Caring for archaeological sites

Practical guidelines for protecting and managing archaeological sites in New Zealand

Kevin L. Jones

Department of Conservation
Te Papa Atawhai

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Pouhere Taonga

Department of Conservation
Te Papa Atawhai

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He kupu whakataki

Tēnā rā tātou katoa. Kua tuhia tēnei pukapuka mahi e ngā kaimātai whaipara tangata e ū tonu nei ki te kaupapa, arā, kia penapenatia ngā wāhi mau taonga o neherā hei mahi whai tikanga mā te iwi Māori, mā te iwi whānui o Aotearoa, ā, mā ngā kaitohutohu penapena taiao i roto i ngā mahinga pūkenga o te motu. I rūnangatia tētahi tuhinga tauira tōmua i Waitangi, i Tāmaki-makau-rau, i Kirikiriroa, i Tauranga, i Ahuriri, i Te Whanganui-a-Tara. Ko tētahi o ngā ture tuatahi hei whai mā rātou i roto i te whakatakoto mahere penapena, ko te tātari i ngā uara rerekē ka pā ki tēnā, ki tēnā wāhi o nehe. He whenua whai tikanga ki a wai rānei, ā, he aha rātou i pēnā ai? Pēnā i ētahi Māori maha noa, e whakapono ana ngā kaimātai whaipara tangata he rawa whakahirahira ēnei wāhi, ahakoa wāhi tapu rānei, ahakoa wāhi noa mō te iwi whānui rānei, arā, he rawa e tika ana kia āta tiakina, kia āta pupuritia mō ngā whakatipuranga kei te heke mai. Whaipānga ai tēnā, tēnā o tātou ki ēnei wāhi. He mea nui tonu hei ata, hei tohu, hei mātāpuna mō te tuakiri Māori, tuakiri Pākehā hoki o Aotearoa. He wāhi mātauranga aua wāhi, he wāhi rangahau hoki e tika ana kia tino pai rawa atu te whakamarumaru mā ngā whakahaere mahi huakanga hou e kōrerotia ake nei i roto i tēnei pānui. Heoi anō, kia maumahara tonu tātou tērā pea ngā whakatupuranga o āpōpō e tau te hē ki a tātou ki te hohoro rawa tā tātou kuhunga ki te wāhi kāore i tika, ki te whakarite whakamarumaru rānei i nui atu ai ngā kino i ngā pai. Me whai wāhi hoki koutou ki aua mahi huakanga hei mahara mā koutou, hei patapatai mā koutou, hei tautoko hoki mā koutou.

Foreword

This manual has been written by archaeologists who believe that conservation of archaeological sites is an important task, for iwi Māori, for the public, and for all those people in professional employment who are privileged to advise on conservation. One of the first rules to be followed in planning conservation is to analyse the different values that relate to a site. To whom does the place matter, and why? Like many Māori, archaeologists believe that the sites, whether they are tapu or open to the public, are a valuable resource that deserves to be protected and conserved for future generations. Everyone has an interest in their protection. They are important as icons, symbols and resources for the identity of Māori and Pākeha New Zealanders. They are also places of education and research that deserve the best protection that our new techniques presented here can provide. However, we must always remember that future generations may judge us harshly if we have rushed to intervene where it was not necessary, or carried out protective measures that have done more harm than good. This work deserves your attention, your questions, and your support.

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ABSTRACT

It is important for our sense of history and national identity that archaeological sites be protected. However, only a small proportion of archaeological sites in New Zealand are in reserved areas. This guide is intended to help improve on-site protection of archaeological sites, features and areas through practical land management. Archaeological sites can be visible at or above the ground surface or lie buried beneath it. For all sites, minimising deterioration is a key management objective. Earthwork fortifications are a common form of surface-visible site in New Zealand. Surface erosion by visitors and farm animals, and planting in pine forests both cause significant problems. Sub-surface sites also need specific attention. The management of archaeological sites requires close consideration of plant ecology, because plants will generally be the most cost-effective cover. Techniques and management philosophies are recommended for five broad ecological settings: native grassland, exotic (pasture) grassland, native shrubland, indigenous forest, and exotic (plantation) forest. Techniques include encouragement of native grass covers, site-adapted mowing regimes, stock management, fencing patterns and methods, manipulation of native forest succession, felling and removal of problem trees, artificial covers such as geosynthetic cloths, and deliberate site burial. Mowing and line-trimming should be preferred to grazing for all significant sites, especially those which are open to the public. Wider cultural or historic landscape design needs to be considered, particularly for large reserves. The general principles outlined in these guidelines will be useful when preparing management or conservation plans for archaeological sites.

Keywords: resource management, reserves, local government, restoration, reconstruction, conservation plan, ICOMOS, archaeological sites, Maori, wahi tapu, landscape, monument, historic places, weed control, forest succession, forestry, farming, fire management

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Introduction

It is important that archaeological sites are reserved, accessible, protected, and authentic. Of all the sites in New Zealand, only a small portion is in a reserved area. The largest portion is on freehold land, particularly in the northern regions of New Zealand. Thus site protection requires good will on the part of the landowner. Once a particular type of protection is decided on—for example, a form of vegetation cover—it will always be wise to seek competent local advice on how to achieve that cover. Landowners are a key source of this kind of advice.

These guidelines do not give highly prescriptive advice, because the natural setting, and the conservation and heritage significance of places vary so much; and because techniques and proprietary products may change. The general principles and the techniques explained in these guidelines should be able to be incorporated into, or referred to in, management or conservation plans. Such plans should have resolved issues in detailed site management, including the role of tangata whenua. The principles stated here may help define the issues and resolve problems in conservation planning, but they are not the final word.

The Historic Places Act 1993 (s. 2) defines an archaeological site as any place in New Zealand associated with human activity (including shipwrecks) which is, or may be, able, through investigation by archaeological methods, to provide evidence relating to the history of New Zealand, and which date to the period before 1900. Such sites include middens (deposits of what was once waste from food preparation), storage pits, fortifications, and quarries. Some may be visible on the surface, some not. Appendix 1 identifies the different types of physical places that are found in New Zealand.

In New Zealand, 'historic places' can be buildings or other standing structures, wahi tapu (sites of historical significance to Maori), or archaeological sites. The vast majority of the recorded archaeological sites are pre-European Maori in age, while all of the registered wahi tapu are Maori in origin. As time goes on, the potential inventory of post-European archaeological sites continues to increase, but the pre-European Maori archaeological sites are a finite resource that needs special conservation and protection. Most of the historically significant buildings in New Zealand are post-European in age and many have significance to both Pakeha and Maori. There are a number of different marae building structures that, in some cases, are nationally significant, but most tend to be significant to particular hapu and iwi.

This guide is not about buildings, or primarily about wahi tapu, although some archaeological sites may incorporate elements of both and the general conservation principles and techniques described here can also be applied to wahi tapu, if required. Nor is the guide about the legal protection process. Instead, it is aimed at practical land management to give improved on-site protection to archaeological sites, features, and

areas. It is important to our sense of history and national identity that archaeological sites are reserved, accessible, protected, and authentic.

An archaeological site/wahi taonga is part of a cultural pattern of occupation which may be evident in the landscape. It may be the product of a succession of activities and occupation. There are 56 000 sites recorded in New Zealand. A high proportion is of Maori origin. Most sites are quite small—maybe just a few pits on a ridge. A small number cover up to 1 ha or occupy as much as 500 m of a ridgeline. A typical farm in coastal regions or on major rivers of the North Island might have one or two medium-sized sites and a scatter of sites of small area. The largest sites are the large pa, such as Otatara in Hawke's Bay, or the pa on the Auckland volcanic cones (Fig. 1). There are also extensive areas of pre-European gardens in the coastal Bay of Plenty, or on the flanks and surrounding stonefields of the volcanic cones of Auckland or Northland.

Figure 1. One Tree Hill, Auckland, viewed from the southeast. Relatively light grazing by sheep has maintained features well. Having staff and concessionaires on site (to right) enables close supervision of visitors. The pattern of treeland reveals the upper features of the site well to visitors on the ground.

A whakatauki (Maori proverb), 'He whakatipu ngā otaota' (Let weeds flourish), implies that all man-made productions are in a cycle of decay and being resumed by the earth. Consultation, planning, and working—with appropriate Maori authorities and hapu in particular—is an essential early stage in any planned work on archaeological sites. As it is sometimes difficult to ascertain who the appropriate Maori groups are that should be consulted and worked with over any planned work on sites, the New Zealand Historic Places Trust Pouhere Taonga maintains a list of iwi authorities and Maori heritage groups that can be accessed. As an organisation, the trust has developed good working relationships with iwi across the country on a range of heritage issues and can be consulted for advice about how and who to contact for consultation and partnership purposes.

Section 4 of the Conservation Act 1987 requires the Department of Conservation (DOC) to actively protect resources of interest to tangata

whenua, and to consult. Similar duties are imposed on other departments and the wider community under the Resource Management Act 1991 and the related Historic Places Act 1993. In the future, district plans are the medium which will impose restrictions and duties on land managers, but practical advice and good will are needed to make regulation work. Early in any consultation phase, good examples of positive management of sites to conserve their archaeological, visitor-appreciation, and other commemorative values should be part of the approach of the land manager to Maori communities.

Any kind of disturbance of the ground surface sets an archaeological site at risk. This raises questions about the best way to manage archaeological sites on farms or forestry land, or in urban areas, in a manner that is complementary to productive use. Sites with surviving surface earthworks—such as pa or storage pits—are often on high points or on ridge lines. Their protection and management in the course of farm or forestry operations is of particular concern. Many subsurface sites are in areas of intensive rural and urban use (under houses, under flat land used for yards), so that impacts on the sites are always possible. Archaeologists, in turn, have to recognise that rational protection of site values requires good methods of protection, balanced with the recognition that landowners should enjoy usage and commercial return. The Historic Places Act 1993 is the principal regulatory tool which enables the Crown to balance these factors.

Although only a small proportion of sites are actively managed, other sites should be kept in stable vegetative cover that protects the archaeological values and requires the least long-term management effort and cost. Sites for public appreciation should have the vegetation managed so that the stratigraphy, earthworks, and other structures are not only visible, but also protected. Opening up rare or unique types of sites (this includes the display of excavated areas) should be done with great caution. The same applies to the exploration and documentation of delicate sites such as cave floors and places with rock art.

The alternative to active management is to accept that there will be a steady loss of archaeological sites and values, or that there should be a cost to record and to recover information from the archaeological sites. The Historic Places Act 1993 is based on the premise that the destruction of sites should be controlled. Under the act, where destruction is inevitable there may be a requirement for an excavation, which can be expensive. For many years, archaeologists have seen excavation as an early resort where site protection could not be guaranteed. However, in the last decade, all international guidelines, such as the International Charter for Archaeological Heritage Management (ICAHM), have moved away from the assumption that sites should be excavated where they come under threat. Instead the stress is on in situ (in the ground) management and protection of sites for the information they contain and for their broader cultural interest.

A managed site is a recognised asset, and is less likely to be inadvertently destroyed by careless land development. Even if they are damaged in

some way, sites will still have significance to tangata whenua (Maori people) and local communities, and will also still have archaeological value. Evaluation of the protection possibilities for damaged sites should be the subject of discussion between landowners, archaeologists, and tangata whenua.

Examples of the damage that can happen on farms are roading or fencing, which may cut through a site. Yet farmland grazed by sheep provides the most obvious way to reveal the form of ancient surface earthworks for visitors or for passers-by. Forest or shrubland cover will obscure these reminders of a more ancient landscape. Tree root growth and tree harvesting destroy sites, but there are also opportunities to protect sites in small patches of grass or native shrubs within the forest. Where a site is to be open to the public and interpreted for public presentation, visitors may come from any part of New Zealand or the world. The preservation of archaeological sites in the long term depends on the good will of local people. These guidelines will assist in defining these issues, and will provide logical steps in planning for protection and describing techniques that can protect sites in a variety of situations.

The guidelines presented here cover methods for the conservation and restoration of archaeological sites. They revise and replace 'A manual of vegetation management on archaeological sites' (Hamel & Jones 1982). In 1994, the sites in that manual were re-visited and re-surveyed (and additional sites were surveyed) by Jones & Simpson (1995a, b). They noted that few sites had been managed positively following the recommendations of the 1982 manual. Some of the sites were in far worse condition than in 1982. In more recent years, positive investigations have been carried out on ground covers at Ruapekapeka (Woods 1993, 1999) and insights have been drawn from that work. Such documentation is particularly needed because without it experience of stabilisation initiatives cannot be consolidated and more widely disseminated to professional land managers. In addition, published guidelines for international practice (Jones 1993, 1998; Andropogon Associates n.d., 1988; Thorne 1988, 1989, 1990; Berry & Brown 1994, 1995) have influenced this study.

These guidelines are intended for people professionally involved in the management of land where there are archaeological sites, which includes:

Land owners and managers

- DOC conservation officers and technical services officers
- Farm and forest owners and managers
- Local and regional government reserve managers and operations staff
- Private landowners administering covenanted areas or areas where there are archaeological sites

Waitangi Tribunal and Office of Treaty Settlements

Maori Land Court

Tangata whenua

- Iwi authorities and iwi heritage management groups
- Trustees and lessees of Maori Reserves

Professional groups

- Landscape architects
- Queen Elizabeth II National Trust
- New Zealand Historic Places Trust
- Archaeological and resource management consultants

The work is arranged as follows:

Part 1—Discussion of heritage policy issues that will assist an understanding of archaeological values and management objectives for archaeological sites.

Part 2—Techniques for maintaining condition of sites.

Part 3—Guidance on archaeological site management under particular land uses (amenity, forestry, farming), with several case studies.

1. Conservation policy and planning

This part deals with the policy background to the practical care of archaeological sites—the values, conservation threats, and interventions involved. All land managers will need to consider a broad range of values: cultural, policy, local community relations, resource management and logistical matters. Any conflict in values will need to be resolved by good conservation planning.

The statement of outcomes—the long-term results and benefits—was developed in discussion with staff of the New Zealand Historic Places Trust.

1.1 DESIRED OUTCOMES FOR ARCHAEOLOGICAL SITES

If these recommendations outlining the care of archaeological sites are followed, outcomes for archaeological site management will be different from those at the moment. Most sites will continue to be managed as part of farming or forestry operations. At the least, continued heavy stocking with animals or forest reversion on sites will become a matter for decision by land managers. At best, archaeological sites and the landscape areas in which they can be appreciated will have distinctive management that conserves them properly, and guarantees that in the long term they will be available as landscapes or places of tribal identity, mana, commemoration, education, and research.

Distinctive management for archaeological sites will lead to the following outcomes:

- All archaeological sites are managed with care and in a professional way to maintain authenticity of the original fabric and stratigraphy.
- Reserve land with archaeological values have distinctive management in sympathy with the values protected and different from that of other classes of land.
- Wahi tapu are treated and valued as heritage resources in the same way as archaeological sites.
- The archaeological landscape is distinguished within the natural landscape by appropriate use of vegetation contrasts and links.
- A large number of sites remain under shrubland or other appropriate cover and are protected, so that in the future a decision could be made to allow for a range of management purposes—including public visitation or to conduct research.
- Damaging or potentially damaging land uses on areas that have archaeological sites are avoided.

- Some archaeological sites are actively managed to preserve them for the longest time frames (thousands of years).
- Land owners and managers have a good relationship with the public, tangata whenua, and other descendant groups such as New Zealand Chinese:

  —At appropriate sites, members of the public take an interest in and appreciate the place and the lives of the people who lived or worked there.

  —Kaitiaki and other descendant group(s) are involved in conservation planning and active management.

  —Sites of Maori origin are conserved and managed in partnership arrangements between landowners and relevant iwi.
- Accessibility and appropriate use is provided for:

  —Where access is part of an approved conservation or management plan, sites are maintained to allow the public to visit and appreciate them, without risk to the site.

  —Sites with high archaeological, historic, landscape, and educational values are a valued part of the visitor/tourist infrastructure.

  —Archaeological sites, and the historic landscapes of which they are a part, are maintained so that the cultural features are visible and able to be appreciated from within the reserve and from the surrounding area.
- Site management techniques are understood and supported by the wider public:

  —Appropriate resources are available for the management of archaeological sites.

  —Sound techniques are in widespread use by land managers and are taught in training programmes.

  —Conservation planning can rely on a growing body of experience and proven practices.

1.2 CONSERVATION AND LAND MANAGEMENT OBJECTIVES

In addition to these outcomes, a number of objectives relating to good land management need to be achieved. These are as follows:

- Public access to a range of archaeological sites in reserves is maintained and enhanced.
- Site management is cost-effective and efficient.
- Vegetation covers used are stable and ecologically appropriate.
- Maori values are fundamentally integrated into land and conservation management planning.
- Archaeological site management takes into account the need for biodiversity conservation, recreation, farming and commercial uses.
- Sites managed under these guidelines are seen to be examples of good management.

1.3 PRINCIPLES OF CONSERVATION

In the 1990s, the process and principles for conserving historic places, buildings and sites alike were systematised. Figure 2 (based on Thorne 1988) shows the process of site conservation.

The Australian ICOMOS Charter (The Burra Charter) of 1981 (Australia ICOMOS 1999; Kerr 1996), the Aotearoa Charter (ICOMOS New Zealand 1992), the International Charter on Archaeological Heritage Management, and the Cultural Tourism Charter all have relevance to the task of site

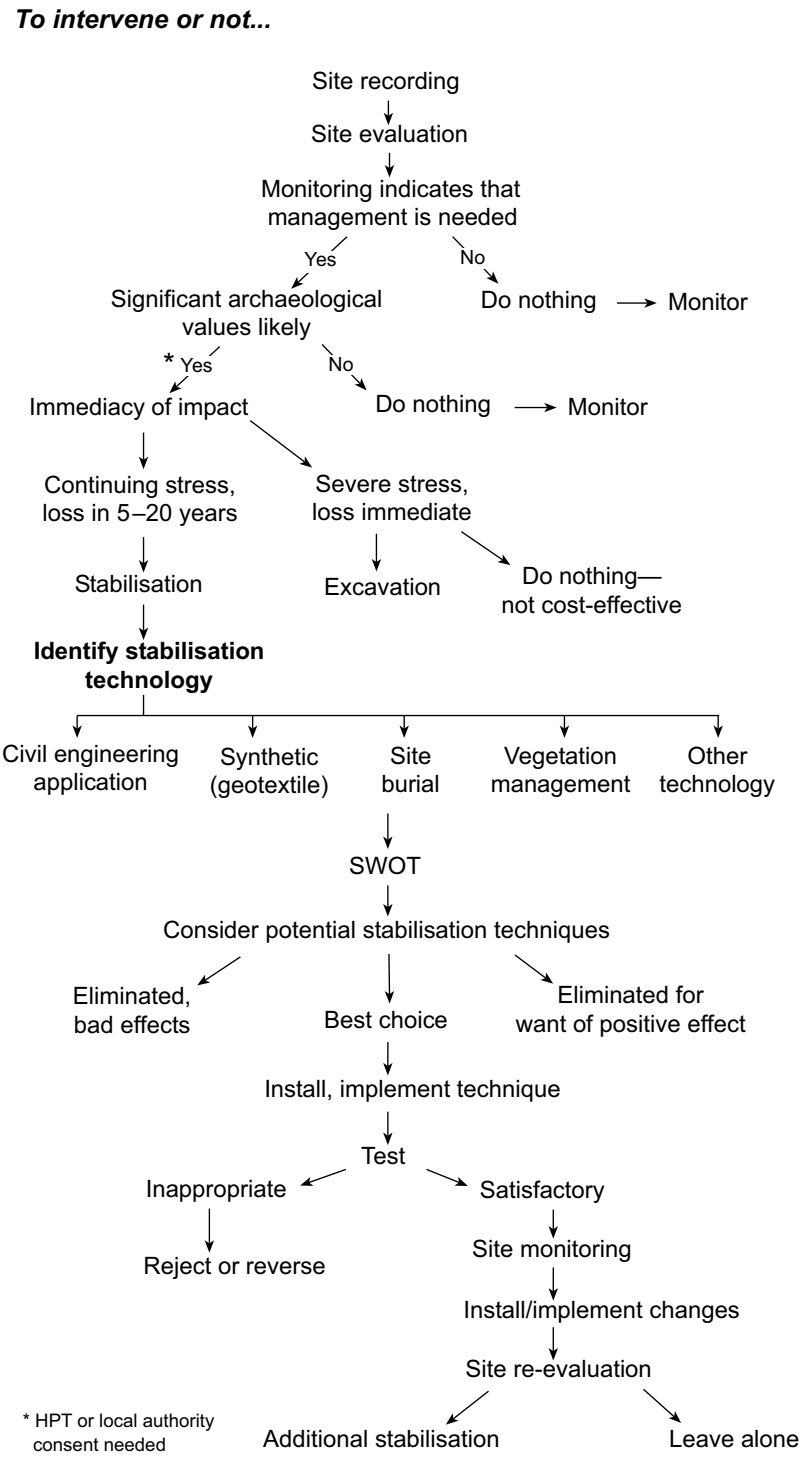


Figure 2. A model of the conservation process. SWOT: Strengths, weaknesses, opportunities, threats. After Thorne (1988).

preservation. (ICOMOS is the International Council on Monuments and Sites, a UNESCO agency.)

These charters adopt a conservative approach to the preservation of historic places. Although recognising that a range of values need to be considered and respected, they stress the principle of the need to maintain the integrity of surviving fabric. The existing materials of a site or place should have their condition stabilised, and not restored or reconstructed. Key concepts of the charters as they apply to archaeological sites, particularly earthworks, follow.

Some conservation concepts

Authenticity—The physical constituents of a site and its associations for people reflect continuity with and respect for the past. Authenticity depends on maintaining the overall form of the site and standing earthworks and the stratigraphy.

Conservation—All the processes involved in caring for a place so as to retain its significance.

Preservation/Stabilisation—Maintaining a place with as little change as possible.

Restoration—Returning a place to a known earlier state by the re-assembly and reinstatement of surviving but dislodged fabric or by the removal of additions.

Reconstruction—Returning a place to a known earlier form by the introduction of new or similar materials ... usually where a place has been damaged.

Monitoring—Measuring or other recording of condition at time intervals so as to determine whether change is occurring, and in particular whether it is accelerating.

Intervention—Actions taken to improve the condition, or reduce the deterioration of an archaeological site. Intervention may include ceasing an activity which is damaging a site.

(For further comment on Reconstruction and Restoration see section 2.6.)

1.4 VALUES OF ARCHAEOLOGICAL SITES

1.4.1 Potential for archaeological research

Archaeology is an essential part of identifying and evaluating the evidence of past human activities. Sites are not just pieces of dirt with artefacts in them. They are a product of human activities, which have been altered over the succeeding years by physical, biological, and chemical processes and human activity. These processes eventually reduce a place to a fairly stable state, but one in which soil layers and surface features can still be detected and investigated. For successful investigation, the condition of a site at this stage should be maintained as far as possible. Further

disruption by alteration or destruction needs to be inhibited or prevented if the archaeological evidence is to be preserved. The authenticity of the site requires protection of its scientific and information potential as well as the form of surface earthworks.

1.4.2 Wider community values

Sites should be not only places of potential archaeological research, but also places that commemorate the past. Some sites may be important simply because an important event happened there and may have no surface expression of that event. All these sites hold different meanings for different groups within New Zealand society. There may be some places the nation does not wish to commemorate, or some particular local community does not wish to see commemorated, interpreted, or investigated—for whatever reason. However, these places may need protection through control of the vegetation or other means. Authenticity is still relevant.

1.4.3 Educational values

Education about the past is an important function of historic sites. The knowledge on which education depends may require research into the site, including its archaeology. Commemoration is also a part of education. Learning may be regarded as a form of recreation.

1.4.4 Landscape values

These include the need to view the site as part of the historical values which have accrued in a wider area. Maintaining sites in a visible condition in the landscape is important for understanding and 'reading' a place, for educational purposes and to encourage an interest in and appreciation of the past and archaeological sites in particular. This may require appropriate management to maintain views to and from the place, use of appropriate vegetation cover, etc.

1.4.5 Other values

Other values will include amenity and recreation values, vegetation values, and landscape value. Vegetation can itself have historical and commemorative value. Many historical sites will have amenity values for low-impact activities such as walking, relaxation, and visiting for the view.

1.5 THREATS TO ARCHAEOLOGICAL SITES

The authenticity of a site depends on maintaining two characteristics. The first is the surface form of standing earthworks and their relationship to standing structures. The second is stratigraphy (the layers of the site) which will, in many instances, be related to the surface-visible earthworks. Stratigraphy is not only structures in the ground—such as the cut marks and fill of terraces, pits, postholes and drains—but also deposits such

as oven rake-out and midden, and layers of soil that may have formed when people left the site.

A threat is any factor which will destroy the commemorative associations of the place or disturb, disrupt, or remove any earthworks or stratigraphic evidence.

1.5.1 Major classes of threat

English experience shows that the risk to archaeological sites is highest on forestry and arable land. There are moderate risks in urban areas and on pasture land (Darvill & Fulton 1998: 225–226). New Zealand experience would also suggest that farming and forestry are major sources of risk (Prickett 1985). Figure 3 gives a shorthand summary of these classes of threat. There are further threats that need to be managed. These include public visits to land within the protected area network, and any intensive management to cater for this visitation. The final threat is to sites with unstable and rapidly changing vegetative cover such as weeds or specimen trees (Fig. 4). There are other broad classes of land use change which can threaten sites such as pasture to viticulture or urban subdivision, but these are generally governed by wider regulatory arrangements and are not within the scope of these guidelines. Some particular techniques covered in these guidelines, such as deliberate site burial, will be relevant.

Some threats to archaeological site condition

Natural causes

- Root growth from the site's vegetation cover
- Weed growth and inappropriate weed removal practices

Figure 3. General diagram of threats to surface earthworks and sub-surface layers of an archaeological site.

