Developing a land capability system for the Western Plains of New South Wales

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Abstract

Land capability is a system that is used for classifying landscapes according to the risk of soil degradation, particularly soil erosion. The system helps contribute to land use planning at property, catchment and regional scales. It has conventionally been determined by a combination of attributes including climate, soil, slope, terrain and existing soil degradation. The land capability system has mostly applied to the lower slopes and tablelands. There is no existing land capability system that adequately covers the dry Western Plains of NSW.

The Western Plains of NSW is defined by the Darling Riverine Plains, Cobar Peneplains, Murray-Darling Depression, Riverina and Wentworth bio-regions. It is characterised by little landscape variation, consisting of plains, small ridges, wide and undefined river channels and semi-permanent wetlands. Poor understanding of the capability of the land to support various agricultural land uses has contributed to extensive soil degradation in the area.

In 2002 a group of natural resource specialists with expertise in soil management on the Western Plains met to determine how the existing land capability system could be modified to be more relevant for this region. The primary purpose of this modification is to provide landholders in the Western Plains with a more appropriate means of classifying land on their property. The proposed land capability system is based mainly on soil attributes such as texture, clay behaviour, topsoil structure, subsoil colour, root depth, visible soil biota, salinity risk, watertable depth and pH. Under this system the land is classified as Class I-III (Land suitable for all agriculture), Class IV-VI (Land suitable for grazing) and Class VII-VIII (not suitable for agriculture).

This poster presentation shows how the proposed land capability system could be used to classify landscapes at the property scale in the Western Plains.

Key Words

Soil information, soil management principles, management recommendations, land class, land use.

Introduction

Sustainable agricultural systems are dependent on the use of land resources within their limitations. In this way acceptable levels of production can be achieved without leading to resource degradation. Consequently a number of systems have been devised to classify rural land according to its ability to sustain particular land uses with minimum risk of resource degradation (Cunningham et al. 1988). Rural land capability has been mapped at a scale of 1:100 000 for the Eastern and Central Divisions of New South Wales using climate, soils, geology, soil erosion, site and soil drainage characteristics and current land use attributes (Emery, 1986). The Western Division has mostly utilised Land Systems Mapping, carried out at a scale of 1:250 000 and based on recurring patterns of topography, soils and vegetation (Christian & Stewart 1958).

At the property level, land capability assessments have also been used as a basis for property management plans. Property scale land capability assessments require more detailed knowledge of soils than the broadscale mapping (Sonter et al. 2003). In response to this a more appropriate land classification system was devised specifically to assist landholders readily assess land capability at the property scale (Stanger,
This system aims to encourage landholders to use a suite of attributes when undertaking land capability assessment on their properties. It is based on attributes such as soils, slope, aspect and position in the landscape, as well as limitations such as nutrient imbalances, acidity, salinity, structural degradation, lack of organic matter and soil organisms (Brouwer et al. 1999).

Nevertheless, this property level land capability system has limited compatibility when applied to the landscapes of the Western Plains. The authors felt that it would be useful to further modify the system so that it can be applied to the parts of the Western Plains not covered by the Land Systems Mapping, based predominantly on soils information. The basic elements of this land capability system are that it is easy to use and based on soil management principles, rather than specific management recommendations.

The purpose of this paper/poster is to gain additional input from soil professionals on the appropriateness of using landholder derived soil information for making property management decisions. Following necessary modifications the authors intend to develop a publication to provide landholders and land managers in the Western Plains with a guide for assessing land capability on their own properties. This information could be shown on a property plan and used by landholders/managers in making land use decisions.

The Western Plains

The region designated as the Western Plains is located in the far-west of NSW and covers an area of approximately 240,000 km². They extend west from near Boggabilla to Weilmoringle on the Queensland Border in the north and from near Jerilderie to Wentworth in the south, extending south-west along the Darling River floodplain. The Western Plains comprise of the Darling Riverine Plains, Cobar Peneplains, and Riverina bioregions. Approximately half of the Western Plains is in the Western Division.

The Western Plains are characterised by little landscape variation, consisting of low gradient alluvial fans, extensive floodplains, wide and undefined channels, sand plains, dune fields, rolling downs, low undulating plains and stony ridges and ranges, and semi-permanent wetlands. The climate varies throughout the region including persistently dry semi-arid, which is characterised by hot summers and cool winters (Riverina), hot, persistently dry semi-arid (Cobar Peneplain) and hot, persistently dry (Darling Riverine Plains). The broad soil types distributed throughout the region are Rudosols, Tenosols, Chromosols, Sodosols, Calcarosols, Kandosols and Vertosols.

The importance of the Western Plains is determined by its increasing cropping pressure. This reflects an increasing trend for the establishment of broad acre cropping practices in areas that have been traditionally regarded as marginal for cropping. Within this region there is pressure to undertake activities that have potential to result in soil disturbance and vegetation removal.

