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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.

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