1 Farming to reduce soil loss

The basic principles of erosion management are the same for all farming enterprises, but management techniques vary according to the enterprise. This section looks at groundcover, the crucial element in erosion prevention in all farming enterprises, and specific erosion management practices for the three main agricultural enterprises on the NSW north coast: grazing, orchards and plantations, and cropping.

Groundcover

Sloping land needs contact and canopy cover.

Groundcover is any material that protects the soil. The most efficient groundcovers for large land areas are living plants because

- foliage reduces the impact of raindrops
- foliage and stems reduce the speed of overland flow
- roots bind the soil
- soil organisms feeding on dead vegetation produce gums that aggregate soil particles, making them less erodible.

Plants protect the soil by providing canopy cover (more than 5 cm above the soil surface) and contact cover (up to 5 cm above the soil surface). Canopy and contact cover both protect the soil against raindrop impact, but contact cover is more effective in protecting soils because it slows runoff so that water infiltrates the soil and deposits any dislodged sediment around the plants. Good contact cover is crucial on sloping country.

Without groundcover the soil erodes.

A complete and permanent cover will usually reduce erosion to a negligible level. Any activity that disrupts vegetation cover on the land usually results in accelerated erosion rates. On cultivated soils, the nature of the canopy, the proportion and time of the year that the soil is covered and the amount and nature of residues left on the soil between crops are all significant.

Groundcover is a good indicator of farm productivity and sustainability. Without it, up to 85% of rainfall from storms can run off into creeks and streams rather than soak into the soil and be available for plant growth. When groundcover is thin, patches of bare soil provide a path for runoff to build up speed and erode the soil.

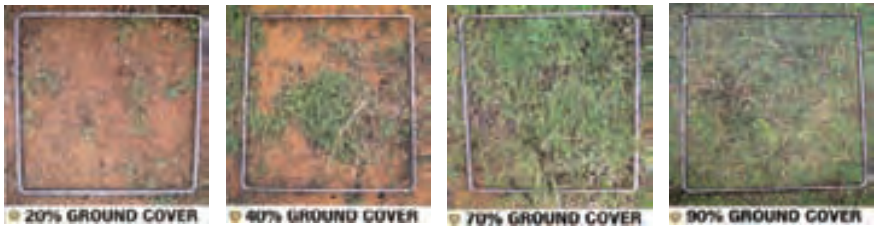
Groundcover levels

Generally groundcover is adequate when there is minimal runoff and no soil is being eroded. Runoff and erosion indicate the need to improve groundcover. The amount of groundcover needed depends on

- the amount of rainfall
- the intensity and seasonality of the rainfall
- the soil moisture
- the slope gradient and length
- the soil characteristics.

There is more detail on how these factors affect erodibility in the Erosion basics section, see page 146.

Groundcover is measured as the percentage of plant material covering the ground, including crops, stubble, pasture plants and their residues, leaf litter, bark and twigs. Research by the Department of Natural Resources (DNR) in the Hunter Valley found that at least 70% groundcover is needed to prevent excessive runoff and erosion on red clay soil with a gentle slope of 10% and average rainfall of 625 mm.



Source: Greg Lodge NSW DPI

Estimates of minimum groundcover (%) required to reduce erosion for a range of slope gradients and soil erodibility classes and soil types.
Source: NSW DPI Agfact P2.1.14 January 2005. Maintaining groundcover to reduce erosion and sustain production.

Erodibility	Typical soil types	Flat	Gentle	Moderate	Steep
Low	deep sands	60	80	90	100
Low to moderate	sandy loams, light clays, ferrosols	60	85	95	100
Moderate to high	dermosols, vertosols	65	90	100	100
High	kandosols, sodosols	70	90	100	100
Low to high	drainage lines (all soil types)	100	100	100	100

On the NSW north coast 90-100% groundcover is recommended because of the region's sloping country and intense rainfall events, especially in the storm risk period from October to May.

In drainage lines where water runs with considerable force, 100% groundcover is required to prevent erosion and formation of gullies. This means drainage lines may need to be fenced, with regular slashing or selective grazing of the groundcover to maintain plant growth.

Groundcover assessment

There are many ways to assess groundcover. Several methods are described in the worksheets at the end of this publication (see page 176).

Types of groundcover

The best way to maintain good groundcover is to select plants that are well adapted to the climate, the soil and the farming system, so that they persist without a lot of attention.

