

**Soil-landscape mapping for the
Buntine-Marchagee Recovery Catchment**

For the Department of Conservation and Land Management

Land Resource Assessment and Monitoring

**Department of Agriculture
Western Australia**

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Summary

A soil-landscape map of the Buntine-Marchagee Catchment at the scale of 1:100,000 was prepared, largely as a desk-top digital upscaling mapping exercise. This was prepared for the recovery catchment process under and commissioned by the Department of Conservation and Land Management. It was based on draft soil-landscape mapping at the scale of 1:250,000 that was reviewed with the benefit of digital geology mapping, satellite imagery and digital elevation model derivatives such as shaded relief map. The mapping was briefly validated by field observations. Very little revision was needed for the level of field observation undertaken.

The map units were described and to each, the soils expected to be present from the point observations were proportionally allocated. From the model soil and land characteristics developed in the Map Unit database of the Department of Agriculture, interim land quality data was generated for each map unit. The main land quality issues for the catchment were briefly discussed.

Thirty-four soil-landscape units were mapped (subsystems and phases) in the catchment. These belong to 5 soil-landscape systems. Separate maps of the systems and subsystems/phases are provided on the CD-ROM. Also on the CD-ROM are interpreted products showing the distribution of the main soils and a selection of land qualities.

Over fifty representative soils were recognised for the Buntine catchment. These are assigned to the mapped units and representative profiles have been identified.

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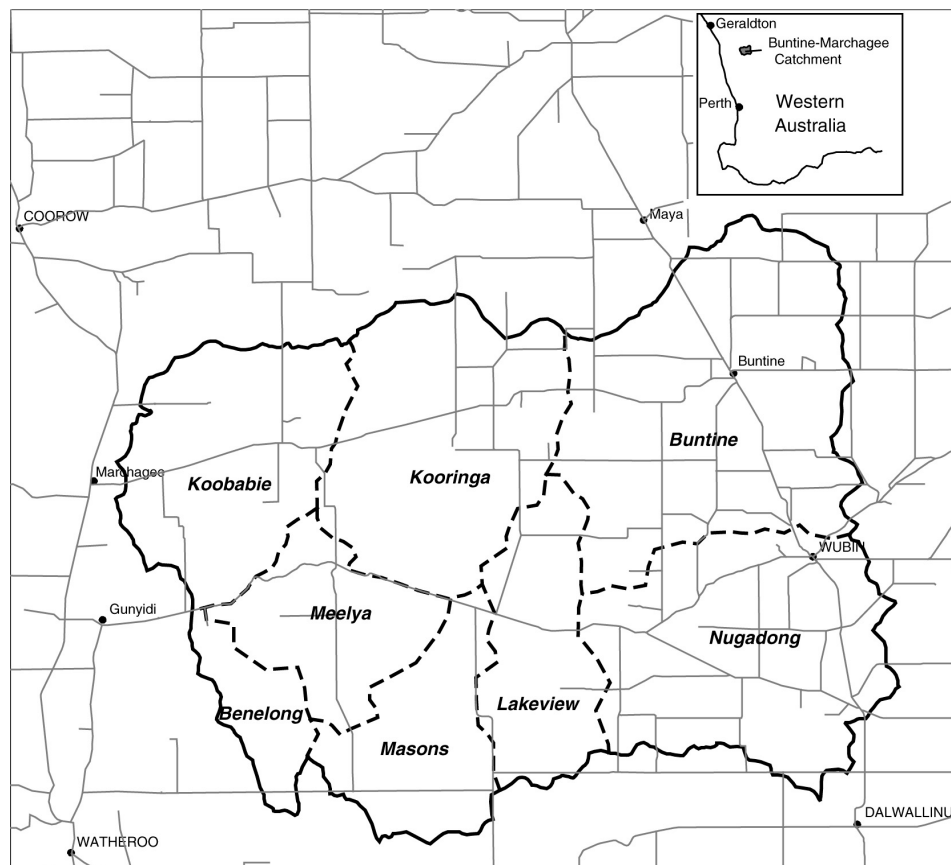
Introduction

The Buntine-Marchagee Catchment has been designated a recovery catchment under the Western Australian Salinity Action Plan. The development of management plans to foster the protection of the valuable biodiversity identified to be under threat from the products of land clearing requires a map of soil and landscape attributes at an appropriate scale.

The catchment is a tributary of the Moore River and occurs between Dalwallinu and Coorow (Figure 1). It is within the regional scale draft soil-landscape mapping prepared by Mir Framand at a scale of 1:250,000. This mapping was used in the studies on the Marchagee Recovery Catchment.

