

management is used, it should be ecologically appropriate for the district and for the site, and meet with the approval of adjacent landowners and managers. It should also be cost-effective. The most labour-free method is usually the most cost-effective. Systems of management should be as self-perpetuating as possible. The amount of tending and degree of grooming will need to be related to the archaeological value of the site. For example, if a site has been so badly disturbed that the stratigraphy is ruined and only major earthworks remain, it would be inappropriate to keep it in a high-maintenance ground cover such as a mown grass sward. Low bracken or a shrubland would be more appropriate. If a site is in a native shrubland cover, there would have to be compelling reasons to attempt to place the site in grass.

### **2.2.1 General principles**

The techniques described here are based on field experience of archaeological sites, plant ecological and physical processes, and site management from throughout New Zealand (Hamel & Jones 1982; Jones & Simpson 1995a, b). Some key species in site management (both good and bad) are restricted to certain climate zones. The concept of 'warm temperate' is used to cover districts from coastal Marlborough northwards, and 'cool temperate' is used for the balance of the South Island and the North Island's volcanic plateau. Of course, many species, such as manuka and gorse, occur throughout New Zealand, and the principles associated with their management are widely applicable.

The other major distinction that is relevant is the physical consistency of soil. The main concern is with friable soils, such as many of the soils derived from volcanic ash or from dune sands. Where this distinction is needed, it is satisfactory to refer to 'friable' soils and 'firm' soils.

The next section gives a broad outline of the types of stabilising vegetative cover that are appropriate to different settings and management objectives. At most sites, the basic vegetation cover will be in place before any management actions are contemplated. It can be manipulated, but it is unlikely to be possible to effect a complete and rapid change of the vegetative form without risk to the site. Most sites will have some weed problem or weed risk, and site surface visibility may not always be maintained over time as tall or woody vegetation develops. The management objective of site visibility, where it pertains, may not be achievable in the longer term. Perhaps the most rapid change on grassland that can be effected is to cease animal stocking, but this is not always recommended. Likewise, it is seldom desirable to remove shrubland or forest, or to initiate grazing or mowing.

There is no justification for plantation forestry on archaeological sites. Within afforestation programmes, careful management is needed to keep sites unplanted, and free of risk at harvest time.

***Desired or established vegetation type, and regime for site conservation***

**Grass or grass-legume-herb swards**—the most desirable cover for views of a site in its landscape context and for visitor appreciation. May require management of the soil fertility. Will require cutting, mowing, or grazing to prevent scrub invasion. In rare circumstances, periodic drought or fire may maintain the grassland. Timing of cutting is important to allow desired species to flower and set seed. Requires removal of noxious or undesirable weeds. Without clear conservation objectives, grazing and farm management routines will override the need for site protection.

**Young native trees, early several stages**—a good protective cover, but will not normally allow for public appreciation of the site. Management intervention depends on whether succession to trees is desired. If not, then occasional cutting or selective removal of potentially large trees is required.

**Low-growing or ground-cover shrubs**—a stable and easily managed cover for sites where protection of subsurface remains is desired. Needs infrequent removal of seedlings of potentially large trees to prevent forest growth. This is recommended as the optimum long-term cover for sites.

**Mature native forest**—the most stable of vegetation forms with least potential to disturb surface earthworks. Attractive cover for sites open to the public. Thinning of trees can be undertaken to provide a ‘gallery forest’ and canopy to prevent erosion. Planting in (or encouragement of) ground covers and replacement canopy trees can be undertaken. Where species are being chosen for establishment or renewal they should be growing locally or sourced from local provenances.

A number of species, with an indication of their form and the habitats in which they flourish, are contained in ‘Native covers for archaeological sites—what plant, where?’ (Appendix 3) and ‘Native grasses and other ground-hugging covers’ (Appendix 4). Notes on the establishment or encouragement of some of these plants, with particular emphasis on conditions and needs as they apply to conservation of archaeological sites, are set out below. Guidelines on aspects of native plants which have some applications in archaeological site conservation include National Water and Soil Conservation Authority (1986), Porteous (1995) and Waitakere City Council (1997); specifically for coastal dunes are Bergin & Herbert (1998), Bergin & Kimberley (1999), and Bergin (2000).