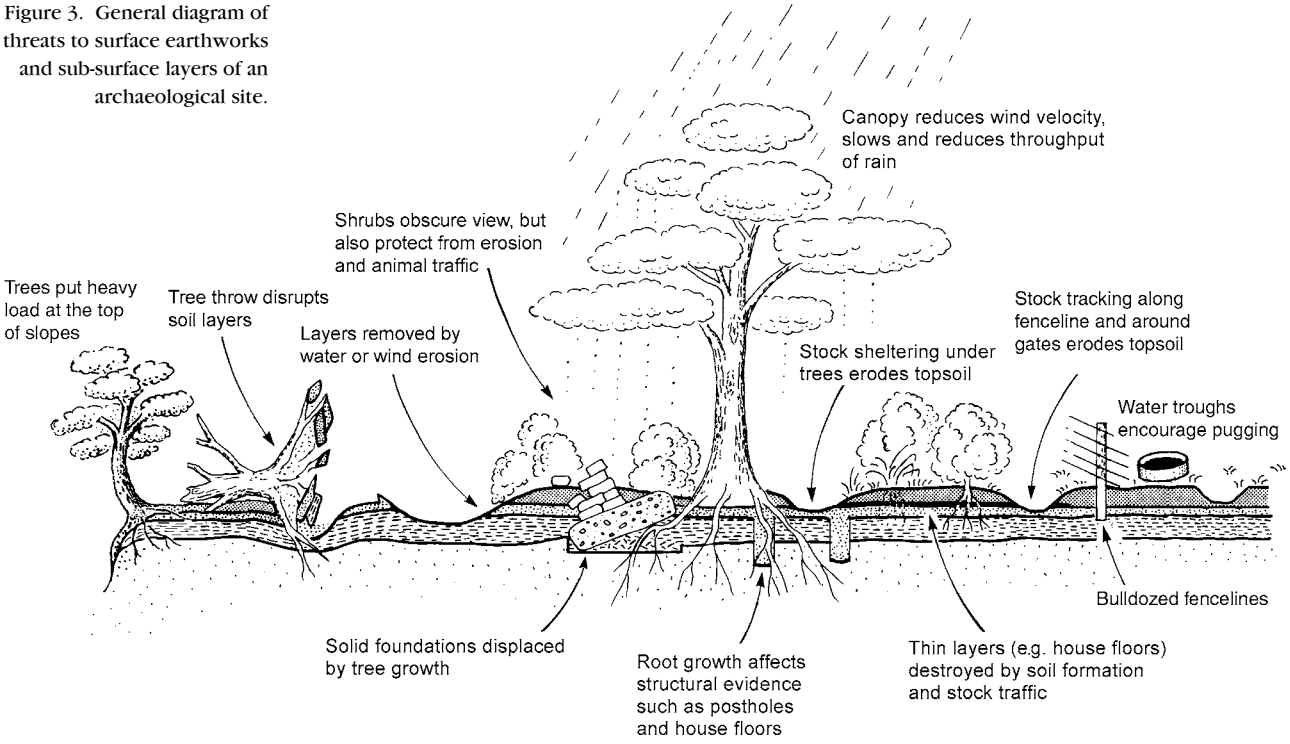


Figure 4. Root plate of a thrown tree at Whangapoua, Great Barrier Island (Aotea Island), showing midden and oven-stones in the dislodged earth. *Photograph: Dianne Harlow.*

- Tree throw, generally caused by wind pushing over the tree and lifting the tree's root plate (Fig. 4)
- Soil processes—physical, chemical, and bioturbation (disturbance caused by plant roots or animals), including freeze-thaw
- Erosion and gross movement—gullies, sheet erosion, wave and stream erosion at site margins and in landslides or subsidence, deposition of erosion products
- Burrowing animals—principally rabbits and pigs; ground-nesting birds such as petrels may burrow in areas such as coastal headlands

Human activities

- Roads and tracks, fencing
- Inappropriate mowing practices
- Damage caused by excavation of all kinds
- Wear from walking, 4WD vehicles, and mountain biking (Fig. 5)
- Damage from camping, tent sites, fireplaces
- Wear from machinery used in park management, including line-trimmers and mowers
- Compression of layers, especially where fill is placed or vehicles run over the site

Farming and forestry

- Damage caused by farm animals including soil compaction, pugging, tracking (especially near fences and gates), pawing and dust bowls (especially by bulls), scrapes and 'camping' areas for shade or shelter from wind, downhill soil creep, terracette formation, and slumping
- Inappropriate fencing practices
- Ploughing/disking
- Tree planting and root growth disturbing stratigraphy
- The impact of tree felling and hauling

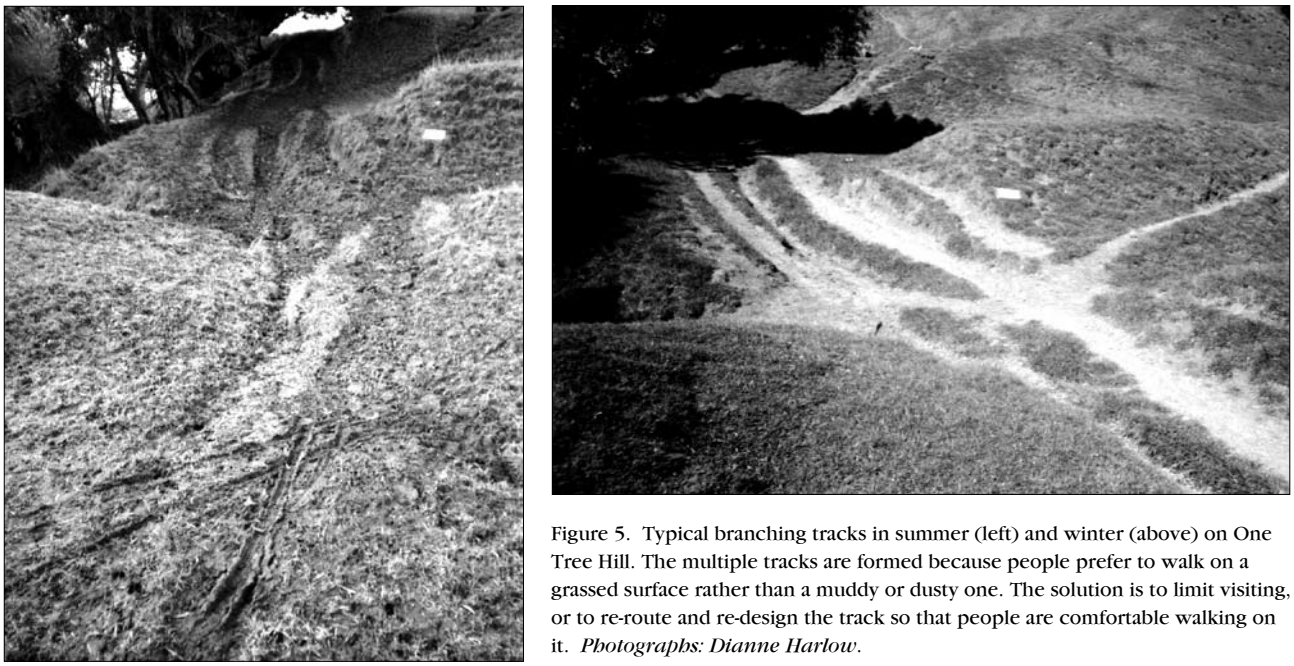


Figure 5. Typical branching tracks in summer (left) and winter (above) on One Tree Hill. The multiple tracks are formed because people prefer to walk on a grassed surface rather than a muddy or dusty one. The solution is to limit visiting, or to re-route and re-design the track so that people are comfortable walking on it. *Photographs: Dianne Harlow.*

- Damage caused by any kind of machinery use including bulldozing, ploughing, stump pulling and posthole diggers

1.5.2 Past disturbance and soil formation

The modification of a land surface did not end when its first occupiers departed. In hill country, pre-European sites commonly had a grass, bracken (*Pteridium esculentum*), shrubland and forest succession from the 1820s to the 1840s—a period of rapid population decline and radical changes in settlement pattern for Maori. This forest probably lasted for up to a century until the 'breaking-in' of hill country for farming from the late nineteenth century through to the 1940s. Most sites will have experienced some soil development under these vegetative covers, even without major disturbance such as tree throw.

There are many soil-forming forces at work on archaeological sites. The chemical and physical constituents of the soil break down through weathering and some are leached out of the soil. Trees are felled by the wind. Soil animals live within confined surface horizons, and in some areas of the country wild pigs root for their preferred foods. All the above processes are accompanied by soil development. However, it must be remembered that most of the biological activity is in the topsoil and is inevitable. Topsoils will have formed beneath the bush that covered many archaeological sites before farm development or plantation establishment. Such soils will vary in depth and may contain archaeological evidence. Generally, the topsoil provides a protective blanket for all but the most fertile and deeply buried of the old soils or fill preserved in the archaeological site. The surface of the topsoil may show depressions or humps that indicate the presence of a pit or a mound or other sub-surface features beneath it.

An understanding of modern disturbances of the soils on archaeological sites is important when deciding on appropriate management. If a site has

been deeply cultivated, pig-rooted, or if large trees have grown on it in the past, it may reasonably be argued that further root growth can do no further harm and trees may be allowed to grow. The interiors of pa have warm, fertile and often sheltered soils. Since abandonment, the surface layers may have been cultivated—initially through Maori horticulture in the early to middle nineteenth century, and then by European arable farming.

Erosion products have buried all or part of some sites, protecting them beneath a robust mantle. Elsewhere, erosion may be removing or destroying some sites, leaving little of archaeological value. Any sort of disturbance of the soil degrades the surface profile of a site.

The following is a generalised history of rural sites from about A.D. 1820:

- Repeated fires sweep through site, destroying wooden structures
- Short-lived fire weeds and grasses establish
- Pits, trenches, depressions, holes fill in and form a stable profile
- Bracken/manuka cover develops
- Banks, first rapidly, then gradually, attain a more stable profile and angle of repose
- Forest becomes established
- Long-term slow forest processes are established
- By 1890–1910, land containing sites is either reserved or subject to forest/shrubland clearance and farm development
- The latter causes rapid changes to soil surfaces and greatly increases erosion

Later, remnant patches of forest, unsustainable farmland that has reverted to shrubland, and farmland itself, can be subjected to more intensive uses. Plantation forestry introduces roads, farmland may be more closely fenced, and fertiliser and stocking density increases. For a number of reasons, the decades since 1945 have seen great increases in the intensity of land management which have been destructive and continue to have potential to cause more destruction. These influences include farm re-settlement of soldiers after WWII, land development grants, lifestyle blocks, bulldozing and ploughing technology improvement, and changes in product demand (e.g. from sheep to cattle, from grazing to arable). Greater efficiency and profitability is unavoidable, but it does not need to be accompanied by destruction of archaeological values.

1.6 CONSERVATION PLANNING

The ICOMOS New Zealand Charter stresses the need for close consideration and documentation of the values and management intent behind stabilisation or restoration, and the need to document any changes made. When the values and physical features of a place have been documented, it is possible to develop a conservation plan (Kerr 1996). Examples are the Pukerangiora Pa and Te Koru Pa conservation plans (Department of

Conservation 1998, 2000). At this stage also, the management agency or landowner should have given an indication of the resources that are available for the proper conservation of the place. Some interventions may have technical merit and be feasible, but they may not be possible because of cost.

Under the Reserves Act 1977 (s.41), all reserves should have a management plan which specifies conservation practices at the reserve. The Department of Conservation, Queen Elizabeth II National Trust, the New Zealand Historic Places Trust and most local government agencies will also have some form of over-arching management strategy and specific plans for land and sites under their management or covenanted with them. International models such as those of English Heritage (1999) also have potential application.

There is no statutory requirement for plans—formal or informal—for freehold land where there are archaeological sites. However, the Historic Places Act 1993 gives protection to all sites. District plans will also often have provisions requiring protective measures for sites. A minimum plan for good freehold land management which accommodates archaeological site protection is given next.

1.6.1 Minimum management requirements for archaeological sites

- Are there any sites on the land?
- What are they?
- Where are they and what is their extent?
- How important are they?
- What risks are there to site condition?
- Can they be effectively managed within the general farm or forest operation?
- What operational measures or expenditure (e.g. on fences) is needed to protect the site?
- Where can advice be sought on the above matters?
- Is there financial or other assistance available?

1.7 INTERVENTION

Intervention is any action taken to improve the condition or reduce deterioration of an archaeological site. Intervention may include ceasing any activity which is causing damage to a site. Intervention is one of the key deliberations framed in conservation plans. Planning philosophy stresses the importance of the decision as to whether or not to intervene (e.g. ICOMOS New Zealand 1992). For archaeological sites, relevant matters to be taken into account are:

- Review of the values and a cultural or scientific assessment of the site
- Management intent—what is being sought by intervention and site management?

- Consultation with tangata whenua
- Are there any requirements for authorities/consents under the Historic Places or Resource Management Acts?
- The likelihood and rate of change to site condition with no intervention
- The impact of intervention on the values of the site
- The proven long-term reliability, cost, and cost-effectiveness of the technique used
- The need to monitor and record the effectiveness of the intervention
- The impact of intervention on non-archaeological values of the site and its environs (e.g. the flora or broader ecological processes)
- Public attitudes toward intervention—public education or information may be needed to explain the intervention

When is intervention warranted?

Intervention is warranted to achieve these outcomes:

- Prevent degradation of archaeological layers
- Manage vegetation cover that is, or will become, unstable
- Maintain clear definition and surface visibility of earthworks for public appreciation
- Close off features from public access or viewing
- Encourage greater public visitation
- Maintain views of the site, and views from one site to another
- Stabilise backfilled archaeological excavations
- When monitoring shows that damage to a site is occurring, particularly when the condition is accelerating or worsening rapidly
- When minor damage can be easily and effectively arrested

Intervention may be warranted to protect one or a combination of the following: surface features, stratigraphy, ruins and excavated sites which have been left open to the elements, or backfilled archaeological sites. Restoration and repair are also justified for earthwork sites damaged by machine work, animal or human tracking, or natural processes such as tree throw.

Some modification and even deterioration of sites visited by the public is inevitable. The benefits for conservation to be gained by greater public awareness will outweigh the disadvantages. The deterioration, however, should be made good at regular intervals so that the public gains an impression of care and concern for the archaeological values. An obviously damaged site will suggest to the public that the site and others like it are unimportant. Also, destruction left by vandals leaves an impression of lack of care and the site is more likely to suffer further deliberate damage—vandalism breeds vandalism.

The archaeological ideal is to establish relatively permanent vegetation which will preserve the site indefinitely by preventing erosion, but which will not cause damage by invasive large roots. As a general rule, stable

cover means a stable site underneath (Jones 1998). An existing native forest has probably taken 100–200 years to establish on a site and is generally stable. There are few grounds for removal of such forest—equally there are limited grounds for attempting to establish new native forest on sites. On some sites which are not to be interpreted for public visiting, it may not matter if the views of the site are obscured by dense bracken or manuka. However, in many cases it is desirable to maintain earthwork sites in a condition where they remain visible from a distance, even if not accessible to visitors. Particular forms of vegetation can be established on sites where the public are to be kept out. Thick shrubland or gorse (*Ulex europaeus*) are examples: these are usually successional species in most parts of the country and will inevitably be invaded by larger shrubs and trees with potentially damaging roots. In the course of a vegetation succession, management should generally be aimed at retarding the development of larger trees within areas of intact archaeological sites. The growth of trees may be more acceptable in damaged areas or on immediate site boundaries if root spread problems have been considered (Crow & Moffat 2005).

For sites which are to be presented to the public, a different kind of vegetation and management will be needed. Grass cover, with or without patches of treeland, or an open, managed treeland are vegetation types most suited to the needs of visitors.

Small incremental changes, reversibility of method (or reversibility by relaxing of vegetation management), and improved monitoring effort are the key steps forward.

When is intervention not warranted?

Intervention is not warranted when:

- Following a period of monitoring, the site is judged to be in stable condition
- There is a high risk of intervention causing damage or catastrophe owing to lack of knowledge of the site or ecological setting
- There are no patches of active erosion
- There is no risk of earthmoving equipment gaining access (e.g. during fighting fires or to remove gorse)
- There is stable native vegetative cover—climax forest or advanced succession
- There are no damaging weeds present and the site is not a source of weeds of concern to adjacent landowners
- There is an expression of wishes by tangata whenua, or from other culturally appropriate practices, against intervention
- Ease and simplicity of management are required (i.e. no-care management)

1.8 MONITORING

Monitoring is essential in most site management. Monitoring is of particular importance because almost all of the technologies in use for archaeological conservation do not have proven long-term effectiveness. It is needed to judge the stability of the site. It allows reflection on the values of the site and the complexity of the forces which may be at work and causing damage. Detailed regular monitoring should be carried out on sites of high significance. Sites of lesser significance should be monitored at longer intervals, or when there is reason to believe that deterioration is accelerating.

For sites under active management, the functions of monitoring are to:

- Assess how effective management techniques have been, and whether further inputs are required
- Detect whether further action is needed and take steps to see that it is carried out
- Assist in determining whether a particular management technique has wider applicability

Every site that is under a regime of managed care needs to have a formal review (preferably annual) of earthworks or site condition, evaluating the existing conditions. Special attention should be paid to conflicts between access and condition, the appropriateness of infrastructure, current maintenance operations (e.g. mowing or line-trimming), and the causes of any damage. The goal is to clarify and amend future work programmes, conservation plan annotations, mowing plans, etc.

Any acceleration in the rate of movement, or cracking of the soil or soil surface, should be examined for possible causes. The rate of acceleration may give a clue as to whether catastrophic failure is possible. However, most of the damage done to sites is creeping and accumulative. Fretting (patches of surface erosion) are cause for concern because they are the clearest indicator of a process that in the long term will accumulate severe damage. On many earthwork sites it is possible to observe small areas under active erosion (e.g. where a foot track goes over a bank or where the bank is undermined by sheep camping). In some instances, the erosion will heal by natural processes. In others, some intervention is needed. In yet other instances, the eroded profile may be more stable and intervention in the erosion process will interfere with the original fabric, introducing the need for costly long-term maintenance. Another frequent cause of disturbance is the growth of tree weeds (Fig. 6). In time these will become unstable and will be toppled by high winds.

Figure 6. Monitoring wattle blown over on Matekerepu Historic Reserve, Bay of Plenty. The wattle has grown from seeds fallen into cattle-pugged areas of a former grazed grassland. Although part of a process of natural soil formation and plant succession (in this instance, to coastal hardwood forest), this type of damage is unnecessary and can be controlled on archaeological sites.

The choice of monitoring technique is not as important as the specification of points on a site at which observations are taken. All monitoring requires accurate site plans on which photo points, written notes, sketches, other measurements, or installations can be located. For

monitoring to have long-term meaning it is important the points used each time are the same, so that comparison over time is possible. In relatively featureless ground, accurate central points and perimeter boundaries need to be determined by GPS so that the site can be re-located. The Pukerangiora Pā Historic Reserve Conservation Plan (Department of Conservation 2000) contains a detailed plan of the site with extensive notes on condition, based on low-level aerial photographs and ground inspections, with archived photographs.

Monitoring reports should be kept so that they can be referenced to see changes. For institutions, this can be in files that will be archived. Reports on the condition of sites are welcome in the New Zealand Archaeological Association site recording scheme, filed under the site number (see www.nzarchaeology.org/recording.htm).

Monitoring methods are the subject of ongoing research and development of operating procedures by DOC and by the Auckland Regional Council (Walton 2003).

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. It deals first with erosion control, followed by vegetation and ecologically appropriate methods. Then a range of broader environmental influences that raise management issues (such as burrowing animals) are covered. Physical methods of site protection and issues which arise 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 these are 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 which 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. The New Zealand Forest Service stabilised dunes by planting a sequence of marram, lupin, and then *Pinus radiata* in a number of large-area programmes. Marram grass can create high unstable dunes and, being an exotic, is no longer encouraged as a method of stabilisation. Recommendations on native 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 banks by rivers and streams is a natural phenomenon and any control measure needs to be based on a knowledge of the whole of the catchment and the 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 cause local erosion. Changes in land use, such as urbanisation, can increase flood peak flow rates and increase the energy the stream has available 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 of their spread.

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 to rise. As with wind erosion, the underlying systems of coastal currents, sediment supply and removal are complex and cover a large area. Small local interventions may not work. 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, addition of sediment to beaches, and sea walls (Fig. 8). The last

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

of these poses particular problems. Sea walls reflect waves and cause greater turbulence and erosion immediately in front of them; they often fail through being undermined by such erosion; and 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.

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 been slowed, it will not stop as the slope evolves to a flatter, more stable profile.

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 shores 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 at the other 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 interventions.

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 (Jones 1988). 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 stone and earthwork structures, earthen mortars, and bricks. The moist, lower parts of a structure may freeze. The water in the structure expands as it freezes, expanding the soil volume 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 pig-rooting. 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 on 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 cookianum*).
- 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 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

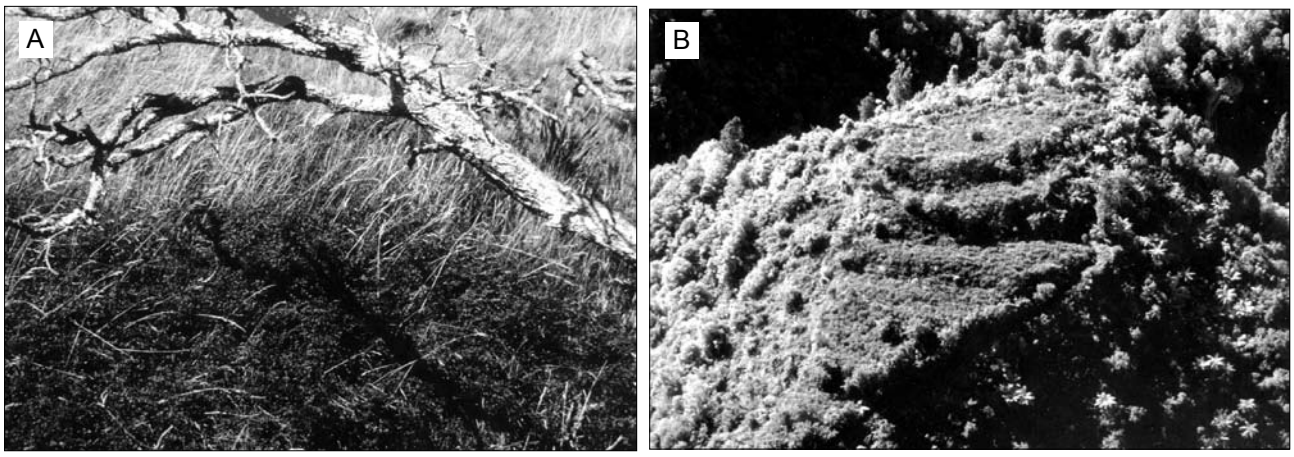


Figure 9. Longer-term changes in vegetation cover. A. Thirty years after the cessation of grazing, there is a cover of cocksfoot (on the flat) and Muehlenbeckia on the bank of this pa at Station Bay, Motutapu. The site is stable, but the pohutukawa, which would have been acceptable in this coastal setting, 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

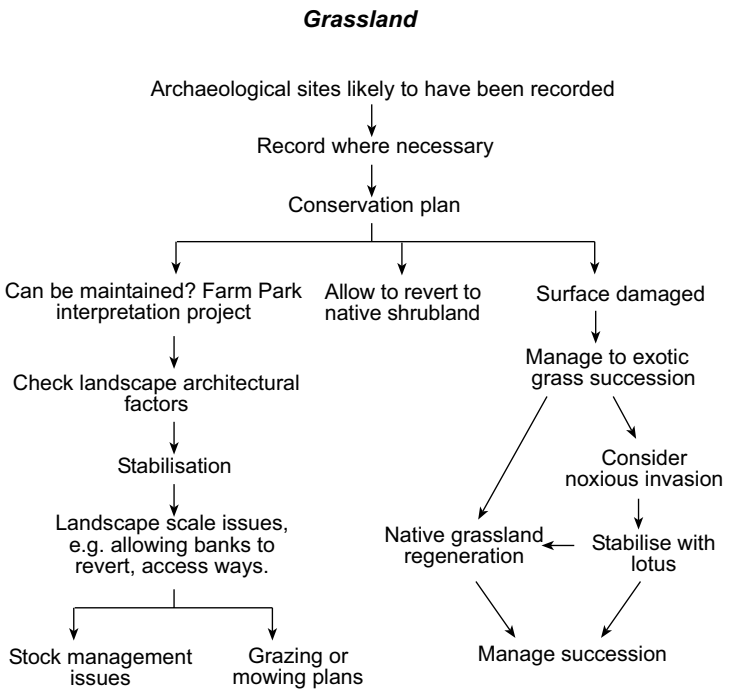


Figure 10. Likely options to take in deciding on the management of grasslands on archaeological sites.

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 (*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.

† 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
	Grasses bolt to seed
Can be left alone with little or no mowing	Seed and flower heads shade legumes
Opportunity for native shrubland to succeed the grass cover	Tussock forms poor for soil stability
May be combined with native shrub canopies	Risk of weed and shrubland invasion; weeds may suppress grass
No fertiliser required; grasses tolerate acid soil conditions (nutrients less available)	Fire risks of dry tall grass
	Tall grass obscures archaeological features
Local adventives (not commercial varieties) will arrive	Stock camping/erosion without intensive fencing and grazing management
Varieties/species will adapt to highly localised conditions	
Low palatability to stock and may slowly become dominant in the sward if no fertiliser is applied	Not resistant to treading
	Cattle stocking needed to reduce tall poor grass
Self-perpetuating and stable cover if flowering and seed set is allowed to occur	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

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

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 down-slope.

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 planning may need to allow for a suitable lead-in period.

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

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.

2.2.5 Establishment of grasses on ground cleared of scrub or fern

Scrub- or fern-covered ground can present a major problem in 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.

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, over-sowing 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.

2.2.6 Grazing

Grazing is a potentially useful tool for archaeological site management. It ensures, among other possible objectives, that a site remains visible and accessible at little net cost. However, cattle and high densities of smaller animals can cause rapid changes to ground surfaces (Trimble & Mendel 1995). It is noticeable that grazing 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 and other evidence of heavy wear, on grazed banks.

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 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. (Stock units are further defined in the Glossary, see Appendix 5.) A fertiliser maintenance rate of 15–25 kg per s.u. is an accepted rule of thumb to achieve these grass heights and grazing levels. The Auckland Regional Council recommends a base rate of 375 kg per ha which for 6–10 s.u. per ha is a somewhat higher rate of application. These rates may be contrasted with rates for a high-producing dairy farm of about 1000 kg per ha.

Any reserve that is being grazed and which shows satisfactory conservation condition can be checked to re-affirm this guidance. Stock and pasture consultant Ross Duder notes that Mount Eden (Auckland) is stocked at 4.5–7 s.u. per ha in spring and summer. Problem microsites and the overall archaeological values of the area will still need to be monitored closely. Ross Duder also recommends that young cattle used on large

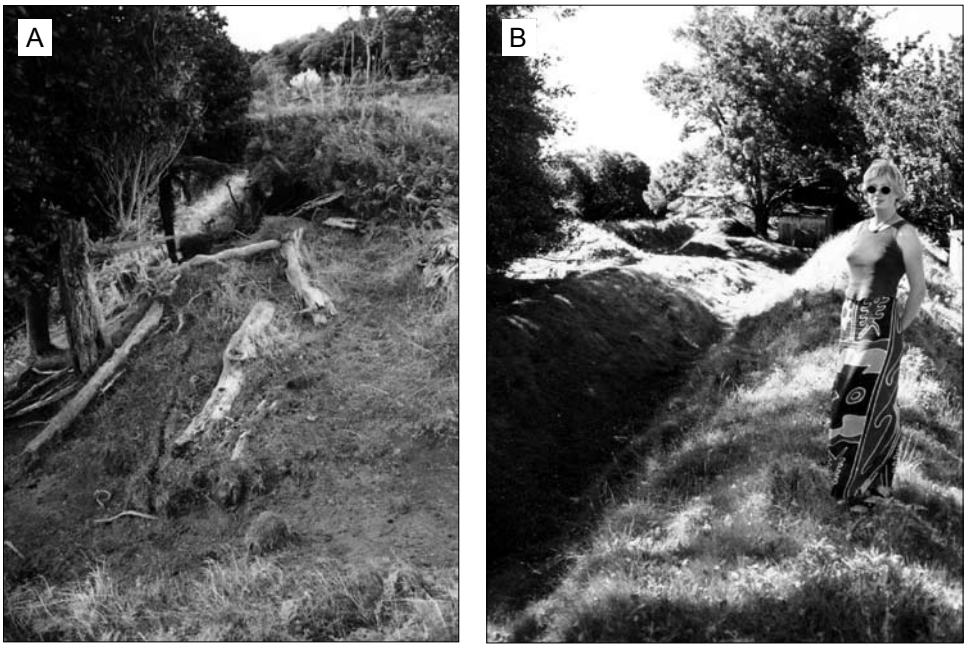


Figure 15. Grazing. A. Sheep are tracking through and camping below these karaka on Pukerangiora Historic Reserve. An early attempt to move the sheep off using prickly branches has worked at one spot, but has displaced the site of erosion down to below the trees. B. Light set grazing by sheep (probably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

sites such as the Auckland cones need to be conditioned (trained) to the presence of people, so that they do not rush about.

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 larger 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—up to 10 stock units (s.u.) per ha
- Stock-type—sheep (preferably not rams) or goats, yearling cattle (equivalent of 5 s.u.) only
- Permissible grazing seasons—not in winter or very wet weather
- Set stocking is preferable to intensive 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. per 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
- No gates or yards on a site
- Stock water and shelter should not be supplied on the features of the archaeological site

Specific comments on stock type and grazing intensity are given below in section 3.2 on farming practice. 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 advantages and disadvantages of intensive management are summed up in Table 3. They may be compared with a similar range of advantages and disadvantages for native or low-intensive grassland management in Table 2.