This was initially evaluated and considered to be imprecise both spatially and in its characterisation of the map units. Also, from experience, catchment planning requires a mapping scale of approximately 1:100,000. The challenge was to improve the scale of mapping in a timely and cost efficient manner.

Figure 1 Buntine Marchagee Location Map
(subcatchments named)



Methods

Mapping units used

The mapping style will be compatible with the existing soil-landscape mapping conducted by the Department of Agriculture. This has an hierarchy of map units with a number of ranks (levels) which recognize different degrees of complexity of landscapes, soils and parent materials (Purdie 1993b). Figure 2 provides an example of the hierarchy. The mapped units are typically subsystems and phases for scales more detailed than 1:250,000. It is implicit that through the hierarchy smaller scale maps of, for example systems, can be produced by aggregating larger scale units (subsystems and phases).

These units are still heterogeneous. They are characterized by both descriptive elements, eg landscape and soil, and semi-quantitative estimations of a number of recognised but unmapped land units. For the database they are defined as combinations of soil type and landscape position. They are expected to be mappable, either singularly or as complexes at more detailed scales of say 1:5,000.

As part of a standard procedure for soil-landscape mapping, a range of soil and landscape values for land qualities (eg water repellence and water logging risk) have been assigned to the land units allowing the preparation of indicative maps of land degradation risks and land capability maps.

The current product uses subsystems and phases as its most detailed unit. Its expected reliable scale of printing is 1:100,000. The degree of accuracy and detail contained is expected to be useful at the catchment scale. Its use at farm scale needs to be considered with caution. The scale influences:

- how homogeneous the map unit is,
- how accurate the lines are, and
- how accurate the descriptions and attributions are.

Also, because the description and attributions are based on an summary of all occurrences of each map unit, there may be significant deviation from this summary for a particular occurrence. The information provided, however, is based on the best available at the time of preparation.

Figure 2. Hierarchy of soil-landscape map units used by the Department of Agriculture.

1. Regions

Broad subdivisions of the Australian continent (Bettenay 1983).

e.g.: The Western Region (2)

2. Provinces

Provides a broad overview of the whole state suitable for maps at scales of about 1:5,000,000 (Division of Soils, CSIRO 1983).

e.g.: The Avon Province (25)

3. Zones

Areas defined on geomorphologic or geological criteria, suitable for regional perspectives.

E.g.: South-western Zone of Ancient Drainage (259)

4. Systems

Areas with recurring patterns of landforms, soils and vegetation, suitable for regional mapping at scales of 1:250,000.

E.g.: Kukerin System (259Kk)

5. Subsystems

Areas of characteristic landforms features containing definite suites of soils, suitable for mapping at regional scales of 1:100,000.

E.g.: Kukerin 1 Subsystem (259Kk_1)

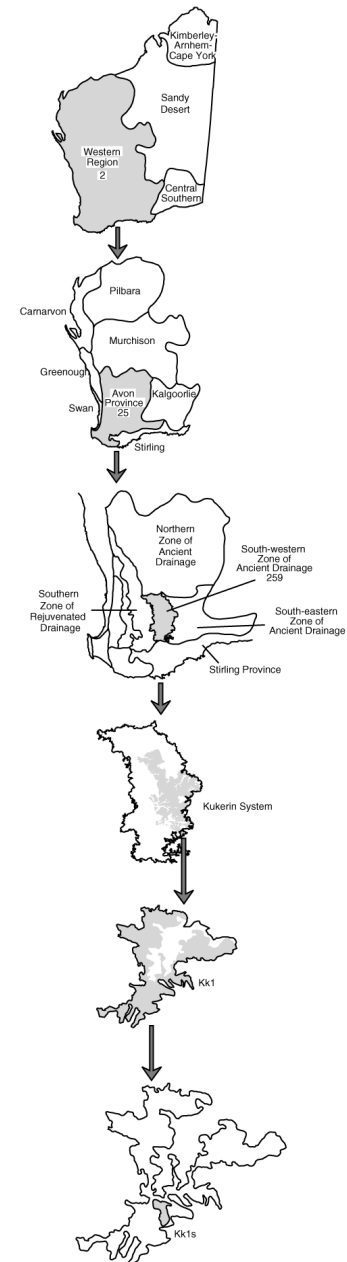
6. Subsystem phases

Division of subsystems based on land use interpretation requirements.

E.g.: Kukerin 1 sandy phase (259Kk_1s)

7. Land units

Describe areas of land with similar soils, slopes and landforms. Land units are unmapped at regional scale mapping.



Current Mapping

Initial Evaluation

With the experience of the mapping at Lake Bryde (Griffin et al 2001) it was considered that a desktop exercise based on interpretation of the Land Monitor digital elevation model (DEM) might be successful. Several other data sets were available for use including the draft soil-landscape mapping, soil site observations, surface geology mapping (Baxter and Lipple, 1985, Carter and Lipple, 1982), satellite imagery and 1:25,000 colour photography.

