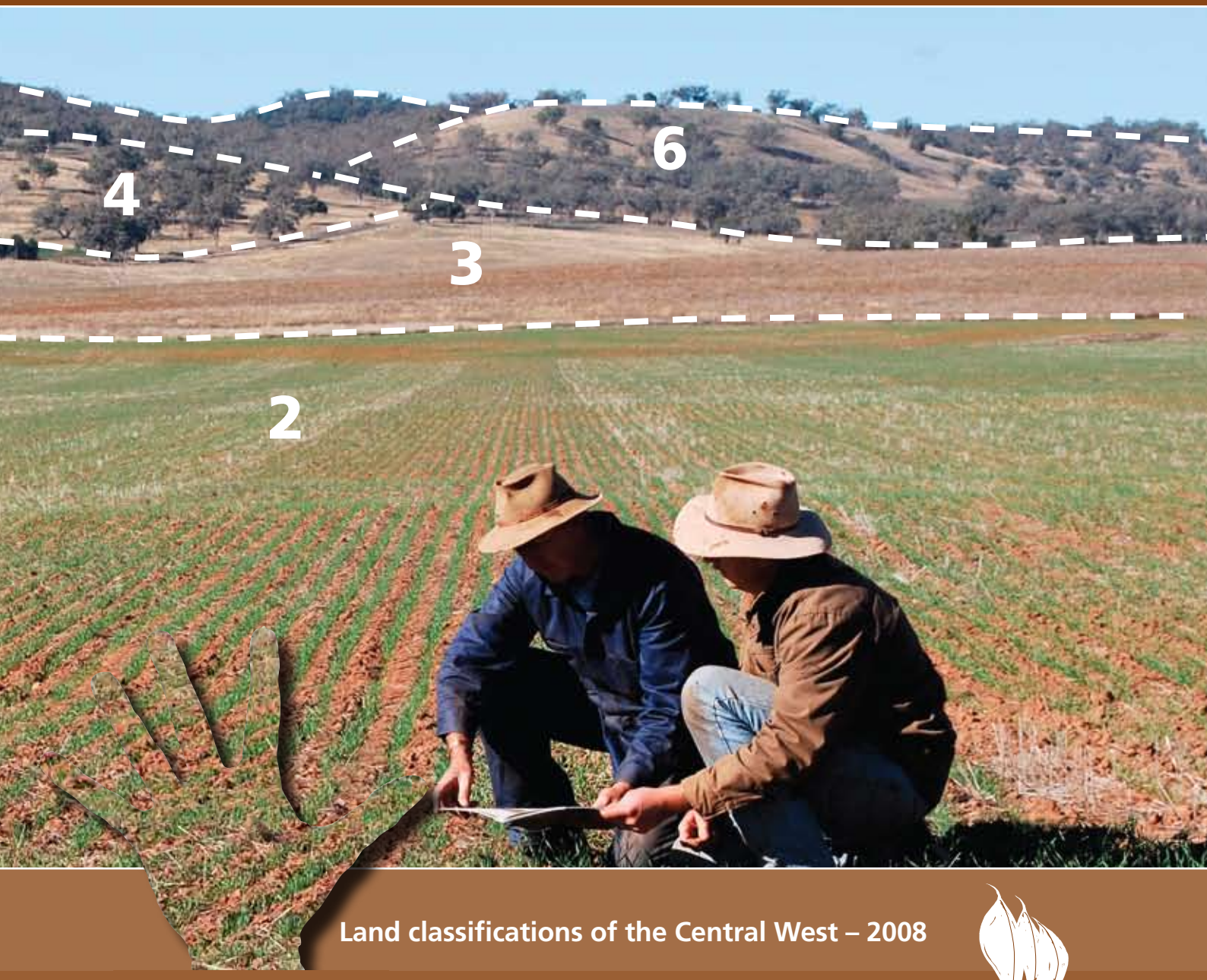
Land and Soil Capability – How we safely manage the land



Land classifications of the Central West – 2008

Central West catchment management authority

Contents

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Central West catchment management authority

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Central West Catchment Map

Chairman's Foreword

The Central West catchment covers approximately 85,000km^2 and is one of the most productive and diverse catchments in New South Wales. Improved knowledge of our catchment's natural systems leads to better natural resource management, which is the foundation of the Central West Catchment Management Authority's vision of '*vibrant communities and healthy landscapes*'.

Our knowledge of the quality of our natural resources such as soil health, water quality, native vegetation and habitat health, is constantly improving.

Scientists, economists and practitioners alike are striving to develop land management practices that aim to improve catchment health whilst delivering a level of production that is profitable and sustainable.

The Central West Catchment Management Authority is a key organisation to convey this information to landholders and the wider community, in the form of current best management practice.

The Central West CMA has produced this series of Best Management Practice manuals, fact sheets and case studies in conjunction with key organisations, agencies and academics to help people make key management decisions on their farm.

I commend this publication to you as the best management practice currently accepted for the sustainable management of our natural resources.

At the heart of the technical information presented in these Best Management Practice manuals lies a simple message that is emulated in an indigenous saying from the Wiradjuri nation: *'Ngangaana-gu Kairai billa's dya Kairai billa's durai ngangana ngindu' – 'Look after the land and the rivers and the land and the rivers will look after you'* (Cec Grant 2001).

Tom Gavel
CHAIRMAN
CENTRAL WEST CATCHMENT MANAGEMENT AUTHORITY

Introduction

A revised rural land and soil capability classification system has been developed for NSW by the NSW Department of Environment and Climate Change. It is part of the Monitoring and Evaluation Program in the State Plan. The revised system is the 'Rural Land and Soil Capability Classification for Monitoring and Evaluation' (LSC). It builds on the earlier 'Rural Land Capability Classification' system produced in the 1950s and retains the eight class structure. The system presented here focuses on modern soil management techniques and cropping and grazing systems to improve catchment health. It has been modified to meet the needs of land managers in the area managed by the Central West Catchment Management Authority.

In summary, this system:

- Defines LSC classes based upon on-site and off-site limitations of the land
- Assesses the impact of land use and land management practices on the land
- Specifies the level of inputs, expertise and investment required to manage the land sustainably without causing degradation.

For higher LSC class numbers there are greater limitations to land use and higher levels of inputs, expertise and investments to manage the land sustainably. On land in the higher LSC classes it is often not possible to overcome all of those limitations using economically sustainable land management practices.

What is LSC?

Land and soil capability classification is a major tool to assess the sustainability of land management practices. Within each class there is a range of limitations caused by differences in climate, soil type, slope, landform position, aspect, nutrient balance, acidity, salinity, drainage, stoniness and a host of other physical factors. Each limitation will need to be managed to make full use of the capability of the land.

