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

2.3 Water erosion

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2.3 Water erosion

Key messages

Condition and trend

- Water erosion hazard across the south-west of WA – during the growing season – has diminished because of declining winter rains, increased stubble retention and adoption of reduced tillage practices.
- Water erosion events are mainly caused by intense, localised summer storms.
- There appears to be a trend towards more frequent, potentially erosive summer storms in the eastern wheatbelt and south-eastern coastal areas, and relatively little change in other areas.

Management implications

- The average annual opportunity cost of lost agricultural production in the south-west of WA from water erosion is estimated at $10.1 million. This loss is cumulative because of the irreversible nature of soil erosion.
- The requirement to retain a cover of 70% or greater of plant material anchored by intact roots, means that total prevention of water erosion is difficult, particularly with livestock grazing systems.

Figure 2.3.1 Resource hazard summary for water erosion.
Table 2.3.1 Resource status and trends summary for water erosion

<table>
<thead>
<tr>
<th>Ag Soil Zone</th>
<th>Summary</th>
<th>Hazard and trend</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Mid West</td>
<td>High intrinsic risk and long history of erosion. Nangetty district and Moresby Ranges remain at risk.</td>
<td>High</td>
<td>In condition</td>
</tr>
<tr>
<td>2 Mullewa to Morawa</td>
<td>Largely stable, due to good stubble retention and minimum tillage. Emerging problem is increased erosion on poorly productive, acidic sandplain soils.</td>
<td>Very high</td>
<td></td>
</tr>
<tr>
<td>3 West Midlands</td>
<td>Largely stable; erosion limited to localised summer storms coinciding with poor ground cover.</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>4 Central Northern Wheatbelt</td>
<td>Erosion isolated to irregular summer storms that are increasing in eastern parts of the zone. Less reliable growing season rain further increases future risk.</td>
<td>Mod</td>
<td></td>
</tr>
<tr>
<td>5 Swan to Scott Coastal Plains</td>
<td>Largely stable. Enterprises in the north are exposed to erosion from flooding of major rivers.</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>6 Darling Range to South Coast</td>
<td>Stock enterprises present erosion risk from summer storms. Irrigated farms are managing erosion risk.</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>7 Zone of Rejuvenated Drainage</td>
<td>Excessive grazing pressure on sloping land in some parts perpetuates risk of erosion. Cropping land is largely stable.</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>8 Southern Wheatbelt</td>
<td>Good condition but increasing intensity and frequency of summer storms in the east remains a concern.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>9 Stirlings to Ravensthorpe</td>
<td>Episodic events in the east have driven recent decline; this trend is expected to increase in future.</td>
<td>Very low</td>
<td></td>
</tr>
<tr>
<td>10 South Coast – Albany to Esperance</td>
<td>Condition continues to gradually decline due to insidious sheet erosion of shallow topsoil and sodic subsoil.</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>11 Salmon Gums Mallee</td>
<td>Largely stable at present.</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hazard grades</th>
<th>Water erosion hazard</th>
<th>Recent trends</th>
<th>Confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very low</td>
<td>Very low</td>
<td>Improving</td>
<td>Adequate high-quality evidence and high level of consensus</td>
</tr>
<tr>
<td>Low</td>
<td>Low</td>
<td>Deteriorating</td>
<td>Limited evidence or limited consensus</td>
</tr>
<tr>
<td>Moderate</td>
<td>Moderate</td>
<td>Stable</td>
<td>Evidence and consensus too low to make an assessment</td>
</tr>
<tr>
<td>High</td>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very high</td>
<td>Very high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Overview

Water erosion is the removal of soil from the earth’s surface by water. Water erosion occurs when raindrops impact the soil surface and displace soil particles and when water flowing over the land surface mobilises soil particles. It occurs naturally at low rates, but it can become accelerated as a result of human-induced management changes to the natural landscape. In each case the same processes operate and the distinction is only a matter of degree and rate of erosion.

