2. Management issues and conservation techniques

This part of the guide concentrates on techniques to manage archaeological sites that will be applicable to a wide range of different ecological settings. We deal first with erosion control followed by vegetation and ecologically appropriate methods. Then we cover a range of broader environmental influences (such as burrowing animals) that raise management issues. Physical methods of site protection and issues arising in restoration and reconstruction are also covered briefly.

The primary focus of most of the techniques is on erosion control. There will generally be no single solution for any particular problem. Land managers must assess the factors affecting the site and determine their own course of action. It must be remembered that we are providing guidelines, not certain solutions. One advantage with archaeological sites is that usually the area to be dealt with will be small, and labour-intensive methods which could not be used on large areas may be quite practical for conserving the archaeological values of a site.

2.1 EROSION CONTROL: GENERAL CONSIDERATIONS

Erosion of archaeological sites by wind, water and slope movement is a frequent cause of their degradation or loss (Fig. 7). This section is an introduction to the protection of sites from erosion with some advice on where assistance might be obtained.

Figure 7. Ill-advised planting of trees is failing to protect this deep, rapidly eroding midden at the mouth of the Waiotahi River, Bay of Plenty.

2.1.1 Wind

Wind erosion in New Zealand often affects sites in dune areas that were occupied when the dunes were stable, but are threatened when the dunes re-mobilise. Sites can be damaged by sand removal from the surface or by being undermined from the margins. Active dunes bury existing vegetation and then move on—leaving the site exposed and putting even apparently stable sites at risk. Midden sites which become pedestals with a cap of shell or stone protecting a small area of sand beneath them, but generally being undermined all around, are usually beyond protection.

The causes of sand erosion can be remote from the site and connected with sea erosion of foredunes, vegetation loss some distance from the site, and overall changes in sediment supply to beaches. Large-scale movements covering tens of hectares or more require major efforts to manage and are the province of local or national governments rather than individual landowners. Localised efforts to control erosion within large sand dune areas may succeed for a period, but in the long term are usually to no effect. Sometimes, however, the problem may be of a smaller scale and interventions such as local planting and fabric-covered fences transverse to the prevailing wind direction can be effective in aiding restoration, provided the fundamental initiating cause is also addressed. Soil conservation officers in regional councils may be a source of advice for good practice appropriate to a local area. Vegetative methods such as a succession of marram grass (*Ammophila arenaria*) followed by lupins (*Lupinus luteus*) have been successful over much of New Zealand. Such interventions usually require monitoring and maintenance beyond their initial construction and can be undone by one extreme storm. Recommendations on sand-binding plants (Bergin & Herbert 1998; Bergin & Kimberley 1999; Bergin 2000) should be read in the light of the severe long-term processes that are at work on the coast.

2.1.2 Rivers and streams

Erosion of their banks by rivers and streams is a natural phenomenon and any control measure needs to be based on a knowledge of the whole floodplain, not just parts of the bank. Most waterways move course by meandering across a plain. Any intervention to limit that has to be of a scale commensurate with the size of the plain over which the stream or river is moving. Sometimes bank erosion is human-induced because of a failure of understanding of the wider system. Measures taken upstream to confine a stream or river within banks can have downstream consequences of more erosion. Discharges of stormwater drains can be a local erosion cause. Changes in land use, such as urbanisation, can increase flood peak flow rates and increase the energy the stream has to apply to bank erosion.

Effective local interventions can be made through river training and bank protection. Interventions within waterways are subject to the Resource Management Act 1991 controlled through regional councils. Councils will also give advice on what waterway erosion control methods are effective and permitted. Willow plantings, which can be effective in stabilising banks, are not permitted in some areas because of the consequences their spread may have.

2.1.3 Coastal erosion

Erosion of archaeological sites, which may be part of beach deposits or on top of slopes and cliffs, is a common experience in New Zealand. It is one which is likely to increase if and when global warming causes sea level rise. Severe erosion events usually result from a set of conditions: high tide, currents, particular wind direction and strength and large waves and storm surge, especially when low atmospheric pressure causes a rise in sea level. Waves are never all the same size. Protection is needed against the largest and most infrequent, not the average wave.

On 'high-energy' coasts—where breaking waves are continuous or common—the design criteria for sea defences must give permanent protection against substantial waves combined with storm surges. Such structures are very expensive and are usually only affordable when very valuable real estate lies behind them. It is common to see under-engineered structures (built in an attempt to protect property) which fail in the next large storm. The cost of failure is multiplied by the loss of what has been assumed to be protected; often new structures that have been built behind the under-engineered structure.

Interventions can include groynes to trap sediment moving along a beach, off-shore artificial reefs to break waves before they reach the shore, and addition of sediment to beaches and sea walls. The last of these pose particular problems. Sea walls reflect waves and cause greater turbulence and erosion immediately in front of them. Also, they often fail through being undermined by such erosion. As well they often fail to retain the beach material behind them and the erosion continues despite their presence. Specialist engineering advice is needed for any of these structures (Fig. 8).