Land uses and land management practices are assessed for their impact on the land and soils. High impact management practices place increasing pressure on the land and soil resource. Management practices that adversely affect the resource may include:

- Increasing soil disturbance by excessive cultivation
- Reducing ground cover as a result of cultivation or grazing pressure
- Reducing levels of organic matter as result of cultivation or reduced biomass production (grazing intensity)
- Burning stubble, especially when using hot burns a long time before sowing
- Changing pasture species composition with heavy grazing
- Compacting soils by machinery and stock, especially on susceptible soils
- Changing water use patterns and the hydrology on the landscape – clearing of trees and perennial pastures in catchments that are susceptible to increased salinity
- Removing biomass material in agricultural products (farm gate losses)
- Lowering soil pH with nitrate leaching under annual pastures
- Clearing of native vegetation from sensitive areas such as sand hills.

Both on-site and off-site impacts need to be considered in assessing land and soil capability. The impact of not managing the limitation must also be considered. For example, in more marginal cropping land, if the water erosion limitation is not managed, significant water erosion will degrade the soil on-site, leading to sedimentation and turbidity of water off-site. However, on such land, the water erosion limitation can be controlled by readily available and widely accepted land management practices. The costs, technology and management practices to overcome limitations also need to be considered. In theory, it is possible to overcome most limitations with sufficient investment and technology inputs, though this is often not a realistic option.

Hazards and limitations used to determine rural land and soil capability

The following attributes of land and climate are used to determine LSC in Central West NSW.

- Climatic limitations to plant growth
- Water erosion
- Wind erosion
- Soil structure breakdown
- Organic matter soil carbon decline
- Sensitive terrain unit (streambank, lunettes, swamps/wetlands)
- Salinity/salinisation
- Stoniness and shallow soils
- Soil acidity
- Soil fertility
- Water holding capacity
- Mass movement
- Flood hazard.

Each one of these limitations is assessed individually to determine the overall land and soil capability of a parcel of land.

Table 1 shows how the limitations are used to determine the LSC Class for an area of land (page 22).

TOP
Assessing land and soil capability in the field.
MIDDLE
Wind erosion on sandy surface soils south of Dubbo. **(Fergus Job)**
BOTTOM
Disc seeder is used for No Tillage sowing and results in minimum soil disturbance.

Land and Soil Capability Class 1

Class 1 Definition

Very slight to negligible limitations – no special land management practices required

- **On-site** impacts of land management practices on soil and land condition are minor and may include some effects that can be readily managed such as nutrient depletion of the soils and some soil structure decline under intensive use.
- No special land management practices required apart from those required to maintain or improve soil condition (soil carbon, soil nutrients, soil pH).
- **Off-site** impacts of land management practices are generally minor.
- Land capable of most rural land uses and land management practices, and the few minor limitations can be very readily managed. Occasional flooding may restrict its use for some specific rural land uses (e.g. some horticulture).

PHOTO 1
Alluvial plains on the river flats.

PHOTO 2
Irrigation on the Macquarie River Flats.

Description

LSC Class 1 is prime agricultural land and the best cropping country in the Central West catchment.
It is capable of most rural land uses and land management practices, and the few minor limitations can be very readily managed in this class. Occasional flooding may restrict its use for some specific rural land uses (e.g. some horticulture).

This land is capable of a wide variety of agricultural uses that involve regular cultivation. These parcels of land are usually uniform with deep fertile soils. They have low slopes (<1%) and are shorter than 1000m in length with no erosion problems. The soils have sufficient clay content to inhibit wind erosion and offer some resistance to soil structure decline even under regular tillage. However, under very intense use, some structure breakdown can occur and management of soil structure is required by reducing tillage and adding organic matter. The broad flats along major rivers such as the Macquarie, Bell, Cudgegong and Talbragar are typical examples. Flooding is sometimes a problem on this land class because it is adjacent to major rivers and streams.

Land management considerations

No special land management practices to control water and wind erosion are required. Some land management practices that will preserve soil structure and chemical fertility are required.
This land is free of rock outcrop and large stones that would restrict farm machinery operations. It has good drainage, with sufficient water holding capacity to supply growing crops and pastures. The soils generally have good buffering capacity against soil acidity and no specific management practices to control soil acidity are required.

PHOTO 3
Narrow alluvial plain of the Bell River in the foreground and Classes 6 and 7 land in the background.

1

Land and Soil Capability Class 2

Class 2 Definition

Slight but significant limitations – can be managed by readily available, easily implemented management practices

- **On-site** impacts on soil and land condition are slight. Soil and land condition can deteriorate due to minor water and wind erosion. Some acidification and organic matter decline may also occur, but not to critical levels.
- **Off-site** impacts of land management practices are slight, and limitations can be managed by readily available management practices.
- Land is capable of a wide range of land uses and land management practices (ie suitable for, intensive cropping with cultivation, grazing, forestry or nature conservation).

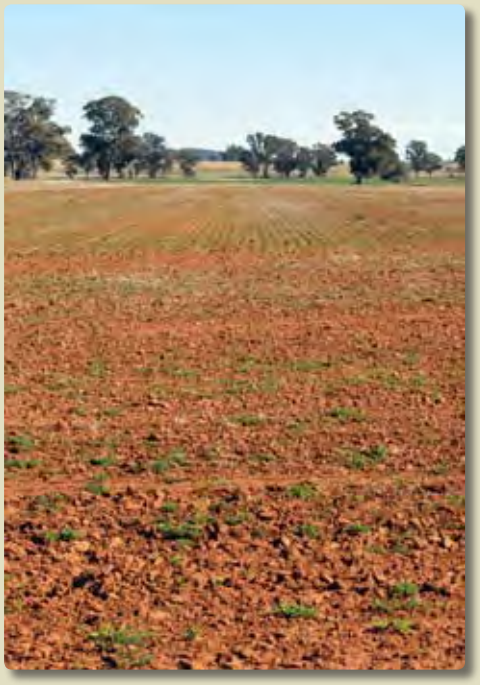

PHOTO 4
Class 2 land on the Mid-Macquarie slopes.

PHOTO 5
Class 2 land sown using No Tillage.

PHOTO 6
Class 2 land showing controlled traffic and stubble retention.

