Agricultural Land Use in the Stokes Inlet Catchment

Esperance Catchment Support Team[1]
Department of Agriculture and Food Western Australia
April 2007

Compiled by Frank D'Emden and John Simons

Introduction

Off-site impacts from the agricultural industry in the Stokes Inlet catchment such as sedimentation, erosion, salinity and eutrophication are a major community concern. This was revealed through a community survey, with typical concerns being "upstream agricultural pressure, sedimentation, erosion of creeklines, salinity, nutrient input," and "the present and possible threat of contamination to rivers and Inlet from agriculture and pesticides washed into Inlet from catchment areas".

This paper will discuss the impacts of agricultural landuse and catchment condition on the Stokes Inlet. Current and recommended strategies to manage these impacts will also be discussed.

Description / Background

The Stokes Inlet catchment encompasses both the Lort and Young River catchments. There are 280,000 ha of agricultural land within these catchments, spanning across two broad areas known as the Esperance Sandplain and the Esperance and Salmon Gums Mallee.

The catchments have a temperate climate with cool wet winters and dry warm summers, with average annual rainfall ranging from 600mm/yr along the coast to 350mm/yr in the upper catchment. The dominant soil types in the catchment are alkaline grey shallow sandy duplex, grey shallow sandy duplex and grey deep sandy duplex.

Agricultural land use is predominantly dryland agriculture with some feedlotting. Crops include wheat, barley, canola, lupins, oats and pulses, while livestock operations mainly comprise beef cattle and sheep for meat and wool. The gross annual value of agricultural production in the catchment is approximately $90 million.

1. Climate

1.1 Rainfall

The Lort and Young River catchments have been analysed using data from across the Esperance Sandplain and the Esperance Mallee areas (Figure 1). Table 1 indicates there is a 20 per cent chance (one out of every five years) that the Esperance Sandplain will receive an annual rainfall above 590 mm (wet year) or below 443 mm (dry year). Figure 2

[1] Work from previous team members is referred to in this paper – see Bowyer (2001)

depicts the average monthly rainfall and Figure 3 shows the yearly total rainfall and growing season rainfall for each year from 1957.

Table 1: Statistics for annual rainfall for the Lort and Young River Catchments.

Location	Average annual rainfall (mm)	Percentile			Minimum annual rainfall & year (mm)	Maximum annual rainfall & year (mm)
		20% Dry year (mm)	50% Median (mm)	80% Wet year (mm)		
Esperance Sandplain	510	443	486	590	291 (1994)	748 (1999)
Esperance Mallee	380	336	365	448	203 (1994)	574 (1999)

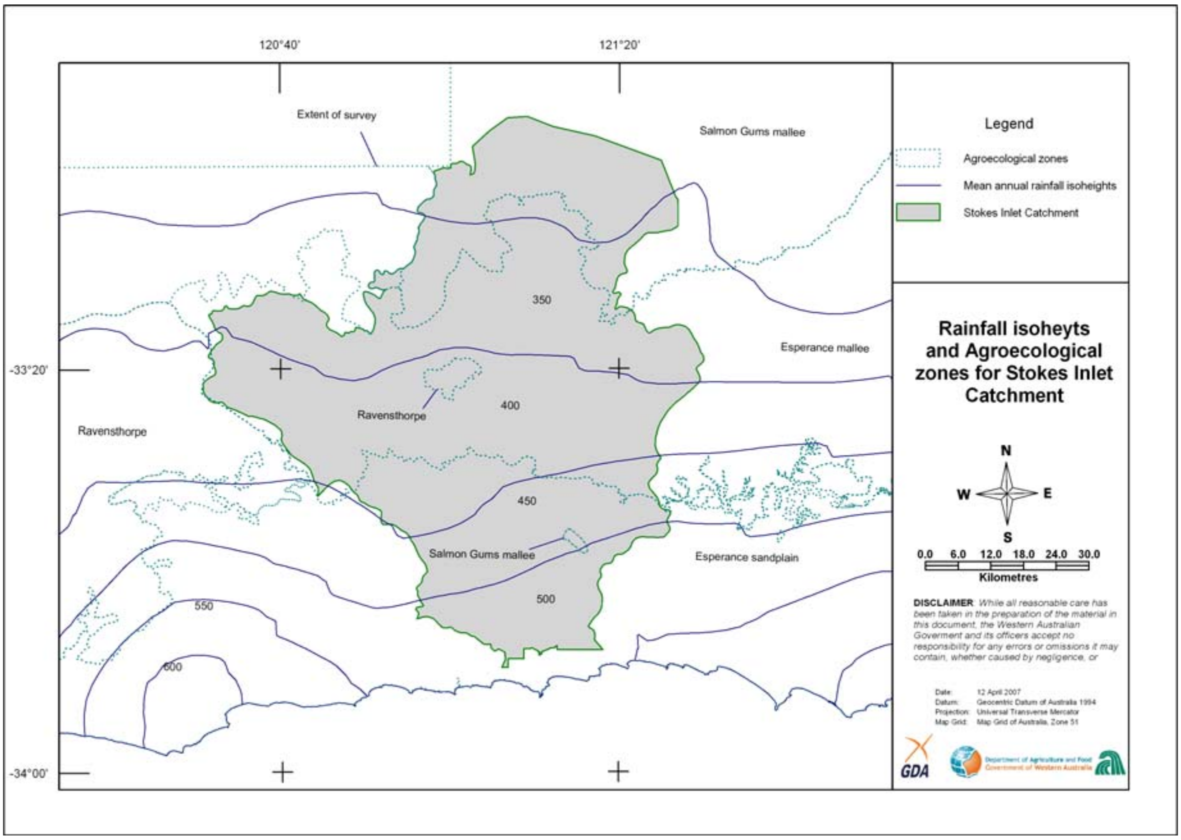
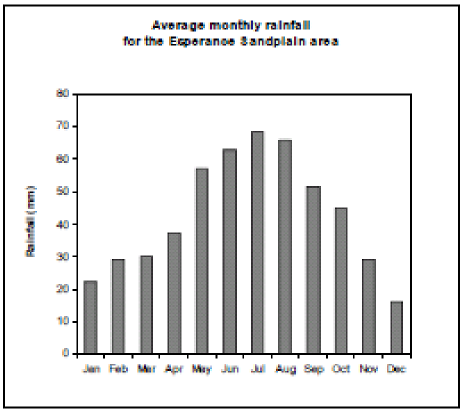


Figure 1: Rainfall isohyets for the Esperance region.

a)



b)

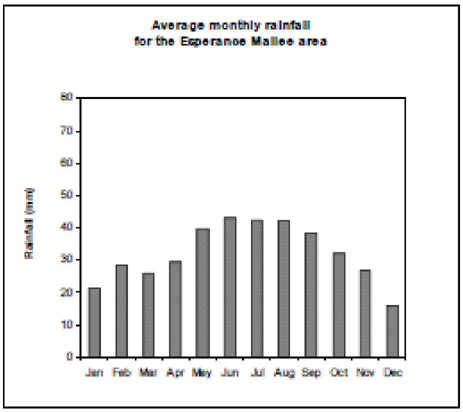
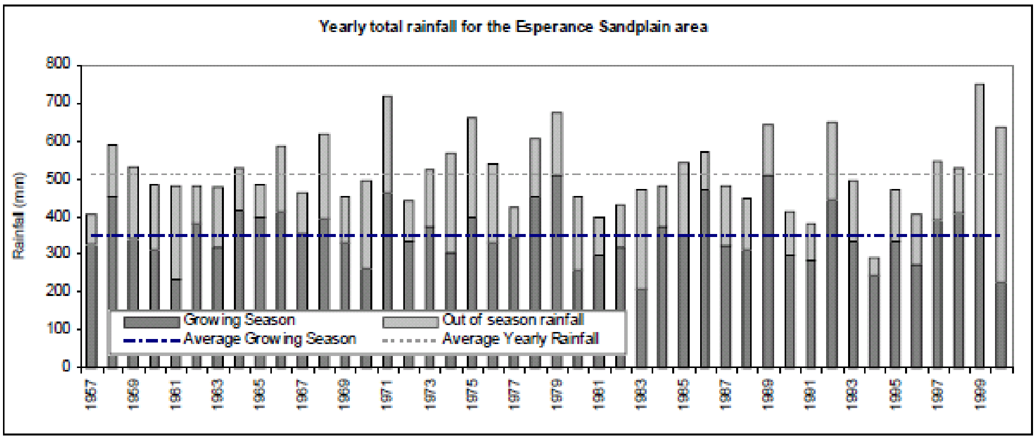