Erosion of soft rock cliffs can often be stopped by quite modest interventions of sea walls, particularly in more sheltered waters. Toe protection for the wall is important. It must be remembered that the slope behind such a wall will not usually be stable in the long term. While erosion may have be slowed, it will not stop as the slope evolves to a flatter, more stable profile.

Figure 8. Rip-rap sea wall protecting areas of the site of Tokitoki, Ōhiwa Harbour.

Interventions in the coastal zone are subject to Resource Management Act 1991 controls through regional councils. Councils are a source of advice on coastal erosion problems and are also responsible for permits.

2.1.4 Erosion along the shore of lakes and reservoirs

Wave erosion on the shores of artificial reservoirs built for water supply or hydropower can expose and damage archaeological sites. Because sites tend to be near rivers, they may be submerged near the dam but exposed to erosion in the strand line further upstream and at the upstream end of the lake. The interventions needed in these circumstances can be quite modest compared with sea defences but the same methods apply. Some ruins, such as foundations, may be strong enough to be left in the strand line—for example, the structures of old Cromwell on the shoreline of Lake Dunstan, Central Otago.

2.1.5 Slope failure

Slope movement is common in New Zealand's broken topography and can take many forms: some may be shallow, some deep-seated. The mechanical properties of the slope will vary depending on the type of soil or rock involved.

A common cause of damage to New Zealand archaeological sites is slope movement where tracks or roads have been cut into the sides of sites, leaving over-steepened slopes which are slumping or fretting back to a flatter profile. Maintenance of the road or track by removing any accumulating sediment will keep the process active. One possible intervention is to decide whether the road is necessary and to either backfill the cut, or stop the removal of debris to allow natural re-stabilisation.

Anther intervention is to stabilise the slope. Where slumping is happening, possible interventions include re-shaping, re-filling using appropriate methods (where small areas are concerned), drainage (if water is a factor), toe-weighting and gravity retaining walls. Engineering advice is needed to assess the problems and for the design and construction of these.

Where surface fretting is taking place, vegetative control methods can be effective. Retaining vegetation at the top of the slope, and providing a more sheltered environment on the slope are important measures. Hydro-seeded grass can be helpful in starting the process of revegetation on areas of bare ground, but in the generally infertile soil exposed in cuttings, grass may only survive as long as the fertiliser applied with it lasts. A succession to vegetation tolerant of the soil conditions is needed. Studying the methods applied on local public roads, particularly where these have been in place for several years, will give ideas on what is effective with the local soils and geology. Roadsides are especially useful because they receive little or no grazing and are cut infrequently. In this respect, they match the general recommendations of these guidelines for archaeological site management.

2.1.6 Freeze-thaw

In Central Otago and on the North Island's volcanic plateau, frost may cause damage to earthwork structures, earthen mortars and bricks. The moist, lower parts of a structure may freeze. The water in the structure expands as it freezes, squeezing the soil and displacing it. On thawing, small amounts of surface soil fall away. In the course of many cycles of freeze-thaw, large volumes of soil may be removed, giving rise to a characteristic hollowing and undercutting of the base of walls. It may be mistaken for pigrooting. If similar damage can be seen in road batters in the district, then it is likely to be freeze-thaw. The solutions are literally 'stop-gap' ones:

- Maintain a convex surface to the top surface of the bank or wall by adding limited amounts of topsoil and plant some water-shedding vegetation such as grass or flax (*Phormium colensoi*)
- Avoid placing too much topsoil mass on the top of the bank, except the limited amounts needed to maintain the convex surface
- Keep the grass long on the tops of banks and line-trim annually after the main visitor season
- Place a mulch, e.g. from line trimmer debris, in and at the base of the hollowed-out area and do not line-trim in these cavities
- Discourage people from walking on the bank by keeping grass long, by not providing easy access to problem parts of the site, and by signs asking people to stay off
- Reconstruct or restore only if the bank does slump completely
- Pack the overhang at the base of the bank with vegetative matter to reduce the effect of frost.

2.2 VEGETATION MANAGEMENT FOR SITE PROTECTION

For any particular site, a land manager has to predict what the future development of the vegetation is likely to be if it is either left to its own devices or subjected to some form of management. Such assessments may require input from a botanist or an ecologist with an understanding of the development of the local vegetation. Whatever form of vegetation 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 by pigs 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 and Jones 1982; Jones and Simpson 1995a, 1995b). Some key species in site management (both good and bad) are restricted to certain climate zones. We have used the concepts of warm temperate to cover districts from coastal Marlborough northwards, and cool temperate to deal with the balance of the South Island and the North Island's volcanic plateau. Of course, many species such as mānuka 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. Our 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 we simply refer to 'friable' soils and 'firm' soils.

The box below shows 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 able to be achieved 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 treelands or to initiate grazing or mowing.

DESIRED OR ESTABLISHED VEGETATION TYPE AND GENERALISED REGIME FOR ARCHAEOLOGICAL 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 soil fertility management. 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 over-ride the need for site protection.

Young native trees, early seral 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.

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.

Plantation forest—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.

