed.

Musk Monkey Flower (*Mimulus moschatus)* – Invades pools and dominates native vegetation.

Timothy Grass (*Phleum pratense*) – Spreads insidiously into undisturbed areas.

Pine (*Pinus* spp.) - Heavy seeder that was commonly planted in the past around lodges and in former townships. Only mature trees produce seed – immature plants should be controlled early.

Briar Rose (*Rosa rubiginosa*) - This is a Noxious Weed so control is mandatory. Woody weed that requires persistent control.

Blackberry (*Rubus* spp.) - This is a Noxious Weed so control is mandatory. Grows and spreads quickly and therefore should be controlled when first identified. Tends to be inhibited by very cold temperatures, therefore it is more of a problem in the lower parts of the Park.

Willow (*Salix* spp.) – This is a Noxious Weed therefore control is mandatory. Flourishes in wet areas, potentially choking bogs and streams (One species, *Salix cinerea* has become a significant problem invading bogs in the Victorian Alps). Roots easily from vegetative matter, and also from windblown seed. Isolated seedlings can be pulled out and destroyed. Infestations are treated by cutting in Summer or early autumn and painting or injecting with herbicide.

Mullein/Aarons Rod (*Verbascum thapsus*, also *V. virgatum*) – Burry seeds are very viable and spread easily on fur, clothing and machinery. Flower spikes are produced in the second year of growth so plants should be destroyed before flowering.

Periwinkle (*Vinca major* and other species of Vinca) – Periwinkles are very invasive and hard to control once established, therefore they should be controlled when first identified. They are most common on river banks and spread by broken off pieces of plant, like willows.

A12.3 Common weeds at lower elevations

These two potentially very invasive species must be controlled if found in the Park

African Lovegrass (*Eragrostis curvula)* – Thrives and easily dominates dry, low fertility soils where it also creates a fire hazard, as it is extremely flammable. Occurs on the Monaro and many lower areas surrounding the Park and has the potential to significantly affect KNP. African Lovegrass is a Noxious Weed so control is mandatory. Report any occurrence of the species to the National Parks office in Jindabyne and make sure it is positively identified. Care must be taken to distinguish this species from native *Poa* grasses. In the interim period, remove and destroy any seed heads.

Serrated Tussock (*Nasella trichotoma)* – Occurs on the Monaro but easily invades adjacent grassland and bush. Has the potential to significantly impact on KNP. The species is a Noxious Weed so control is mandatory. Report any occurrence of the species to the National Parks office in Jindabyne and make sure it is positively identified. Care must be taken to distinguish this species from native *Poa* grasses. In the interim period, remove and destroy any seed heads.

A12.4 Three weeds that are common but should be controlled

Minimising ground disturbance will reduce opportunities for these species to spread or become established in new areas.

Sheep Sorrel (*Acetosella vulgaris)* – Commonly found in Podocarp heath, snowpatch vegetation, subalpine woodland, sod tussock grassland, stream side vegetation and montane frost hollows, suggesting that these areas are probably more vulnerable to infestation, therefore extra precautions should be taken to minimise risk in these areas.

Cat's Ear/Flatweed (*Hypochaeris* spp.*)* – Commonly found in subalpine heath and montane frost hollows, suggesting that these areas are probably more vulnerable to infestation, therefore extra precautions should be taken to minimise risk in these areas.

Dandelion (*Taraxacum officinale)* – Generally prefers richer, more moist soils but occurs throughout the park.

A12.5 Other Exotic Species Recorded in KNP

Anagallis arvensis (Scarlet Pimpernel)
Aira caryophyllea
Alchemilla xanthochlora
Alnus glutinosa (Alder)
Alstroemeria aurea
Amsinckia calycina
Anthemis arvensis
Aphanes arvensis
Aranaria serpyllifolia
Arrhenatherum elatius
Avena spp. (Wild Oats)
Borago officinalis (Borage)
Bromus spp.
Callitriche stagnalis
Campanula ranunculoides
Capsella bursa-pastoris
Centaurium erythraea (Centaury)
Cerastium spp.
Chenopodium spp.
Chondrilla juncea (Skeleton Weed)
Collomia grandiflora
Conium maculatum (Hemlock)
Conyza bonariensis (Fleabane)
Crepis capillaris (and *C. virens*) (Hawk's Beard)
Dianthus barbatus
Diplotaxis tenuifolia
Elytrigia repens
Epilobium ciliatum (Willow Herb)
Erodium cicutarium
Erophila verna
Festuca rubra
Fumaria spp.
Gnaphalium coarctatum
Hordeum spp.
Hyacinthoides hispanica
Hypochoeris radicata
Ilex aquifolium (Holly)
Juncus spp.
Lamiastrum gemeobdolen
Lepidium spp. (Peppercress)
Leucanthemum spp. (Ox-eye Daisy)
Linaria arvensis (Toadflax)
Lolium perenne
Malus x domestica (Apple)
Malva spp.
Marrubium vulgare (Horehound)
Medicago lupulina and *M. sativa* (Black Medic)
Melilotus albus
Mentha spicata (Mint)
Moenchia erecta
Muscari armeniacum (Grape Hyacinth)
Myosotis discolor
Narcissus spp. (Jonquil)
Oenothera glazioviana
Onopordum acanthium (Scotch Thistle)
Oxalis corniculata
Paspalum dilatatum (Paspalum)
Pastinaca sativa
Penstemon sp.
Petrorhagia nanteuilii (Proliferous Pink)
Plantago lanceolata (Ribbed Plantain)
Poa annua and *P. pratensis*
Polygonum spp.
Populus alba (White Poplar)
Potentilla recta
Prunella vulgaris
Prunus cerasifera (Cherry Plum)
Quercus spp. (Oak)
Ranunculus muricatus and *R. repens*
Raphanus raphanistrum (Wild radish)
Reseda luteola (Weld)
Ribes uva-crispa
Rorippa palustris
Rumex spp. (Clustered Dock)
Sagina procumbens
Salvia verbenaca
Silene vulgaris
Sisymbrium officinale
Sonchus spp. (Sow Thistle)
Spergularia rubra
Stellaria graminea and *S. media*
Tragopogon dubius (Salsify/Goat's Beard)
Trifolium spp. (Clover)
Ulex europaeus (Gorse)
Veronica spp.
Viola arvensis
Vulpia spp.