Figure 2: Average monthly rainfall♣ for a) the Esperance Sandplain, and b) the Esperance Mallee areas of the catchment.

a)



b)

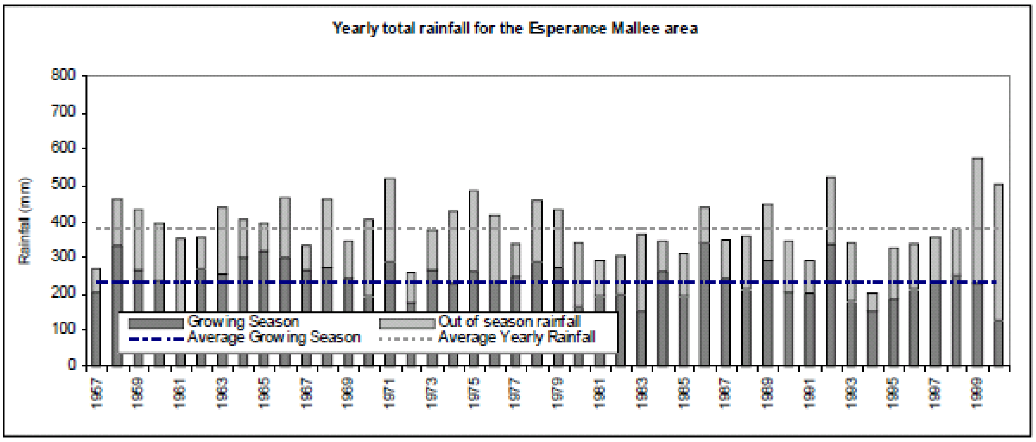


Figure 3: Annual rainfall♣ separated into growing season (May to October) and out-of growing season for a) the Esperance Sandplain, and b) the Esperance Mallee areas of the catchment.

♣ *These interpolated rainfall and temperature data were obtained from the Silo Data Drill web-site. The daily climate data are derived from the Bureau of Meteorology climate stations. For more information see the web-site at www.bom.gov.au/silo (The Data Drill, Climate Impacts and Natural Resources Systems, Queensland Department of Natural Resources, 2000).*

1.2 Temperature

Temperatures throughout the entire catchment are similar and range from average daily highs in summer of 27-29°C, to average winter highs of 16-18°C (Figure 4). The highest temperature since 1957 in the catchment reached 46°C (February 1991), while the lowest temperature dropped to 1.5°C (July 1969).

a) *b)*

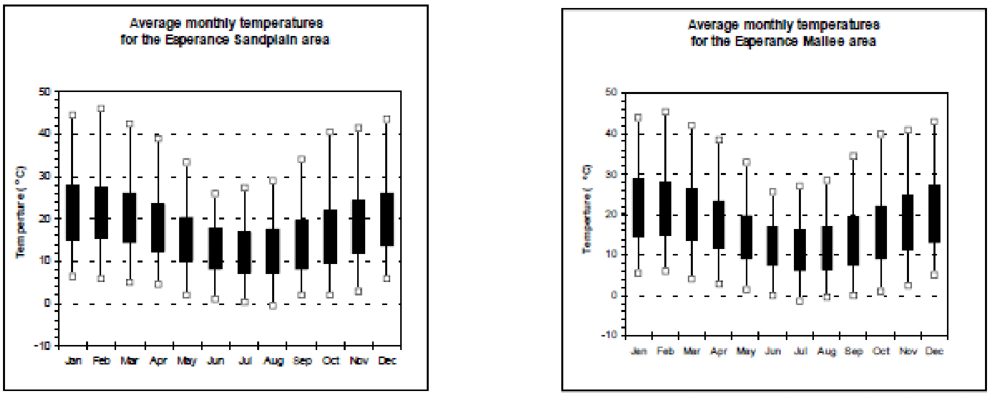


Figure 4: Average monthly temperatures♣ for a) Esperance Sandplain, and b) Esperance Mallee areas.

1.3 Wind

Wind speeds over 29 km/h can move exposed particles of soil up to sand grain size and cause wind erosion. The hours of winds greater than 29 km/h for the nine years 1992-2000 have been recorded by the Department of Agriculture and Food's climate station at the Esperance Downs Research Station, near Gibson. Although each year is highly variable and strong wind events occur episodically, the predominant direction of strong winds in the region is west and west-north-west (Figure 5).

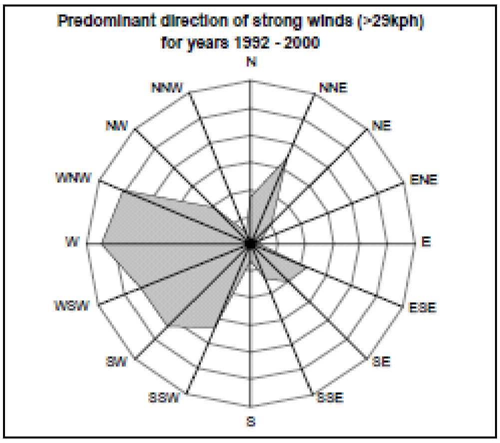


Figure 5: The predominant direction of strong wind (>29 kph) from 1992 to 2000.

♣ *These interpolated rainfall and temperature data were obtained from the Silo Data Drill web-site. The daily climate data are derived from the Bureau of Meteorology climate stations. For more information see the web-site at www.bom.gov.au/silo (The Data Drill, Climate Impacts and Natural Resources Systems, Queensland Department of Natural Resources, 2000).*

1.4 Climate change

Climate change has the potential to threaten agroecological processes in the Young and Lort River catchments over the next century. Projected rainfall patterns suggest decreases of between 20% and 40% in June to August rainfall (IPCC, 2007a; CSIRO, 2001) over the next 70 to 90 years relative to current levels.

Production from agriculture and forestry is projected to decline over much of southern Australia by 2030 due to increased drought and fire. However the region has substantial adaptive capacity due to a well-developed economy and scientific and technical capability, but there are considerable constraints to implementation and major challenges from changes in extreme events (IPCC, 2007b).

2. Soil-landscape summary

2.1 Soil groups

The soil groups (Schoknecht, 1997) found in the Lort and Young River Catchments are shown in Table 2. Alkaline grey shallow sandy duplex, grey shallow sandy duplex and grey deep sandy duplex (gravelly) are the three most common. Associated soils include calcareous loamy earths and pale deep sands (Figure 6).

