



Agriculture futures: Potential rural land uses on the Palusplain



Resource Management Technical Report 372

Agriculture futures: Potential rural land uses on the Palusplain

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Summary

The purpose of this project was to identify agricultural land use options and opportunities within the Serpentine–Jarrahdale and Murray Shires, with particular focus on the Palusplain wetland section. The report will contribute to the Department of Planning's natural resource management plan for the region and guide development of regional and local planning strategies.

Historically, the Palusplain was a slowly moving, interconnected, seasonal wetland system with areas of higher ground. Extensive clearing and drainage occurred in the late 1800s through to the mid-1900s to facilitate agriculture; however, agriculture has been found to be a major contributor of nutrients to the system. The area is now under pressure from urban and rural lifestyle development. This report provides a spatial element to assist in identifying areas deemed suitable for continued agriculture.

The policy setting is clear through Statement of Planning Policy 2.1 (SPP 2.1) The Peel–Harvey Coastal Plain Catchment, which recognises the importance of the Peel–Harvey Estuarine System, the environmental impact of excessive phosphorus, and the need to prevent land uses likely to result in excessive nutrient export. In particular, in relation to agriculture, proposals must consider land capability and nutrient export management.

A community workshop was held to explore potential futures for the Palusplain. The vision that emerged from the workshop was that the Palusplain should support a strong, diversified and sustainable economy, as a food bowl for Perth, be set in an environment that maximises biodiversity and nutrient retention and be supported by clear, consistent integrated governance.

Key findings from consultation during the project are:

- a) Retaining large lots is important to: maintain opportunities for new, large-scale agricultural enterprises; maintain land prices at agricultural market levels; reduce likelihood of lifestyle ownership; maintain agricultural options into the future if market signals change; and preserve future land use options.
- b) The lack of a soil amendment to 'bind' phosphorus is the key limiting factor influencing more intensive agricultural development. Recognised phosphorus-binding soil amendments, such as 'red mud' and bio-solids, need to be encouraged for general use within the catchment.
- c) Research is required to determine the relative benefits of catchment approaches, such as perennial pastures, revegetation, stock exclusion and retention of water in the landscape, to reduce nutrient export. Since revegetation may not reduce nutrient export, because soluble nutrients bypass the physical filtering functions of the riparian zone surface vegetation, the strategies in SPP 2.1 may need revising.
- d) Provision for ongoing monitoring of nutrient export is required because soil amendments will need to be replaced regularly, possibly on a 20-year cycle.
- e) Closed-loop agricultural systems, such as poultry and hydroponic/glasshouse enterprises, that export minimal nutrients, should be encouraged.
- f) Source of high nutrient loads, such as feedlots, need to be managed at all scales of production.
- g) Tried and innovative nutrient management strategies, and long-term monitoring strategies, need to be tested.

The report documents:

- the environmental conditions currently operating in the catchment including the latest knowledge on nutrient movements
- current water and land management practices used to mitigate impacts
- the nutrient export status of different land uses
- the status and potential of the predominant agricultural industries, as well as ideas for agricultural industry development:
 - total gross value of agricultural production, including poultry, in the Serpentine–Jarrahdale Shire is over \$84 million, and nearly \$41 million in the Murray Shire
 - the main agricultural industry, beef cattle production, is marginally economic as a stand-alone enterprise for many landholders
 - intensive enterprises, such as dairying, are providing strong economic returns when supplying milk for local cheese and yoghurt production
 - the meat poultry industry is successful and the equine industry is strong both as a hobby and as a racing industry
 - there is potential for increased horticulture in the east and south of the study area if recycled water from Mandurah becomes available
 - there is potential for closed-loop agricultural systems, such as hydroponics, and for industries that can be supported by recycling industries
 - firewood and other perennial-based fibre and carbon systems are alternative enterprises that can be integrated with other land uses
- the potential mechanisms to reduce nutrient export, include:
 - Fertiliser Action Plan (FAP), which recommends anyone purchasing phosphorus-based fertilisers in the FAP policy area to only do so on advice from a FertCare Accredited Advisor following soil testing
 - phosphate-binding soil amendments
- catchment approaches for reducing nutrient export including application of adsorption materials and filters in drains, revegetation, stock exclusion near streams and drains, perennial pastures, and retaining water in the landscape
- the layers of information required to make planning decisions, including phosphorus export hazard, land capability mapping, buffers, lot size distribution and infrastructure requirements.

1. Introduction

The purpose of this project was to identify agricultural land use options and opportunities within the Serpentine–Jarrahdale and Murray Shires, with particular focus on the Palusplain wetland section. This report will contribute to the Department of Planning's natural resource management plan for the Palusplain and guide development of regional and local planning strategies.

The policy setting is guided by Statement of Planning Policy 2.1 (SPP 2.1) *The Peel–Harvey Coastal Plain Catchment*, which recognises the importance of the Peel–Harvey Estuarine System, the environmental impact of excessive phosphorus and the need to prevent land uses likely to result in excessive nutrient export. It is also set within the frameworks of the Metropolitan and the Peel Region Schemes rural zoning and applicable state planning policies, and considers social, economic and environmental constraints of the study area (Appendix A).

Key components of this report are:

- the environmental context
- agricultural land uses and impacts
- strategies to reduce nutrients
- nutrient-sensitive, rural land use planning
- future options for the Palusplain.

1.1 The Palusplain study area

This project focuses on the broad land type known as the Palusplain. The Palusplain is a seasonally waterlogged, flat wetland typical of the duplex and sandy soils found on the Pinjarra Plain to the east of the Swan Coastal Plain (Semeniuk, cited in Hill et al. 1996).

The study area is located south of Perth, mainly in the Serpentine–Jarrahdale and Murray Shires, along the Swan Coastal Plain at the lower end of the Serpentine River, Murray River and Harvey River catchments (Figure 1, Figure 2 and Figure 3). The area was derived from 'Areas not under consideration for urban development' and 'Areas under further investigation' in the *Southern Metropolitan and Peel Region Urban Growth Management Strategy* (Department of Planning and Infrastructure 2009). The study area is currently zoned 'rural' under the Peel Region Scheme.

Potential rural land uses on the Palusplain

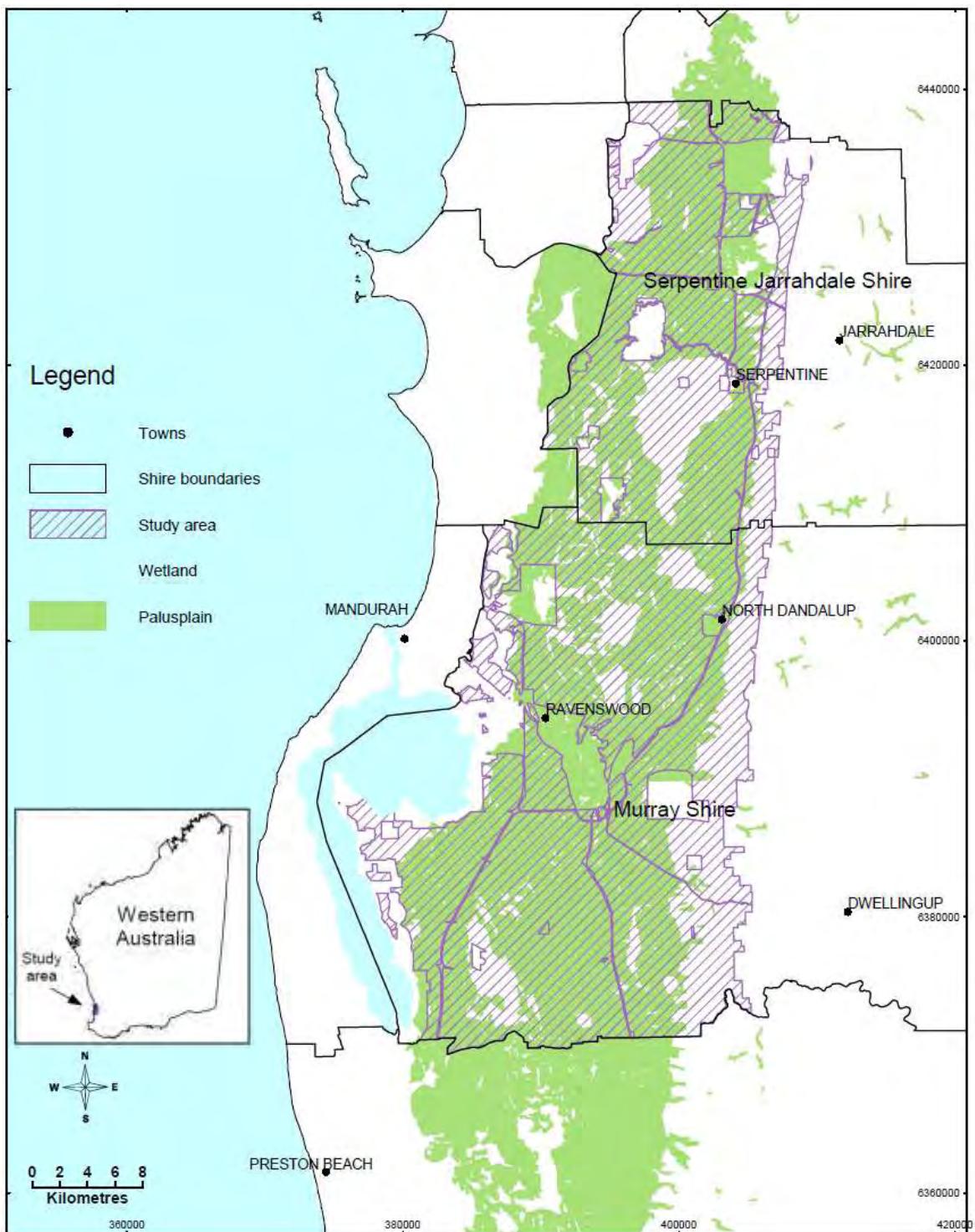


Figure 1 Location of the Palusplain wetland and study area



Figure 2 Aerial photograph of the study area with infrastructure

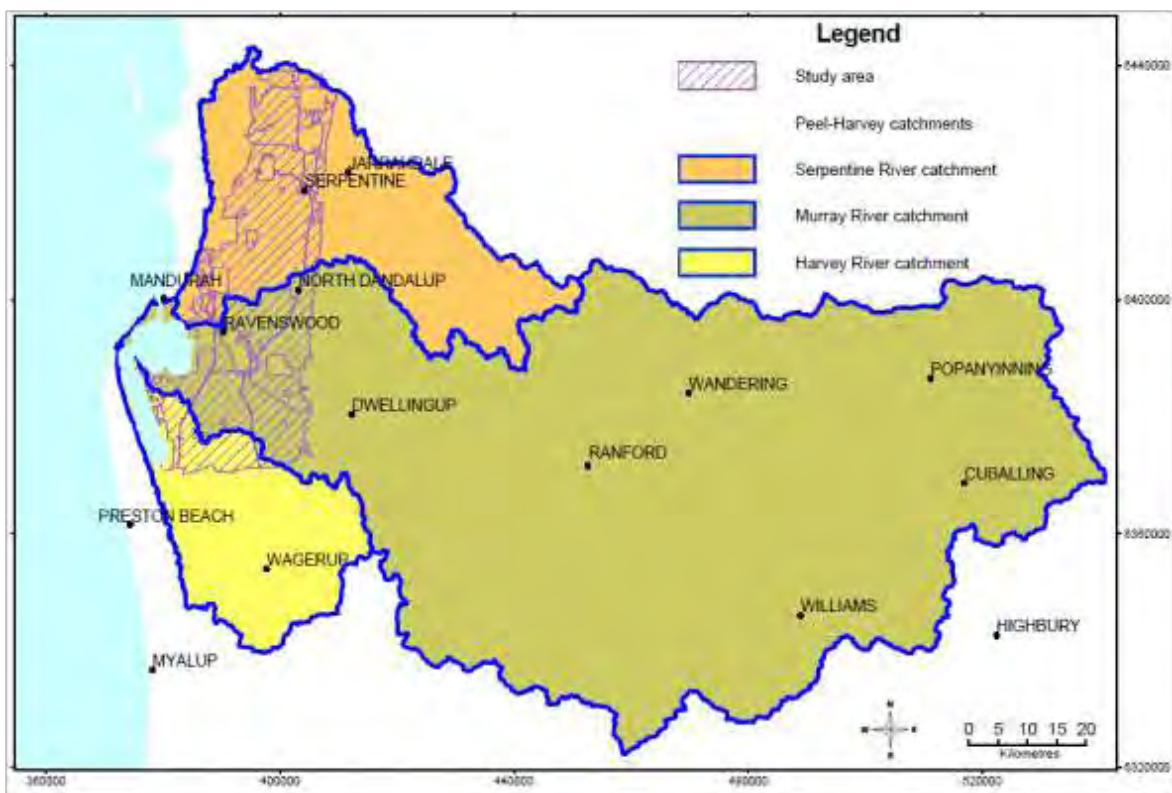


Figure 3 Peel–Harvey catchments in relation to the study area

1.2 Background

The Palusplain presents land use challenges as it is constrained by a very gently undulating landscape, high winter watertables, sandy and duplex soils, variable quality groundwater resources, and a high risk of nutrient export. Prior to European settlement, the Palusplain was a slowly moving, interconnected, seasonal wetland system with areas of higher ground, and a rich food source for the local Noongar peoples. Extensive clearing and drainage occurred in the late 1800s through to the mid-1900s to facilitate agriculture.