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 pa: trees on the bank appear to exacerbate the problem, as 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, or where sheep can rub against a post).

Before a solution is attempted, the area of the paddock enclosing the archaeological site and adjacent paddocks should be surveyed to see if

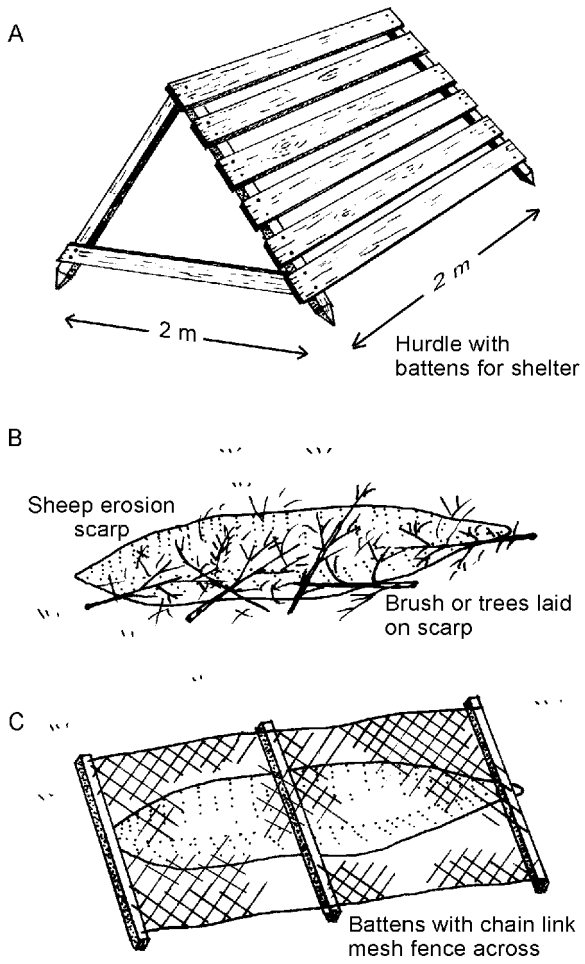


Figure 16. Shelters and barriers. A. Wooden hurdles with slats to provide shelter for sheep. B. and C. 'Uncomfortable' temporary barriers to stop sheep camping.

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 provision 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 5 years, the temporary protective fence could be removed to allow the sheep back in. Otherwise, movable forms of shelter (e.g. wooden hurdles, constructed up to 2 m long, with slats) could be provided (Fig. 16A).

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 ingenuity of sheep 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 about 2 m long, stapled 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. 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.

TABLE 3. ARCHAEOLOGICAL SITES AND INTENSIVELY MANAGED GRASSLANDS.

ADVANTAGES	DISADVANTAGES
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	

2.2.7 Native shrublands

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

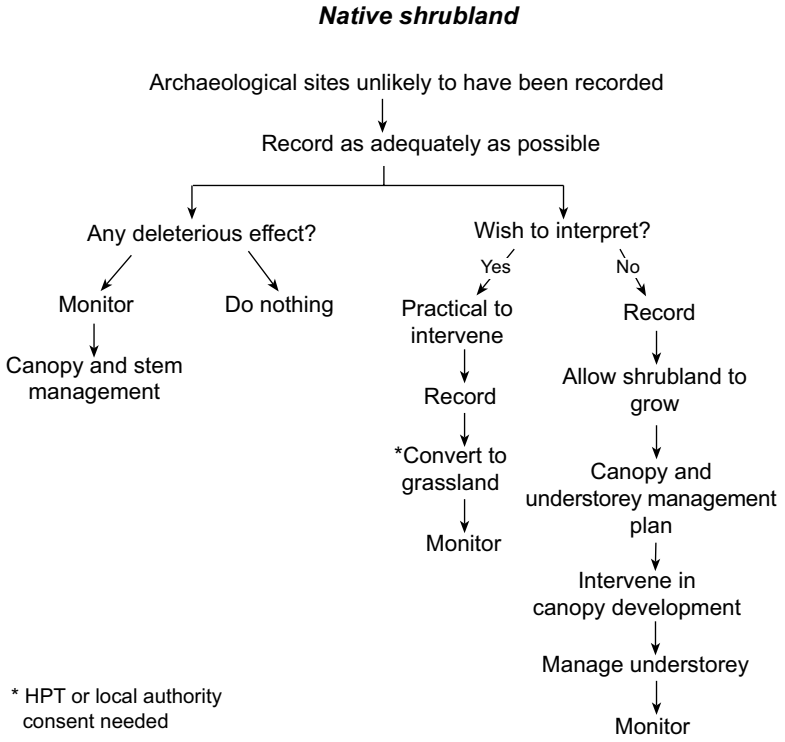


Figure 17. Management issues and likely ecological processes in native shrubland.

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. This includes older-growth manuka, although an even-aged old stand should not be felled. The interval between inspections will depend on growth rates of the trees, and can be determined by the local land manager.

Kanuka and manuka brush

On bare soils, especially subsoils exposed in old roadways or on heavily eroded banks or ridges, manuka mats may be of use. The objective is to get the seeds of the manuka to settle on the soil surface. Branches of manuka or kanuka are scattered and pegged down, or laid in loosely woven mats. This can be done at any time of year for manuka, but only in March or April for kanuka. 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 which were maintained in bracken and shrubland by nineteenth-century burning, and subsequently farmed, will have had little tree growth. These sites will include most ridges in populated areas in the North Island. Regeneration of native forest on these sites will be destructive in the long term and should be controlled.

On sites where forest is regenerating (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.). Inspection of parts of the stratigraphy of the site by excavation may be desirable. In any event, the felling of stable, mature 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, making them vulnerable to root growth.

Manuka and kanuka 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 manuka should be monitored over a 20–50-year time period. Trees should be removed (or selectively removed) where that is prescribed for in a conservation plan. (Plans should allow for such removal.) Kanuka larger than 10 cm d.b.h. should be removed, not only because of the root growth, but also because this species is prone to wind-throw.

In many situations, archaeological sites exist in areas of former pasture destined for overall native revegetation. Examples are the reserves on Motutapu Island, Tiritiri Matangi, and Mana Island. A conservation plan in these circumstances will often allow for, or prescribe, a mosaic of grass over the archaeological sites and planted shrubland and developing forest in the balance of the area. Sometimes this pattern will be present in mixed shrubland/grass areas where grazing has simply been removed. Excluding an area from grazing without additional planting will also often result in an increase in weed species, some of which can grow into substantial trees. It will be necessary to allow additional resources for weed control when leaving open areas ungrazed. If not, the shrubland will come to shade the grassland, reducing the latter's ability to compete, and the shrubland and trees will naturally encroach. In these circumstances the encroaching shrubland should be taken back to its planned or original

boundaries around the grassland. 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 20–50 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 archaeological site protection.

Some trees are prone to wind-throw in the medium term (50–150 years). Examples are rewarewa or wattle, which are both trees that can grow to a large size and become unstable early 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). In this context, where ground-level visibility is required, it should be remembered that some smaller species, such as whauwhaupaku (five-finger) or mahoe, 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 a site by Maori, such as ti (cabbage trees) or karaka, should be left as elements of the cultural landscape. Karaka can form dense thickets of seedlings which thin out naturally. In 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 used by 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.

Principles for native shrublands and tree cover

- If an earthwork site has a stable tree cover (i.e. coverage of long-lived species), leave it alone—stable cover equals stable surface earthworks.

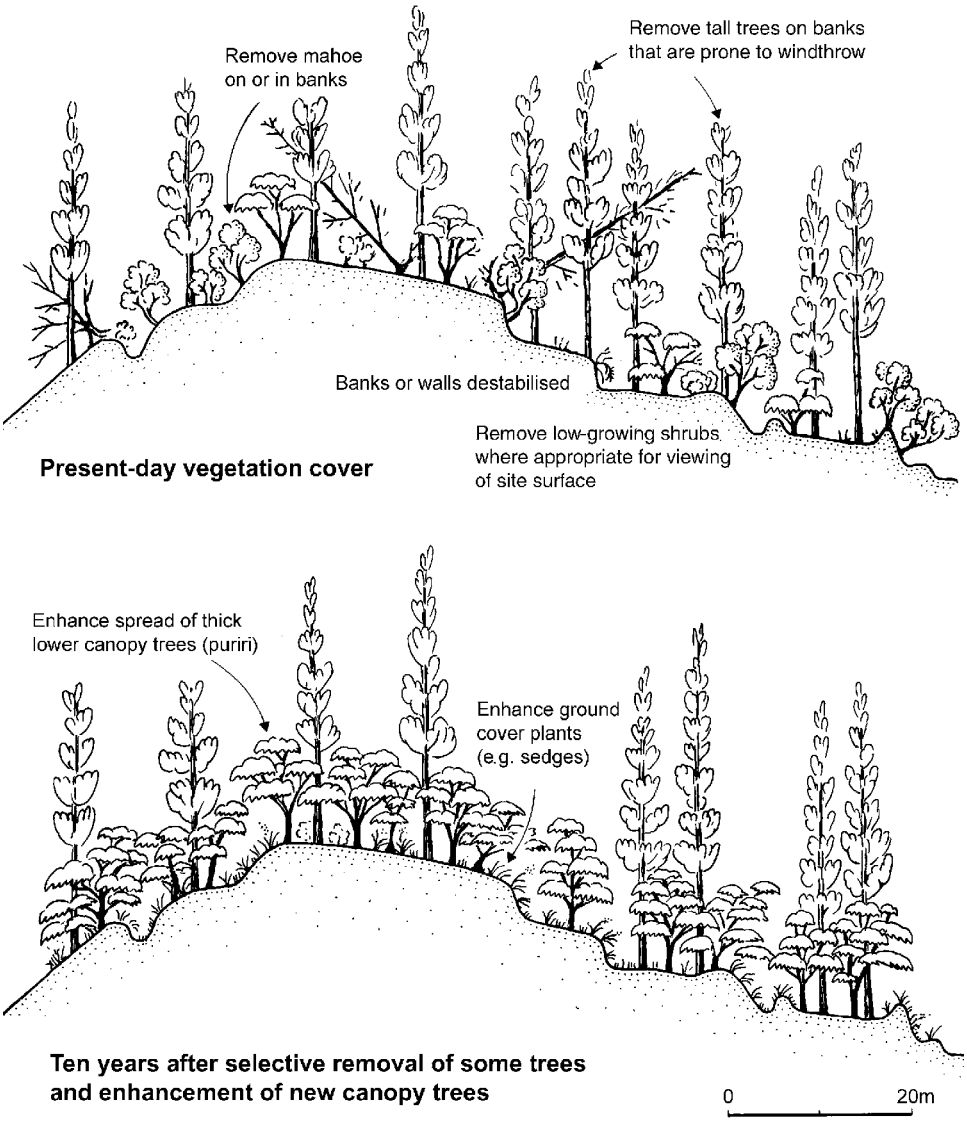


Figure 18. Suggestions for reducing risk from unstable trees (rewarewa), opening-out a gallery forest, and enhancing canopy and ground cover at Te Koru.

- If trees are potentially unstable (e.g. rewarewa or wattle), they should be removed according to specifications in a conservation plan.
- Allow for replacement canopy by planting in seedlings or allowing the growth of naturally adventive broad-canopied trees such as puriri or karaka (both culturally appropriate to sites).
- Protect the existing and future canopy trees in any site operations.
- In regenerating forest, remove trees that have the potential to grow bigger than 10 cm d.b.h. Removal should allow for canopy replacement with low density of stems per unit area if long-term forested cover is sought.
- Bare land or cleared land should not be planted in trees or shrubs, but suitable low ground covers should be planted either from seed or container seedlings.

2.2.9 Gallery forest and canopy maintenance

A gallery forest has wide-spaced mature trees with single boles which support a closed canopy. The concept can be seen in natural forests where the forest floor has been immersed in silt or gravel during floods or

where goats have destroyed the understorey. The closed canopy reduces light (and hence the potential for weeds) and erosion from rainfall, while the widely spaced single boles allow visibility of the surface features. Figure 19 shows a good example of a naturally established beech gallery forest over the cemetery at Lyell. The canopy also suppresses much weedy growth, but not all—privet is a weed that will establish in poor light. Where there are large trees already on a site or reserve, a careful survey is needed as part of the conservation plan to decide whether they can be converted to a gallery forest, and the canopy maintained at a density which protects the site from erosion. The following questions need to be answered before determining a plan:

- Are the trees likely to be stable in the long term?
- Do they provide a spreading dense canopy?
- If thinned, will the site be seen amongst the boles of the trees?
- Can fallen trees be easily removed without damage to the site?
- Is the canopy too dense, causing dry erosion of banks and reducing potential growth of desirable ground covers?
- What saplings can be planted to eventually replace the canopy trees that are cut?
- Are there particular trees that are causing a problem—or will cause a problem—to particular archaeological features (e.g. trees at the head of a bank)?

If the site is to be kept open for public visiting and viewing, it will be possible to thin out the trees, while still maintaining a canopy to protect the ground surface from erosion and reduce weed growth. Puriri, mangeao, tawa, karaka (culturally appropriate), kanuka and most tree ferns are the main species that may lend themselves to management as gallery forests. On Te Kahu o Te Rangi, Kapiti Island, the shrublands and trees along a transect from high-water mark to tawa forest (Fig. 20) are maintained to protect stone-faced terraces and archaeological features

Figure 19. A gallery forest of beech and kamahi at the Lyell graveyard, West Coast. The ground slopes and is vulnerable to erosion because of the high number of visitors who are attracted to this notable commemorative setting.

on the coastal strip. The karaka and kohekohe treeland is managed as a gallery forest so that the archaeological features can be seen.

It seems that puriri planted and maintained so that it retains a straight bole and spreading canopy at a height above about 6 m is the most suitable species for planting on archaeological sites. Of course this is in

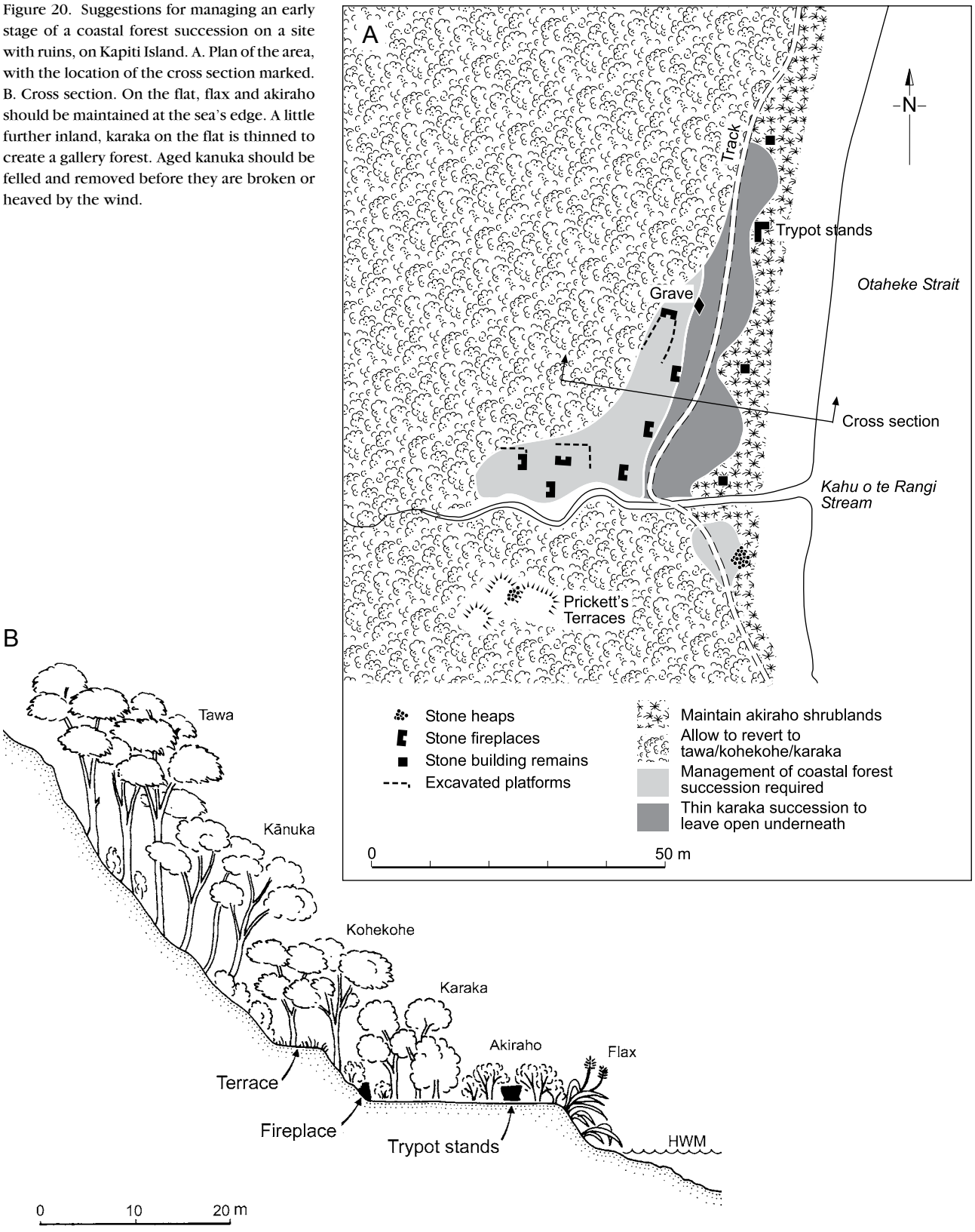


Figure 20. Suggestions for managing an early stage of a coastal forest succession on a site with ruins, on Kapiti Island. A. Plan of the area, with the location of the cross section marked. B. Cross section. On the flat, flax and akiraho should be maintained at the sea's edge. A little further inland, karaka on the flat is thinned to create a gallery forest. Aged kanuka should be felled and removed before they are broken or heaved by the wind.

warm temperate areas with little frost, or where puriri occurs naturally. Spacing of specimens is a matter for judgement, but one sapling per 20 m^2 may be suitable. Thinning could be carried out later. The most desirable trees with the right bole and canopy form will manifest themselves and unsatisfactory specimens can be removed.

In moist areas, kamahi and tree fern will grow easily. Kanuka is suitable on most harsh sites, such as dry ridgelines or exposed coastal headlands, where it may form a stable forest. Generally, these are seral species; experimental trials are needed to see whether they can be re-planted to renew cover in cycles of 30–60 years. Where tree growth with the potential to cause deterioration of a site has been removed, care should be taken to retain seedlings/saplings desirable for eventual canopy maintenance, or to plant saplings that will fill this role. On most sites where trees have been removed, the rapidly establishing natural adventives at ground level will provide a good degree of protection from surface erosion. For example, Fig. 21 shows fireweed and broad-leaved poa on a pa in the Bay of Plenty, where potentially unstable rewarewa trees have been removed. Figure 22 shows a satisfactory shrubland cover of five-finger and toetoe on an archaeological site on the Coromandel Peninsula.

(For tree removal/felling, see section 2.5.1, below.)

2.2.10 Weeds

Many weeds are present on archaeological sites. (The statutory expression is 'plant pests', but 'weed' is the commonly used word.) Weeds provide a reasonable stabilising cover on many sites (see discussion below on gorse and blackberry). Some can grow in deep shade (and hence prevent establishment of native seedlings) and can be useful in preventing dry erosion. Weeds may be retained, but only where the species are already present/common and widespread in the locality. The Biosecurity Act 1993 and consequent regulation require landowners to control certain plant pests. Local regulations will need to be checked with regional councils.

The main risk to the site from weeds is that they reduce visibility and lead to the site's existence being forgotten, with subsequent use of heavy machinery to clear the weeds. Careful consideration is needed to balance weed control imperatives with the need to retain some form of cover. Historical relevance to the site must also be considered. In many instances they will have been plants brought in by the original inhabitants of the place. The vine *Eleagnus* sp., for example, was once commonly used as an ornamental hedging plant.

Any intervention in archaeological site management (including the removal of grazing animals) risks an increase in weeds. This work contains no particular guidance on weeds since this subject is increasingly well-covered by local government and DOC weeds specialists and procedures. Data on the distribution, identification, and control of weeds can be found in several sources including the Department of Conservation National Weeds Database, and publications and services from the Forest Research Institute and regional councils.

Figure 21. On Te Pari Pari Historic Reserve, following removal of rewarewa, a satisfactory initial cover of broad-leaved poa, sedges, and fire weeds has established.

Thinking about weeds—are they a problem?

- Almost all interventions made to protect archaeological sites run the risk of increasing the numbers of weeds present.
- Many historic reserves have small areas, patchy ecology, are adjacent to settled areas and, therefore, have high numbers of weeds.
- Weeds on archaeological sites should be monitored.
- Plant pests that are not controlled by national or regional regulations should not be removed unless another stabilising vegetative cover is available.
- Plant pests that are controlled by national or regional regulations should be removed and another stabilising vegetative cover, including grass, should be planted.
- Long-term natural successions culminating in suitable native shrubland or forest cover will remove many weed problems.

Figure 22. An excellent conservative low cover of five-finger and toetoe on the slopes of a coastal pa at Onemana, Coromandel Peninsula.

- Some weed vines and shrubs will prevent or smother succession.
- Heavy machinery must never be used to clear weeds on archaeological sites.

Gorse and blackberry

Both gorse (*Ulex europaeus* L. and *U. minor* Roth) and blackberry (*Rubus* sp.) may provide a practical protective cover and means of erosion control on archaeological sites which are not interpreted or open to the public. Gorse in New Zealand can grow up to 5 m high with proportionately large roots. The roots are highly branched, usually with a deep tap root, and roots of large specimens will destroy stratigraphy. Dwarf gorse (*U. minor*), present in the Tauranga region, may be a better cover there than *U. europaeus*.

Some local authorities forbid planting gorse. In areas already heavily infested with gorse or blackberry, these plants may be tolerated, if not approved of, on archaeological sites. The legality of deliberately maintaining gorse on a site could be problematic. Fire hazard is another potential problem. A stand of gorse used to keep the public off a vulnerable site could be seen as a fire hazard by local land owners. In such instances, in the interest of retaining public goodwill for the protection of archaeological sites, the gorse should be removed.

In general, the most desirable stand form is dense small-stemmed plants, maintained by occasionally removing large bushes to allow dense regeneration of young plants. Periodic burning will, of course, return the gorse to the start of its succession.

Gorse can be a nursery for native shrublands. Gorse seedlings and plants need full sunlight, and they can be eliminated by regenerating or planted native shrublands. If a native shrubland is the desired long-term cover, then the ground beneath the gorse should be checked for native seedlings. They will only be there if native forest or shrubland occurs in the vicinity. Otherwise planting of natives within the gorse may be required.

If maintaining a gorse or blackberry cover is regarded as inefficient, costly, a fire risk, or a source of infestation for surrounding 'clean' land, then a more appropriate and lasting cover should be planned. The removal of gorse and blackberry from an archaeological site is best achieved by spraying, using one of the proprietary chemicals available. Gorse seed will remain viable in the soil for many years and ongoing control, coupled with alternative shrubland revegetation (in areas of the site specified in a conservation plan) will be necessary.

Bulldozing must never be used to clear gorse or blackberry or any other cover from archaeological sites. If controlled by goats, both gorse and blackberry will provide suitable cover on archaeological sites on farms where these animals are raised.

2.3 NON-VEGETATIVE METHODS FOR SITE PROTECTION

In some situations on archaeological sites, it is not feasible to have a vegetative cover, or any vegetative cover will be ineffective. There is a range of potentially cost-effective physical methods that can be used in place of vegetation. They can be divided into:

- Civil engineering applications (e.g. retaining walls, rip-rapped slopes, or groynes) to prevent large-scale river or coastal erosion—a topic which is covered briefly under general erosion earlier in section 2.1.
- Application of synthetic or natural geotextile covers, either exposed on the surface or buried beneath other cover (e.g. soil, shingle, bark).
- Site burial with or without geotextile membranes.
- Other technology, including composite vegetation and geotextile management of slope stability.
- Applying particular surfaces to paths and viewing areas so as to control behaviour of visitors and reduce any damage caused.

Specialist engineer's or landscape architect's advice and resource consents under the Resource Management Act 1991 may be needed for some non-vegetative methods.

2.3.1 Bunds and underground cut-off walls

Where an area containing wet archaeological sites is being drained, lowering the water table may directly threaten buried wooden material which has been preserved in the wet, anaerobic conditions. Further, the shrinkage of organic soils likewise exposed by a lowered water table may change the character of a site and its vegetation. Designing drainage ditches, dams, pumping arrangements and tide gates so that the site or sites is not affected is important. Building a bank (or bund) to retain water on the margins of the site may be an effective way of preventing these threats. On some wetland sites in the United Kingdom, an impermeable sheet membrane has been inserted vertically in trenches around the site. The trenches were then packed with clay to hold water and maintain anaerobic conditions. Deliberate introduction of water to maintain water-table levels may be required.

2.3.2 Geotextiles and geogrids

Geotextiles are synthetic or natural fibres, woven, felted, or moulded into sheets, with varying porosities. Geogrids are moulded (as opposed to woven) modules which can lock together to form sheets or moulded porous sheets. They are commonly used in soil conservation and civil engineering applications. In the United States they have been used to protect sites in stream-banks (Thorne 1988, n.d.). They also have potentially wide use for a number of archaeological site conservation problems (see Koerner 1990). Geotextiles can be used in a number of ways—laid on the surface or buried (Fig. 23), or as surfaces in drainage structures.

Figure 23. Open-pored moulded geogrid provides a base for well-bedded angular gravel protecting a midden on this track in the Ohope Scenic Reserve, Whakatane.

In applications where geotextiles are buried, they take effect through one of two different mechanisms. One is where the geotextile has small openings which filter soil particles, preventing smaller soil grains from migrating into a coarser medium on the other side of the cloth. Puncture resistance is an important feature of filtering cloths because to be effective, they need to be put into position without damage. The other geotextile mechanism is the strengthening and reinforcing of weaker soil materials.

For surface applications, some geogrids offer three-dimensional box-like or honeycomb structures made up of many small moulded units that can be locked together on the site. Some geotextiles designed for surface use have biodegradable media as part of their structure so that they prevent weeds (by excluding light) and can be used as a seedbed for grasses. Such textiles have a light steel open weave, sandwiched in or packed around with organic material such as coconut husks. The material can be laid directly on eroded areas and is strong enough to withstand stretching or being pinned down on slopes. The organic surface can be directly planted with grass seed and fertilised. It rots away quickly and the steel weave eventually rusts (Berry & Brown 1994: 34, 47).

Materials designed and sold as weed mats and shade cloths are sometimes represented as geotextiles; their utility outside their specific purpose is limited.

Geotextiles can also be used to reinforce slopes, thus taking the place of gabions, sandbags, or other structural reinforcing devices. Laid on archaeological surfaces, geotextiles can provide erosion control, improve the efficacy of drainage, and protect against root damage by restricting the size of roots that can penetrate the layer. Sites can be protected by covering them with a geotextile topped over with soil brought in from elsewhere (see deliberate site burial in section 2.3.3 following). Where trees or shrubs are planted on such a sacrificial layer of soil, a suitably tough moulded geotextile should assist in preventing penetration of roots into the site.