Appendix 13
Simple Soil Testing Procedures

A13.1 Introduction

This appendix contains instructions on how to carry out some simple soil tests that will help you understand more about the characteristics of the soil you are working with. It includes instructions on how to identify the different soil layers, and tests for composition, dispersible clays, structure/compaction and infiltration.

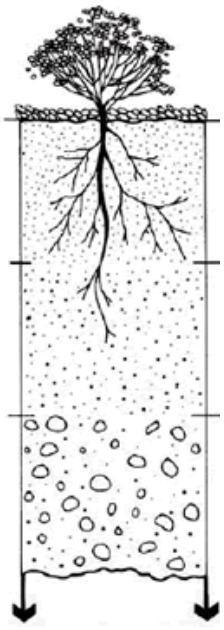
pH testing can also be easily carried out using a commercially available kit and following the enclosed instructions.

A13.2 Identifying the Different Soil Layers

As shown in Figure A13.1, most soils are made up of distinct layers, each of which has different characteristics. For plant growth it is the topsoil that is most important as this is where conditions are optimal for roots to develop and take up water and nutrients. All testing should be carried out on samples of topsoil.

In some soils, one or more of the horizons or layers shown in Figure A13.1 may be absent. In disturbed areas, often the topsoil is absent or degraded. You should try to identify the topsoil on your site and how thick it is, to determine whether there is an adequate amount for plant establishment or whether other strategies will be necessary to prepare the soil for planting.

Figure A13.1 The main soil layers or 'horizons' in the Kosciuszko area



O	Organic: decomposing plant material on the surface of the soil.
A	Topsoil: a mixture of organic and mineral matter. If uncompacted it should have an open texture with space for water and air between the grains of organic and mineral matter. Normally, the darker the soil the more organic matter it contains. Most alpine and subalpine soils in the Kosciuszko alpine area are high in organic matter.
B	Subsoil: usually high in clay or fine particles but in the alpine and sub-alpine areas it may be gravely due to the break down of the underlying granitic rocks. Generally subsoils are more compact or dense than the topsoil. A few deep roots may reach into the subsoil but most will remain in the topsoil.
C	Broken down, weathered material from the underlying rock.
R	Rock: the natural, underlying bedrock. Under most of the Kosciuszko area this is granite, which gives rise to gravely soils.

A13.3 Soil Tests

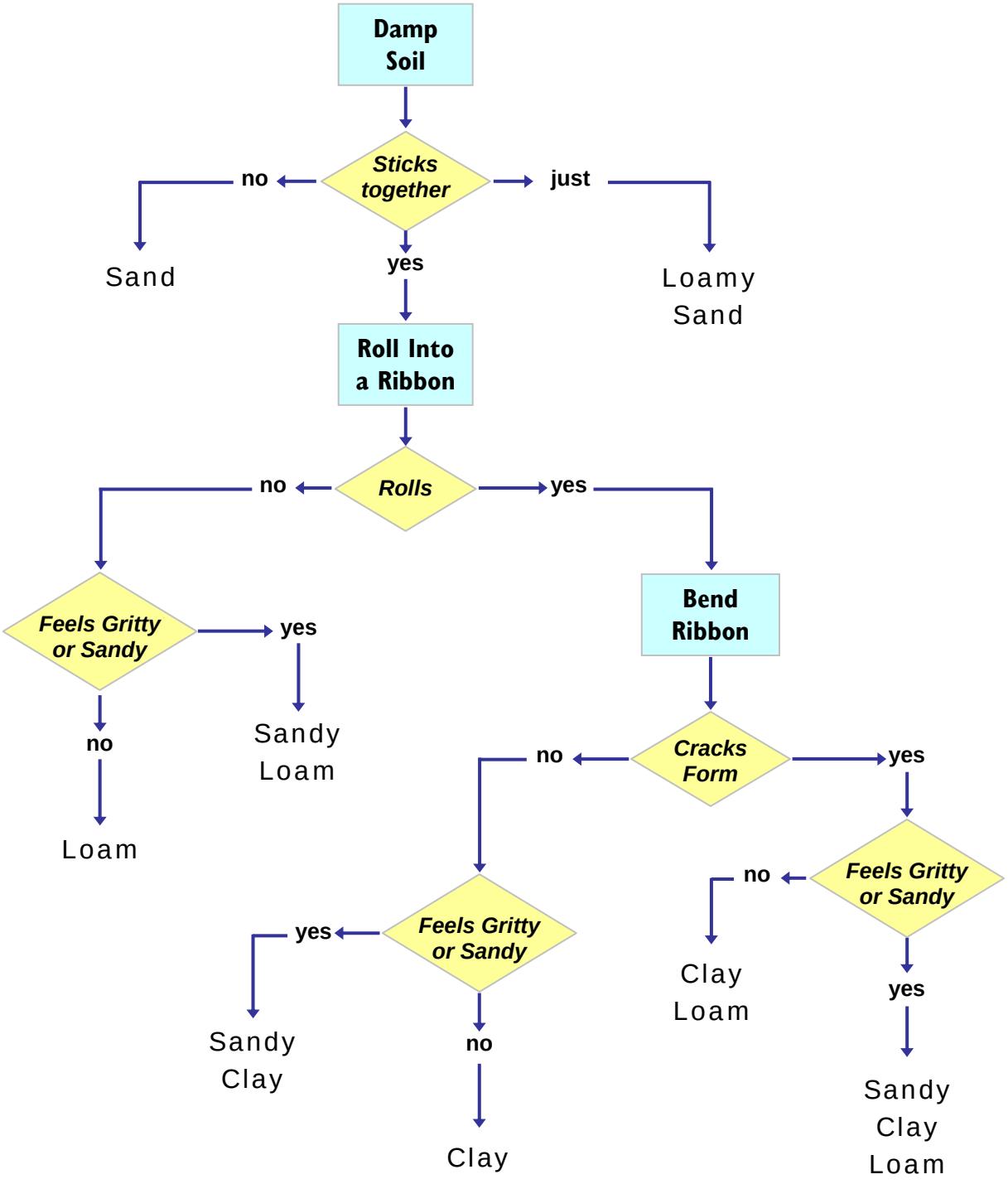
I. Soil Composition Ribbon Test

This test gives you an idea of the composition of your soil sample, that is, the relative proportion of sand, silt and clay that it contains. Knowing the composition of the soil will give you some idea how it will behave, including its erodibility.