Initial interpretation led to the following conclusions about the data:

1. The draft soil-landscape systems (small scale map units) based on the mapping of Frahm and (unpublished) are sound.
2. Surface geology maps contain valuable interpretations. The challenge was to determine how spatially accurate and representative of the landscape they were. The need to edge-match two separate geology maps added to the challenge. It was concluded that the information content was quite valuable and broadly reflected the soils and landscapes. The maps proved to be incorrectly placed with the shift being variable and up to several hundred metres out. The mapping was warped (adjusted) by a computer program so that shapes representing distinct features such as playa lakes were in the same position as they were on the satellite image and the DEM.
3. A semi-automatic classification based on the DEM derivatives was not considered likely to distinguish the landscape elements as well as was done at Lake Bryde. This was because the very low relief, the smoothed slopes of the landscape, the frequent occurrence of sand dunes in elevated parts of the landscape and the significant amount of “noise” in the 10 m DEM.

However, the sunshaded relief map (derived from the DEM) includes strong evidence of landscape processes. More detail of these was available in the 10 m DEM than in the 25 m smoothed DEM that was used for Lake Bryde. The features such as flat valleys, dunes, playa lakes and stripped slopes showed out well. These features were mappable by on-screen digitising.

4. The TM satellite image (summer, 2003) provided valuable information about lakes and drainage lines and surface soil colour. In the latter regard, bands 7, 4 and 1 represented as red, green and blue respectively appeared very satisfactory in separating the red and brown soils from the yellow and pale soils. When combined with a landscape development model that was becoming evident, strong correlations were evident.

Methods Followed

1. Define hydro-aeolian drainage lines (and major flat valleys) from DEM derivatives, generally on-screen digitizing from the sun-shaded relief map. The satellite images helped clarify the location of some lines.
2. The draft soil-landscape system concepts were accepted and the boundaries refined using the DEM derivatives and geological boundaries in areas where system boundaries appeared likely to be coincident or diffuse.
3. Accepted that the “correctly” positioned geology units probably represent the main landscapes and soil materials. This geology was then intersected with the refined soil-landscape systems (above) and the product shapes assigned concatenated labels from both the system and the geology units. These new shapes were considered potentially subsystems or phases.
4. Correlated and renamed the new units to the best match of exiting soil-landscape subsystem concepts. Some review was needed and occasionally a new subsystem was required.
5. Lakes, drainage lines and saline areas, all potentially soil-landscape phases, were digitized on screen from the satellite image. Areas of dunes were common were mapped distinct from undulating sand plains.
6. The mapping was reviewed on screen, map unit at a time, in an attempt to improve the correspondence of the mapping to the shaded relief map and the 741 TM satellite image. The existing several hundred soil point observations were used to assist in the understanding the map units. Some checking was done against stereo pairs of 1:25,000 colour aerial photographs.
7. The draft mapping, in its electronic form, was taken into the field for checking on strategic transects along road sides. Real time GPS recording was used to match new field observations to the mapping. Over 200 site-specific observations were made including data such as the most likely WA Soil group. While the transects were strategic, the specific observations were made in response to changes in the “real” landscape, vegetation and soil. In most cases, the field observations were consistent with the mapping. The observations served a second role in assisting in the documentation of the map units.
8. The mapping was further reviewed, especially in the case where some of the geology units were ambiguous. Some further on-screen digitizing was possible because of the clarity which the field observations brought.

9. Many of the geology units were amalgamated especially those that indicated the presence of various different rock types near the surface. This was done on the basis that evidence was scanty that these meant different soil-landscape units. They may prove to be so. The lines used in this stage of mapping are available to follow that through if appropriate.
10. The map unit in which each soil occurred was determined by a spatial intersection with the map units. From this association, evidence was compiled to clarify the map unit concept and particularly to assist in the description of the map units.
11. The expected unmapped land units for each of the map units was determined from existing attribution from the draft regional surveys, the map unit's concept and the soil point observations. In cases, where there were no soil point observations in a given map unit, the allocation relied on its concept and landscape to soil correlations for the area.
12. Representative profiles were selected from soil point observations within the catchment and in the surrounding areas. Criteria for selection included how detailed the observations were. High consideration was given to selection if the observation was from a pit and/or it had laboratory analysis.
13. The representative soil point observations were allocated to the unmapped land units, but many land units, especially the least common ones, were left with no representative soil allocated.
14. By means of an elaborate semi-automatic procedure of allocating characteristics to soil types and landscape positions, a set of land quality values (eg water repellence and water logging risk) were assigned to all land units. It should be emphasised that these values for land qualities have not been validated as they should be.
15. A series of maps were produced showing the distribution of soil types (deep sands) and the distribution of the more limiting values from the range of land qualities (eg high water repellence).