A number of species with an indication of their form and the habitats in which they flourish are in 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 and Herbert (1998), Bergin and 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 pōhutukawa 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 iwi, may have views on vegetation management that should be discussed with them. They may wish to retain certain species, such as pōhutukawa, tōtara and tī (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)

Pōhuehue (*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 pōhuehue *(M. complexa)* is a smaller plant and is suited to open areas. 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 pā, 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 and Simpson 1995b: p. 23, fig. 14B).

Flax, harakeke (*Phormium *spp.)

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

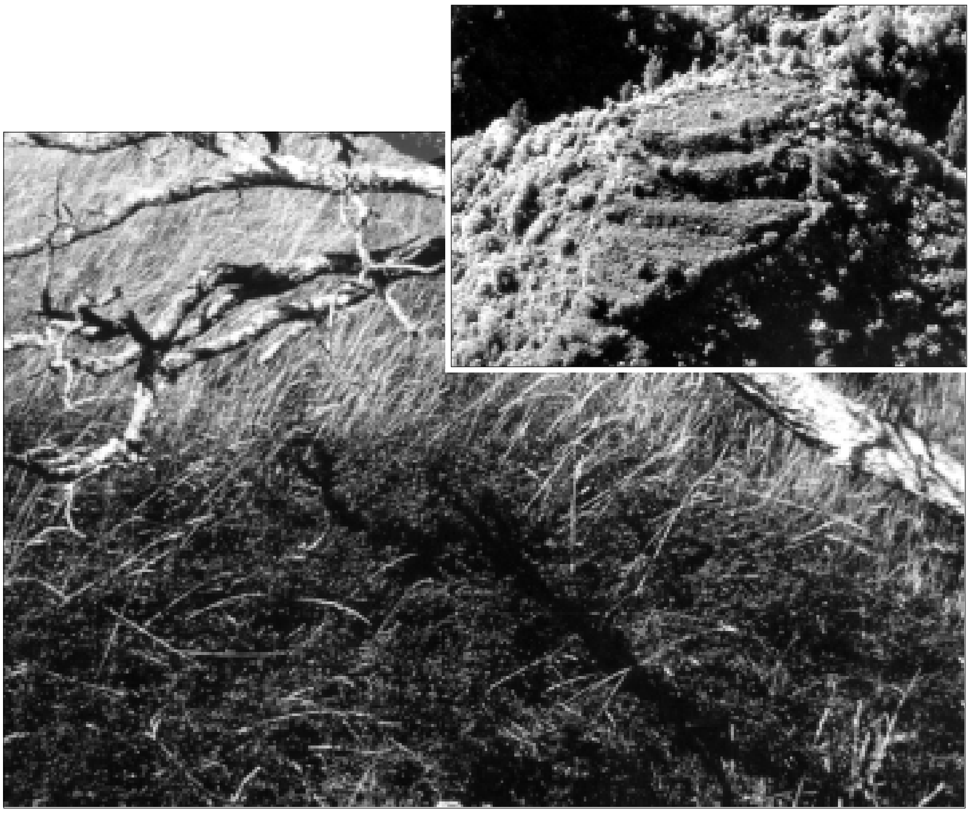


Figure 9. Longer-term changes in vegetation cover. (A, main) Thirty years after the cessation of grazing, there is a cover of cocksfoot (on the flat) and *Muehlenbeckia* on the bank of this pā, at Station Bay, Motutapu. The site is stable but the pōhutukawa, which would have been acceptable in this coastal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

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, but instead is replaced with a grass or shrubland. 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 mānuka 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 and Mills 1999). Their bracken is a different species from New Zealand bracken; the latter remains, in our view, 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.

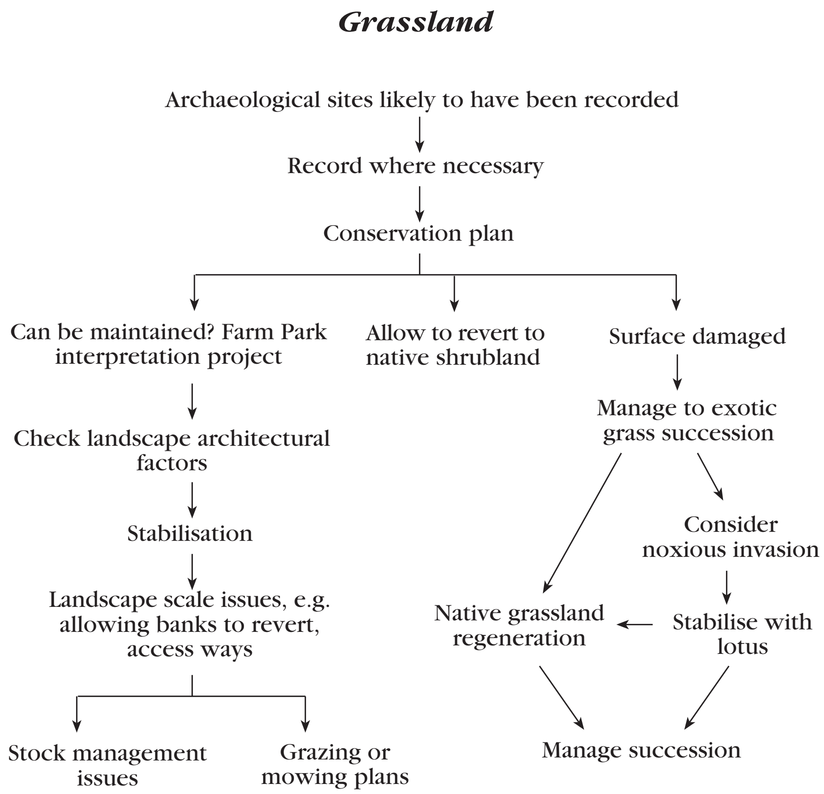
2.2.3 Grass and sedge maintenance and establishment