The Palusplain became, and remains, an important food growing area for Perth with beef, dairy and some horticulture. Poultry for meat has become a significant industry with potential to expand. Pork and mushroom production and composting are complementary industries on industrial land in the Nambeelup area, east of Mandurah. The total gross value of land-based agricultural production, including poultry, in the Serpentine–Jarrahdale Shire is more than \$84 million and nearly \$41 million from the Murray Shire (Australian Bureau of Statistics 2008).

The Palusplain is also a peri-urban region, greatly valued by the horse industry for its rural living values and for its urban potential, particularly in the Serpentine–Jarrahdale Shire. High land prices, both real and anticipated, represent a challenge for commercial agriculture. The land is seen by many as waiting for more intensive development. Nevertheless, the region has potential to increase its value as a food production area through developing hydroponic agricultural production systems, increasing niche food production marketed through cooperatives and farmers markets, increasing annual horticulture using recycled water, and developing agri-industry processing centres.

Challenges for conventional agriculture on the Palusplain are the winter-saturated and highly permeable soils. These soils have very low nutrient-holding capacity which has resulted in high levels of fertiliser use with a significant portion of fertiliser applications leaching into the

river, wetland and estuarine systems through the constructed drainage network, leading to eutrophication and algal blooms. There has been a steady build-up of nutrients, particularly phosphorus, in the silts in the system which are capable of being held and released over a long period of time.

Attempts to reduce nutrient export by tree planting and encouragement of more responsible nutrient applications have, to date, led to only small or zero reductions, and in some cases may have increased the soluble component of nutrients such as phosphorus. Research on the use of 'red mud' or Alkaloam®, a by-product from aluminium smelting, has shown high potential for nutrient retention when applied as a soil amendment because of its ability to bind phosphorus, but it is currently not commercially available.

The proximity of the study area to the City of Mandurah and metropolitan Perth has led to demand for subdivision for rural residential and small land holdings. This pressure has raised the question of the most sustainable use for the Palusplain in the long-term. Proximity to population centres and infrastructure, such as roads, railways and power, are significant opportunities to explore alternative agri-food business which can add value to primary production, provide complementary services such as energy and recycling, and provide additional employment opportunities. These opportunities are being explored by DAFWA in a complementary project.

1.3 Limitations of the study

This report has been developed through desktop research and consultation with representatives from state and local government, and the community. The community tour and workshop held on 13th May 2010 created a vision for the region and its findings are summarised in Section 7.

Social analysis is an important part of land use planning. There was minimal existing information available so the study included community consultation and an existing social analysis of the horse industry to inform its findings. A detailed social analysis of agricultural land uses was beyond the scope of this project.

Future land use decisions would be informed by a dedicated social analysis given the rapidly changing social picture, lack of profitability of some agricultural land uses, the advent of farmers markets and direct selling, and strong demand for lifestyle land uses.

2. Environmental context

2.1 The original system

Bradby (cited in Environmental Protection Authority 2008) describes the Swan Coastal Plain in 1829 as being a wetland. Each winter, it and the upstream jarrah forest would be hit by heavy and concentrated rains. Streams and brooks would flow onto the plain, dissipating their energy into a broad, interconnected chain of swamps many kilometres wide. Only the rivers of the largest system, the Murray and the Dandalup, stayed in clear stream beds for all their length, except in larger floods. The other main rivers, the Serpentine and the Harvey, were well-defined in their upper and lower sections, but their middle reaches were a maze of swamps. Here, the rivers would spread out in winter and join forces with the flow from all the smaller brooks and streams. Some of this water would eventually seep through to the rivers' lower reaches, and flow through the estuary to the sea. The plain would be flooded from the scarp through to the long ridge of tuart-covered Spearwood dunes towards the coast, with only occasional sand hills remaining exposed.

2.2 Drainage and clearing

The land was heavily vegetated with paperbark woodland and jarrah-marri forests to the east of the catchment. With increased colonisation in the late 1800s came increased clearing for agriculture resulting in groundwater rise which exacerbated the extent of seasonal inundation. Eventually, after landholders lodged numerous complaints relating to lost crops and property damage, the government addressed the problem of inundation by implementing a network of drains. In 1900, the first Drainage Bill was passed by state parliament. Over the next 70 years, trees on the banks of the waterways were removed, lower river reaches were de-snagged, the rivers were straightened and deepened, and systems of interconnecting drains were dug across pastoral lands. Swamps were drained and the flow rate of the river courses increased (Department of Water 2010b). There are now 1330 km of waterways (artificial and natural) in the Peel-Harvey coastal plain, including 1014 km of waterways which make up the Mundijong, Waroona and Harvey Gazetted Drainage Districts (Environmental Protection Authority 2008).

The extensive drainage networks, which intercept surface and groundwater, have been effective in draining the system to enable agriculture and other land uses. The drains have also transported nutrients directly and quickly into the Serpentine and Murray Rivers which are now in a very poor state with algal blooms and fish deaths occurring each year and directly stressing the Peel-Harvey Estuarine System.

2.3 Climate and excess water

The region experiences a Mediterranean climate, characterised by warm dry summers and cool wet winters with daily temperatures from 17 °C to 30 °C in summer and from 6 °C to 17 °C in winter (Rivers 2004). The average annual rainfall at Pinjarra from 1877 to 1975 was 970 mm, which is 14 per cent greater than the average rainfall between 1975 and 2008 (830 mm), indicating the commonly referred to 'step down' in rainfall over the past 30 years (Figure 4) (Department of Water 2010b). This reduced rainfall is likely to result in a reduction in the duration and frequency of soil waterlogging.

Winter rainfall exceeds evaporation and, when combined with ground saturation and soil types of the area, large volumes of run-off can occur. Consequently, there are many lakes and some areas of seasonal waterlogging on the Palusplain. The drainage network greatly reduces the amount of inundation, but despite this, stream flow rises and peaks over several

days following rain events as water pools and is stored on the flat landscape (Department of Water 2010b).

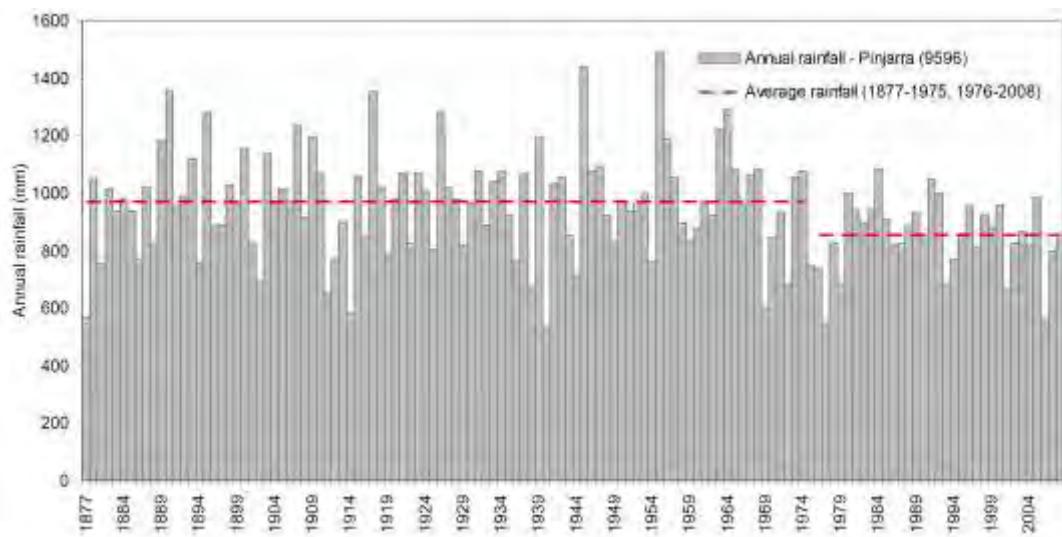


Figure 4 Annual rainfall in Pinjarra displaying the 'step-down' in average rainfall post-1975 (Department of Water 2010b)

2.4 Groundwater availability

Water flow, in groundwater and run-off, from the hills in winter recharges groundwater aquifers and creates wetlands as it flows underground and out to sea.

Water planning endeavours to balance the retention of wetlands and economic needs for water. Across the Murray groundwater area, the Department of Water (2010a) estimates 57 GL of groundwater can be allocated from all aquifers and sub-areas annually, with about 5 GL exempt from licensing for stock and/or domestic purposes (Figure 5). The volume of licensed entitlements in March 2010 was 15 GL so there is about 42 GL potentially available for new users.

While there is a significant volume of water potentially available, it is challenging to identify good supplies of high quality water. Difficulties include:

- highly variable water quality, ranging from fresh to saline
- high nutrient levels may be encountered in areas that are, or have been, heavily fertilised
- variable yields from pumping meaning that a number of bores may be required to reduce drawdown impacts
- environmental considerations including acid sulphate soils.

Potential water licensees will be required to determine potential environmental impacts and provide a management strategy for managing those impacts.



Figure 5 Planning boundaries for the Murray Groundwater Allocation Plan and the Murray Drainage and Water Management Plan (Department of Water 2010a)

2.5 Soils and their relationship to nutrient export

The soils of the Peel–Harvey coastal plain catchment are generally, with some exceptions, formed in alluvial deposits overlain by deep weathered sands that form low parallel dunes running north to south. More than 60 per cent of the catchment has coarse sandy surfaces of varying depths on top of impermeable layers of ironstone or clay. The Palusplain wetland covers several soil-landscape systems and the main ones are the Pinjarra System and the Bassendean System (Figure 6 and Figure 7, Appendix B).

The Pinjarra System (213Pj) is a poorly-drained coastal plain on alluvium over sedimentary rocks. Soils include semi-wet soils, grey deep sandy duplexes, brown loamy earths, pale sands and clays. Native vegetation is mainly jarrah-marri-wandoo-paperbark forest and woodland. The Bassendean System (212Bs) is sand dunes and sand plains with flats and swamps on sandy alluvium over sedimentary rocks. Soils include pale deep sand, semi-wet soil and wet soil. These soils have low fertility and are susceptible to leaching. In the Peel region these soils may become waterlogged because of high groundwater levels and may become flooded in some areas. Native vegetation is mainly banksia-paperbark woodlands and mixed heaths.

Details of the soil types and soil profiles are included in Appendix B.