Grasses

Grasses with fibrous roots systems are preferable to tap-rooted plants because the roots increase soil organic matter, provide habitat for microorganisms, improve soil structure and encourage water infiltration.

Dense pasture

Perennial grasses are preferred because of their greater potential to provide year round cover. Species with above ground runners or stolons, such as kikuyu (*Pennisetum clandestinum*) and couch (*Cynodon dactylon*), are good for drainage lines because of their ability to spread and provide good contact cover. Smothergrass (*Dactyloctenium australe*) is proving a useful groundcover in low-light conditions such as macadamia orchards.

Smothergrass

Shrubs and trees

Shrubs and trees provide additional canopy and protection from rainfall. Plant species need to be suited to the soil and climate. Local species will have a higher survival rate. Information about the best species to plant is available from local native vegetation specialists.

Trees and shrubs

Mulch

Biodegradable organic mulches such as woodchips, straw and compost provide short term protection from raindrop impact, hold moisture in the soil, and enrich the soil with organic matter. Mulch can help bare, degraded soils recover and support plant growth. It can also be a good 'band-aid' for small bare patches in pastures, to allow time for grass to recolonise before weeds invade. But unless suitable materials are available on site, mulching can be expensive, so it is mainly used to protect new plantings and suppress weeds on rehabilitated erosion areas.

Leaf and twig mulch

Grazing

Animal grazing is the largest agricultural land user on the north coast. As such it has the greatest potential to cause soil erosion, so good grazing management techniques are crucial. This section focuses on grazing management practices that can reduce erosion.

Other sections of this book that may be useful to graziers include:

» **Dams that minimise erosion (page 65)**
» **Stable roads and tracks (page 89)**
» **Erodibility of northern rivers soil types (page 152)**

How grazing causes erosion

Any erosion problem on grazing land almost always starts with a break in pasture cover. The most common causes of erosion on pastures are overgrazing and high wear in specific areas. Erosion risks intensify on steep land, in areas with soils of high erosivity, and in areas with a lot of stock movement such as cattle tracks.

A good land manager will have a sound understanding of the impact of stocking rates and grazing techniques on soil and be able to respond to changing conditions.

How to avoid erosion

Maintain healthy pastures

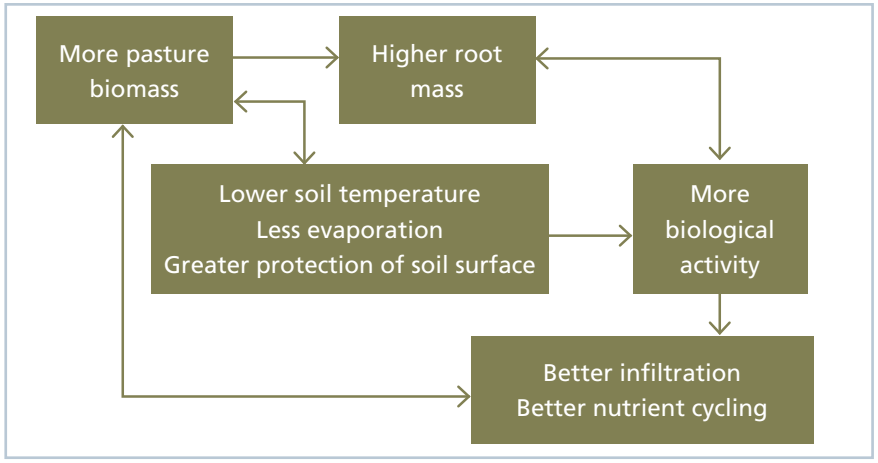
Healthy, actively growing pasture plants cover the soil and protect it from the erosive forces of wind and rain. In addition, the roots hold soil particles and make them less easy to erode. Any rain that falls is more likely to soak into the soil, rather than flow along the soil surface. This reduces the likelihood of erosion from surface runoff and increases soil moisture levels to prolong the plant growing season.

Deep-rooted perennial grasses are better able to survive dry periods, recover quickly after rain and reduce the likelihood of wind erosion in droughts. Land managers should aim for at least 70% pasture cover on flat country and close to 100% cover on slopes.

Stoloniferous or running grasses are more suited to sloping land and erosion-prone situations than tufted species. They are also better able to maintain groundcover in dry times.

Biomass flowchart - How better pastures help the soil.

