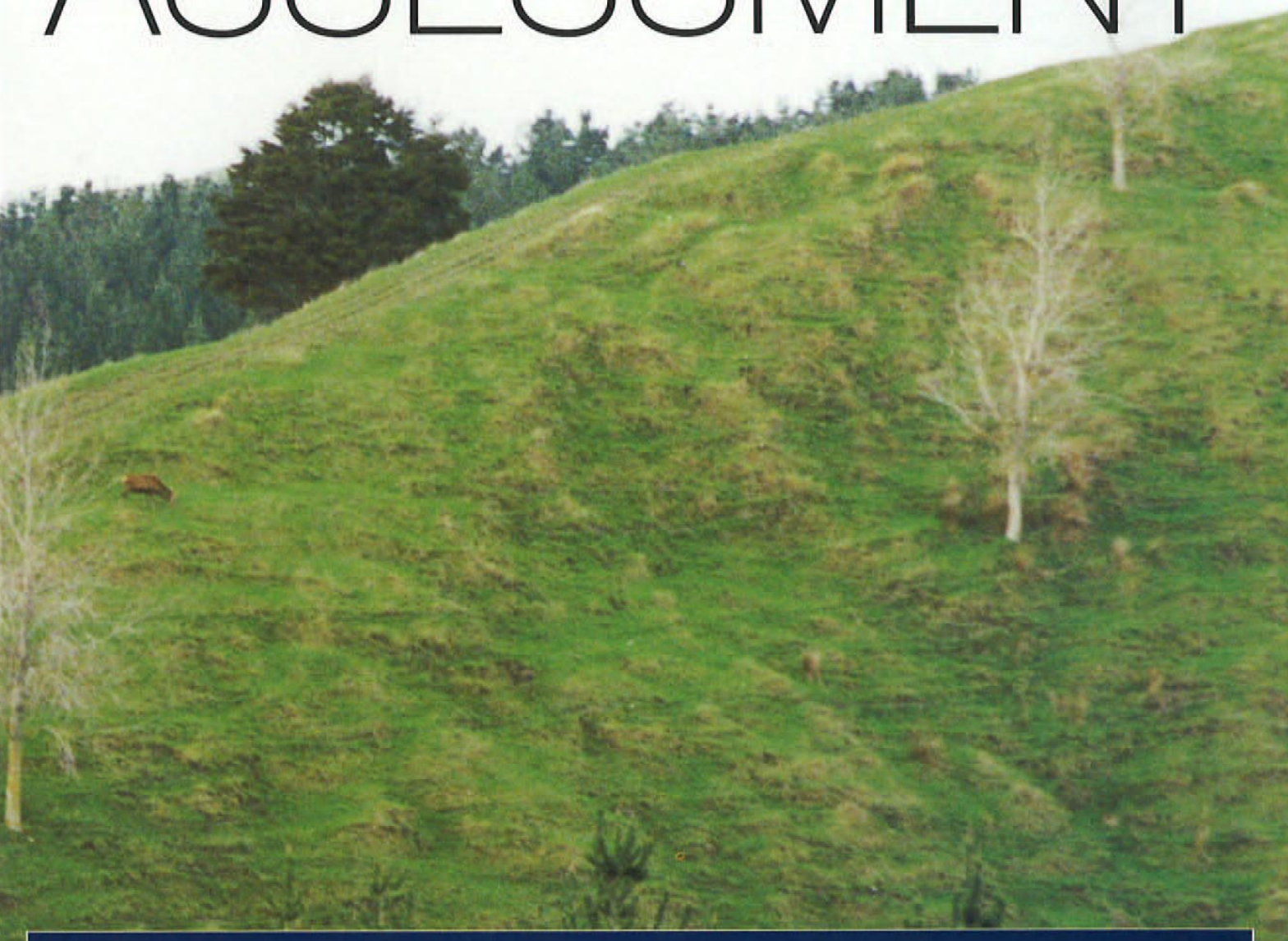
Volume 4

VISUAL SOIL ASSESSMENT

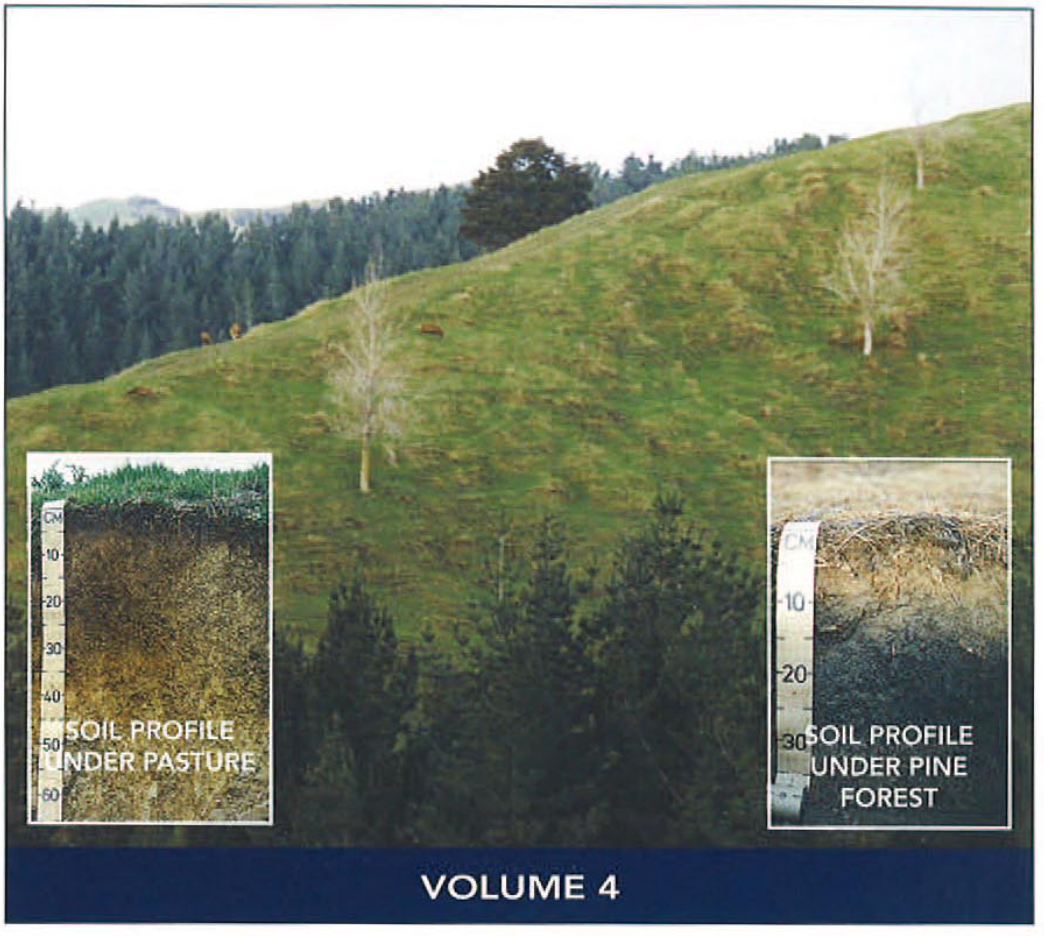


SOIL MANAGEMENT GUIDELINES

hill country land uses

Graham Shepherd, Helmut Janssen & Lou Bird

VISUAL SOIL ASSESSMENT



Soil management guidelines for hill country land uses

Graham Shepherd, Helmut Janssen and Lou Bird

VISUAL SOIL ASSESSMENT

Volume 4: Soil management guidelines for hill country land uses

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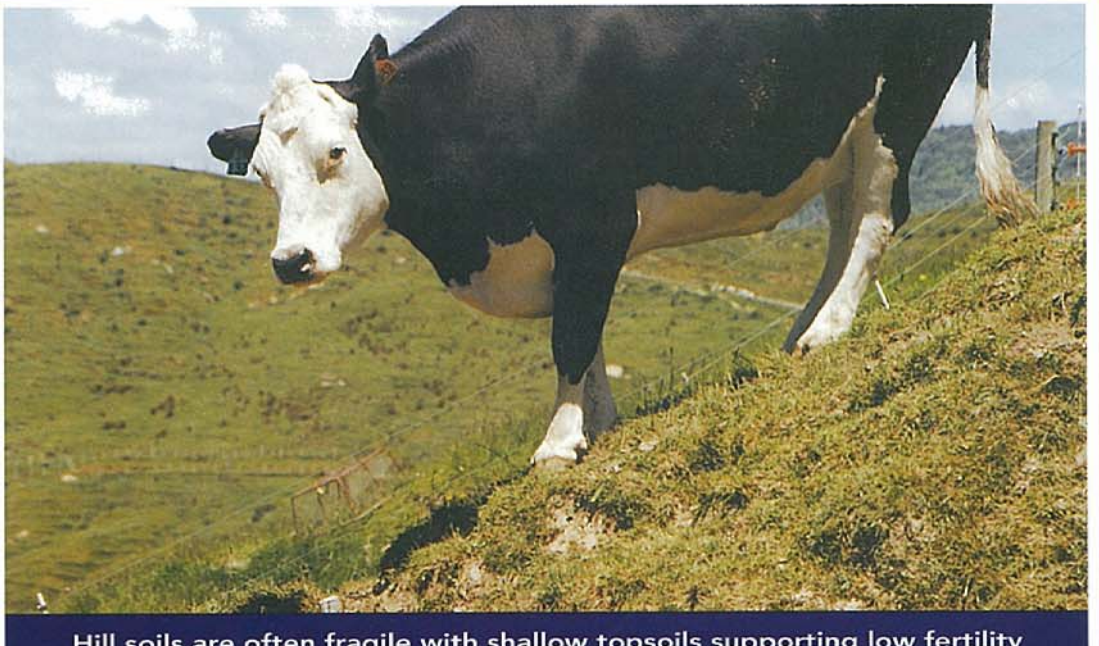
INTRODUCTION

These guidelines are designed to be used in conjunction with *Volume 3: Field guide for hill country land uses*. If the visual soil assessment (VSA) of your paddock shows that soil structure is deteriorating and/or there is significant loss of soil by erosion, these guidelines will suggest management practices to help minimise the problem. If VSA indicates that your soil is in good condition, use the practices in these guidelines to keep it that way. The guidelines provide methods to sustain soil quality under pastoral grazing in hill country by looking after soil structure and minimising soil erosion. They do not cover acidification, insecticide and herbicide residues, nor nutrient movement through the soil and into groundwater and waterways. The guidelines also do not address the management of forestry in hill country. There are a number of publications already available that cover forestry management (see References at the end), and your regional council will be able to provide advice and concise pamphlets/booklets on these matters.

Hill country grazing occurs over diverse landforms and climatic zones, and often involves diverse livestock programmes. Individual farms have less management flexibility than their lowland counterparts, particularly hill country breeding properties supplying the store livestock market, where winter stock will be capital breeding stock rather than trading stock. The guidelines recognise this reduced flexibility, and acknowledge that in spite of good planning and management, soil erosion and structural degradation (through pugging) cannot be avoided in all situations.



Hill soils are often fragile with shallow topsoils supporting low fertility pastures. Good grazing management practices can minimise the possible adverse effect of stock treading on the stability, soil quality and productive capability of hill soils

COURTESY OF KEITH BETTERIDGE

A key function of good soil management on pastoral hill country is the maintenance of soil structure and the minimisation of soil erosion. As soil resources are finite and only slowly renewable, their sustainable management is of prime importance. Given the physical environment of hill soils and the extreme climatic conditions that prevail in hill country, any physical damage to soil and pasture is likely to last for a very long time. As mechanical renovation to recover from pugging impacts is not an option for hill farmers, prevention is the best management strategy.