How to use this report and CD-ROM

The soil-landscape map and the detailed survey results are presented on the accompanying interactive CD-ROM using Web-browser software. A hard copy of the soil-landscape map can be printed from the pdf provided or purchased from the Department of Agriculture, Western Australia.

The CD-ROM is a complete presentation of the survey results together with several supporting documents and general information of Land Resource Assessment in Western Australia. The CD is designed for better access to information and to allow efficient creation of new editions as new information and better interpretations are made.

The map and associated files on the CD-ROM have three main functions:

- describe and represent spatially areas with similar soil and landforms,
- to identify soils and associated soil properties at a point or area of interest, and
- to show the general distribution of soils, soil properties or land qualities.

Descriptions

A series of auto-generated descriptions are the core of the CD-ROM. These are generated from various parts of the CD-ROM. There are a number types of descriptions.

1. Soil-landscape zone

- descriptions of the unit, and
- an outline of the systems within the zone. These have links to the system descriptions.

2. Soil-landscape systems

- descriptions of the system under the headings: location; landform; geology; soils; and vegetation,
- an outline of the map units which comprise the system within the survey area. (with links to the subsystem descriptions), and
- a summary of the WA Soil Groups present in the system (with links to the WA Soil Group descriptions),

3. Mapped Units (usually subsystems and phases, sometimes systems)

- a description of the map unit under the headings: landform; geology; soils and vegetation,
- a table presenting the expected proportion of unmapped land units in the subsystem. Each land unit is a combination of a WA soil group, the soil group qualifier and landscape position. There are usually several land units present, each occupying different proportions of the map unit. The most common soil is included under the heading Main Soil. Each land unit has links to WA Soil Groups, land qualities and Main Soils.

4. Land Qualities

- a tabulation of the attributed land quality values for the current land unit with links to the definition of the land qualities.

5. Main Soils

- a description of the main soil with links to the description of soil profiles. Most of these (eg Buntine 505ALK) are concepts linked to a profile. Some are formally described Soil Series. These have definitions, links to profiles and some land use comments.

6. WA Soil Groups

- a description of the current WA Soil Group with links to a distribution map and photo.

7. Soil Points

- a description of the location of the soil point, morphological description of the layers observed and a tabulation of any laboratory data.

The home page on the CD-ROM is a menu that provides access to various aspects including report chapters, mapping and of specific map units, main soils or soil point observations. Most of these documents have links to different portions of the results. If you want a specific map unit or soil, use the menu to open the descriptions. If you want to view the mapping or a particular portion of it, click on the "Interactive Maps".

Mapping

The presentation of the mapping is designed to show various profiles and topics (left-hand side menu) such as soil-landscape systems, each with various legend items, eg towns and roads (right-hand side menu). The legend items can be turned on or off. The maps are interactive, as moving the cursor over the map window will demonstrate. The active map unit will be highlighted and a brief label (known as a tool-tip) will appear. By clicking on the map window, a report of either the active map unit or soil point is generated.

Soil-landscape maps are presented as two levels of detail, systems and mapped units. (The latter is typically a combination of subsystems and phases.) You may choose the particular level or start with systems and zoom in. This will automatically switch to the more detailed mapping.

You can view the whole map and then zoom and pan into an area of interest. Alternately, you can use the Find tool, which, after selection, focuses you on that locality or road name.

There are two types of interpretive maps, one showing the distribution of the main WA Soil Groups and one showing the distribution of the main land

degradation issues. Both are based on the subsystems mapping and can only be viewed at that scale.

Results

Map units

The catchment is in the Northern Zone of Rejuvenated Drainage. This is an area of gently undulating plains with sluggish drainage dominated by playa lakes. Five soil-landscape systems (Figure 3) are recognised representing areas of land where different soil formation processes dominate. One is low hills and rises, three are undulating plains and one is an alluvial plain.

Inering Hills system is an area of low hills and intervening valleys with moderate to gently inclined slopes, with many rock outcrops and some dolerite dykes particularly along ridge crests. Its soils are typically brown and yellow sandy and loamy duplexes, some earths, clay and rock.