An acceptable erosion rate is one that is less than, or closely matches, the soil formation rate. Estimated soil formation in WA ranges from 1 mm/100 years to 1 mm/1000 years, which equates to between 14 t/ha/year and 1.4 t/ha/year (McFarlane et al. 2000; State of the Environment 2011 Committee 2011). Elsewhere in Australia, soil erosion of about 0.5 t/ha/year is regarded as natural, but in WA, “soil loss at almost any rate is unlikely to be sustainable” (George 2001).

Water erosion and sedimentation processes can be both insidious and episodic, and are largely irreversible. Once the soil has eroded and a new base level established, it is difficult or impossible to revert to the previous state. Further, the time required to form new soil is so long that soil should be considered a finite resource.

Water erosion is a two-stage process:
• Stage 1 occurs with raindrop impact and broad overland flow on slopes, before that flow becomes concentrated into channels and streams.
• Stage 2 occurs within the channelised flow of gullies, streams and rivers.

Distinguishing between the two stages is important because the processes in action during each stage are different (although related), the impacts of each stage on the landscape are different, and the methods used to identify, monitor and/or model the rate and extent of these processes are different.

Severe hillside erosion in lower left hand corner progressing to gully erosion in upper right-hand corner. Most sediment is delivered to our watercourses from gullying, stream bank and bed erosion, but the direct costs to agriculture emanate mostly from hillside erosion. Both are adverse for the economy, environment and societal values of WA.

Stage 1 is commonly called hillside erosion or ‘sheetwash and rill’ erosion. This erosion reduces agricultural productivity by:
• removing or moving nutrients
• bringing hostile subsoils closer to the surface, thus reducing effective rooting depth and plant available water capacity
• silting up dams, waterways and lowlands with inert sandy sediments, which can exacerbate flooding and waterlogging.
Hillside erosion contributes only a small fraction of the total sediment delivery to its ultimate resting point in a catchment, and it also contributes a relatively minor direct cost to agriculture. The annual direct cost of water erosion to dryland farming in WA is estimated to be $10.1 million (Herbert 2009).

Accelerated hillside erosion occurs when raindrops impact and run-off increases, due to one or a combination of the following:

- ground cover comprises less than 70% of intact plant material anchored by roots (Marston et al. 2001; Coles & Moore 2004)
- low ground cover at critical times, including during summer storms and at the break of season
- degraded surface soil due to structure decline, sodicity and non-wetting
- inappropriate tillage practices exposing the soil surface and concentrating water flow
- inadequate engineering works, including absent or poorly constructed surface water earthworks, inappropriately sited dams and poorly designed or constructed dam overflows, and poorly located or insufficient road and rail culverts.

These factors increase the erosivity of water flowing through catchment drainages, resulting in erosion rates being orders of magnitude higher than in uncleared situations.

Channelised flow is the second stage of the water erosion process. It occurs when overland flow concentrates in gullies and streams, scouring the heads, beds and banks of gullies and channels. The direct effects of this erosion on agricultural productivity in WA over the short term are limited to reduced trafficability on paddocks affected by gullying, and a cost to businesses in rectifying or living with the gullies in these paddocks.

Off-site impacts of channelised erosion on the environment are far greater. Erosion and associated sedimentation alters or destroys habitat for riverine and estuarine flora and fauna. Eutrophication of rivers, lakes and estuaries, caused partly by the mobilisation of soil fines and attached nutrients, also impact habitat values. Both processes result in a decrease in economic and societal value of fisheries and tourism.

Voluminous, fast-flowing water in gullies, streams and rivers has repeatedly disrupted farming communities and the broader WA society by destroying bridges, roads and infrastructure for utilities, and burying infrastructure under sediments.