SUSTAINING YOUR SOIL RESOURCES

MAINTAIN SOIL STRUCTURE BY MINIMISING COMPACTION AND PUGGING

Treading damage can occur in two forms – compaction of moist soils, and pugging of wet soils. Maintaining and improving soil aeration by minimising compaction and particularly pugging is an important aspect of soil quality of which land managers should be aware. Poor soil aeration will result in reduced pasture growth rates that will, in turn, reflect in poor livestock performance and reduced profit. In the hill country, pugging is the single biggest contributor to poor aeration. Stock treading on moist and wet soils reduces the number and size of soil pores important for water and air movement, and root penetration becomes more difficult. Consequently, pasture root activity, density, vigour and growth are reduced. Pasture growth rates can be reduced by about 50% as a result of heavy stock treading during wet periods. The loss in pasture production is greater on pugged than compacted soils. As pugging reduces the rate of water movement through the topsoil and subsoil, soils remain wetter and more susceptible to further damage for longer periods. Soil temperatures remain at lower levels, slowing growth rates in the spring. Treading damage can cause increased weediness and a drop in clover production, a reduction in earthworms and a decline in soil biological activity. It can also have adverse long-term effects on soil organic matter decomposition, nutrient cycling, soil structure development and resilience (i.e. ability to recover after pugging).

Under very dry conditions, soil structure can become brittle, topsoil can be turned to dust by treading, and subsequently wind eroded.

Management options to minimise treading damage and maintain soil aeration

Know the soils on your farm and use that knowledge

Some soils pug less easily than others – knowing where these 'dry' soils are on your farm is the first step in planning to avoid pugging and protect the productive capability of your enterprise. You will then be able to target your more resistant 'dry' soils better during the wet winter periods, and so take the grazing pressure off the wet country. The greater resistance of dry soils to pugging results from the inherent properties of the soil. These include soil drainage, the development, strength and stability of the soil structure, the amount of soil organic

(left) Soil with a strongly developed, stable structure and a high resistance to pugging. (Right) Soil with a weakly developed structure and a low resistance to pugging

matter and the parent material from which the soil is formed. Slope, aspect, vegetative cover and microtopography also contribute to soil resistance to treading damage. Soils that are more resistant to pugging are often more resilient, and will generally bounce back more rapidly, provided the level of pugging damage is not too severe. Ask your Regional Council Soil Conservator or a soil scientist to help you identify the wet and dry soils on your farm.

Use an enlarged aerial photo of the farm to identify where the wet and dry soils are, particularly how they are distributed between and within paddocks. With this information, you can plan your farm-management programme to avoid/reduce pugging, rather than having to accept it as a problem you just have to live with.

When you are planning your stocking and grazing programme to avoid pugging damage, you also need to think about animal welfare to ensure stock are not exposed to unnecessary stress. Being able to use the dry soils to maximum effect may require some longer-term development investment in shelter belts, tracks (to get hay/silage to stock), or siting of barns or silage pits. As drier soils are usually more drought susceptible, you should also think about the best pasture species selection that can provide good wet weather resistance to pugging without compromising late spring and summer production (see Volume 3).

Plan ahead to minimise pugging

Establish a flexible livestock policy whereby you can adjust the class of stock in terms of the cattle:sheep ratio, the ratio of young to older cattle, and buying and selling dates.

- Re-evaluate the de-stocking dates you have planned so that fewer stock are carried through the winter period when pugging risk is highest.

- Re-evaluate the live-weight targets set for heavier stock types. Selling stock earlier at lighter weights may mean a negative short-term cash flow but can improve pasture productivity later by avoiding pugging damage.
- Plant trees to dry out soils, so that the onset of high-risk pugging conditions is delayed.

Manage your pastures for grazing under wet conditions.

- Ensure high pre-grazing pasture levels (2500–3000 kg DM/ha) for brief periods over the winter. This increases the cushioning effect and load-bearing capacity of the soil, which increases resistance to compaction and pugging. A high leaf mass has a vigorous root system below ground which also helps to provide protection.

  Low pre-grazing levels expose the more susceptible parts of plants (growing points, leaf buds and surface roots) to treading damage, and result in lower pasture production in winter and spring.
- Maintain high post-grazing pasture levels over the winter. This will depend, however, on your stock and grazing management plan and seasonal feed budget. Leaving post-grazing levels of pasture of about 1500–1600 kg DM/ha encourages greater pasture re-growth.
- High growth rates and pasture levels (2000–4000 kg DM/ha) help reduce soil wetness by intercepting more rain and increasing evapotranspiration. High pasture levels also encourage earthworms near the soil surface, which open up drainage channels and improve soil aeration.
- Select paddocks for grazing during wet periods that have a well-developed turf mat. As with high pasture levels, a turf mat can provide a degree of cushioning to treading.

A soil with a well-developed turf mat

- When leasing or buying more land, think about whether the soil types (wet/dry and the mix and distribution of each) increase or decrease your planning flexibility to avoid pugging.

Limit the extent of pugging when there is no other option

In a very wet winter, you may not be able to avoid pugging damage. However, there are steps you can take to limit the extent of damage:

If possible, graze 'wet' paddocks when the soils are sufficiently dry to minimise pugging. To test whether moisture conditions are suitable for grazing, apply the 'worm' test. Take a piece of soil (half the volume of your index finger) and press firmly to form a 'pencil' with your fingers. Roll the soil into a 'worm' on the palm of one hand with the fingers of the other until it is 50 mm long and 2 mm thick. Exert sufficient pressure with your fingers to reduce the diameter of the thread to 2 mm in 15 to 20 complete forward and back movements of the fingers. The soil is suitable for grazing if the worm cracks before it is made, and too wet to graze if you can make the worm.

The 'worm' test

Select paddocks with 'dry' soils for a feed bank of saved pasture or winter crop to be used during wet periods.

Limit the grazing time:

- Use break feeding rotational grazing regimes with short breaks. Shift the mob regularly (e.g., twice each day) to reduce the duration of grazing, and back fence the mob to ensure areas grazed earlier are not exposed to unnecessary excessive treading.
- Use on-off grazing. During wet periods, decrease the grazing time and increase grazing frequency to increase animal intake. For example, provide two shorter 'on'

grazing times during the day rather than one long period. This can avoid feed waste in the 'on' paddock and reduce 'marching' in the 'off' paddock. Well-fed stock are more settled, and consequently cause less treading damage. Consider using a 'dry' sacrifice paddock and on-off graze adjoining paddocks in the wettest periods, if break feeding is not used.

Reduce stock density (grazing intensity). Re-evaluate your winter stocking policy to see if stock numbers can be reduced to better match pasture growth and soil conditions. This is a strategy similar to that recommended for drought management, but applied at a different time of the year. Reducing stocking density reduces treading pressures and damage to the soil and pasture.