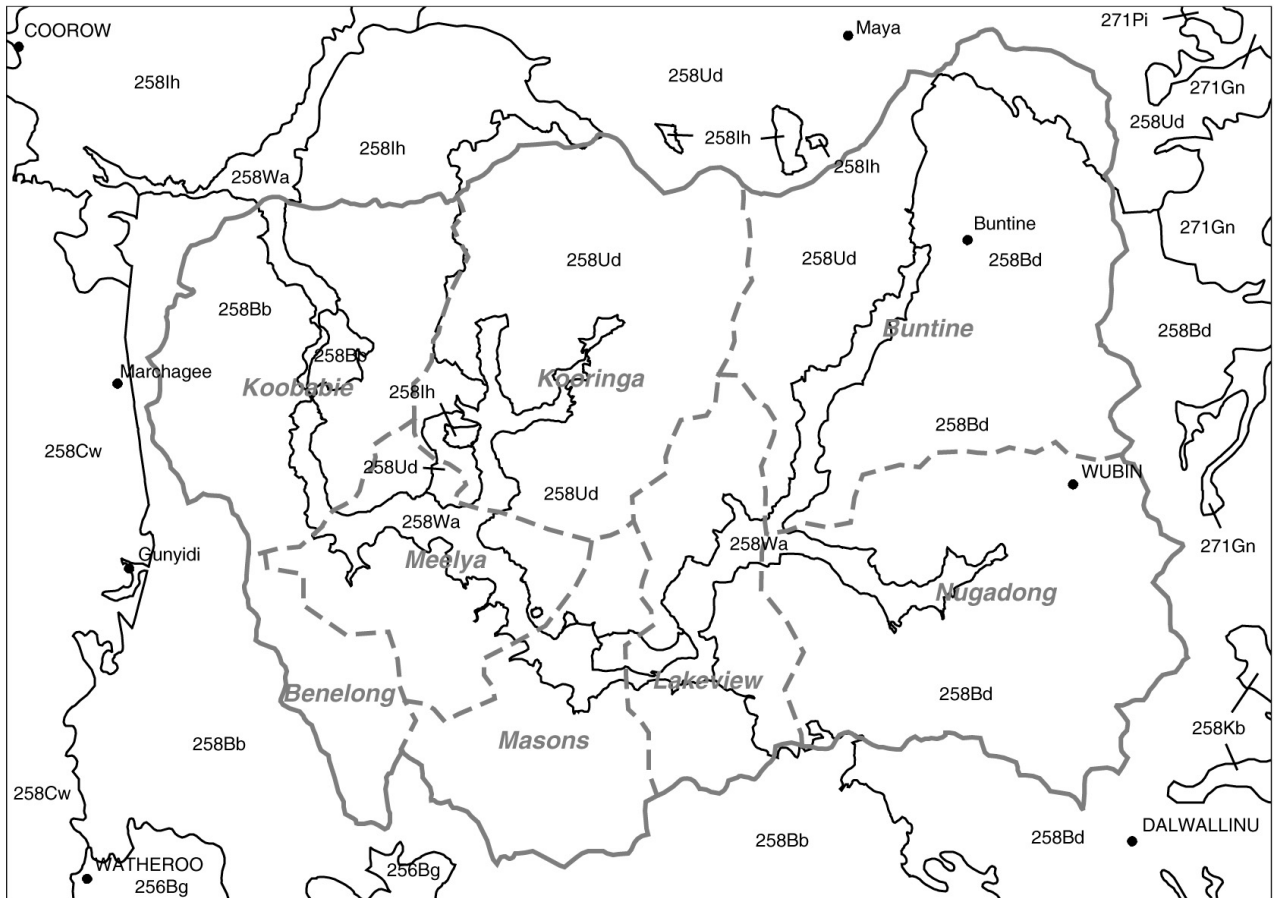
The Upsan Downs system is an area dominated by sandplain. It has small areas of soils derived from partially weathered rock. Narrow drainage lines filled with sandy colluvium and finer textured alluvium on which duplex soils formed.

The Ballidu system is also a gently undulating plain with a significant proportion of sandplain but has generally lower relief than Upsan Downs. It also has small areas of soils derived from partially weathered rock with rock outcrop being more common. Its valleys are more prominent than in Upsan Downs being narrow alluvial plains dominated by red and brown duplex soils.

In the west of the catchment the Balgerbine system. This is a gently undulating plain over which parabolic sand dunes have passed from their origin in vicinity of the Pinjarrega Lake. (Although they started many kilometres away, much of the sand would probably be of local eg < 5 km from its destination.) These dunes have left the majority of the area clothed by sand, some of which is in recognisable dunes. The more conspicuous dunes have originated locally in the wider of the sandy valleys. These valleys have swales which are now commonly either small lakes or swamps. The sand sheets have in places filled or crossed the major alluvial plain of the catchment.