Appropriate management can reduce erosion, although not to pre-clearing rates unless land is permanently vegetated. Costs to agriculture are cumulative, but the cost may not be realised until a threshold is reached. For example, there will be little reduction in profitability, nor increase in costs beyond additional fertiliser applications and possibly re-sowing badly eroded areas, until the bulk of the topsoil has been removed and crop roots are attempting to invade the subsoil to gain access to nutrients and water.

Previous assessments

National land and water resources audit (NLWRA)

The first consistent national-scale assessment of water erosion was conducted in 2001 as part of a national audit of the condition of Australia’s land and water resources (Marston et al. 2001).

This study identified the south-west of WA as having very low sheetwash and rill erosion rates, in the range of 0–0.5 t/ha/year.

An associated study by Lu et al. (2003) compared the estimated soil loss due to sheetwash and rill erosion under current and pre-European settlement conditions. They expressed the result as a ratio between current and pre-European erosion. A low ratio of 1.5–5, for example, means that current erosion rates are estimated at 1.5 to 5 times pre-European erosion rates.

This study found that water erosion has increased since European settlement across most of the lands cleared for agriculture and other purposes, with the increases in south-west of WA generally in the low (1.5–5 times) to medium (5–10 times) range.
Radioactive Caesium studies

Recent erosion rates determined from the Caesium 137 ($^{137}$Cs) content of soils indicate that the NLWRA (2001) assessment underestimates recent erosion rates. This radio-isotope was released during atmospheric nuclear weapons tests since the mid-1950s.

The isotope is firmly adsorbed to the soil and can be used as a marker of soil movement. Stable sites lose $^{137}$Cs only by radioactive decay. Eroded sites will have lost relatively more $^{137}$Cs than nearby stable sites, and depositional sites accumulate $^{137}$Cs from their eroded source areas. By comparing the amount of this isotope in soil along transects subject to human disturbance with nearby stable areas, it is possible to calculate how much soil has moved recently.

The study was conducted on a limited number of sites throughout irrigated and dryland agriculture and rangelands areas of WA. Sites were grouped according to land use and rainfall zone (McFarlane et al. 2000). Erosion rates between apparently similar land uses and rainfall zones varied significantly and finding valid reference sites in WA was sometimes problematic.

The measured erosion rates under different land uses and rainfall distributions varied from 5 to 10 t/ha/year, (Table 2.3.2) which is an order of magnitude greater than the NLWRA (2001) results.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Number of sites</th>
<th>Rainfall range (mm/year)</th>
<th>Mean erosion rate (t/ha/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horticulture/ Pasture</td>
<td>17</td>
<td>1400–700</td>
<td>4.8</td>
</tr>
<tr>
<td>Pasture/Wool</td>
<td>7</td>
<td>700–500</td>
<td>9.8</td>
</tr>
<tr>
<td>Crop/Pasture</td>
<td>27</td>
<td>500–300</td>
<td>6.6</td>
</tr>
</tbody>
</table>

Table 2.3.2 Mean erosion rates of different land uses and rainfall ranges at sites in the south-west of WA.

Source: Modified from McFarlane et al. (2000).

Assessment method

The assessment in this report is limited to hillside erosion since it directly affects agricultural production. It uses a GIS-based modelling approach to assess the relative change in water erosion hazard over recent years due to climate change. This assessment uses the best available datasets that account for important erosion-causing factors, identified in the Revised Universal Soil Loss Equation (RUSLE) (USDA 1997).

The assessment provides relative erosion potentials and indicates where changes in location of erosion risk are likely to occur because of climate change. The assessment does not quantify the current erosion rate, nor the extent or condition of agricultural land currently affected by hillside erosion, because little data exists regarding actual occurrence, severity, and change in productivity. It also does not assess degradation caused by gully and river erosion, because a paucity of reliable data limits model applicability for channelised flow in WA conditions (Marillier et al. 2008).