Set stock earlier than originally planned to minimise pugging

Use off-pasture standing areas. Remove heavy stock from pasture to a feed-lot, loafing pad or a woodlot for a short duration, and provide supplementary feed. Enhanced pasture growth from un-pugged or lightly-pugged paddocks will offset the temporary disruption to stock growth rates. If available, use forestry blocks to hold cows with calves during wet winters. Ideally, blocks should be aged between 6 to 15 years to maximise pasture availability and minimise treading damage to trees.

Use off-farm grazing for your heavier weight stock during prolonged wet winters. Try to select a property that has 'dry' soils so that you do not transfer the pugging problem.

Help the soil recover quickly

There are steps you can take that will shorten the soil recovery time:

Prevent repeated severe pugging. Ensure that a paddock pugged in one year is not pugged in the following year, or 2 to 3 years in a row. Time is the main requirement for recovery of soil quality following a pugging episode. The soil develops a 'memory' of accumulative pugging damage. The greater the accumulative damage, the longer the recovery time. Pasture production can recover completely within six months on moderately pugged soils. The effects of severe pugging persist into subsequent years, with pasture production declining by up to 30%.

Mob-stocking with sheep can smooth out the soil surface and allow pasture to close up more quickly and re-establish full surface cover.

Oversow with desirable pasture species to fill the gaps in the pasture and reduce the opportunity for invasion of weed species (e.g., wing thistle, ragwort, hawkbit).

Weeds commonly invade damaged soils. Repair pugging damage and help loosen the soil by including useful tap-rooting herbs with the grasses.

Increase topsoil depth

Topsoil depth decreases under overgrazed pastures that have shallow root systems.

Use on-off grazing. Allow grass and roots to grow. Grass height and pasture composition affects root development and topsoil depth. A vigorous root system reaches deep into

Poor pasture quality due to weed invasion on bare ground created by severe pugging

COURTESY OF DES COSTALL

the soil. Plants can better access soil nutrients and soil water. A deeper topsoil develops, which is more resilient to degradation and capable of storing more nutrients and water. On-off grazing and palatable deep-rooting herbs such as chicory, plantain, dandelion, yarrow, clovers and nitrogen fixing tree lucerne and alders access subsoil nutrients, improve aeration, drainage and soil structure. Improved topsoil quality and depth limits potential for weed infestation. Earthworms integrate organic matter from surface litter and roots and sustain topsoil depth.

Look after your earthworms

Earthworms help restore damaged soil, but need a continuous supply of suitable plant litter. Earthworms feed on mull-type organic litter (see pp. 22–23, Volume 3). Establish shelter belts, grazeable woodlots, or multiple use forests, using mull humus forming trees (see Plant-up p.15) to support a larger earthworm population. This will help improve soil drainage, aeration, and soil stability. If earthworm numbers are very low, consider re-introducing earthworms from a worm farm.

MINIMISE SOIL EROSION

About 60% of pastoral hill country farmland in the Manawatu-Wanganui, Wellington and Hawke's Bay regions is susceptible to erosion. Mass movement erosion removes large quantities of soil off-site through slips, flows, tunnels and gullying, or repositions the soil semi-intacked by slumping. Mass movement of the subsoil can reduce pasture production to zero in the short term. While over-sowing and topdressing can restore

pasture cover, pasture production is slow to recover on slip scars, and can take 40 years to reach only 75% of uneroded levels. In the long term, dry matter production can remain suppressed by 10 to 40%. Mass movement can markedly increase farm costs through increased expenditure on fences, tracks, buildings and on erosion control measures. Stock grazing of potentially productive paddocks can also be restricted due to the need for close planting or reversion, to encourage the regeneration of young trees. While gully development and the subsequent creation of long, narrow scars do not cause much loss in pasture production, they disrupt farm improvements, stock movements and vehicle access.

The rate at which water enters the soil and percolates through it, is determined by its structure. If the topsoil is compacted or pugged, infiltration will be slow, regardless of how permeable the subsoil. Surface run-off during heavy storms will increase, causing greater sheet erosion. Soils with poor sub-surface drainage remain wet and susceptible to pugging far longer than well-drained soils. Poorly drained soils therefore, need careful management to protect soil quality and to maintain and increase production levels. Surface erosion of topsoil (sheetwash, rilling) can reduce dry matter production by up to 60%, and can significantly reduce feed utilisation and stock-carrying capacity.

Cattle give rise to more sheet, creep and rill erosion than sheep, and cattle-induced erosion can be nearly three times that of sheep. Erosion can also have significant off-farm effects, including reduced water quality through increased sediment and nutrient loading in streams and rivers.

Severe soil erosion on unstable hill country under pasture compared with area in pine forest

COURTESY OF NOEL TRUSTRUM (1988)

Management options to minimise soil erosion

Identify where the highly erodible soils are

Develop an erosion protection management plan by identifying where the highly erodible soils are on your farm. Using aerial photos, prepare a map identifying areas with different erosion potentials. Target first those areas that are most affected and have the highest potential to erode. Your Regional Council can help you identify where these are.

Limit the extent of treading damage

Graze pastures when the soil is sufficiently dry to:

- minimise the downslope displacement of topsoil by treading.
  Wet soils have a low soil strength and are easily pushed downslope under stock treading. Dislodged, loose soil is readily washed downslope by surface run-off into gully floors and streams.
- maintain good ground cover by minimising the opening up of pasture that exposes the soil to sheetwash and rill erosion. The depletion of ground cover also creates an opportunity for tunnel gullies (under-runners) to form in the subsoil.

Downslope displacement of soil by treading

COURTESY OF KEITH BETTERIDGE

- maintain surface infiltration and percolation of water by minimising treading damage. Increased surface run-off and associated sheetwash erosion is likely to be accelerated on compacted hillslopes due to the soil's reduced surface infiltration rate and ability to absorb water. The problem is more severe on farms with high cattle/sheep ratios, and on soils with a low resistance to structural degradation and slow subsoil permeability.

Compacted soil with slow infiltration and high surface run-off accelerates sheet erosion

COURTESY OF KEITH BETTERIDGE

Consider maintaining a low-fertility pasture system in your wetter, more erosion-prone country. Low-fertility pastures develop a dense turf mat that helps protect soil from treading damage, helps maintain infiltration, and reduces surface run-off and sheet erosion. The extra protection against soil erosion could more than compensate the losses incurred by not converting to more open, more productive high fertility pastures.