The Wallambin system is an alluvial plain characterised by hydro-aeolian processes. In particular it has many playa lakes with lake fringes and plains which show signs of wind transport. Characteristic of the system is the evidence that saturated subsoils played a part in the development of the majority of the soils. These features distinguish this system from the narrow alluvial plains of the other systems. The areas of sand transgressing from the west has made the soils in the vicinity sandier but not significantly modified the nature of the system.

Figure 3 Soil-landscape Systems of Buntine Marchagee
(subcatchments in grey)



Soils

Yellow deep sand and Yellow sandy earth dominate more than a third of the catchment. Related sandplain soils such as Ironstone gravelly soils, and Yellow/brown sandy duplexes account for an additional third. About 10% are hydro-aeolian valley floor soils such as salt lakes. The remainder of the catchment has soils of the relatively “fresher” soils associated with exposed and partially weathered parent rocks.

To be expected from the map descriptions above, Balgerbine is dominated by Yellow deep sand. Yellow deep sand or Yellow sandy earth dominate Ballidu and Upsan Downs. However, Ballidu has in addition more valley floor duplexes and Upsan Downs has more Ironstone gravels and related sandplain soils. Inering Hills is dominated by the duplex soils from colluvium and fresh rock. The main trunk valley (Wallambin) is dominated by saline soils and pale sandy duplexes.

Interpretation of land resource survey results

The interpretation of data collected in regional land resource surveys is based on current knowledge of soil properties, distribution and behaviour. This information is used to determine whether a soil or a mapping unit is susceptible to degradation or is suitable for a particular use (land use interpretation). This assists land managers in making decisions. The interpreted data is presented as land qualities.

Land qualities are attributes of the land that affect its capability for a specified use (Wells and King, 1989). Some characteristics such as water repellence or susceptibility to subsoil acidification can be attributed directly to soil. Others are linked directly to the land unit such as flood risk regardless of the soils present. Most land qualities are derived from a combination of soil and landscape characteristics.

Land qualities have been assessed for each land unit (the combination of qualified soil group and landscape position). The assessments were made using the methods outlined in van Gool, Moore and Tille (in prep.). The complete set of land quality assessments for each map unit can be accessed using the CD-ROM.

Land qualities are used when making capability assessments for particular land uses or to prepare specific land degradation hazard maps. No land capability maps have been included in this report as the methodology and results are being assessed. Interpreted maps for five land degradation issues considered most relevant to the survey area have been included on the CD-ROM. These are Salinity Risk, Structural Degradation, Water logging, Water Repellence and Wind Erosion.

Salinity Risk

Salinity can be classified into primary and secondary types. Primary soil salinity is not induced by land clearing. It occurs throughout the world in arid climates and is prevalent towards the eastern margin of the agricultural region, but also includes existing salt lakes and salt marshes in higher rainfall areas. Secondary soil salinity occurs due to changes in land use and management - mainly the clearing of perennial vegetation. It develops when groundwater (especially that which is saline) rises and evaporates leaving the salts behind. Salts accumulate in the soil to toxic levels, which only the most tolerant plants can survive. Extremely high salt levels result in bare soil. The lower water use by agricultural species has been the main cause of groundwater levels rising.

About 5% of the Buntine Marchagee catchment is presently saline and an additional 5% have a moderate to high risk of becoming saline. As expected, most of these areas are in the valley floor (Wallambin system). The channels

and to a lesser extent the narrow alluvial plains of other systems are also expected to have some risk of salinity. The sandy swales and swamps of the Balgerbine system have a distinct but small risk due to the evaporation of relatively fresh water.

Surface and subsurface acidification

Across the survey area, the sandy surfaced soils usually have acid or strongly acid topsoils or near surface soil. Most commonly these include deep sands, sandy earths and some sandy duplexes.

Acid surface and subsurface soils are most common in all but the Inering Hills and Wallambin Systems.

The development of low soil pH depends on a number of factors. Soils can be naturally low under some native vegetation. They may also be low caused by the fertiliser, crops and pasture plants grown in agriculture systems. In which case the length of time since clearing may be significant. Just how much lowering of pH occurs also depends on whether it was alkaline, neutral or acid to start with as well as its pH buffering capacity. Thus it can be judged how quickly a soil is likely to reach a critical pH.

When the pH is low, some soils release toxic elements. Aluminium is one such toxic element that in some soils reaches concentrations that are likely to affect plant growth at pH values of less than 5 (in CaCl₂). From the limited evidence available, much of the soil in the Buntine Marchagee Catchment which has a low pH (or is likely to become low) will have plant limiting levels of toxic Aluminium.