Table 2: Soil groups in the Lort and Young Rivers Catchment

Soil group	Area (ha)	% of catchment
Alkaline grey shallow sandy duplex	146,990	45
Grey deep sandy duplex	53,510	16
Grey shallow sandy duplex	51,940	16
Calcareous loamy earth	29,067	9
Pale deep sand	17,341	5
Shallow gravel	9,523	3
Alkaline grey deep sandy duplex	5,457	2
Other soil groups	15,035	4
Total	328,863	100

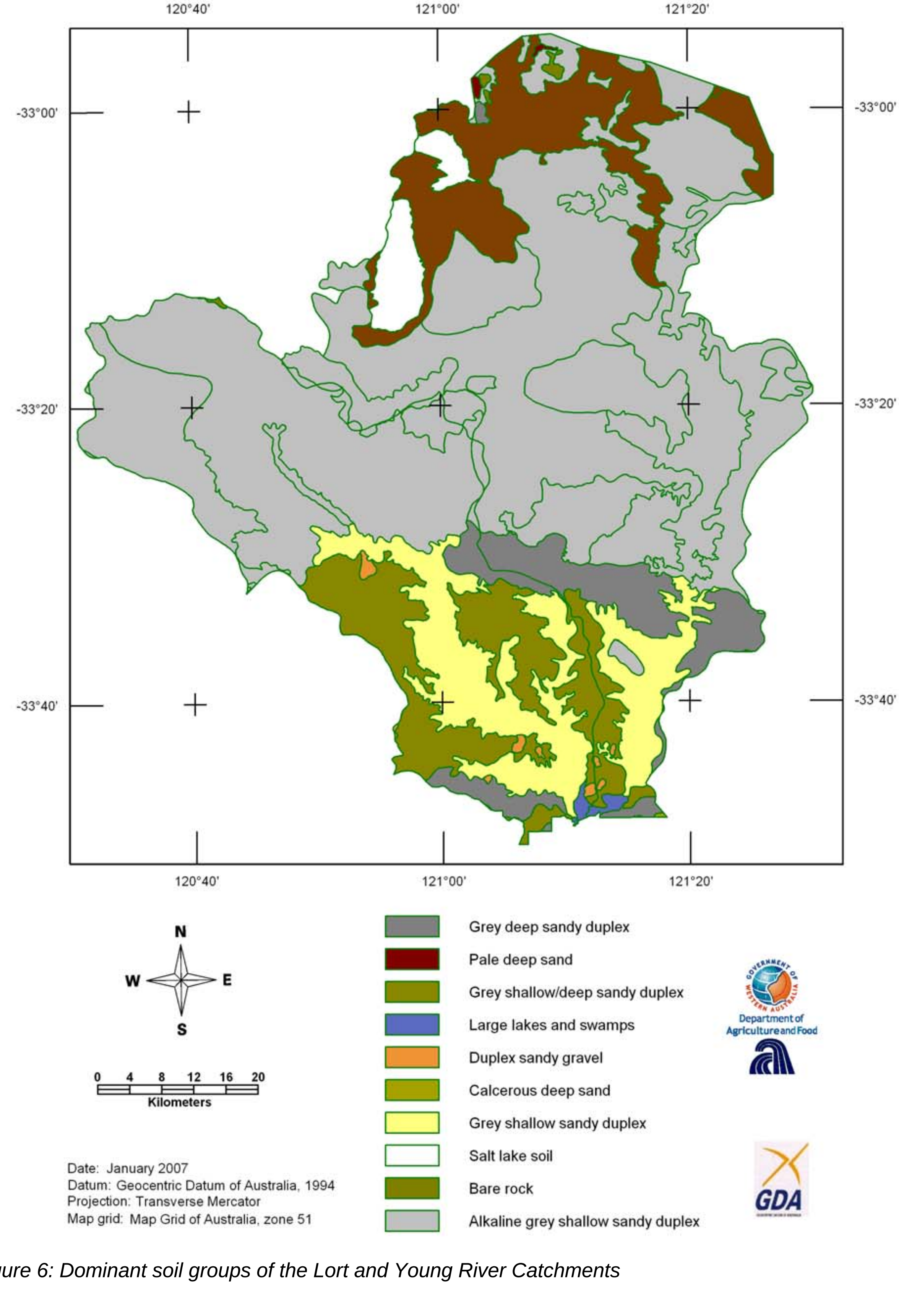


Figure 6: Dominant soil groups of the Lort and Young River Catchments

2.2 Soil-landscapes

Twenty major soil-landscapes have been identified in the Lort and Young River Catchments (Tables 3a and 3b). The most common is Sc1 which occupies 27 per cent of the catchment and represents the shallow alkaline duplex soils of the mallee plains. The Yo1 soil landscape occupies 15 per cent of the catchment and represents the duplex soils of the incised river valleys. Sc6 represents mallee plains with shallow incised tributary drainage in the Young Catchment. The Mu1 soil-landscape of the plains and rises between the incised river valleys of the Young and Lort Rivers occupies 14 per cent. The other soil-landscapes occupy just under 30 per cent of the catchment (Figure 7).

Table 3a: Soil-landscapes of the Lort and Young River Catchments

Soil-landscape	Legend description
	Esperance System
Es1 (28,433 ha, 9%)	Level to gently undulating plain with subdued dunes, swamps and incipient drainage lines. Grey deep sandy duplex (gravelly) soils with associated pale deep sands. Minor grey shallow sandy duplex soils and clays.
Es2 (17 ha,<1%)	Gently undulating sand sheet with subdued dunes and minor swales. Pale deep sands with associated grey deep sandy duplex (gravelly) soils.
Es4 (577 ha,<1%)	Gently inclined scarp (40 m high) with soaks on lower slopes. Grey shallow and deep sandy duplex soils, associated pale deep sands. Minor wet soils.
	Gore System
Go1 (1,171 ha, <1%)	Poorly drained low-lying level coastal plain with occasional dunes. Grey deep sandy duplex soils and pale deep sands. Minor calcareous deep sands and saline wet soils.
Go3 (1,313 ha, <1%)	Large swamps and lakes. Dominant soils are saline wet soils (that are regularly inundated for long periods) with minor pale deep sands.
	Halbert System
Ha1 (58 ha, <1%)	Gently undulating to undulating plain with many small playas. Alkaline grey deep and shallow sandy duplex soils with associated salt lake soils, pale deep sands and calcareous loamy earths.
	Munglinup System
Mu1 (44,763 ha, 14.%)	Externally drained plains and rises with gently inclined slopes some small level plains on upper slopes and catchment divides. Grey deep and shallow sandy duplex soils (gravelly) with minor pale deep sands, gravelly duplex soils and deep sandy gravels
Mu3 (1,145 ha, <1%)	Gently inclined hillslopes of a low scarp (40 m), externally well drained with short ephemeral streams. Grey deep and shallow sandy duplex (gravelly) soils with minor pale deep sands, duplex sandy gravels and alkaline grey deep sandy duplex soils.
Mu6 (1,437 ha, <1%)	Gently sloping rises consisting of broad crests in upper landscape positions. Duplex sandy gravels and associated grey deep sandy (gravelly) duplex soils and minor pale deep sands
	Oldfield System
Od1 (4,267 ha,1%)	Undulating rises and plains in places increasing to rolling rises with incised ephemeral streams. Alkaline grey shallow sandy duplex soils, minor grey shallow sandy duplex soils, duplex sandy gravels, and reddish brown non-cracking clays.