Establish and maintain good pasture cover in your higher fertility, less erosion-prone paddocks over the wet winter period to protect the soil surface from treading damage and subsequent sheet and rill erosion. This can be achieved partly by maintaining greater residual feed in paddocks through rotational grazing, avoiding heavy mob-stocking and heavy set-stocking, de-stocking when wet, and by oversowing and regular fertilising every 2 to 3 years. Improved pasture can reduce surface erosion by 50 to 80%, and can reverse pasture growth losses of 40% or more.

Reduce the grazing density of heavy-weight stock on hillslopes during wet periods when the soils are vulnerable to accelerated sheet wash and rilling resulting from surface damage by treading.

Avoid grazing cattle on steep slopes when wet.

Plant-up

Tree roots act like reinforcing mesh in concrete, they stabilise soil and reduce erosion risks. The loss of soil has a similar effect on the farm as the loss of capital in the financial world.

Establish a permanent tree cover on erosion-prone sites, open slip scars and earthflows.
Trees with readily decomposable litter improve soil quality by:

- cycling nutrients from subsoil to topsoil and
- increasing a soil's resilience and productive capacity.

Establish shelterbelts, a grazeable woodland or forests with multiple uses.[1]

- Match tree species to site
- Establish hardy, fast growing trees first to provide shelter,[2] then inter-plant trees for specific purposes. Alternatively, combine several tree species at once by space-planting fast growing trees and close-planting slower growing trees (see p.18).
- Certain oaks and acacias may give better results in hill country prone to summer drought.
- Consider planting trees,[3] producing quality humus from rapidly decomposing litter (see humus types on pp. 22-23 of the Field Guide, Volume 3).
- Avoid weedy exotic trees that are very shade tolerant or fire-adapted colonisers. Eucalypts and pines can degrade soil quality by intensifying soil dryness over summer, developing a mor humus type and depleting soil nutrient reserves.
- For best results mix predominantly deep-rooted tree species[4] with surface-rooting plants.[5]

Plan a succession of suitable tree species, space-plant, close-plant or inter-plant in scrub or an existing stand of exotic trees.

Ask your Regional Council, a forest ecologist, the Tree Crops -, Permaculture -, or Farm-Forestry Associations for advice on:

- permanent plantations with multiple uses that integrate production and protection needs of your farm
- a comprehensive planting design, including:
  - the range of tree species suitable to your site
  - tree density and species combinations in space and time (forest succession)
- tree establishment techniques, silviculture and
- available environmental grants.

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1 Durable fence-posts from Robinia, Chestnut coppices; Forage for stock, deer, pigs, poultry from Tree Lucerne, Elms, Oaks, Chestnuts, Poplars, Mulberry, Hickory, Linden; Food and timber for human uses.

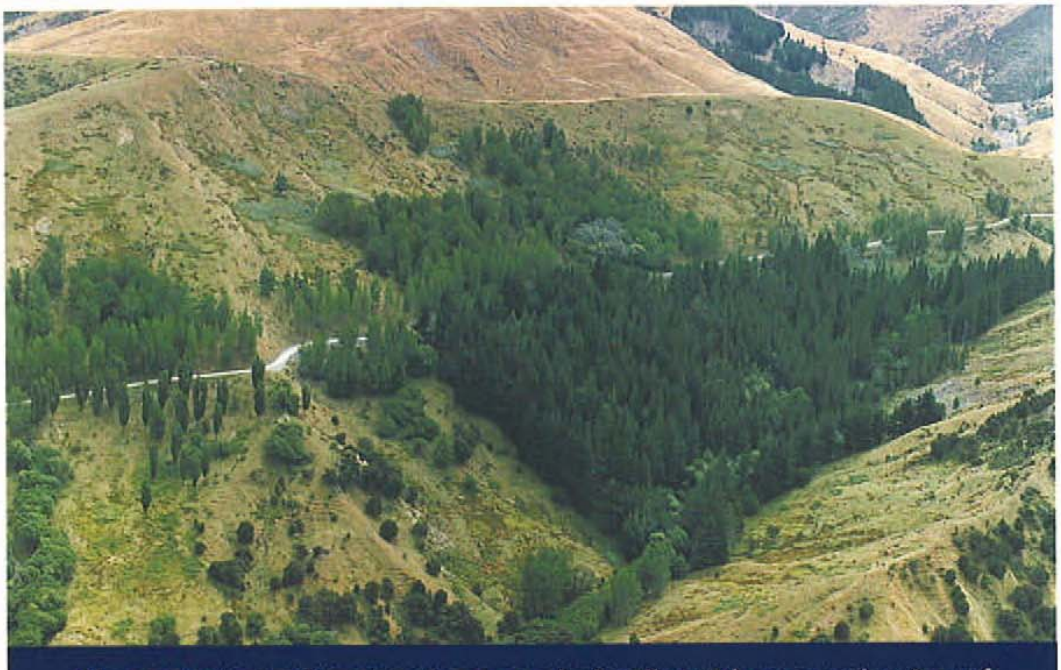
2 Alders, Acacias, Akeake, Wild cherry, Five-finger, Fuchsia, Kanuka, Karamu, Lacebark, Pittosporum, Mapou, Poplars, Robinia, Rowan, Tree Lucerne.

3 Alders, Ashes, Birch, Elms, Fuchsia, Hazelnut, Mahoe, Mulberry, Kowhai, Linden, Maple, Poplars, Robinia, Tree Lucerne, Titoki, Wild cherry, Willows, Wineberry.

4 Alders, Acacias, Ashes, Tasmanian Blackwood, Broadleaf, Chestnuts, Elms, Five-finger, Fuchsia, Hickory, Hinau, Kanuka, Kamahi, Kowhai, Lancewood, Maire, Maple, Ngaio, Oaks, Pittosporum, Poplars, Puriri, Putaputaweta, Rata, Rewarewa, Robinia, Rowan, Walnuts, Tagasaste, Totara (includes tap-root and heart-shaped root systems).