Adapted from Keeping it in place – controlling sediment loss on grazing properties in the Burdekin River catchment, Meat & Livestock Australia, 2004



Encourage plant roots

The size of a plant's root system is proportionate to its size above ground. Pastures kept continuously cropped short have shallower root systems, and are less productive, more susceptible to drought and at risk of developing bare patches. Pastures that are allowed to periodically grow higher develop deeper and larger root systems. When plants are grazed the roots die back to balance the smaller above-ground size of the plant.

As this root material decomposes, it feeds soil organisms whose activities make more nutrients available to plants and so improve plant growth. The activities of soil organisms improve soil structure, encourage water to enter the soil, and make soil less erodible. The more diverse the pasture species, the more diverse the habitat they provide for soil organisms.

Match stock numbers to pasture availability

Pasture condition determines how many stock it can feed. Land managers wanting 100% groundcover 100% of the time will usually carry less stock per hectare than someone aiming for 70% groundcover. There is usually higher production per head when stocking rates are low, as the animals have more feed, but there is higher production per hectare with higher stocking rates. At excessive stocking rates, production is at the expense of soil resources so soils will degrade over time. Whatever the groundcover goal, the actual number of animals that a pasture can sustain varies from season to season.

Rest pastures from grazing

Continuous or set stocking of pastures is not generally recommended because of the potential for overgrazing and erosion. Research has found that resting pastures from grazing has enormous benefits for both pasture and soil. It allows pastures to develop diversity, and encourages plant growth, reducing the likelihood of erosion. Resting allows soils to recover from compaction so that soil structure and water infiltration improve and runoff is minimised. Resting periods can vary from weeks to months, depending on stock numbers and the growing season.

Minimise compaction

Some degree of soil compaction from the impact of hooves is inevitable with livestock production. Compaction compresses air spaces in the soil, making it difficult for water or plant roots to move in the soil, so pasture growth slows, leading to reduced groundcover and increased erosion.

Compaction severity varies with soil type, being worst on wet soil with a high clay content. If possible move stock onto lighter soils when heavy rain is likely. After rain, avoid grazing clay soils when they are wet, especially when stock numbers are high. Where possible, avoid mustering when soil is wet.

Compacted soils can be slowly restored with appropriate grazing management of deep-rooted perennial grass pastures that contain persistent productive legumes. Where there is a compacted layer within the subsoil, deep ripping along the contour can break up compacted layers and improve infiltration. Deep cracking clay soils that swell and shrink have the greatest ability to recover from soil compaction by livestock. However, these soils do require very careful management with rest periods and moderate grazing pressures to ensure minimal long term impact.

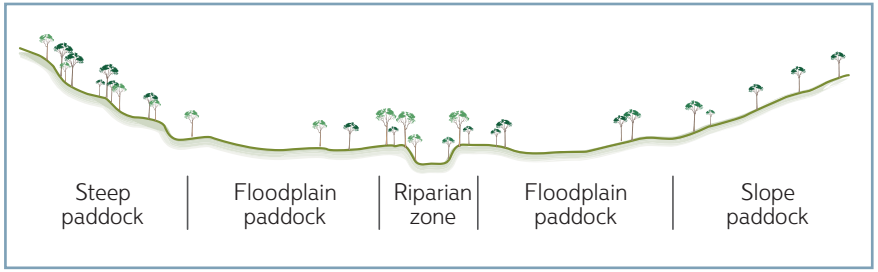
Fence paddocks according to erodibility

Fencing paddocks according to their susceptibility to erosion makes it easier to prevent erosion. Traditional 'square' paddocks that contain more than one soil type or slope make erosion management difficult. Try to fence land so that each paddock has similar characteristics, for example all flat, all slope, all sandy soil, or all heavy clay.

Where paddocks have varied conditions, manage them to minimise erosion in the most vulnerable areas. It may be worth constructing temporary electric fencing around these areas. Grazing management becomes difficult in paddocks larger than 40–50 ha, so subdivision into smaller paddocks should be considered even if soil and slopes are consistent. Some areas of a property may not produce good pasture cover at any time. These areas are best fenced off and used for timber production or nature conservation.

Fence paddocks according to the landscape.

Adapted from Keeping it in place – controlling sediment loss on grazing properties in the Burdekin River catchment, Meat & Livestock Australia, 2004



Have several shaded areas

On hot days, stock prefer shade to sun and will gather under any tree available. These camps lead to trampled groundcover and denuded soil, making the soil very prone to erosion. By planting several shade areas, the impact of the cattle camps is spread over a wider area, and there is less chance of severe erosion.

