5 Land conservation and susceptibility

5.1 Land susceptibility

The terms hazard and susceptibility are often used interchangeably, causing much confusion. Susceptibility of land to a specific deterioration process is defined here as a constant inherent feature, but the hazard changes depending upon the level of management and the type of land use.

Soil erosion and sedimentation is considered to be a major problem and can reduce the productivity of agricultural land. Sediment is the greatest pollutant of the world's surface waters as it degrades water quality and may carry adsorbed polluting chemicals (Robinson 1971). Furthermore most soils have very slow rates of formation and should be considered as a non-renewable resource thus the management of these soils is a very important consideration. It is therefore prudent to assess the risk, or susceptibility, of land to various forms of degradation.

Factors and processes

In this report seven land degradation susceptibility processes were identified and studied. These are listed as follows:

- gully and tunnel erosion
- sheet and rill erosion
- wind erosion
- soil structure decline (compaction)
- soil sodicity (topsoil and subsoil)
- soil pH (topsoil and subsoil).

These processes have been investigated in previous studies. Previous land studies have used a suite of methods and approaches to define criteria and outputs representative of land degradation susceptibility across study areas. After evaluating existing methodologies with questionable output qualities, it was recommended to undertake an expert decision making approach for these processes. Experts with knowledge on catchment processes and limitations, collaborated in a suite of conferences and major meetings to identify limitations and inherent susceptibilities of the land to further degradation.

The main soil-landform characteristics influencing the susceptibility of land to decline included soil chemical and physical properties, topographic indicators (slope, aspect etc.), geology, geomorphological processes and climate. Vegetation, land use and historic land management practices weren't considered in this approach. The inherent susceptibility to land degradation (ha and %), soil sodicity and soil pH for land in the WCMA region is presented in Table 5–7.

Table 5 Inherent susceptibility to land degradation (ha and %) for land in the WCMA region

Hazard	High and Very High		Moderate		Low and Very Low	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Gully and tunnel erosion	132443	5.7	1076613	46.5	1107970	47.8
Sheet and rill erosion	63401	2.7	985185	42.5	1268422	54.8
Wind erosion	1001457	43.2	1098882	47.4	216668	9.4
Soil structure decline (compaction)	436212	18.8	770353	33.2	1110443	48.0

Table 6 Soil sodicity (ha and %) for land in the WCMA region

Sodicity	Very strongly sodic (ESP > 25		Strongly sodic (ESP 15–25)		Sodic (ESP 6–15)		Non sodic	
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Topsoil	117686	5.1	0	0	576971	24.9	1622371	70.0
Subsoil	846019	36.5	477772	20.6	660388	28.5	332830	14.4

Table 7 Soil pH (ha and %) for land in the WCMA region

Soil pH	Acid (pH < 5.5)		Neutral (pH 5.5–8.0)		Alkaline (pH >8.0)	
	(ha)	(%)	(ha)	(%)	(ha)	(%)
Topsoil	89750	3.9	1551669	67.0	675590	29.1
Subsoil	1994	0.1	987044	42.6	1327971	57.3

Gully and tunnel erosion

The susceptibility of land to tunnelling and gully erosion depends on a number of interrelated factors. These are principally rainfall intensity, vegetation cover, rooting depth, microrelief, slope, position in landscape, contributing upslope area, soil permeability, soil depth, soil cohesion and dispersibility. As the volume of overland flow increases and becomes channelised, the erosive power increases and resistance of the soil aggregates and particles to detachment becomes critical. The size and weight of the soil particles and their cohesion, or the tendency to slake or disperse will determine the resistance.

Gully and tunnel erosion is potentially a major degradation threat to water quality and biodiversity. Nearly 132 000 hectares of the catchment has a high inherent susceptibility to gully and tunnel erosion. The areas of highest potential include the Cambro-Ordovician sediments in the Western Uplands, but gully and tunnel erosion is also common on granitic parent material across the uplands. The Pyrenees Range is extremely prone to tunnel and gully erosion where cleared (e.g. Joel South, Mapunit). When gradational soils and stony loams on crests and upper slopes are cleared of the native deep-rooted vegetation, some rain percolates through the soil profile to the watertable, but some becomes overland flow with the potential to sheet erode the sloping land and scour out drainage depressions.

The presence of gullies and tunnels adversely affects productivity in a number of ways. As well as the land directly lost from production, the soil adjacent to the gully or tunnel is excessively drained thus reducing the vigour and number of plant species able to survive.

Sheet and rill erosion

The susceptibility of land to sheet and rill erosion is governed largely by the topsoil texture, slope of the land and length of slope. Other factors include hydrophobicity, percentage stone cover, tendency for aggregates to slake and disperse, size and weight of surface particles or aggregates, and the probability of intense summer rainfalls.

Soil loss from sheet and rill erosion is difficult to assess because of variability in soil loss within an area, and the problem of measuring something that is no longer there. Sheet and rill erosion greatly reduces productivity, particularly in the case of texture contrast soils. The topsoil or A horizon is where most nutrients, organic matter, seeds and macroporosity so desirable for a seedbed exists. If this is stripped away through soil loss the fertility of the soil is lost and productivity reduced.

Nearly 45% of the region has a moderate inherent susceptibility to degradation by sheet and rill erosion. Lanscapes most prone to degradation include the Grampians Ranges, Pyrenees Range, and the sediments and granitic slopes of the Western Uplands.

Wind erosion

Wind erosion is the loss of soil particles by wind. It occurs when the lift forces of the wind exceed the gravity and cohesion of the soil grains at the surface.