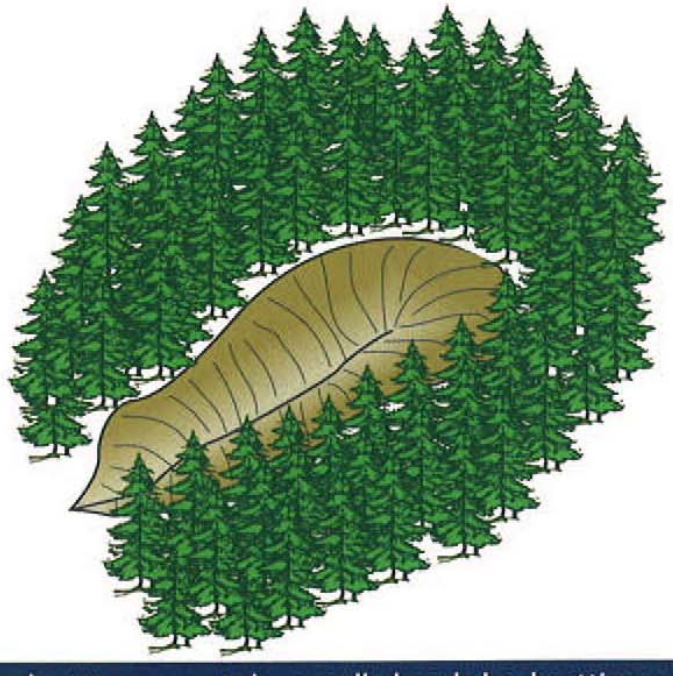
5 Beeches, Cabbage Tree, Flax, Hazelnuts, Nikau, Kohekohe, Pate, Tawa, Willows.

Close plant on unstable ground to provide a continuous tree canopy as well as a continuous, dense root network. Close planting young trees at 1000–2700 stems per hectare and thinning to not less than 300 stems per hectare can reduce mass movement on steep, erodible faces by 90% or more, relative to levels expected if left in pasture.



Close planting with pines in an eroded gully, with space planting of poplars to the left on slightly more stable slopes

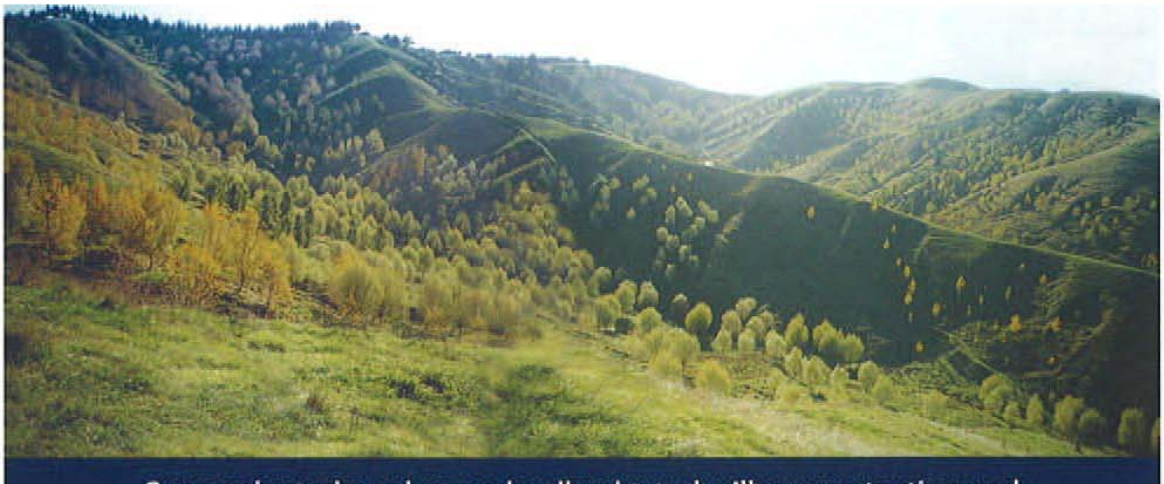
COURTESY OF DAVID CAMERON



Close plant to prevent deep gully heads backcutting upslope

A stabilised close planted gully on the left, and an unprotected, actively eroding gully on the right

Space plant to reduce mass movement erosion in pasture by 50 to 80%, improve feed utilization through ability to graze stock on formerly unstable areas, and reduce expenditure on fence and track repair. Wet hill country farms with strategically positioned trees are likely to be drier and less likely to erode. Trees delay the on-set of waterlogging in the winter and reduce the frequency of saturation, by 'pumping' excess water out through their roots and leaves, but conserving soil water in droughts. Poplar and willow poles have commonly been space planted on erosion affected hillsides at 10–12 metre intervals (70–100 stems per hectare).



Space-planted poplars and gully planted willows protecting and enhancing hill country environments

COURTESY OF DAVID CAMERON

Combine space-, and close-planting.

Space-plant fast growing trees and close-plant succeeding trees to establish a productive forest rapidly on bare land. Fast growing trees help shape slower growing trees. The most vigorous trees self-select naturally. Costly plant breeding is not necessary. Silvicultural activities can focus on promoting desirable trees. Fence-posts, forage and food can be harvested from years 10 to 20.

Afforestation design

The following examples outlined below use any of 4 tree species at 2200 trees/ha. The 4 tree species consist of 2 fast growing tree species, each planted separately at 100 trees/ha and 2 slower growing tree species, planted together in rows between the rows of fast growing trees.

1. Plant fast growing pioneer trees such as *Poplars, Alders, Rowan, Ribbonwood, Lacebark,* on dry sites *Acacias* or thornless *Robinias* at 10x10 m spacing, using 2–3-year-old seedlings (100 trees/ha).
2. Plant diagonally interspersed amongst these at 10x10 m spacing other fast growing trees such as *Chestnuts,* red *Oaks, Wild cherry, Ashes, Elms, Maples, Mulberry* or *Five finger,* using 3-year-old seedlings (100 trees/ha).