Description

Land in this class is capable of a wide range of land uses and land management practices (intensive cropping with cultivation, grazing, forestry and nature conservation). Included in Class 2 land is very good cropping land with fertile soils and short, low slopes (1% to 3% less than 500m in length). This gently sloping land is capable of a wide variety of agricultural uses that involve cultivation. These uses include vegetable and horticultural production, and a range of crops including cereals, oilseeds and pulses. It has a high potential for agricultural production on fertile soils similar to Class 1, but has some restrictions on land use due to slight limitations.

Land management considerations

This land can be subject to sheet, rill and gully erosion as well as wind erosion and soil structure decline. However, these limitations can be controlled by land management practices that are readily available and easily implemented, such as conservation tillage practices and conservation farming practices. These practices include retaining stubble, reducing tillage, sowing with minimum disturbance and rotating pastures. Windbreaks and ground cover should be retained in areas prone to wind erosion. In more western areas, some timber should be retained in strips or clumps to reduce wind velocity.

Salinity can be a slight hazard. Land managers need to be aware that deep drainage may cause salinity. Acidity can be a slight hazard. Land managers need to ensure their practices are not slowly acidifying the soils, and pH levels should be monitored regularly.

PHOTO 7
Wheat germinating on Class 2 land in the Gilgandra area.

2

Land and Soil Capability Class 3

Class 3 Definition

Moderate limitations – can be managed by more intensive readily available and accepted management practices

- **On-site** effects on soil and land condition can be moderate if limitations are not managed. Soil and land condition can deteriorate as a consequence of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline or soil salinisation.
- **Off-site** impacts of land management practices can be significant if limitations not managed (e.g. salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
- Limitations can be managed by readily available and accepted management practices.
- Land capable of most land uses (cropping with appropriate practices, grazing, forestry and nature conservation). However, to manage the limitations, cropping should change by reducing tillage and retaining stubble. Intensive grazing should change to rotational grazing.

PHOTO 8
Erosion control banks on erodible red-brown earths (red chromosols) near Wellington.

PHOTO 9
Erosion control earthworks and stubble retention on Class 3 land, protecting soil from raindrop impact, sheet erosion, rilling and gullies near Tooraweenah. (Chris O'Brien)

Description

Class 3 land has limitations that must be consciously managed to prevent soil and land degradation. However, the limitations can be overcome by a range of widely available and readily implemented land management practices. Included are sloping lands (3% to 10%) with slopes less than 250m in length that can erode when cultivated if runoff is not controlled. Slopes longer than 250m will require earthworks to control runoff and erosion. Also included are lands that can be subject to wind erosion when cultivated and left bare. It is important to minimise soil disturbance, maintain stubble cover and maintain good organic matter levels.

Class 3 land includes sloping land that is capable of sustaining some cultivation on a rotational basis. This land can be readily used for a range of crops including cereals, oilseeds and pulses. Productivity will vary with soil fertility. It has greater restrictions on land use than Classes 1 and 2 due to increased limitations. Severe problems may arise if land management practices do not address its limitations. For example, severe soil erosion can be caused by regular cultivation without effective erosion control measures. Poor water quality can be caused by water erosion and dust storms may result from wind erosion.

Land management considerations

This land can be subject to sheet, rill and gully erosion as well as wind erosion and soil structure decline. However, these limitations can be controlled by land management practices that are readily available and easily implemented (See Cropping Practices in Glossary).

Included are conservation tillage and farming practices such as retaining stubble, reducing tillage, pasture cropping or pasture rotations. Windbreaks and ground cover should be retained in areas prone to wind erosion. In more western areas, some timber should be retained in strips or clumps to reduce wind velocity.

Salinity can be a moderate hazard. Land managers need to ensure that management practices do not cause deep drainage and movement of salt stores in the soil. Practices to manage salinity are ensuring that plant growth is adequate to maintain evapotranspiration rates, and the elimination of fallows from cropping cycles.

Acidity can be a moderate hazard and needs to be managed or the soils will suffer long term degradation, particularly if acidity extends into the deeper soil. Under long term acidifying land uses, soil acidity levels should be monitored and lime added, or acid tolerant perennials used where required.

PHOTO 10
Gully erosion that has developed in Class 3 land through insufficient protection.

3

Land and Soil Capability Class 4

Class 4 Definition

Moderate to severe limitations – for higher impact land management practices (e.g. cropping). Limitations can only be managed by specialised management practices with high level of knowledge, expertise, inputs, investment and technology.

For lower impact practices (e.g. grazing) limitations are more easily managed.

- **On-site** impacts on soil and land condition can be moderate if limitations are not managed. Soil and land condition can deteriorate because of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline and salinisation.
- **Off-site** impacts of land management practices can be significant if limitations are not managed (e.g. salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
- Limitations can only be managed by specialised management practices with high level of knowledge, expertise, inputs, investment and technology.
- Land is capable of a range of land uses (e.g. cropping with minimal or no cultivation and specialised practices, grazing, forestry and nature conservation). However, for some land uses (e.g. cropping and intensive grazing), practices need to be able to manage the limitations.

PHOTO 11
Class 4 land near Bathurst. **(Rosemary Hook)**

PHOTO 12
Improved pastures on Class 4 land in the Rylstone area.
(Bruce Christie)

Description
For some land uses Class 4 land has moderate to severe limitations that need to be consciously managed to prevent soil and land degradation. The limitations can be overcome by specialised management practices with high levels of knowledge, expertise, inputs, investment and technology. This land includes sloping lands (10% to 25% slope).

Land management considerations
This land is generally used for grazing, and is suitable for pasture improvement. Acidification can be a problem under introduced annual legume pastures.

It can be cultivated occasionally for sowing of pastures and crops. However, it has cropping limitations because of erosion hazard, weak structure, salinity, acidification, shallowness of soils, climate, wetness, stoniness or a combination of these. It is only suitable for intermittent cultivation with specialised practices. Required erosion control practices include advanced conservation tillage, pasture cropping, well-planned rotations and maintenance of ground cover.

It has a high potential as grazing land. Soil structure decline, stoniness and soil depth can be moderate to severely limiting. Practices to manage these include well-planned rotations, additions of lime and maintenance of ground cover using perennials and natives.

Erosion problems encountered in these lands include sheet, rill and gully erosion as well as wind erosion and soil structure decline under cropping. Lands with weakly sodic surface soils are included in this classification. These limitations can be managed by well planned and carefully implemented conservation farming practices. Essential cropping practices include retaining stubble, reducing tillage and sowing with minimum disturbance. Minor drainage depressions with low flows are included in this land class. Windbreaks and ground cover should be retained in areas prone to wind erosion. In more western areas, some timber should be retained in strips or clumps to reduce wind velocity.