Factors contributing to hillside erosion and accounted for in RUSLE (see information box and Figure 2.3.2) include:

- **intrinsic susceptibility of the land, comprising:**
  - slope length
  - slope steepness (gradient)
  - soil erodibility
- **rainfall erosivity**
- **cover, comprising:**
  - land cover (usually by vegetation)
  - land management practices.
RUSLE Step 1: Susceptibility – the intrinsic susceptibility of the land

This step brings together slope length, slope steepness (gradient) and soil erodibility factors and is based on an assessment of the soil-landscape characteristics from DAFWA’s map unit database (Figure 2.3.3). Soil erodibility, slope length and steepness were accounted for.

The Revised Universal Soil Loss Equation (RUSLE)

RUSLE is an empirical model that uses experimental erosion data from a series of sites and compares the erosion rate of these to a ‘standard plot’. The result is presented as an average annual soil loss value, based on steady-state conditions of overland flow on hillsides. The RUSLE is unable to present reliable results for extreme events, and requires extensive data to deliver a reliable absolute result. The RUSLE does not attempt to account for erosion caused by channelised water.

Figure 2.3.3  Intrinsic susceptibility of water erosion, combining soil erodibility, slope length and steepness, classified according to the proportion of the map unit with a water erosion hazard of high or greater (adapted from van Gool et al. 2005).
together by applying a water erodibility index, based on expert opinion, to DAFWA’s soil-landscape mapping, which is the most detailed available (Schoknecht and Tille 2002). The index derives from the water erosion hazard ratings described in van Gool et al. (2001), and was not altered for the different time-steps in this model.

**RUSLE Step 2: Cover – the protective cover on the land**

The cover factor was determined by applying a cover index, based on expert opinion, to different categories of the broad land use classes of the Land Use of Australia, Version 4, 2005–06 (ABARES 2010). Classes defined, from highest to lowest cover, were:

- natural vegetation and reserve
- forestry
- grazing only
- cropping (incorporating grazing).

This index remained static across the time-steps. The relative cover factors are shown in Figure 2.3.4.

Land Use of Australia provides a very general assessment of the use of agricultural lands. Its distinction between ‘grazing’ and ‘cropping incorporating grazing’ is questionable in relation to the south-west of WA. It also does not identify land that is only cropped, since the destocking of farmlands is a recent phenomenon. Even so, it is the most detailed land use mapping available.

**RUSLE Step 3: Rainfall erosivity**

Most erosion is episodic and in this assessment it is assumed that rainfall has the most erosive impact when cover is likely to be least, which usually occurs twice in a year. The first period we call the ‘break of season storm’, when cover is low because land is disturbed for seeding and grazing has reduced pastures and stubble to their lowest levels. The second we call ‘summer storms’, which are intense rainfall events occurring over summer after harvest and when cover has declined by stock grazing, photodegradation, and paddock manipulation, such as burning and fallow tillage to reduce weed burdens.

Relative assessments of erosion risk can be determined by considering the trend over time for the occurrence of potentially erosive rainfall events at these critical times.

Figure 2.3.4  Broad land use categories used to determine the cover factor (adapted from ABARES 2010).
The first time period considered was the 30-year period of 1961–90, regarded by the World Meteorological Organization as the current ‘normal’ baseline period (WMO 1989). See Trewin (2007) for a detailed discussion of ‘normal’ periods. This period is hereafter called the historical period.

The second time period considered was the 12-year interval from 2000 to 2011, which was the latest period available at the time of analysis. This period is hereafter called the recent period.

To normalise each dataset and negate any bias introduced by analysing different time slices, data for all weather stations were converted to storm frequencies and then to an index based on the highest frequency encountered at any weather station over all time periods, before conducting the spatial interpolation described below.

Potentially erosive rainfall events for the two key risk periods have been determined by expert opinion to be generally representative of ‘threshold’ values and were calculated from daily rainfall data extracted from south-west weather stations. Each time-slice for each risk period was spatially interpolated (Jeffrey et al. 2001, 2006) to create rainfall erosivity maps for both break of season storm and summer storm for the aforementioned time periods (Figures 2.3.5, 2.3.6, 2.3.7, 2.3.8).