Since part of this area occurs within the Western Division the Land Systems classification is applicable. The proposed Land Capability: Western Plains system is targeted mostly at the area to the east of the Western Division.

The system

Land capability is the ability of land resources to support particular uses without causing permanent land degradation or requiring unacceptably high inputs to maintain that use. The land capability system therefore provides a planning scheme enabling land to be allocated to appropriate land uses. It is a means of classifying landscapes according to the risk of soil erosion, and other forms of land degradation, under various agricultural land use systems. The land is classified on its development potential for sustainable use.

The existing Land Capability system was primarily developed for the eastern parts of NSW and has been a useful guide to landholders in this area. In these areas sloping land and the risk of water erosion were the main criteria used for determining the appropriate land capability class. The landscapes of the Western Plains are such that slope and water erosion is less useful criteria for assessing land capability. The land capability for the Western Plains is a modification of the existing system, still acknowledging the importance of these factors, while placing a greater emphasis on soil limitations, risk of wind erosion and the potential for other forms of soil degradation. The existing land capability system also tended to
prescribe particular land management practices based on conventional farming techniques for land classes. The modified land capability system involves establishing soil management principles for each class of land, thereby allowing for innovative farming practices.

The modified Western Plains approach is based on the eight class land capability systems as defined by Emery (1986). Table 1 shows that the Land Capability: Western Plains system also utilises these eight classes, designated by Roman numerals (I – VIII). As with the other systems these classes indicate that a progressively greater degree of physical land and soil limitations are present from class I to VIII (Murphy et al. 2004).

### Table 1 Draft land capability management principles and recommended practices

<table>
<thead>
<tr>
<th>Land Class</th>
<th>Land use</th>
<th>Management Principles</th>
<th>Recommended Management Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Land suitable for all agriculture</td>
<td>Maintain soil structure and organic matter levels.</td>
<td>No special soil conservation needs</td>
</tr>
<tr>
<td>II</td>
<td>Adoption of soil management techniques such as crop rotation and maintenance of groundcover levels.</td>
<td>Up to 4 crops in 10 years with conservation farming practices or more often if roots are undisturbed (i.e. no-till and control traffic). The inclusion of a pasture phase could also be used where direct drilling or controlled traffic is inappropriate.</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>Appropriate soil management measures as for Class II. Inclusion of specific soil conservation measures such as graded or diversion banks, grassed waterways or windbreaks. The adoption of conservation farming practices (direct seeding, stubble retention and stubble incorporation). May also include liming, fertiliser amendment and less intensive crop rotations.</td>
<td>Suitable for limited rotational cropping. Up to 4 crops in 10 years, or more if using conservation farming practices where the soil undisturbed. If conservation farming practices are not used then graded banks or permanent vegetation cover should also be used to prevent runoff damage.</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>Mainly grazing</td>
<td>Conservation farming Strategic grazing, fertiliser application, active management of topsoil organic matter levels, soil structure and acidification. Use of strategic earthworks and/or windbreaks Maintenance of adequate groundcover</td>
<td>Suitable occasional fodder cropping or semi-intensive grazing. May be capable of dryland development or irrigation where applicable. Up to 2 crops in 10 years with conservation farming practices or more often if roots are not disturbed - for the purpose of renewing</td>
</tr>
<tr>
<td>V</td>
<td>Grazing management to maintain groundcover and/or intensive soil conservation earthworks to control erosion. Earthworks may include diversion banks and contour ripping together with management practices defined in Class IV.</td>
<td>Permanent pasture or woody weed control. Attempt to achieve 60% groundcover or more of which at least 60% to 70% is perennial vegetation cover. Maintain pasture cover taller than 5 cm.</td>
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1 While these are recommended practices they do not preclude the adoption of innovative practices that are found to be more appropriate.

Factors used to determine land capability in the Western Plains

The proposed system is designed so that landholders can carry out land capability assessments of their properties. As such, we have adopted landscape and soil rating terminology that is commonly used by landholders in this region. This approach is consistent with recent research in soil health monitoring using classification schemes that are understood and defined by landholders (Lobry de Bruyn & Abbey 2003).

In this region land capability is most appropriately defined according to soil attributes such as texture, pH, depth, soil biota, sodicity, salinity, wind erosion risk, and other attributes including climate, rock outcrop and drainage.

Climate

The relevant climatic factors are those affecting plant growth, such as soil moisture availability, rainfall and wind erosivity. Note that in the Western Plains, stored soil moisture plays a greater role in determining the potential for crop growth than in eastern NSW. The classification criteria are as follows: Moist climates are those where winter cropping is generally not restricted more than 40% of years by available soil moisture. Dry climates are those where winter cropping is restricted to less than 50% of years by lack of soil moisture. Semi-arid climates are those where cropping is only possible in years of exceptional rain or flooding events. Arid climates are those where soil moisture is so low most of the time that native plants are the only properly adapted vegetation that can provide land protection.

