Report card on sustainable natural resource use in agriculture

Status and trend in the agricultural areas of the south-west of Western Australia

Supporting your success
1. Introduction

The primary purpose of this report card is to present the best available information on the current condition (or risk to condition) and trend in condition of the natural resources that support agriculture. In particular, it:

- provides a transparent process explaining how this condition, risk and trend was determined
- highlights any issues which impinge on the sustainable use of this resource
- discusses the implications of these findings on the agricultural industries
- provides recommended actions where appropriate.

Sustainable natural resource use for agriculture means maintaining (and where possible improving) the productive capability of the land which underpins agriculture, while mitigating off-site impacts.

The study area covers the agricultural areas of the south-west of WA, other than native vegetation and reserves (Figure 1.1).

The environmental performance of our land is a complex interaction of numerous processes. In simple terms, however, the performance of the land is driven by three primary factors:

1. Climate – how much rain falls, and when. When do the strong winds blow? What are the trends in climate change?
2. Land characteristics – the characteristics of our soils and landscapes that make up our diverse environment.
3. Land management – what we grow or graze and how we manage it. What land practices do we use in association with the different land uses?

These three factors are illustrated in Figure 1.2. Together, these factors will determine the current condition of the land and how the land is performing. An understanding of the trends in land use/land management and climate change will also provide evidence for determining and monitoring trends in land condition.
The climate and land characteristics factors are mostly outside of the influence of land managers, although land characteristics can be modified to a limited degree by management options, such as claying and delving. Land managers must therefore work within the given climate and land conditions and adopt land management practices that lead to profitable and sustainable outcomes. Land management will need to respond where one of the other factors (e.g. climate) is changing.

There are critical situations where the current land management, even under current conditions, is unsustainable and leading to an unacceptable decline in land condition. Land management will need to change in response to these conditions, otherwise the land use will become unviable.

In discussing specific natural resource degradation issues, the influences of these three factors are considered and commentary is provided on what management is appropriate to ensure a sustainable and profitable agricultural future.

**Climate**

Climate is the primary factor that influences the performance of the land. Soils will not wind erode if the wind does not blow. Intense summer thunderstorms that occur when the land is bare may lead to catastrophic water erosion.

Climate is not a static factor; it is continually changing, and has always done so, but we need to understand the current climatic conditions and how they are trending to predict current and future condition of the natural resources.

![Figure 1.2](image-url)  
*Figure 1.2* The three primary factors that influence the environmental performance of the land.
Analysis of climate data over recent decades has demonstrated six key messages relevant to the sustainable and profitable management of our agricultural land:

- Mean temperatures are rising.
- Annual rainfall is declining.
- Autumn and winter rainfall is declining.
- Spring and summer rainfall is increasing.
- Predictions indicate that these trends will continue.
- In the short term, year-to-year climate variability may be more important than the longer term trends.

A brief analysis of each of these messages is presented below. The time period used to analyse these trends is 1950 to the present, in line with information and analysis presented in the Indian Ocean Climate Initiative (ioci.org.au).

**Key message 1: Mean temperatures are rising.**

Like global temperatures, WA temperatures have increased since 1910. The strongest trend has been observed since the 1950s, though in the far north of WA there has been a slight cooling in average temperatures. Across the state as a whole, mean annual temperatures have increased since 1910 by about 0.8 °C. The current warming trend began in the 1950s and is illustrated in Figures 1.3 and 1.4.

![Figure 1.3](image1.png)

**Figure 1.3** Trend in mean temperature, 1950–2012 (°C/10 years). Source: Bureau of Meteorology.

![Figure 1.4](image2.png)

**Figure 1.4** Annual mean temperature anomaly time series map for south-western Australia (1910–2012), using a baseline annual temperature (1961–1990) of 16.3 °C. 15-year running average is shown by the black line. Source: Bureau of Meteorology.
Key message 2: Annual rainfall is declining.
Annual rainfall is declining throughout most of the agricultural area, with the decline most marked in the south-west corner of the state. In contrast, small increases in annual rainfall are occurring in the eastern wheatbelt and eastern south coast, largely due to increased summer rainfall (Figure 1.5).

Key message 3: Autumn and winter rainfall is declining.
Autumn and winter rainfall is declining throughout most of the south-west of WA (Figures 1.6, 1.7 and 1.8). This trend is especially marked in the winter when traditional grain crops are growing. The reducing rainfall during these periods is impacting on crop establishment and winter growth.