Susceptibility of land to wind erosion is determined by taking into account the inherent features of the soil, the climate and position in landscape. The erodibility of the topsoil is a major factor, but structure, texture, stoniness and organic matter are all significant. Land use and management may have a major influence on the degree of deterioration, particularly if dry soils are exposed when erosive winds are likely to occur. Wind erosion is likely to reduce the organic matter and nutrients available in the topsoil, while the reduction in topsoil depth also leads to reduced water infiltration causing increased runoff and a fall in productivity.

Over 1 001 457 ha (43.2%) of the region is considered to have a high inherent susceptibility to wind erosion. The loose sandy topsoils of the Little and Big deserts, the sandy dunes and ridge crests in the north of the region, and the granitic slopes of the Midlands are highly susceptible to wind erosion. The basalt plains with fine sandy loam topsoils, the well structured self-mulching soils of the Kalkee Plains, and the gradational and uniform soils of the Western Uplands have moderate to low susceptibilities.

Soil-structure decline

Soil structure decline is the terminology used to refer to changes in the stability of soil aggregates and changes in arrangement of spaces (porosity) within soil material that result in conditions that are less favourable to plant growth. Changes in aggregate stability occur through excess tillage (pulverising when dry, dispersing when wet) and through prolonged (over years) cropping or grazing with resulting reduction of soil organic matter. Changes in porosity may result from compressing and churning moist or wet soil by wheels or hooves causing compaction and pugging. The primary affects are on soil hydrology, aeration, soil strength and root development. Soil structure decline can also increase the incidence of waterlogging and make the soil more susceptible to erosion by wind or water.

Soil texture, organic matter, mineralogy, climate, topography, and vegetation all affect the degree to which soil structure is susceptible to decline.

Potentially the greatest land degradation issue across the WCMA region, soil-structure decline has a large area highly likely to be inherently susceptible to degradation. Over 436 000 ha or 18.8% has a high rating. Landscapes thought most vulnerable include the sedimentary slopes and plains of the Western Uplands where hardsetting soil surfaces are common, and the massive cracking clay soils and sodic texture contrast soils of the North West Dunefields and Plains.

Soil sodicity

Soil sodicity refers to the measure of exchangeable sodium (Na^+) ions in soil relative to other exchangeable cations including calcium (Ca^{2+}), potassium (K^+), aluminium (Al^{3+}) and magnesium (Mg^{2+}) with sodic soils having high levels of sodium. Sodium causes soils to disperse where aggregations of clay separate into individual platelets, leading to soil structure decline. This dispersion often results in reduced hydraulic conductivity and reduced percolation of water through the soil profile. As well, surface sealing can occur also contributing to poor infiltration rates. Sodic subsoils are therefore extremely prone to gully and tunnel erosion where subsoils are exposed.

Sodicity can have significant effects on agricultural production. Management problems associated with sodic subsoils are many, including poor trafficability, soil structure decline (compaction) and poor aeration (waterlogging) for example. Surface sealing also forms a suite of physical constraints to plant growth. Fertility constraints of sodic soils are often conveyed through secondary affects including reduced nitrogen availability, calcium deficiency and low organic matter levels. Engineering and erosion problems are many including piping (tunnel erosion) that often impact on bank and earth structures as well as road pavements.

Soil sodicity (topsoil) is thought to affect 30% of the WCMA region soils, while sodic subsoil affect nearly 2 000 000 ha (85.6%) across the catchment. This greatly impacts upon not only soil compaction and waterlogging, but also gully and tunnel erosion as well. Areas included are the plains and dunes in the north of the catchment (often calcareous and sodic, mesonatric or hypernatric); the swales and rises west of the Douglas-Natimuk valley and Lowan Salt Valley; the Cainozoic rises and plains within the lower reaches of the upper Wimmera area; and the hardsetting plains associated with prior streams and modern stream channels in the east of the catchment.

Soil pH

Soil acidity and alkalinity present widespread limitations to plant and animal production across the WCMA region. Soil pH reflects the concentration of H^+ ions against OH^- ions with values less than 7.0 considered 'acidic' and values above 7.0 'alkaline'. A soil pH of 7.0 ± 0.5 is loosely referred to as 'neutral'.

Soil acidification effects are primarily related to an increase of soluble and exchangeable aluminium leading to toxicities in sensitive plants, and a decrease in soluble and exchangeable calcium and magnesium leading to deficiencies. This alumium toxicity has a direct effect on plant metabolism where roots become shortened and thickened. Alkaline soils contain significant concentrations of calcareous, dolomitic or sodic carbonate. This carbonate causes alkaline conditions with the most common effect being chlorosis of leaves of sensitive plants. Chlorosis is reflected by the plants inability to process and utilise iron and managanese, therefore impacting on overall plant metabolic activity and efficiency. Phosphatic deficiencies are also common on calcareous soil.

Over 90 000 ha (4%) of the region is considered to have a high inherent susceptibility to acid soils. The higher rainfall areas of the ranges (Grampians, Pyrenees and Langi Ghiran) typically have moderately acidic surfaces that trend towards neutral in the subsoil. Plains south of the Little Desert (e.g. Ullswater, Kowree, Horsham South) also show distinctly lower topsoil pH values than those north of the desert. This has been attributed to slightly higher rainfall and land use differences as a result. Topsoil pH on the Kalkee plains are near neutral along with the rises and swales further west, however further north (e.g. Jeparit, Peppers Plains) values are often alkaline with some surface values near a pH of 10. Subsoils here are still alkaline but may become neutral at depth (>1.5 m).