Instructions:

i) Take a small handful of soil and dampen it enough so that it sticks together but is not oozy. It should have a similar consistency to plasticine or putty.

ii) Roll it around in your hands and work your way through the following flowchart to identify the soil type:



II. Simple Test for Dispersibilty

If your soil contains a large amount of clay, you may wish to test for dispersibility. Dispersible clays are clays which virtually dissolve in water and, because they are very fine, they easily pass through most sediment barriers. You can easily test to see whether the material you are using as a sediment barrier is adequate using the following test.

Instructions:

i) Line a funnel with a piece of the sediment barrier material and sit this over a large jar.
ii) Mix about half a cup of your soil sample with 1.5 cups of water – shake it vigorously.
iii) Pour the water into the funnel and allow it to filter through. You may need to leave it overnight for all the water to pass through.
iv) In the morning, remove the funnel and look at the water. Is it very cloudy? If so, it probably contains a large amount of dispersible clay which will pass through your sediment barriers. If this is the case, you may need to use a more sophisticated sediment retention system incorporating settling ponds.

III. Simple Test for Compaction

If soils are too compact it will be difficult for plants to establish. A good soil should have a crumbly texture (like breadcrumbs). Compaction can easily be tested by pushing a pencil into it with a normal, steady force. If the pencil goes in reasonably easily, the soil is not too compact. If you really have to push hard to make the pencil go in, you will need to cultivate the soil to loosen it up. The addition of sterile organic matter will also help reduce compaction.

IV. Infiltration Test

This is a simple test to see how well water soaks into the soil. Some soils have a poor absorption capacity resulting in increased runoff and erosion, while the soil itself is dry.

Instructions:

i) Prepare a can by removing both ends.
ii) Draw a line around the perimeter of the can, 3 cm from one end, using a permanent marker.
iii) Push the can 3 cm into the soil, until it reaches the line encircling the can.
iv) Quickly fill the can with water.
v) Time how long it takes for the water to soak completely into the soil.

It may take up to 10 minutes or longer for all the water to soak into a very compact or water repellent soil. More absorbent soils will soak up all the water in only a minute or two.

V. pH

To test the pH (acidity) of the soil, simple kits can be acquired from most landscaping/gardening suppliers.

Appendix 14

Rehabilitation in Asset Protection Zones

A14.1 Introduction

An Asset Protection Zone (APZ) is an area surrounding buildings and other assets that are vulnerable to bushfires. Within this area, vegetation and other combustible materials are managed to ensure that the risk to the asset is minimised. In particular, fine fuels that could easily ignite from embers, and potential paths by which a fire could move to the asset or into the canopy of woodland or forest are minimised. The size of APZ for a building or other asset is based on an assessment of slope and vegetation type. Generally the steeper the slope and the higher the fuel load of the vegetation, the greater the APZ will be.

This Appendix contains general guidelines for landscaping and managing vegetation within the APZ. It is not designed to replace a site specific bushfire assessment, however, the recommendations within it can be used to help protect existing buildings and other assets if nearby rehabilitation is planned. The information in this section is generally based on the following references, except where otherwise noted:

- Ramsy, C. and Rudolph, L. (2003) ***Landscape and Building Design for Bushfire Areas.***
- NSW Rural Fire Service (2006) ***Planning for Bushfire Protection*** - Appendix 5 contains information specifically about landscaping and property maintenance.
- ACT Planning and Land Authority (2005) ***FireWise Home Gardens*** (brochure).

Websites:

- NSW Rural Fire Service: http://www.bushfire.nsw.gov.au/index.cfm
- Bushfire Cooperative Research Centre: http://www.bushfirecrc.com/
- Australian National Botanic Gardens site - fire, gardens, and fire resistant plants: http://www.anbg.gov.au/bibliography/fire-plants.html

Full details of these references and other useful resources can be found in Appendix 19 (Resource List).

A14.2 Design of Plantings in APZs

The most important thing to consider when designing plantings is to ensure that there is defendable space around the asset to allow ample access for fire fighting.

Design plantings with the likely movement of a fire in mind. Use discontinuous plantings rather than large masses that can provide a path for the fire to the asset, or to other large areas of vegetation. Consider how to avoid ladder effects with vegetation height grading from short to tall, as this can result in the transfer of a ground level fire to the canopy. Generally trees and shrubs, or small groups of trees/shrubs should be well spread out rather than forming a continuous canopy. A 10 metre head separation is recommended to minimise the likelihood of a fire jumping from one area of vegetation to another.

Preferably, plants near the building/asset should be more widely spaced and lower growing than those used further away.

Trees and shrubs must not touch or overhang the building or asset. If possible, the head of the tree should not be within 5 metres of the building to minimise the potential for litter to build up around the building. They should be located far enough away from buildings that they will not ignite the building by direct flame contact or radiant heat emission.

Heathy shrubs should generally not be planted closer than 1.5 metres from buildings.

Consider using decorative rock features, container plants or garden art closer to the asset. Alternatively, moisture loving alpine forbs, snow grasses and ground covers would be preferable for use near to buildings.

Consider the potential for creating a wetland water feature nearer to buildings. Although alpine bogs will burn in the right conditions, the low growing vegetation and presence of water will make a fire easier to manage in these conditions, providing that access is adequate.

On steep ground, stone retaining walls can help to reduce the steepness of the slope and deflect heat away and upwards.

A14.2 Plant Selection

It should be noted that, in a severe fire all plants will burn. Some plants, however, burn more readily and dangerously than others.

When selecting trees and shrubs for use within the APZ, aim to choose species that do not retain dead material or deposit excessive quantities of ground fuel in a short period, particularly during the summer bushfire season. Avoid plants that:

- accumulate dead leaves and twigs,
- have loose or flaky bark, masses of fine leaves, or
- dry leaves with a high oil content (particularly *Eucalyptus*).

Also avoid plants that won't flourish and are prone to frost, drought or wind damage as they will tend to die off and retain dry, flammable sections.