Prevent stock tracks forming

Stock often form tracks in paddocks and these need to be monitored because once a track is worn lower than the pasture, it can concentrate runoff and scour out quickly. The sooner stock are stopped from using an eroding track, the smaller the problem that needs to be fixed.

Management options include placing obstacles across the track, fencing it off, or moving watering points.

This cattle track has become a gully.

Reduce the impact of dairy cattle movements

The regular movements of dairy herds tend to trample groundcover, making the soil more prone to erosion, particularly around the dairy. Below are some ideas for reducing the erosion potential on dairy farms.

Fencing narrower laneways can reduce erosion.

- Make laneways as narrow as practicable, as this reduces the amount of ground subject to the pressures of cattle movement.
- Avoid sharp corners in laneways or fence lines used to guide stock movement, as stock will tend to mill around at the corner and this increases the wear and disturbance to the ground. Consider fencing off and planting out sharp corners.
- Install gateways in well-drained areas, and don't allow water to pond in or flow through a gateway.
- Use concrete pathways near dairy buildings.
- Install feeding pads for wet periods so cattle don't pug up the wet soil on the farm. Pugged soil becomes very prone to erosion once it dries out.

Manage weeds carefully

When controlling weeds, try not to leave soil bare. Have pasture seed on hand to sow in the bare areas as soon as possible (observing replanting recommendations when using herbicides), otherwise these areas are vulnerable to erosion and recolonisation by weeds. When using earthmoving or cultivation equipment, exclude stock from the disturbed area until pasture cover is re-established.

Slash rather than burn

To promote a green pick, slash and mulch pasture rather than burn it, because the cut vegetation contributes to protective groundcover and adds organic matter to the soil as it breaks down. Regular burning depletes groundcover, organic matter and plant nutrients and leads to long term soil degradation.

Burning off leaves the ground bare and vulnerable to erosion.
Source: Michel Dignand NSW DPI

Slashing leaves groundcover in place and adds organic matter to soil. Source: Joshua Quinn

Minimise cultivation when improving pastures

There is a high risk of erosion when soil is cultivated for new pastures. Direct drilling into existing pasture carries much less risk of erosion and, in many situations, over-sowing existing pastures with legumes and topdressing with fertiliser is the lowest risk and most cost-effective pasture improvement method. Earthworks that disturb soil or remove groundcover need to be carried out in drier months when there is low risk of intense rainfall events. Only cultivate when the soil moisture is right to avoid damaging the soil structure, and work across, not up and down slopes. Erosion rates increase dramatically on slopes above 10%.

For more information on when soil is at the right moisture content for cultivation go to: http://www.dpi.nsw.gov.au/agriculture/resources/soils/structure/compaction

The Native Vegetation Act 2003 restricts some pasture improvement practices where existing pasture contains native species.

Note: Pasture improvement may be associated with an increase in certain livestock health disorders. Livestock and production losses from some disorders are possible. Management may need to be modified to minimise this risk. Consult your veterinarian or adviser when planning pasture improvement.

A coulter, tine and press wheel mechanism for direct drilling seed minimises soil disturbance.

Source: Natalie Moore NSW DPI

Destock in drought

Once groundcover is below 70% on flat country or 85–90% on slopes, there is an increased risk of severe erosion. When this point is reached landholders need to decide whether to sell or agist stock, or hand feed them in one paddock where pasture is 'sacrificed' to save the other paddocks. Confining animals to a 'sacrifice' area allows destocked areas to recover quickly when rain returns, and minimises the cost of re-establishing pastures. Letting animals wander in search of scarce feed wastes their energy, increases erosion and threatens the survival of remaining pasture.

Further information on drought grazing management is available from http://www.dpi.nsw.gov.au/agriculture/emergency/drought/managing

Orchards and plantations

This section is relevant to horticultural enterprises such as macadamias, low chill stone fruit, avocados, custard apples, coffee, blueberries and bananas. It focuses on orchard management techniques that can reduce erosion.

Other areas of this book that may be useful to orchardists include:

» **Managing water flow (page 43)**
» **Dams that minimise erosion (page 65)**
» **Stable roads and tracks (page 89)**
» **Erodibility of northern rivers soil types (page 152)**

Develop orchard drainage plans

The most efficient and cost-effective way to reduce erosion risk in orchards and plantations is to determine where water naturally flows, ascertain slope lengths and grades, and design an appropriate drainage management plan before any trees are planted. 'Retrofitting' drainage plans in established orchards is more difficult and expensive and may entail removal of trees.