Scenario 1
Break of season storm events, which were defined as:
20 mm or more of rain falling over a standard BoM (Bureau of Meteorology) 24-hour period (9.00 am to 9.00 am the next day) between April and July inclusive AND where there had been less than 30 mm of cumulative rain in the previous two months.

This definition describes conditions of a heavy opening rainfall event with no effective prior rain. These conditions are likely to be the most erosive because in annual cropping and pasture agricultural systems there is unlikely to be living groundcover. By definition, such an event can either not occur, or can occur only once, at each location each year.

For each weather station, data were queried to identify all events fitting the definition of a break of season storm, classified by historical and recent time period. For each station over each period, the number of storm events was summed and then converted to a frequency by dividing the number of storms recorded by the number of seasons analysed. Each stations’ frequency was converted to an index by dividing its frequency value by the highest frequency value calculated for any station over any time period. The index was then spatially interpolated (Jeffrey et al. 2001, 2006) to create maps (Figures 2.3.5 and 2.3.6). The scale of each map represents the probability (0–100%) of an area encountering a break of season storm in any year for the periods analysed.

There appears to be a trend, over the last decade or so, towards reduced chance of erosive rainfall events at the break of season across most of the south-west. This also indicates an increase in the proportion of seasons where the season break is less well defined and occurs over an extended period with smaller rain events. This phenomenon was noted by the Indian Ocean Climate Initiative (IOCI 2012). It documented that the south-west of WA had 150 mm less annual rainfall than 50 years ago, with autumn rainfall declining 15% and May rainfall declining 25% since 2000 (IOCI 2012). This trend is expected to continue.

The exception is an increased chance of a break of season storm on the Swan and Scott Coastal Plains zone and the northern portion of the Darling Range to South Coast zone, an area analogous to the ‘western woolbelt’. This increased probability could result from more common, extended dry spells preceding a significant rainfall event, thus increasing the chance of fulfilling the criteria for a break of season storm (i.e. greater chance of a dry summer – early autumn preceding a 20 mm or greater rainfall event between April and July).
It is not known from this analysis if these apparent trends will continue, although the IOCI (2012) state with 99% certainty that a highly significant downward trend in the Phillips criterion (an index that relates to south-west winter rainfall) occurred from 1950–99, and that model forecasts a continued trend into the future (IOCI 2012).

**Scenario 2:**
Summer storm events, which were defined as: 20 mm or more of rain falling over a standard BoM 24-hour period between December to February inclusive.
Data for each weather station was first separated into historical and recent time periods. For each weather station over each time period, data were queried to identify all events fitting the definition of a summer storm. The number of storms recorded was converted to a frequency by dividing by the number of seasons analysed. Each frequency was converted to an index by dividing its value by the highest frequency value calculated for any station over any time period. The index was then spatially interpolated (Jeffrey et al. 2001, 2006) to create maps (Figures 2.3.7 and 2.3.8). The scale of each map represents the probability (0–100%) of an area encountering the highest frequency of summer storm for any year over all periods analysed.
The analysis indicates that, over the last decade or so, there appears to be a trend towards an increasing number of potentially erosive summer storms in the eastern wheatbelt and south-eastern coastal areas, and relatively little change in other areas.

This apparent increase in summer storms along the eastern margin of the wheatbelt match the broader ‘large and significant’ increase in summer rainfall in north-west Australia, a trend whose mechanism is poorly understood (IOCI 2012). However, recent rainfall modelling suggests that an increase in aerosols may be contributing to increasing rainfall across the north-west and central Australia, even when ‘greenhouse gas forcing’ suggests rainfall should have decreased (IOCI 2012). The modelling runs mimic the observed trends in our analysis. It is not known if this trend will continue into the future.