   Consider using naturally regenerating scrub to your advantage. Alternatively consider planting or sowing smaller pioneering trees or shrubs to suppress competing grasses, by filling the two fast growing rows at 2x10 m spacing with *Coprosma, Mapou, Wineberry, Kowhai, Kanuka, Manuka, Pittosporum, Broadleaf, Akeake* or *Tree Lucerne.*
3. Plant more shade tolerant or slower growing trees, such as white *Oaks, Linden, Tasmanian Blackwood, Walnuts, Hickory, Totara, Beech, Rata* or *Rewarewa,* using 2–3-year-old seedlings at 3x5 m intervals (667 trees/ha).
4. Plant or place several seeds in same row at 1x5 m intervals. Consider planting *Black Maire, Pidgeonwood, Hinau, Puriri, Tawa, Mangeao, Taraire, Tanekaha, Matai, Miro* or *Rimu,* using 1400 seedlings or more seeds/ha. Propagate native plants from nearest forest remnants

Two rows, alternately containing one or another species of fast growing trees (selected from 1 or 2 above) flank each row of slower growing trees (selected from 3 and 4 above).

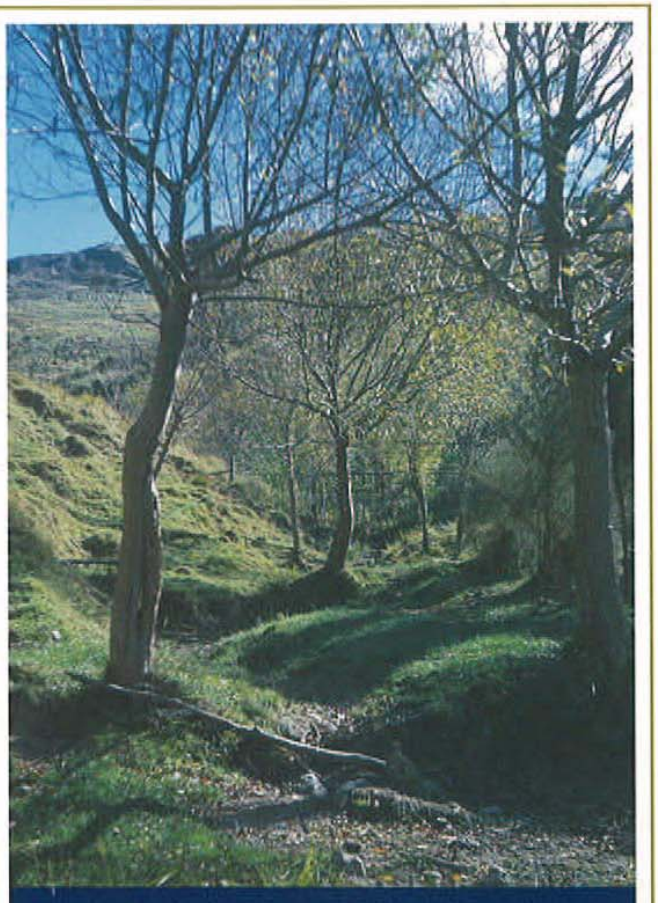
Consider your specific needs and site conditions when selecting your preferred tree species (refer to footnotes on page 15).

Plant only locally sourced native plants, adapted to local site conditions. Native birds are good propagators of suitable native plants from adjacent native forest remnants.

Consult your Regional Council, a forest ecologist, the Tree Crops -, Permaculture -, or Farm-Forestry Associations to:

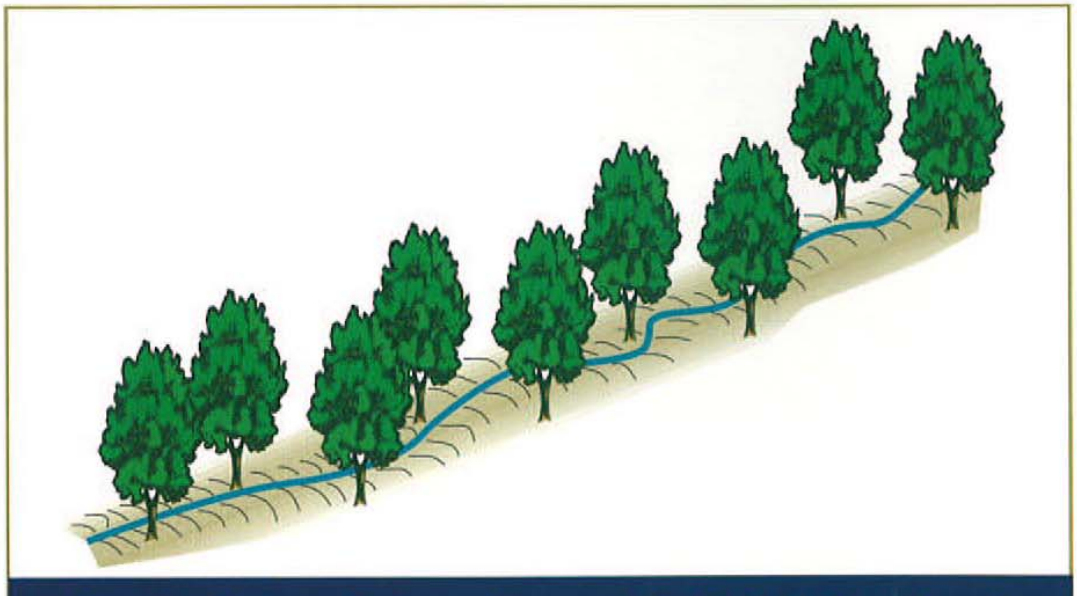
- identify the most suitable trees for your site and
- develop a planting strategy that can achieve a rapid succession towards a multiple-use and productive permanent forest.

Pair or alternate planting of willows, alders and poplars with kowhai, fuchsia and N.Z. flax close enough to the watercourse for roots to interlock along channels. Such space planting techniques can reduce the length of watercourse damage during floods by 30 to 80%, and can reduce the extent of mass movement on adjacent slopes by 10 to 20%.



Paired planting of willows in gully to control bank erosion

COURTESY OF DAVID CAMERON



Alternate planting with trees close enough to interlock along channel to control bank erosion along watercourse

Construct debris dams in combination with paired (or close) planting to stop downcutting of eroded gully floors. Debris dams combined with close planting can reduce new gully development by 30 to 80%. They are also beneficial to pasture production and stock-carrying capacity as stemming gully incision helps prevent slips or earthflows in pasture on either bank. Consult your local Regional Council for advice on design, materials and construction.