An orchard drainage plan should include:

- drainage and discharge of excess runoff
- problem areas such as waterlogged spots and steep areas
- location of planting areas
- tree row orientation (planned and existing)
- windbreak location
- design and location of access tracks
- location of existing infrastructure.

The space left for the natural drainage line in this newly planted orchard may not be enough to maintain a grassed waterway when the trees mature.

A contour plan at 1 m intervals is very useful when developing drainage plans and could well pay for itself in avoiding the need for future remediation works. Many local councils now have accurate topographic maps, with 1 m contour intervals, that can be purchased at a reasonable price.

The orchard drainage plan will identify where erosion control measures may be needed and where planting should be avoided or trees removed. Trees should not be planted in or near drainage lines, even ephemeral ones, or gullies. The minimum recommended planting distance from drainage lines is generally 15–20 m to allow adequate grass cover when the trees are established and to allow a small buffer to filter runoff before it enters the concentrated flow.

Breaking the site into a series of smaller subcatchments using an integrated system of well-planned drains, banks, waterways and roads can reduce both the volume of water and the length of the slope over which it flows, and will reduce the erosive potential of runoff waters. Excess water can be directed to safe discharge areas such as watercourses retained for this purpose, or broad, flat, well-vegetated basins.

Divert water

A diversion bank directs water between blocks of macadamia trees.
Source: Ian Clapham

Banks, waterways and roads can all be used to divert water from erosion risk areas to safe areas, but poorly-designed structures and poorly-executed works can increase the risk of erosion. All diversion works require establishment of adequate groundcover (living or non-living). Under existing legislation, redirection of water from one catchment to another is not permitted. Under common law the construction of drainage features to dispose of excess water into a neighbour's property

is not permitted without their consent. So when directing water off your property you may need to work with neighbouring landholders. Specialist consultants with qualifications and experience in erosion management can assist with the design of diversion works. Possibly the easiest diversion technique is to install a bank and/or a channel to direct runoff water from further up the slope to a 'safe' disposal area. This could be a flat well-grassed basin with 100% groundcover and/or a farm dam, or it may be possible to direct water into an existing natural waterway.

Another useful diversion technique is to break up long slopes with banks or drains. Long slopes allow water to build up speed and become erosive. Cross slope drains divert water collected in the interrow drain before it reaches the end of the row. The spacing of cross slope drains will be determined by characteristics such as slope grade, soil type and groundcover present. On slopes between 5–10%, low profile banks are needed to cope with a 1 in 10 year rainfall event. On steeper slopes, banks need to be higher or closer together.

Use the worksheet to estimate slope (see page 175)

A cross bank breaks up long rows of blueberries running downslope.

Shallow dish drains are preferable to V-shaped drains because they spread the water flow, and are easier to grass and maintain. V-shaped drains channel water along a narrow path, increasing erosion risk, and are more difficult to maintain.

A low, broad dish shape is the best drain profile.

Roads can be incorporated with diversion works, but need well-designed drains and stable, vegetated discharge areas. Waterways and roads need to be able to cope with a 1 in 20 year rainfall event. Roads should be on ridges and higher slopes. Minor access tracks can be located at the upslope end of tree rows, or can incorporate grassed waterways.

Repair small scale eroded flowlines

Many orchards or plantations have small scale gullies and washouts. Profiling of the interrow may be necessary to achieve the correct shape to prevent further washouts, or these can be rehabilitated to some extent by placing check structures (see page 57) across the path of the flowing water.

A grassed waterway

In areas that experience significant concentrated water flows, even periodically, specialist structures/works may be required. Appropriate professional advice should always be sought for the design and construction of such works.

Trap sediment

Sediment traps prevent eroded soil from leaving the property and/or entering a permanent watercourse. Once a trap reaches 60% capacity, the sediment has to be removed and stabilised at an appropriate site. Sediment traps need to be designed by a professional to ensure they are sized and positioned correctly. Dams can be used to collect sediment (see page 62).

A sediment pond at the farm's lowest point allows this plantation to discharge cleaner water.