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 process with respect to grassland cover for archaeological sites. Mowing (Fig. 11), grazing (Fig. 12), low natural fertility, drought, severe winters, or fire-prone soil conditions 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
- to allow easy access for people
- to provide the best protection for sub-surface layers
- to reduce surface erosion
- to provide a stable, relatively low maintenance, cover
- to establish native grasses if practicable
- to provide economy of management, particularly if grazed.

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



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 inimicable 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 is the case at present. Grazing can be a very cost-effective way of maintaining large areas, but the primary purpose of conservation for such lands must never be lost sight of. 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. Other sites will have existing unsatisfactory grass cover, e.g. kikuyu, which will extirpate native grasses that would otherwise be useful (Fig. 12). There may be a combination of grass and woody weeds. A site 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 grasses, introduced and indigenous, are available and selection will depend on the 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 and other regions needs to be remembered.

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.

GRASS AND LEGUME SPECIES SUITABLE FOR ARCHAEOLOGICAL SITE COVER

Species suited to high-fertility soils

Temperate perennials	**Subtropical perennials**
Perennial ryegrass (*Lolium perenne*)*	Paspalum (*Paspalum dilatatum*)
Cocksfoot (*Dactylis glomerata*)*	Kikuyu (*Pennisetum clandestinum*)
Tall fescue (*Festuca arundinacea*)*	Mercer grass (*Paspalum paspaloides*)
Prairie grass (*Bromus willdenowii*)	Limpo grass
White clover (legume) (*Trifolium repens*)	
Red clover (legume) (*Trifolium pratense*)	
Temperate annuals	**Subtropical annuals**
Italian ryegrass (*Lolium multiflorum*)	Summer grass (*Digitaria* spp.)
Annual poa (*Poa annua*)	Barnyard grass (*Echinochloa* spp.)
Barley grass (*Hordeum* spp.) (not suitable in grazed areas)	Crowfoot (*Eleusine indica*)

Species suited to low-fertility soils, e.g. tops of banks

Temperate perennials	**Subtropical perennials**
Browntop or creeping bent (*Agrostis* spp.)	Kikuyu (*Pennisetum clandestinum*)
Chewings fescue, Creeping red fescue (*Festuca rubra*)	Ratstail (*Sporobolus africanus*)
Meadow rice grass (*Microlaena stipoides*)	Buffalo grass (*Stenotaphrum secundatum*)
Danthonia (*Rytidosperma* spp.)	Indian doab (*Cynodon dactylon*)
Canary grass (*Phalaris* spp.)	Bay grass (*Eragrostis brownii*)
Lotus (legume) (*Lotus pedunculatus*) (not for grazed areas)	
Poa spp., *Festuca* spp.	
Temperate annuals	
Goose grass (*Gallium aparine*)	
Crested dogstail (*Cynosurus cristatus*)	
Suckling clover (legume) (*Trifolium dubium*)	
Subterranean clover (legume) (*Trifolium subterraneum*)*	
Annual lotus (legume) (*Lotus pedunculatus*)	

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

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.

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

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 (Clunie 1998, pers. comm.): dwarf tall fescue 45% at 30 g m^{-2}, dwarf perennial ryegrass 45% at 30 g m^{-2}, New Zealand browntop 10% at 20 g m^{-2}. These mixes do not need frequent mowing.

Other possible grasses are shown in the box on previous page. Seed for non-weed species should be obtained from commercial sources after the most recent 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 either from 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); *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.

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 immediately before planting (May–July) on an as-required basis. Appendix 2, section A2.1 provides a specimen work plan for sowing or oversowing a grassed site.

NATIVE GRASSES FOR LOW-FERTILITY SITES

Positives	Negatives
Lowering and reducing 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 cover

In warm temperate regions, particularly north of the North Island's 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 light raking will dislodge any seed held in the surface vegetation. Covering the seed with up to 5 cm thickness of straw (or hay, if potential weeds are not a problem), a germination cloth or hessian will provide protection for the seeds and seedlings and help the absorption and retention of moisture by the soil (it will eventually rot down).

Where there is a well formed topsoil or if the site is known to have been ploughed or cultivated, scarifying the surface of the soil is acceptable. In firm soil or clay—on or towards the top of banks, for example—scarification by swinging a hoe may be acceptable but care should be taken not to dislodge too much of the soil downslope.