Some species may be damaged by fire but do not carry it well. They may slow the progress of a fire and act as a good break. In general, the following observations have been made of the reactions to different indigenous vegetation communities to fire:

- Alpine heath is generally the most flammable part of the subalpine landscape (Good and Wahren et al. in Williams 2003). Continuous areas of heath should be minimised in APZs, especially on steep slopes.
- Sphagnum bogs often support a shrubby canopy and are surrounded by heath. During the 2003 fires, it was found that, if the surrounding heath burnt, the bog also invariably burnt (Williams 2003), although these fires have been reported to move slowly and erratically on bog. Planting or preservation of bog species on wet areas near buildings is unlikely to be hazardous if there is adequate discontinuity from large expanses of heath.
- Native grassland also grows on relatively wet areas and appears to have a low flammability. Many cases have been documented where fires burnt through dense heathland, causing 100 percent scorching, but went out as soon as they came up against grassland, on both gentle and steep slopes (Williams 2003).
- Alpine complex, which includes tussock grassland and alpine herbfield also appears to have a low flammability. According to an eye witness to the 2003 fires, "the Main Range acted as a fire break. Most of the western faces have been burnt, but, as the flames came over the main ridgeline and hit the alpine herbfields they petered out… snowgrass was only able to sustain the

fire while it had the heat and winds coming from the western faces, and in the Mt Carruthers-Twynam area the fire only progressed 30-50 metres into the snowgrass area… Snowgrass wasn't particularly flammable and snow daisies and pineapple grass almost have fire retardant status." (Dr Ken Green, in Worboys 2003).

Alpine complex and native grassland appear to offer great potential for use in APZs, because of their apparent fire retardant behaviour.

- Snowgum woodlands should be considered according to whether their understorey is heathy or grass/forb dominated. The trees should be treated as detailed in A14.1, ensuring there is clearance from trees and they do not create a path for fire.

A14.3 Mulch

Mulch can help to retain moisture around plants and allow the production of moist, green foliage, however, it should be used with care. It can be very flammable and contribute to fuel availability.

Consider also using pebbles, rocks and also effective use of shade to protect the roots of plants. Use of large logs can also reduce the need for finer mulches to be used. Dense logs burn more slowly than fine fuels and are a valuable habitat feature in natural environments.

Use just enough mulch to reduce weed growth, rather than thick mats of mulch. Keeping mulch away from the trunks of trees will help avoid ring-barking due to a fire. Have a watering system for the mulch if you have adequate water during the fire season, but avoid plastic or rubber components that will melt.

A14.4 Maintenance

The following measures should be undertaken regularly to control fire hazards:

- Control weeds, which often contribute to high fuel loads.
- Keep the APZ area clean and remove litter, leaves and dry branches.
- Keep grass short (less than 10 cm).
- Remove annuals and perennials once they have gone to seed and are beginning to dry out.
- Remove plants that have been, or are constantly being damaged and have dead, dry parts.
- Carry out regular pruning of other plants to remove dead or old foliage and encourage succulent new shoots.

A14.5 Furniture and Other Structures in the APZ

Consider the use of stone where possible rather than wood. If timber is used, give preference to heavy, fire retardant timbers. If thick enough, these timbers can sometimes be planed back and reused after a fire.

Consider how and where debris is likely to build up around the structure, such as in nooks and crannies and between floor boards.

Do not store fire wood, mulch or other combustible materials within the APZ unless they are within a shed that is well sealed to prevent the entry of burning debris.

Appendix 15

Basic Propagation Methods

A15.1 Introduction

Propagation and culture of native plants is a specialist field and it is generally recommended that this is carried out by a suitably qualified and experienced person or contractor. This guideline, however, provides some basic notes on propagation and culture of native species. It will provide you with an understanding of how plants need to be handled to ensure that they are healthy and suitable for use in rehabilitation.

Some additional notes on the specific requirements of various species suitable for rehabilitation in KNP are included in Appendices 19-11.

A15.2 Hygiene

As with all aspects of plant handling, hygiene is important to prevent the spread of disease and potential loss of a great deal of stock. A simple disinfectant can be made from a mixture of 20ml of domestic bleach in 1 litre of water. This can be stored for up to a week and re-used during that period. The mixture can be used for disinfecting hands, pots, benches and other equipment. Pots and tools should generally be soaked for 5-10 minutes.

A15.3 Propagation Media

There are two broad kinds of propagation media;

- seed raising mix is used for germinating seed and rooting cuttings; and
- potting mix is used for raising plants once their roots are well developed.

Seed Raising Mix

Recommended seed raising mix blends include:

- 1:1medium grade river sand and peat or coconut fibre (by volume); or
- 2:1 vermiculite and horticultural (not builders) perlite.

Seed raising mix should have a pH of 5 - 6.5, a fairly constant volume (whether wet or dry), retain moisture enough to minimise the need for frequent watering and be free from weeds, pests or diseases.

Potting Mix

Potting mix should:

- comply with AS 3743.1996;
- include native plant fertilizer with trace elements (e.g. Osmacote™ native plant mix);
- have a pH of 5 - 6.5;
- have a fairly constant volume (whether wet or dry),
- retain moisture enough to minimise the need for frequent watering; and
- be free from weeds, pests or diseases.

Potting mix should not contain soil unless it is required to contribute mycorrhizae for certain species.

Sterilising Propagation Media

Small quantities of propagation media can be sterilised so that it is free of weeds, pests and diseases, by moistening it, placing it in an oven bag and heating to a temperature of 60^{o} for 30 minutes. Large quantities should be sterilised commercially.

Pots, germination trays, hands, work surfaces and tools can be sterilised in a bath of 20ml laundry bleach to 1 litre of water. Pots, germination trays and tools should be soaked for 5-10 minutes in the disinfectant.

A15.4 Germination Trays

Germination trays, about 150 x 100 x 50 mm are useful for germination of large quantities of seed.

A15.4 Breaking Seed Dormancy

Many native species will not germinate unless they are specially treated to break dormancy. Some notes on techniques to break dormancy in specific KNP species have been included in Appendix 2. Ralph (2003) provides useful information on propagation techniques for many native species (refer to resource list, Appendix 6). The two most common treatments used include heat treatment and cold treatment.

- Heat treatment involves adding the seed to boiling water and boiling for 1 minute before allowing it to cool in the water. Seed with a semi-hard coat may only need to be soaked in water that has boiled rather than boiling it.
- Cold treatment is commonly required for alpine species. There are two alternatives; either the seed may be stored for several weeks in the fridge before planting, or it could be sown before being covered in a plastic bag (to reduce drying) and placing it in the refrigerator.

In general, species that do not require special treatment will germinate at temperatures of 15-20^{o}.

A15.5 Sowing Seed

Sow into moist planting medium by sprinkling evenly over the surface but not too densely. Expect a significant proportion of seed to succumb to pathogens. Very fine seed can be sown by mixing with sand or using a salt shaker. Once the seed is sown, it should be covered lightly – as a general rule, cover to the same depth as the thickness of the seed. For very fine seed an equally light sprinkling of sand will be necessary. Coarse seed can be covered with a mulch of grit or sand which will prevent a crust forming on the surface and make even watering easier.