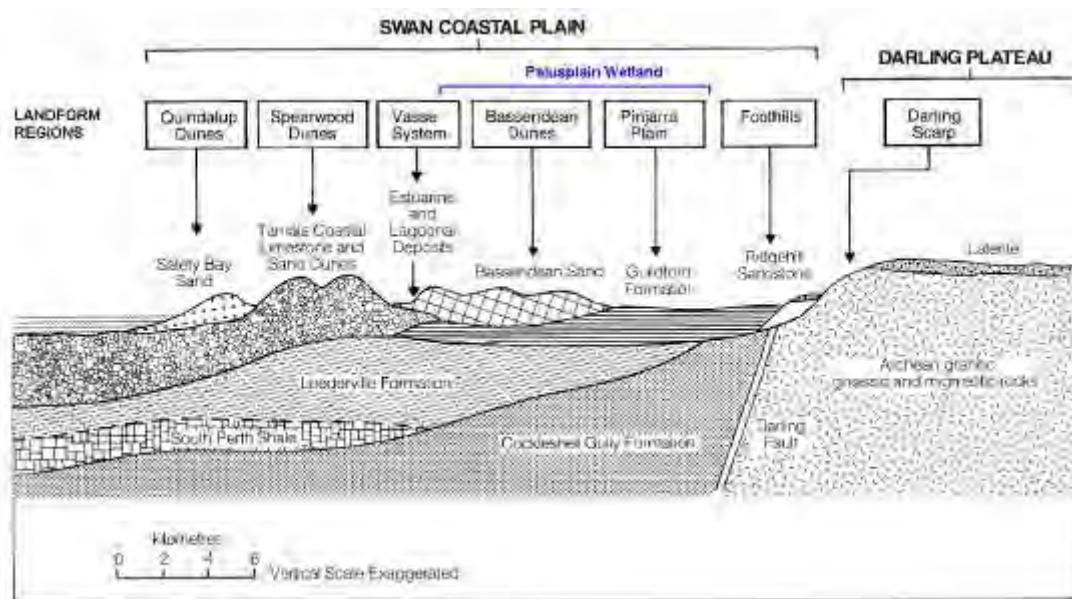


Figure 6 Cross-section of the Swan Coastal Plain showing the relationship of the Palusplain wetland with the landform regions and the geology (adapted from Wells 1989)

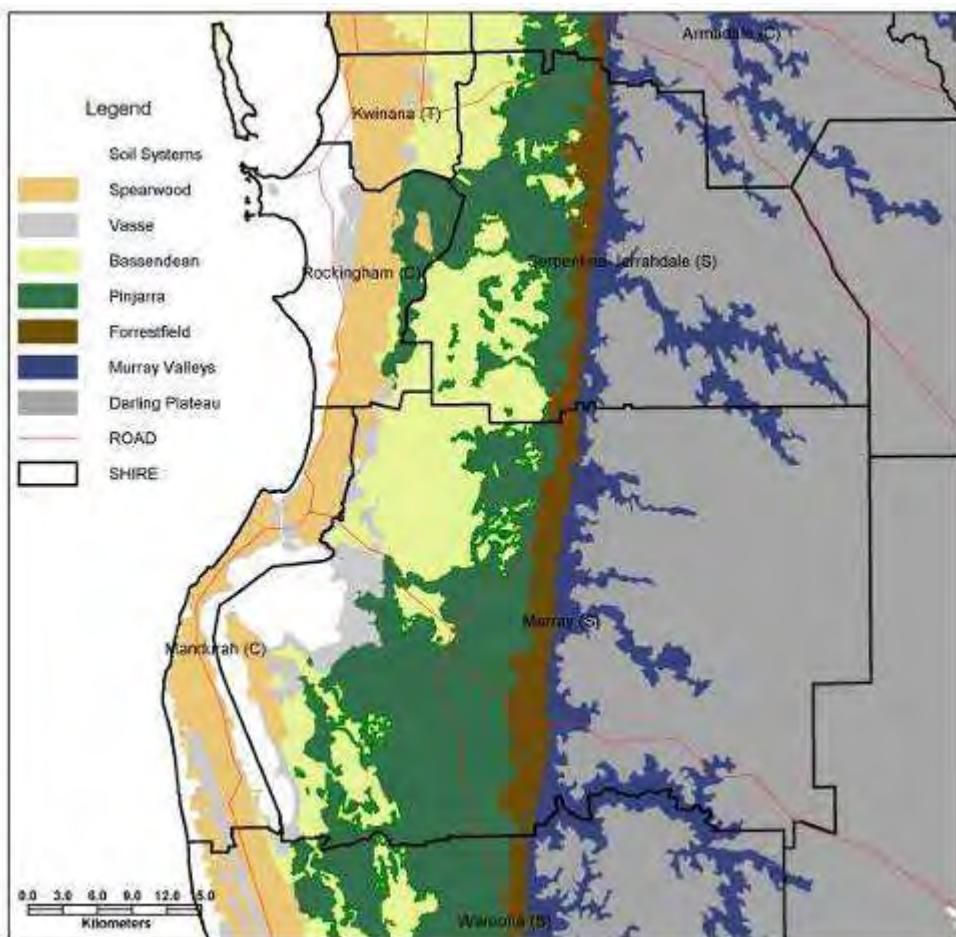


Figure 7 Soil-landscape systems of the Serpentine–Jarrahdale and Murray Shires

Inundation is common during winter because of the flat landscape and a short but relatively wet and intense winter rainfall season. Sandy soils have combined leaching, subsurface drainage and surface flow when the overlying sands become saturated. The sandy soils become saturated because of the relatively impermeable ironstone and clay beneath (Summers et al. 1999). Nutrient run-off from clay soils is predominantly over the surface.

A large number of risk factors influence the pathway of phosphorus (P) loss from the soils including proximity to drains or streams, waterlogging, amount of phosphorus applied, slope of the land, soil characteristics, management practices and distance from the estuary.

The Phosphorus Retention Index (PRI), which is a single point phosphorus sorption index routinely measured since 1980, measures the ability of soil to bind and retain (sorb) phosphorus (Bolland & Windsor 2007). Figure 8 shows the PRI of the study area, with the areas of lowest phosphorous absorption capacity in red. The Phosphorus Buffering Index (PBI) is now the national, single point phosphorus sorption index which ranks the capacity of the soil to sorb phosphorus (Bolland & Windsor 2007), most studies reviewed use the PRI method for reporting. PRI can be converted to PBI.

Soils with a low PRI (less than 5), or weakly P-adsorbing, can leach phosphorus by movement with water through and across the soil, and soils with a high PRI (more than 20), or strongly P-adsorbing, lose phosphorus from across the surface (Figure 9 and Figure 10) (Allen & Jeffery 1990). The lower the PRI, the easier it is for phosphorus to move through the sandy soils and therefore soils with a PRI less than 5 represent an extreme risk for phosphorus loss (R Summers (DAFWA), 2010 pers. comm.; Environmental Protection Authority 2008).

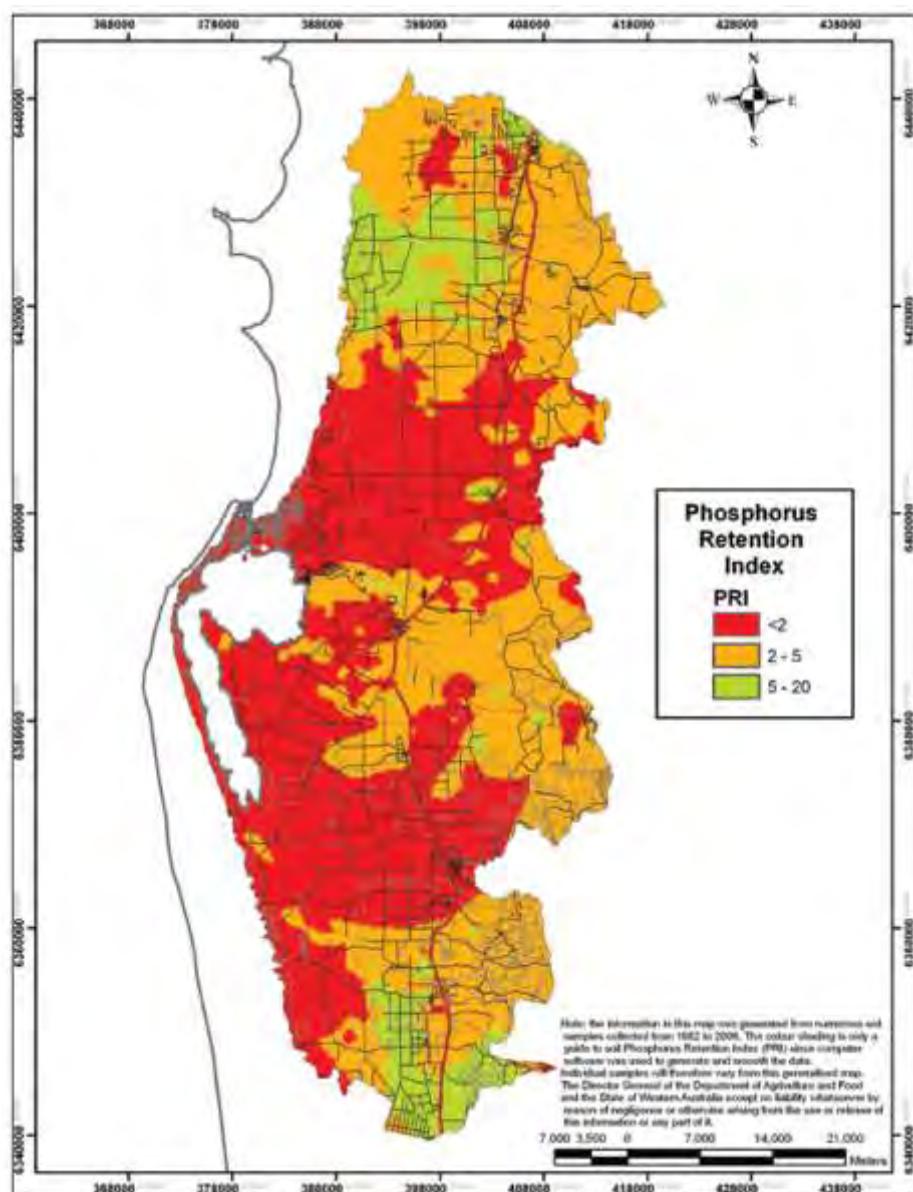


Figure 8 Phosphorus Retention Index (PRI) of the Peel-Harvey catchment

Sandy soil – low Phosphorus Retention Index (PRI) or Phosphorus Buffering Index (PBI)

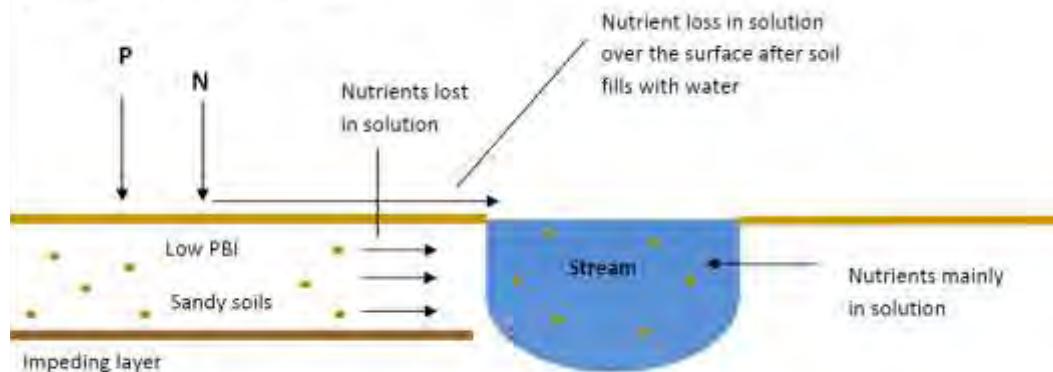


Figure 9 Pathways of phosphorus export on sandy soils or weakly P-adsorbing soils with low PRI (< 5) or PBI (< 15)