Where there is easy vehicular access to a site, it may be worth considering hydroseeding, the procedure used to grass road cuttings. This is a very fast and effective method of re-grassing bare ground. Private companies dealing in erosion control and management may offer useful advice as well as the hydroseeding service.

As with any form of vegetation establishment, considerable forethought needs to be given to organisational budgeting, planning and approval cycles. The biological cycle involved with seed collection and sowing does not fit well with normal financial year cycles, and a considerable lead-in period may need to be allowed for.

The specimen work plan in Appendix 2, section A2.1 gives further details on seeding.

2.2.5 Establishment of grasses on ground cleared of scrub or fern

Scrub- or fern-covered ground can present a major problem is establishing a suitable seedbed, especially where there is a heavy growth of native shrubland. Burning provides an ashy seedbed and the remaining semi-burnt woody material will provide shelter for the young seedlings. Burning will stimulate the germination of legume seeds such as gorse or wattle. Where burning is not feasible, herbicide spraying followed by removal of most of the woody material may be the only solution. Immediately after the death of most of the vegetation, the site may be vulnerable to erosion, and as much broken-down, dead vegetation as possible should be left on the site. A temporary mulch or geosynethetic cover (see below) may be needed on some areas.

Figure 14. The tall native sedge *Gahnia* sp. with its drooping habit provides a good protective cover on the banks of this pā in the northern Urewera.

The timing of ground preparation and seed sowing is critical. In the South Island late winter or early spring is the best time to oversow with grass seed, but in the North Island oversowing in autumn can be successful. It is usually advisable to sow a mixture of two to four species of grass and clover. White clover and a rank ryegrass such as Grasslands Nui will be useful where gorse seedlings must be suppressed, but browntop and the finer ryegrasses may be more durable on paths which will have to cope with treading. In drier areas where there is not much control on the grazing, cocksfoot and subterranean clover may be considered. On steep slopes with low fertility, browntop, crested dogstail and Danthonia can be used to get a quickly established sward, in conjunction with a legume (e.g. white clover). Most sites will profit from a dressing of fertiliser, particularly of lime and superphosphate. On small areas of steeper slopes (greater than 30 degrees), it will be desirable to broadcast fertiliser by hand ensuring that it is thrown into the slope and on to the soil surface—or use hydroseeding. Although costly, irrigation should be considered for the first summer or in dry periods within the first year of growth.

Sedges

Several native sedges such as *Gahnia* spp. or 'hookgrass' (*Uncinia* spp.) can form good protection against erosion and some, such as the tall species of native sedges, may also prevent or discourage access away from approved tracks (e.g. Fig. 14). Some sedges may do well in drier areas. Sedges can be propagated by stripping seed in the appropriate season and planting the seed, or by planting stem and root divisions of existing plants. Local advice should be sought on the appropriateness of and methods for planting sedges.

2.2.6 Grazing

Grazing is a potentially useful tool for archaeological site management. It ensures, among other possible objectives, that a site remains visibile and accessible at little nett cost. However, cattle and high densities of smaller animals can cause rapid changes to ground surfaces (Trimble and Mendel 1995). It is noticeable that the grazing of heavy animals on archaeological sites, especially in winter, is destructive of surface features. Stock camping can also be a problem. Much erosion occurs on microsites (patches of banks less than 10 m long) and, cumulatively, these small individual areas of erosion will do much damage. Stock damage over decades can completely wear away a site (Fig. 15A). This long-term trend to almost complete destruction can be observed when comparing old and current aerial photographs. It is not uncommon to find the lateral roots of trees perched up to 60 cm above the ground surface on grazed banks and other evidence of heavy wear.

In hard hill country, hares can be important in maintaining grass cover. Rabbits will burrow and should not be tolerated on archaeological sites.

Grazing licences or concessions on reserves have not always protected archaeological conservation values and have destroyed other historically associated elements of a site or landscape such as trees. Grazing should be carried out for particular site management objectives and strictly controlled. The objectives are:

- General vegetation control
- Keeping height of grass down for site visibility and lessening fire risk
- Preventing shrubland succession.

Grazing may often be the least-cost means of maintaining and perpetuating grasslands but cost-saving should never be the overriding consideration. Earthwork sites should not be grazed as high-producing grasslands. Managers of archaeological sites should monitor grazing licences or informal arrangements with neighbours, to ensure that:

- The archaeological site is not used for winter run-off pasture
- Inappropriate or unapproved fencing, gateways, or water lines or troughs are not installed
- The land is grazed only lightly
- Treeland or artificial shelter for the animals, consistent with the reserve setting, is in place.