Table 3b: Soil-landscapes of the Lort and Young River Catchments (cont'd)

Soil-landscape	Legend description
	Scaddan System
Sc1 (87,194 ha, 27%)	Level to gently undulating plain with incipient drainage and occasional gilgia microrelief. Alkaline grey shallow sandy duplex soils often in a complex with associated calcareous loamy earths
Sc2 (2,279 ha <1%)	Gently undulating to undulating plain with occasional subdued sand dunes and sand sheets. Alkaline grey shallow sandy duplex soils, associated pale deep sands and alkaline grey deep sandy duplex soils.
Sc4 (10,197 ha, 3%)	Level poorly drained plain or plateau with gilgia microrelief. Alkaline grey shallow sandy duplex soils, associated calcareous loamy earths and uniform non-cracking clays.
Sc5 (17,627 ha, 5%)	Gently undulating to undulating plain. Alkaline grey shallow sandy duplex soils associated calcareous loamy earths and alkaline grey deep sandy duplex soils.
Sc6 (47,019 ha,14%)	Gently undulating plains with shallow defined tributary stream channels. Alkaline grey shallow sandy duplex soils, associated calcareous loamy earths.
Sc8 (26,300 ha, 8%)	Shallow incised river valley with gently inclined slopes. Alkaline grey shallow sandy duplex soils associated calcareous loamy earths.
	Salmon Gums System
Sg2(3367ha,1%)	Very gently inclined scarp with external drainage via a well developed network of incipient streams. Alkaline grey shallow sandy duplex soils and calcareous loamy earths with minor non-cracking clays and bare rock.
Sg4(272 ha,<1%)	Gently inclined to moderately inclined slopes and crests of very low relief occurring in upper landscape positions. Alkaline grey shallow sandy duplex soils and duplex sandy gravels.
	Tooregullup System
To1 (89 ha, <1%)	Coastal parallel dunes with linear swales and granite headlands. Calcareous deep sands, associated calcareous shallow sands and minor pale deep sands.
	Young System
Yo1 (51,330 ha,15%)	Incised river valley with gently to moderately inclined slopes and narrow alluvial plain, Some breakaways on upper slopes. Grey shallow sandy duplex soils with associated deep grey sandy duplex soils and other minor soils.

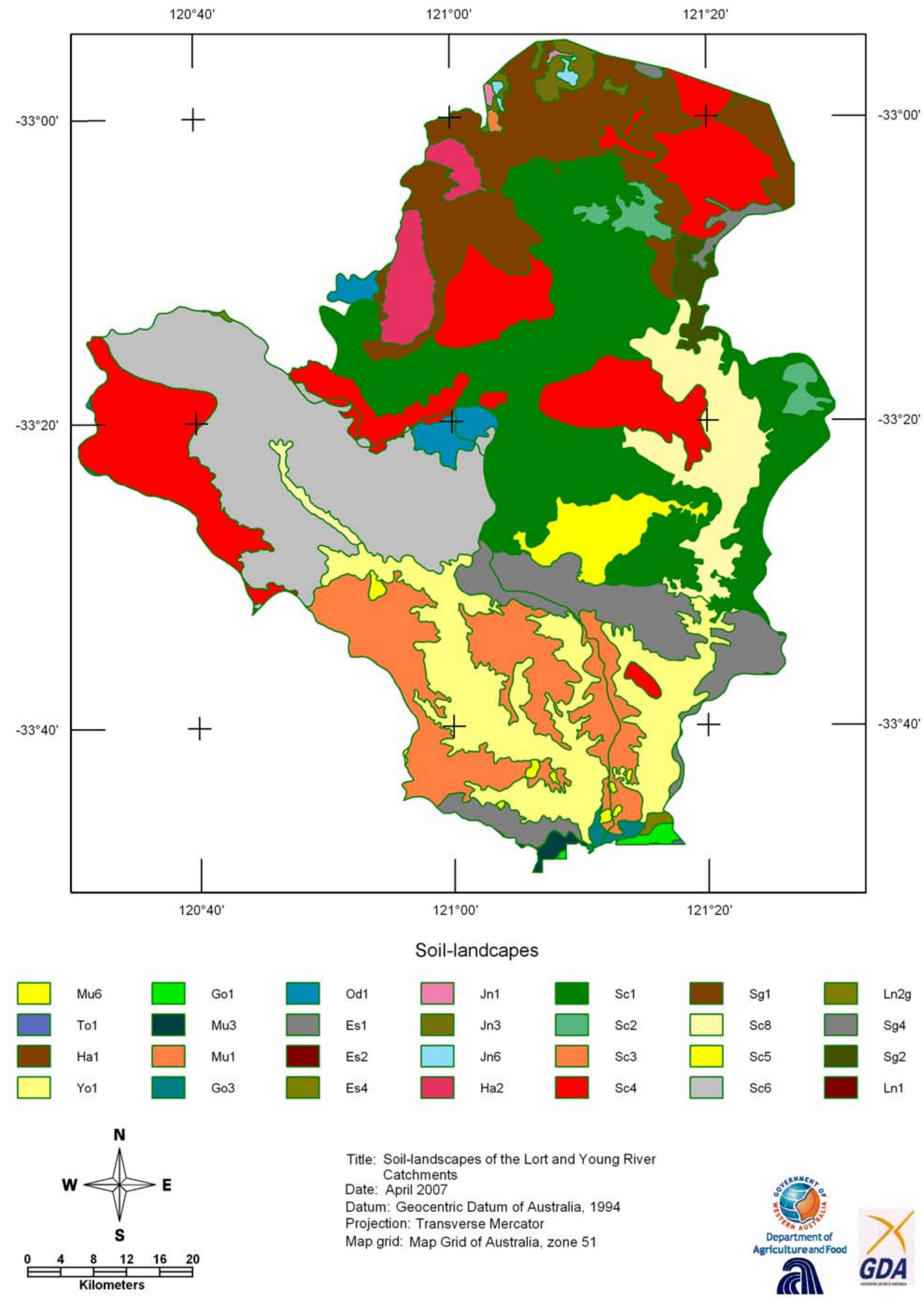


Figure 6: Soil-landscapes of the Lort and Young River Catchments

3. Land Use

The predominant land use in the catchment is ‘production from dryland agriculture and plantations’ according to the Australian Land Use Management (ALUM) Classification System (Figure 7). The predominant farming enterprises in the catchment are broadacre, mixed livestock/cropping, dryland agricultural systems, with the proportion of cropping increasing with distance from the coast. Agroforestry is developing as a minor land use across the catchment, with most commercial plantations comprising *Eucalyptus* and *Pinus spp*. Dryland crops include wheat, barley, canola, lupins, oats and pulses (Table 4). Beef cattle along with sheep meat and wool are the main livestock enterprises, which are mainly based on annual pastures with a small component of lot-feeding (Table 5).