Figure 1.8 Trends in winter rainfall in south-western Australia for the period 1900–2012. The 15-year running average is shown by the black line.
Key message 4: Spring and summer rainfall is increasing.
Spring and summer rainfall is increasing throughout most of the agricultural area, with the exception of the south-west corner where rainfall is declining, not just in spring and summer, but throughout the entire year. These trends are illustrated in Figures 1.9 and 1.10.

Key message 5: Predictions indicate that these trends will continue.

Projected changes in the climate
In the south-west of WA, rainfall has already decreased and is projected to continue decreasing throughout this century. Future increases in temperature and potential evaporation are also anticipated; however, predicting impacts of global climate change at a regional and local level is difficult (IOCI 2012).
The Indian Ocean Climate Initiative (IOCI) research program has been studying the climate of WA’s south-west since 1998. Projections under all scenarios and all models point to drier conditions across the south-west in the future.

The current global climate models all agree on the direction of change in winter (June to August) across the south-west, with a mean reduction in winter rainfall of about 20% predicted. Table 1.1 summarises the IOCI predictions for rainfall and temperature in the south-west of WA (Bates et al. 2008):

In addition to the broadscale projections in Table 1.1, IOCI scientists have applied statistical techniques to downscale the climate projections for 29 stations across the south-west of WA. The results from six of these stations highlights the variability of projections, but also indicate a drier future for the south-west of WA (Table 1.2).

Table 1.1 Summary of expected changes in the south-west of WA over the next 20–50 years, relative to 1960–90 values

|------------------|-------------|----------------------|------------------------------|-----------------------|------------------------|-------------------------------|-------------------------|

Table 1.2 Range, from downscaling five global climate models, of present day (1962–1999) and projected annual mean rainfall (in millimetres) for selected stations across south-west of WA. Projections are given for mid-century (2047–2064) and end of century (2082–2099) periods under low (B1), intermediate (A1B) and high (A2) emissions scenarios. For present day and for each emissions scenario and period, downscaling from each of the five global climate models produces a different result. The range across these different results is one source of uncertainty in the downscaled results, as shown by the range in each cell (IOCI 2012).

Key message 6: In the short term, year-to-year climate variability may be more important than the longer term trends.

The south-west of WA experiences significant seasonal variation in rainfall. This variation is also not equally spread across the south-west – one area may experience a very dry growing season and poor crop growth, whereas another may experience a very good growing season.

Land managers need the best climate advice to help them protect and sustain national ecological resources in the face of climate extremes. Improved understanding of climate variability, and application of appropriate management techniques, will be crucial to achieving sustainable development.
Managing for climate variability has been a staple of agricultural production for many years. Dry seasons, flooding, frost, severe wind events and rain at harvest all have the potential to cause significant losses on both a localised and broad scale. In some cases, continuation of severe climatic events can contribute to the failure of farm businesses.

With the possibility of changing rainfall patterns and greater frequency of severe climatic events, it is more important than ever to examine the opportunities to manage risk and develop a plan. The risk of significant losses of land condition and profitability exists possibly more in association with the extreme events than to changing rainfall patterns. In response to the latter, landholders have gradually adapted to seasonal conditions and responded with appropriate management. Adaption options include:

- diversification of crops
- extending the opportunities for both on- and off-farm income
- greater use of off-farm labour to increase the speed of operations
- opportunity cropping
- managing for biodiversity to maintain ecological function
- managing for soil health to increase the resistance of farming systems and its capacity to recover from an imposed stress.
Land characteristics

The inherent nature of the land, especially soil type and landform, is a key factor in determining present land condition and trend. Some soils and landscapes are vulnerable to forms of land degradation, or may already be in a state unsuitable for agriculture. For example, under cropping, sandy soils with low pH buffering capacity are likely to become acidic. Some soils were too acid for agriculture prior to clearing. Sandy surfaced soils in windy locations are prone to wind erosion. Soils with saline subsoils have become too salty for agriculture through rising saline watertables.

Therefore, fundamental to interpreting current, or predicting future condition of the soils and landscapes, is a requirement to understand their inherent properties and spatial distribution, and how they perform under different management regimes. In the south-west of WA, land capability mapping has been developed by van Gool et al. (2005) to provide guidance to the spatial distribution of soils and land vulnerable to degradation.

Key messages for land characteristics:

- Land characteristics strongly influence the capability of the land to support a particular land use.
- To achieve sustainable natural resource use, land managers need to recognise and understand the inherent properties of the land.
- Land characteristics can, to a limited degree, be modified by land management practices, such as claying and deep ripping.