The archaeological conservation values of the land should be assessed, and stock numbers, animal type and grazing levels set so as to ensure protection of those values. For a grazing licence, these calculations will also give an indication of the price to be charged for the licence. A suggested guideline is to

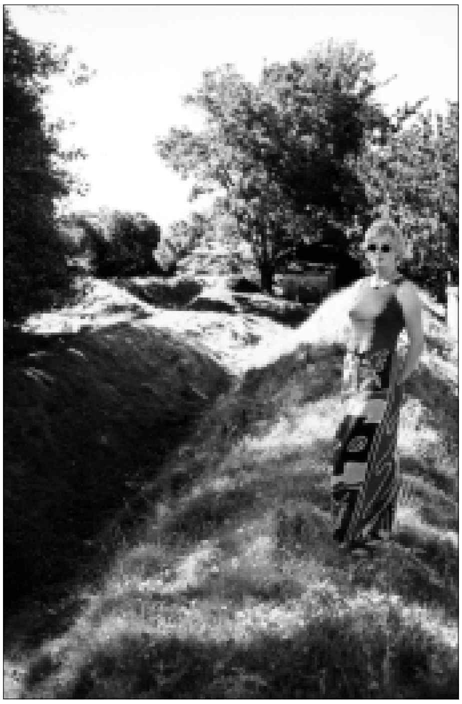


Figure 15. Grazing. (A, left) Sheep are tracking through and camping below these karaka on Pukerangiora Historic Reserve. An early attempt to move the sheep off using prickly branches has worked at one spot but has displaced the site of erosion down to below the trees. (B, right) Light set grazing by sheep (probably less than 10 s.u./ha) with ample shelter has protected the banks of Tapui, a pā near Manutūke, Gisborne district.

maintain a grass height of 6–10 cm. On firm soils in the north, this will mean an average stocking of no more than 10 stock units (s.u.) per ha. Problem microsites and the overall archaeological values of the area will need to be monitored closely.

Figure 15B illustrates the maintenance of very steep banks by using set stocking of a few sheep for a long time with few fertiliser inputs. Although set stocking is recommended, it should be possible to manage several large-ish sites or reserve areas by rotating the same stock from one area to another. One area can have no stock for a period while the animals are put to use elsewhere. Seasonal fire risks and roading and fencing practices to allow for grazing are further factors to be taken into account. These technical points are covered in more detail later in these guidelines.

RELEVANT FACTORS IN STOCK MANAGEMENT ON ARCHAEOLOGICAL SITES:

- Stock numbers—no more than 10 stock units (s.u.) per ha
- Stock-type—sheep or goats, yearling cattle only
- Permissible grazing seasons—not in winter or very wet weather
- Set stocking is preferable to rotational grazing
- Keep plenty of feed available; grass should be 6–10 cm in height (in the north this means average stocking of 10 s.u./ha)
- Fencing should not slice across a site
- Top-dressing—soils should not be fertilised to maximise production but to maintain even grass cover and prevent erosion
- Stock water and shelter—do not supply on the features of the archaeological site.

Specific comments on stock type and grazing intensity are in section 3.2 on farming practice (p. 67). Another form of intensive grassland management is in areas used for haymaking or for amenity areas, such as city parks. Their management shares some similarities with grazing. The positives and negatives of intensive mangement are summed up in the box below. It may be compared with a similar range of positives and negatives for native or low-intensive grassland management in the box on page 29.

ARCHAEOLOGICAL SITES AND INTENSIVELY MANAGED GRASSLANDS

Positives	**Negatives**
Legumes supply nitrogen	Cost of fertilisers and lime
Amenity grass varieties have good cover, low growth and drought resistance	Winter is period of peak need for grass which may lead to undesirably high stocking in that season
Fencing and gateways may be designed to assist conservation	Stock camping, tracking around ill-designed fence lines
Varieties tiller, therefore good ground cover	Pugging and erosion around water troughs
Stock numbers may be kept low; grazing rotated	Risk of erosion, severe erosion if overstocked
Varieties palatable	Severe erosion if stocked with cattle
Reduced scope for weed and shrub erosion	Water must be supplied for cattle
On flat land or easy slopes, can be combined with mowing, and hay-making	
Little net cost when farming returns considered	
Tread-resistant, may be used in pathways	

Sheep tracking and camping, cattle wallows—some solutions

All grazing should be monitored to identify erosion hotspots—for an example see Fig. 15A where sheep are burrowing for shelter in the banks of a pā. Trees on the bank appear to exacerbate the problem. The reason is that animals are attracted to the shelter that banks and trees provide, and create destructive 'camping' grounds (Prickett 1985: 63–70). The question to ask is: Why are the sheep camping at this spot? The answer is probably because it is level or can be made level by trampling and provides shelter from wind and sun—e.g. under a tree on the north side of a bank or beside a ruined wall.

Before a solution is attempted, the area of the paddock enclosing the archaeological site and adjacent paddocks should be surveyed to see if alternative shelter is available in a less damaging position. There is no point in diverting sheep away from their camping spots unless there has been adequate provison for shelter elsewhere within the paddock. The paddock configuration could be designed or re-arranged to allow stock access to this shelter, e.g. by including an existing patch of trees or part of a windbreak. If there simply is none, a means of providing it should be sought. Small patches of trees and undershrubs could be planted inside a temporary fenced-out corner of a paddock. Within five years, the temporary protective fence could be removed to allow the sheep back in. Otherwise constructed and movable forms of shelter, e.g. wooden hurdles up to 2 m high with slats, could be provided (Fig. 16A).