Ecological restoration and archaeological site conservation are not the same process. On the one hand, care should be taken in evaluating archaeological and historic values in all forest restoration projects. On the other hand, significant native trees such as well-established pohutukawa or historic trees growing on a site of less than outstanding importance should not be removed to preserve surface archaeological features. It should also be remembered that local people, especially tangata whenua, may have views on vegetation management that should be discussed with them. They may wish to retain certain species, such as pohutukawa,

totara, and ti (cabbage trees). In historic reserves or other areas where there are archaeological sites, any planning for vegetation restoration should follow conservation planning for the historic site.

### 2.2.2 Low vegetation (less than 120 cm tall)

#### Pohuehue (*Muehlenbeckia* spp.)

This is an adaptable genus of native ground covers which can be readily maintained so long as trees do not overshadow them. The two common species are *Muehlenbeckia australis* and *M. complexa*. The former will smother small trees and is considered by some to be a weed in some native vegetation associations (such as treelands or shrublands with an open canopy). Creeping pohuehue (*M. complexa*) is a smaller plant, suited to open areas and the best cover for archaeological sites. It could be used instead of bracken to cover steep slopes and banks of earthworks which should remain visible, but covered (Fig. 9A). The adult plant is intolerant of water-logging, but will grow well on a wide variety of soils from clay to sand with some humus (Brock 1996). In good soils, it does not compete well with production grasses. It is common on stony or harsh ground (e.g. on banks or gravel beds or tumbling over holes). Although grazed by cattle, older plants are rarely browsed by sheep. In fenced-off areas, old stems running along the ground may reach 1-2 cm diameter, forming a tough network. On Station Bay pa, Motutapu, where animals have been fenced out and grazing prevented for three decades, the predominant ground cover is a naturally adventive, open-textured mat of *Muehlenbeckia complexa* overlying stems of cocksfoot (Jones & Simpson 1995b: 23, and fig. 14B).

#### Flax, harakeke (*Phormium* spp.)

*Phormium cookianum*, the smaller and hardier of the two *Phormium* species, is the only flax tentatively recommended for archaeological site conservation because of its smaller root system. On grassed coastal

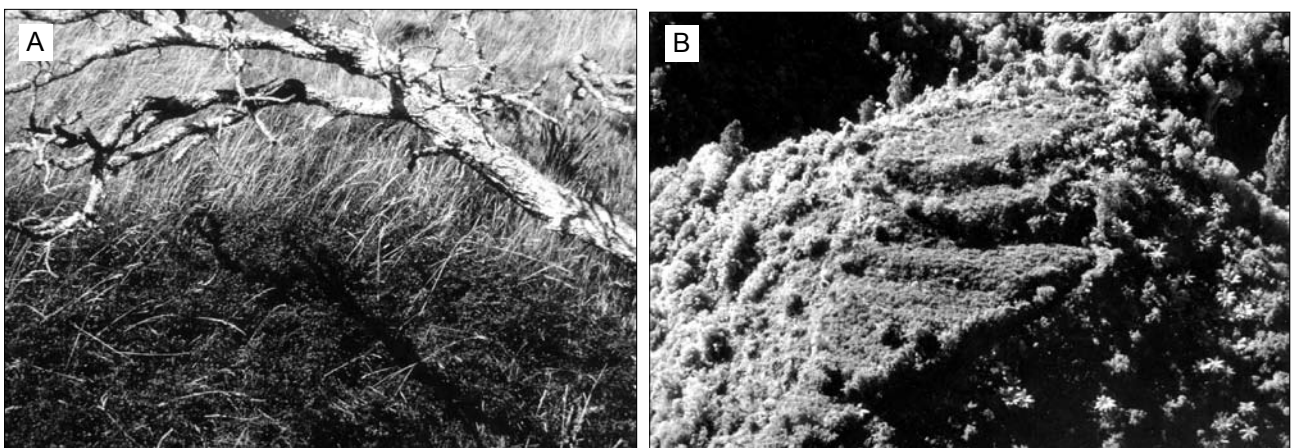


Figure 9. Longer-term changes in vegetation cover. A. Thirty years after the cessation of grazing, there is a cover of cocksfoot (on the flat) and Muehlenbeckia on the bank of this pa at Station Bay, Motutapu. The site is stable, but the pohutukawa, which would have been acceptable in this coastal setting, has died from possum browsing. B. Bracken covers the terraces and platform of this pa near Waikirikiri, Whakatane district, Bay of Plenty. Fires have periodically burned up the ridge line, but have been halted by the ditch and bank at top.