Open gully initially stabilised by debris dam followed by the paired planting of S. Matsudana pole

COURTESY OF DAVID CAMERON

Oversow and topdress

To revegetate mass movement scars on hill slopes and help restore production, oversow and topdress. Oversowing and topdressing can increase dry-matter production on slips from less than 20% to more than 50% of that on adjacent stable ground within 2 years, provided stock are excluded.

Use remedial techniques

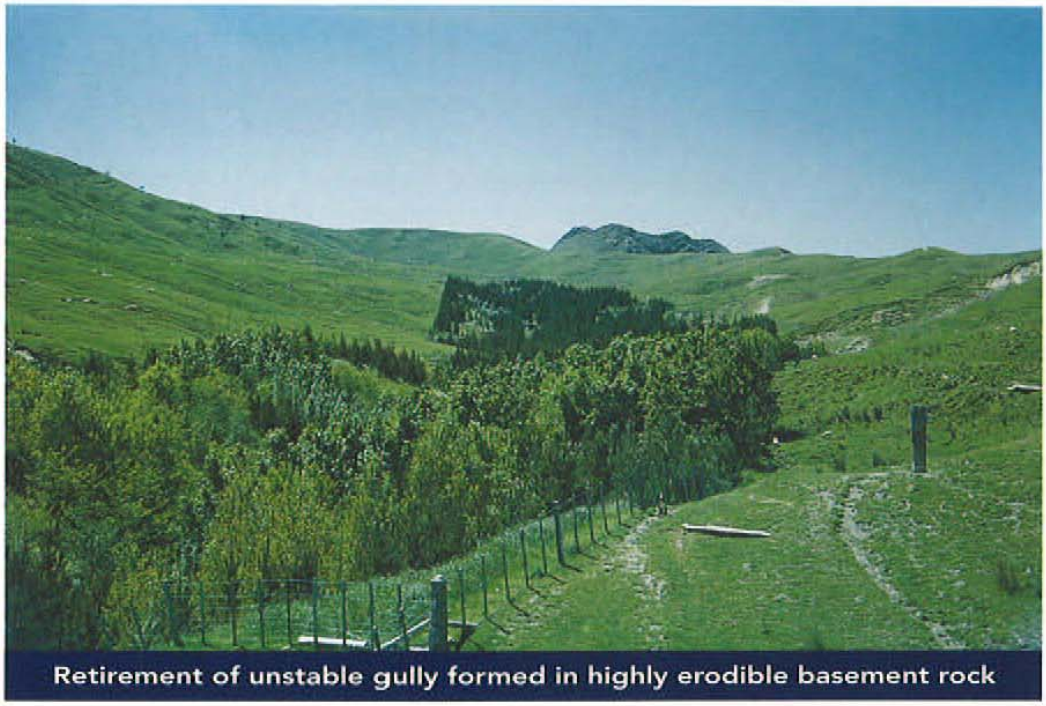
- Re-contour wet areas on earthflows where low-angle slopes are accessible by machinery, and plant willows. Alternatively, subsurface drainage followed by oversowing and topdressing can raise pasture production from less than 60% to more than 90% of the level on adjacent stable ground within 2 years.
- Use engineering measures to stabilise large, deep-seated slumps in bedrock. For example, gabions can be installed at the toe, and surface cut-off drains at the head. Subsurface drains and horizontal bores could also be installed to reduce pore-water pressure in the subsoil and rock. Consult your Regional Council for advice.

Retirement/reversion of unstable and very steep land

Avoid clearing very steep unstable faces still in bush or scrub. Maintaining scrub and tree cover can keep mass movement down to 10% or less of the level expected if it were converted to pasture.

Allow reversion if previously cleared, and encourage the regeneration of young trees by excluding stock and pests. This will help minimise erosion. The amount of extra grazing obtained by clearing very steep faces is small and often does not repay the expense of pasture establishment.

Retire unstable gullies.



Retirement of unstable gully formed in highly erodible basement rock

COURTESY OF DAVID CAMERON

TAKE HOME MESSAGES

- Minimise soil compaction and particularly pugging

- Plant-up to minimise soil erosion

and

- Maintain topsoil depth.

FURTHER INFORMATION ON FORESTRY

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For additional information, Hawke's Bay Regional Council produce "Environment Topics", a series of information sheets that provide both general and technical information on a wide range of subjects, including:

Conservation Trees

- Planting poplar and willow poles
- Managing poplar and willow trees
- Poplar agro-forestry
- Veronese Poplar
- Kawa Poplar
- Matsudana Willow
- Booth Willow
- Eucalyptus for erosion control
- How to care for poplar and willow pole
- Chinese (Yunnan) Poplar
- Eridano Poplar
- Tangoio Willow
- Aokautere Willow
- Moutere Willow

Sustainable Land Management

- Tree planting on boundaries – a guide
- Shelter belt design – hill country
- Debris dam construction
- Constructing small earth dams
- Soil erosion and pasture in Hawke's Bay hill country
- Protecting in-filled valley bottoms from gullying
- Protecting your farm from storm damage
- Shelter belt design – plains
- Shelter belt species selection
- Flood detention dam construction
- Slips and their effects on pasture productivity
- Are you interested in protecting your native bush?
- Repairing slip damage

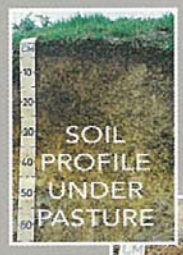
Native Trees

- Native plants or erosion control
- Enhancing indigenous vegetation in protected areas
- Raising native plants from cuttings

Riparian Management

- The importance of riparian protection

A farm's long-term economic viability hinges partly on the maintenance of soil quality. These *Soil Management Guidelines* provide management options for sustainable hill country land uses, and promote an awareness of the key management issues. Issues covered include soil compaction, pugging, soil erosion and silvicultural options. The *Guidelines* are used in conjunction with the *Visual Soil Assessment Field Guide for Hill Country Land Uses* (Volume 3), which provides a simple, quick tool to assess soil quality. If the *Field Guide* indicates that your soil is in moderate or poor condition, the *Soil Management Guidelines* provide management options and recommendations to repair the loss of soil quality, and establish best management practices. If the *Field Guide* indicates that your soil is in good condition, the *Soil Management Guidelines* provide suggestions to keep it that way by preventing or minimising soil degradation.



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