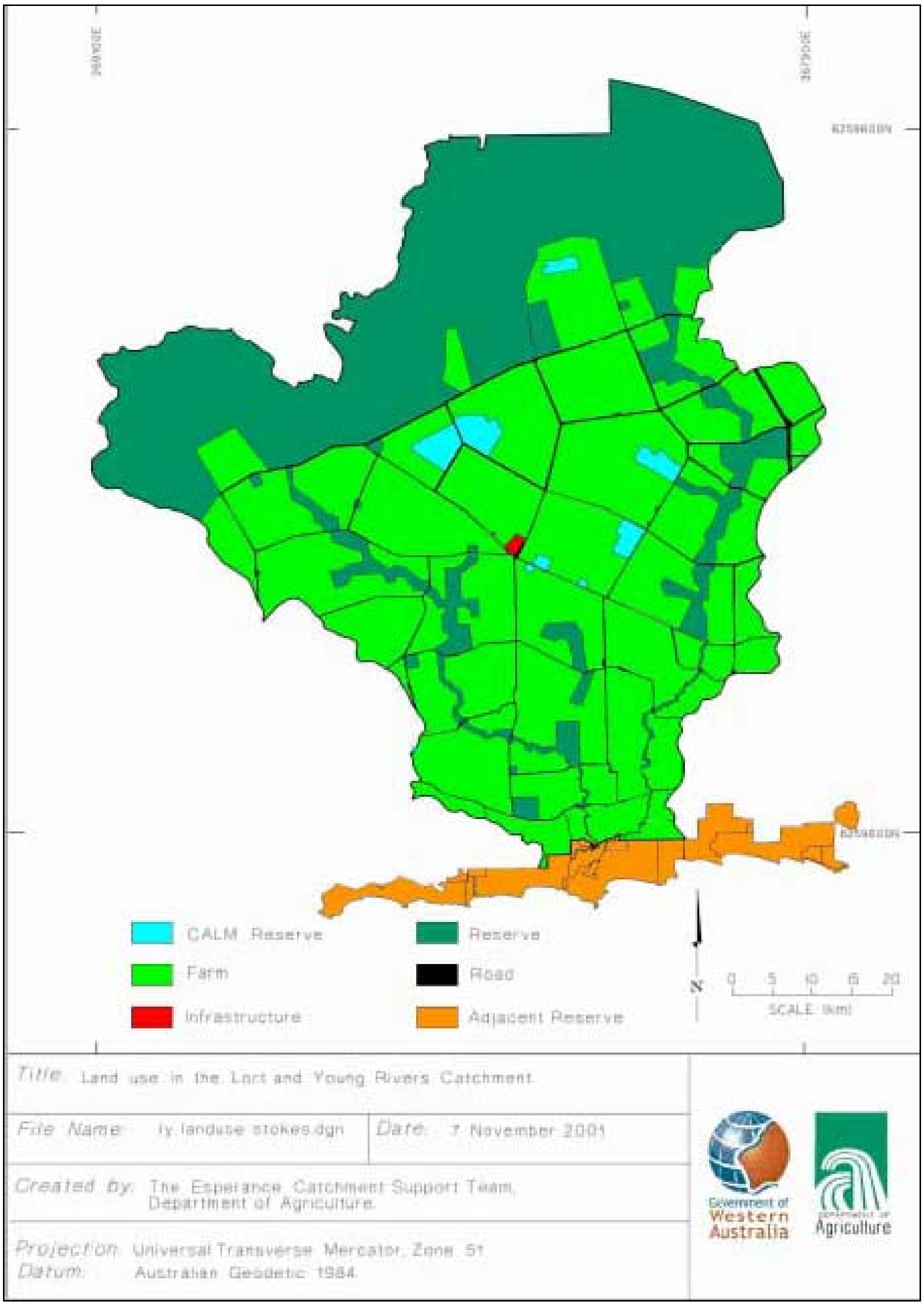


Figure 7: Land use in the Stokes Inlet Catchment

3.1 Agricultural systems

Cropping rotations and enterprise mixes vary greatly between farms and are dependant on soil type distribution, capital structure and individual business preferences. Farm businesses put resources totally into cropping or combine crops with sheep and/or beef cattle. Sheep are primarily raised for wool, however prime lamb production is becoming increasingly significant.

3.2 District production

The area cropped in the Esperance Shire has been steadily increasing since 1998, with an associated decline in pasture area (Figure 8). This trend is also evident in the Lort and Young River Catchments[2]. The total gross value of agricultural production (GVAP) in the catchment was $87 million in 2003/4. Cropping is dominated by wheat and barley with canola also being an important break crop and contributor to farm production and income (Table 4). In recent years, as has been common throughout the Esperance district, barley production has increased relative to canola. Grain legumes form an integral part of the cropping rotation and contribute about 2 per cent to crop income.

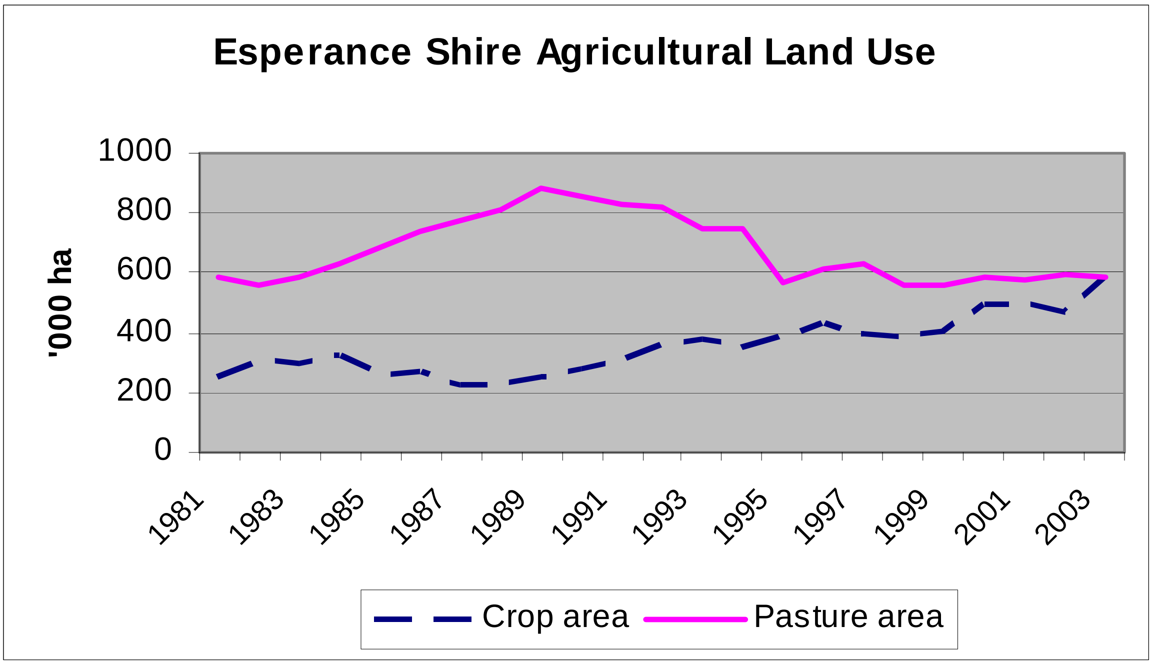


Figure 8. Trends in agricultural land use for the Esperance shire (Source: ABS, Department of Agriculture)

[2] Crop area in the Stokes Inlet catchment increased by approximately 50% between 1999/00 and 2003/04, while livestock numbers increased by approximately 30% over the same period (Source: ABS, Department of Agriculture).

Table 4: Area, yield and value of crops in the Stokes Inlet Catchment

	Lort & Young Catchments 2003/04		
Crop	**Area (ha)**	**Tonne**	**GVP ($/m)**
Wheat	63,946	124,840	21.7
Barley	51,146	118,013	18.5
Oats	3,883	6,479	1.2
Canola	23,684	29,956	12.1
Lupins	3,050	3,003	0.8
Other pulses	1,444	1,892	0.5
Hay & pasture seed	6,468	14,096	5.9
Total	**153,621**	**298,279**	**60.7**

Table 5: Livestock numbers, production and value in the Stokes Inlet Catchment

	Lort & Young Catchments 2003/04		
Livestock production	**Number (hd)**	**Tonne**	**GVP ($m)**
Cattle slaughter	13134		8.7
Sheep & lamb slaughter	188170		6.2
Wool		2182	11.4
Sheep & lambs shorn	478989		
Total			**26.3**

4. Land management issues

Land management hazards in the Lort and Young River catchments, along with suggested actions for controlling recharge for specific soil types, are covered in Appendix 1.

4.1 Hydrology

Clearing of native vegetation for agricultural development in the catchment was completed in the 1970s and 80s, therefore the catchment water balance is still establishing a new equilibrium. Changes within the water balance components have caused an increase in the frequency, volume and velocity of surface water run-off and an increase in groundwater recharge which is causing groundwater levels to rise and the area of groundwater discharge to expand. Water erosion, sedimentation, eutrophication, inundation, waterlogging, flooding and secondary salinity are all symptoms of these changes. These hydrological hazards are adversely affecting both the inlet and the agricultural enterprises within the catchment. For example, Table 6 highlights the damage caused to farms during the January 2007 floods in which up to 250mm of rain fell in 36 hrs.

Table 6. Damage to farm infrastructure in Young and Lort River catchments from January 2007 flood event.

	Total	**Estimated cost ($'000)[1]**
Fences (km)	43	172
Tracks (km)	31	10
Creek crossings (no.)	44	176
Banks and drains (km)	13	8
Erosion, sedimentation & flooding (ha)	963	500
Total		**866**

[1] – Based on scheduled rates from SCRIPT's Southern Incentives program.