Salinity can be a moderate to severe hazard. Land management practices need to prevent deep drainage that causes salinity. Practices to manage salinity include ensuring plant growth is adequate to maintain evapotranspiration rates and maintaining the perenniality of pastures.

Acidification can be a moderate to severe hazard and needs to be managed so soils do not suffer long term degradation. It is particularly a problem if deeper parts of the soil profile become acidified. Land management practices need to prevent possible soil acidification and pH should be monitored regularly. Lime or acid tolerant perennials should be used when required.

PHOTO 13
Class 4 land with sodic surface soils. Note the scalding of the soil surface. The soil will show severe crusting, surface sealing as well as cloddiness and poor workability when tilled. These soils are likely to respond to gypsum and lime applications.

4

Land and Soil Capability Class 5

Class 5 Definition

Severe limitations – for higher impact land management practices (e.g. cropping) there are few methods available to overcome limitations. Highly specialised land management practices can overcome some limitations for high value crops/products.

For lower impact practices (e.g. grazing) there are some methods to overcome limitations.

- **On-site** impacts on soil and land condition can be severe if not managed. Soil and land condition can deteriorate as a consequence of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline or soil salinisation.
- **Off-site** impacts of land management practices can be severe if limitations not managed (e.g. salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
- No management practices are available to overcome the limitations for some land uses (e.g. most cropping). Highly specialised land management practices can overcome limitations for high value crops/products.
- Land capable of some land uses (grazing, forestry and nature conservation), and practices are available to manage the limitations.

PHOTO 14
Class 5 land prone to erosion with low fertility. Earthworks are often required to prevent erosion. Subsoils are sodic. The Class 5 land is in the foreground with Class 3 in the centre and Class 7 in the background.

PHOTO 15
Class 5 land with low fertility. Earthworks may be required to control gullies.

Description
Class 5 land has severe limitations for high impact land management uses such as cropping. There are few management practices generally available to overcome these limitations. However, highly specialised land management practices can overcome some limitations for high value crops or products. This land is generally more suitable for grazing with some limitations or very occasional cultivation for pasture establishment.

Land management considerations
Class 5 land includes sloping lands (10% to 25% slope) that can be eroded severely by runoff when cultivated, or land that will be subject to wind erosion when cultivated and left bare. It is important to minimise soil disturbance, maintain cover and maintain good organic matter levels.

This land is not capable of supporting regular cultivation due to a range of limitations including slope, terrain location, soil erosion, shallowness and stoniness, climate or other limitations. Soil erosion can be severe without adequate erosion control measures. Fertility is generally lower than lands in Class 4 and there is a lower capacity to regenerate ground cover. Class 5 land can be cultivated occasionally for fodder crops and pasture renewal or establishment. Included are lands that have been damaged or degraded by earlier erosion.

Eroded lands that require earthworks for rehabilitation are included in this class. This land is usually best suited for grazing, especially with pasture improvement and fertiliser application. However, acidification can be a severe problem under introduced annual legume pastures. This land can be subject to severe sheet, rill and gully erosion as well as wind erosion and soil structure decline. Windbreaks and ground cover should be retained in areas prone to wind erosion. In more western areas, some timber should be retained in strips or clumps to reduce wind velocity.

Salinity can be a severe hazard. Land managers need to ensure their practices don't cause deep drainage and movement of the salt stores in the soil. Practices to manage salinity include minimising deep drainage with plant growth to increase evapotranspiration rates, and increase perenniality of pastures. Acidification can be a severe hazard and soils can be naturally acidic in the surface and at depth. Where natural acidity is a problem, practices that are needed include growing acid-tolerant species and adding lime.

PHOTO 16
Class 5 land in the Hill End trough country of the Macquarie catchment.

5

Land and Soil Capability Class 6

Class 6 Definition

Very severe limitations – no management practices available to overcome limitations for a wide range of land uses (e.g. cropping, moderate to high intensity grazing, horticulture). Highly specialised practices can overcome some limitations for some high value products

- **On-site** impacts can be very severe if not managed. Soil and land condition can deteriorate as a consequence of water erosion, wind erosion, soil acidification, organic matter decline, soil structure decline or soil salinisation.
- **Off-site** impacts can be very severe if limitations are not managed (e.g. salinity, leachate from acid sulphate soils, water erosion and water quality, wind erosion and air quality).
- No management practices are available to overcome limitations for a wide range of land uses (e.g. cropping, moderate to high intensity grazing, horticulture). Highly specialised land management practices can overcome limitations for some high value products.
- This land is capable of a limited range of land uses (low impact grazing, forestry and nature conservation). Practices need to be able to manage the limitations.

PHOTO 17
Extensive rock outcrop on the slope allows grazing but not cultivation. (Alan Welch)

PHOTO 18
Slopes on Class 6 land that are too steep for cultivation.

Description
Class 6 land has very severe limitations for a wide range of land uses and few management practices are available to overcome these limitations. Land generally is suitable only for grazing with limitations and is not suitable for cultivation.

Land includes steeply sloping lands (25% to 33% slope) that can erode severely even without cultivation, or land that will be subject to severe wind erosion when cultivated and left exposed. It is important to minimise soil disturbance, retain perennial ground cover and maintain high organic matter levels.

Land management considerations
Class 6 land has severe to very severe site limitations for grazing and other land uses. Limitations include: slope, terrain location, soil erosion, shallowness and stoniness, coarse soil texture, poor drainage, flooding, wind erosive power and climatic limitations to plant growth. It may have very severe limitations due to off-site effects such as salinity and the impact of soil erosion on water and air quality. Soil erosion can be very severe without adequate erosion control measures. Fertility varies with geology, soil depth and type. This land is suited for less productive grazing. Limitations prevent most other land uses.

This land requires careful management to maintain good ground cover (maintaining grass or cover taller than 8cm high is a guide). Grazing pressures need to be lower than those used on Class 4 and 5 land. Rotational grazing systems with adequate recovery time for plant regrowth are essential.

Limitations can include steep slopes (25% to 33%), shallow soils (less than 50cm), rock outcrop (50% to 70%), salt outbreaks, naturally acid soils of low fertility, major flow lines with high flows and flooding, areas that are poorly drained and wet for long periods, and areas that are severely eroded, including scalds.

Class 6 land may be defined in terms of slope, shallow soils, rock outcrop, scalds, waterlogging, erosion beyond the scope of structural treatment, landslip hazard or a combination of these factors.

Salinity can be a very severe hazard. Land management practices need be changed in badly affected saline catchments. Practices to prevent salinity include minimising deep drainage, treatment of discharge areas and ensuring suitable perennial plants are retained in recharge areas to maintain evapotranspiration rates.