Properties and uses

Surface uses for geotextiles and geogrids:

- Protect against the erosive effects of raindrops and runnels
- Reduce the volume of runoff by retaining moisture on or within the textile
- Reduce wind-erosion and modify the microclimate of the soil surface (Coppin & Richards 1990: 84)
- Geogrids provide a hard surface for tracks

Subsurface uses for geotextiles:

- Separate archaeological layers and excavation surfaces from fill placed to protect them
- Strengthen layers in tension across the plane of the fabric
- Allow air/water vapour/moisture to percolate so that layers are not sealed in an anaerobic state
- Reduce growth of roots into an archaeological site
- Prevent the migration of fine particles into coarse aggregates (e.g. when used in drains or under paths)
- Minimise the thickness of fill/aggregate needed to surface a buried site or a walking/vehicle track

A covering layer of soil protects a geotextile from sunlight and surface traffic. When planted over, the geotextile is bound into the soil by the plant roots. Buried beneath layers of soil as thin as 10 cm, planted-over geotextiles can:

- Reinforce the soil surface layers in a similar way to plant roots
- Create preferential root-growth paths, and improve the lateral continuity of the root network
- Reduce penetration of roots
- Form a soil-root-geotextile composite layer which acts as a surface mat protecting the site beneath
- Reduce the risk of soil compaction
- Absorb part of the impact of foot or even wheeled traffic, thereby reducing compaction in areas of heavy traffic (Coppin & Richards 1990: 84)

For tracks, or other high-use areas (e.g. around an interpretation sign), a filter cloth will minimise the thickness of surface gravel needed. If not used, the fine material (sand and silt) will work its way up into the gravels (and vice versa), and the value of the gravel is soon lost. For almost all applications, joint and edge detailing is most important, otherwise applications will fail from the edges, even when the textile is performing satisfactorily in the centre of the areas to which it has been applied. Turning the edges of a textile in and down into the ground and covering them with soil is one minimal precaution to take. Geogrids can be left on the surface, but again, the treatment of edges is important. They should be well feathered into or slightly buried under the surrounding soil, bearing in mind any potential future erosion there.

Weaknesses of surface-laid geotextiles are:

- They are prone to vandalism or pilfering
- UV degradation is inevitable, even with UV-resistant compounds
- By design, they are permeable to water, and when laid on slopes may trap silt or sand within the lower inside surfaces (facing the bank), leading to stress and failure of the textile

Good suppliers of professionally used geotextiles are Permathene (Auckland) or Maccaferri (Australia) (www.maccaferri.com.au).

2.3.3 Deliberate site burial

The objective of deliberate burial is to seal the site from damage such as surface tracking, root growth, ploughing, etc. In New Zealand, a few sites have been buried, but without the benefit of an intermediary geotextile membrane. It is not known how satisfactory the longer-term results of this will be. Examples are the midden at Tairua, covered by a car park; and pits covered at Port Underwood, Marlborough Sounds. In addition, there are many sites that have been buried by natural processes or engineering works, but again no systematic consideration has been given to their condition. The technique has considerable potential in engineering works programmes, and routine domestic house-building. Its utility on steep ridge-top sites seems less certain.

Roots—particularly large tree roots—must be prevented from damaging the stratigraphy of archaeological sites. The introduction of layers of soil or gravel over a site to take up surface wear and root growth may be worthwhile on valuable sites, although the measure is unlikely to be of any use if large vigorous trees are planted. This protective layer should also be considered in the protection of sites from other uses. Sites could be buried under roads, car parks, and buildings and building yards.

Deliberate burial of archaeological sites

How deep to bury?

- No more than 1 m

Advantages of burial

- Can provide good protection for underlying features
- Sites are protected from all damage caused by activity on the surface

Disadvantages of burial

- Site becomes less visible and its plan area will need to be clearly documented
- Can cause changes to the physical, chemical, and drainage properties of the site
- Increased pressure on the site and compaction of fill
- May break solid foundations or artefacts or displace their position in relation to site stratigraphy
- On steep country, will increase loads at heads of slopes, leading to failure

Until examples of deliberately buried sites have been excavated and further investigated, the procedure should be regarded as experimental. As a general rule, no more than 1 m thickness of soil (estimated to apply a pressure of 10 psi) should be laid over a site, or the minimum depth to protect the site in relation to the likely depth of future disturbance should be used. This will minimise the risk of compression of the site but still give a good protective cover. Consideration should be given to the thickness of the existing topsoil which will have developed since site abandonment. Although it is an integral part of the site, it can be sacrificed and provide some protection for the main layers of the site beneath. A thin layer of added soil (30 cm) will reduce or restrict topsoil formation and incorporate the existing topsoil as part of the protective layer.

Small amounts of fill may be added over areas where midden may be exposed, preferably over a geotextile. There should be no risk of further erosion leading to exposure of the geotextile. If not carried out with care, the process of spreading the cover soil could be very damaging and offset any protection that it may offer. The surfaces and soil should not be wet, and friable soils will need particular care. Wheeled machines should not be allowed onto the surface to be covered. Tracked machines are generally preferable, and hydraulic diggers are likely to be the best. They should extend the area covered in one pass, working from the filled area, so that they track over and consolidate the full depth of newly deposited soil. Tracks should not be turned or slewed over the site surface. Trucks bringing material to the site should unload outside the area to be covered and the material then lifted or pushed into place by the digger. If the area to be covered is large, self-propelled scrapers may be acceptable to pass over the uncovered surface, but some trials adjacent to the site would be a wise investigatory step to take first.

Unintentional effects of burial (from Thorne 1989) may include:

- Physical changes such as changes in drainage and water table; compression, especially of softer layers or voids, or creation of discontinuities in stratigraphy; crushing or breaking up of artefacts, solid foundations, or delicate floors.
- Chemical changes such as more acidic conditions will damage shell, bone, iron, and other metals; more basic (alkaline) conditions will lead to deterioration of wood, plant remains, some glass and ceramic glazes, and metals; drier conditions will enhance protection (unless the deposits were previously wet anaerobic); wet anaerobic conditions will enhance the preservation of plant remains but, if accompanied by increases in acidity, will damage most other site contents; increased wet conditions will create more plastic stratigraphy.

These effects will be difficult to judge. A rule of thumb would be to exercise caution if the burial will:

- Be deeper than the equivalent of 1 m thickness of soil cover
- Change drainage factors to create drier or wetter conditions
- Differentially affect soft or plastic parts of stratigraphy

- Lead to greater stresses on hard or longer components (such as solid foundations) which are in more plastic surrounds or stratigraphy
- Increase pressures at slope margins or at the head of scarps, increasing risk of slope failure

Also, be careful where ceramics, glass, or other readily broken artefacts are likely to be present at the site.

Protection of a site from activities such as backyard play or gardening will require no more than 30 cm depth of fill. If there is an existing topsoil over the site, the fill could be as thin as 20 cm on level surfaces. Fill other than soil may be used with care. A geotextile and a layer of sand should be in place before using demolition fill. Large boulders (over 60 cm diameter) should not be used in landscape schemes over sites. Gravels laid over geotextiles should be no more than 30 cm thick.

2.3.4 Building platforms/engineering applications on sites

In recent years, the Museum of London, working in that urban environment, has investigated a number of issues: fill stability and using fill as a foundation; the utility of reinforced concrete slab foundations; and the practice of piles being inserted through a preliminary concrete slab foundation (Nixon 2004).

Foundations are best seated on rock or deep into the subsoil, so current practice in excavation and setting of foundations invariably does great damage to archaeological sites where they occur. However, it is possible to test the load-bearing capability and the consistency of archaeological deposits with a view to designing suitable slab foundations to be emplaced on the surface of the site. One method is to set a waterproof skip on the site and to fill it with water while observing the degree of settling using theodolite observations of marks on the four corners of the skip. Obviously, minimal and even settling of the archaeological deposits is desirable. (A skip full of water 1.2 m deep is exerting a pressure of just over one tenth of an atmosphere: 4 psi.)

If the ground at the site is stable, a slab can be poured. Piles for walls or other core elements of the building can be excavated through the floor of the slab with a minimum of disturbance to the archaeological site.

All these techniques would require authority under the Historic Places Act.

2.4 FIRE

2.4.1 Preventing fire

In areas with dry summers where visitors to a site could cause fires, a site covering which has low flammability is desirable. Uncut, long grass could be disastrous in areas where people might get trapped. Spraying, mowing, or grazing may be needed late in spring to make a fire break around a site that is predominantly grassed. Large sites could be segmented with mown strips, the exact position of which should be determined by a fire

control management plan. Care should always be taken to avoid creating bare ground that might erode.

Some changes in vegetation cover may be desirable. Fire-resistant species could be planted at key locations such as a car park, or planted or allowed to grow in areas that provide a key to slowing or stopping the spread of fire. Shrubs or trees with low flammability such as five-finger, taupata, karaka, kawakawa or poroporo can be planted in 'green breaks' (dense bands) to form a moderate fire break where needed. Flax is regarded as a species of moderate flammability. The Forest Research Institute has recently published a pamphlet and a report on the flammability of various species (Fogarty 2001).

On coastal sites, ice plant (the New Zealand native horokaka, *Disphyma australe*) or other succulents such as the native spinach (*Tetragonia tetragoides*) may be satisfactory. Near urban areas and where already present, the introduced ice plant *Carpobrotus edulis* may be propagated. Local species will usually be found that can be adapted to protective use.

2.4.2 Fire for site conservation

Managed fire has some potential for maintaining archaeological sites. Continued wild fires have had the effect of maintaining sites in good condition in some areas (e.g. around the margins of the Urewera Ranges; Fig. 9B). The use of fire is under consideration for certain nature conservation purposes also. These include grassland maintenance, generally to prevent natural succession for particular purposes, and to reduce fuel loads and minimise the effect of accidental fires. Problems include technicalities such as when and how often to burn, fire control, and the potential for undesirable weeds to increase (Allen et al. 1996). At the Richmond National Battlefield National Park, United States, prescribed burning is used to promote the regeneration of native grasses and to control woody plants. Problems recognised there include 'the inherent risk of fire escape', 'the unpredictability of good burning days', and increased surface erosion (Aust et al. 2003).

Archaeological conservation objectives where fire might be useful are:

- Where a site needs to be maintained in early successional stages such as grassland or young manuka
- Where the character of a historic landscape needs to be maintained (e.g. grassed ridges and faces with open treelands in valleys)
- Where low impact on surface profiles is important, compared with other methods of grass or shrub control such as line-trimming or grazing

Factors which may suggest that fire should not be used are:

- Community attitudes, public safety factors
- Potential for certain weeds to grow vigorously after the fire, especially legumes such as broom, gorse, or wattle
- The management costs of a fire—controlled or not—which may be high
- The presence of some desirable plants (such as cabbage trees or flax), or desirable animal species, which may be killed

- Wooden structural remains, and possibly metal and glass, on nineteenth and twentieth century sites, which will be destroyed by fire
- Exposed artefacts (such as stone flakes on stone quarries), which may be altered by fire
- Reserve boundaries, which may not be designed to allow the fire to be easily or effectively managed (some small islands and narrow peninsulas excepted)

2.4.3 Fire control management plans

- Management plans must have provisions that prevent bulldozing as a fire control measure, even where this may increase the cost or difficulty of putting out the fire
- Management plans must be written so that the potential historic conservation benefits can be realised; a greater area could be left to burn to more manageable boundaries than for other classes of reserve, if life and property are not at risk
- All managed fires require a written prescribed burn plan and a fire permit approved by a Rural Fire Officer (Department of Conservation Fire Control SOP QD Code: C/1022).

2.5 SPECIFIC SITE MANAGEMENT TECHNIQUES

2.5.1 Problem trees

Some trees pose particular problems for archaeological sites. Trees that are rapid-growing, or that form an intermediate stage in forest succession, or both, are especially difficult. Mature rewarewa on Taranaki reserves, for example, is prone to wind throw and can cause damage if growing on an archaeological site. Wattle, a typical tree of early coastal hardwood succession in the Bay of Plenty, is another tree that is prone to wind throw.

In the last 40 years, before legislative site protection measures were fully in place, a number of archaeological sites were planted in pine forest. Although these trees may have protected the surface features of the site, their roots will have damaged stratigraphy. In addition, their eventual felling, hauling and log staging puts the site at risk of complete destruction. There are, however, methods of removing the trees that minimise the risk of site damage.

One approach is to cut trees down while they are small (perhaps at fence post size). At the other end of the harvesting cycle, it is not an option to leave isolated patches of trees unfelled on the archaeological site area, because they will be prone to wind damage.

The following procedures should only be executed by professional harvest planners and tree-felling specialists. They are detailed here so that archaeologists advising on forest harvest have a grasp of the techniques that have potential for use.

Figure 24. Heavy branches come down with great destructive force on earth works. A. On the pa Te Rau o Te Huia, Taranaki, a log corduroy has been laid to receive one branch. (The logs forming the corduroy should be longer than those used here.) B. Another smaller branch has come down on a corduroy with no damage to the site.

When a tree is cut down, its head hits the ground with considerable force and it is worth taking steps to ensure that it does not damage features of an archaeological site (Fig. 24). It is possible to fell a tree well away from the falling position indicated by its natural lean. Winching the tree, orientation of the scarfing cut, and wedging the back cut—or a combination of all three—can be used to fell a tree quite accurately in a desired direction. The direction of felling can be as precise as an arc measuring ± 2 degrees in plan, measured from the stump, particularly for trees of symmetrical form and with vertical trunks. This is sufficient precision to be able to plan to avoid archaeological features or desired canopy replacement species. The ability to fell trees directionally should be used to avoid upstanding earthworks and to get the tree to fall on protective layers (Fig. 24; see also the section on Corduroy, below). Other factors to be considered are the disposition of neighbouring trees, and whether there are high branches that may come down separately in the course of the tree falling.

Generally, the sequence of felling is the key to successful protection of the site. Trees around and outside the site perimeter should be felled first so that trees on the site itself can be felled outwards. When felling trees, care needs to be taken to avoid them hanging up on the neighbouring trees and to avoid problems with rotten trees or branches suspended aloft (Figs 25 and 26).

Procedures for tree felling on archaeological sites

- Direction and sequence of felling is the key to successful protection of the site
- Safety of personnel is the paramount consideration and should be entirely at the discretion of the logging supervisor

- Initial cutting of limbs can be carried out to change the natural lean of the tree and reduce its mass
- Large horizontal limbs which would spear into the site should also be removed before the tree is felled
- If resources permit, piecemeal cutting and lowering of sections from the top down can reduce damage
- Branches or small trees may be placed on or near the areas to be protected so as to cushion the impact from felling of large trees
- 'Sacrificial' felling of small trees to protect archaeological features is best done at the earliest stages of felling
- Felling along the line of existing features, e.g. ditches and banks, rather than across them will assist to preserve the form of these features

In some circumstances, it will be necessary to decide whether to extract the trees, to poison them, or to fell them to waste. Hauling may not be possible or, in the interests of site protection, they may be best felled into ground that may be too difficult for recovery (e.g. over a cliff). In other instances, where both archaeological site values and wood values are high, helicopter removal of fallen trees could avoid damage from hauling logs through a site. Slash should generally be moved as little as possible, but cut finely so that it is in contact with the ground and rots quickly.

Figure 25. On Te Koru Historic Reserve, a rewarewa growing in an unsatisfactory position at the top of a revetted bank has just been felled. It has caught in some high branches of the other trees and the base has sprung to the right, missing the corduroy (visible just above the cut of the new stump).

Because many sites are on friable ground, not only machine and log movement, but also unnecessary foot traffic needs to be avoided.

After trees are felled, consideration should be given to the vegetation succession on the site. Native shrub species, tree ferns, ferns, grasses, and sedges will also provide useful successional cover after felling. The risk of damaging weeds (e.g. pampas grass, seedling pines) becoming established should be considered. Control must be planned for, and indicated in any management plans for the site, including new forest compartment management documents. Weeds and wilding pines will need to be monitored and sprayed with a herbicide or cut down before they become too dominant in the succession.

Corduroy and its use

- Corduroy is a protective layer formed from branches/timbers (no less than 10 cm in diameter), up to 2–3 m long. It is placed at right angles to the line of tree fall, particularly where the upper part of the tree is expected to land.
- It is needed at especially vulnerable places, such as the edges or tops of banks.
- The head of a felled tree comes down with considerable force and the corduroy should ensure that it does not impact on upstanding earthwork features.

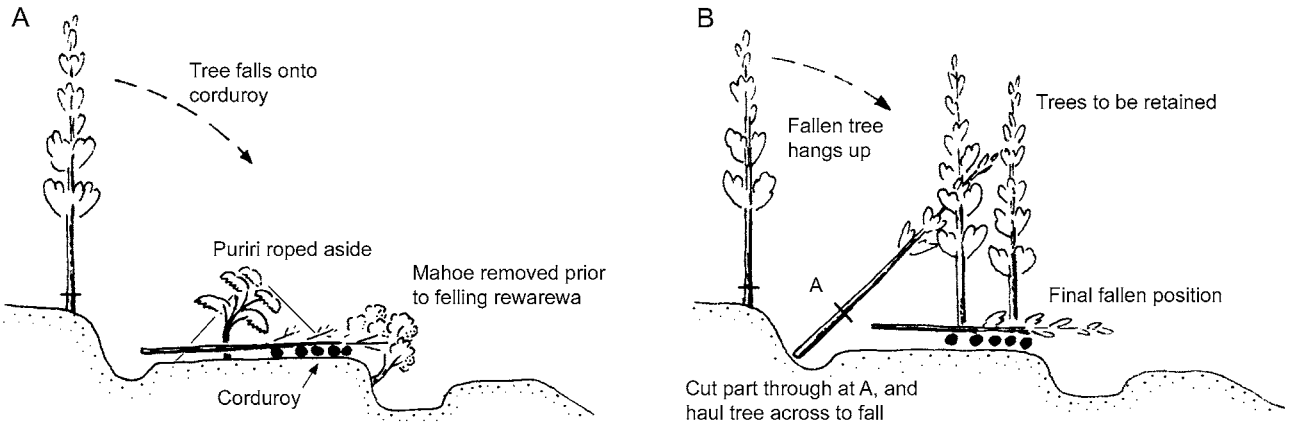


Figure 26. Felling problem trees within the gallery forest of Te Koru Historic Reserve. A and B show two different procedures for successful tree removal without damage to the site. (See also Fig. 25.)

- Old car tyres, tied together, can be used instead of timber.
- The minimum extent of a patch of corduroy should be three logs/branches placed side by side, with their length spanning an arc of 10–15 degrees in the line of intended fall.
- Corduroy will be difficult to place if the tree to be felled will fall across the line of a bank. Felling of smaller trees along the line of the ditch, to form a tangled mat on which the big trees will fall, may be easier to implement.
- Corduroy may also be used as a temporary track for hauling logs across a site.

Figure 27. A selection of young (c. 20 years) closely spaced Douglas firs has been poisoned on gunfighter pa Hinamoki I, Whirinaki Valley. Scrub and ferns grow in the improved light coming through holes in the otherwise closed canopy of the Douglas fir trees.

An alternative to felling trees is to poison and leave them to die (Fig. 27). Ring-barking is effective on most species provided it is accompanied by application of a poison solution to the cut. The main advantage of this method is that the dead trees will drop branches gradually and the trunks will be much lighter when they eventually break or fall down. Impact on the site will be minimised and it is also a cheap method. However, ring-barking and poisoning of large trees should not be undertaken lightly. Dead upper branches may fall on visitors, especially during heavy rain or wind. If, for some reason, a dead standing tree is subsequently felled, the upper branches are likely to fall unpredictably.

The best practice would be to close off an area completely for the duration from shortly after ring-barking/poisoning (no later than three months) to the eventual fall of the trees. Poisoning and ring-barking is therefore recommended only for sites not open to the public, where few management operations are needed for the subsequent 3–5 years.

Where large trees have been felled, land owners or managers will be faced with the issue of whether or not to remove the logs. Hauling logs can be very destructive and, if the public are not likely to visit the site, it may

be possible to leave logs to rot naturally, or to cut them up on the site and leave them there. Piles of slash, logging debris, or logs too difficult to move should be stacked so that they keep contact with the ground. This will assist the material to rot quickly and minimise problems with climbing or scrambling weeds establishing. If logs have to be hauled off a site, an archaeologist should be consulted as to the best route to take. If feasible, corduroy or a causeway of spoil should be built to buffer any destructive effects. If they are not to be salvaged for timber, cut logs into smaller sections to make their size more manageable.

When very large trees are removed in amenity areas, the stumps should always be cut at, or close to ground level. This is cosmetically satisfactory in the short term. Small tree stumps can be easily removed by a stump grinder if access for the machinery is readily available. The temptation will be to leave larger tree stumps. As they rot, they may leave sharp-ended ribs of harder stump wood and cavities—these are extremely dangerous, especially if visibility is obscured by long grass. Before this stage is reached, the partly rotted stumps should be ground or smashed with a sledge hammer to as much as 30 cm below ground surface. The cavities should be filled with a suitable fill marked at its bottom by a geosynthetic cloth. The hole should be overfilled and left with a convex surface so that the soil settles over time. However, if the site is to be mowed, the fill may need to be topped up from time to time as it settles.

2.5.2 Control of burrowing animals, pigs, petrels

The burrowing animals most likely to affect archaeological sites are rabbits. Well-meaning interventions, such as opening an area in shrubland so that the archaeological features are more visible to visitors, may provide the conditions that pigs and rabbits enjoy—such as warmth and grass and bracken growth. Rabbits and cattle can make a destructive combination. If rabbits are concentrated on the archaeological site itself, then poisoning is likely to be effective. If they are widespread in the district, then rabbit-proof fences may be desirable, to control population movement within manageable areas, followed by gassing, poisoning, ferreting, and night shooting in the site area (see also Jones 1993: 25). Good planning, persisting until the job is done, and making use of the most effective poisons available seem to be the key. Historic Scotland has recently published advice on ridding sites of burrowing animals (Dunwell & Trout 1999). Gassing of warrens is the preferred method there.

Pigs may be kept out by fences (Fig. 28; see also Aviss & Roberts n.d.). The design may be adapted for rabbit control by using smaller mesh sizes, but localised extermination and keeping numbers down in the district will be better.

Petrels burrow in many coastal headlands and offshore islands, and on inland mountain ranges. Their range is also becoming extended. There is no acceptable means of removing them from such areas. Any decision to re-introduce petrels and other seabirds to areas with archaeological sites needs to be a balanced one, and will be subject to the authority provisions of the Historic Places Act 1993.

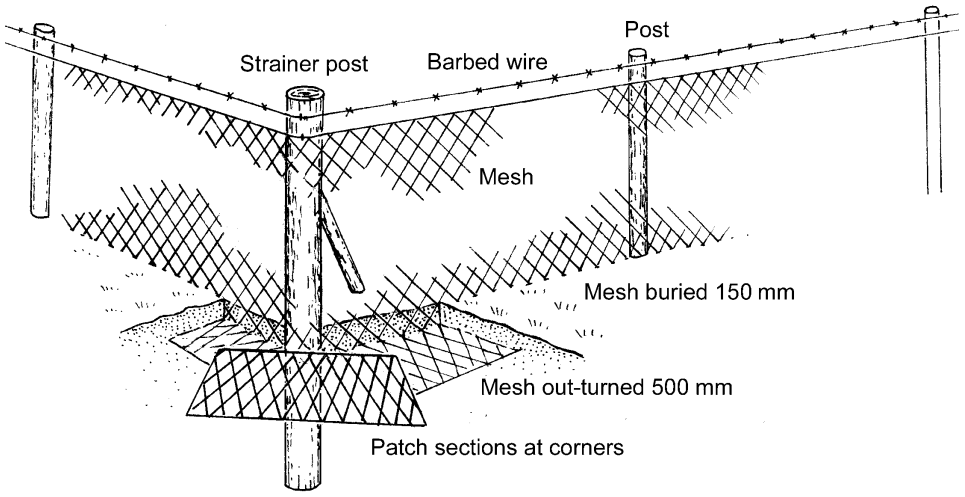


Figure 28. Concept for pig- or rabbit-proof fencing for archaeological sites.

2.6 EARTHWORKS RESTORATION OR RECONSTRUCTION

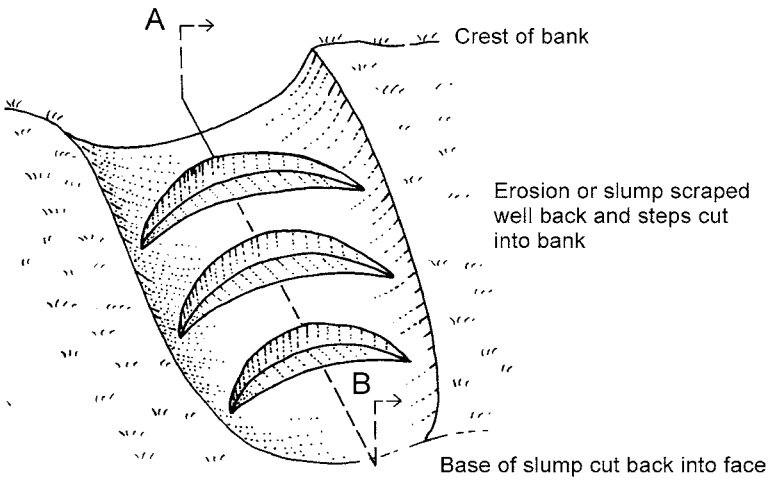
A conservation plan should determine whether restoration or reconstruction of surface earthworks is warranted. An authority under the Historic Places Act 1993 will be required.

2.6.1 Restoration

Restoration is most likely to be carried out where there has been recent damage to a bank, or infilling of a ditch, or both (see Furey 1984). Cuts with faces more than 1 m high will need careful attention to the soil used, drainage at the base, and reinforcement to prevent slippage. Reinforcement could be temporary (layers of brush, bracken, or hessian laid in or knitted into the horizontal plane), or permanent (layers of geotextile or 'bags' made of geotextile) (Fig. 29). The brush or bracken layer should be as thin as possible once compacted. Hessian can be doubled over to increase strength. With geotextiles, the layers should be positioned so that the edges of the geotextile are not visible on the surface of the restored bank.

Geotextile or hessian bags are made by laying the geotextile on the surface and filling over it. The geotextile is pulled back up over the fill at the intended line of the face and filling again on that surface, and so on. The face of restoration done in this manner will be unsightly unless hessian, which will rot away rapidly, is used. Jute sacks could also be used.

New earth surfaces on slopes should be well-compacted. Grass and lotus seed should be applied before compaction. Rapid grass establishment is desirable and watering may be needed. Annual ryegrass will establish quickly, but overall it is better to apply a mix of rapidly establishing and perennial grasses. (See Table 1; also Appendix 2, section A2.1, and Appendix 4 for more detail.) In many instances, it will make sense to obtain turfs from a local source. The base of an adjacent ditch may be one source, provided it is well filled with topsoil, and a note or other



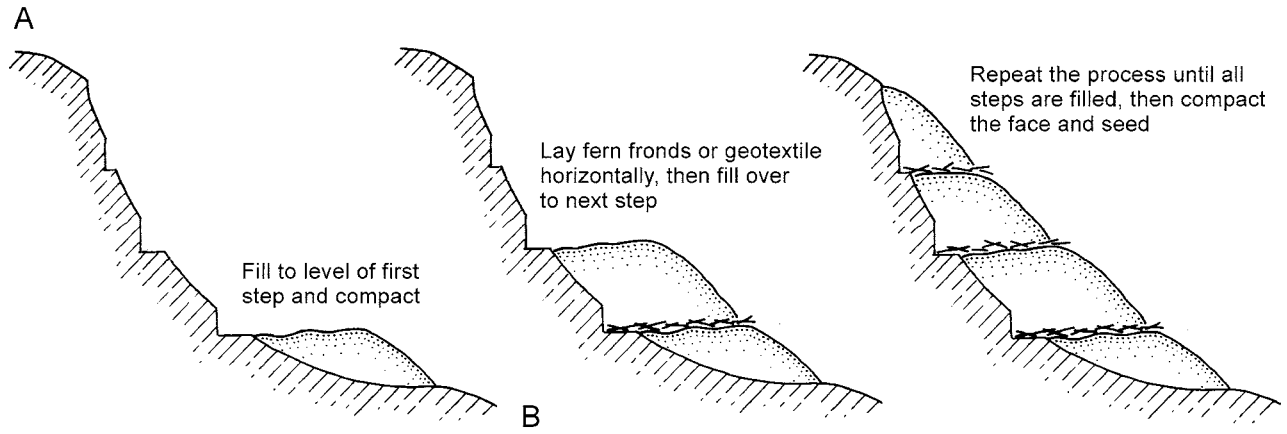


Figure 29. A suggested procedure for restoration of minor breaks or slumps in earthwork banks; successive details of the cross-section A–B are shown below.

record is made of what has been done. The record of management action could be filed with the archaeological site record.