Reduce the erosion risk of drainage works

Newly formed surfaces, banks and drains are vulnerable to severe erosion if they are hit by heavy rainfall before groundcover is established. There are several techniques to reduce erosion risk at these times.

Carry out earthworks when there is less risk of intense erosive rainfall, but enough warmth and moisture to allow rapid groundcover establishment once works are complete, ie, around September. Retain all topsoil for respreading on the surface of all excavated drains, as it will encourage groundcover growth.

Leave grass in existing watercourses, but if these are being reshaped, plant a quick-growing groundcover immediately after reshaping. Seed and fertilise immediately to provide rapid groundcover. Where works cannot immediately sustain a permanent level of more than 70% groundcover, then sow quick germinating annuals, such as oats, ryegrass or Japanese millet. Slower growing perennial groundcovers can be sown into this rapid cover. Alternatively, turf can be laid or erosion matting used to protect soil where it may have to carry fast flows immediately following works before vegetation can establish from seed.

Use groundcovers

The best orchard groundcovers are stoloniferous (with runners) such as kikuyu (*Pennisetum clandestinum*) as they provide better cover than clumping grasses such as paspalum (*Paspalum dilatatum*) and ryegrass (*Lolium perenne*). It is also important to choose species that will survive machinery traffic used for spraying and harvesting. Establishing groundcovers is relatively easy in open orchards but more difficult in dense plantings where there is little light. Shade-tolerant species are available but these will not grow in dense shade.

Macadamias pose a difficult case for erosion control. The crop needs to be picked up from the orchard floor, so harvesting has favoured bare ground. This practice, coupled with the region's rainfall pattern, steep slopes and soil types, has combined to produce a high erosion risk for the industry. However, many successful growers have found that a bare orchard floor is not a prerequisite for reliable harvesting operations.

This orchard has good groundcover. Source: Rex Harris

Groundcovers such as smothergrass (*Dactyloctenium australe*) protect the soil from pre-harvest blowing and sweeping, and surface water flow.

In banana plantations, contour strips of groundcover help reduce erosion. The interval between removing old plants and replanting new ones is a high risk erosion period so groundcover needs to be planted among the old banana plants before their destruction and then sprayed off before new plants are put in the ground. Choice of groundcover needs to consider its weed or fire hazard potential.

Use mulch and compost where appropriate

Mulch and compost can protect the soil to some degree, but do not provide the binding action of a living groundcover. They benefit areas where low light levels prevent any living groundcover establishing. Both mulch and compost need to be applied thickly (50–100 mm) to eliminate raindrop impact and prevent concentrated flow, and need to be replaced, particularly after intense rainfall events when they are washed away.

Compost can be washed away by concentrated stem flow.

In heavily shaded macadamia plantations where nothing will grow, a 5 cm mulch cover may be needed to protect bare soil. Mulch can also be used where groundcover is discouraged because of its perceived competition with trees.

Banana trash is good mulch.

In banana plantations, trash from the plants themselves provides good mulch. Heaping the trash on the contour in every alternate row is also beneficial. Mulching materials for avocado tree mounds include straw, interrow slashings or chipped wood from prunings. Slightly 'hayed off' and coarsely cut crops such as oats, sorghum, setaria mixed with legumes such as lablab, soybean or lupins provide an open mulch that decomposes gradually. Finely cut materials such as sawdust and bagasse are undesirable because they tend to pack down and induce root rot.

Prune trees for more light

In older orchards where row spacings and cultivar selection cannot be altered, pruning and removal of branches will provide light to allow groundcovers to grow on the orchard floor. Pruning techniques depend on the fruit or nut crops being grown.

Further information on pruning is available from your local NSW DPI horticulturalist or http://www.dpi.nsw.gov.au/agriculture/horticulture

Hedging of macadamia trees

Remove trees where necessary

Tree removal may well be the only option where trees are planted too closely or are growing in ephemeral waterways. In most cases, trees that need to be removed are not healthy or productive because there is too much competition or soil around the tree roots has washed away due to concentrated water flow. Removing these trees disturbs soil in high risk erosion areas so quick-growing groundcovers need to be sown immediately after tree removal or the area needs to be covered with an appropriate erosion matting. If necessary, the area can be oversown later with more permanent grass cover species.

Removing trees may be the only way to get enough light to grass this watercourse.

Grassed waterways reinstated by the removal of trees can be used as drains and disposal areas for excess runoff water from other parts of the orchard.