Cropping cannot be recommended in arid regions unless sustainable irrigation is available.

Position

The position of the area within the landscape can affect the presence and amount of surface and subsurface run-on. There is less time for water to soak into the soil on convex slopes such as ridges and
therefore soil moisture for plant growth is more likely to be lacking. The ridges, which are numerous throughout the Western Plains, shed water more easily and therefore have a higher soil erosion risk. **Side slopes** generally have deeper soil and better capacity to store soil moisture than ridges. However, heavy rains can cause high velocity flows and gully erosion along drainage lines. Also, major rainfall events can result in sheet and rill erosion from overland flows. **Foot slopes** may accumulate more soil moisture by run-on from up-slope areas but have a higher erosion risk if the flows are confined. The risk of soil erosion is lower on the **plains**, as floodwaters generally rise and fall with little velocity. **Creeks and swamps** are generally not recommended for cropping because of erosion risk or environmental impacts such as loss of wetland vegetation, nutrient and sediment pollution of water or salinity.

**Slope**

Erosion hazard increases with slope steepness because it produces greater volumes per unit of time and velocities of runoff water. As hills and undulating areas exist within the Western Plains this factor is utilised in the scheme. **Flat** slopes are those where even heavy rain produces very little runoff, and nearly all the water eventually soaks into the soil or evaporates. **Gentle** slopes produce some runoff in heavy rains but are generally < 2% (a rise of 2 metres in 100 metres). **Hilly** slopes produce significant amounts of runoff with heavy rain even when fully vegetated and **steep** slopes produce runoff even with light rains and need to retain perennial vegetation for land protection. Slope length should also be considered as small amounts of runoff accumulating down the slope can become a significant flow at the bottom of a long slope.

**Soil factors**

Information on soils can provide an indication of the land’s ability to support cropping and grazing activities without soil degradation. It is particularly relevant in the Western Plains where the widespread low relief terrain it is often difficult to assess. The following soil characteristics can be used to help assess land capability in the Western Plains:

- **Texture.** Topsoils with a relatively even distribution of particle sizes from sand to clay, i.e. loams to clay loams, have greater capacity to support agricultural activities than soils that are either very sandy or very clayey. They are better able to withstand cultivation and stock trampling with minimal soil degradation. Soils with medium to heavy textures (loams to light medium clays) have a greater ability to support cropping. Soils with light textures (sands, clayey sands and loamy sands) are less stable and require protection against erosion, which can only be provided by undisturbed vegetation, and have less ability to store soil moisture.

- **Depth to bedrock.** The depth of the topsoil and the total soil profile is important, along with soil texture, as it governs soil water-holding capacity. It also determines the volume of soil available for root penetration, and is also important in controlling the available store of plant nutrients. A depth of at least 75cm of soil is required for cropping. Shallow soils are more suitable for grazing, while very shallow, less than 5cm soils, need the protection of a permanent undisturbed cover of vegetation. Shallow soils and soils with shallow topsoils are inherently more fragile in respect to soil erosion. Any soil loss from a shallow soil represents a greater proportional loss of the resource and thus is more significant than on deeper soils.

- **Subsoil colour.** The colour of the subsoil is an indicator of soil drainage and soil erodibility. Red and brown subsoil colour is indicative of good drainage and is usually found on sloping country. Yellow and grey subsoils are indicators of impeded drainage and more erodible soils, and are usually found on the lower slopes and within drainage lines. Mottled (speckled) subsoils also indicate poor drainage and high erodibility, and may be associated with waterlogging or a fluctuating watertable. The subsoil, not the topsoil, is used to assess soil colour.

- **Soils structure (Ease of Tillage).** Soil structure refers to the way in which soil particles are arranged or combined into soil aggregates. The structural stability of a soil determines its response to wetting, drying and manipulation and their ability to sustain tillage and grazing practices. The criteria for soil structure include: Self-mulching; these soils have high clay content which gives them the ability to expand and contract upon wetting and drying. The high content of expansive clays allows natural rebuilding of structure through cracks that let moisture and roots invade the soil. Soils that are Easy to Work may be loamy or have sufficient organic content to allow low horsepower tillage. Soils that are Hard to Work include those with tough clays that need to be moist to allow tillage and may be easily

damaged by compaction. There is a higher horsepower requirement for tillage. Soils that Set Hard have a sodic clay content high enough to cause surface sealing, poor seedling emergence, and loss of pore spaces when organic matter is low. Soil that Set Very Hard are highly sodic clays that form water resistant pavement surfaces. They are sloppy when wet, but will reform the hard pavement surface quickly when they dry i.e. a hardpan condition whereby iron or silica forms the cement. These soils are very difficult to prepare when dry and cause high wear rates on plough equipment. Vegetation establishment is naturally difficult a situation exacerbated by a propensity to scald.