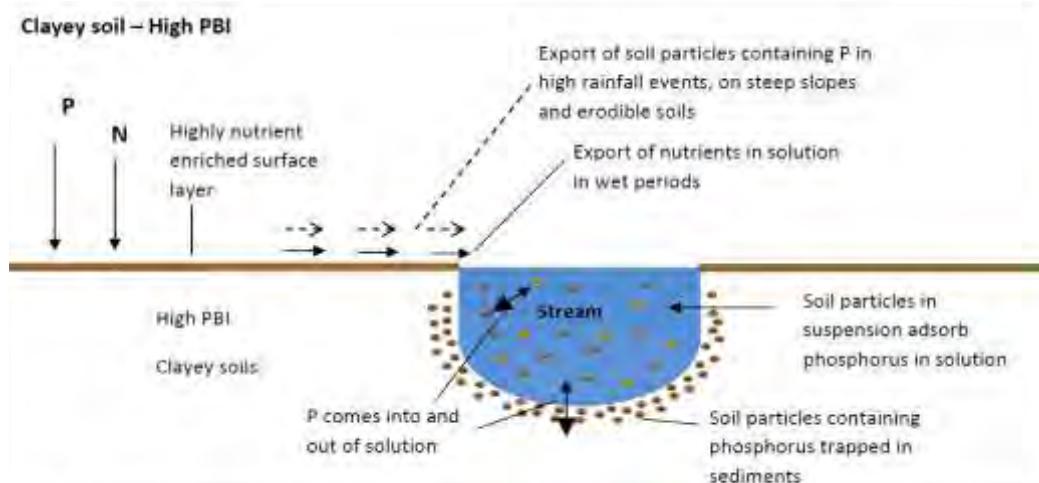


Figure 10 Pathways of phosphorus export on clayey soils or strongly P-adsorbing soils with high PRI (> 20) or PBI (> 70)

DAFWA has developed mapping that describes the landscape's inherent phosphorus export hazard. Phosphorus export hazard refers to the likelihood that phosphorus (usually applied as fertiliser, but may also be from other sources such as septic tanks), will move from a given land unit to where it can contribute to eutrophication of surface water. This mapping takes into account the PRI of a soil as well as the water erosion hazard, flood hazard and landform. In assessing nutrient export risk of proposed land uses on the Palusplain, it is appropriate to use the phosphorus export hazard mapping as it includes the risk from all nutrient movement pathways. Figure 11 and Table 1 illustrate the landscape's phosphorus export hazard with areas closest to the coast generally having a higher hazard rating than more inland areas.

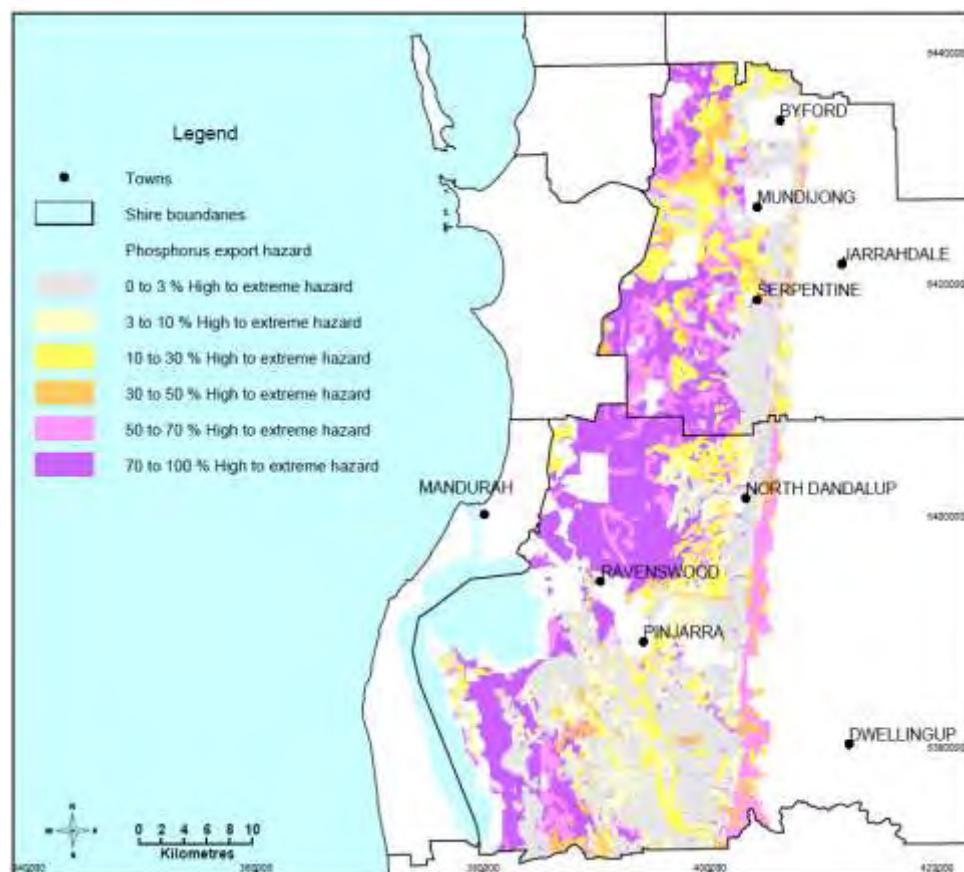


Figure 11 Phosphorus export hazard map

Table 1 Area of phosphorus export hazard classes shown in Figure 11

Phosphorus export hazard	Area (ha)
0–3% High to extreme hazard	25 600
3–10% High to extreme hazard	8 300
10–30% High to extreme hazard	13 200
30–50% High to extreme hazard	7 900
50–70% High to extreme hazard	7 300
70–100% High to extreme hazard	44 500

2.6 Nutrients

The Palusplain has been described as the ‘kidneys’ of the Peel–Harvey system because the waters from surrounding areas that travel through the Palusplain were once cleansed by the swamps and slow moving streams that dominated the system (R. Summers [DAFWA] 2010, pers. comm.). The majority of the soils are sands or sands over clays which have little or no capacity to retain phosphorus, nitrogen or water, but originally this system naturally retained the limited nutrients.

During the 1980s and early 1990s water quality in the rivers and estuary declined and large accumulations of macro-algae and blooms of toxic blue-green micro-algae *Nodularia soumigena* appeared in the Peel Inlet and Harvey Estuary. These accumulations were caused by the progressive nutrient enrichment (eutrophication) of these waters over several decades of catchment land use practices (Environmental Protection Authority 2008).

The nutrients with the biggest influence on eutrophication are nitrogen (N) and phosphorus (P). Nitrates (NO_3^-) are water-soluble and once applied, may leach into the groundwater or end up in surface run-off. Nitrates are not easily managed except by reducing inputs or changing from soils-based agriculture to closed-loop agricultural systems. Unlike nitrates, phosphates (PO_4^{3-}) can adhere to soil particles and often accumulate in soil and erode with the soil into aquatic environments.

While the problem of eutrophication and algal blooms has been recognised, landcare works including stream side revegetation, and fertiliser strategies have failed to meet expectations of reducing nutrient export. The Dawesville Channel, constructed in 1994 south of Mandurah, was designed to improve water flow between the estuary and the sea to improve water quality and reduce the severe algal blooms. Research has shown that the channel has improved the water quality in the main body of the Peel Inlet and Harvey Estuary (Environmental Protection Authority 2008). However, the water quality and environmental problems have remained in the rivers and wetlands. The Dawesville Channel was one part of the catchment management strategy; the other part of the strategy was to ‘cap’ the phosphorus input into the waterways. This part was done through many different projects and the findings from these projects support earlier work that the main cause of the algal blooms is nutrient discharge from the catchments that feed into the estuary (Environmental Protection Authority 2008). The ‘Water quality improvement plan for the rivers and estuary of the Peel–Harvey System – phosphorus management’ aims to guide improving water quality by reducing phosphorus discharges from the catchment through changes to agricultural and urban practices and land use planning (Environmental Protection Authority 2008).

Revegetation adjacent to streams may not reduce nutrient export because soluble nutrients bypass the physical filtering functions of the riparian zone surface vegetation (Figure 12) (Weaver 2010). The largest sources of phosphorus from the Serpentine River catchment and the Murray River catchment are agriculture, contributing a total of 45 per cent and 40 per

cent respectively, and residential, contributing 21 per cent and 7 per cent respectively (Figure 13).

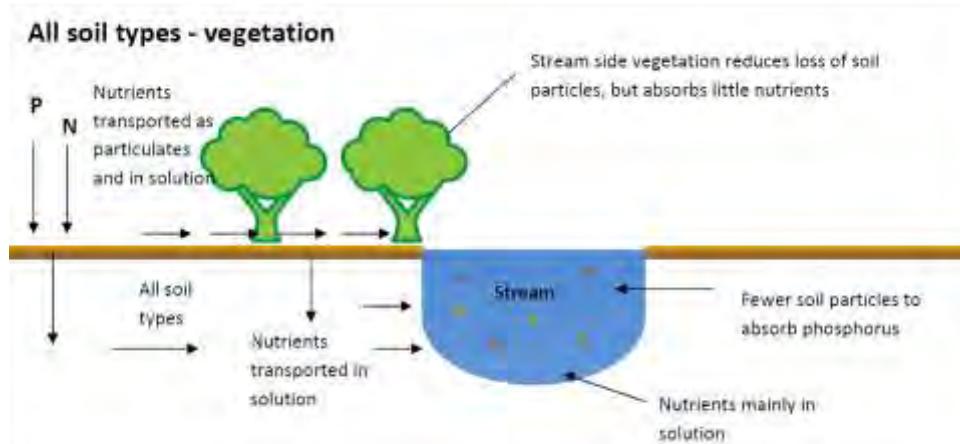


Figure 12 Movement of soluble nutrients into streams

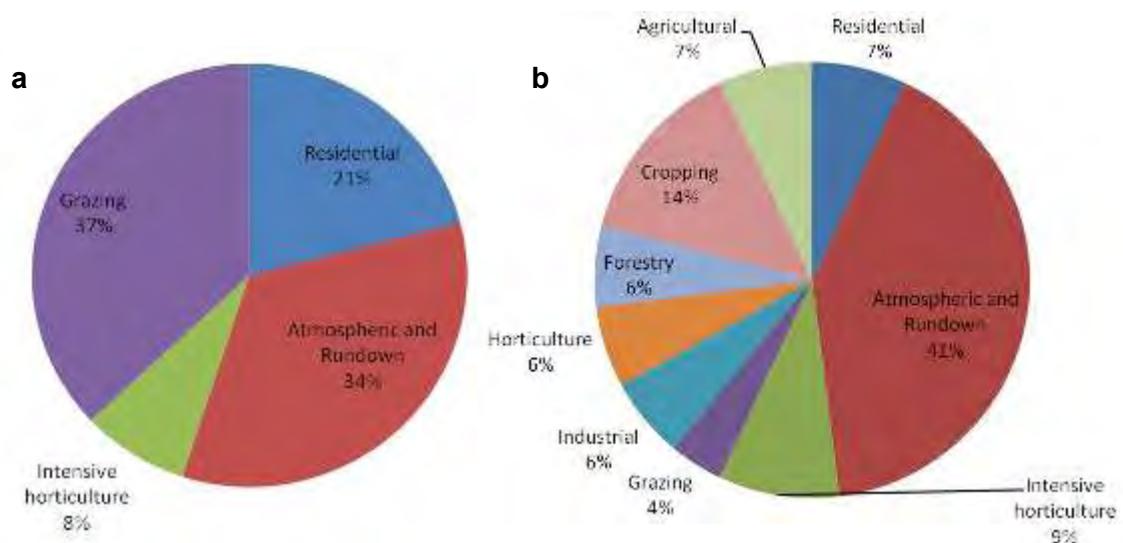


Figure 13 Current sources of phosphorus by landuse type to the Peel–Harvey Estuarine System for a) the Serpentine River catchment, and b) the Murray River catchment (Zammit et al. 2006)

Soils-based agriculture creates large nutrient (phosphorus and nitrogen) surpluses under their current fertiliser management regimes (Table 2). Annual horticulture contributes the highest by an order of magnitude, and urban/peri-urban from septic systems and poor fertiliser practices and piggeries have higher nutrient surpluses than general agriculture. The values were obtained from farm-gate budgets of nutrient inputs and outputs from a farm enterprise (Ovens et al. 2008; Weaver et al. 2008).