sites, it is a common seral plant taking root in rotting tussock bases. On archaeological sites, suitable (and sometimes naturally adventive) locations for flax are banks and the tops of banks where the leaves drape the earthworks. Planting of *P. cookianum* for archaeological site conservation should be regarded as experimental. Massed planting of known small varieties or ecotypes of *P. cookianum* could be from root trainers or from divisions, whichever is the less intrusive on the soils of the earthwork. Care should be taken to plant in mass. If individual plants are isolated, on windy days the leaves will sweep the surface of the ground, kill grass and initiate localised erosion. Cutting of flax down to just above the ground level will reduce its vigour and a two-yearly cut of flax on sites or banks to be preserved may be satisfactory. Any cutting of flax should be aimed at reducing vigour, not extermination, and should be accompanied by sowing of grasses.

### **Bracken, aruhe (*Pteridium esculentum*)**

Bracken can be a useful plant on many sites in New Zealand. It forms a dense mat on the ground surface and a woven mass of relatively small-diameter rhizomes underground. It is a common element in the early plant succession in most areas and can maintain itself on a site for a long time (Fig. 9B). Bracken responds to fertiliser and good drainage, and could probably be used effectively on large sites open to public viewing to cover eroding banks of earthworks without destroying their contours. It is likely to be of greatest value on steep slopes and narrow ridges on friable soils.

In most areas of New Zealand, bracken will be succeeded by a shrubland and then forest. However, in areas with rainfall less than 800 mm p.a., such as throughout Central Otago, old stands can defend themselves against invasion by trees. Otherwise, spraying or tree removal will maintain the bracken stand, as will occasional burning. Bracken can be difficult to establish. If it is to be introduced on to a site, large clods should be lifted in winter from areas with known rhizomes and the whole mass of soil and rhizome planted.

One disadvantage with bracken is that wild pigs will dig for the rhizomes. For this reason, on unfenced sites in localities with wild pig populations, bracken should be discouraged. It should be replaced with a grass or shrubland, instead. If it is decided to remove bracken, shading is the most effective technique in the long term. Appropriate spray applications may be able to suppress the bracken and allow manuka regeneration. Grubbing of the rhizomes would be destructive of the stratigraphy and earthworks and is not recommended. *Muehlenbeckia complexa* and flax may be effective substitutes for bracken.

In the United Kingdom, the Historic Scotland organisation has, with qualifications, recommended the removal of bracken from sites (Rees & Mills 1999). The UK bracken is a different species from New Zealand bracken; the latter remains a suitable protective cover for many sites.

### Small ground ferns

Some ferns make good ground covers. A wide range of species will establish naturally in damp and shaded conditions. The smaller ferns *Paesia scaberula*, *Blechnum nigra*, and *Blechnum penna-marina* can all be grown from cuttings. They are adaptable and can survive in drier conditions. The methods of establishment are similar to those for clinging rata (described below). Crown fern (*Blechnum discolor*) is particularly strong on sour wet soils, and hard or ring fern (*Paesia scaberula*) naturally establishes itself on poor pasture in higher and wetter country.

### Ground creepers

Clinging rata (*Metrosideros perforata*) can be grown from cuttings. It is especially suited to steep or overhanging banks in moderate shade. This plant has been established on banks on Ruapekapeka, Bay of Islands, for the last 20 years. Vegetative material from cuttings should be planted during late autumn and winter (late May–July). They should be slotted into the soil using a single knife or trowel cut to approximately 6 cm depth. Application of rooting hormone is not essential, but may improve cutting strike rate. The native bindweed (*Calystegia soldanella*) dies back in winter but would otherwise be a good ground cover for coastal sites.