Fill is not always readily available; moreover, many New Zealand soils are friable and will not compact readily. These techniques, therefore, need to be supplemented and varied. 'Instant lawn' or any commercially available turfs of firm consistency have sufficient strength to enable them to be stacked (flats horizontal) up a steep face (but not a vertical one) in a form of revetting. Sufficient of the outwards-facing live grass will survive to establish a new cover. Rotting of the roots from the buried parts of turf revetments may lead to a loss of strength and to collapse. Soil placed behind the turfs may force bulges at the base of the stack and the soil can wash out with rain. Careful compacting is necessary. These are potential applications for the strengthening and filtering properties of geotextiles, used in combination with the turfs. Instant lawn is rich in fertiliser and well watered when supplied. It is a potentially good cover where subsoil is exposed in banks or at the crest of banks. It was used successfully in restoration of parts of the standing redoubt at Pirongia (Ritchie 1995).

2.6.2 Reconstruction of archaeological features

There have been a few examples of reconstruction in New Zealand (see Jones 1989). The wish to reconstruct the original features of buildings or other structures on their surviving archaeological remains is often expressed, usually when tourist development or interpretation is in prospect. Reconstruction is a particularly difficult subject in heritage conservation. It is doubly difficult with archaeological sites, since the original fabric is much decayed and it may be argued that it is only useful as a source of information.

The fashions and the ethics with respect to reconstruction have changed in recent decades. Something of the problem can be appreciated from the paradox that reconstructions are argued to be more 'authentic' when they are built on the original site—irrevocably destroying that site. Generally, this practice is opposed by the ICOMOS charters (e.g. the International Charter on Archaeological Heritage Management, Article 7), and also by other significant sources of published policy such as the US National Park Service. The latter's policy in 1983 was as follows.

'A vanished structure may be reconstructed if:

- 'Reconstruction is essential to permit understanding of the cultural associations of the park established for that purpose.
- 'Sufficient data exist to permit reconstruction on the original site with minimal conjecture.
- 'Significant archaeological resources will be preserved in situ or their research values realised through data recovery.

'A vanished structure will not be reconstructed to appear damaged or ruined. Generalised representations of typical structures will not be attempted.' (United States National Park Service 1983, 44738; also Jones 1993: 111–113).

This policy reflects NPS dissatisfaction with questionable reconstructions which were often designed to present a 'typical' representation and which might not have been on the site originally. A redoubt not sited on its original vantage point on the top of a hill is unlikely to feel correct. A broader ethical problem also arises where the reconstruction work is used as the rationale or motivating factor in gaining resources to investigate the archaeological site. The site may not be well investigated, because of time constraints, or for want of close consideration of precise research goals formulated in the light of the most advanced state of knowledge. These are broadly ethical problems. The problem may be summed up by the following sequence:

- It is better to stabilise than repair
- It is better to repair than restore
- It is better to restore than reconstruct.

In New Zealand, there are few reconstructions, so the ethical problems relating to authenticity and the destruction of original fabric have not been fully debated. Table 4 (next page) lists some of the advantages and disadvantages of reconstruction of archaeological features.

TABLE 4. RECONSTRUCTION OF ARCHAEOLOGICAL FEATURES.

ADVANTAGES	DISADVANTAGES
Assists with interpretation of a place	Will almost certainly damage original fabric
Gives a tangible result to archaeological research excavations	Will be expensive, require maintenance and may fail
Original fabric may have been destroyed or greatly modified by excavation	Has no patina, appearance of age or the accrual of change that is part of heritage
May be able to incorporate and display elements of the original fabric and offer vantage points	

3. Management of sites under reserve, farming, and forestry land

Archaeological sites may be found under most land uses. This part of the guideline gives specific advice to reserves and amenity managers, farmers, and foresters. Its three main sections should be able to be read independently, but the sections read together will provide a guide to practical site conservation.

In almost all cases, specialist advice is needed to determine the existence of archaeological sites, their true extent, and their values. Consulting and following these guidelines is not a substitute for determining whether authorities to modify are required under the Historic Places Act 1993. A starting point will be the Historic Places Trust website (www.historic.org.nz). Again, specialist advice will often be needed. Other specialist areas where additional professional advice may be needed on a case-by-case basis include: conservation plans for particular areas, landscape analysis sensitive to archaeological site conservation, engineering issues, local government requirements, statutory land management processes and consents, pasture and grasslands, fire risk, and tree felling and forestry operations.

3.1 AMENITY AREAS OR RESERVE LANDS WITH PUBLIC VISITING

On a small number of selected and accessible sites, land managers may wish to carry out a more intensive form of management which allows for higher numbers of visitors. As few as 20 people per day can create bare patches or informal tracks on a grass sward. As a general rule, any reserve with more than 5000 visitors per annum will need careful planning of visitor tracks and other facilities.

Picnic grounds have destroyed many archaeological sites, since modern-day picnickers like the same sheltered spots that were favoured by Maori and early European settlers. Where an archaeological site is to be presented to the public, it should be assumed that there will be particular parts which will come to have much use by families with small children. Anything which could be dangerous for small children, such as some types of herbicide sprays, or holes concealed by vegetation, will have to be avoided. Even banks of sand or loose pumice, which children may tunnel into while adults are picnicking, can present dangers.

Figure 30 shows typical problems and possible solutions for a large reserve area containing archaeological sites and to which the public has

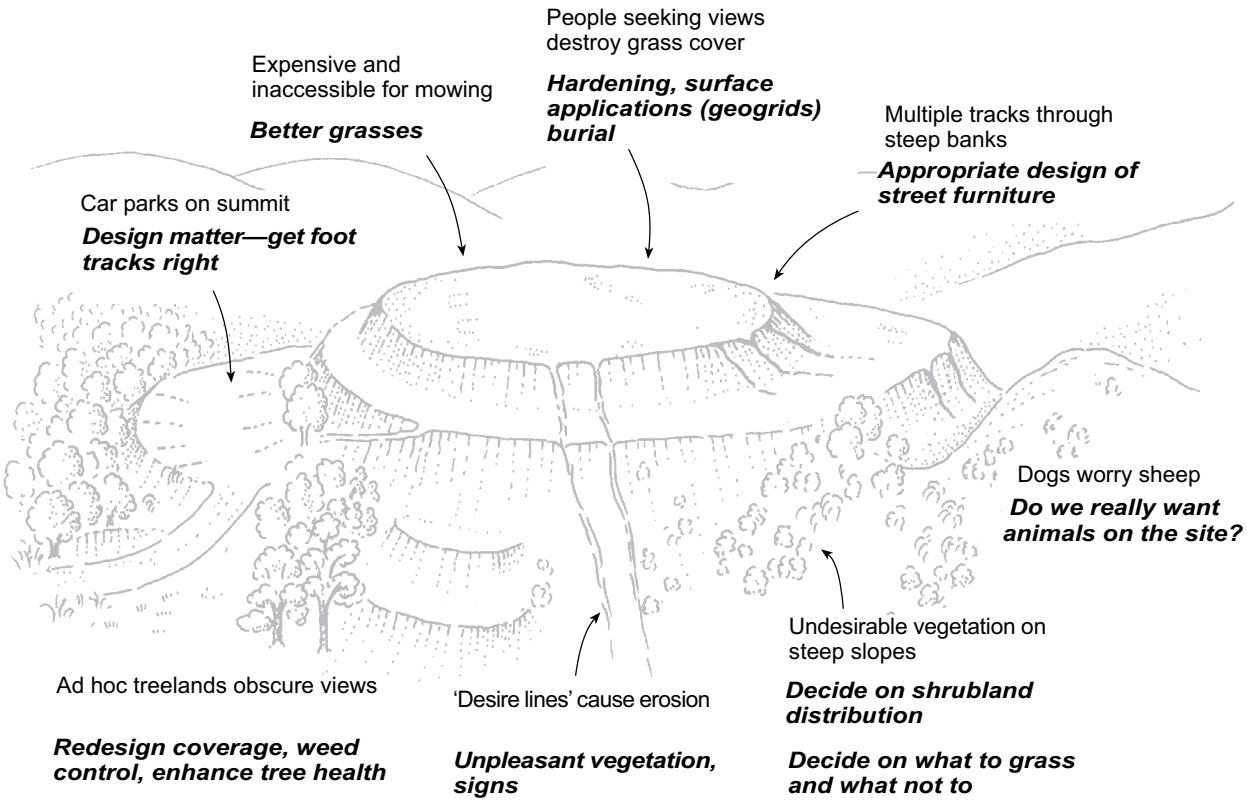


Figure 30. Problems and solutions in the management of a hilltop pa site, at a landscape scale.

access. Besides the need to obtain authorities under the Historic Places Act 1993, important practical issues are:

- Understanding how the public gets access from the road end, and the behaviour and needs of the public in general, while they are on foot on the site
- Maintaining grasslands, shrublands, and treelands, and their role in ensuring site protection
- Designing and utilising signs and other structures, such as boardwalks, viewing areas, and barriers

3.1.1 Public access and use

Monitoring and surveys should reveal the use people make of the reserve and how facilities could be improved. Desire lines are a common phenomenon: tracks made by people as they follow what is perceived to be the best or most interesting way around the site. These should be studied quite closely for two reasons: first, to gain an understanding of people's use and intentions, and second, to divert the traffic in a realistic way or to improve the track alignments and construction (Fig. 31).

Any erection of structures will require consents under the Resource Management Act and the Building Act from the territorial authority. Some earthworks (e.g. for tracks and roading) may also require consents under the Resource Management Act from regional councils. The New Zealand handbook: tracks and outdoor visitor structures (see Standards New

Figure 31. Steps and railing (built to an accepted engineering standard) on a severely eroded track leading to a viewpoint on the exposed platform of a pa on Motuarohia, Bay of Islands.

Zealand 2004) incorporates the Building Code and should be followed. It will be held by all local government agencies and by the Department of Conservation.

Tracks and roads/car parks

Benched tracks need to be routed carefully so they do not destroy archaeological features such as banks, ruins, or middens. All tracks on archaeological sites should be raised formations and only if necessary lightly cut into the surface. They should have a geosynthetic cloth between the topsoil surface and any track-surfacing material such as gravel. This minimises not only disturbance of the site, but also the amount of gravel needed. Care is also needed with drainage of tracks. A geosynthetic can be laid on the undisturbed soil surface and gravel laid on the surface of the geosynthetic. This creates a durable track surface with a minimum thickness of gravel and no risk of the gravel being absorbed into the soil surface. Under- or cross-track drainage can be provided by geotextile 'tubes' buried beneath the surface gravels, aligned across the track and filled with a coarse gravel. The base of the tube should be lower on the outer side of the track.

Near ruins or floors of ruins, gravel use should be restricted so that it cannot be kicked on to plastered, earth, soft stone or brick surfaces. Crushed hard metal with angular edges should be avoided. If gravel or metal gets on to soft surfaces, it will be worked into them and cause damage. In general, softer irregular grades of beach or river gravel with rounded edges should be favoured, provided it is obtained lawfully. Where softer rocks such as crushed tuff, limestone, mudstone or weathered greywacke are available, their use should be considered. Local farmers are usually a good source of advice on what locally available material makes good cheap surfaces for light traffic.

Structures—towers, boardwalks, toilets, signs

In heavily used areas, the ideal in most places is probably a tough grass sward with built-up gravel paths and/or board walks which will withstand wind and water erosion and visitor activities. On steep slopes, advantage

may be taken of existing eroded routes, rationalising their number, and stabilising those that are selected for continuing use. The maximum recommended grade on a walking track is 15 degrees (see Standards New Zealand 2004: section 2.5). In some situations (e.g. on a steep defensive bank), the ergonomic rules for tracks cannot be made to work. Rather than introduce a visually intrusive structure, some lateral thinking (quite literally) is required. It may be possible to divert the track and steps to an easier grade elsewhere.

The function of boardwalks and/or steps in protecting fragile or erosion-prone ground-surfaces (Fig. 31) is self-evident. Steps and staircases must be properly designed. There are ergonomic rules for the dimensions and proportions of flights of steps which should be followed in all built structures (see Standards New Zealand 2004: section 3.18). They should be followed where there is a gradual fall in a path greater than 15 degrees and where the grade has to be improved or made up at specific intervals. If the design guides are not followed, visitors will find the steps uncomfortable, and will continue to look for and make tracks away from them.

Walking on top of breastworks or banks should be discouraged. By and large, these features give an earthwork site its character, and they can be all too easily ruined. On redoubts, the best ground-view is very often obtained from a vantage point on the breastworks or at the top of the bank. People tend to walk along the bank to obtain these views. Viewing towers constructed near the site allow a better oblique view than any obtainable on the site; signs asking visitors to stay off walls and explaining why, are obvious solutions to this problem. The viewing towers constructed at Te Porere (redoubts with free-standing walls), on the central North Island volcanic plateau, have considerably reduced the numbers of people walking on the walls there.

Toilets and fireplaces, like stock fences, should be placed well clear of the site. Siting such features requires advice from an archaeologist familiar with the location. It will be advisable to ask an archaeologist to check the amenity planning on the actual ground and to dig test-pits to ensure there is no archaeological material present.

A pad of sand, soil, or clay, 15–50 cm thick, may be a useful device for protecting parts of a site where general erosion is tending to occur. As discussed in section 2.3—Non-vegetative methods for site protection—the pad may or may not be underlain by a moulded geotextile which will reduce the size of roots penetrating to the site. Depth of the pad should not be more than 60 cm.

Only in the rarest of circumstances should roads or car parks be built over archaeological sites. Where inevitable, they need careful conservation planning with the objective of deliberate site burial (see section 2.3.3).

Barriers

Many historic places have inherent risks (to a modern visitor) that are part of their heritage character—pa are often on cliff edges, derelict structures have unprotected falls or failed structural elements. The degree of risk to visitors needs to be carefully balanced against the competency

and care that might be exercised by visitors, the desirability of providing access, and the intrusiveness and expense of barriers and other structures on the heritage fabric of the place.

Dangerous or particularly vulnerable parts of a site may require barriers, including vegetation. However, vegetation such as low shrubs/flax should never be used as a barrier between visitors to a site, and dangers such as cliffs or rivers. They can be walked through without seeing the danger or may even overhang the danger—and they do not offer the support needed to arrest a fall. Barrier structures should be professionally designed and installed by tradesmen (see Standards New Zealand 2004: section 3.3.19–3.22).

Signs

Signs warning of danger are common in many reserve areas, but could also be used more than at present to help control potentially damaging visitor behaviour. Visitors may be asked not to walk on or climb up banks. One can take a gloomy view of the efficacy of signs, when repeatedly faced with evidence of the damage that they are meant to prevent. Yet, they probably have an ameliorating influence even though they may not prevent the worst behaviour. Signs can also be used to assist understanding of the conservation practices being used at a site—for example, the use of tall grass, shrubland clearance, tree felling, or restrictions on access to certain areas.

3.1.2 Vegetation management

Analysis of overall pattern of vegetation

Most reserves will have a balance of areas in grass, shrubland (which may be an important element of weed control) and treeland. Part of a particular site may have intensively managed grass to allow for access, good visibility of the site, and views from the site. At the margins of the grass there may be ranker growth and a possible weed problem from past endeavours to manipulate the vegetation there. Other parts of the site may have specimen or single trees, such as a large pohutukawa. How can the grass cover be maintained in these environments? The long-term processes which affect archaeological site conservation, the enjoyment of visitors, ongoing costs, and other relevant factors need to be carefully studied.

The economical management of sites will require a minimum of mown grass in areas that are important for visitor access, the maintenance of views and certain kinds of weed control (e.g. where broom is a problem).

Roundup topping as a growth retardant

This treatment is applied to kikuyu in autumn, and other grasses in spring. The advantages of such treatment are:

- Reduces growth of weeds
- Improves grasses

- Reduces spring growth flush and need for frequent mowing/heavy grazing
- Reduces stock numbers
- Improves grass palatability
- Kills kikuyu (like a frost)
- Reduces fire risk

The disadvantages of Roundup treatment are:

- Public objection to chemical use
- Possibly particular cultural objections to use on sites
- Aerial spray drift and legal liability

Mowing and line-trimming

More reserves should be mown or line-trimmed than is the case at present. The following applies to sites which are under established mowing regimes. In the mown grassland setting, grasses that are present and establishment methods for desired species will depend on climate. Mowing itself will alter the composition of grass swards. Over-sowing of grass seed or application of fertiliser may be warranted in some areas. This can be a waste of time and money unless carried out on the advice of a grassland specialist, who may wish to make soil tests. The peculiar features of archaeological sites need to be considered. Banks may have sterile subsoils (thrown up from the base of the ditch), with little topsoil (because of erosion). Grass seed or fertiliser may tumble to the base of the bank or the ditch where it is not needed. (Further notes on this subject are found in section 2.2.3.)

Much mowing is too close to the ground and is sometimes too frequent (Fig. 32A). This 'scalps' convex surfaces, reducing the profile of banks, and also kills the grass, leaving an opening for weeds. Mowing heights should be a minimum of 7–10 cm on level ground and 10–15 cm on convex surfaces. No more than $^{2}/_{3}$ of the existing grass height should be cut. For steeper banks which cannot be reached safely with a mower, a line-trimmer is best (Fig. 32B).

If a site is to be maintained by mowing or line-trimming, planning needs to be undertaken to determine the appropriate frequency and to ensure that access for the mower does minimal damage to the archaeological site features. Tractor-drawn reel mowers capable of giving low grass cutting heights may have uses on broad level areas, provided there is good access.

Where mowing is to be instituted, attention needs to be paid to designing access routes. A major drawback of mowers, and ride-on mowers in particular, is that they will generally require a smoothing of surfaces and access ways around the site. They may require wider access ways than are already present. Where possible, pre-existing tracks or other access ways should be used, even if they are not the most convenient routes. Modification of the original fabric (surface profile) of the site is not justified, except for safety reasons. If ride-on vehicle safety is an issue, then either hand-pushed mowers or line-trimming should be used.

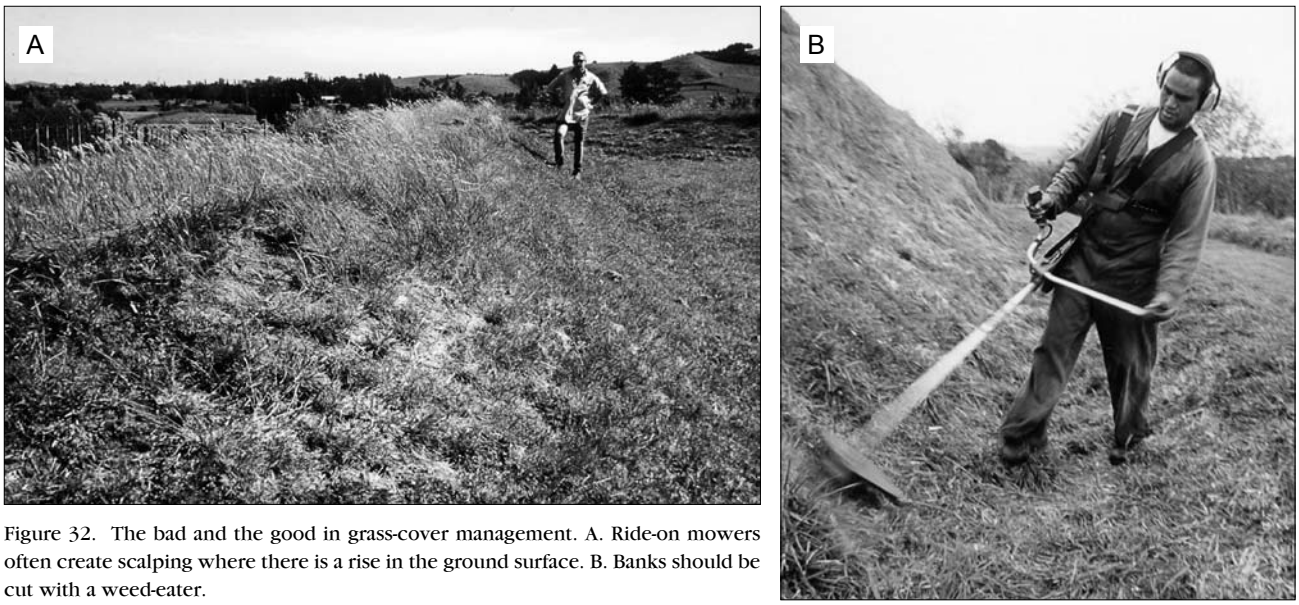


Figure 32. The bad and the good in grass-cover management. A. Ride-on mowers often create scalping where there is a rise in the ground surface. B. Banks should be cut with a weed-eater.

Mowing or line-trimming should be timed so that desirable native grasses such as *Microlaena* or broad-leaved poa have an opportunity to flower and set seed. Generally, this will mean no mowing from late spring through to mid- to late-summer.

If mowing frequency is reduced, the existing mowing equipment may not be powerful or robust enough to tackle the longer grass which has grown in the increased interval. Utilising larger mowers will also have knock-on problems such as larger access ways and wheel damage to the site surface. The solution to this type of problem, balancing infrequent mowing with larger, more robust machines, needs to be the subject of planning and adjustment in the course of the year.

Tread-resistance will be a desirable characteristic of the sward in some areas of sites which receive high numbers of visitors. Existing patterns of use and wear should be analysed. In areas or on routes where people tend to create tracks, managers need to decide whether this foot traffic is to be allowed to continue or not. If it is to continue, these areas or tracks could receive an autumn or spring over-sowing of dwarf ryegrass and dwarf tall fescue.

Mowing is generally a useful way of controlling weeds. In areas in which mowing is difficult and in which tall grasses are desired, weeds may need to be controlled using a selective herbicide. Herbicides such as Roundup at full strength will kill all plants and should not be used unless a replacement vegetative cover is planned.

Appendix 2 (section A2.2) provides a specimen work plan for mowing on an archaeological site.

What is needed for sward maintenance plans?

Mowing

- A plan of the site showing areas to be mowed/line-trimmed
- Planned access ways and clear instructions on their use and/or creation

- Safety considerations for maintenance people/contractors and the public
- Specific mowing and line-trimming instructions—never less than 7–10 cm, or 10–15 cm on banks and not less than $^2/_3$ of the existing grass height
- Instructions to maintenance people to avoid scalping and mowing too close, a risk especially when using mowers with rotary blades
- A planned mowing schedule which takes special care to allow for seeding of native grasses and reduction of fire risk—these two will have to be balanced

Ensuring healthy grass growth and shrublands

- Over-sowing planned and carried out as necessary
- Survey irrigation, fertiliser and lime needs for microsites and apply as necessary
- Specify treatment of marginal areas and areas to be left to revert
- Treatment of specimen trees/groves of trees within the mowing regime—line-trimmers or scrub saws should be used with care, to avoid damaging trees/shrubs
- Spraying for weeds, especially seedlings of leguminous trees or shrubs (gorse) and weedy grasses such as kikuyu
- Monitoring and inspection by someone knowledgeable about the archaeological site values

Shrublands in amenity areas

In general, amenity plantings should harmonise with the natural vegetation of the area and of the site itself. There should be a landscape plan in place as part of the overall conservation or management plan to ensure that the vegetation which is planted or maintained is in keeping with the historic landscape setting, to maintain viewing corridors and screening unwanted sights (such as modern housing or a car park) adjacent to a reserve.

There are numerous fast-growing natives that will quickly provide shelter. The pittosporums, especially *P. eugenioides*, make rapid bushy growth at first and very attractive small trees after 20 years. *Olearia arborescens* rivals lilac for scent when in full flower and, with some pruning, forms dense shrubby growth. *Pomaderris kumerabo* forms more open and smaller shrubs, but provides a mass of soft yellow bloom over a long period. All three species are tolerant of damage and, mixed with flax and the true native toetoe (*Cortaderia* spp.), would form good attractive shelter on many sites.

Plantings around picnic grounds beside pre-European sites will generally look much more appropriate if native species are used. There is no need to be purist about native vegetation on gun-fighter pa, European redoubts, or whaling stations. Historic trees or species in the vicinity such as poplars could be retained and supplemented with rust-resistant forms. Old forms of shrub and rambler roses were commonly established at an early

date around European settlements and a durable and vigorous rambling rose such as 'Felicite et Perpetue' could be useful cover, especially on a bank where the aim is to keep people off. Otherwise, as for all archaeological sites, planting of trees and shrubs should be kept at a minimum. Sustainable exotic grass cover should be the aim.

When planting shelter to protect areas used by visitors, e.g. grassed picnic areas, the possibility of the planted tree species seeding onto the site should be considered and such species avoided—karaka or karo (*Pittosporum crassifolium*) are examples. On sandy ground, shelter for people can also be designed to provide shelter from wind erosion.

3.1.3 Case study 1—Historic landscape

Wider setting

This case study comprises a large site (over 100 ha) protected as a scenic and recreational reserve. It has many discrete sites and three major pa. It is located in the northern North Island, with the sea on one side and suburbs on the other. A Maori Reserve containing a pa bounds on to one corner. The Maori Reserve is in regenerating forest with some areas of gorse and ungrazed grassland.

Site description and condition

The three pa sites are of ring-ditch form with difficult access to the platform. There are old bulldozed tracks onto the platforms of two of them. These two are covered in gorse. The third has not been damaged and has a cover of manuka and shrubland, with tree ferns in the ditch. Vegetation on the rest of the reserve is patchy with areas of ungrazed grass and gorse, and some pohutukawa on the coastal cliffs. In the gullies, there is regenerating tawa forest. Cattle are occasionally let in to graze in winter. The aim of the grazing is to keep the grass down and to keep ground vegetation clear in the shrub and treeland areas. The substrate of the site is friable volcanic clays and tuff.

Identification of management issues

The reserve is for recreational activities. Some parts of some sites are impacted by the yards of houses. In the treelands, there are numerous shrubby weeds which have escaped from the suburban gardens.

Problems

- There is no operative management plan
- Tangata whenua are concerned about erosion of two wahi tapu at specific places on the site
- Kikuyu is spreading rapidly through the grassland areas
- Cattle are eroding the banks and camping in the shrubland and the treelands
- Mountain bike riding is exacerbating foot erosion in some places
- The track network in the reserve is largely informal and unplanned

Particular management issues

- Vehicles are not able to get access, but a large car park is adjacent to the reserve boundary
- Rubbish is being dumped
- The track network needs thorough review and rationalisation
- Fencing needs thorough review and improvement
- The local community wishes to maintain pedestrian access and open areas for recreational purposes, and use of the reserve for access to fishing spots and for scenic lookouts

Management options

The land managers must deal with some imperatives such as the maintenance of recreation opportunities and co-operation with neighbours. To a greater or lesser extent the following options are open:

- Improve conservation of the archaeological and historic features
- Review reserve classification
- Define current recreation activities and set out the limitations, opportunities and places for those activities
- Increase the rate of planting to revegetate the area while keeping tracks and viewpoints open
- Continue grazing at the present level or increase it
- Do more labour-intensive management including mowing of selected parts

Management objective

The management objective is to maintain recreation opportunities and conserve the historic features so that they can be appreciated. The specific objectives should be to achieve an overall cover of stable grassland and treeland that would allow public visitation and restrict the opportunity for invasion by woody weeds.

Recommendations/guidelines

- Consultation should be undertaken with tangata whenua, and with local community interests and other stakeholders.