Cropping

Sugar cane fields. Source: John Gasparotto NSW DPI

The region supports broadacre and intensive cropping. Broadacre cropping enterprises include sugar cane, soybeans and cereals, mostly grown on coastal and river floodplains where there is low risk of soil erosion. Intensive cropping enterprises include sweet potatoes, potatoes and beans grown mainly on the fertile volcanic soils of the Comboyne, Cudgen, Dorrigo, Alstonville and Acacia plateaus. Landholders cropping in these areas have to contend with more intensive rainfall and steeper slopes.

Other areas of this book that may be useful to croppers include:

» **Managing water flow (page 43)**
» **Dams that minimise erosion (page 65)**
» **Stable roads and tracks (page 89)**
» **Erodibility of northern rivers soil types (page 152)**

Since the early 1990s, there has been a marked swing to cropping techniques that conserve soil and water and reduce runoff and erosion. Conservation farming techniques minimise cultivation by planting crops and pastures directly into soil protected by a mulch of stubble or dead vegetation. The direct drill planter is very popular with growers because it places seed and fertiliser precisely with minimum soil disturbance.

Plan to prevent erosion

The main considerations when controlling erosion in cropping paddocks are slope, management of water flow within individual paddocks and farm/paddock management practices. Croppers need to know where the water flows, the location of steep slopes and permanent and intermittent watercourses, and the slope and erosion risk of both individual paddocks and the farm. With this information they can determine row direction and length and design and locate headlands and access tracks to minimise erosion.

Maintain groundcover

Retain crop stubble

Retained stubble protects bare soil from erosion after harvest by absorbing raindrop impact, increasing infiltration and slowing the speed at which water runs over the land, thereby reducing soil movement. Fitting a trash chopper or straw spreader to the header at harvesting helps to produce a more evenly spread blanket of crop residue on the soil surface. Alternatively, graze the crop.

Retained stubble protects the soil.

Double crop

Double cropping involves growing a summer and a winter crop each cropping year.

Sowing a winter crop such as oats into the stubble of a summer crop such as soybean ensures there is enough groundcover to protect the soil from erosion all year. The north coast's mild climate and relatively high rainfall makes double cropping an option in most years.

Seed by air

Land managers in the region commonly use planes to sow oats or ryegrass into soybeans before harvest. The pasture germinates during harvest and uses the residual nitrogen in the soybean root nodules. This process ensures the soil is never bare.

Avoid bare fallow

Bare fallow is used to store soil moisture for the next crop, but leaves the soil vulnerable to erosion in high intensity rainfall events.

Cultivate carefully

Use low till techniques

There are now several cultivation techniques that maintain groundcover: reduced tillage, direct drill, no till and zero till. These techniques retain stubble, maintain groundcover, control weeds with herbicides and rotations, and sow seed into stubble with equipment designed to handle the harder soil conditions. As organic matter builds up and soil health improves the soils become easier to handle.

On virgin ground, it may be necessary to cultivate once or twice to create an even ground surface. Otherwise direct drill sowing is preferred. A pioneer crop can be direct drilled into sprayed-off pasture.

Choose appropriate machinery

Tined and non-inverting implements are preferable to discs and mouldboard ploughs. Tined implements open the soil up without pulverising it. Coulter and tine combinations have proven to be the most successful implements for direct drilling into pastures and stubble in the region.

This John Deere precision planter uses a coulter and tine mechanism.
Source: Natalie Moore NSW DPI

Cultivate at correct moisture content

If cultivation cannot be avoided, work the soil at the correct moisture content. Cultivating soil when it is too wet or too dry damages soil structure and compacts the soil. Heavy clay soils are best cultivated when the soil is dry. If a handful of clay topsoil from mid-cultivation depth can be rolled between the hands into a rod that is less than 3 mm in diameter without crumbling, then the soil is too wet to plough. Light sandy, silty, or loam soils should be cultivated only when a handful can be squeezed into a coherent ball, but does not feel wet.

Avoid cultivating through natural drainage lines

Cultivating natural drainage lines makes these areas prone to soil erosion and the development of gullies. Natural drainage lines in a cultivation paddock are best kept grassed for safe disposal of stormwater runoff.

Avoid cultivating steep slopes

Cropping is best restricted to the flattest available sites, as the risk of soil erosion increases dramatically when slopes exceed 10% (6°). Slopes greater than 20% (9°) should never be cultivated.