The catchment has a high salt output/input ratio indicating streamflow salinities have increased above the natural level (Mayer 2005) and the catchment salt balance has not yet equalised. Under the current land use and climate patterns it will take at least 50 years until a new hydrological equilibrium is reached (George et al. 2005).

Depth to watertable varies greatly and the rate of groundwater rise is 0.05 to 0.30 m/year. Baseflow generated by groundwater discharge as a direct result of rising watertables is currently occurring along some of the tributaries and the main channel of the Young River. Recent Flowtube modelling suggests that shallow watertables will develop along the upper tributaries within the next fifty years (Simons, 2001).

Currently salinity is developing across the catchment in areas of shallow basement rock and at the base of deep sand ridges where groundwater storage has already been exceeded. Secondary salinity is also developing in undulating areas, with groundwater discharging due to geological structures and groundwater convergence zones, particularly above and within the incised tributaries.

The Land Monitor Project mapped 1.4 per cent of the agricultural land as salt-affected by 1997 and 21 per cent of the catchment as having low-lying areas with the potential for shallow watertables to develop. Secondary salinity and/or other water related degradation hazards as listed previously have the potential to increase in severity across these low lying areas of the catchment.

4.2 Surface water management

There are many options for managing surface water. The preferred approach is to reduce the speed and amount of surface water flow by land management and soil improvement, then manage the excess surface water (run-off) with earthworks.

Surface water earthwork options

Surface water earthworks reduce the velocity and volume of excess run-off through diverting or retaining water. The area of slope classes of seven major soil-landscapes, which represent 92 per cent of the cleared farmland in the catchment, are shown in Table 7.

Table 7: Area of slope classes for the Lort and Young Rivers Catchment

Soil-landscape	Slope class and area of soil-landscape (ha)				
	0-1%	1-3%	3-5%	5-10%	10%+
Sc1	41,921	43,060	2,062	132	3
Yo1	2,622	13,890	15,253	16,111	3,204
Sc6	15,869	26,429	4,021	649	16
Mu1	16,766	21,961	4,260	1,488	149
Es1	15,937	11,234	1,090	162	10
Sc8	4,525	14,476	5,603	1,560	81
Sc5	6,175	8,919	1,775	199	1
Total	103,815	139,969	34,064	20,301	3,464

Grade and absorption banks may be used on land with slopes ranging up to 10 per cent. Considering the slope and dominant soil groups, the most suitable soil-landscapes for these banks are Sc1, Yo1, Sc6 and Mu1. Surface drains may be used where the slope is less than 1 per cent and therefore the most suitable soil-landscapes for these are Sc1, Sc6, Mu1 and Es1.

Structures with no land slope criteria need site specific land assessment to determine their suitability. Only 1 per cent of the catchment is unsuitable for banks and surface drains, and 92 per cent of this area falls within Yo1, an incised river valley.

Land management options

Land management options reduce the speed or velocity of surface water by slowing the rate of water movement. Three land management options may be used within most areas of the Lort and Young River Catchments:

- vegetative cover;
- working land along the contour;
- grass strips and permanently grassed waterways.

Soil improvement options

Soil improvement can reduce the volume of surface water by increasing soil water retention. Table 8 shows six major soil groups or 85 per cent of the catchment may be improved with gypsum, clay or ripping.

Gypsum can be used on shallow duplex soils that have developed a hardsetting surface. Claying is an option for deep sandy soils that have become non-wetting. Deep ripping can be used on deep sandy soils to loosen compacted layers.

Table 8: Soil improvement options for six major soil groups in the Lort and Young Rivers Catchment

Soil group	Area (ha)	%*	Gypsum	Claying	Ripping
Alkaline grey shallow sandy duplex	146,990	45	✔	X	X
Grey deep sandy duplex	53,510	16	X	✔	✔
Grey shallow sandy duplex	51,940	16	✔	X	X
Pale deep sand	17,341	5	X	✔	✔
Alkaline grey deep sandy duplex	5,457	2	X	✔	✔
Alkaline grey shallow loamy duplex	2,630	1	✔	X	X
Total	**277,868**	**85**			

∗ percentage of catchment

4.2 Soil degradation

Soil degradation not only affects agricultural productivity, but also has off-site impacts, particularly in relation to water quality, and ultimately having adverse impacts on the inlet. The main soil degradation hazards in the catchment are subsurface acidity, water repellence, phosphorus export and wind erosion (Nicholas, 2005).

The Department of Agriculture and Food WA reviewed the NRM issues and risks to agricultural assets and developed possible targets and management options. These are specified in the Section 5 (Suggested actions for Draft Management Plan).

4.3 Weeds and Pests

The main pests on agricultural land are foxes and rabbits; however starlings are also posing a threat to parts of the Stokes Inlet catchment. The current starling outbreak (which includes areas including the western parts of the lower Young River catchment, see Figure 9) was first recorded in 2006. The outbreak is currently being closely studied and researched, with SCRIPT is investing $255 500 over 3 years in the Starling Program.

The key objectives of the Starling Program are to:

- engage the community in starling surveillance
- conduct research in association with the Agricultural Protection Board and the Centre for Excellence in NRM on starling movement and control techniques and test these in eradication situations, and
- produce recommendations for management and control of starlings.

(Andrew Woolnough (DAFWA Albany), pers. comm.)

Bridal Creeper, (*Asparagus asparigoides*), has been noted to occur on the foreshore of the Young and Lort Rivers, with the potential to release bio-control agents (i.e. Bridal Creeper rust and leaf hoppers) in the catchment in the future.

4.4 Agricultural chemicals

The Australian Pesticides and Veterinary Medicines Authority (APVMA) administers the National Registration Scheme for Agricultural and Veterinary Chemicals. Before being registered for sale, all agricultural chemicals must go through a risk assessment process conducted by independent evaluators to decide whether they are safe for the environment. The Department of the Environment and Heritage (DEH) advises on whether products might harm the environment, and how to avoid this. The DEH keeps a record of all pollutants through the National Pollutants Inventory (PSIC, 2005).

No pollutant monitoring sites are present in the Lort or Young River catchments. In partnership with participating industries, the Australian Government Department of Agriculture, Fisheries and Forestry conducts the National Residue Survey (NRS) to monitor chemical residues in raw foods. The NRS also surveys heavy metals and organochlorines, such as DDT, that could still be present in the environment as a result of past industry use (PSIC, 2005).

The only agricultural chemical used in the Young and Lort Catchments to have been reviewed by APVMA in recent times is the active constituent atrazine. At the time of the review, insufficient data was available to support a conclusive risk assessment regarding the effects of atrazine in amphibians. The review concluded that the issue of atrazine and amphibians should be revisited if additional data demonstrate that atrazine may be likely to impact on frog populations at realistic levels of exposure, but such outcomes are not considered likely (APVMA, 2004).