Acidification can be a very severe hazard. Soils can be naturally acidic both at the surface and at depth. This is particularly a problem when associated with low fertility. The land management options are very limited for these soils.

PHOTO 19
Saline scald on Class 6 land.

6

Land and Soil Capability Class 7

Class 7 Definition

Extremely severe limitations – most land uses are restriced. Limitations cannot be overcome

- On-site and off-site impacts of land management practices can be extremely severe if limitations not managed.
- May be suitable for commercial plantations.
- May have alternative role as a water source and biodiversity habitat.

PHOTO 20
Steep rocky country near Wellington.

PHOTO 21
Very rocky, very shallow soils suited only to trees and conservation. (Alan Welch)

PHOTO 22
Severely eroded, unstable soil – now unsuited for agriculture.

Description
This land has extremely severe limitations for most land uses. It is unsuitable for any type of cropping or grazing because of its limitations. Use of this land for these purposes will result in severe erosion and degradation. It may be too steep, rocky, swampy or fragile for grazing. The land may be suitable for commercial timber plantations or for native timber on undeveloped land. These areas can be high recharge areas and cause salinity problems off-site if cleared.

Class 7 land includes slopes from 33% to 50% (except on basalt soils which could still be Class 6). It also includes areas with extreme soil erodibility (often sodic soils, or prior stream sand dunes), catchments where salinity and recharge are a serious problem, and where rock outcrop and shallow soils are a severe problem.

Land management considerations
Class 7 land is not capable of any cultivation or cropping or grazing by stock. It also has severe to very severe site limitations for other land uses, but may be suitable for wood production, passive tourism or honey production. Limitations include: slope, terrain location, soil erosion, shallow soils and stoniness, coarse soil texture, poor drainage, flooding, wind erosive power, climatic limitations to plant growth. It may have very severe limitations due to off-site effects such as salinity and the impact of soil erosion on water and air quality. Soil erosion control is difficult because of site limitations. Fertility varies with geology, soil depth and type. These limitations prevent most land uses.

Class 7 land can also include the following:
- Very severely eroded areas that are badly scalded
- Large areas of exposed subsoils
- Some infertile sodic soils in the mallee areas
- Naturally acidic soils that are infertile and occur in steep rocky areas.

PHOTO 23
Landslips created by clearing trees on steep Class 7 land in the Warrumbungles. **(Peter Thompson)**

7

Land and Soil Capability Class 8

Class 8 Definition

Limitations so severe that the land is suited only to management for conservation

- On-site and off-site impacts sufficiently severe to prevent any land use other than preservation for conservation.
- It is non-farming land incapable of sustaining agricultural production – billabongs, quarries and cliffs.
- This land may have an alternative role – scenic amenity, tourism, biodiversity and cultural heritage.

PHOTO 24
Class 2 land in the foreground with Class 8 land (Warrumbungles) in the background.

PHOTO 25
A permanent wetland which is considered to be Class 8 land. (Alan Welch)

PHOTO 26
A billabong – Class 8 land.

Description
Class 8 land is not suitable for any agricultural production due to the extremely severe limitations. Class 8 land includes precipitous slopes (>50%), areas with a large proportion of rock outcrop (>70%), or areas subject to regular inundation and water logging (swamps, lakes, lagoons, stream beds and banks).

Land management considerations
This land is unusable for any agricultural purposes. It includes areas with precipitous slopes (>50%), cliffs, quarries, rock fields, swamps, lagoons, wetlands, lakes, beds and banks of streams of fifth order or greater (See Figure 1 below). Recommended uses are restricted to those compatible with the preservation of natural vegetation including: water supply catchments, wildlife refuges, national and state parks, scenic areas.

Figure 1.
Strahler's Stream Orders and Class 8
The illustration depicts a progression of stream orders: Starting at the top of the catchment, any stream that has no other stream flowing into it is a 1st order stream. Going from left to right, where two 1st Order streams join they form a 2nd Order stream. Where two 2nd Order streams join they form a 3rd Order stream, etc. When a stream of lesser order connects there is no change to the order of the main stream. The order only increases in number where streams of equal order connect. This process continues downstream as illustrated. The streams included are those shown on the most detailed topographic maps available for the Central West. Where the stream becomes 5th Order its bed and banks are classified as Class 8.

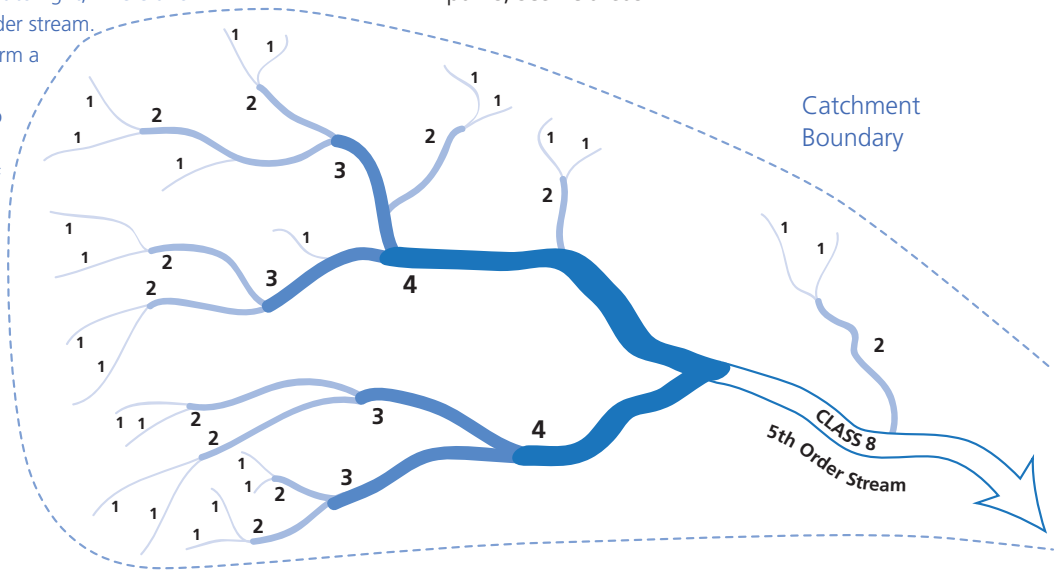

PHOTO 27
Bed and banks of a well defined 5th order stream are Class 8 land (See Figure 1 above).They are destabilised by grazing or agriculture.

PHOTO 28
A major stream where the streambed is Class 8 land. **(Cherie Hughes)**

Table 1: Determining Land and Soil Capability Class

The following table outlines the limiting factors that are used to determine land and soil capability class for a given area of land. These are generally consistent with the Property Vegetation Planning tools.