Landscape/site evaluation

- Re-survey archaeological features to determine which should be retained in grassland for site conservation, landscape visibility, and visibility to the public.
- Analyse views to maintain desirable ones and minimise intrusion of undesirable ones.
- Conduct a detailed evaluation of archaeological features and their desirable degree of visibility to visitors.
- Devise a revegetation plan aimed at reducing negative features such as informal tracks or other erosion 'hot spots' (localised fretting) and stock pressure if any.

- Evaluate practicable mowing and grazing regimes and determine the appropriate amount and nature of mowing.
- Map all disturbance including bare soil and significant areas of weed invasion.

Devise an infrastructure plan

- Lay out desired/acceptable uses for different parts of the site/ landscape.
- Review the existing infrastructural elements (paths, drains, etc.) including informal tracks and 'desire lines' on the site.
- Design a fencing pattern that allows control of stock in treeland areas, so that native grasses can establish, and install the fences.
- Design for improved paths, lookouts, seating, mowing access and drainage.

Devise a vegetation management plan

- The adequacy of existing fencing needs to be evaluated. Closer subdivision may be needed to minimise numbers of stock and prevent access to their preferred camping areas.
- Grazing should be restricted to the ridge crests (by fencing), allowed only in certain seasons (i.e. only late spring and autumn), and controlled in intensity.
- Where present, kikuyu grass could be removed by spraying with glyphosate (Roundup), and native grasses such as meadow rice grass (*Microlaena stipoides*), or a low-growing shrub such as *Muehlenbeckia complexa* could be encouraged instead.
- Level or near-level areas, which have been defined in the landscape evaluation as needing to be kept clear, should be mowed.
- On areas to be kept in grassland, mowing should be instituted, with blade settings at a minimum of 10 cm, or higher depending on whether surfaces are convex or not. An attempt should be made to establish native grasses which will adapt well both to the arid ridges, and to the semi-shade of the areas of open forest.
- The overall pattern of these factors should be determined to allow for public and mowing-machine access, and provide an acceptable accidental-fire control procedure.
- Soil fertility surveys of microsites should be carried out to determine whether selective fertiliser applications are needed in the spring and autumn seasons.
- Advice should be sought on means to enhance the establishment of the native grasses—mowing or grazing at the wrong time may make establishment difficult (see section 3.3).

Shrubland and treeland

- In those areas not to be kept in grass, a mix of shrubland and treeland would be consistent with original vegetation, Maori values, soil protection and amenity usefulness.
- Define areas into which appropriate native trees may be planted to create a fairly open treeland but one not subject to weed invasion.

- Define those areas which can be allowed to revert to a low shrubland/ flax/fern cover, to be managed by a line-trimmer or scrub saw perhaps on a 2-year cycle. Such areas should include the steep, otherwise unmowable scarps of archaeological features.
- Select shrub or tree species to enrich habitat and to improve erosion control. Plant them in designated areas with the objective of enhancing any existing treelands.
- Following evaluation of archaeological, landscape and visitor values, plant any steep slopes currently suffering stock damage and which are to be fenced-out in an appropriate cover of low shrubs or trees.
- Initiate repair and re-planting of bare areas, or areas with weeds, that in the long term can be shaded out.
- Remove unstable trees, or trees that could become unstable, before they disturb the soil.

3.1.4 Case study 2—Pa in mown grassland

Wider setting

The following case study applies to sites north of Nelson–Marlborough, the region in which most pa sites are found. Recommendations could also be extrapolated to archaeological sites located in environments where the recommended grass species occur naturally.

Site description and condition

The archaeological features comprise a central area with many pits and a perimeter ditch and bank. The site presents several microsites reflecting different environments which should be considered for separate treatments. Species recommended for each microsite vary according to their adaptation to the environment of each microsite, and their impact on feature visibility. Soil fertility and pH are likely to be lower on steep faces and in areas such as banks where subsoil has been exposed.

Microsites present will include:

- Open areas of the site interior: some areas of heavy wear from visitors and tracks, and level or near-level areas with a reasonable sward of grasses and herbs well adapted to dry hot conditions.
- Banks and ditches: north-, west-, and east-facing aspects, sunny with minimal shading, well drained (e.g. banks, mounds, trench and pit walls and scarps), south-facing shady aspect, well drained slopes, and scarps facing south, wet, poorly drained, heavily shaded areas, and areas prone to short-term saturation, bases of trenches and pits.

Identification of management issues

- The site has always been regarded as an important one, but the statutory management plan is 20 years old and out of date.
- Weediness, including large growths of gorse in areas not accessible to the mower.
- High visitor numbers are expected to continue and to increase.
- Visitors take inappropriate desire lines over banks and attempt to get into pits or depressions.

- Mowing has been too close and is scalping the tops of banks.

Management options

- Cease mowing and allow site to revert to gorse weedland in the expectation that regeneration of forest will occur in next 100 years. Restrict public access.
- Reduce costs by grazing the site with low numbers of sheep or yearling cattle. Large cattle are not an option if only because of lack of water source. Sheep are likely to be stolen off the site.
- Devise clear mowing and line-trimming plan that will allow good conservation of existing site and also allow for weed control. Some improvement to grass cover and the ground covers of the banks.
- Institute monitoring to fine-tune mowing and other management.
- Improve signs to inform visitors and to encourage them to keep off banks and out of pits.

Management objectives

- A mowing and line-trimming plan that will allow good conservation of existing site and also allow for weed control.
- Improvements to grass cover and the ground covers of the banks by determining the best times to mow to allow for seeding, reducing fire risk, etc.

Recommendations/guidelines

Prepare a conservation plan, incorporating the following points:

- Ride-on mowers should not be used on this particular site. On hand mowers, the blade should be set at a height of 7–10 cm above the ground for level areas, and 10–15 cm on slopes or convex areas such as tops of banks.
- Provide on-site assistance when setting up a new mowing contract, walk the site with the contractor.
- Legume and broadleaf weeds should be controlled.
- Institute Roundup 'topping' (see 3.1.2 above) as a means of reducing weeds and slowing grass growth.
- Steep banks that cannot be safely mowed should be line-trimmed. Any shrub growth in these areas should be cut with a scrub saw and swabbed with a systemic herbicide to prevent regrowth.
- Use mowing pattern to assist in the control of visitor behaviour, e.g. keep rough long grass on banks to deter walking there.
- Well-sited interpretation signs should be erected asking visitors to stay off banks.
- In areas where there are worn patches, appropriate re-seeding of grasses should be undertaken. Clinging rata and ferns should be planted on the steep shaded slopes of banks.
- Regular monitoring should be instituted.

3.2 SITES MANAGED WITHIN FARMLAND

Land with warm microclimates and with sources of fresh water were prime spots for Maori settlement in the period from c. A.D. 1400 to 1830. Only small areas of such land lie within New Zealand's formal protected area network. These tend to be small areas of coastal forest reserve. A majority of pre-European archaeological sites exist on privately owned farmland with limited or no public visiting. They may occupy only a small proportion of the area of a farm, but are often features which are prominent in landscape views and public appreciation. Outside the warmer regions, there are still some sites of Maori origin. In most areas, there are other important sites relating to past industrial or farming activity. Such sites or places are often grazed or ploughed. Some features remain as the only visible elements of an ancient past in the landscape. They are important to Maori and other New Zealanders and are also repositories of unexcavated archaeological data. Their protection is an important obligation of trust on private land owners.

The general management objective for archaeological sites in farm land should be least-cost identification, protection, and management of the archaeological sites, with the least possible restriction on farm activity. It will be possible to integrate some seasonal farm activities on most sites, but not all. For example, many archaeological sites on hill country should not be used for close winter grazing, or for the establishment of bull paddocks or for farm forestry patches. A secondary objective which might be expressed in district plans could be to maintain landscape views, some of which reveal aspects of the past.

Figures 33 and 34 show some typical farmland problems and possible solutions. Sites consisting mostly of surface earthworks are particularly vulnerable to a wide range of every-day farm activities—roading, preparation for fencing, fencing, stock tracking and stock erosion generally, weed clearance, and ploughing. Overgrazing on friable soils may be a problem

Figure 33. Erosion on a pa in North Taranaki. The main causes are friable soils and overstocking with sheep. Sheep do not have access to the small shrub and tussock-covered knoll in the distance which is in good condition. A site such as this should be fenced-off and monitored.

(Fig. 33). Sub-surface sites buried more than 20 cm below a topsoil on level or near-level ground may also be at risk from ploughing or road or gateway construction. The principal farming activities that need some care when carried out on or near archaeological sites are: grazing, farm infrastructure (fences, paddock design, irrigation channels, roads and tracks), and ploughing and disking (including border dyking). Figure 34 shows a suggested good fence pattern, based on an actual example in the Waikato.

3.2.1 Grazing and pasture care

Control of the behaviour and density of grazing animals is the key to maintenance of surface-earthwork archaeological sites such as pa (there are 6000 in New Zealand), earthwork fortifications in general (there are about 600 nineteenth-century fortifications) and the ruins of European structures and industry. Relevant factors in grazing are included next.

Stock type and numbers

- Limit stock numbers to no more than 10 stock units/ha
- Control stock-type: sheep or goats, yearling cattle only, not bulls or dairy cows
- Mob stocking is not recommended, but if needed it should only be carried out infrequently and for a short spell (less than 7 days)

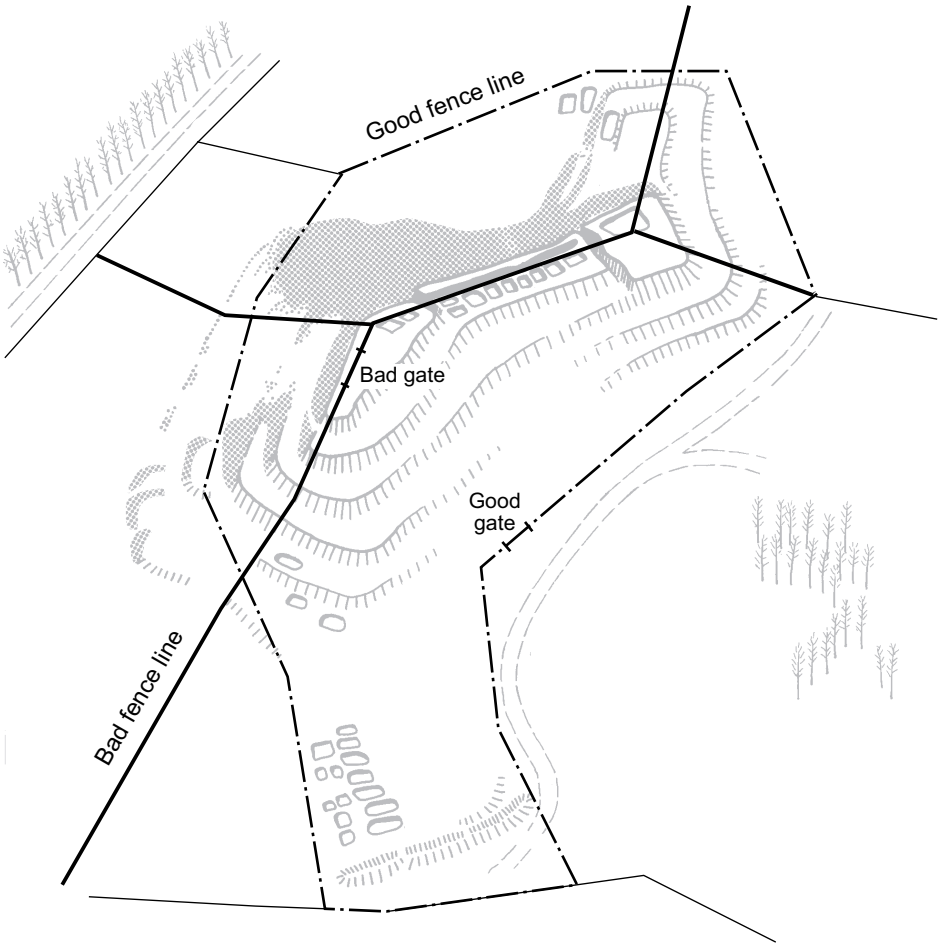


Figure 34. Good and bad fenceline and gate positions on a typical pa site.

Grazing season and format

- Limit the grazing season: not in winter or very wet weather
- Either use rotational grazing (but keeping grazing period short with plenty of feed available), or use set stocking (at no more than 10 s.u. per ha)

Best form of sward to maintain

- Fertiliser to be applied to maintain sward cover and not for production
- Maintain a desirable grass height of 6–10 cm (note: this height is also consistent with satisfactory levels of production and pasture weed control)

Paddock design and stock water

- Sites should be fenced into their own small paddock
- This paddock should receive limited stocking, but otherwise be integrated with a useful grazing strategy for the farm
- Stock water should be supplied at a point away from the actual site, because animals will create soil damage at the water trough

The objective of grazing and pasture-care on archaeological sites should be to maintain the surface sward so that soil erosion is prevented. Within individual paddocks, any vulnerable 'microsites' (such as the tops of banks or places of shelter) need to be monitored. Set grazing to maintain a grass height of 6–10 cm is the most preferred balance between pasture production and weed control on the one hand, and archaeological site protection on the other. The section on Grazing (below) shows preferred stocking rates of no more than 10 s.u. per ha. On friable soils and in cool temperate or dry areas, stocking rates will probably need to be lower than this, but it is difficult to specify rates for those conditions. The key principle is: if damage is being done, then further review is needed. Omata Stockade Historic Reserve in Taranaki is set-grazed at very low stock numbers and the grass in summer is tall and rank. In winter on South Island hill country, stocking at 10 s.u. per ha will be too high. The sheep in such places need to be hardy. Occasional rotations may be desirable. This will allow any small areas of erosion (e.g. in camping places) to heal over.

Suggested optimum maximum stocking rate (s.u. per ha) for archaeological sites on lowland (e.g. Waikato basin) and warm coastal hill country are shown below.

Grazing—Sheep and goats

Set-stocking with sheep is the best type of grazing for archaeological sites; it should be managed so as to avoid the need for cattle or periodic mob stocking to graze down coarse grasses.

- Wethers are the preferred animals for grazing. They should be used at low stocking rates (6–10 s.u. per ha) to maintain a pasture height of 6–10 cm.
- Stock units per hectare will need to be varied during the year to avoid weediness in summer and poor grass survival in the autumn.

- Gates and water (if provided) should be well away from site features.
- Dogs from urban areas will be problematic with sheep, so young cattle may be preferred for urban or near-urban areas.
- Goats at low stocking densities may be used for removing weeds such as thistles or gorse, but they can cause severe erosion by tracking up and down slopes and camping on high points.

Grazing—Cattle, horses, deer

- Cattle grazing should be minimised.
- Never graze cattle on archaeological sites in winter.
- Yearling cattle may be used occasionally to graze archaeological sites, but only for short periods in summer/autumn, or when the feed is too coarse for sheep.
- Horses have especially damaging grazing behaviour (pawing and ripping out lumps of grass) and should not be allowed on sites.
- Deer should not be used for grazing because they mob and their sharp hooves displace soil down-slope.
- Deer fences distract from the landscape visibility of the site unless carefully planned.

Grazing—Shelter and water

- Sheep need to be provided with ample shelter (from sun, rain and cold winds) away from the site features so that they do not camp on parts of the site and create erosion patches.
- Water should not be reticulated to stock on the archaeological site itself.

A possible disadvantage of set grazing is that animals will find preferred places for more or less permanent shelter and over time can do a great deal of damage by creating and enlarging sheltered spots. Rotational grazing could be attempted, but with the objective of maintaining the sward cover, not to maximise production. Mob stocking has been carried out on Turuturumokai near Hawera where sheep were forced to eat dry long grass stalks. This stocking initiated erosion in some places. Mob stocking should only be carried out infrequently, and for a short spell (less than 7 days).

Particularly slip-prone or friable soils, for example those based on papa, sand, or volcanic ash, are very vulnerable to erosion. Decisions on grazing of archaeological sites on such soils need to be made carefully. Generally, it will be best to avoid grazing.

Pasture maintenance

Pasture grasses on archaeological sites should be in good condition, tillering and maintaining good coverage of the soil surface. If the grass is to be utilised for stock grazing, clover could be over-sown in the appropriate season. Fertiliser and lime need to be applied. Fertiliser use should be limited to what is required to maintain strong plant cover and preferably to allow a cover of perennial grasses (native or not) to

establish. Two cardinal rules are: keep stocking density low (no more than 10 s.u. per ha) and never let the pasture be overgrazed. Limited feed will lead to animals roaming the fence lines looking for 'greener pastures'. Where fence lines run through the site, this behaviour will produce destructive erosion.

Low intensity of stocking by light animals is on balance the most desirable practice to maintain archaeological features. It minimises the risk of erosion, but keeps the site visible and clear of potentially intrusive tree and shrubland roots.

Weed control

- Do not use bulldozers to clear weeds such as gorse if there is a possibility of archaeological sites under the weeds
- Weeds may be sprayed
- Some weedy areas (e.g. steep slopes) may be more efficiently fenced out and left to regenerate
- Disturbance of grass cover (e.g. by cattle pugging, or removal of shrubland) will commonly lead to weed infestation in most farmland areas

Drought

Drought is a particular problem for headlands and ridges. These often have the most outstanding archaeological features, are the first to be denuded of grass cover during drought, and are then exposed to wind erosion. In moist periods following a drought, dusty eroded ridge surfaces are likely to develop unsatisfactory weed and weedy grass covers.

Particular problems associated with dry periods

- Stock in dry periods become restive and roam around the fences creating tracks
- Most grasses will bolt to seed and only cattle will eat the coarse forage so created
- Stock trampling and resting in dry dusty ground can be as damaging as on wet ground
- Stock should be removed from sites early in any prospective dry season so that dead or dormant grass cover will remain

Reversion to shrubland or forest

Tall grassland or a shrubland is the best long-term stabilising cover. The preferred cover for most sites will, therefore, be infrequently grazed grass which will eventually revert to tall grass, native grass and/or shrubland.

When a grassed site is fenced off from stock to give added protection, it will present a short-term weed problem in most farmland. This could be treated by short spells of grazing or application of a selective herbicide which works on the weeds, not the grass. This will remove any potential problem from having a source of noxious weeds on a property. An adequate weed-free tall grassland can be assured by patching any erosion scarps with fescue or cocksfoot or other varieties of grass species adapted to relatively low fertility and seasonally dry conditions. The site area could

be stocked on a few occasions before final exclusion of all stock, or the area could be stocked on a set basis in early summer or early autumn. Eventually, provided there is a local shrubland seed source (within, say, 2 kilometres), most areas that are fenced out and permanently retired from grazing will become shrublands. Five decades of being fenced out from grazing will do no harm to most archaeological sites, unless there is a problem with aggressive weed trees.

On the principle that long-term stable vegetation cover is the best cover, native forest on archaeological sites should be left alone and it should not be used for shelter, grazing, or relief grazing.

Farm roads, fencing, paddock design

Farm roads and the bulldozing of fence lines have damaged many archaeological sites over the years. The construction of roads and fences are possibly the single greatest cause of harm to archaeological sites.

Pa were often built on narrow ridge lines which controlled access from rivers or the coastal strip to the hill country. To take advantage of good drainage, pits were also built on ridges and are common both on high points and saddles; therefore, they too are vulnerable to roads installed to give access to remoter parts of a farm. For a typical site on a farm, suitable arrangements for fencing are shown in Figs 34 and 35. In the past, a common pattern in bulldozing has been for part of the perimeter ditch of a pa to be filled in and used as a road. The defensive ditches also form a barrier to stock (nineteenth-century ditch and bank fences sometimes used sections of pa defence), so that rough tracks were sometimes pushed through to provide access for stock along the ridge or onto the platform of the pa.

Farm roads, gateways, and bulldozed fencing lines should not be put through or on archaeological sites. If they are essential for some reason, such construction will require an authority or consent from the local body or an authority from the Historic Places Trust under the Historic Places Act 1993. When there is no alternative but to run a permanent fence through a site, damage to subsurface features can be minimised by using driven waratahs or proprietary 'Stapelok' fence types which use small footprint galvanised steel posts.

Existing roads through sites should not be widened unless with authority or a consent. As far as possible, current or future uses should utilise existing roads and the roads should not be extended. Alternative routes should be sought for new or wider roads, even if it means a less satisfactory, sidling route.

In designing new developments, it is well worth considering the long-term design so that key sites are protected. Paddocks should be designed, as far as possible, so that the fences run across, rather than along the ridge line. Stock will wander along fence lines and do extensive damage along ridges. Fences should not intersect on archaeological sites for the same reason (Figs 34, 35). For example, if a site is on a high point it could be ring-fenced, perhaps with one gate for periodic access for stock

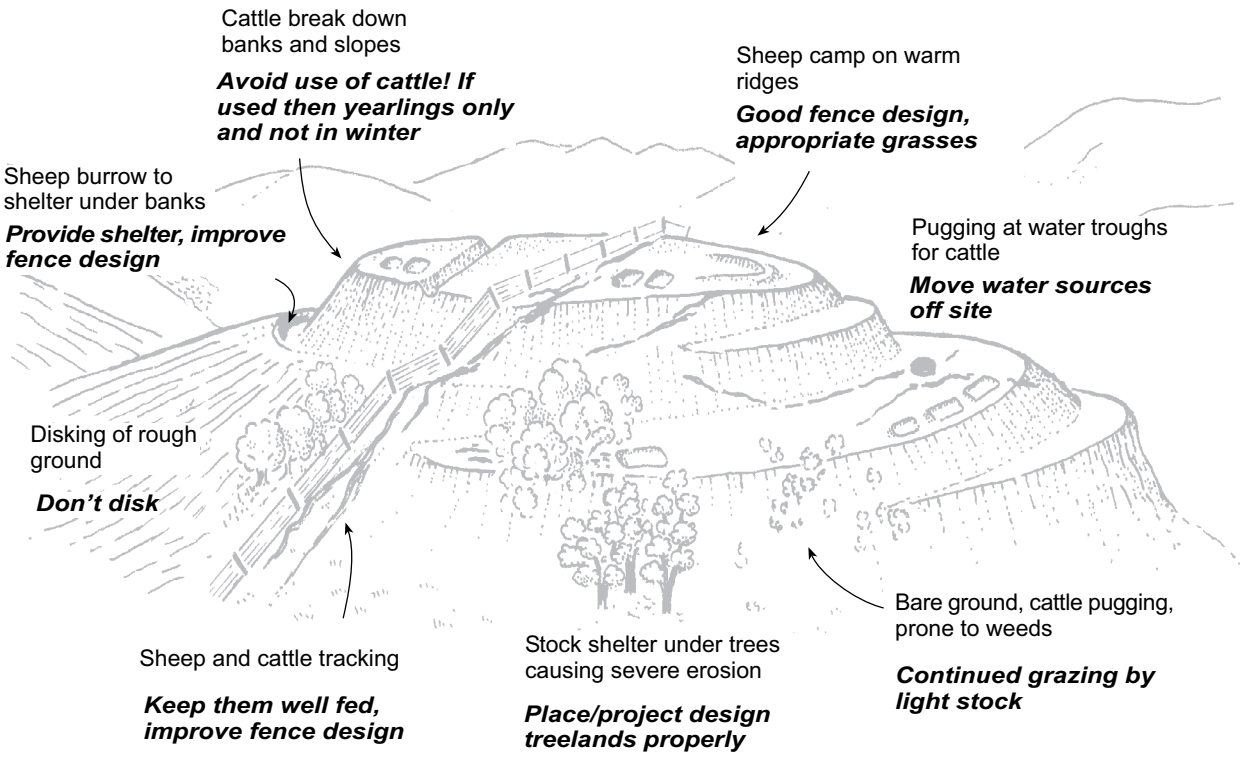


Figure 35. Typical problems on a grazed site, with suggested solutions (in ***bold***).

as noted elsewhere. The sides of paddocks could radiate out from the central ring fence around the high point.

Permanent, well-sited fences which allow sheep through, but not cattle are the best. This can be achieved by removing or not installing the bottom wires of a fence. Because they are temporary and of generally light construction, electric fences should also be considered for use where a site needs to be grazed for short periods only.

Coastal lands can be a particular problem for grazing, where privately owned land abuts against beach and dunelands. Cattle may have access to the dunelands from the adjacent farms, even though the dunes may be Crown property. Middens are common in dunelands and these areas are seldom fenced.

Roads and fences

Sites are especially at risk when creating access roads or fence lines. Before bulldozing roads or fence lines, landowners or managers should check first for the existence of pits, pa or other archaeological sites, and call in an archaeologist where there is doubt. It should be possible in most instances to design roads and fence lines that do not impact on sites. Any modification or damage that is necessary to a site to establish a satisfactory line should be the subject of an authority from the Historic Places Trust.

New roads or improvements including gateways, water tanks and water troughs should not be placed on archaeological sites. Where damage to a site exists already, this area may be used as a fence line or for stock access.

Fencing can damage archaeological sites. Fencing should not run through sites, nor should gates be placed on sites. Check for sites, especially pits, before bulldozing to create smooth fence lines.

Use special techniques (such as extra-long battens or sections of wooden planks) to securely fence depressions such as pits. Plan fences so resulting paddocks set aside archaeological sites, to allow effective management of set stocking.

Ploughing and disking in hill country

The first ploughing or border dyking of an archaeological site will do immense damage and completely destroy shallow features. In the past it may have been preceded by deliberate levelling of earthworks or uprooting of foundations. Such damage is relatively unusual today and would normally be controlled by the need for an authority under the Historic Places Act 1993 and, perhaps, under the district plan. Areas with sites that might still be vulnerable to ploughing or other destructive activities include isolated coastal terraces and flat ground around river mouths; also, high country terrace land where there are nineteenth- and twentieth-century sites such as gold mining races, dams, etc.

Subsequent ploughing probably does less damage, provided it is no deeper than the first. However, the issue of subsequent ploughing involves more than the depth of penetration of the plough. Repeated ploughing increasingly disperses archaeological materials and, on sloping ground, tends to displace soil downslope so that new soil layers are penetrated with each ploughing.

In some hill country where 'hard grasses' establish, bulldozers pulling large sets of disks are sometimes used to rehabilitate pasture. This is particularly destructive of sites such as pits which lie on mid slopes or ridges. The same applies as for ploughing new ground.

Sites should not be newly ploughed—or old ploughed areas given a deep ploughing—without an authority from the Historic Places Trust under the Historic Places Act 1993. However, on flat or near-flat land, a site that has been ploughed may be ploughed again to the same depth. On previously ploughed sites, renewed ploughing may still turn up archaeological evidence and artefacts.

A margin of 5 metres or more of unploughed land should be left around archaeological sites when the surrounding land is being ploughed. Fencing sites off makes accidental ploughing impossible.

Plantation trees on farmland

Trees should not be planted on archaeological sites. The removal of plantation trees already on a site may be left to the planned cropping period, but precautions to protect the site need to be carried out as detailed elsewhere in these guidelines. Sites should not be planted in native trees.

3.2.2 Case study 3—Pa in warm temperate pasture

Wider setting

This pa site is in production pasture. The district receives good rainfall, and has warm winters and naturally fertile, but friable volcanic soils. The wider ecological setting includes gorse and pampas grass with no native regeneration underneath in nearby gullies. The nearest native forest is some 5 km away. There is some poorly managed farm forestry (*Pinus radiata*) nearby with pine seed blown from this onto the site. The district plan has a general clause supporting the protection of significant sites and some assistance is available for fencing.

Site description and condition

The site consists of a ring-ditched platform which has been levelled on one side and a road-cut up onto the platform. The site occupies a hill crest. The sides of the site are steep and there are open rua (cave-like pits) on the platform. The site is grazed by dairy cows. There is extensive erosion of banks, with the banks also undercut for shelter. Two fence lines run through the site and intersect at a gate on the platform of the pa. On the pa platform there are some large pine trees—stock shelter under them, creating erosion patches. Some gorse is growing in patches on the steep banks.