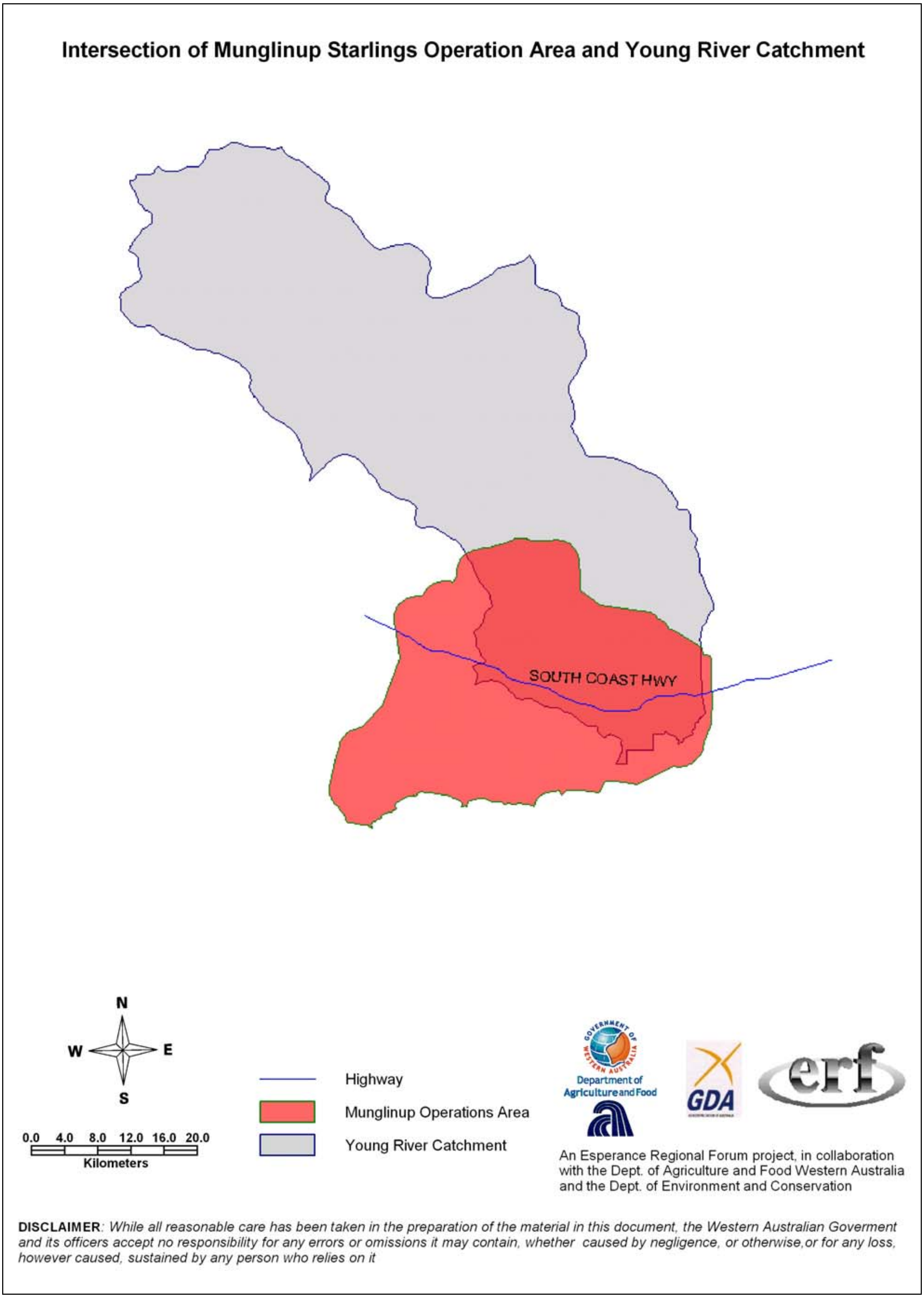


Figure 9 Munglinup starlings operation area

5. Suggested actions for Draft Management Plan

5.1 River restoration

Fencing

It is recommended that areas at high risk of water erosion along creeklines be identified and fenced to prevent further degradation from stock. Fences should be placed at least 20 metres from the main channel to allow for revegetation and flooding.

If these areas are showing signs of secondary salinisation, then EM38 and EM31 surveys of the immediate area should be carried out to ensure that fences are positioned to allow for future growth in saline areas.

Riparian revegetation

Once these areas have been identified and fenced, then revegetation should be carried out using a range of local groundcover, understorey and overstorey species and provenances where possible. Saline areas will need to be treated differently, using locally adapted species where possible.

5.2 Water management

Surface water

Many landholders have implemented surface water management earthworks in the past; however some of these structures have been designed with inadequate regard to the location of disposal points. Surveys of existing and planned structures and recommendations for disposal point location and design should be carried out by a qualified surface water engineer.

Salinity

Investigation and characterization of groundwater flow systems affecting riparian zones should be carried out, along with determination of resource condition baselines.

Engineering and biological management options for groundwater discharge areas need to be identified, and in areas where implementation is possible, monitoring and evaluation of their effectiveness carried out. Technical support for salinity management planning and evaluation also needs to be provided, while groundwater monitoring needs to be improved and remote-sensing training sites established.

5.3 Soil

Soil quality investigations are currently being planned for the Young River catchment in collaboration with the Esperance Regional Forum and landholders in the Young River catchment. Ideally, these investigations will be extended to growers in the Lort River catchment. The following soil quality risks ultimately pose a threat to the Stokes Inlet.

Possible targets and management options include:

Subsurface acidity

- Participative research and development with land managers on:
  - ⇒ investigate extent of acid sulfate soils; and
  - ⇒ optimal treatment methods.
- Investigate links between acidity and other management issues (salinity, water quality).

Water repellence

- Identify suitable clay types for claying.
- Develop best management practices (BMPs) for agronomy on clayed soils.
- Develop BMPs that minimise or ameliorate water repellence.
- Investigate biological control of water repellence.

Phosphorus export

- Establish nutrient balance models and industry benchmarks.
- Identify and quantify priority areas and priority actions for study catchments.
- Identify and quantify key nutrient sources for study catchments.
- Identify and quantify soil nutrient saturation constraints.
- Identify nutrient balance indicators, standards, targets and benchmarks for different enterprises.
- Establish BMP implementation and nutrient point source audit methodology, database, web interface, tracking and reporting system.
- Establish nutrient balance methodology and models and industry benchmarks.
- Develop catchment BMP models.
- Prepare BMP documentation and verification.
- Investigate approaches for implementation and adoption.

Wind erosion

- Participative research and development examining:
  - ⇒ amelioration of non-wetting soils;
  - ⇒ levels of groundcover needed to protect land in adverse seasons; and
  - ⇒ adoption of perennials and practices suitable for sustaining groundcover on erosion-prone areas.

Waterlogging

- In a participative research and development process:
  - ⇒ implement BMPs for waterlogging landscapes;
  - ⇒ develop water management guidlines for new systems such as raised beds and tramlines.
  - ⇒ implement best practice surface water management;
  - ⇒ match land use to land capability.
- Research and develop a method to predict areas susceptible to water erosion, using spatial data techniques.
- Continue extension and promotion of best management practices that minimise risk of water erosion.
- Review best management practices for water erosion.
- Develop linkages to nutrient export management.

Structural decline

- Participative research and development on:
  ⇒ gypsum, organic matter ameliorants;
  ⇒ subsurface applications of gypsum and other ameliorants;
  ⇒ gypsum response on highly sodic surface crusting soils; and
  ⇒ raised bed farming and application of precision agriculture.
- Develop decision support tools using agribusiness.

Subsurface compaction

- Participative research and development of:
  ⇒ tramline farming and farm-scale testing by industry;
  ⇒ perennials and phase farming systems;
  ⇒ progressive tillage to ameliorate compacted soils;
  ⇒ impacts of claying and minium tillage on compaction; and
  ⇒ zone farming for compaction amelioration.

(Nicholas, 2005)

Contact details:

Frank D'Emden
Natural Resource Management Development Officer
Department of Agriculture and Food Western Australia

Ph: 9083 1133
Fax: 9083 1100
Mob: 0429842413

fdemden@agric.wa.gov.au

PMB 50, Melijunup Rd
Esperance WA 6450

References

APVMA (2004). The reconsideration of approvals of the active constituent atrazine, registrations of products containing atrazine, and their associated labels. Australian Pesticides and Veterinary Medicines Authority, Canberra, Australia.

Bowyer, J. (2001). Lort and Young Rivers Catchment. Rapid Catchment Appraisal. Resource Management Technical Report 231. Department of Agriculture Western Australia.

CSIRO (2001). Climate Change Projections for Australia. CSIRO Atmospheric Research, Aspendale, Victoria. URL: www.dar.csiro.au/publications/projections2001.pdf [Accessed 12/4/07].