Table 2 Median values of P input, output and surpluses and P use efficiencies in the Peel–Harvey catchment (Ovens et al 2008 and Weaver et al 2008)

Land uses, all study catchments	P inputs kg/ha		P outputs in products kg/ha	Total P surplus kg/ha	P surplus kg/ha*		P lost to streams kg/ha*	
	fertiliser	non- fertiliser			Soil P storage	P lost to streams	Stream P storage	Export expressed at inlet
Cattle for dairy	14.9	4.2	7.3	11.8	5.3	6.5	5.7	0.8
Cattle for beef	11.4	0.1	1.9	9.6	4.0	5.6	4.9	0.7
Mixed grazing	9.7	1.2	1.7	9.2	4.5	3	2.6	0.4
Annual horticulture	205		17	188				
Perennial horticulture	13		1	12	7	5	4.9	0.1
Urban/peri-urban	12	5.5	0	17.5	9.5	8	3.6	4.4
Horses		14.6	1.2	13.4	7.6	5.8	5.4	0.4
Piggery		112	29.6	82.4	25	57.4	54	3.4
Poultry meat		621	615	6				
Poultry eggs		87	63	24				
Hobby farms	6		0	4				

* Modelled values

Kelsey et al (2010) found that:

- the highest levels of phosphorus inputs per hectare occur in piggeries, annual horticulture, dairies and urban residential land uses (Table 3).
- Urban residential users have the highest phosphorus inputs for lots of 601–730 m² and the lowest for lots less than 400 m², the primary difference being because of smaller garden size.
- Urban residential properties of 401–730 m² have higher nutrient input rates than the rural land uses that are generally displaced, such as beef grazing, mixed grazing, horse and lifestyle blocks.
- If the fertilising practices of householders are not modified, it is expected that urban development will further degrade adjacent rivers and estuaries.

Table 3 Nitrogen and phosphorus input rates for rural[†] and urban^{††} land uses (Kelsey et al 2010)

Land use	Nitrogen (kg/ha/yr)	Phosphorus (kg/ha/yr)
Piggery	629.3	144.7
Turf farm	432.8	14.5
Dairies	145.1	25.5
Annual horticulture (vegetables)	142.6	126.9
Urban residential (601–730 m ²)	100.6	26.4
Urban residential (401–600 m ²)	91.2	22.8
Beef grazing	86.4	22.8
Mixed grazing	79.5	12.7
Urban residential (> 730 m ²)	74.2	9.9
Horses	70.1	18
Lifestyle block	49.2	13.2
Cropping	46.7	3.4
Sheep	34.7	8.4
Perennial horticulture (orchids)	27.2	2.5
Viticulture	23.5	12.3
Urban residential (< 400 m ²)	23.4	6.9
Tree plantation	12.6	8.2

[†] Rural values determined from DAFWA farm-gate nutrient budgets (Ovens et al. 2008; Weaver et al. 2008)

^{††} Urban input rates are those for different lot sizes (age of dwelling not considered)

3. Agricultural land uses and impacts

3.1 Overview

The Serpentine–Jarrahdale and Murray Shires make a significant economic contribution to WA, with the gross value of agricultural production (GVAP) being \$84 million and \$41 million respectively (Table 4) (Australian Bureau of Statistics 2008). Part of this production comes from areas within the shires outside of the study area. The GVAP for the Wanneroo Shire, north of Perth, which has been a major vegetable production area, is provided for comparison. It is expected that production in the Wanneroo Shire will fall in the future because of the conversion of horticultural land to urban uses and this fall could be partly taken up by expansion of the Harvey Irrigation Area with recycled water.

Table 4 Gross value of agricultural production for the Serpentine–Jarrahdale, Murray and Wanneroo Shires (Australian Bureau of Statistics 2008)

Shire	Pastures & broadacre crops (\$)	Livestock (\$)	Nurseries, flowers, turf (\$)	Vegetables (\$)	Fruit (\$)	Total (\$)
Serpentine–Jarrahdale	1 321 600	57 382 700	15 329 700	2 903 200	7 358 000	84 295 200
Murray	2 264 000	30 072 100	1 675 500	144 400	7 024 400	41 180 300
Wanneroo	19 100	22 520 800	53 063 700	53 986 600	36 128 700	165 718 800

The Australian Bureau of Statistics data may not include information from small growers. A study by the Oakford–Oldbury Community Association assessed the practicality and sustainability of planning and promoting parts of rural Oakford and Oldbury for small lot, commercial agricultural development (the Oakford and Oldbury study area is in the north-west of the Shire of Serpentine–Jarrahdale). This study found turnover of existing agricultural enterprises was conservatively estimated at \$30 million, with many four-hectare lots being used for commercial agriculture, such as vegetables, vines and orchards (Ironbank Environmental and Sustainable Development 2006). The study also showed that the majority of its participants wanted a mixture of rural living and agricultural production to remain in the study area.

In the past, the main agricultural commodities in the Serpentine–Jarrahdale and Murray Shires have been beef, dairy and some horticulture. Changes in environment, economics and regulations have resulted in a reduction in dairying and a predominance of beef production. There is a sheep and a beef feedlot still operating south of Mundijong, poultry for meat production has become an important industry, and there is a significant pig enterprise and value-adding through production of dairy products. There is a composting facility leading the way in recycling agricultural wastes and the region is favoured for stud and amateur equestrian activities. The Peel Farmers Market is providing a short supply chain, an outlet and potentially higher returns for smaller producers. Because of population pressures, agricultural land has been subdivided for urban, rural residential, rural small holdings and industrial uses. Rural living and lifestyle land users tend to use beef cattle to manage the land and not as their main source of income.

While agriculture is a strong economic contributor to the region, nutrient export from agricultural industries impacts on the wetlands, rivers and estuary systems. Variable groundwater quality and quantity combined with poor, winter wet, soils and the hazard of nutrient export have restricted intensification of horticulture and dairying. Apart from soil amendments, maintaining drainage and perennial pastures will improve production and

reduce nutrient export hazard in some situations. Although rural land is viewed by some as a land bank with associated land speculation waiting for capital growth through urban or industrial development, the following sections focus on current and potential agricultural industries and their potential for further development on the Palusplain.

3.2 Beef

Beef grazing is the main agricultural land use and there are about 400 beef grazing properties in the study area, which contains the majority of the beef grazing land in the 200 000 ha Peel–Harvey coastal catchment (Figure 14).

Economics

The beef enterprises tend to be smaller scale and privately owned, with many having mixed incomes and reliance on beef for only 20–60 per cent of their income. They are currently only marginally economic and for many, may be a cheap way to manage land; the land being a lifestyle choice and a speculative investment for possible future development. If current conditions persist, many in the local beef industry are unlikely to increase in scale or efficiency.

Benchmarking of the individual business and improved grazing management has the potential to improve productivity on most farms. However, increased stocking rates could lead to increased nitrogen export. Skills development to run larger herds more efficiently, with less risk and reduced labour per unit of stock, is required.

The median beef farming lot size in the study area is 25 ha and the median property (holding) size is ten times greater with most properties consisting of multiple lots that could be sold individually.

Environment

Fertiliser run-off and eutrophication of waterways are issues the beef industry needs to address (Department of Agriculture and Food 2009). While beef grazing is a major contributor of nutrients, its surplus per hectare (9.6 kg/ha) is about half that of urban (17.5 kg/ha) and at the estuary, the phosphorus export is 0.7 kg/ha for beef and 4.4 kg/ha for urban (Table 2). Beef grazing systems could greatly improve nutrient retention by using soil amendments, which would complement other measures used, such as perennial pastures and improved fertiliser management (Figure 15).

Social

Consultation during the project found that the population of commercial beef producers is aging, that there are few drivers for their replacement, and that significant areas of land are held in ownership where agricultural production is not the strongest driver.

Conclusion

Beef grazing on the Palusplain has a competitive advantage being close to markets but local saleyards have closed, reducing this advantage. The relatively high cost of land, small lot sizes and sub-commercial approaches by the majority of landowners suggests that beef farming will not be an economic driver. The advantage of beef grazing over other land uses is that it has a relatively low nutrient export per hectare at the inlet, which could be further ameliorated by soil amendments and improvements in management practices.

Retaining lots greater than 100 ha with a predominance of soils with fair to good land capability will help maintain flexibility for grazing systems in the long-term.

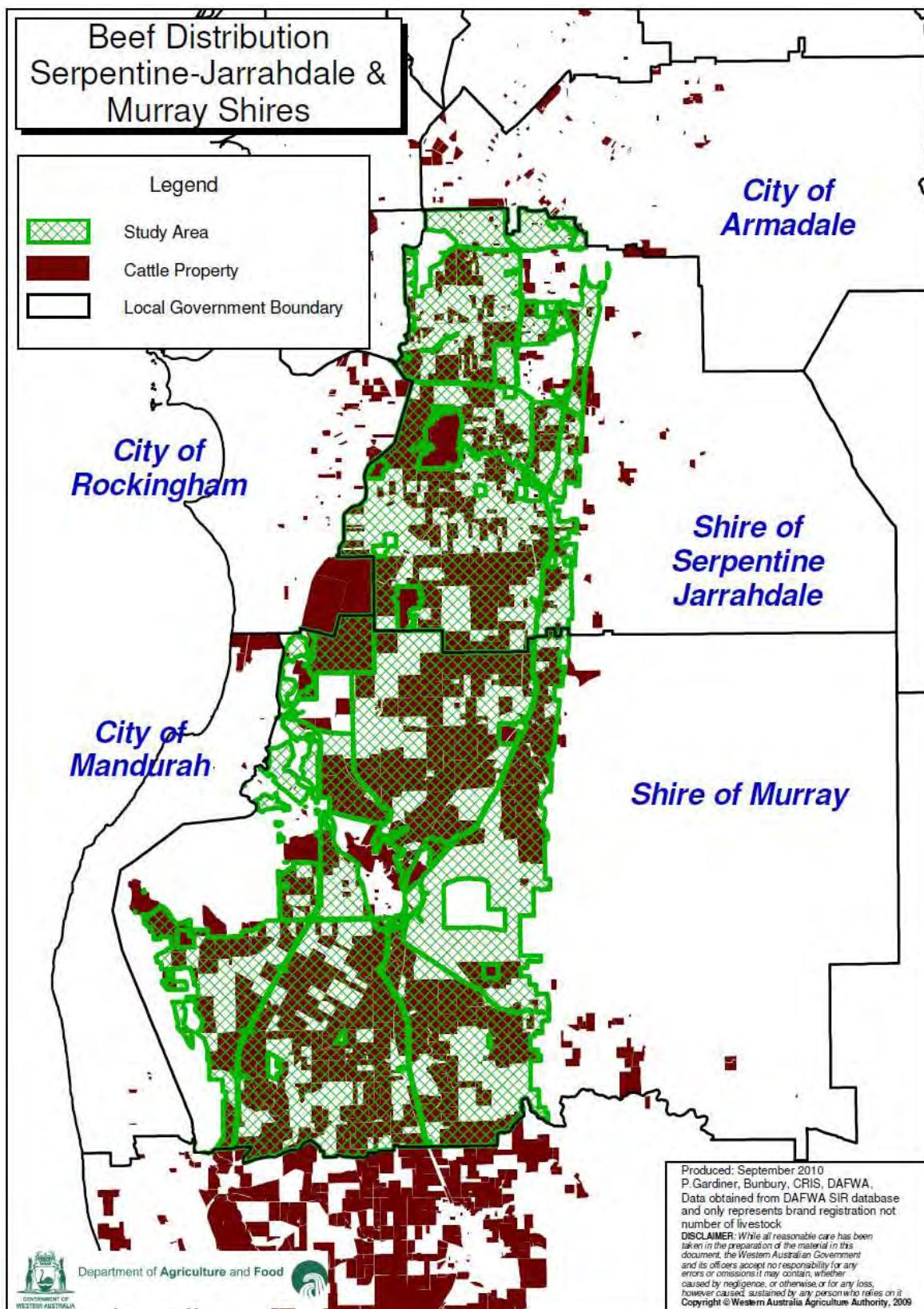


Figure 14 Beef properties based on brands (the number of cattle is not considered)