Water each tray immediately and mark it with the name of the species it contains, where the seed was collected and the date of sowing.

A15.6 Watering

The seed raising mix should be kept damp but not overly wet. With some very fine seed and seedlings, overhead spraying can be damaging therefore an alternative is to create a ‘bog’ in which the germination tray sits and draws up water from below. This can be done using the method shown if Figure A15.1.

Once seed has germinated, watering once or twice a day, to keep soil moist, should be adequate. Avoid over-watering as this is likely to encourage disease.

A15.7 Light

Once seed has germinated it should be placed in a location with warm, gentle, even light. Inadequate light may produce weak, leggy seedlings. Too much light can result in the seedlings drying out.

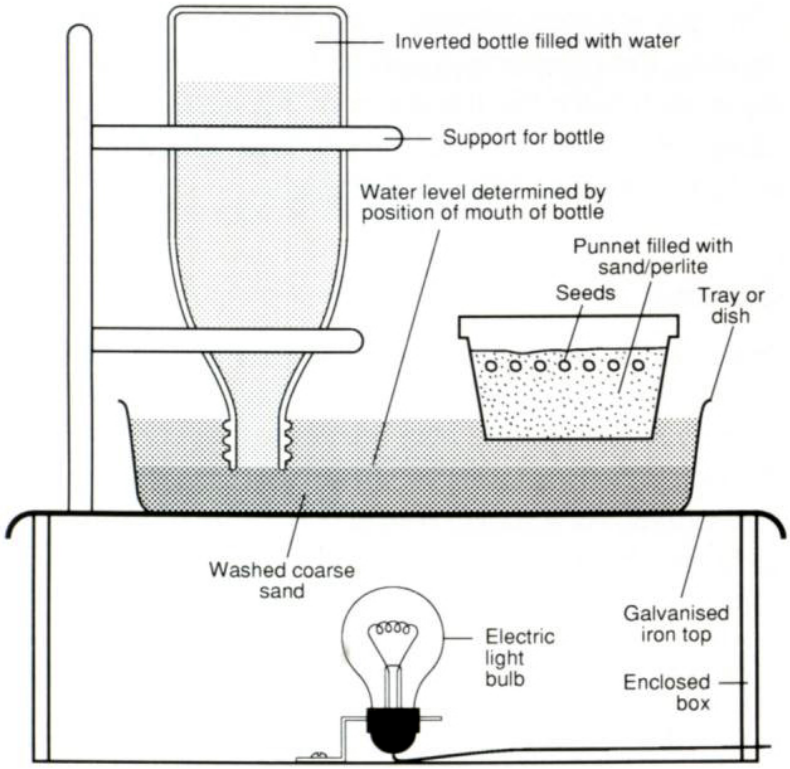


Figure A15.1 Alternative method for keeping fine seed moist

Source: Greening Australia (undated brochure)

A15.8 Ventilation

Good air circulation is necessary to minimise the potential for disease. Too much wind, however, may be drying.

A15.9 Fertilising

While they are germinating seedlings generally do not require fertiliser, however, once they are pricked out, weekly fertilising may help the plants to establish and grow more vigorously.

A15.10 Pricking Out

When they germinate, seedlings generally produce one or two special seed leaves (cotyledons) first. After this the first set of real leaves appears. Generally, once a small shoot appears above these (or the plant is 1-2 cm high), the plant is ready for 'pricking out', or transplanting to an individual pot.

A small poker or 'dibble stick' (e.g. an old knitting needle) can be used to remove the plant from its tray. To avoid damaging it, hold it by a cotyledon. Try to distribute the roots evenly when planting the seedling – avoid placing them so that they become kinked as this can impact on the long term survival of the plant (particularly trees).

A15.4 Sizing Tubes and Pots

When they are first pricked out, seedlings should be planted first into tubes (pots) with a diameter of 4-5 cm (1.5 – 2 inches). As a general rule, they can be grown in these until their height nears that of the tube, after which they should be potted up with the size of the pot chosen in proportion to the rate at which the plant grows. If a pot that is too large is used, the unused soil in the pot may become 'sour' before the roots of the plant reach it.

Plants should be grown on to 7.5 cm pots for planting out, although 5cm pots or tubes may be adequate for forbs, sedges and grasses.

Appendix 16

Checklist for Quality Control of Tubestock

Pots	**Check**
Woody plants are provided in round 7.5 cm pots*.	☐
Grasses, sedges and/or forbs are provided in round 5 - 7.5* cm pots.	☐
Plants fill their pots well.	☐
Potting media in the pot is moist, with an even, non-crusty surface, and is not drawing away from the edges of the pot.	☐
Shoot Development	
Grasses: • Should be rapidly putting out new blades and have at least 10 live blades.	☐
Forbs: • Rhizomatous plants, such as *Helichrysum rutidolepis*, should have strong rhizome growth, i.e. you should see shoots coming up in different parts of the pot, from roots under the soil, or roots forming where stems touch the ground. • Rosette forming plants should have a strongly growing, fleshy, rosette.	☐ ☐
Shrubs: • Should have a sturdy stem as this will provide plenty of carbohydrate to help withstand transplant shock.	☐
Root Development	
Roots should be actively growing and have fleshy looking white or bright coloured tips.	☐
Roots fill the container well but are not too tight. They do not spiral around the base of the pot (especially woody species).	☐
Hygiene	
There are no signs of disease (e.g. withered or discoloured leaves, or deformed growth).	☐
No pests are visible (e.g. tiny worms or bugs in soil, on roots or shoots).	☐
The pot is free from weeds.	☐