Subsurface compaction

Subsurface compaction of soils can result in plough and traffic pans. Plough pans develop in response to repeated tillage and are found in medium and fine textured soils just below the tilled layer. Traffic pans occur deeper in the soil and are caused by the compression due to traffic. They are more common on coarse to medium textured soils (Needham *et al.* 1998). Susceptibility to subsurface compaction was assessed using the method outlined in van Gool *et al.* (in prep) was used.

The most susceptible soils have low organic carbon (<2% which most of the catchment has) and loamy sand to sandy loam textures at 10-50 cm. These include sandy earths, some Yellow deep sands, loamy earths and red, yellow and brown loamy and sandy duplex. On shallow duplex soils, the presence of the shallow clay subsoils usually presents a more significant impediment to root growth than compacted subsurface sand layers.

More than half the survey area has soils that are highly susceptible to subsurface compaction. The Upsan Downs system and to a lesser extent Inering Hills and contain significant areas of highly susceptible soils.

Surface soil structure decline

Soil structure decline refers to the changes in the structure and surface condition of the top layers of the soil since clearing and cultivation. This decline makes the topsoil hard and more compact, effectively reducing the amount of infiltration while increasing the level of run-off (van Gool, *et al* in prep.). Topsoil textures of sandy loam to clay are generally moderately or highly susceptible to soil structure decline and most become hardsetting after repeated cultivation. In the catchment Brown loamy earths, Red/brown non-cracking clays and Red and Alkaline red shallow loamy duplex are the main soils.

These soils are mostly related to either the fresher soils associated with the partially weathered rock or the heavier textured lower slopes and valley floors. Thus much of the Inering Hills and parts of the Ballidu and Upsan Downs systems are most likely to be affected.

Water erosion

All soils are susceptible to water erosion which contributes to decline in soil fertility through the loss of soil nutrients. It also has off-site effects as the loss of topsoil causes siltation and contributes to eutrophication. Water erosion can provide a major source of phosphorus into waterways and water bodies. Water erosion is not continual and often associated with high intensity rainfall events that occur at irregular intervals. Management factors that expose the soil surface to rainfall such as cultivation, overgrazing and burning plant residues also play an important role in the severity of soil loss due to water erosion. Landscape features such as slope gradient and length, as well as soil properties combine to determine the susceptibility of a land unit to water erosion.

Properties that increase a soil's inherent erodibility include:

- low organic matter content (<1% organic carbon)
- high silt or fine sand content (>65%)
- unstable soil structure, particularly dispersive soils
- waterlogging, except for coarse sands, as runoff occurs more readily.

In assessing risk it is difficult to separate low frequency high severity events from high frequency low intensity risk. In the model used, the former has been given higher weighting hence the valley floors are interpreted as having the highest risk.

The normally expected highest water erosion risk are the steeper slopes (all be it rarely >3%) of the Inering Hills system. These typically have loamy surface layers, sometimes hardsetting. They quickly generate an infiltration excess. These soils have, however, only been considered to be a low risk, principally because of the very low slopes. Virtually all other slopes are considered to have a very low risk because they have sandy surface soils through which the water readily infiltrates.

Wind erosion

As with water erosion, major wind erosion events occur infrequently. This is important to note, because the maps show susceptible soils, not currently eroding soils. However although bare, lighter soils blow frequently on winds as low as 8m/s or 28 km/hr (Moore, Findlater, and Carter 1998) during late summer and autumn. Wind erosion can have many effects including sand blasting of crops, loss of soil nutrients and associated losses in productivity, and air pollution. In extreme events, soil can bury fences and roads, and fill dams. A soil's susceptibility to wind erosion can be assessed from its soil texture and surface condition. The most susceptible soils have loose topsoils. Hardsetting soils with sandy loam or clayier surface textures are the least susceptible to wind erosion. More than 50% surface cover of stones or gravels protects the bare soil from wind erosion to some extent.

Highly susceptible soils include Pale deep sands, Gravelly pale deep sands, Pale shallow sands, Yellow deep sands, Brown deep sands, Grey deep sandy duplex soils and Alkaline grey deep sandy duplex soils. Gravelly soils such as Deep sandy gravels, Duplex sandy gravels and Shallow gravels are also highly susceptible to wind erosion if their surface gravel cover is less than 50%. Other sandy surfaced soils such as the Grey shallow sandy duplex soils have a low to moderate wind erosion hazard, as their surface condition is generally firm or hardsetting.

Practices that disturb the surfaces of these soils such as cultivation or overgrazing in dry seasons will increase the hazard on these soils. The loss of sandy topsoil from the shallow duplex soils brings the poor clay subsoils close to the surface and in extreme circumstances the clay subsoils become exposed at the surface.

Most of the Balgerbine system has a high or extreme risk of wind erosion. These are typically the loose sandy surface soils common in the area. Although much of the rest of the catchment has sandy soils (especially Upsan Downs and Ballidu systems), the risk is considered less severe because the slightly higher clay content tends to hold the surface together a little better.