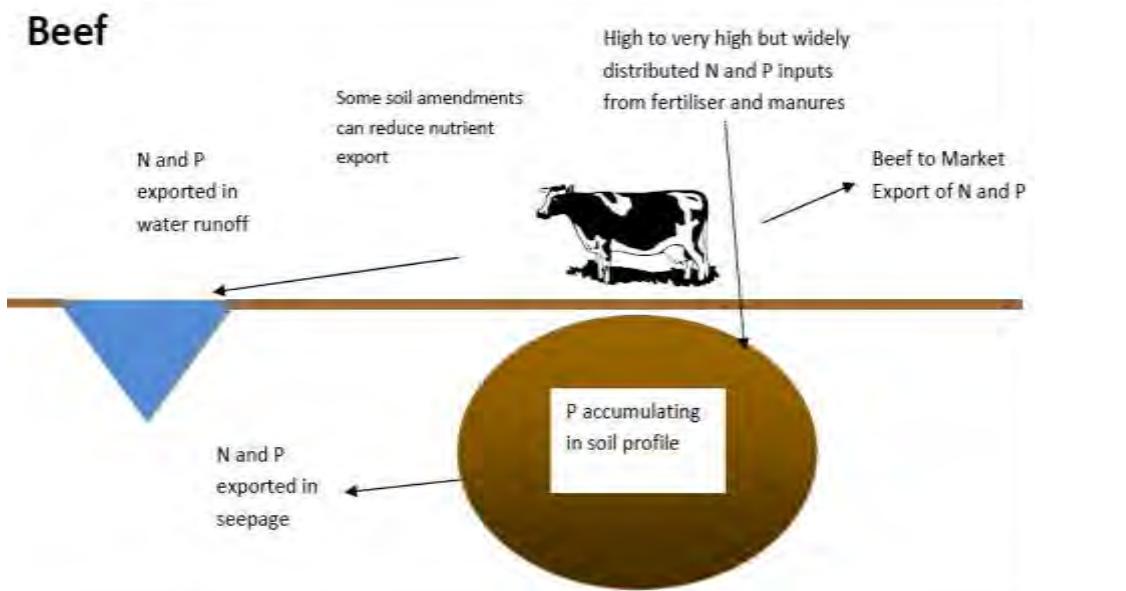


Figure 15 Possible nutrient flow on a beef farm

3.3 Beef and sheep feedlots

Economics

There is one beef feedlot close to the Harvey River and one sheep feedlot south of Mundijong servicing the live export industry

Environment

Soil-based beef and sheep feedlots compared with closed loop feedlots contribute very high point source nutrients to the wetland systems no matter how well managed, and ideally should be located 1–2 km (depending on size) from sensitive wetland and waterways (Environmental Protection Authority 2005). Key issues are rapid entry through infiltration of water and nutrients, and disposal of run-off water and nutrients from compacted surfaces (Figure 16).

The Peel–Harvey Catchment Policy (SPP 2.1) provides for intensive agriculture including feedlots to be approved by local government. Intensive grazing includes any grazing at stocking rates above those recommended by DAFWA (van Gool et al. 2000). Approval from the Environmental Protection Authority is required to operate feedlots with more than 500 cattle.

Social

Indications from consultation are that growers will be opportunistic in establishing feedlots, driven by market conditions.

Conclusion

Because of the very high point source pollution from intensive agricultural systems such as feedlots, only closed-loop, intensive animal industries are recommended on the Palusplain. It is also recommended that DAFWA develop feedlot management guidelines.

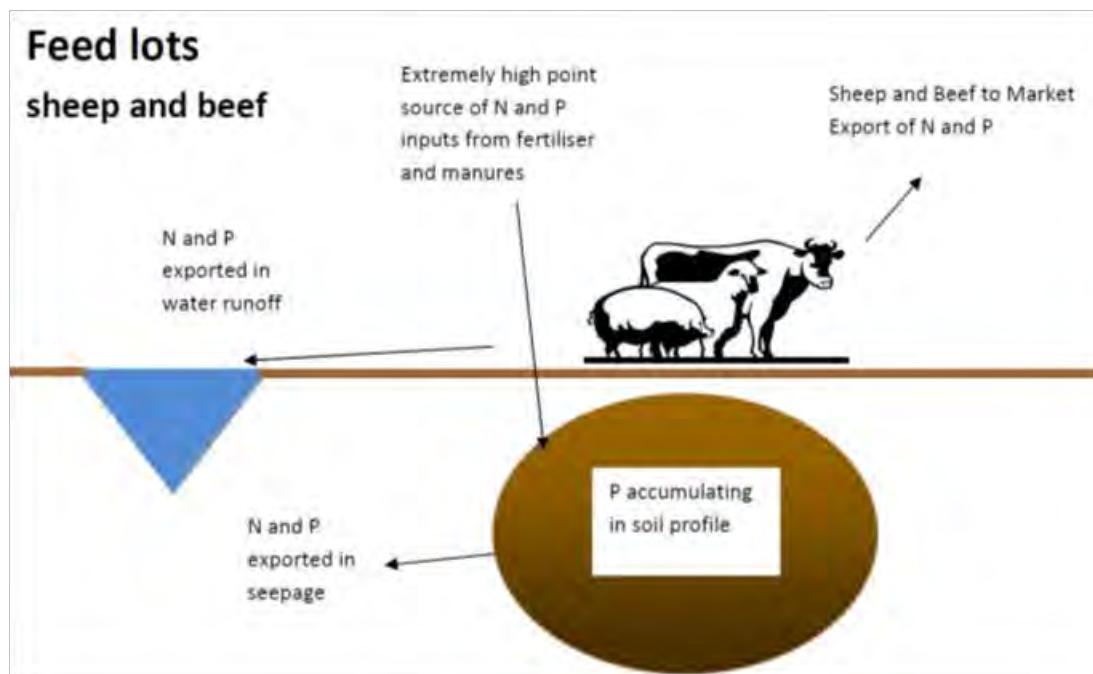


Figure 16 Possible nutrient flow on feedlots

3.4 Beef processing

Beef processing facilities (abattoirs) are high water users and require environmental approval from the Environmental Protection Authority.

Harvey Beef currently operates at the southern end of the catchment and is reportedly investigating expansion in exports and capacity. T&R Pastoral may be considering expansion plans on their Lakes Road facility, east of Mandurah, depending on a number of operational, environmental and structural planning considerations, as well as the Peel Development Commission's concept proposal for a waste water pipeline which is in the early stages of investigation.

DAFWA has awarded a consultancy to investigate the possible locations and viability of agri-food processing precincts within the Peel region via three studies:

- investigation of an agri-food processing precinct within the Nambeelup industrial estate
- investigation of an agri-food processing precinct in the rural-zoned Peel hinterland
- market demand and economic analysis of the above.

Improved markets for beef and local processing increase the potential for improved viability of local beef production (Department of Agriculture and Food 2009).

Conclusion

Expanding beef processing facilities that manage their effluent cycles in closed systems or export their wastes are encouraged because they provide good employment and increase demand for local animal produce. Potential locations of such closed-loop agricultural systems will be influenced by availability of land of a suitable lot size, proximity to sensitive land uses such as urban and rural-residential areas, and infrastructure availability, rather than by soil type.

3.5 Dairy

Economics

Because of the relatively small scale of the WA dairy industry, it competes at some disadvantage in the national market for yoghurt and cream, and in the international market for cheese. WA milk receivals have been in decline since 2005 and until recently, have been offset by rising global milk prices which have created profitable conditions. However, in 2008, global milk prices fell markedly during the global economic crises and are expected to slowly recover (Department of Agriculture and Food 2009).

WA holds a competitive advantage over other dairy industries for supply to the Asian fresh, chilled milk market because of proximity, transport access and short shipping times. Improved access to these markets will create industry growth opportunities (Department of Agriculture and Food 2009).

There are now fewer than 12 dairies in the study area (Figure 17). These dairies supply milk to local processors Mundella Foods in Mundijong with its award-winning yoghurts, the Borella Cheese Factory in Oakford, as well as to Fonterra (formerly Peters and Brownes), Harvey Fresh and National Foods. De-regulation of the dairy industry in 2000 removed the quota system and forced adjustment of milk prices to reflect world prices, which put pressure on small producers unable to expand because of land prices or water availability. Recent closure of the Fonterra ice cream factory in Balcatta has created further competition pressures on producers.

There is potential for dairying to expand if there is an increased demand for milk and milk products and if this demand is translated into higher milk prices for producers. Local dairy processors give local growers a price advantage. A significant barrier to the expansion of dairying is the price of land which is significantly higher than the expected return. Consequently, dairy farmers have focussed on increasing efficiency, purchasing feed and expanding irrigation, rather than purchasing more land. Some operations have tried to improve their soils by importing soil amendments but have been hampered by restrictions on big trucks on local roads.

Environment

Dairying is a more intensive land use than beef production. The use of irrigated pastures and imported feed leads to very high nutrient inputs, which leads to very high levels of nutrient export despite adoption of good practices (Table 2 and Figure 18).

Social

Indications from consultation are that while there has been a significant reduction in the number of dairy farmers, many of the remaining producers are passionate about growing their businesses.

Conclusion

Dairying supplying local manufacturers is a secure industry but is a high source of nutrient export. Its capacity to expand is probably dependent on the ability of the local manufacturers to expand their markets. Spatially, the best locations are areas with lot sizes greater than 200 ha and with irrigation water available which depends on local circumstances and licence application. This industry could have the economic capacity to invest in soil amendments and best practice pasture, irrigation and nutrient management.

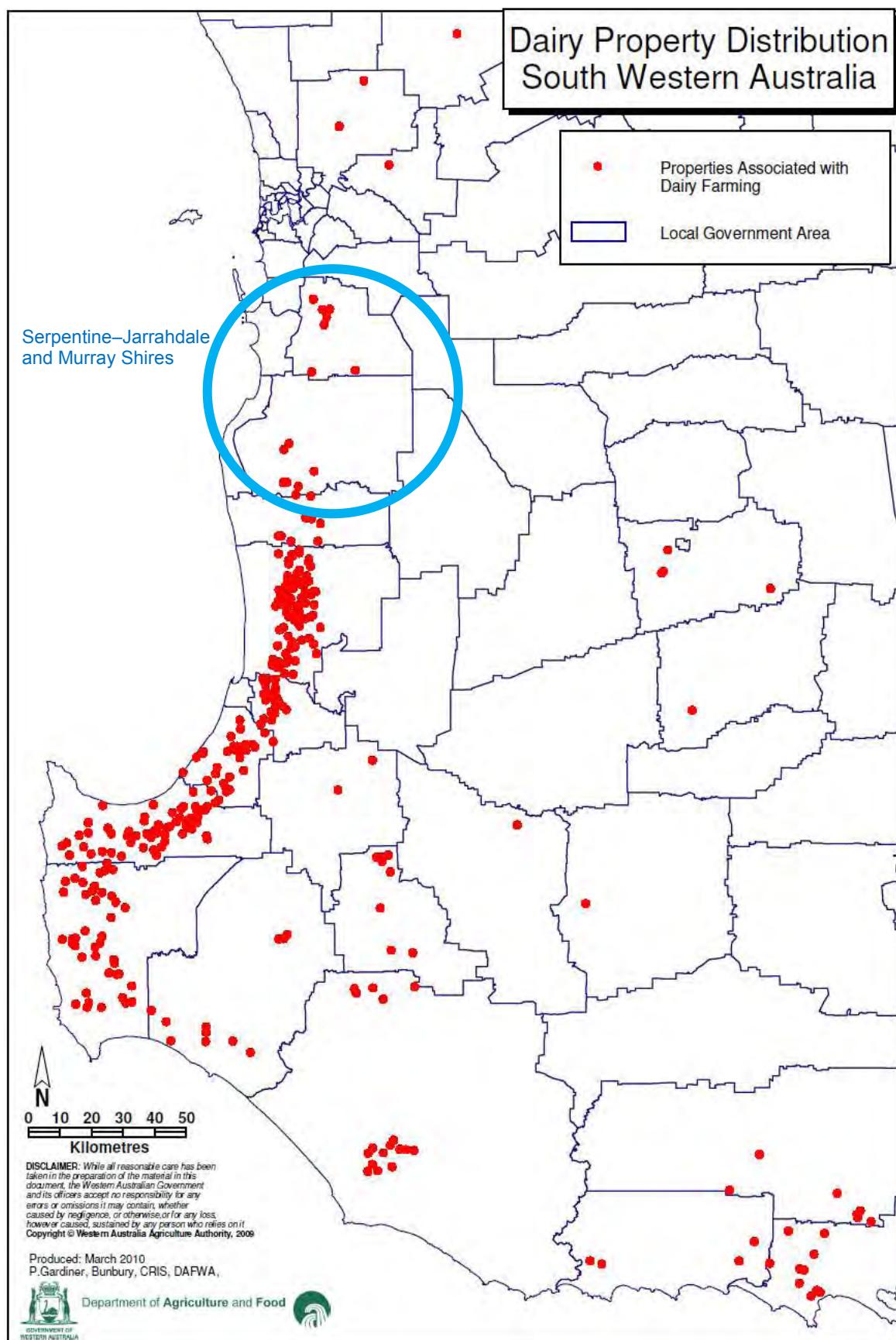


Figure 17 Dairy properties in the South West of WA (the number of cattle is not considered)