### 2.2.3 Grass and sedge maintenance and establishment

Grass cover on an archaeological site has several advantages over all other forms of cover and should be the preferred form of cover for most sites. However, in warm temperate New Zealand it is seldom the long-term natural cover. Figure 10 shows a management decision-making

Figure 10. Likely options to take in deciding on the management of grasslands on archaeological sites.

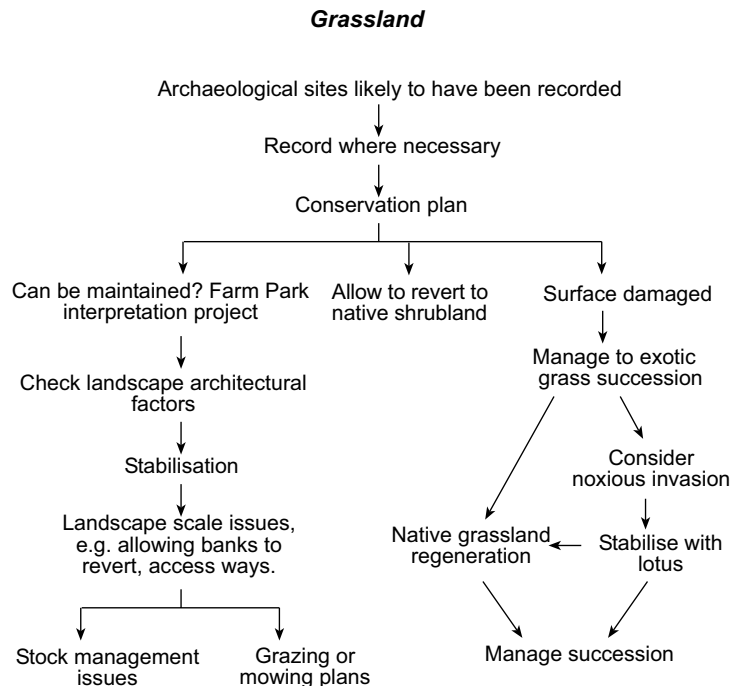


Figure 11. Partly mowed grass cover on the ditch and bank of a redoubt at Pirongia, Waipa district, Waikato. The banks are stable and the grass is probably weed-eaten once or twice a year. The base of the ditch is mown by a small ride-on mower. The pattern of varying grass heights in the ditch tends to obscure the profile of the ditch and bank, but is satisfactory.



process with respect to grassland cover for archaeological sites. Mowing (Fig. 11), grazing (Fig. 12), low natural fertility, drought, severe winters, hot summers, sandy soils, and plain and ridge line topography (as opposed to gullies and valleys) are the main reasons why grass cover persists rather than any other form of vegetation.

The objectives of grass cover management are to:

- Ensure that surface features are visible
- Allow easy access for people
- Provide the best protection for sub-surface layers
- Reduce surface erosion
- Provide a stable, relatively low maintenance, cover
- Establish native grasses if practicable
- Provide economy of management, particularly if grazed

Figure 12. Beyond the fence on Oruaka, beside Lake Forsythe, Canterbury, the natural silver tussock cover (prominent in foreground) has at some time been killed by overstocking. Silver tussock would provide good low-intensity grazing cover for this reserve. Oruaka now needs low grazing intensity and some shelter for the stock, which otherwise will continue to burrow into the banks.



When decisions are made about the use of grass as the cover of choice on an archaeological site, there is potential for conflicting objectives to arise in deciding to graze rather than to mow. It is possible to offset the cost of management by using the income from the sale of grazing animals or products from those animals. This can lead to a desire for higher stocking rates and heavier animals, both of which are inimical to archaeological preservation. Sustaining these goals requires fertilisers and high-producing varieties of grass species. Improved access for feeding-out, the need to move animals along new roads, and more fence construction to better manage stock rotation are all consequences which may affect archaeological sites. Sometimes the archaeological site may be the warmest or most sheltered part of a paddock or grazed area and the animals will camp there in high numbers.