Water repellence

Water repellence results in uneven wetting in topsoils and patches of dry soil among wet soil. This affects the germination of crops and pastures. A soil's susceptibility to water repellence is related to its surface area and the supply of water repellent compounds which varies with land use and the productivity of the agricultural system. Water repellence can promote sheet erosion in areas where it is not expected to occur. The water repellence of the soils in the catchment was assessed using the method outlined in van Gool, *et al* (in prep).

Generally the most susceptible soils have the sandiest topsoils with less than 2% clay. These include Pale deep sands, Pale shallow sands, Gravelly pale deep sands and some Yellow deep sands. Other sandy surfaced soils are moderately susceptible to water repellence. They are more likely to develop water repellence as organic matter levels build up under long-term clover-dominant pasture or on sheep camps. These include Alkaline grey deep sandy duplex soils, Grey deep sandy duplex soils, Yellow deep sands, Duplex sandy gravels, Shallow gravels and Deep sandy gravels.

The areas most likely to have water repellent soils are more or less the same as those at highest wind erosion risk. This is most of Balgerbine system and parts of Upsan Downs.

Water logging/inundation risk

Waterlogged areas have an excess of water and limited soil oxygen. This might be at various depths within the soil profile. If this occurs within the zone of active root growth (plant species dependent) it can mean reduced plant growth. On the other hand, deep layers of water logged soil can extend the growing season of a crop. The extent of water logged soils tend to be underestimated.

Inundated areas are where ponding occurs. In some cases it is a severe kind of water logging, but in others where the inundation is temporary and a surface seal might occur, the impact of temporary inundation can be mild.

Water logged and inundated areas tend to occur where the site drainage is poor. The proximity of water tables is important as is the infiltration rate of the soils. Clays and duplexes tend to have a slow infiltration.

These assessments indicate that most of the Wallambin system and the larger valleys of the Upsan Downs, Ballidu and Inering Hills have moderate to very high risk. The valleys of the Balgerbine system have a much lower risk because of their sandy nature.

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References

- Baxter, J.L. and Lipple, S.L. (1985) Geological survey of Western Australia. 1:250 000 Geological Series - Explanatory Notes. Perenjori, Western Australia (Sheet SH50-6). Geol. Surv. West. Aust., Perth 32pp.
- Bettenay, E. (1983). Western Region (II). *In* "Soils: an Australian viewpoint", Division of Soils, CSIRO, pp179-187. (CSIRO:Melbourne)
- Carter, J.D. and Lipple, S.L. (1982) Geological survey of Western Australia. 1:250 000 Geological Series - Explanatory Notes. Moora, Western Australia (Sheet SH50-10). Geol. Surv. West. Aust., Perth 25pp.
- Griffin, E.A., Verboom, W.H., Caccetta, P., Goulding, P.M. and Schoknecht, N.R (2001) Lake Bryde Recovery Catchment, WA, Soil-landscape Mapping. Unpublished report for WA Department of Conservation and Land Management. Department of Agriculture, WA. Project
- Isbell R.F. (2002). Australian soil and land survey field handbook: The Australian soil classification. Revised edition. CSIRO Publishing, Collingwood, Victoria.
- Moore, G., Findlater, P. & Carter, D. (1998). Wind erosion. *In*: 'Soilguide. A handbook for understanding and managing agricultural soils'. (ed. G. Moore), Agriculture Western Australia Bulletin No. 4343. pp. 211-222.
- Needham, P., Scholz, G. & Moore, G. (1998). Hard layers in soils. *In*: 'Soilguide. A handbook for understanding and managing agricultural soils'. (ed. G. Moore), Agriculture Western Australia Bulletin No. 4343. pp. 111-115.
- Purdie, B.R. (1993b, revised 1995, 1996, 1997, 1998). Natural Resource Assessment Standards – Standards used for soil and soil-landscape mapping in Western Australia. Unpublished internal report. Agriculture Western Australia.
- Schoknecht, N. (2002). Soil groups of Western Australia A simple guide to the main soils of Western Australia. Ed. 3. Resource Management Technical Report 246. Department of Agriculture, Western Australia.
- Van Gool, D., Moore, G. & Tille, P. (in prep). Land evaluation standards for land resource mapping. Guidelines for assessing land qualities and determining land capability in south-west Western Australia. (revision of Van Gool & Moore 1999). Department of Agriculture, Western Australia.

Wells, M.R. & King, P.D. (1989). Land capability assessment methodology for rural-residential development and associated agricultural land uses. Land Resources Series No.1. Western Australian Department of Agriculture.