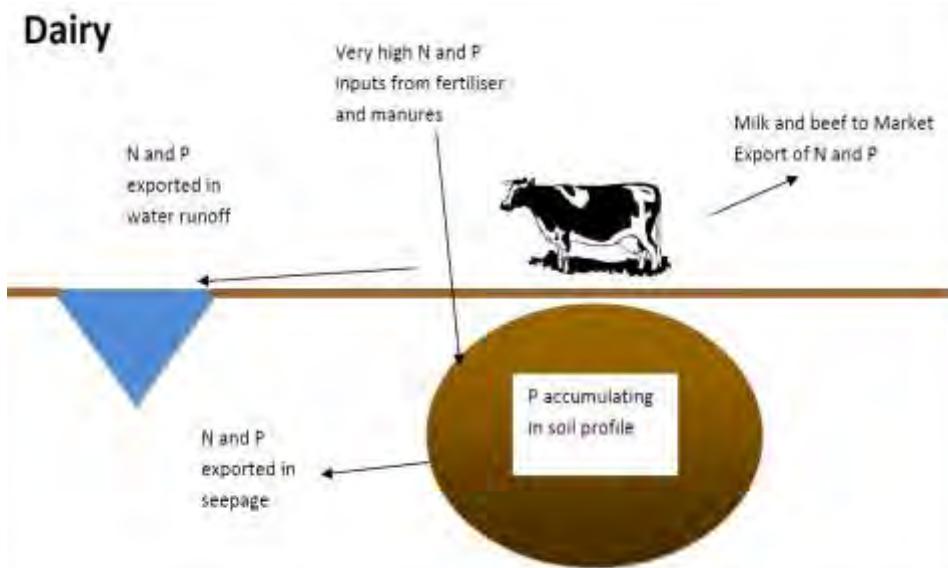


Figure 18 Possible nutrient flow on a dairy farm

3.6 Horticulture including turf and nurseries

Economics

Horticulture is limited because of high winter watertables, availability and quality of groundwater, and nutrient export risk. However, on the eastern edge of the study area where the soils have higher capability for horticulture, there are two turf farms and some viticultural and horticultural properties (Figure 19). The climate in this area is harsher than closer to the coast though and it may limit crops and influence profitability (R Summers (DAFWA) 2010, pers. comm.).

The concept of a waste water pipeline from Mandurah to the Harvey Irrigation Area creates the potential for expanding horticulture on high capability soils in the east and south of the study area. The development of the pipeline could match the impending reduction in horticulture in the Wanneroo area, north of Perth, because of urban development and reduced rainfall, which may in turn lead to reduced water allocations to growers. There is increasing interest from local and interstate growers seeking large lots and reliable water supplies close to Perth to expand or set up new annual horticulture enterprises. Retaining large lots in the areas identified as suitable would increase the potential for establishing annual and perennial horticultural enterprises in the future.

Should an irrigation scheme within the area be deemed feasible, consideration can be given to the creation of a 'Priority Agricultural Zone' or similar. A district level, nutrient and irrigation management plan will need to be prepared and approved by the Department of Water to set nutrient and irrigation management targets and best management practices to be employed within the irrigation district. Farm-scale nutrient and irrigation management plans will be required for any intensive farming development and should be consistent with the district level management plan.

There may be potential for hydroponic production in areas where there is natural gas, three-phase power and water with low (less than 150 mg/L) Total Suspended Solids. Uncertainty around quantity and quality of water supplies limits the ability to map prospective areas without detailed site investigations. Reverse osmosis can be used to reduce salt levels if necessary, but may not be economically feasible. The study area is not an ideal location because of frost and high summer temperatures, compared to coastal locations, but gas heating can be used in winter. Land may be needed for holding dams for recycling water and

evaporation ponds. Buffers and landscaping may be required to reduce visual impacts of greenhouses.

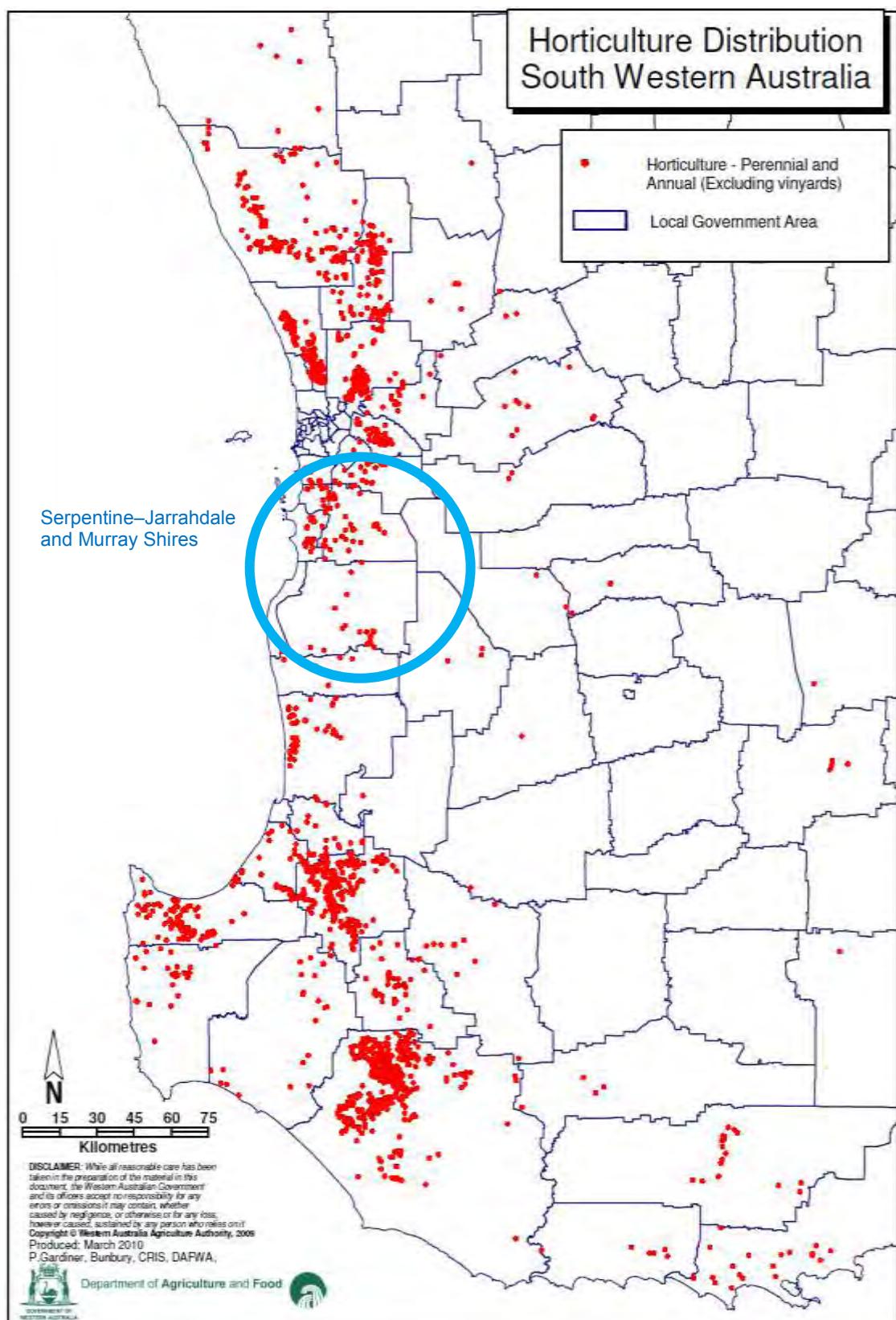


Figure 19 Horticultural properties (perennials and annuals, excluding vineyards) in the South West of WA (area or volume of horticulture is not considered)

Environment

Current horticultural systems are significant contributors of nutrients to groundwater and wetland systems, even with best practice management (Figure 20). It is estimated that annual horticulture contributes 188 kg/ha total phosphorus surplus, compared with 9.6 kg/ha for beef. Perennial horticulture is more efficient with estimated surpluses of 12 kg/ha (Table 2). The turf farm, with its collection and re-use of groundwater and large removal of nutrients in cut-off turf rolls, offers a way of reducing nutrient export. There is potential to improve on current nutrient practices in horticulture.

Some users, such as the Greenacres Turf farm, are building earth dams to capture and hold run-off and groundwater which is then used for irrigation in summer. This system has the potential to recycle nutrients into agricultural systems; however, flow-through must be allowed in the ponds to avoid gradual build-up in nutrients and eutrophication.

Horticulture

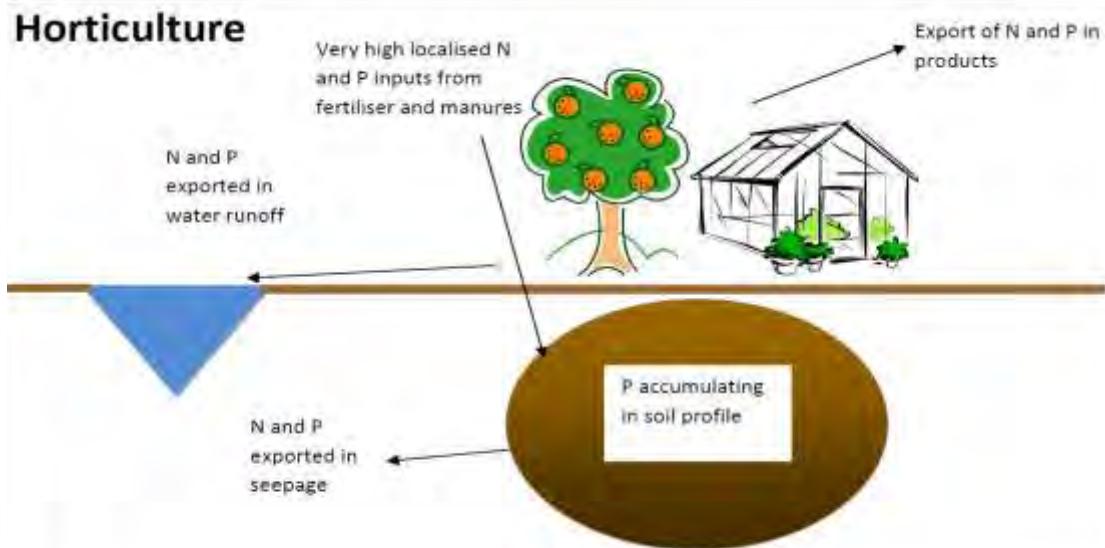


Figure 20 Possible nutrient flow for horticulture

Social

Consultation was unable to engage with sufficient horticulturalists to contribute to social findings in this area.

Conclusion

Soils-based intensive horticulture has potential to expand on highly capable soils in the east and south of the study area away from streams or wetlands, if alternative water supplies, such as recycled waste water, become available. The Department of Water, in consultation with the Department of Health and Department of Environment and Conservation, governs the approval process for use of non-drinking water based on suitability of classes of recycled water for different types of agriculture. Use of recycled water for horticulture has potential to support increased production. Best practice soil and water management could be linked to water licensing.

Intensive, closed-loop agricultural systems, greenhouse and hydroponic production have potential to expand but are constrained by hot summers and the uncertain quality and quantity of water supplies.