George, R., Kingwell, R., Hill-Tonkin, J. and Nulsen, R. (2005). Salinity investment framework: Agricultural land and infrastructure. Resource Management Technical Report 270. Department of Agriculture Western Australia.

IPCC (2007a). Climate Change 2007: The Physical Science Basis. Summary for Policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC Secretariat, Geneva, Switzerland.

IPCC (2007b). Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability. Summary for Policymakers. Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. IPCC Secretariat, Geneva, Switzerland.

Mayer, XM, Ruprecht, JK & Bari, MA. 2005,.Stream salinity status and trends in south-west Western Australia, Department of Environment, Salinity and Land Use Impacts Series, Report No. SLUI 38.

Nicholas, B. (2005). Natural Resource Management Issues for the South Coast Regional Strategy. Resource Management Technical Report 285. Department of Agriculture Western Australia.

PSIC (2005). An Overview of Australia's National System for Managing Agricultural and Veterinary Chemicals. Product Safety and Integrity Committee, Department of Agriculture, Fisheries and Forestry, Canberra, Australia.

Schoknecht, N. (1997). Soil Groups of Western Australia. A guide to the main soils of Western Australia. Agriculture Western Australia, Resource Management Technical Report 171.

Appendix 1

Soil type	Land management hazard	Water use options	Recharge as % of rainfall 400 mm
ALKALINE GREY SHALLOW SANDY DUPLEX **Description** Duplex soil with 10-30 cm sand over alkaline, sodic and domed subsoils. High production in good years. Nutrient availability low because of pH. **Current agriculture:** Pasture/cereal, pasture/2 cereal or continuous crop rotations including combinations of pea/wheat/barley/canola. Pasture species are medics, sub. clover or serradella depending on pH and depth of sand.	• High wind erosion where surface is loose • Moderate water erosion on slopes • Shallow unrestricted rooting depth (<30 cm) due to high bulk density of subsoil • Very low waterlogging hazard • High salinity risk in low-lying flat areas • Low subsurface acidification risk • Nil to low risk of subsurface compaction	**Current agriculture**: Pasture/cereal or continuous crop **Options:** *Perennial pastures* Lucerne as a phase in crop rotation 2 lucerne/2 cereal *Trees* Oil mallees (*Eucalyptus* & *Melaleuca* sp.) for oil & biomass, sugar gums *Saline areas* Saltbush, tall wheat grass, puccinellia and balansa clover **Pre-clearing vegetation**	 5-10 0-5 0-5 na 0-5

<table>
<tr><th>Soil type</th><th>Land management hazard</th><th>Water use options</th><th>Recharge as % of rainfall 525 mm</th></tr>
<tr><td>GREY DEEP SANDY DUPLEX
Description

Duplex soil with sand over gravel over clay at around 80 cm. Land use determined by depth to gravel where shallow gravels can cause waterlogging and limit crop options

Current Agriculture:

Lupin/wheat/canola/wheat (or barley) or 2 pasture/barley in higher rainfall or where shallower profiles cause waterlogging. Annual pasture legume species are sub. clover or serradella. Some perennial grass pastures in higher rainfall areas</td><td>• High risk of wind erosion
• Moderate risk of water erosion in sloping landscapes
• Low risk of soil structure decline
• Moderate unrestricted rooting depth (30-80 cm)
• Low waterlogging risk in flat and low-lying areas, very low to nil in sloping areas
• Moderate risk of subsurface acidification</td><td>Current agriculture:
Lupin/wheat/canola/wheat
Options:
Perennial pastures:
A range of perennial pasture species is suited including kikuyu, Rhodes grass, perennial veldt grass, and lucerne
Fodder shrubs:
Tagasaste on deeper, well drained sites
Trees:
Sugar gums for logs, blue gums for chips and Melaleuca, Acacia & Eucalyptus spp. for biomass
Saline sites:
Tall wheat grass, saltbush, puccinellia and balansa clover
Pre-clearing vegetation</td><td>
10-15

2-8

2-6

2-6

na

2-6</td></tr>
</table>

Soil type	Land management hazard	Water use options	Recharge as % of rainfall 525 mm
GREY SHALLOW SANDY DUPLEX **Description** Less than 30 cm sand over clay, sand may contain gravels. Shallow rooting depth and waterlogging limits crop options **Current Agriculture:** Permanent annual pasture, 2pasture/cereal or pasture/cereal. Some perennial pastures including phalaris. Raised beds increasing cropped area and allowing lupins and canola to be grown more reliably.	• High risk of wind erosion • Moderate risk of water erosion in sloping landscapes • Shallow (<30 cm) unrestricted rooting depth due to clay subsoil • Moderate to high risk of soil structure decline due to shallow, often sodic, subsoil that may be brought to the surface by cultivation (past or present) • Low risk of subsurface acidification • Low to moderate risk of waterlogging in flat and low-lying areas. Nil to very low in sloping landscapes • High risk of water repellence	**Current agriculture:** Permanent annual pasture or pasture/cereal in lower rainfall areas	10-13
		Options: *Perennial pastures:* Phalaris, tall wheatgrass and to a lesser extent kikuyu. Strawberry clover in summer wet sites	5-10
		Fodder shrubs: Acacia saligna	2-6
		Trees: Oil mallees (*Eucalyptus & Melaleuca* sp.) for oil & biomass, flat-topped yate for logs	2-6
		Saline sites: Saltbush, tall wheatgrass, puccinellia and balansa clover.	na
		Pre-clearing vegetation	2-6

Soil type	Land management hazard	Water use options	Recharge as % of rainfall 400 mm
CALCAREOUS LOAMY EARTH **Description** Shallow sand (sometimes absent) over loam over clay. Similar to kopi but lacks powdery surface. Alkaline throughout Current agriculture: No typical rotation but the following crops grown: peas, wheat, barley, canola and other pulses. Pastures are largely medic based.	•Low risk of wind erosion •Low to moderate risk of water erosion •Moderate to high risk of soil structure decline •Rooting depth 10-20 cm •Not prone to acidification •Highly saline below 30 cm	**Current agriculture:** Pea/wheat/canola/barley **Options:** *Perennial pastures:* Not many options here due to low rainfall, tall wheat grass and lucerne in better areas *Trees* Oil mallees (*Eucalyptus.* & *Melaleuca* sp.*)* for oil & biomass *Saline sites:* Saltbush, tall wheat grass and balansa clover **Pre-clearing vegetation**	 5-10 0-5 0-5 na 0-5

Soil type	Land management hazard	Water use options	Recharge as % of rainfall 525 mm
PALE DEEP SAND **Description** Deep fine sand, grey at the surface grading to white then yellow. Nutrient status low with poor moisture-holding capacity Current agriculture: Lupin/cereal or lupin/cereal/canola or permanent annual pasture in higher rainfall areas. Areas of perennial veldt grass and tagasaste. Annual legume pasture species are sub. clover or serradella depending on sand depth and potassium nutrition.	High wind erosion risk, increasing to extreme on exposed crests and ridges Moderate water erosion risk on slopes and ridges, low on flat areas Low to moderate water holding capacity Moderate risk of subsurface acidification Deep unrestricted rooting depth (80-150 cm +) •High risk of water repellency Low risk of soil structure decline Nil to very low risk of water logging only in flat low-lying areas	**Current agriculture:** Lupin/wheat **Options:** *Annual pastures:* Serradella *Perennial pastures:* Perennial veldt grass, Rhodes grass, lucerne and kikuyu on better sites. *Fodder shrubs:* Tagasaste ideally suited *Trees:* Maritime & radiata pine & tuarts for logs, blue gums for chips & logs **Pre-clearing vegetation**	15+ 15 + 5 -10 2-8 0-5 4-8