A map of soil types (Agricultural Soils – abbreviated to Ag Soils) and their distribution in the south-west of WA is shown in Figure 1.12 and described in Table 1.3. Ag Soils are a simplification and grouping of the WA Soil Groups (Schoknecht and Pathan 2013), and are used to show the general distribution of soils types.
<table>
<thead>
<tr>
<th><strong>Ag Soil</strong></th>
<th>Description</th>
<th><strong>Land type</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare rock</td>
<td>Rock outcrop scattered throughout the south-west.</td>
<td>Rocky or stony hilly lands</td>
</tr>
<tr>
<td>Stony</td>
<td>Shallow stony soils associated with rock outcrop throughout the south-west.</td>
<td>Rocky or stony hilly lands</td>
</tr>
<tr>
<td>Gravel</td>
<td>Ironstone gravelly soils that are widespread on undulating to hilly land and plateaus throughout the south-west. Most common in the jarrah and wandoo forests east of the Darling Scarp from Moora to the south coast.</td>
<td>Ironstone gravelly lands</td>
</tr>
<tr>
<td>Calcareous sand</td>
<td>Calcareous coastal dunes and sandplains.</td>
<td>Plains and rises with sandy soils</td>
</tr>
<tr>
<td>Pale sand</td>
<td>Grey and pale yellow deep sands on plains and rises near the west coast from Busselton to Geraldton. Also common on south coastal plains near Albany and Esperance and scattered throughout the wheatbelt.</td>
<td>Plains and rises with sandy soils</td>
</tr>
<tr>
<td>Sandy earth</td>
<td>Yellow, brown and occasionally red earthy sandplain which is very common in the north-eastern wheatbelt and scattered elsewhere.</td>
<td>Plains and rises with sandy soils</td>
</tr>
<tr>
<td>Coloured sand</td>
<td>Yellow, brown and red deep sands that are widespread on sandplains in the northern and eastern parts of the central wheatbelt.</td>
<td>Plains and rises with sandy soils</td>
</tr>
<tr>
<td>Calcareous loamy earth</td>
<td>Calcareous loamy soils which are common on lower slopes around salt lakes in the eastern wheatbelt and the Salmon Gums area north of Esperance.</td>
<td>Plains and rises with loamy soils</td>
</tr>
<tr>
<td>Shallow sand</td>
<td>Shallow sands over rock, most common on undulating coastal limestone from Bunbury to Geraldton, and around granite outcrops in the wheatbelt.</td>
<td>Rises and hills with shallow soils</td>
</tr>
<tr>
<td>Shallow loam</td>
<td>Shallow loams, usually red and overlying red-brown hardpan, occurring in the far north-east of the wheatbelt.</td>
<td>Rises and hills with shallow soils</td>
</tr>
<tr>
<td>Alkaline shallow duplex</td>
<td>Soils with shallow sandy to loamy topsoils over alkaline and often calcareous clays – widespread on undulating land throughout the eastern and south-eastern wheatbelt and the Salmon Gums area north of Esperance.</td>
<td>Plains and rises with duplex (sand or loam over clay) soils</td>
</tr>
<tr>
<td>Deep loamy duplex and earth</td>
<td>Soils with deep loamy topsoils over non-alkaline clay loams to clays. Most common in the jarrah and wandoo forests east of the Darling Scarp from Moora to the south coast and parts of the eastern wheatbelt.</td>
<td>Plains and rises with duplex (sand or loam over clay) soils</td>
</tr>
<tr>
<td>Deep sandy duplex</td>
<td>Soils with shallow sandy to loamy topsoils over non-alkaline clays – widespread on undulating land throughout the wheatbelt and plains along the south coast.</td>
<td>Plains and rises with duplex (sand or loam over clay) soils</td>
</tr>
<tr>
<td>Shallow sandy duplex</td>
<td>Soils with shallow sandy topsoils over non-alkaline clays – widespread on undulating land throughout the wheatbelt and plains along the south coast.</td>
<td>Plains and rises with duplex (sand or loam over clay) soils</td>
</tr>
<tr>
<td>Clay and shallow loamy duplex</td>
<td>Soils with shallow loams over clays and often red or brown in the north and grey in the south, on sloping land throughout all but higher areas of the south-west.</td>
<td>Heavy (clayey) lands</td>
</tr>
<tr>
<td>Self-mulching clay</td>
<td>Small areas of clays that have a self-mulching “crumby” surface in the northern wheatbelt.</td>
<td>Heavy (clayey) lands</td>
</tr>
<tr>
<td>Saline wet</td>
<td>Saline wet areas, typically valley floors with salt lakes throughout the south-west but most widespread in the wheatbelt.</td>
<td>Saline wet areas, typically valley floors with salt lakes throughout the south-west but most widespread in the wheatbelt.</td>
</tr>
<tr>
<td>Semi-wet</td>
<td>Non-saline wet areas, on the Swan and Scott river coastal plains and in valley floors in the higher rainfall parts of the south-west.</td>
<td>Wet lands</td>
</tr>
</tbody>
</table>

* Ag Soils are groups of WA Soil Groups
Soils tend to occur in different parts of the landscape. The land type column in Table 1.3 indicates the predominant types of land associated with Ag Soils, and these land types are shown spatially in Figure 1.13.