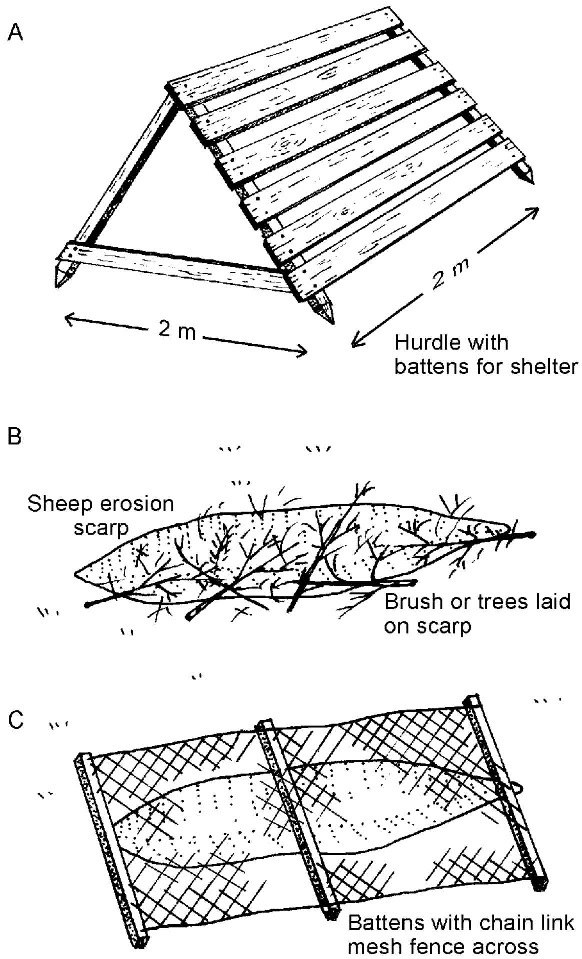


Figure 16. Shelters and barriers. A. Wooden hurdles with slats to provide shelter for sheep. B. and C. 'Uncomfortable' temporary barriers to stop sheep camping.

Where patches of erosion have formed, it is best to deter sheep by piling branches with plenty of twigs on to the erosion scars (Fig. 16B). It is difficult to get complete coverage and sheep's ingenuity in displacing brush or slightly relocating their camping should not be underestimated. An advantage of the branches is that grass will readily grow underneath and the branches will eventually rot away. Another method is to use short lengths of recycled chain link mesh fence (say 2 m long, nailed on to two or three battens) placed in a slightly elevated position over the erosion area and its margins (Fig. 16C). Grass will grow underneath. The fence portions can be made in a workshop and easily transported to the field. The short lengths of chain link mesh will not be attractive to thieves. This also works well where sheep are burrowing or working their way into banks. The wire can be pulled up every 18 months, so that it does not become fixed beneath tall grass, and can be re-located to problem areas elsewhere.

2.2.7 Native shrublands

Where an archaeological site is not meant for public visitation and where it is not in a stable native treeland cover, the objective should be to create and maintain a thin-stemmed, densely canopied cover, such as a mānuka shrubland. Figure 17 shows a decision-making process for maintaining sites in a thin-stemmed native shrubland.

Many native shrublands are nurseries for large tree species. However, large trees are not a desirable cover on a site where the stratigraphy is to be preserved. (They may be acceptable on sites which are open to the public and where the main point of interest is in the surface earthworks.) On archaeological sites all potentially large trees will require regular inspection. Specimens with the potential to grow to more than 10 cm diameter at breast height (d.b.h.) will need to be removed. The interval between inspections will depend on growth rates of the trees and can be determined by the local land manager.