Work through each row and rate the land against each factor. The factor with the highest rating (1 being low, 8 being high) determines the overall capability of that land. For example, if wind erosion is rated 6 and is the highest rating recorded, steps will need to be taken to manage this hazard by retention of groundcover throughout the year.

FACTORS LIMITING TO CAPABILITY	LAND AND SOIL CAPABILITY CLASSES		
	1	2	3
SLOPE LIMITATION TERRAIN LIMITATION	Slope <1% Slope length <1000m No critical terrain	Slope 1–3% Slope length <500m No critical terrain	Can include slopes 3–10 % Slope length <250m No critical terrain
WIND HAZARD	Clayey and loamy soils High rainfall No exposure to wind	Clayey and loamy soils Moderate rainfall Some exposure to wind	Fine sandy loam soils Moderate rainfall Some exposure to wind
SOIL ACIDITY	Alkaline to neutral soils (pH water >6.5) High buffering capacity	Naturally neutral soils (pH water > 6.0) High buffering capacity	Naturally neutral soils (pH water > 6.0) Moderate buffering capacity
SOIL STRUCTURE STABILITY SODIC SURFACE SOILS	Strongly self-mulching cracking clays, friable dark loams and clay loams	Friable red loams and clay loams	Sandy loams, fine sandy loams, loams, clay loams and sand clay loams which are non-sodic (Exchangeable sodium percentage <3%)
SALINITY	No salinity present	Very minor salinity	Very minor salinity Hydrologic system: rapid in, slow out and only a minor salt store
ROCK OUTCROP	Deep soils No rock outcrop	Some minor floating rocks	Deep soils (>75 cm) Occasional rock outcrop (<10%)
WATERLOGGING	Well drained throughout the year		Well drained but remains wet for a week after heavy rain
EXISTING EROSION	Nil erosion	Very minor sheet and rill erosion	Evidence for some sheet and rill erosion and minor gully erosion which is restricted to the major flow lines

4	5	6	7	8
Can include slopes 10–25% Minor flow line No critical terrain	Can include slopes 10–25% Erodible soil/sodic subsoils No critical terrain	Can include slopes 25–33% Major flow lines and scalds No critical terrain	Can include slopes 33–50% Ephemeral wetlands and sand dunes	Can include slopes >50% Swamps, lunettes, lake bed, cliff face. Bank and bed of 5th order or greater streams.
Fine sandy loam soils Low rainfall Some exposure to wind	Fine sandy loam soils Low rainfall Some exposure to wind	Loamy sands and loose sands Moderate rainfall High exposure to wind	Loamy sands and loose sands Very low rainfall Very high exposure to wind	Not applicable
Naturally neutral soils (pH water >6.0) Low buffering capacity	Naturally acidic surface soils (pH water <5.5) Subsoils naturally acidic	Naturally acidic soils (pH water <5.5) Low fertility	Naturally acidic soils (pH water <5.5) Very low fertility Rocky and steep	Not applicable
Weakly sodic clay loams and clays, weakly self-mulching clays. (Exchangeable sodium percentage 3–8%)	Weakly sodic non self-mulching clay loams and clays. (Exchangeable sodium percentage 3–8%)	Sodic coarsely structured clays (Exchangeable sodium percentage 8–15%)	Strongly sodic clays (Exchangeable sodium percentage >15%)	Not applicable
Localised salinity outbreaks Hydrologic system: rapid in, slow out and a minor salt store	Numerous localised salinity outbreaks Hydrologic system: rapid in, moderate out and a moderate salt store	Widespread salinity outbreaks Hydrologic system: rapid in, rapid out and a moderate salt store	Widespread salinity outbreaks Hydrologic system: rapid in, rapid out and high salt store	Not applicable
Deep soils (>75 cm) Some rock outcrop (10–30%)	Shallower soils (75–50cm) Rock outcrop common (30–50%)	Soils shallow (<50 cm) Rock outcrop very common (50–70%)	Soils very shallow (<25 cm) Rock outcrop very common (50–70%)	Rock outcrop dominant (>70%)
Land is seasonally waterlogged for 2 to 3 months every 2 to 3 years	Land is seasonally waterlogged for 2 to 3 months every year	Land is waterlogged for 3–6 months of the year. Associated with drainage depressions and lower slopes in colder wetter climates	Land is waterlogged for more than 6 months of the year	Permanent water bodies
Evidence for some sheet and rill erosion and minor gully erosion which is restricted to the major flow lines	Severe sheet and rill erosion, active gullies on many minor flow lines	Severe sheet and rill erosion, active gullies on many minor flow lines. Many areas show bare ground and scalding. Gullies often show tunnelling	Extensive areas of sheet erosion and gullies are deep and remain active	Not applicable

Glossary

Cell Grazing — See Grazing Practices

Controlled Traffic — A technique, which can be used in cropping systems. Machinery used in the cropping operation is confined to the same wheel tracking width and ideally the same wheel width. The tracks are usually GPS-located and many operators are now using GPS for automatic steering to maintain tracks. Controlled Traffic aims to restrict soil compaction to the wheel tracks and allow maximum soil health improvement between them.

Conventional Farming or Tillage — See Cropping Practices

Cropping — A land use requiring sowing a cereal, oilseed or legume for the purposes of harvesting seed. The actual management practices used to grow the crop can have a large impact on the soil and land. Factors which determine that impact include:

- Was stubble retained?
- If stubble was burnt, how long before sowing was the stubble burnt?
- Was the soil tilled prior to sowing and when?
- What equipment was used to sow the crop?
- How much soil disturbance was there at sowing?
- Was Controlled Traffic used for machinery operations?

Cropping Practices — Terminology used in conservation farming and cropping can be confusing. Central West CMA supports the use of standardised terms adopted by the Conservation Agriculture Alliance of Australia and New Zealand (CAAANZ) and the Conservation Farming and No-Tillage Farming Association (CANFA).The sowing methods used will be influenced by the potential for erosion, paddock topography, existing vegetation cover and availability of appropriate machinery. There are several techniques that can be used; however the Central West CMA promotes the use of No-Tillage and Zero-Tillage in preference to higher land disturbance techniques.