Avoid cultivating for weed control

Control weeds with herbicides or crimp rolling rather than cultivation. The use of herbicides is usually cheaper than cultivation, and soil structure is not damaged. A crimp roller can be towed behind a tractor to flatten and kill weeds or a standing crop. The roller is a drum generally 0.6–1 m in diameter with water or oil for additional ballast, with a series of 10–12 blades or blunt knives running around the drum approximately 15–16 cm apart and 6-8 cm tall. The roller flattens vegetation and crimps it every few centimetres, breaking the stems and killing the aboveground plant structures. Crimp rolling produces a mulched layer of several centimetres thick on the soil surface, suppressing weed germination, improving water infiltration into the soil and reducing evaporation.

Rolling a crop leaves a thick mulch cover.
Source: Eric Koetz NSW DPI

A crimp roller can reduce the need to cultivate for weed control.
Source: Eric Koetz NSW DPI

Manage water flow

Maintain natural watercourses

A permanent grassed waterway at Woodford Island. Source: Natalie Moore NSW DPI

Permanent and semi-permanent flowlines should be maintained and not disturbed. Natural drainage depressions need to be kept as permanent grassed waterways for safe disposal areas for runoff from elsewhere. Any activity within the bed and banks or within 40 m of the top of the bank of any stream or waterbody requires approval under the Water Management Act 2000.

Crop in strips

Strips of crops planted on the contour break up sloping land and prevent surface water flow building up speed and eroding soil.

Cropping in rows across the slope. Source: Summit Organics

Keep paddock access in good condition

Paddock access for heavy machinery is important in cropping enterprises, so farm roads and tracks (see page 89) need to be well constructed and maintained so they can be used in all conditions.

A graded bank breaks up the slope, reducing erosion from the lower part of the field.

Use banks to slow water flow

Contour and graded banks (see page 47) are used on sloping land to intercept surface water and divert it away from the paddock to safe stable disposal areas. Waterways behind the banks are broad and shallow to ensure that they do not erode. The banks and waterways need to be designed so that farm machinery can cross without damaging machinery or the earthworks.

Build organic matter in soils

Cultivation breaks down valuable organic matter in the soil and makes it more prone to erosion, so it's particularly important to build up organic matter in cropping soils using some or all of the following techniques.

A pasture phase follows soybeans at Tabulam. Source: Natalie Moore NSW DPI

Include a pasture phase in the cropping cycle

Pasture phases are the most effective way of increasing organic matter levels in cropping soils. On the region's fragile hill soils the recommended phase is a minimum five years of pasture and a maximum three years of double cropping. On the better soils, the cropping phase can be longer.

Retain stubble

A significant portion of stubble left on the surface after harvesting becomes incorporated in the soil and increases the organic matter content. Stubble also protects the soil surface from wind and water erosion.

Grow green manure crops

Green manure crops are usually grown specifically to be slashed and incorporated into the soil. However, while they provide organic matter, they also require cultivation, so in the region they are only really suitable for flatter alluvial soils where erosion is unlikely.

Use organic fertilisers

Organic fertilisers such as animal and poultry manures provide nutrients and organic matter, but transport and spreading costs can make their use prohibitive.

Rotate crops

Crop rotations help vary the types of organic matter (roots and plant material) in the soil. The NSW cane industry is increasingly using soybeans and triticale as rotation crops to break disease cycles. In the past cane growers cultivated during the wet season, but now use crop rotations, permanent raised beds and precision agriculture techniques to reduce compaction and increase productivity.

Re-establish groundcovers after harvest

When vegetable crops are harvested in summer there is a high risk of erosion from summer storms. This risk is reduced by quickly re-establishing groundcover, improving infiltration and ensuring all erosion control works are in good condition.

Post harvest techniques on the Dorrigo Plateau

Post harvest considerations

- All land must be stabilised within 7 days of post harvest cultivation by:
  - seeding with appropriate pasture/crop and agronomic practices to encourage strike
  - immediate deep ripping on contour at maximum spacing of 2 m and mininimum depth 30 cm

and with

  - maintenance of existing or installation of new in-paddock sediment control filters/barriers.
- All works maintained and inspected and repaired following rainfall, and sediment removed when it reaches above 50% of the measure's capacity.
- Temporary measures not removed until 70% groundcover established.

Source: Cultivation management on the Dorrigo Plateau: Code of practice and guidelines, 2005, J Clerke and P Parbury