Soil life. Organic matter is nature’s slow release fertiliser and the presence of organisms is the difference between living soil and dirt. Excessive cultivation can reduce organic life Soil with Lots of signs of life display the presence of earthworms, beetles and ants etc or their burrows. The presence of large animals may indicate high levels of microorganisms etc. if the latter are a food source. Soils with Some signs of soil life are those with plant roots and fungi but little evidence of larger soil organisms. Soils with Little life signs have few roots or living organisms. There may be charcoal present, which indicates previous soil life, but there is currently little living organic matter. None, means there are no life signs visible to the naked eye.

Existing erosion
Existing gullies impede cultivation access, can force furrows into an undesirable up-down slope arrangement, and lower local subsoil moisture-levels. Soil erosion may modify soil texture and structure, if loamy topsoils are washed or blown away exposing sub-soil material. Eroded sodic subsoil clays deposited down slope may degrade that topsoil, and prevent vegetation persistence. The criteria for recognising existing erosion include: None, where there is no evident loss of soil or organic matter by water or wind. Areas of Little erosion are limited to minor topsoil loss through sheet erosion or wind loss. Some erosion can be recognised by scars (gullies or scalds), or loss of topsoil by wind with reduced production potential. Lots is where existing erosion is not controlled and affects access, cultivation or grazing production by changes to soil fertility, water-holding capacity and drainage, or local topography.

Wind erosion risk
The risk for wind erosion is related to the ease or transport and the power of the wind. Wind power increases with speed and duration of a wind event. Wind erosion is a significant problem in the drier areas of NSW where the more sandy soil types can be mobilised if they are not protected by plant cover. Repeated disturbance of a soil surface by tillage or stock will break soil into finer aggregates that are more susceptible to wind erosion. The loss of these finer particles (organic matter and clay) often results in a loss of fertility and the ability of the soil to retain moisture for plant growth.

Wind erosion usually occurs on land that is cultivated or on grassland or shrubland that has been severely grazed to leave bare soil. Frequent cultivation to prepare a seedbed for sowing often causes the break down of soil structure and increase its susceptibility to wind erosion. The most severe wind erosion problems occur in areas of light sandy and loamy soils. Areas of Low Risk occur where there is heavy soil texture and good groundcover. Areas of Medium Risk occur where there are medium textured soils used for crops or where grazing reduces groundcover. Areas of High Risk occur where there are light textured soils exposed to wind by loss of groundcover through cultivation or poor grazing management.

Soil salt level
Soil salt is an important contributor to the overall salinity hazard within a landscape. Soil tests such as Electrical Conductivity (measured in deciSeimens per meter) can be used to determine whether or not salinity is a hazard. The following scheme can be used to assess soil salinity levels:

- Low salinity: < 2dS/m
- Moderate salinity: 2-6 dS/m
- High salinity: 6-15 dS/m
- Extreme salinity: >15 dS/m
**Watertable depth**

Water table is that level in the soil where the pore space is occupied by water, with all air excluded. A high water table can become a problem for plant growth and land stability if waterlogging or salinity occur. The following criteria are used. At more than 5 metres there is minimal risk of the soil surface being effected by waterlogging or salinisation. The soils are likely to be well drained. At between 5 - 2 metres there is sufficient risk of waterlogging or salinisation from the fluctuating watertable that actively growing vegetation cover should be maintained. At less than 2 metres there is an extremely high risk of waterlogging and salinisation which can affect plant growth. For this reason deep-rooted perennial vegetation should be either retained or restored.

**pH level**

Most plants grow best with a soil pH close to neutral (pH 7). The pH levels used here are those from a water test or simple field test kit available to all land owners at garden shops or hardware suppliers. As pH moves away from neutral, nutrient deficiencies or imbalances are more likely, and a smaller range of plants are able to cope. Land stability or land use sustainability is compromised as fewer plant species are able to persist. The criteria that are used for pH are: Soil with a **pH Near 7** are suitable for most plants. A soil with a **pH < 5** are acidic and are generally unsuitable for cropping due to aluminium toxicity, manganese toxicity, calcium deficiency and molybdenum deficiency. Soils with a **pH > 8** are highly alkaline and may be evident of soil sodicity or saline soils.

We have developed a key that enables landowners/managers to determine the land class by inputting the above nine land and soil characteristics. This key is the central component of the poster presentation.

**Conclusion**

This adaptation of land capability system is being developed primarily to support landholders in the Western with the development of property management plans. The system is intended to align closely with the revised statewide land and soil classification system (Murphy et al. 2004).

**References**