Conventional Farming or Conventional Tillage (see Multiple Tillage below)

Multiple Tillage
Two or more tillage operations before seeding
This term effectively replaces 'Conventional Tillage' as the convention for many regions of the world is No Tillage.
Crops are sown into a seedbed which has had two or more cultivations before sowing with primary or secondary implements. Grazing and burning of residues are often practiced. Cultivation is for weed and soil disease control and residual herbicide incorporation. This has often been referred to as 'conventional farming' 'conventional tillage' or 'traditional tillage' in the past.
(Generally not sustainable)

Minimum Tillage
This term is now discouraged because of confusion associated with it in some parts of the world.

Reduced Tillage
One tillage pass before seeding with a full cut-out during seeding.
This describes the reduction in the number of cultivations from the Multiple Tillage system referred to above. The cultivations are usually replaced with the application of a knockdown or pre emergent herbicide. Grazing and burning of residues are sometimes practiced.
(Sustainable on LSC Classes 1 and 2)

Strategic Tillage
This is a single one-off cultivation or deep ripping of the soil for a specialised purpose.
Cultivation may be necessary for incorporation of ameliorants such as lime, leveling rough paddocks after a wet harvest, soil disease control or to alleviate compaction after a pasture phase.
(Sustainable on LSC Classes 1, 2, 3 and possibly 4)

Direct Drilling
One pass seeding with a full cut-out (topsoil disturbance).
Direct drilling is a direct seeding technique with no tillage before sowing. It may involve a sequence of operations such as: (i) hard grazing in the fallow period for weed control and residue depletion, and burning if necessary; (ii) the application of knockdown herbicides before sowing and (iii) sowing directly into an undisturbed seedbed with a full disturbance.
(Sustainable on LSC Classes 1, 2 and 3)

No Tillage
One pass seeding with a narrow knife point or disc, with 5-20% topsoil disturbance.
This is the direct seeding of crops into an undisturbed seedbed with soil disturbance only in the sowing rows. Stubble should be retained except for identified agronomic or physical reasons. The many forms of No Tillage must be based on maintaining maximum ground cover for erosion protection, providing a food source for organic matter improvement and protection for the soil biology. Ideally, stock should be excluded, or at least carefully managed to avoid compaction and soil pulverisation.

No Tillage uses sowing equipment with modified tines or suitable new machinery to overcome potential problems such as stubble handling, compacted soils, hardpans and seed/fertiliser placement. No Tillage machines usually feature at least one of the following items: specialised sowing points, high 'breakout' pressure tines, press wheels, advanced sowing systems (e.g. parallelograms, split systems) and coulters. The ideal combination and sowing width will be determined by soil type, soil physical condition and climate.
(Sustainable on LSC Classes 1, 2, 3 and 4)

Zero Tillage

One pass disc seeding with less than 5% topsoil disturbance.

This is the direct seeding of crops into an undisturbed seedbed with soil disturbance only in the sowing rows. It uses disc seeding technology to direct seed and fertiliser into the soil. The system involves minimum ground disturbance and has the ability to handle large amounts of stubble, usually at higher speeds. Soil diseases and sub-surface compaction and stones are potential limitations that need to be identified.
(Sustainable on LSC Classes 1, 2, 3, 4 and 5)

Pasture Cropping

Involves the direct seeding (using No Tillage or Zero Tillage) of an annual crop into permanent perennial pasture. It is a relatively new technique developed by landholders in Central West of NSW. One objective is to have minimal or no detrimental effect on the existing pasture. There is often an improvement to the pasture from residual fertiliser after the crop, and seed germination promoted by this slight disturbance involved.
(Sustainable on LSC Classes 1, 2, 3, 4 and possibly 5)

Raised Beds

This involves forming raised beds on soil types that are prone to waterlogging and soil structural problems (e.g. sodic soils). They are ideally suited to high clay content sodic soils. The beds must remain permanently to allow soil health development. Machinery has to be highly modified to suit the system.
(Sustainable on LSC Classes 1, 2, 3 and 4 where soil structure is the limitation)

Grazing Management

Grazing Management refers to the process of managing the frequency and intensity of how livestock graze pasture. Grazing Management should aim to manage the health of the pasture and balance the needs of the grazing animal. Any Grazing Management should maximise pasture production, improve groundcover and promote soil health. Grazing Management practices need to account for:

- Pasture species sown
- Annual or perennial
- Stocking rate
- Stocking rate matched to expected pasture growth rates
- Set stocking used
- Phased Grazing Management used
- The reasons for shifting stock off a paddock.

Grazing Practices

Continuous Stocking

This system allows animals to graze with a high degree of selectivity as the pastures rarely if ever receive a spell from grazing. Grazing of preferred species may lead to patch grazing or uneven growth. Depending on stocking rates, this system may result in poor ground cover and desirable plants may be eliminated from the pasture.

Set Stocking

Often used to describe continuous stocking, but more appropriately it is a term used to refer to a specific grazing period when stock are not moved. The bigger the

paddock and the lower the stocking density, the more selective the animals can be, placing pressure on desirable species.

Cell Grazing
Grazing cells comprise multiple paddocks, with stock densities normally above 200 DSE/ha. For most of the growing season, graze periods range from one to three days and rest periods from 40 to 90 days. Each paddock in the cell is rested for 95% to 98% of the year. The stocking rate and the length of the graze and rest periods are adjusted according to the feed on offer and the anticipated seasonal growth rates. The planned rotation is continuously monitored and re-planned as necessary. Nothing is fixed, and livestock may move through the paddocks in any order. (Earl & Jones 1996)

Rotational Grazing
The practice of maintaining a period of grazing followed by a period of rest. The rest period, or rotation length, is generally influenced by pasture growth rate and may vary from days to weeks and sometimes months. There is a wide variation in the number of paddocks in a rotational grazing system, hence the wide variation in graze period and rest period. The minimum number is usually four paddocks and may be as high as 30 or more in intensive rotational systems, for example cell grazing.

Tactical or Strategic Grazing
This grazing system involves setting objectives for a change in pastures.
It covers the adoption of a flexible management system with the aim of achieving a desired outcome. Tactics used in an individual year or paddock may not be applicable in a different year. Some examples for manipulating pastures by tactical grazing methods are listed below:

- Changing stocking density at critical times
- Resting at critical times e.g. after drought conditions or other stresses
- Allowing thin perennial pastures to seed down and regenerate
- Allowing newly sown pastures to set seed in years 1 and 2
- Using different types of stock. Sheep and cattle have different grazing habits and dietary preferences. Sheep tend to graze closer to the ground and can be highly selective, while cattle are less selective and are better able to utilise tall pasture growth
- Using dry stock, particularly wethers, to eat less palatable species or lower quality feed without penalty compared to young or lactating stock
- Crash grazing during flowering will reduce seed production of undesirable species as will tactical cutting for fodder conservation or even slashing.