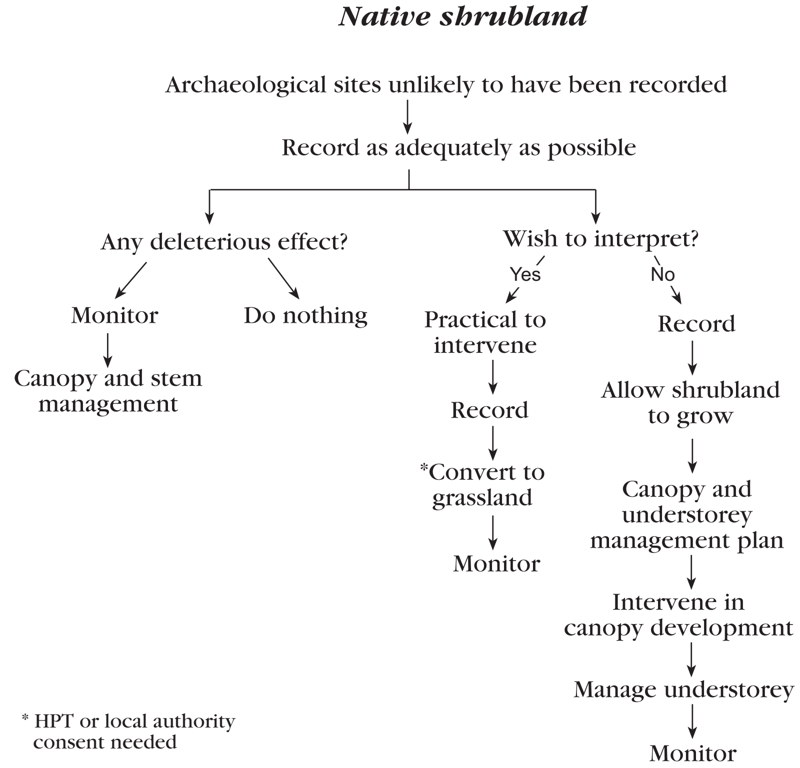


Figure 17. Management issues and likely ecological processes in native shrubland.

Kānuka and mānuka brush

On bare soils, especially subsoils exposed in old roadways or on heavily eroded banks or ridges, mānuka mats may be of use. The objective is to get the seeds of the mānuka to settle on the soil surface. Branches of mānuka or kānuka are scattering and pegged down, or laid in loosely woven mats. This can be done at any time of year for mānuka but only in March or April for kānuka. Before the branches are gathered, they should be checked to ensure that seed capsules are present and that they have not released seed. The brush layer should be thin to allow plenty of light to reach the seedlings.

Applying brush will be most useful on any areas of bare subsoil; for example, in mitigating the effect of a road or track scar or in holding slips on the steep ground below archaeological sites in hill country. Brushwood held by short stakes driven in rows across a slip has the advantage of applying an instant poultice to a bare surface to reduce rain wash. Brush is also useful in preventing or healing 'desire lines' created by people walking outside of designated tracks.

2.2.8 Native forests and treelands—issues and guidance

Many sites that were maintained in bracken and shrubland by nineteenth-century burning, and then subsequently farmed (this will include most ridges in populated areas in the North Island), will have had little tree growth. Regeneration of native forest on these sites will be destructive in the long term and should be controlled.

On sites where forest is re-generating, and provided significant stratigraphy has not already been destroyed, it is recommended that any young tree with the potential to grow larger than 10 cm d.b.h. be felled. Destruction of stratigraphy may be supposed to have occurred in any areas where trees have grown to a large size (over 30 cm d.b.h.). An inspection by excavation of parts of the stratigraphy of the site may be desirable. In any event, the felling of stable native treelands is not recommended.

On some soils, tree roots may not penetrate very deeply, particularly if there is an iron pan, stones or indurated ash shower close below the surface. However, most archaeological sites contain layers and pockets of very fertile soil and are above any hardened layers, and are vulnerable to root growth.

Mānuka and kānuka are often preferred as a nursery crop for larger native species whether naturally recruited or planted. On archaeological sites the recruitment of potentially large tree species into mānuka should be monitored in a 20–50 years' time period and trees removed or selectively removed where that is prescribed for in a conservation plan (which should allow for such removal).

Native tree protection provisions in district plans will take precedence over any special-purpose plan such as a conservation plan. These provisions are becoming more common and restrictive, particularly in urban areas. Special council permission will be required in some circumstances to remove trees. Also, removal may be allowed in a current land management plan, but it may not be allowed in 20 to 50 years' time. Conflicting objectives may therefore arise in such circumstances, with the risk that native vegetation protection will uniformly prevail over archaeological protection. Shrubland or gorse areas are sometimes underplanted by people interested in promoting future native forest regeneration areas. Managers responsible for archaeological sites in such areas must work to ensure that such planting is done in accordance with the objectives of site protection.

Some trees are prone to windthrow in the medium term (50–150 years). Examples are rewarewa or wattle—trees that can grow to a large size and become unstable early (50–100 years) in a forest succession. They should be removed if there is reason to believe that they will become unstable within 5–20 years, or if monitoring shows that they are causing site damage.

Figure 18 shows the general procedures carried out at Te Koru Historic Reserve, Taranaki, to remove potentially damaging trees and to improve ground visibility and ground covers (for the conservation plan, see Department of Conservation 1998). Some smaller species, such as whauwhaupaku (five-finger) or māhoe, coppice vigorously with probably little slowing down in root growth when the stem is cut. The stumps should be treated with a systemic herbicide immediately after cutting; if treatment is delayed the application of herbicide becomes ineffective.

Trees that were probably introduced to the vicinity of site by Māori, such as tī (cabbage trees) or karaka, should be left as elements of the cultural landscape. Karaka can form dense thickets of seedlings which thin out naturally. On particular places, such as the edges of banks or in ruins, they may need to be removed. Any increase in coverage by such species should only be according to a conservation plan. Generally, they should not be allowed to cover archaeological features.

In grazed grassland areas, the ground beneath individual trees or groves of trees will be use by the stock for shelter. An evaluation of the effect on the site should be made. Such trees or groves should be removed if damage is or will be severe in the long term. Alternative shelter should of course be provided. This may be arranged by new planting in a temporarily fenced area or by re-arranging fence alignments and paddock areas to incorporate shelter.