The total area of the site is about 1 hectare. A boundary fence runs close by the edge of the site, but otherwise it is simply one part of a large paddock about 5 hectares in area.

Identification of management issues

- Sheep would be the best animal for grazing but are not available on this property nor in the district
- There is a need to reduce erosion of banks; also banks are being undercut for shelter
- If left ungrazed, the grassland will revert to gorse and pampas grass, and become a source of weeds elsewhere on the farm and in the district
- There is a need to re-arrange inappropriately placed fences which are concentrating stock on the platform
- There is no water in the paddock so cows are only let in over winter and spring; hence there is severe site damage

Management options

- A landowner could make long-term income by fencing off the site and planting it in pine trees. This is not a suitable option because of damage the tree roots will do, damage caused to the site by the eventual harvesting of the trees, and the risk of damage from wind-throw in an isolated small plantation on an exposed ridge or hill.
- Special precautions could be taken to ensure the site is conserved while allowing the area to serve a low-intensity use in the overall

management of the farm. Fencing off an appropriate area with minimal stocking would maintain a moderate-height grass cover and good conservation of the site. Some repair or accelerated grassing of erosion spots would be desirable.

- The precise area of the site could be fenced off to allow it to revert to tall pasture grasses, native grasses, and weeds with no further action. The small area of land concerned would minimise loss of productive land and would require no further inputs other than the fencing. There would almost certainly be a weed problem and many pine seedlings would establish on the site.
- The area could be fenced off with revegetation using an appropriate shrubland cover, and with the intent of allowing native forest to develop in the long term. Any native plant cover would have to be deliberately planted as seedlings.

Management objective

The site is to be conserved while ensuring some return from the land and minimising maintenance costs.

Recommendations/guidelines

Allow the area to serve a low-intensity use in the overall management of the farm. Fence area of site and allow a minimum of stocking to keep grass at a moderate height and to control weeds.

Stock management and fencing

- Seek assistance and advice from the district council or other sources, cost any changes, and apply to the district council for a grant
- An attempt should be made to find hardy wethers, stocking at a density of no more than 6 s.u. per ha
- Maintain minimal stocking with yearlings or with sheep within the fenced area
- Maintain a moderate height grass cover (6–10 cm) at all times and good conservation of the surface of the site
- Remove fence lines through the site and the gateway. Fence to create a single paddock for the site; the new fence should be a minimum of 20 m from the recognisable surface features of the pa. This will allow simpler management of stock on the site itself and prevent the stock wandering up and down fence lines causing erosion
- If a 1-hectare paddock is created, six wethers or two yearling cows would be sufficient stock
- Since the site occupies a hill crest, it should be fenced either within the smallest possible area which encloses the site, or within a fence pattern that allows a division into dry or north-facing aspects and wetter south-facing aspects
- Where there is erosion, fence it out or find some other means of preventing erosion or excluding stock
- Away from the site, but within its fenced area, fence in some trees or tree-plantings or provide shelter in some other form

Stock water

- Water outlets should be positioned by the new fence and its use minimised by appropriate stocking
- In periods of abnormally low rainfall, yearlings should be kept out of the paddock, but wethers may be kept there
- Big drinkers like cattle and dairy cows should not be allowed into the paddock in any season

Shelter

- At some point, preferably when the fences are being installed, the trees should be felled. Care should be taken to ensure that the stock have other adequate shelter from sun and cold winds within the new paddock.
- Trees that are away from the site could be retained if they are providing shelter, or the paddock fencing arrangement could be designed to incorporate trees or other sources of shelter such as a gully head.
- An artificial shelter could be installed for the sheep, or a small protected planting could be fenced out from stock and eventually made available to provide shelter. If properly designed, the yearlings or sheep will shelter there, rather than on the pa.

Pasture and grass cover

Generally, only sheep should be obtained and retained for this particular site. If their numbers are kept low, there will be spring surpluses of grass which will go to seed and produce a cover of coarse grass. Young cattle, yearlings and heifers, but not fully grown cattle, could be let in only on occasions when the grasses have become too coarse for the sheep. In periods of long drought (which is not expected in this district), the sheep could be taken from the paddock and grazed on better pasture within the farm. Some repair or accelerated grassing of erosion spots will be desirable at that time in anticipation of better rainfall.

The option of tall grass cover should be explored. If stock are removed, grasses will grow rank for a number of years, but will eventually stabilise in a cover of perennial ryegrass, cocksfoot, some weedy exotic grasses such as brome, and native grasses such as meadow rice grass (patiti, *Microlaena stipoides*). The possibility of accidental fire needs to be considered since this sort of rank cover can become a fire risk. If the ground surface is broken (e.g. by pugging), the neighbourhood weeds, especially woody legumes, will take hold. Gorse and wattle, in particular, will rapidly establish. They can be controlled by occasional grazing, but are likely eventually to take hold unless full stocking is re-instituted. With little or no grazing, the woody legumes will need to be spot-sprayed or pulled by hand.

Some encroachment of benign weeds such as hard or ring fern, bracken fern, inkweed, and thistles might be tolerated in areas to be given light grazing.

Condition of archaeological features

It will be worth making a record of the archaeological features and the land manager should inspect the place for active erosion at least twice a year in winter and late summer. There may be assistance available from the Department of Conservation, Historic Places Trust or the district council to carry out these tasks. Any particular problems with erosion should be addressed. Some minimal restoration may be necessary.

3.2.3 Case study 4—Midden in eroding foredunes

Wider setting

Dunelands are the products of high winds and coastal forces, and are intrinsically unstable. Foredune areas are subject to extreme conditions including excessive summer drying, shifting sand with little or no organic matter, and exposure to salt and sand-laden winds. Establishment of satisfactory vegetative stabilising is therefore difficult. In this case, the foredunes are active while inland the dunes have long been stabilised with marram grass and subsequently by pine trees or kikuyu grass.

It will be worthwhile in most cases to evaluate whether the overall setting and land management in the vicinity of the site will allow for long-term success and management of any surface treatment devoted to stabilisation. The advancing face of blowouts move through an area, and will break up existing vegetative cover. Isolated blowouts in farmland and forest lands will be worth concentrating on, as will areas in back dunes. Where there is shrubland and some soil formation on back-dune areas, concentrated effort may be more worthwhile.

Middens could be found in any of three zones: extreme coastal margin near high tide (pingao present), silvery sand grass zone, and open areas of shifting sand.

Site description and condition

The middens are widespread scatters of shell and oven stone over the slopes of the dunes. Some of these are downslope from caps of in situ middens which are protecting the crests of the dune. The middens are on slopes of 15–20 degrees and inland from a point about 10 m above h.w.m. Marram grass is forming clumps in places in association with silvery sand grass, but the overall aspect is that of a duneland with occasional patches of light vegetation depending on disturbance by wind and propagation from stolons.

Identification of management issues

- Recreational vehicle drivers are using steep slopes and the crests of ridges to gain thrills. Cattle from the farmland further inland have access to the foredunes because there is no fencing. Rabbits are present.
- Sites are generally exposed wind-blown sand surfaces, with little or very open vegetation. Minimal preparation is necessary for sowing.

- There are no regional council or DOC staff servicing the remote coast on a routine basis. Any valuable materials such as fencing are stolen.

Management options

- Leave the area alone and monitor/recover archaeological information as it is revealed by erosion
- Archaeologically excavate in situ deposits to mitigate long-term loss of the site
- Isolate areas or patches of midden that are top priority for treatment and attempt to plant using simple methods of an effective sand-consolidating vegetative cover such as marram grass, silvery sand grass and pingao. Such revegetation should tie in with the present vegetation continuum (from h.w.m. inland)
- Experimental use of sand fences
- Exclude vehicles and stock and then deal with other issues such as revegetation
- Exclude vehicles and stock and then leave alone and monitor to see what natural vegetation processes take place
- Deliberate burial of some key sites using a sacrificial layer of sand

Management objective

Attempt to plant site area and immediate environs using simple methods of effective sand-consolidating vegetative cover.

Recommendations/guidelines

- Do not attempt to revegetate small areas (less than 100 m^2) in isolation—to be effective, larger areas need to be revegetated.
- Pingao and silvery sand grass are the only species that have been evaluated which are adapted to these zones. However, both marram and pingao require constant physical disturbance to propagate themselves. Generally, pingao should be preferred as the primary coloniser, with silvery sand grass (spinifex) to be established as a secondary coloniser. Once these have become established, kikuyu may arrive naturally in areas of high fertility.
- Recommendations are not made for sites exposed to the less extreme back dune climate, although some of the species evaluated in Woods' (1999) trial programme are likely to be successful in those areas.
- Where silvery sand grass is the dominant species, an attempt can be made to stabilise the site.

Consideration should be given to site selection in light of the pattern of wind direction, undercutting, and current dune formation. Often, middens form a hard cap which has lasted for some time and protected the dune, or part of the original dune beneath. If, at the head of a steep scarp, the midden is in a structurally unstable position, it may not be worth the effort. Alternatively, the planting could be done so as to stabilise the slopes leading to the site while at the same time allowing

for replenishment of sand. Consideration should be given to use of sand fences to concentrate the accumulation of sand at sensitive areas.

Fencing and pest management

Temporary fences would be useful to exclude stock and all-terrain vehicles, but this is unlikely to be practical. The fences will be stolen or destroyed in many areas. Northland Conservancy have been trialling cheap fences using two strands of electric fence tape but without the electrical charge. Very large areas can be fenced. The tape is cut at intervals and re-knotted, which reduces the risk of the tape being stolen and improves its visibility. Likewise, the standards can be reduced in value.

Monitor and repair fences at intervals. After a time, and a period of repairs, both cattle and the 4WD public have come to accept these fences.

Plant damage from rabbits and cattle were noted in the unfenced trial areas in Northland. Rabbit control may be warranted in some districts. Damage to the seed by birds is unlikely to be a problem.

Outside the protected area, it is necessary to explain the protective measures and to find other areas that are more suited to recreational use of 4WDs.

Silvery sand grass

Seed collection—Silvery sand grass (*Spinifex sericeus*) seed should be collected in late January and early February, preferably from plants in the same locality to where the seed is to be sown. Only the female heads should be collected, as male flowers do not produce seed (see Bergin & Kimberley 1999). In some regions, the seed may be infertile so it is worthwhile checking that female and male plants are well interspersed with each other, and that the seed germs are not suffering from floral smut.

Establishment—Sowing of unthreshed seed should occur well after autumn rains commence (e.g. from April to September). Prolonged post-harvest seed dormancy does not seem to be a problem, and further seed treatment is unnecessary. For ease of planting, seed heads should be broken up, but full threshing is not needed. Conditions at sowing need to be wet enough to ensure that sand is not likely to dry and become prone to wind erosion before seedlings germinate and establish.

Longer term management—A light rate of nitrogen as urea (50 kg urea per ha) should be applied 6–8 weeks after seedlings have emerged. Nitrogen application should not be made during drier conditions. Nitrogen application may also be warranted in areas where resident silvery sand grass is to be encouraged. Resulting increased stolon and rhizome growth from resident plants may assist site coverage.

Pingao

Pingao tends to enjoy repeated disturbance and its ability to survive in competition with other plants depends on this disturbance. It is quite common to see pingao established on foredunes subject to wind and

storm waves, but driven out by other plants such as marram grass on more stable sand surfaces nearby. Its use for stabilising archaeological sites in sand dune areas is not recommended. Planting from nursery stock is not recommended for archaeological site stabilisation because too much disturbance is caused to the midden.

Marram/yellow lupin

Marram is not a New Zealand native, but it persists longer in stabilised dunes. Marram requires less physical disturbance than pingao to maintain a stable cover and to propagate itself. It should therefore be preferred as a dune stabilising plant. Marram is often used as an initial stabilising cover and, when stable, planted in yellow lupin. This will form soils which will soon allow planting of adaptable native plants such as poroporo. In commercial forestry, a sacrificial zone of pine trees can be planted as close as 150 m from the h.w.m. However, these trees should not be planted on archaeological sites. It will be possible to establish native shrublands in lupin cover (e.g. poroporo, *Solanum laciniatum*). If long term physical stability and soil development is assured, then other native shrubs and coastal trees such as kanuka or akeake may be planted or become established naturally.

3.3 SITES MANAGED IN PLANTATION FOREST

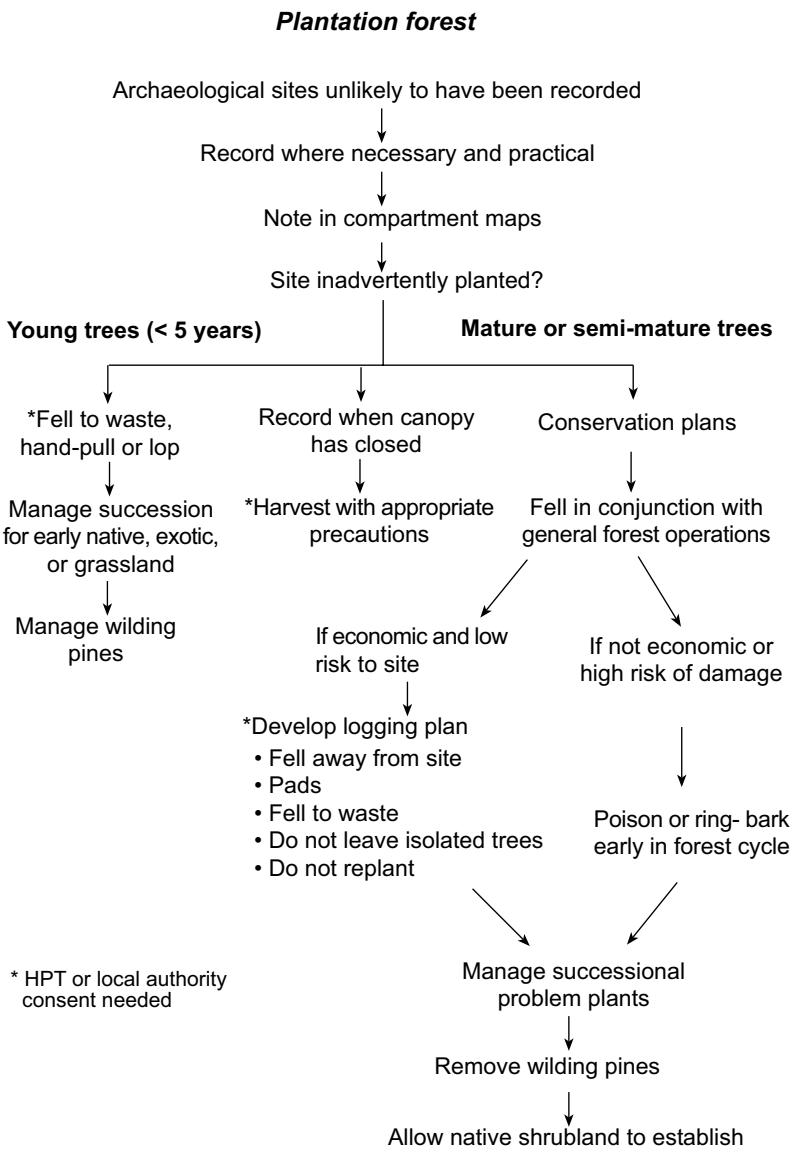
Plantation forests, with limited or no public visiting, are often established in areas where there has been past human settlement and where nature conservation values have been heavily modified by that settlement. Both the forest establishment phase (which reached a peak in the 1970s and 1980s) and forest operations such as fire control and harvest need consideration. Establishment and operations such as harvest are widely spaced (a minimum of 30 years), so records need to be kept and new staff (managers, field supervisors and contractors) need to appraise themselves of sites

It is important to evaluate any proposed planting land, even small woodlots, for the probability of archaeological sites being present. An assessment of known records of sites by a consulting archaeologist should be able to determine the probability of new ones. This may require surveys of areas proposed for afforestation not only before any land management is undertaken, but also by the end of the planting season. Land clearance and planting will reveal many sites that could not have been detected beforehand. Figure 36 shows a decision-making process for archaeological site management in a plantation forest or where plantation forestry is planned.

Land evaluation

- Is there a good survey of the area mapped at a scale of about 1:10 000 suitable for forestry and detailed records of archaeological site location and extent?

Figure 36. Archaeological site management process in a plantation forest.



- Forest managers should insist on careful detailed evaluation, by an archaeologist, of sites before land purchase or re-planting. Statutory provisions should be followed and their implications for the management of the sites reviewed.
- The archaeologist should describe sites and record site location and extent on forest management records/maps.
- There should be re-evaluation and reassessment of the condition and significance of sites before each planting and harvest phase.
- The forestry company should have detailed management objectives for the land area of the sites. Although pa are often ideal hauler sites or landing stages, they cannot be used as such.
- The effect of leaving archaeological sites open or in shrubland cover in the overall management of the forest must be assessed. The shrubland is most at risk from fire and of being used as a trail in a fire emergency.

3.3.1 Planting around protected sites

Sites to be protected should not be planted. Where trees have had to be felled off a site which should have been protected, it should not be re-planted. The area of the sites should be defined on the ground by the archaeologist. The area of disturbance due to roots will not extend much beyond the drip line of any particular tree. However, the desirable set back or planting perimeter around sites can and should vary, but as a guide should be a minimum of 10 m horizontally or 20 m slope distance outside the site itself. Otherwise, distance from the site will depend on slope (flat ground requires less distance), whether vehicle access is required past or around the site, and on the way in which trees will be felled at harvest. Room for forest operations should be left around the site if it is in a position which will create difficulties for forest management, and specifically allow for eventual felling and hauling. It is not always easy to construct roads or firebreaks around a site on a steep-sided ridge.

Trees planted on the perimeter of an open area will come to lean over the area, so that often they will only be able to be felled into it. Some methods are available to deal with the problem of felling trees in this situation (see section 2.5.1). In the larger area of a forest harvest, operations will commence by felling into open space. The logging face will eventually move in towards the open area of an archaeological site, and allow trees to be felled away from it.

Fire precautions and operations pose particular risks for sites. Where the site is kept open there is a risk that the open area will be used for fire control operations, especially in emergencies.

3.3.2 Harvesting precautions

Before harvest, the archaeologist should visit and re-mark the sites with posts, tape, or spray as necessary, if the site is not already permanently marked. The logging contractor should discuss felling and other harvest procedures on site with the archaeologist. The archaeologist should present the protection of sites as an objective and discuss felling down to the detail of individual trees with the contractor, seeking the advice and co-operation of the contractor as to what is practicable and safe. The contractor should brief the archaeologist on any danger anticipated or to be avoided.

Figure 37 illustrates precautions that can be taken where a site has inadvertently been planted and is coming to harvest. In some cases, trees may need to be felled to waste. It may not be possible to haul them or it may be that, in the interests of site protection, they are best felled into ground from which they cannot be recovered (e.g. over a cliff). In other instances where both archaeological and wood values are high, helicopter removal of fallen trees may be needed. It is essential not to leave trees to stand on archaeological sites. Any slash from forestry operations should be moved as little as possible, but cut finely so that it is on the ground and rots quickly.

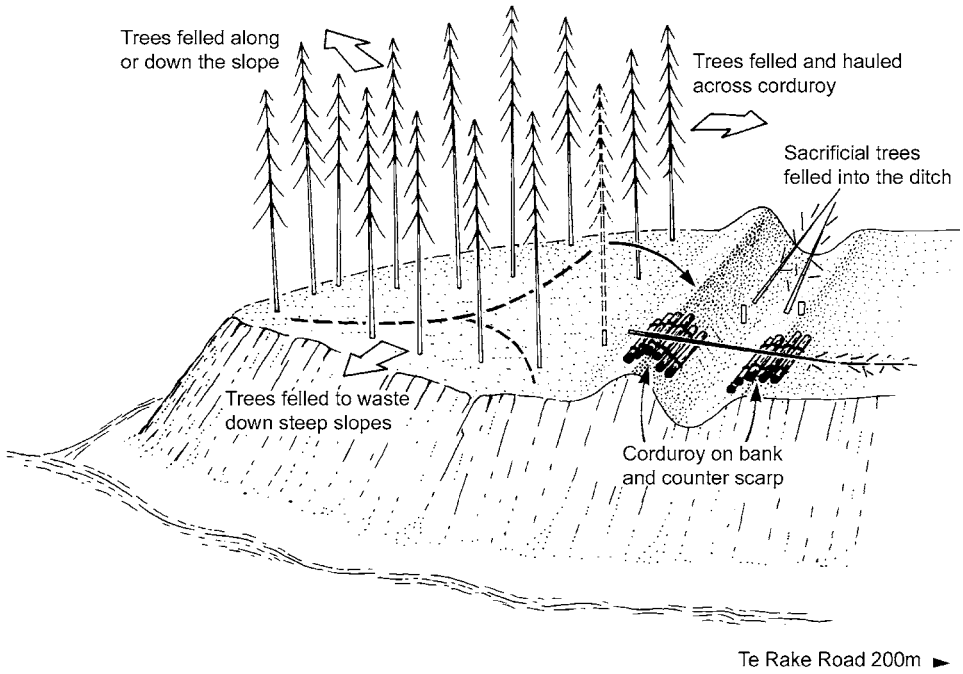


Figure 37. Suggested harvesting sequence for a typical pa site that has been inadvertently planted.

At the time of felling, the person at the stump must be aware of the whereabouts of any archaeologist present in a monitoring role. The onus is on the archaeologist working in a harvest situation to be aware of specific site safety rules and occupational safety and health guidelines. Extra cost may be incurred and felling subsidies may be necessary. District plans may allow for such assistance. Authorities for felling will be needed from the Historic Places Trust. Some companies have best management practices for these activities and these will be reinforced by the conditions contained in the authority.

If sites have been planted in an earlier rotation, it is essential that they be felled at the same time or soon after the rest of the forest. This is not only more cost-efficient, but also removes the risk of windthrow of newly exposed trees left in isolated patches (Fig. 38). Following harvest, blocks that have large numbers of sites or perceived risk of large numbers of sites should stay unplanted. Sites and likely management precautions that will be needed will need to be re-evaluated.

Appendix 2 (section A2.3) provides a specimen work plan for tree felling and removal.

Archaeological site management for forestry companies

- Companies should adopt and internalise archaeological site management procedures.
- Trees should not be planted on archaeological sites.
- Ensure roading, firebreaking and fire control operations do not impact on the site.
- Harvest and fire control plans should cover identification and protection of sites.

Figure 38. On this forest block in Nelson, archaeological sites have been left in tall trees. These patches of forest will be subject to wind-throw, creating more damage than would harvesting the trees. These trees were subsequently felled.

- Sites that are in newly planted or re-planted areas, or in areas that have been harvested and left unplanted, will be open to invasion by wilding pines.
- Weed control requires an annual visit and removal of small wildings in the first 5 years and 5-yearly inspections and management after that.
- Site management can be done in conjunction with other operations.

Bulldozers or any heavy-wheeled or tracked machinery should not be allowed on archaeological sites. Hydraulic diggers may be walked through a site, unless soils are especially friable, but this should be done with caution and with a minimum of turning. Some tracked machines, especially mechanical harvesting machines such as hydraulic excavator-based grapples, which have a fairly long reach, offer a way to remove trees from sites with minimal impact. The trees will have been hand-felled on to each other in a sequence and the grapple will remove them more or less in reverse sequence. Feller-bunchers control the butt of a tree and the speed of fall of the upper parts. Although not used on steeper slopes (above 15–20 degrees), it is possible to walk these machines into a site and to control the harmful effects of logging. Light slash may be laid on the trackways to be used by such vehicles. The use of such machinery in particular cases needs to be planned with consultation between archaeologist and forest manager, and will be subject to authorities under the relevant authority provisions of the Historic Places Act 1993.

Winching to control the line-of-fall of trees onto a mat of previously felled branches or placed corduroy may be needed (see section 2.5.1 on problem trees). Hauler tracks or the routes of cable logging should not pass through sites. Motorised carriages on the hauler lines may be a useful asset for clearing low ridges with sites on them.

Archaeological sites that have been inadvertently planted, and identified some years later, may be harvested (with special precautions to protect

Figure 39. On the pa Hinamoki II, some Douglas firs were poisoned about 20 years ago. The poisoning was intended to be progressive and in the event not all of the trees were poisoned. The trees to the left and in the distance will have to be felled away from the site. Poison at this stage is not practicable because the live trees are scheduled for harvesting and poisoned trees in their midst would create a hazard for the logging gangs.

the site) at the same time as the wider harvesting programme. If identified in time, it should be possible to poison young trees that have been inadvertently planted well before (more than 10 years before) harvest. Figure 39 shows an example of poisoned trees on a pa in the Whirinaki valley.

3.3.3 Ongoing forest management for protected sites

Archaeological sites left unplanted within a plantation forest will always be vulnerable to vehicle traffic, either routinely or in emergencies such as fire. In the course of the final winter inspection or survey of a planted area, obvious ridge access ways should have a minimum of one or two white posts 1.2 m above ground at the 20 m perimeter mark. The post may have identifying details for the site on it, such as a tag saying that it is an archaeological site and giving the site number or compartment plan details. Although ground marking is not particularly effective (it can be obscured by low vegetation and may not be noticed by a bulldozer driver), it is a useful adjunct to marking on forest planning/compartment maps.

Firebreaks and roads should have been planned and constructed to avoid archaeological sites in the winter planting season or before. If this work is not done by then, sites will be at risk not only from ad hoc fire-breaks, if a clearance fire gets out of control, but also from roading constructed just prior to harvest.

Compartment plans or stand records should have the archaeological sites and their extent and identification marked on them in draft by the archaeologist and in 'published' form by the company draftsman. Planting boundaries around the site may be defined by differential G.P.S. and plotted directly into forest planning/compartment maps. The site should have the same prominence as other management details and it should be a permanent record held and available for all day-to-day and longer-term

management purposes. At 1:10 000 scale it should be possible to show the extent of the archaeological site as an outline area. Although this may be a practice beyond the capacity of small woodlot owners, recording and annotation of records and discussion of them with contractors unfamiliar with the land area is necessary.

Routine maintenance of archaeological sites should be carried out in conjunction with regular forestry management operations. For example, when trees are thinned or pruned, wilding pines or other trees could be cut out from and around protected sites. In the early stages of forest establishment, seedling pines (which may have been inadvertently planted on a site) should have been pulled. Broadcast weed control (e.g. for pampas grass) may be necessary. Alternatively, a few sheep may be let loose in the blocks once the trees are established. Sheep tend to concentrate on the clear grassed areas where the protected sites will be. However, wilding pines will not be controlled by either broadcast weed control methods or grazing, so a concerted effort at appropriate intervals is needed to remove them.

A thin-stemmed dense shrubland cover, one of the preferred covers for archaeological site conservation (see sections 2.2.7 and 2.2.8), is likely to establish in some areas (Fig. 40). Clearance of firebreaks should only be done following reference to the compartment plans, and should not be left to the discretion of bulldozer drivers. Bulldozer and other operators should be fully briefed on known sites and should report any damage inadvertently done, or if other sites previously unknown are disturbed.

Figure 40. An ideal thin-stemmed shrubland cover on the bank of Hinamoki I, Whirinaki Valley. Douglas firs such as the specimen at left have been poisoned or felled off the pa in the previous 15 years. Future management should ensure that surviving Douglas firs are felled away from the bank and that shrubs with a propensity to grow larger than 10 cm d.b.h. are removed so that the thin-stemmed shrubland cover is maintained.