In general, more sites should be mowed than are at present. Grazing can be a very cost-effective way of maintaining large areas, but one must never lose sight of the primary purpose of conserving such lands. It is possible to apply a growth-limiting ('topping') spray, such as very dilute Roundup (glyphosate) which will kill some weeds and reduce the potential damage from both mowing and grazing. Later sections give more guidance on mowing and grazing.

Many sites will have an existing grass cover and will merely need semi-regular maintenance aimed at conserving the archaeological surface features. Some sites will have unsatisfactory grass cover (e.g. kikuyu, which forms deep tumbling mounds unless grazed). Weedy grasses such as kikuyu will obscure surface features, and out-compete native grasses that would otherwise be useful (Fig. 12). In many parts of the northern North Island, kikuyu is the only grass that will take sustained grazing. There may be a combination of grass and woody weeds on-site. An assessment should be made by a botanist/ecologist for the land manager, and a revegetation plan (including the grass species/varieties to be encouraged or established) should be prepared. A wide range of introduced and indigenous grasses are available (Table 1), and selection will depend on management objectives, along with climate and soil conditions (including fertility and application of fertiliser). Some species will be more desirable than others for grazing management and the distinction between warm temperate (northern North Island) and other regions needs to be remembered.

Introduced species are available commercially from stock and station agents, and farm seed suppliers. Among those recommended are chewings fescue (*Festuca rubra*) and, for immediate cover in non-grassed areas, the legume lotus (*Lotus pedunculatus*) 'Maku'. For dry banks (slopes steeper than 30 degrees) needing tread resistance, the following mix of seed is recommended by S. Clunie (a garden expert, of Kerikeri, New Zealand, pers. comm. 1998): dwarf tall fescue 45%, dwarf perennial ryegrass 45%, New Zealand browntop 10% at 30 g per square metre. These mixes do not need frequent mowing.

Other possible grasses are shown in Table 1. Seed for non-weed species should be obtained from commercial sources after the most recent

TABLE 1. GRASS AND LEGUME SPECIES SUITABLE FOR ARCHAEOLOGICAL SITE COVER.

SPECIES SUITED TO HIGH-FERTILITY SOILS	
TEMPERATE PERENNIALS	SUBTROPICAL PERENNIALS
Perennial ryegrass ( <i>Lolium perenne</i> )*	Paspalum ( <i>Paspalum dilatatum</i> ) <sup>†</sup>
Cocksfoot ( <i>Dactylis glomerata</i> )*	Kikuyu ( <i>Pennisetum clandestinum</i> )
Tall fescue ( <i>Festuca arundinacea</i> )*	Mercer grass ( <i>Paspalum paspaloides</i> )
Prairie grass ( <i>Bromus willdenowii</i> )	Limpo grass
White clover (legume) ( <i>Trifolium repens</i> )	
Red clover (legume) ( <i>Trifolium pratense</i> )	
TEMPERATE ANNUALS	SUBTROPICAL ANNUALS
Italian ryegrass ( <i>Lolium multiflorum</i> )	Summer grass ( <i>Digitaria</i> spp.)
Annual poa ( <i>Poa annua</i> )	Barnyard grass ( <i>Echinochloa</i> spp.)
Barley grass ( <i>Hordeum</i> spp.) (not suitable in grazed areas)	Crowfoot ( <i>Eleusine indica</i> )
SPECIES SUITED TO LOW-FERTILITY SOILS (e.g. tops of banks)	
TEMPERATE PERENNIALS	SUBTROPICAL PERENNIALS
Browntop or creeping bent ( <i>Agrostis</i> spp.)	Kikuyu ( <i>Pennisetum clandestinum</i> ) <sup>†</sup>
Chewings fescue, creeping red fescue ( <i>Festuca rubra</i> )	Ratstail ( <i>Sporobolus africanus</i> )
Meadow rice grass ( <i>Microlaena stipoides</i> )	Buffalo grass ( <i>Stenotaphrum secundatum</i> )
Danthonia ( <i>Rytidosperma</i> spp.)	Indian doab ( <i>Cynodon dactylon</i> )
Canary grass ( <i>Pbalaris</i> spp.)	Bay grass ( <i>Eragrostis brownii</i> )
Lotus (legume) ( <i>Lotus pedunculatus</i> ) (not for grazed areas)	
<i>Poa</i> spp., <i>Festuca</i> spp.	
TEMPERATE ANNUALS	
Goose grass ( <i>Gallium aparine</i> )	
Crested dogstail ( <i>Cynosurus cristatus</i> )	
Suckling clover (legume) ( <i>Trifolium dubium</i> )	
Subterranean clover (legume) ( <i>Trifolium subterraneum</i> )*	
Annual lotus (legume) ( <i>Lotus pedunculatus</i> )	

\* Species common in tall grasslands after 5–10 years cessation of grazing.