**Current status and trend**

As discussed in the assessment methods, erosion hazard has been assessed at two critical times when land cover is likely to be lowest, so a potentially erosive rainfall event is most likely to cause erosion.

**Erosion hazard – break of season**

The first critical period is the break of season when protective land cover is at a minimum, because stubble has degraded or been grazed and seeding for the year’s winter crop is underway or at least planned.

Erosive break of season rainfall events appear to be contracting to the south-west. A comparison of the historical and recent periods (1961–90 and 2000–11) shows a trend towards a decreasing frequency of potentially erosive events across large parts of the south-west (Figures 2.3.9 and 2.3.10).

The general decline in rainfall and the reduced frequency of intense, early season rainfall reduces erosion risk in the higher rainfall zones in three ways:

1. The soil is less prone to waterlogging and hence, saturation-excess erosion.
2. Reduced waterlogging improves growing conditions resulting in better ground cover.
3. The declining rainfall increases the soil volume available to act as a ‘sponge’, thus perpetuating the benefit over subsequent seasons.

The general decline in rainfall in the central, eastern and northern wheatbelt may also be contributing to increasing water repellence of surface soil, which will increase the likelihood of water erosion occurring when intense rainfall occurs.

These findings are in line with a general and continuing decline in autumn and winter rainfall across the south-west (IOCI 2012). Note that much annual variability exists across the south-west. Break of season rainfall events could lead to soil erosion in any area in any season.
**Erosion hazard, summer storm**

The second critical period is summer. Thunderstorms throughout the summer period, when the protective land cover is often low, increase the risk of erosion.

The combined effect of declining growing season rain (resulting in low cover) and increased chance of summer storms, increases the probability of erosion occurring during summer storms. This effect is most prevalent in the Central Northern Wheatbelt, Mullewa to Morowa, and Southern Wheatbelt zones, where declining winter rainfall has resulted in drought conditions several times in recent years.

Comparing the historical and recent periods (1961–90 and 2000–11) shows a trend to increasing chance of potentially erosive summer
storms in the eastern and south-eastern parts of the south-west of WA (Figures 2.3.11 and 2.3.12). This trend is matched by recent climate modelling (IOCI 2012). Maintaining sufficient ground cover to prevent an erosion event in the summer months in these areas is probably of greater importance now than previously. Land managers need to be aware of these apparent trends. At the same time however, annual variability is great across the south-west of WA and summer storms could lead to soil erosion in any area in any season.

Discussion and implications

The water erosion assessment method presented here only indicates spatial changes in hazard from historical (1961–90) to more recent (2000–11) climate data. It does not map extent or severity of past water erosion events, and DAFWA does not routinely monitor land condition for evidence of water erosion after extreme rainfall events. However, the results of the assessment appear to be borne out on the ground.
Regional intelligence highlights a decreased overall risk of water erosion occurring, with drier winters and softer breaks attributed for these decreases across the south-west of WA (Clarke 2013; Priest 2011; A. Stuart-Street, P. Tille, J. Dee, P. Galloway, pers. comm.).

Average erosion rates under dryland cropping systems appear to be lower than in the past, indicating that recent changes in tillage practices and stubble retention have resulted in a more sustainable farming system, from a water erosion perspective. The flipside is that larger machinery and minimum tillage have changed tillage patterns across the paddock and many farmers have removed fences and conservation earthworks (e.g. grade banks) to till larger areas in straighter lines, more quickly. The reduced density of banks and propensity to ignore contours when working the soil could result in large erosion events if intense rainfall coincides with low cover prior to or just after seeding.

Anecdotal evidence from farmers and agribusiness consultants suggests that reduced tillage reduces run-off, resulting in less effective water catchment into dams. Our assessment suggests that at least a portion of this reduced run-off could be due to climate change. A comparison of rainfall temporal distribution and intensity suggests a significant change over the recent 12-year period compared to the historical 30-year period, with fewer heavy falls prior to and during the growing season.