Risks to sites in forestry blocks

- Bulldozing of roads, firebreaks, and fire control operations
- The full extent of sites has not been properly recorded in the company's compartment maps; out of date documentation
- Harvesting, especially hauling, skidding, and landing construction

- Wilding pines and weeds establishing on non-planted areas
- Pig rooting

Solutions

- No planting or re-planting of sites
- Long term, on-ground identification of sites by marker posts
- Plantation establishment and logging plans that protect sites
- Fire management plans and operations management that deal with the need to protect sites
- During felling operations, sites are clearly marked with posts/red plastic ribbon
- No felling onto sites, no hauling across sites
- Regular hunting should be allowed in blocks

3.3.4 Case study 4—Sub-surface site (midden) in coastal plantation forest

Wider setting

The site is in a plantation forest (*Pinus radiata*) on dunelands, about 3 km inland from the west coast of the North Island. The foredunes have long been stabilised by marram grass and a zone of sacrificial salt- and wind-stunted pine trees. The regional council is concerned about the lack of control of some plant pests (weeds).

Site conditions

The archaeological site is a midden located on an old dune surface with light sand soils. The midden is exposed and spilling on to an iron pan on older Pleistocene dune surfaces. The midden has not been planted and is surrounded by 15-year-old pines about 10 m tall. The layers of midden cover about 50 m^2. The iron pan has various depressions cut into it which appear to be the outline of storage pits. The surrounding pine trees are 10 m from the perimeter of the site and will overshadow it as they come to maturity. Pampas grass and some 3-metre tall seedling pines have established in pockets of more recent sand soils on the site and on the pit depressions. The site has been surveyed out of an area of the former state forest and vested as a wahi tapu with local Maori trustees.

Management options/issues

- Leave alone. Wilding pine trees will grow large and a pampas and manuka shrubland will slowly develop over the site with some bare patches. This is unacceptable to the forestry company and the regional council because they want to see sources of pampas seed eradicated before harvesting and re-planting. Also, minimal interventions as below will enhance the conservation status of the site.
- Remove wilding pines and spray pampas grass and trust that slow soil formation and drifted sandy topsoil plus pine needles, plus some moist shadow areas, will lead to a cover of stabilising grasses and native shrubs. Bracken and manuka will eventually be shaded out by

the surrounding, maturing pines, but will come away again on felling of the surrounding forest.

- Excavate part of the site to evaluate significance and then decide on total excavation or further stabilisation measures. If the site is valuable, cover exposed areas with filter cloth and bury site with a cover of raw sand/sandy topsoil up to 50 cm deep. A total of up to 50 m^3 of sand/soil may have to be moved to cover the site area. The surface of the buried area could be deliberately re-planted by placing manuka slash, etc., but otherwise left to naturally revegetate.

Management objective

Incur the least possible cost by leaving site alone, and carrying out occasional monitoring to check on the natural establishment of native shrubland and to remove pines.

Recommendations

- Ensure the forest records contain an up-to-date reference to the site and a guide to finding it again.
- Wilding pines established on the site need to be removed and the site should be left to revegetate naturally and be monitored by the iwi's archaeologist every 2 years.
- On harvest, trees should be felled and hauled so as to minimise damage to the archaeological features.
- Any action on conservation needs to be taken by the forest manager as part of its general forest operations, advised by tangata whenua and archaeologists. Management options/issues would probably be considered by the iwi trustees following a recommendation by an archaeologist and in discussion with the forestry company with cutting rights.
- Whatever management is chosen, adequate records of the location details should be kept. The extent and condition of the site should also be noted in the forestry company's records. The site should be marked on the ground.
- When the forestry block comes to be felled, the area of the site should not be used to fell trees into or used as a landing or log staging area.
- A midden such as this should only be investigated further on the basis of a clear research plan, and only when that plan is in place.

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Appendix 1

TYPES OF ARCHAEOLOGICAL SITE IN NEW ZEALAND

The list of categories of site given below cannot be comprehensive. A site with features on the surface will almost always have a structure of underground layers.

A1.1 Surface-visible sites

Pre-European period

Earthworks such as pa are readily recognised on the New Zealand landscape. This category may also include:

- Ditches and banks, dug for defence across ridges or enclosing cliff edges
- Scarps, created by cut-and-fill methods to steepen slopes for defence
- Terraces, created by cut and fill methods to make flat areas for gardening or house sites
- Pits, usually dug for the storage of horticultural crops, but sometimes quarry pits
- Drains, ditches associated with house floors, pits or gardening

Also from the pre-European period:

- Urupa, cemeteries, burials
- Middens
- Stone quarry floors and outcrops; places where stone for adzes or other purposes has been extracted
- Stone revetted (i.e. stone-faced) earthworks such as earth mounds, or terrace-edges
- Stone alignments, single placed-stone rows, stone heaps, stones placed to enclose a hearth
- Surviving wooden features, such as palisade posts, or trees from which bark has been removed or on which the bark has been carved
- Artworks either engraved into or painted on to rock surfaces
- Semi-cultivated vegetation which survives next to sites (e.g. karaka or ti: cabbage trees).

European period

The range of surface features includes:

- Earthworks, such as ditch and bank fences, terraces, pits, ring ditches, ditches, including stone-revetted earthworks such as water races
- Plough or other cultivation marks from old fields
- Foundations in stone or concrete, often in unstable ground conditions

- Ruined stone or concrete walls (i.e. upright, but without a capping or roof)
- Stone fences or stone clearance mounds
- Other structures in a ruinous state (e.g. stone fireplaces)
- Structural metal or portable metal artefacts, including engines, vehicles—fully exposed, or partly buried
- Rubbish dumps (e.g. on eroding slopes below the site of now-disappeared buildings)
- Asphalt, stone or brick paving, or other artificial flat surfaces, such as hardened earth floors within ruined walls; gravelled surfaces
- Historic tree plantings, orchards, or formal gardens, house gardens (terraces, paving, drains, kerb and channelling)

Unless erosion and infilling have been very marked, the earthworks or stone sites are often visible on modern ground surfaces. The other types of surface-visible sites are often very fragile, and may warrant quite specialised conservation attention including in situ stabilisation and revegetation.

Some buildings and other structures in a ruinous state, for example the foundations of a dam, that are no longer capable of use or refurbishment, may also be regarded as archaeological sites. Architectural, engineering, and archaeological techniques may be relevant to their conservation.

A1.2 Sub-surface sites

Stratified archaeological layers will usually be detected either by accidental exposure in the course of earthmoving, deliberate test-pitting in the course of an archaeological survey, controlled excavation over wider areas, or by the examination of non-vegetated scarps such as road cuttings or those created by erosion. Since they are often concealed beneath more recent soils, this important class of site can often be neglected when the management or use of an area is first considered.

This class of site includes the following:

- Layers of debris, occupation floors, with wooden materials preserved in the anaerobic conditions of a swamp
- Quarries for stone or sand
- Living or working floors, surfaces modified by the debris of tool-making, house construction, fires and other activities, and which have been subsequently sealed by infilling, and other soil processes
- Midden, refuse from food preparation and consumption, typically shell and bone
- Hearths, concentrations of charcoal and burnt earth with or without enclosing stones
- Ovens, concentrations of charcoal and burnt stones and earth in scooped hollows
- Graves
- Earthwork fill, disturbed and mixed earth, sometimes sealing earlier soils and layers

- Soils that have developed on a site and may have subsequently been buried
- Holes, pits, postholes or palisade lines, filled with soil wash or deliberately infilled
- Drains
- Modified garden soils, soils that have been cultivated and/or had gravel, sand, shell, or charcoal added and mixed into them

Appendix 2

SPECIMEN WORK PLANS

The following specimen work plans are modified from Andropogon Associates: Petersburg National Battlefield Action Plan, Petersburg, Virginia, USA. (Seasonal advice has been adapted to the Southern Hemisphere.)

A2.1 Sowing and over-sowing grassed site

The requirements for the sowing or over-sowing of bare areas or thinly grassed areas to repair existing turf.

Staff needed

- Conservation officer, archaeologist or historic resources specialist plus volunteers

Equipment needed

- Transport, rakes, spades, plastic bags, site plans, recording equipment, safety equipment as identified in OSH plans

Work considerations

- Identification of seed source sites for the required native grasses (e.g. *Microlaena stipoides*, *Rytidosperma* spp., *Poa anceps*).
- Manual seed collecting. It will be necessary to observe the intended harvest area at least weekly, to ensure seed is collected when it is mature and before it drops (timing: from November to January).
- Assemble commercial seed lines (e.g. *Festuca rubra* and *Lotus pedunculatus*).
- Store seed for use 3–6 months later. Seed should be stored away from mice in paper bags, cartons or sacks, not plastic. Hand threshing is not necessary when sowing will occur during favourable periods for germination and establishment.
- Prepare planting plan, including evaluation of zones of soil fertility and shade factors.
- Prepare site (timing: March). Do initial soil test, apply herbicide (if necessary), clear ground with line-trimmer (if necessary), apply basal fertiliser, identify planting zones (timing: March and April), establishment of seed, weigh seed lots, construct exclusion fence.
- Establishment of vegetative material (timing: from late April to July). Identify local sources of *Oplismenus imbecillus*, *Paesia scaberula*, *Blechnum penna-marina* and *Metrosideros perforate*.
- Plant grass seed (timing: from April to July) depending on local knowledge. Lightly rake surface areas, add soil to make grade or repairs, spread seed at recommended rate, OR oversow and rake in seed of: *Microlaena stipoides*, *Rytidosperma* spp., *Festuca rubra* and

Lotus pedunculatus. Protect seed against pests and birds, mulch area with chopped straw or hay, water if necessary.

- Plant cuttings (timing: from April to July).
- Winter and spring maintenance (timing: from July to October).
- Urea application.
- First summer maintenance (timing: December to May). Water if needed, do not mow or line-trim until grass is well established.
- Later summer maintenance phases. Allow grass to flower and set seed; do not mow until February or later.
- Monitor and record results annually.

A2.2 Mowing

The mowing and line-trimming of grassed sites on earthworks of archaeological significance with walk-behind or small ride-on mowers.

Staff needed

- Staff operator and/or contractor

Equipment

- Mowers, line-trimmers, transport, tractor with rotary slasher, safety equipment as identified in OSH plans

Planning precautions

- Areas designated for carefully controlled mowing are the most significant recognisable parts of archaeological surface features, or other historic structures, which should be maintained with a minimum of inadvertent damage.
- A conservation plan will have specified the key areas to be mown, and include any modifications (such as new tracks) needed for effective safe mowing.

Work considerations

- Work to a mowing plan
- Do not mow or line-trim until new grass is well established
- In later summer visits, allow grass to flower and set seed—do not mow until February or later
- Inspect cutting blades and all aspects of equipment
- Check for impediments in taller grass
- Set mowers to 7–10 cm for level ground and 10–12 cm for edges and the tops of banks; do not cut more than $^{2}/_{3}$ of the grass height
- Do not scalp banks
- Sweep or clear grass clippings from use areas, otherwise allow it to form mulch where it lays
- Advise site managers of any significant weed control problems observed

- Line-trimming can be used on small areas, on depressions, or on larger areas of grassed banks; do not cut closer than 10–15 cm
- Any weeds which survive mowing to this height (such as gorse) will need to be controlled with a suitable spray
- A rotary slasher may be used initially and according to mowing plan if the objective is to remove low woody cover that cannot be dealt with by line-trimmer
- Area office must check work of new contractors after mowing
- Annual monitoring of mown areas is part of monitoring plan

A2.3 Tree felling/removal

Removal of trees causing a problem or potential problem for site stability—includes both clearance of all trees (e.g. harvesting *Pinus radiata*), or selective removal of problem trees, or branches.

Staff needed

- Reserve manager or heritage management specialist
- Experienced stumpman—the person at the base of the tree, operating chainsaw, and who signals all other workers on site
- Another experienced timber worker
- Labourers

Equipment

- Transport, chainsaws, winches, ropes, extension ladder, safety equipment as identified in OSH plans, spray paint, tape, signs to warn public, exclusion tape or barriers

Planning precautions

- All work to be done following a detailed conservation plan review
- Trees to be selected in discussion between reserve manager, heritage management specialist, and stumpman
- Neighbours notified
- Warning signs advising no public access to the reserve for duration of the work
- Review weather on the day

Work considerations

- Avoid felling trees across site features such as ditches and banks
- Use natural lean and wedging of initial cut for directional felling; sequence of felling is the key to successful protection of the site
- Fell smaller 'sacrificial' trees on or near the areas to be protected, or install corduroy
- Fell along the line of existing depressions (e.g. ditches)
- Winch trees to ensure direction of felling

- Fell on to a mat or corduroy of logs, or smaller trees felled to form a protective cover
- Avoid damage to trees that will eventually form a new canopy
- Skidders and bulldozers should not be used on sites
- In most instances trees will be felled to waste
- Where both archaeological site values and wood values are high, helicopter removal of fallen trees may be needed to avoid damage from hauling logs through the site
- Slash should not be moved, but cut finely so that it is on the ground and rots quickly
- Some trees or shrubs will sucker and cut stumps need immediate swab with a brushweed killer (Tordon)
- Plant key areas of site with ground cover plants or selected canopy-replacement seedlings

A2.4 Standard conditions for a grazing concession

As a general guide, grazing should not result in damage to any archaeological features.

The following are suggested as standard conditions/clauses:

- Stock levels—in the case of new historic reserves or registered historic sites, this figure is calculated with advice from HPT and this guideline *Caring for archaeological sites*.
- Stock type—generally limit stock type to lambs, sheep and other soft-hoofed animals. In some districts allow (with HPT permission) yearlings on the grounds that there are no sheep, e.g. in Taranaki.
- State who the agreement is with, and the length of the concession. In some cases agreements may carry over to immediate family member successors, so long as they remain the owners of the neighbouring land (this clause usually applies where a farmer has given/sold DOC some, but not all, of their land). In other instances there may be a more specific time period (e.g. 5 years).
- Retain the ability to monitor the effects of grazing and explore alternative options if damage is occurring. Alternative options include reducing stock levels.
- Surrender of the concession/agreement, usually with 3 months notice.
- Ensure all-year-round access is maintained for the public. For example, the farmer can not stop the public entering the reserve because of, say, birthing; that is the farmer's problem, not DOC's, or the public's.

Then there are usually two or three site-specific clauses which deal with a range of matters peculiar to the site (e.g. mustering, gates, fencing, wet weather, etc.), and which impact on the archaeological features.

The above six clauses should be seen as a minimum. The document also has to be able to be supplemented by site-specific clauses. Although sheep, goats, and llamas may be the preferred stocking option, any national template has to allow for the fact that in some parts of the country few farmers bother to keep sheep.

Appendix 3

NATIVE COVERS FOR ARCHAEOLOGICAL SITES

Developed from a pamphlet by P.G. Simpson 1995: What to plant where? Department of Conservation, Wellington.

NAME	FORM AND SPECIAL FEATURES	HABITAT
Ferns		
Blechnum fluviatile—kiwikiwi Kiwakiwa	Medium-sized rosette of many leaves (3.0 cm).	Shaded places. Semi to full sun. Needs moist, light soil.
Blechnum penna-marina Little hard fern	Spreading ground cover. Very hardy. Can form dense mats.	Lowland to high country, moist, open to shaded.
Pteridium esculentum—bracken fern, rarahu, aruhe (rhizome)	Spreading underground stems produce dense growth of 1 m-tall fronds. Can be invasive.	Very hardy, diverse open habitats, especially grassland. Sun to part shade.
Monocotyledons		
Phormium cookianum—flax, harakeke	Fibre plant, tui drink nectar (size 1 m × 1 m).	Windy, cold or exposed sites. Crests of banks, slopes too steep or inacccessible to mow.
Cortaderia richardii—toetoe, *C. fulgens*—kakaho	Large 'tussock' grass with plume seed-heads, kakaho stems used in tukutuku panels. Useful to retain steep banks.	Species varies with region. Open wetlands, streamsides.
Colonisers		
Carex spp.—*C. virgata, C. testacea, C. coriacea* (rautahi), *C. echinata, C. flagellifera,* 30–50 cm *C. comans* 30 cm (maurea) coastal; *Uncinia* spp. (hookgrasses)	Grassy clumps. Throughout most of NZ but sometimes local. Hardy. Useful in areas subject to pedestrian wear. Grown by subdividing clump. Numerous other local species.	Mostly moist soil. Open sunny grasslands, wetlands, to partly shaded forest margins.
Poa cita (ex *P. laevis*)—silver tussock, wi	Single tussock produces offspring by dividing tillers. Short tussock.	Lowland to upland grassland, gravel soils. Sun. Tolerates clay, dry soil.
Poa anceps—broad-leaved poa	Spreading, leafy carpet. Broad leaved grass (to 60 cm). Tall feathery flower spikes.	Shaded slopes, bluffs, stream sides. Sun.
Microlaena stipoides, patiti—meadow rice grass	Spreading tufted carpet. Vigorous growth.	Drought tolerant, forest to open sites.
Elymus solandri (ex *Agropyron scabrum*)—blue wheat grass	Attractive open tussock form.	Dry soils, open sites, tolerates some shade.
Dichelachne crinita—plume grass, patiti	Attractive open small tussock form (size 30 cm).	Coastal to inland open, rocky, or dry sites.
Oplismenus imbecillus	Spreading grass, ground cover.	Deep-shaded areas, North Island.
Vines		
Metrosideros diffusa—climbing rata; *M. perforata*	White flowers in spring, when vine reaches canopy.	Diverse moist habitats and dry soil. Tolerates v. shaded conditions.
Muehlenbeckia complexa, pohuehue	Dense twining low vine; can be deciduous, fast-growing. Excellent for covering banks and difficult areas. Suppresses weeds.	Dry areas, coastal to inland, sand dunes. Partly deciduous in colder areas.
Parsonsia capsularis, P. heterophylla—N.Z. jasmine, akakiore	Slender vine, vigorous, handy, versatile.	Lowland forest and shrubland; mainly dry areas. Sun to part shade. Coastal.

Continued on next page

Appendix 3—continued

NAME	FORM AND SPECIAL FEATURES	HABITAT
Rubus spp. (*R. australis, R. cissoides, R. schmidelioides* depending on habitat)—bush lawyer, tataramoa	Prickly scrambling vine, becoming large forest liane.	Shrubland, young forest. Sun to part shade.
Shrubs		
Pittosporum eugenioides		
Brachyglottis repanda—rangiora	Large leaves with white underside. (Shrub size 3 m × 1.5 m).	Tolerates coastal conditions, or moist forest understorey. Requires good drainage. Sun or shade.
Coprosma repens—taupata	Glossy, fleshy leaves. (Shrub size 2 m–4 m.)	Coastal, mainly N.I. Frost tender. Prefers dry soil.
Coprosma hauwera	Sprawling coastal plant with dense foliage.	Tolerates moist and dry, sun and shade, clay.
Coprosma propinqua		
Mingimingi	Divaricating, twiggy shrub (3 m × 1.5 m).	Coastal to montane, wetland to dry hillsides. Sun—shade.
Hebe stricta (N.I. and northern S.I.); *Hebe salicifolia* (S.I.)—koromiko	Useful as a nurse plant when revegetating large areas (1 m–2 m).	Open ground to bush margins. Sun—semi-shade. Quick growing.
Solanum laciniatum—poroporo	Very rapid growth, short-lived shrub (to 2 m).	Open ground in disturbed places. Sun to part-shade. Tolerates clay, but not wind.
Leptospermum scoparium—manuka	Dense thickets or spreading bushes, honey producer.	Wet, infertile soils in open areas. Excellent seed bed for forest species. Tolerates drought, swamp, frost.
Macropiper excelsum—kawakawa	Medicinal shrub. Hardy. Orange fruit spikes attractive to native birds. (Shrub size 2 m × 1 m.)	Coastal, or lowland forest understorey, south to Banks Peninsula. Sun & Shade. Frost tender.
Olearia arborescens		
Olearia solandri, coastal shrub daisy	Rapid growth, heath-like shrub, (3 m × 1 m).	Wet and dry coastal soil, to Lat. 42°S. Estuary margins. Tolerates clay. Sun.
Haloragis erecta—toatoa	Spreading bushy herb, (40 cm to 1 m tall). Purple foliage.	Forest margins, open disturbed ground. Sun. Tolerates clay.
Muehlenbeckia axillaris, M. complexa—pohuehue	Hardy. Open mat (up to 1 m across). Grows from cuttings/rooted pieces.	Open ground, south of Lat. 38°S. Grows well in harsh places.
Kunzea ericoides—kanuka	Dense thickets of slender, aromatic trees (to 6 m). Quick growing. Hardy.	Sunny, alluvial and hill slopes. Tolerates clay, drought, poor soils, grass.
Other ground hugging plants		
Pimelea prostrata—pinatoro. N.Z. daphne	Spreading patches to small shrubs. Hangs over banks.	Diverse habitats, but local varieties. Sunny dry places are best.
Acaena anserinifolia, A. inermis—'bidibid', piripiri	Creeping patches. Hardy.	Open, grassy places. Tolerates semi-shade and wind.
Dichondra repens—Mercury Bay weed	Carpet-forming or open patches.	Open, moist areas. Tolerates clay. Sun—shade.
Pratia angulata		
Arthropodium cirratum—Rengarenga lily		
Mazus spp. Belongs to the Foxglove family (Scrophulariaceae)	Small herbs, often prostrate and/or creeping.	
Hydrocotyle novae-zelandiae, H. moschata, H. hetermeria	Patches or open ground-cover.	Moist open to semi-shaded places, coastal to lowland.

Appendix 4

NATIVE GRASSES AND OTHER GROUND-HUGGING COVERS

Recommended species, sowing and planting rates for sites in northern temperate areas are listed below. Listing is by aspect.

North-, west- and east-facing aspects, sunny with minimal shading, well drained

- Meadow rice grass (*Microlaena stipoides*) local ecotype, 50 g seed per m^2
- Chewings fescue (*Festuca rubra*) 'Enjoy', 25 g seed per m^2
- Danthonia (*Rytidosperma* spp.) local ecotype, 25 g seed per m^2
- *Lotus pedunculatus* 'Maku', 10 g seed per m^2
- Fern (*Paesia scaberula*) local ecotype, 20 cuttings per m^2
- Fern (*Blechnum nigra*) local ecotype, 20 cuttings per m^2
- Clinging rata (*Metrosideros perforata*) local ecotype, 20 cuttings per m^2

South-facing shady aspect, well drained slopes

- Meadow rice grass (*Microlaena stipoides*) local ecotype, 50 g seed per m^2
- Fern (*Blechnum nigra*) local ecotype, 20 cuttings per m^2
- Clinging rata (*Metrosideros perforata*) local ecotype, 20 cuttings per m^2

Wet, poorly drained, heavily shaded areas, and areas prone to short-term saturation

- *Oplismenus hirtellus* subspecies *imbecillus* local ecotype, 20 cuttings per m^2
- *Lotus pedunculatus* 'Maku', 10 g seed per m^2
- Fern (*Blechnum nigra*) local ecotype, 20 cuttings per m^2
- Fern (*Blechnum penna-marina*) local ecotype, 20 cuttings per m^2

Heavily tracked areas

- Dwarf perennial ryegrass (*Lolium perenne*), 30 g seed per m^2
- New Zealand browntop (*Agrostis tenuis*), 30 g seed per m^2
- Chewings fescue (*Festuca rubra*) 'Enjoy', 25 g seed per m^2

Woods (1999) has provided details of some of these species as follows:

Meadow rice grass

Common name: Meadow rice grass

Species name:	*Microlaena stipoides*
Fineness:	Relatively fine
Leaf colour:	Light green during summer, dark green during winter
Growth habit:	Compact rhizome system giving rise to slow-spreading clumps
Establishment:	Seed
Habitats:	Low-fertility summer-dry soils; shaded environments —often found in open shade under trees in ryegrass and clover paddocks
Productivity:	Main growth during warmer seasons; relatively little growth during winter
Cultivars:	None at present

Poa anceps

Common name:	Broad-leaved poa
Species name:	*Poa anceps*
Fineness:	Very coarse
Growth habit:	Rhizome system, spreading clumps; leaves up to 15 cm long
Establishment:	Seed or division of clumps
Habitats:	Low-fertility summer-dry soils; stony banks; lightly shaded environments
Productivity:	Main growth during warmer seasons
Cultivars:	None at present

Oplismenus imbecillus

Common name:	—
Species name:	*Oplismenus imbecillus*
Fineness:	Fine small leaves under mowing
Leaf colour:	Dark green throughout the year in shade; yellows and browns in full sun or with frosting
Growth habit:	Low-growing stoloniferous grass with short broad leaves
Establishment:	Seed or stolon cuttings
Habitats:	Shaded environments
Productivity:	Most growth occurs during warmer months; dormant during winter
Cultivars:	None

***Zoysia* spp.**

Common name:	Zoysia grass
Species names:	*Zoysia minima, Zoysia pauciflora, Zoysia planifolia*

Fineness:	*Z. minima* extremely fine; other species quite fine
Leaf colour:	Green throughout the year; damaged by frost
Growth habit:	Rhizomatous grass; plants generally less than 10 cm high
Establishment:	Seed or stolons; scarify seeds
Habitats:	Sand and gravel environments
Productivity:	Slow growing; active during summer, winter dormant
Cultivars:	Other species used extensively in USA, Japan, Korea and China; primarily *Zoysia japonica*

Silvery sand grass

Common name:	Silvery sand grass
Species name:	*Spinifex sericeus*
Origin:	New Zealand and Australia
Fineness:	Coarse and sparsely tillered
Leaf colour:	Silvery blue green throughout the year; damaged by wind and frost during winter
Growth habit:	Extensive rhizomatous grass; plants generally up to 60 cm high
Establishment:	Seed or rhizomes; dioecious, separate male and female plants; seeds germinate readily when covered with sand
Habitats:	Fore dunes and sand environments
Productivity:	Active during spring and early summer; relatively winter dormant; responds to fertilisers
Cultivars:	None known; other species used extensively in Australia for dune restoration and coastal protection work

Appendix 5

GLOSSARY

Adventive—Naturally arrived at a place, not deliberately planted.

Arable—Land able to be ploughed.

Bioturbation—All the physical biological processes at work in soil horizons which cause the soil components to move about, including worms, burrowing animals, tree throw.

Bole—The lower trunk of the tree, often straight and free of branches.

Conservation plan—A document which describes and analyses the condition and values of a place. It also sets out the policies, plans and intentions of the authority which manages that place.

Ecotype—A species which is long lived in a particular locality and well adapted to the conditions there.

Fine, fines—Small particles.

Floor, living floor, working floor—Thin stratigraphic layer where people have lived or walked about.

Gallery forest—Forest with widely spaced boles, allowing visibility of the ground surface, and a closed canopy.

Inoculum—A seed coating that reduces risk of disease.

Midden—Accumulation of decaying or decayed food refuse.

pH—A measure of acidity. Acid soils (low pH) suit native plants or plantation forest. Neutral (pH 7) or high pH soils suit production grasses such as ryegrass.

Revetted, revetting—The practice of placing stones against a bank to stabilise it and to enable it to retain a steeper angle.

Root plate—The full extent of roots formed in the soil and which may be torn up with the surrounding soil when a tree is blown over.

Rotational grazing—Putting stock into a small paddock for a short period of time, allowing them to graze the grass down and then removing them. Requires careful planning and installation of fencing.

Runanga—Tribal government (New Zealand usage).

Seral—Stage of growth in an ecological succession.

Set grazing—Permanent grazing, keeping animals on the same piece of land with the natural increase in spring and decrease in autumn. For archaeological sites, requires careful planning and installation of fencing.

Slash—Branch debris lying on the ground from plantation trees that have been pruned.

Stratigraphy—The layers of an archaeological site, the practice of recording them.

Stumpman—Responsible for felling a tree and for safety in the vicinity at time of felling.

s.u. per ha—Stock units per hectare. One stock unit is a 54 kg live weight breeding ewe. A wether (castrated male sheep) is 0.7 s.u. A yearling cattle beast, at about 250 kg, is 4.5 s.u. No more than 10 s.u. per ha is recommended as a stocking rate for archaeological sites.

Tag—Dead grass built up when there is no grazing or mowing.

Tillering, tillers—The growth of new ground-level stems from which new leaves will grow adjacent to existing stems, the ground-level stems.

New Zealand Government