Time Controlled Grazing
This grazing system is a rotational grazing system by definition with the length of graze period and recovery period determined by the pasture growth rates and the number of paddocks used in the rotation. The system pays particular attention to the amount of material left on pasture plants to allow for better recovery during the rest period. The graze period in a time controlled grazing system is usually short and intense with long recovery periods. Stock densities may be high, often in excess

	of 100 DSE/ha. The critical management decision to move the stock is based upon the state of the pasture and how much plant material the manager wishes to retain before stock movement. As a consequence of management being based around plant growth rates, the rate of rotation is likely to speed up during periods of faster pasture growth rates and slows down to allow for more rest during slower growth periods.
Gully Erosion	These are open incised erosion channels generally greater than 30cm deep caused by concentration of surface water flow. Gullies are sufficiently large that they disrupt normal farming operations. Incised erosion channels less than 30cm deep are termed 'rills'. Gullies are often associated with major concentrations of flows in drainage lines and depressions. When branching of gullies occurs away from drainage lines, gully erosion is considered to be severe.
Land Management Practices	The methods used to undertake a particular land use activity. For example reduced tillage might be the land management practice used to implement cropping and set stocking might be the land management practice to implement grazing.
Land Use	The general type of activity being undertaken. It might be grazing, cropping, horticulture or nature reserve or woodland.
Leaching	The movement of water-soluble minerals, including plant nutrients such as nitrate and calcium, through the soil as result of rainfall and irrigation.
Mass Movement	A general term for processes in which gravity is the primary force acting to dislodge and transport land surface materials including soil and rock. It is a function of the gravitational stress acting on the land surface and the resistance of the materials to dislodgement. It is the geomorphic process by which soil, regolith and rock move downslope under the force of gravity. Types of mass movement include soil creep, slides, flows, topples and falls.
Minimum Tillage	See Cropping Practices
Multiple Tillage	See Cropping Practices
No Till	See Cropping Practices
No Tillage	See Cropping Practices
Pasture Cropping	See Cropping Practices
Raised Beds	See Cropping Practices
Reduced Tillage	See Cropping Practices
Regolith	The layer of loose, unconsolidated material covering solid rock. It forms the surface of land nearly everywhere. The regolith includes soil, alluvium, dust and various deposits of weathered rock materials.

Rill Erosion

The removal of soil by runoff from the land surface whereby numerous small channels up to 30cm deep are formed. For practical purposes because they occur together, sheet and rill erosion are often combined to describe all erosion that can be obliterated by tillage. This combination of sheet and rill erosion is the erosion which is predicted by various erosion prediction tools such as the Universal Soil Loss Equation (USLE) and the SOILOSS Program.

Salinisation of Soils/Dryland Salinity

The accumulation of soluble mineral salts near the surface of soil. Usually caused by the capillary flow of water from saline ground water. Where the rate of surface evaporation is high, higher ground water levels can exacerbate the problem by moistening the soil and causing more water to be drawn from deeper levels as the near surface water evaporates. The evaporation of even relatively pure water leaves the salts behind, allowing them to accumulate. To counter the effects of dryland salinity land managers need to be aware of:

- The hydrologic regime of the catchment or the Ground Water Flow System
- The potential recharge and discharge of the hydrological system or catchment and the actual amount and rate of water moving into and out of the catchment
- The scale of the system whether regional, local or intermediate
- The 'head' of pressure driving the system
- The concentration of the salts in the soil and in the groundwater
- The types of salts present
- The pH of the soil.

(Charman and Wooldridge 2007)

Sheet Erosion

The removal of a fairly uniform layer of soil from the land surface by raindrop splash and/or runoff. For practical purposes because they occur together, sheet and rill erosion are often combined to describe all erosion that can be obliterated by tillage. This combination of sheet and rill erosion is the erosion which is predicted by various erosion prediction tools such as the Universal Soil Loss Equation (USLE) and the SOILOSS Program.

Soil Acidity/ Acidification

The build up of hydrogen ions in the soil which lowers the pH and increases the acidity. Many nitrogen compounds, which are added as fertiliser, also acidify soil over the long term. Acidification also occurs when base cations such as calcium, magnesium, potassium and sodium are lost from the soil – often by leaching (see page 28). Leaching increases with increasing precipitation. Plants also take bases from the soil as they grow. Where plant material is removed, as when a forest is logged or crops are harvested, the bases they have taken up are permanently lost from the soil.

This issue is complicated by the fact that many NSW soils are naturally acidic. Coarser textured soils are at most risk of acidification as they are readily leached. Farming systems that include the use of introduced, annual, legume-dominant pastures and the application of fertilisers, can accelerate acidification of soils or induced acidification of previously neutral soils.

For farmers, the most common way of treating soil acidity is to add agricultural lime (calcium carbonate) to the soil. The use of lime has increased markedly over the last 20 years, although its cost is often a limiting factor. Acid tolerant plants can be used in some situations where liming is not economic.

Surface soil acidification can lead to acidity in the subsoil, which is too expensive to treat for most agricultural land uses. (Fenton and Helyar 2007)

Soil Structural Decline/Surface Soil Sodicity

Soil structural decline occurs when the arrangement of soil particles is degraded. This is indicated by surface crusts, excessive cloddiness, high runoff and surface ponding. It is often associated with surface soils that are affected by sodium (sodic surface soils). Problems associated with soil structural decline include:

- Reduced infiltration of rain
- Reduced workability and trafficability of the soil
- Restricted root growth because of high soil strength and low aeration
- Increased erosion which lessens the long term productivity of the soil
- Restricted seedling emergence if the surface crust dries out.

Management of soils susceptible to soil structural decline includes:

- Improvement and maintenance of soil carbon levels
- Careful management of grazing to prevent compaction
- Minimum cultivation or no cultivation
- Stubble retention
- Use of gypsum and lime if required
- Mulching to maintain surface moisture and prevent raindrop impact.

Stubble Incorporation

This is the mixing of stubble and pasture residues into the soil before sowing. The practice commonly refers to the incorporation of cereal stubbles. Incorporation can be partial with a tined implement or nearly complete with a disc implement.

Water Holding Capacity

The ability of the soil to retain water, especially for use by plants. It is mostly influenced by the range of soil particle sizes and their arrangement (texture and structure) in the soil. After being saturated, a soil drains to its field capacity (FC) over a period of time (usually 48 hours). Then plants can extract further water until it is too firmly held by the soil (the permanent wilting point – PWP). The difference between FC and the PWP is the plant available water and is usually highest for loams and silty loams.

Zero Till

See Cropping Practices

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