One area of concern with declining early winter rainfall is the increasing prevalence of non-wetting soils and apparently increasing sheetwash erosion on light sandy and gravelly soils in the West Midlands, South Coast, Central Northern Wheatbelt and Southern Wheatbelt zones.

Another concern is continuing water erosion on sodic duplex soils of the South Coast zone, with historical wind erosion and thinning of...
Sodic subsoil contributes to waterlogging and water erosion in this paddock, Stirlings to Ravensthorpe zone.

Topsoil combining with poor sodic subsoils to cause on-going declines in productivity.

Most erosion events documented over the past 15 years highlight the impact of intense summer storms across the south-west of WA and decaying tropical cyclones in the eastern wheatbelt and adjoining rangeland catchment areas.

Grazing and mixed cropping/grazing enterprises appear to be driving broad-scale erosion risk in most areas. These enterprises are the ones whose cover is most often below threshold levels, although this is by no means universal. Many good land managers have adopted rotational grazing and confinement feeding to reduce erosion hazard and maximise profit.

Areas of most concern are parts of the Darling Range to South Coast, Rejuvenated Drainage Zone, Southern Wheatbelt and Stirlings to Ravensthorpe zones. Erosion appears to be highest with high set-stocking rates on annual pasture and stubble grazing situations. Poor cover due to low growth during drought years contributes to erosion during summer storms.

Increased summer rain on the eastern margin of the central wheatbelt and central south-east presents an opportunity for increased production from pasture, particularly perennial pastures and permanent livestock production on parts of the landscape most prone to drought and episodic water erosion. This opportunity coincides with declining autumn and winter rainfall over similar areas, which can result in poor germination and early season growth, reducing the viability of grain and oilseed production. However, there remains the risk that this apparent trend may be caused by transient and poorly understood features of the climate. These are currently being researched (IOCI 2012).

Although not part of this assessment, damage to irrigated agriculture and rural town infrastructure caused by water erosion and flooding from several summer storms and tropical cyclones over the past 10 years has been costly and damaging to WA’s fresh food supply. The Greenough River, Moore River, Gascoyne catchment and smaller south...
coast catchments have all recently been affected by such events. The severity of damage may have been exacerbated by poor cover and low detention times in the catchments of these rivers.

On the west coast, irrigated pastures and horticulture are largely stable and indicate that plot layout and design, and rotational grazing and supplementary feeding has improved in recent years to make these agricultural systems more sustainable.

The episodic nature and spatial and temporal variability of water erosion events makes it difficult to monitor erosion directly. Surrogate monitoring of land cover through a combination of roadside survey technique and remote sensing is a viable alternative that will enable remedial action to be undertaken on areas that repeatedly display inadequate cover. Importantly, such monitoring provides an early warning signal to prevent erosion, rather than just documenting its presence.

**Recommendations**

- A minimum of 70% intact and anchored ground cover is the land managers’ target for prevention of both wind and water erosion (Coles and Moore 2004). This figure will provide an easy-to-understand DAFWA extension message.
- Programs continue to develop and extend farming systems that maximise crop and pasture biomass and provide continuous ground cover, including:
  - crop-grazing to maximise early growth of pastures following the autumn feed gap
  - pasture cropping to improve ground cover and prevent erosion during seeding and early crop growth
  - pasture mixes that contain summer- and winter-active perennial components (in suitable climatic locations), and diverse swards
  - increased use of confinement feeding systems to reduce grazing pressure on stubble and pasture.
- Research and develop remote sensing to map types of vegetation and biomass, including native vegetation, annual and perennial pastures, growing crops and dry biomass. This should provide early warning of erosion risk when validated by ground-truthing.
- Collect relevant climate, soil, land attribute, soil loss and sedimentation data to populate and validate existing water erosion models, including RUSLE and SedNet, for WA conditions.

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This chapter should be cited as:

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