**Land management**

The third key factor influencing the condition and trend in condition of our lands is land management, which includes land use and associated land management practices.

Decisions on land management are largely within the power and responsibility of the land managers. It is therefore essential that land managers have the required knowledge and support to make the best land use and land management decisions, and to be responsive to changes in the other primary factors – climate and land characteristics.

**Key messages for land management**

- Land management is the key natural resource condition and trend factor within the control of land managers.
- Land managers need to understand and be responsive to the other primary factors – climate and land characteristics.
- Positive natural resource condition and trend outcomes can be achieved throughout the agricultural areas of south-west of WA by the adoption of appropriate land use and land management practices.

**Land use**

The broad classes of land use in the south-west of WA are represented in Figure 1.14. This is a simplification into four classes of the national land use map (ABARES 2010) which uses standard Australian Land Use and Management (ALUM) classification classes.

*Figure 1.13* Land types of the south-west of WA. The lines represent Ag Soil Zones, which are a broad spatial framework for reporting on the themes.
Land degradation issues are more likely to occur in land uses which disturb the soil (e.g. cropping). The impact of land use on the condition and trend of the land is discussed in each section.

**Land management practices**

Land management practices play a crucial role in the condition and trend of the natural resources.

For example, land management choices, such as heavy grazing, can lead to decreased levels of ground cover (the layer of plant matter and other biological crusts holding the soil in place), contributing to the risk of wind erosion and increased dust levels. The loss of these soil particles contributes to the decline of soil resource condition by reducing topsoil depth and removing lighter particles, that may include most of the plant nutrients and soil organic...

No-till uses low disturbance tyne or disc seeding systems. (Photo: Western Australian No-till Farmers Association (WANTFA)

Figure 1.14 Broad land use categories in the south-west of WA (2005–06). Source: ABARES (2010).
carbon, as well as reducing air and water quality as lost soil particles contaminate these systems. In contrast, management practices that contribute to the retention of ground cover will lessen the risk of wind erosion and water erosion removing soil particles. The result is a maintenance or improvement in overall resource condition.

Aware of such risks, WA farmers have been early adopters of practices which aim to protect the land. No-till cropping is a significant example.

Adoption of the best management practices for any given land use can maintain or improve soil condition. This can happen through practices such as maintaining adequate ground cover to reduce soil loss through wind and water erosion, adding lime to slow or reverse rates of soil acidification and reduced tillage to mitigate soil organic carbon decline.

Adoption of land management practices that protect and improve the soil are increasing in WA. A series of factsheets recently produced by DAFF (2013) through its Caring for our Country program, describes the general land management practice trends in WA’s broadacre cropping, grazing, horticulture and dairy industries. These factsheets, including a factsheet on farm biodiversity management in WA’s agricultural industries, are available from www.daff.gov.au.

Within each theme chapter, the influence of relevant land management practices on condition and trend is discussed.
**Reporting frameworks**

Two broad spatial frameworks are used for reporting on the individual natural resource themes.

The first, Agricultural Soil Zones (abbreviated to Ag Soil Zones), is based on repeating patterns of soil and land types. Ag Soil Zones are used for reporting on the following themes:

- Soil acidity
- Wind erosion
- Water erosion
- Soil organic carbon
- Soil compaction
- Water repellence
- Nutrient status (phosphorus)

The second, Hydrozones, is based on grouping areas with similar hydrology. Hydrozones are used for reporting on the following themes:

- Dryland salinity
- Acidification of inland waterways

The Nutrient export (phosphorus) theme only reports on selected coastal catchments.

More detail on the spatial reporting frameworks, terminology and standards are provided in Appendix A.

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**Figure 1.15 Ag Soil Zones**
Figure 1.16 Hydrozones
References


Indian Ocean Climate Initiative (IOCI) (2012). Western Australia’s weather and climate: A synthesis of Indian Ocean Climate Initiative Stage 3 research. CSIRO and BoM, Australia.

Schoknecht, NS and Pathan, S (2013). Soil groups of Western Australia – A guide to the main soils of Western Australia, edition 4. Resource management technical report 380, Department of Agriculture, Western Australia.