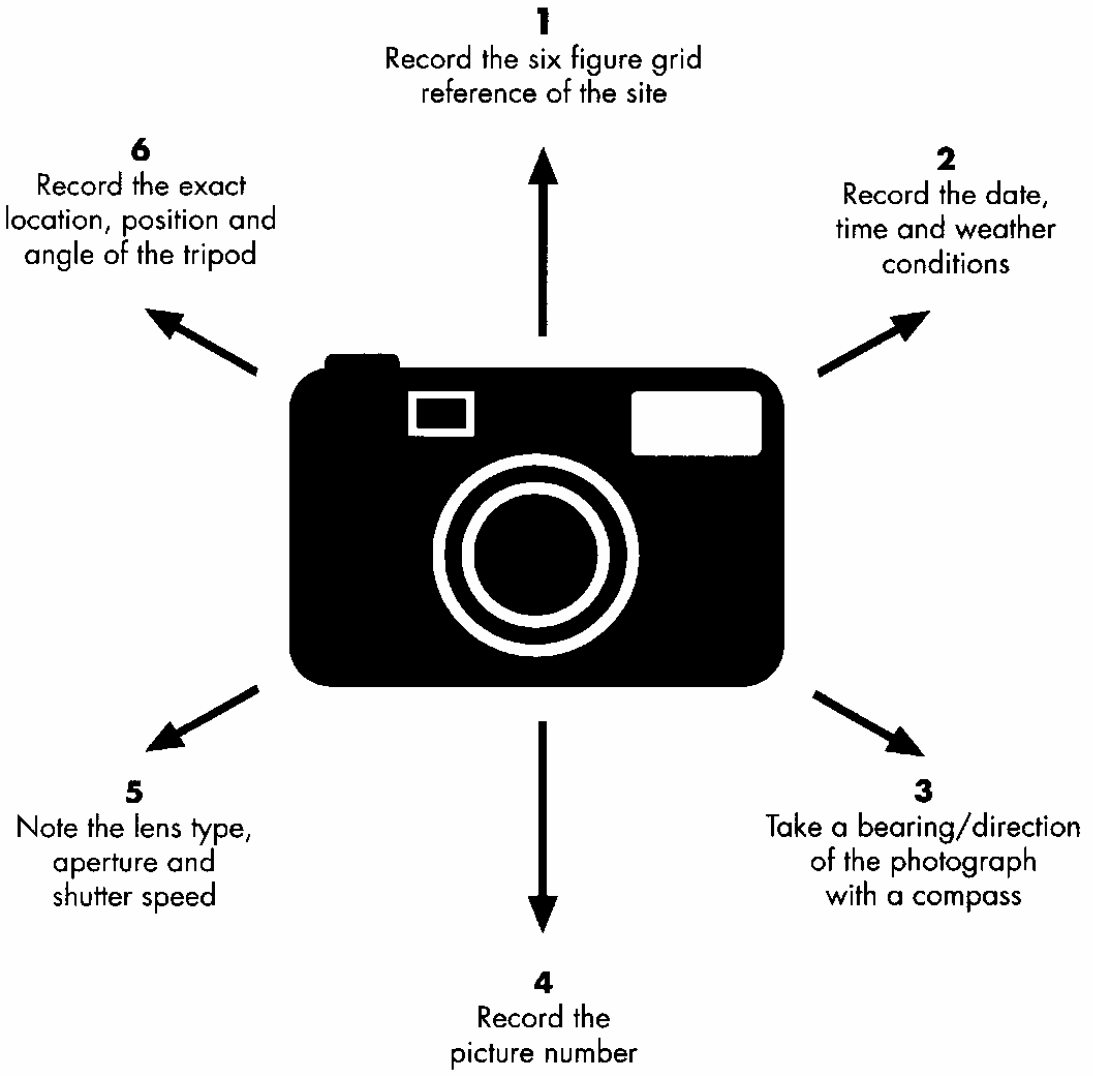
* Note that if plants are destined for a site with shallow soil, smaller sized pots may be acceptable.

Appendix 17

Monitoring Technique: Photo-points

Photo-points are useful for long term site monitoring. They enable comparisons to be made showing changes on the site over different periods of time. The technique basically involves photographing the site from a fixed point at regular, repeated intervals. For a large site, several different points would be used.

The diagram below explains how to establish and use photo-points.



Adapted from Davies *et al.* (1996)

Suggested equipment: Use a good quality SLR camera with a wide angle lense (28-35 mm) and coloured film or high resolution digital images. For sites that will be monitored over a very long term (e.g. over 10 years), black and white film is preferable as it does not fade and loose detail as fast as coloured film.

Include an object for scale, e.g. ruler, people.

You may want to mark the site of photo-points with a permanent marker to make it easier to relocate the point.

Appendix 18

Monitoring Technique: Landscape Function Analysis

Landscape Function Analysis (LFA) is a monitoring procedure developed by the CSIRO. It provides a rapid, reliable, and easily applied method for assessing and monitoring landscape restoration or rehabilitation projects.

LFA examines the way physical and biological resources[6] are acquired, used, cycled and lost from a landscape. For example, water is a landscape resource that can be stored in the landscape, providing for maximum benefits, or may run off and become lost from the system, often taking soil and other resources with it. The manner in which each type of landscape resource is utilised within local catchments influences the individual characteristics or 'function' of the site. These characteristics can be easily measured to provide indicators of different aspects of the functioning of the overall system.

LFA is based on assessment of specific landscape characteristics. On a broad scale, LFA assesses the location and size of vegetation "patches", where resources accumulate, and bare soil areas ("inter-patches"), where resources may be mobilised and lost. By measuring patches and inter-patches over time, the rate and extent of vegetation cover achieved by rehabilitation can be assessed, thus providing evidence of rehabilitation success. This information also gives an insight into whether the rehabilitation area is achieving self sustainability (i.e. a landscape is developing in which minimal resources are lost due to stress or disturbance). This insight is possible because patches of vegetation tend to correlate to areas where natural resources accumulate, whilst inter-patches represent areas where resources are easily transported and, therefore, potentially lost from the system. A landscape where resources are well retained and utilised is referred to as "functional", whilst one that loses resources is, to some extent, "dysfunctional".

On a finer scale, LFA also assesses the "quality" of the patches and inter-patches. Eleven simple, rapidly collected soil surface indicators are used to give an estimate of the effectiveness of a number of landscape processes (refer to table A18.1). In different combinations, these indices can also be combined to indicate the surface stability, infiltration capacity and nutrient cycling potential of the study area. Overall, these indicators can be interpreted to assess whether the natural resources of the site are being lost, maintained or enhanced over time.

LFA is recommended for the assessment and monitoring of rehabilitation work because it offers a range of advantages, including the following:

- At the pre-rehabilitation stage, LFA allows the specific processes needing improvement to be identified.
- LFA can be applied to sites of all sizes, from an individual patch to a hillside; and all ecosystem types.
- LFA also offers a detailed insight into how the landscape function at the rehabilitation site changes over time, and facilitates numerical comparison of restored/rehabilitated sites against reference sites.

LFA is an ideal monitoring tool for rehabilitation work because it is easy to learn, simple and quick to apply, and it provides clear indicators of the progress and condition of rehabilitated areas.

[6] Landscape resources include substances such as topsoil, organic matter, seeds, water etc.