<sup>†</sup> Needs mowing or grazing.

harvest (usually December–February). Germination test information can be requested from suppliers, or a simple test conducted. Specify to suppliers the need to obtain amenity and turf (as opposed to production or grazing) types of grass.

Indigenous grass seed is not generally available commercially and will need to be collected and established from either seed or root division. Suitable species include: *Oplismenus imbecilis* (for shady damp spots); *Microlaena stipoides*, meadow rice grass (very widespread in open shade and/or on poor-fertility sites); *Rytidosperma* spp., danthonia (for dry banks); and *Poa anceps*, broadleaf poa (for dry banks, will compete with cocksfoot and *Bromus* spp. in ungrazed grassland). Native tussocks such as silver tussock (*Poa cita*, *Poa laevis*) or hard tussock (*Festuca novae-zelandia*) (a species well adapted to poorer ground) can be used in cool temperate areas. Native grasses are common on land retired



Figure 13. Stripping mature seed from broad-leaved poa, *Poa anceps*.

from grazing for a reason—they cannot withstand hard or continuous grazing. This should be remembered when deciding what to plant, and their virtues compared with the many varieties of ryegrass that are available.

The native species are quite common and suitable sources should be easily located around most sites. Liaison with land owners may be necessary to ensure that seeds and appropriate vegetative material is available for hand harvesting (Fig. 13). To ensure that material is fresh, cuttings for vegetative establishment should be obtained on an as-required basis, immediately before planting (May–July). Appendix 2 (section A2.1) provides a specimen work plan for sowing or over-sowing a grassed site. Table 2 indicates some of the advantages and disadvantages of using native grasses on low-fertility sites.

TABLE 2. USE OF NATIVE GRASSES ON LOW-FERTILITY SITES.

ADVANTAGES	DISADVANTAGES
Lowers and reduces stocking rates	Poor tillering of grasses
Opportunity for native grass restoration	Poor competition with exotic grasses in full sun and if soils are fertile
Some native grasses have competitive edge over pasture grasses in shade	Liable to have erosion patches, risk of failure of sward
Can be left alone with little or no mowing	Grasses bolt to seed
Opportunity for native shrubland to succeed the grass cover	Seed and flower heads shade legumes
May be combined with native shrub canopies	Tussock forms poor for soil stability
No fertiliser required; grasses tolerate acid soil conditions (nutrients less available)	Risk of weed and shrubland invasion; weeds may suppress grass
Local adventives (not commercial varieties) will arrive	Fire risks of dry tall grass
Varieties/species will adapt to highly localised conditions	Tall grass obscures archaeological features
Low palatability to stock and may slowly become dominant in the sward if no fertiliser is applied	Stock camping/erosion without intensive fencing and grazing management
Self-perpetuating and stable cover if flowering and seed set is allowed to occur	Not resistant to treading
	Cattle stocking needed to reduce tall poor grass
	Tall-grass tag suppresses establishment of warm-season grasses which are needed in peak production seasons

#### 2.2.4 Establishment of grass or sedge cover

In warm temperate regions, particularly north of the North Island central volcanic plateau, seed can be sown in winter. In southern regions, late summer or spring sowing is normal. Seed should be sown by hand-broadcasting since drilling would disturb the archaeological material. Hand-broadcasting is essential for slopes. More seed will be required than would be recommended for drilling the same area, and better results will be obtained if the seed is pelleted, at which time it is given its coating of fertiliser and inoculum. The seed should be sown in two passes from opposite directions and thrown down vigorously so that it goes into cracks and small depressions in the soil and into any slopes. A