Further information and LFA training workshops can be organised by contacting:

David Tongway
Phone 0419 861 615
Fax: (02) 6254 7162
dtongway@iinet.net

Table A18.1: Soil Surface Indicators considered in LFA

Indicator	**Significance**
Rain-splash protection	Indicates how well soil surface is protected from the impact of rain drops, which influences erosion and crust formation. Crusting on the surface of the soil increases water runoff, and hence, the potential for the system to loose resources.
Perennial Vegetation Cover	Amount of vegetation cover is an indicator of below-ground biomass accumulation, an indicator of nutrient cycling.
Litter	The amount of litter, its origin and degree of composition has a strong influence on soil stability and nutrient cycling.
Cryptogam Cover	The presence of algae, fungi, mosses and lichens on the soil surface indicate surface stability and nutrient availability.
Crust Brokenness	Broken crusts indicate innately unstable surfaces that provide loose soil material that is easily eroded.
Soil Erosion Type and Severity	Indicates relative soil stability and potential for the loss of resources from the system. Soil erosion also infers a low water infiltration rate.
Deposited Materials	Detects instability upslope by observing the presence of materials washed down from areas above the site.
Soil Surface Roughness	The presence of surface irregularities contributes to the ability of the ground to capture and retain resources carried by water flowing across the surface.
Surface Nature	Indicates how easily the soil is able to release erodible material when mechanically disturbed. Also indicates potential for infiltration and run-off.
Slake Test	Assesses the stability of natural soil fragments when subject to rapid wetting. Unstable soil may begin to erode simply because it becomes wet.
Soil Surface Texture	Classifies soil texture, which influences permeability.

Appendix 19

Resource List

(including references)

A19.1 Kosciuszko National Park

Publications

Cameron-Smith, B. (1999) ***Plants and Animals of the Australian Alps***, Envirobook, Annadale, NSW.

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Costin, A., Gray, M., Totterell, C. and Wimbush D. (1979-2000) ***Kosciuszko Alpine Flora***. CSIRO Publishing Collingwood, Victoria.

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Environment Australia (EA) (2002) **Recovery Plan for the Threatened Alpine Flora: Anemone Buttercup (*Ranunculus anemoneus*), Feldmark Grass (*Erythranthera pumila*), Raleigh Sedge (*Carex raleighii*) & Shining Cudweed (*Euchiton nitidulus*)**. NSW National Parks and Wildlife Service, Internet version: http://www.deh.gov.au/biodiversity/threatened /recovery/alpine-flora/index.html

Good, R.B. (1992) ***Kosciusko Heritage***. National Parks and Wildlife Service of New South Wales, Surrey Beatty & Sons Pty Ltd.

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Independent Scientific Committee (ISC) (2002) ***An assessment of the values of Kosciuszko National Park – interim report***. NSW National Parks and Wildlife Service.

McDougall, K.L. and Walsh, N.G. (2002) ***The flora of Nungar Plain, a treeless sub-alpine frost hollow in Kosciuszko National Park.*** **Cunninghamia** 7(3): 601-610

McDougall, K.L. and Wright, G.T. (2004) ***The impact of trampling on feldmark vegetation in Kosciuszko National Park, Australia***; **Australian Journal of Botany**, 52, 315-320.

NPWS (1988) ***Kosciuszko National Park Plan of Management (Second Edition)***.NSW National Parks and Wildlife Service.

NPWS (2000) ***Plan of Management, Kosciuszko National Park, Consolidated Version***. NSW National Parks and Wildlife Service.

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Williams, R.J. (2003) ***Fire Ecology and Management in Victorian Alpine Landscapes***, submission to the Victorian Government enquiry into the bushfires of January 2003.

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Websites

Australian Alps Liaison Committee page on KNP: http://www.australianalps.deh.gov.au/parks/kosciuszko.html

Parks and Wildlife website – Kosciuszko National Park home page: http://www.nationalparks.nsw.gov.au/parks.nsf/parkContent/N0018?OpenDocument&ParkKey=N0018&Type=xo

A19.2 Rehabilitation, Plant Propagation and Seed Collection

Publications

Australian Network for Plant Conservation Germplasm Working Group (1997) ***An introduction to the principles and practices for seed and germplasm banking of Australian Species***. Produced by the Australian Network for Plant Conservation, Canberra.

Australian Network for Plant Conservation (2003) ***Plant Conservation: approaches and techniques from an Australian perspective***. Produced by the Australian Network for Plant Conservation, Canberra.

Dalton, G. (1993) ***Direct Seeding of Trees and Shrubs: a manual for Australian conditions***. SA Department fo Primary Industries, Adelaide.

Drury, Markwell (2001), ***VAM, Zn and P effects and interactions in Alpine Ecosystems***, in **Australian Institute of Alpine Studies Newsletter**, January 2001, AIAS, Jindabyne.

Far South Coast Landcare Association (undated) ***Community Seedbank***. Notes on seed collection. Supported by the Southern Rivers Catchment Management Authority.

Florabank (1999)a ***Guidelines 2: Basic Methods for Drying, Extraction, and Cleaning of Native Plant Seed***. Florabank, Canberra.

Florabank (1999)b ***Guidelines 6: Native Seed Collection Methods***. Florabank, Canberra.

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Greening Australia (undated) ***How to Germinate Native Tree and Shrub Seed Enjoyably***. Pamphlet published by Greening Australia with support from the Australian Nature Conservation Agency and Pacific Waste Management.

Parr-Smith, G. and Polley, V. (1998) ***Working Draft Alpine Rehabilitation Manual for Alpine and Sub-alpine Environments in the Australian Alps***. Australian Alps Liaison Committee December 1998.

Ralph, M. (1993) ***Seed Collection of Australian Native Plants***. Bushland Horticulture, Fitzroy, Victoria.

Ralph, M. (2003) ***Growing Australian Native Plants from Seed***. Murray Ralph/Bushland Horticulture, Fitzroy, Victoria.

Vallee, L., Hogbin, T., Monks, L., Makinson, B., Matthes, M. and Rossetto M. (2004) ***Guidelines for the Translocation of Threatened Plants in Australia***. Australian Network for Plant Conservation, Canberra.

Websites

Links to a vast range of useful resources are available on the Australian Network for Plant Conservation website: http://www.anbg.gov.au/anpc/web.html

A19.3 Weed Management

Publications

Australian Alps Liaison Committee (1998) ***Alps Invaders: Weeds of the High Country.*** A full-colour weed identification book.

Blood, K. (2001) ***Environmental Weeds, A field guide for South Eastern Australia***. CH Jerram Science Publishers.

CRC for Weed Management and Commonwealth Dept. Environment and Heritage (2004) ***Introductory Weed Management Manual***. Available online at http://www.weeds.crc.org.au/publications/weed_man_guides.html, or in hard copy from State Government Agencies, the Commonwealth Department of the Environment and Heritage, or the Weeds CRC.

Ensbey, R. (2004-2005) ***Noxious and Environmental Weed Control Handbook: a guide to weed control in non-crop, aquatic and bushland situations***. NSW Agriculture, Orange.

Hitchcock, A.S. (rev. A. Chase) (1950) ***Manual of the grasses of the United States***. USDA Misc. Publ. No. 200. Washington, DC.

Miles, J. and Campbell, M. (2004) ***Weeds of the Monaro***. Pamphlet produced by the former South East Catchment Management Board and Snowy Riiver Shire Council (available from Council).

Muyt, A. (2001) ***Bush Invaders of South Eastern Australia***. RG and FJ Richardson.

Parsons, W. and Cuthbertson, E. (1992) ***Noxious Weeds of Australia***. Inkata Press.

Robinson, Kim (1999) ***Australian Alps Weed Management Manual: Ecoplan for Australian Alps Liaison Committee***, February 1999. - An identification and treatment guide for staff and contractors working in the Australian Alps national parks.

Websites

Commonwealth DEH invasive species site – contains comprehensive pages about on many important weeds: http://www.deh.gov.au/biodiversity/invasive/index.html

CRC for Australian Weed Management website: http://www.weeds.crc.org.au

NSW Agriculture weed management site with lots of information on weed identification and control: http://www.agric.nsw.gov.au/reader/weeds

Weeds Australia website: http://www.weeds.org.au

A19.4 Soil Evaluation and Protection

Publications

Davies, P., Loxham, J. and Guggon G. (1996) ***Repairing Upland Path Erosion***. Joint publication by the Lake District National Park, British National Trust and English Nature, in association with the British Upland Footpath Trust and the Countryside Commission.

International Mountain Bicycling Association (IMBA) (2001) ***Building Better Trails – Designing, constructing and maintaining outstanding trails***. IMBA, Boulder, Colorado, USA.

Landcom (2004) ***Managing Urban Stormwater: Soils & Construction***. Volume 1, 4th Ed., including Hip Pocket Handbook.

McKenzie, Niel, Coughlan, Kep and Cresswell, Hamish (2002) ***Soil Physical Measurement and Interpretation for Land Evaluation***. CSIRO Publishing, Collingwood, Victoria.

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Parr-Smith, G. and Polley, V. (1998) ***Working Draft Alpine Rehabilitation Manual for Alpine and Sub-alpine Environments in the Australian Alps***. Australian Alps Liaison Committee December 1998.

Tongway, D.L. and Hindley, N.L. (2004) ***Landscape Function Analysis Manual***. CSIRO Sustainable Ecosystems, Canberra.

Websites

The Canadian CMHC website has a good page on soils including information on some simple soil testing proceedures: http://www.cmhc-schl.gc.ca/en/burema/gesein/abhose/abhose_073.cfm

A19.5 Fire Behaviour and Vegetation in Asset Protection Zones

Publications

ACT Planning and Land Authority (2005): ***FireWise Home Gardens***, brochure available on line at: http://www.actpla.act.gov.au/publications_forms/publications

NSW Rural Fire Service (2006) ***Planning for Bushfire Protection***. Prepared by the RFS in collaboration with Planning NSW (Department of Planning) – Appendix 5 contains information specifically about landscaping and property maintenance. Available at RFS website, see below.

Ramsy, C. and Rudolph, L. (2003) ***Landscape and Building Design for Bushfire Areas***. CSIRO Publishing.

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Worboys (2003) ***A Report on the 2003 Australian Alps Bushfires***, in **Australian Institute of Alpine Studies Newsletter No. 15**, June 2003.

Websites

NSW Rural Fire Service: http://www.bushfire.nsw.gov.au/index.cfm

Bushfire Cooperative Research Centre: http://www.bushfirecrc.com/

Australian National Botanic Gardens site listing a range of resources relating to fire, gardens, and fire resistant plants: http://www.anbg.gov.au/bibliography/fire-plants.html

A19.6 Other General Resources

Publications

Alpine Flora (2004) ***Rehabilitation Plan- Hotham Chalet***. Prepared by Liz MacPhee, Snow Road, Milawa, Victoria, 3678. November 2004.

Australian Alps Liaison Committee (2005) ***Australian Alps Education Kit***, prepared by the Australian Alps Liaison Committee November 2005.

Costermans, L. (2000) ***Native Trees and Shrubs of South-eastern Australia***. Lansdown Publishing.

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Hennessy, K., Whetton, P., Smith, I., Bathols, J., Huchinson, J., Sharples, J. (2003) ***The Impact of Climate Change on Snow Conditions in Mainland Australia***. CSIRO, Victoria.

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MacPhee, L. (2000) ***Mount Feathertop Walking Track Strategy for Vegetation Restoration***. Prepared for Parks Victoria, Ovens.

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Preston, B.L. and Jones, R.N. (2006) ***Climate Change Impacts on Australia and the Benefits of Early Action to Reduce Global Greenhouse Emissions***. CSIRO, A consultancy report for the Australina Business Roundtable on Climate Change, February 2006.

Whinam, J. and Chilcott, N. (2002) ***Floristic description and environmental relationships of Sphagnum communities in NSW and the ACT and their conservation management***. **Cunninghamia** Vol 7(3).

Williams, R.J. (2003) ***Fire Ecology and Management in Victorian Alpine Landscapes***, submission to the Victorian Government enquiry into the bushfires of January 2003.

Websites

Australian Institute of Alpine Studies - information and contact details of people studing alpine issues: http://www.aias.org.au/

NSW National Parks website summarising many characteristics of the Australian Alps Bioregion: http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Australian+Alps+Bioregion

NSW Threatened Species, Populations and Ecological Communities website: http://www.threatenedspecies.environment.nsw.gov.au/

Publications on the Australian Alps (Victorian website): http://www.australianalps.deh.gov.au/publications/

Wetlands International *Directory of Wetlands of International Importance*: http://www.wetlands.org/RDB/Directory.html

A19.7 Rehabilitation Courses and Training

Alpine Rehabilitation Course – run in alternative years by the Centre for Applied Alpine Ecology, Latrobe University.