Retaining land in large lot sizes, preferably greater than 100 ha to enable good buffers, is required to attract horticultural industries.

3.7 Equestrian

Economics

The Peel region is a popular location for the diverse and valuable horse industry because of the availability of land, proximity to city racing and trotting venues, and urbanisation of other horse hubs. In 1998, the economic contribution of the horse industry was estimated at nearly \$75 million and is a significant contributor to the social wellbeing of thousands of residents (Peel Equine Taskforce and Peel Development Commission 1998). There has been no recent analysis to provide updated information. A significant portion of this industry is located in the Serpentine–Jarrahdale and Murray Shires.

Environment

Equestrian land uses often contribute excessive nutrients through the input of feed and fertiliser. The most suitable land for equestrian uses has a high capability for grazing but horses can be managed on poorer land where there is supplementary feeding and good pasture management. Nutrient applications are likely to be higher on poorer land. It is estimated that horse grazing contributes 13.4 kg/ha nutrient surplus compared with 9.6 kg/ha for beef (Table 2).

The stocking rate guidelines were created to ensure maintenance of soil cover, not to manage nutrient inputs (van Gool et al. 2000). A large portion of the Palusplain has a stocking rate of less than five hectares per horse, which does not include provision for a house and stables. Horses should not be kept separated and so if two horses are to be kept, the minimum lot size would need to be about 10 ha. It is recommended that fertiliser applications are undertaken according to the Fertiliser Action Plan (refer to Section 5.1).

Social

The Peel Equine Taskforce and Peel Development Commission (1998) made a significant effort to understand the social aspect of the equine industry through public consultation and surveys. The main components of the industry are race horses and trotting, stud and recreation. The community identified the need for:

- a single voice—lack of cohesion in the industry
- a horse industry development officer
- safe access to trails
- coordination of a trails network
- safety on roads
- an equestrian complex incorporating an indoor arena
- better planning in subdivisions
- a centralised local body of knowledge.

Other important issues were the lack of recognition of the Peel horse industry by local and state government and the negative perception of horses by the Department of Environment Conservation and some shires.

It is clear that subdivisions near or adjacent to horse facilities have attracted interest from both professional and lifestyle horse people. However, the extent to which the horse industry has grown since 1998 is not known.

Conclusion

Proximity to Perth means that the equine industry will continue to be popular. The challenge is reducing the high phosphorus surpluses. This industry could have the capacity to invest in soil amendments and best practice pasture and nutrient management.

3.8 Poultry

Economics

Growth in poultry has been in line with general national population growth. Markets for WA products are expanding at rates greater than the rest of the Australian market, despite coming from a smaller production base. Producers desire to meet the domestic demand for chicken products (eggs and meat) completely in WA, thereby reducing the importation of chicken products from the eastern states, which provides an area of potential market growth for both the broiler and layer industries. Opportunities also exist in domestic and international niche markets for higher priced products. Value-added chicken meat products are in demand in the south-east Asian market (Department of Agriculture and Food 2009).

Market demand for chicken meat products is predicted to grow domestically at 1–5 per cent per annum. The broiler industry may be in a position to increase production if new farms are established or shed capacity is increased on existing farms.

Poultry production for eggs and meat has become a significant land use (Figure 21). The Serpentine–Jarrahdale Shire has designated a poultry area called the Poultry Development Special Control Area, which is located west of the Serpentine and Keysbrook townsites (Department of Planning 1989). This area allows the poultry industry to relocate to a suitable location, in an environmentally suitable manner to minimise the impact to residential land use.

Environmental

Paddock-based, free range systems could be high nutrient exporters. Conversely, closed-loop agriculture such as shed poultry enterprises, have the capacity to minimise nutrient export (Figure 22). However, the efficiency of exporting manures and bedding is reduced because road trains are limited to major roads. Statement of Planning Policy 4.3 Poultry Farms sets out guidance for the Western Australian Planning Commission and local government when considering poultry farms. Enterprises must also meet the requirements of SPP 2.1.

Social

Poultry growers were not engaged during the community consultation for this project but DAFWA has been working through the Shire of Serpentine–Jarrahdale to investigate suitable locations for a poultry hatchery.

Conclusion

Closed-loop, intensive animal production systems are encouraged on the Palusplain because they make use of good infrastructure and proximity to markets and export minimal nutrients. Retaining large lot sizes, greater than 100 ha in preferred areas, will enable expansion of the industry, with adequate buffers to sensitive land uses.

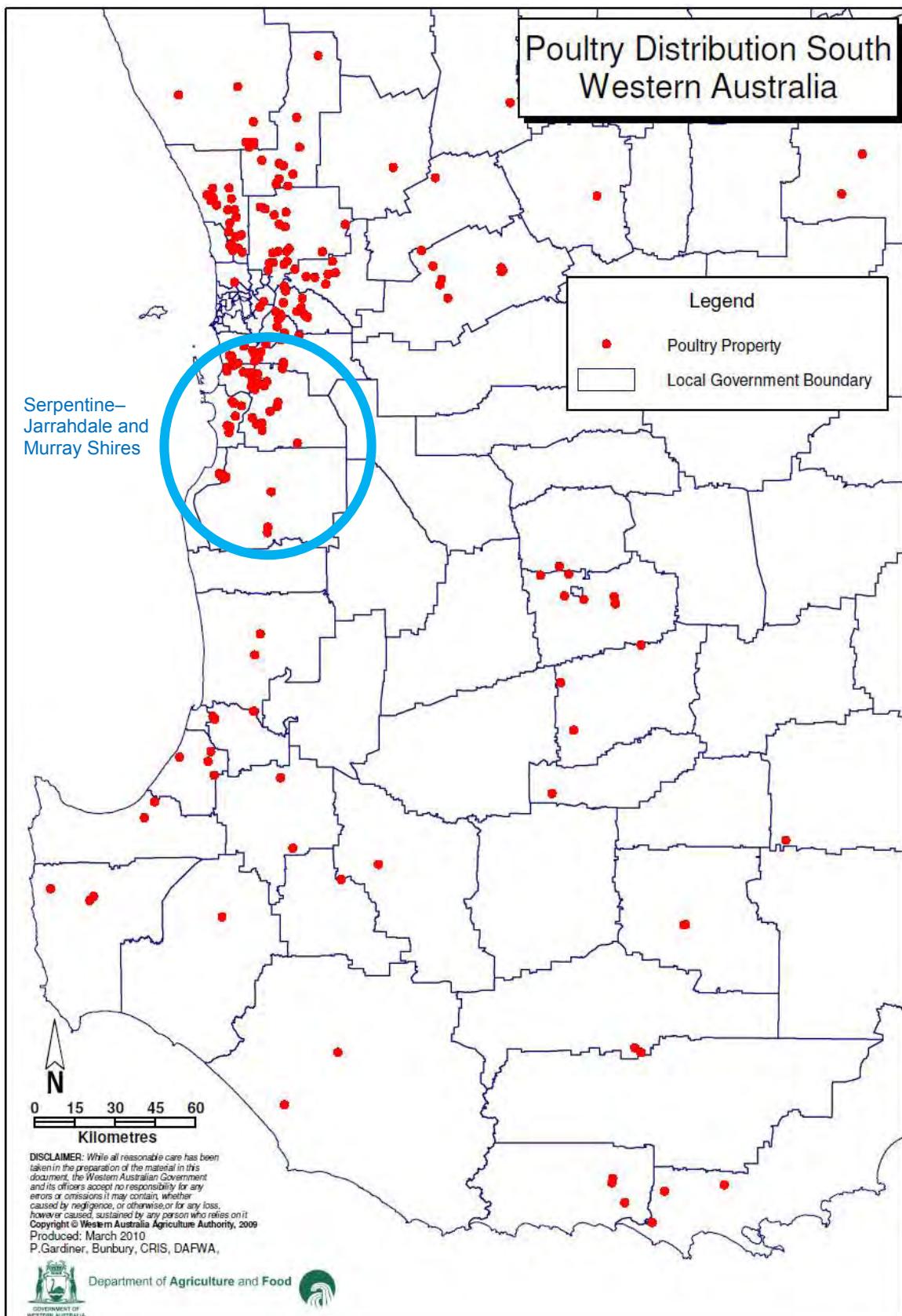


Figure 21 Poultry properties in the South West of WA (the number of poultry is not considered)

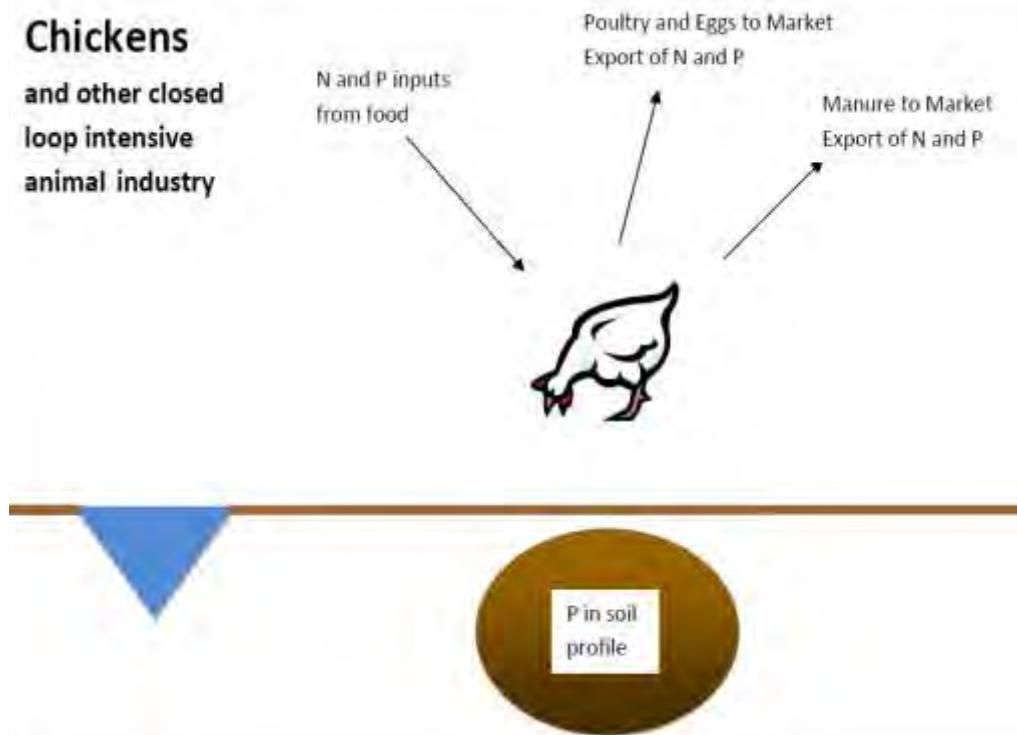


Figure 22 Possible nutrient flow for poultry and other closed-loop, intensive animal industries

3.9 Sheep

There are a number of sheep properties in the Serpentine–Jarrahdale and Murray Shires (Figure 23). Sheep are similar to the cattle for beef industry in terms of their nutrient inputs and outputs to the system, and also have similar environmental issues (Table 2).

There is potential for increases in lamb production if lamb prices remain high but this potential is constrained by high land and entry prices. Generally, smaller lots are more costly per hectare and producers may need a number of lots for commercial-scale production. There could be potential for specialised meat breeds.

3.10 Niche agricultural industries

A number of niche industries have been considered, but most of the landscape is limited by high watertables, risk of nutrient export and lack of a suitable water supply. If additional water sources became available, such as recycled waste water, more industries could potentially establish. Two examples of existing niche industries are goats and bees.

The milking goat enterprise at Mardella supplies fresh and frozen milk, and goats milk soaps which are specifically designed for people with skin allergies. This industry also has to manage nutrients carefully. Lot sizes required depend on scale of production but smaller lots are generally cost-prohibitive.

Enterprises that use perennial vegetation, such as the Packaged Bee industry for export bees, have potential and require production of suitable perennial vegetation, such as sugar gum and lavender, which would also benefit the environment.

There has been no social study of niche producers and no economic analysis is provided here because of uncertainty in market forces in potential industries.

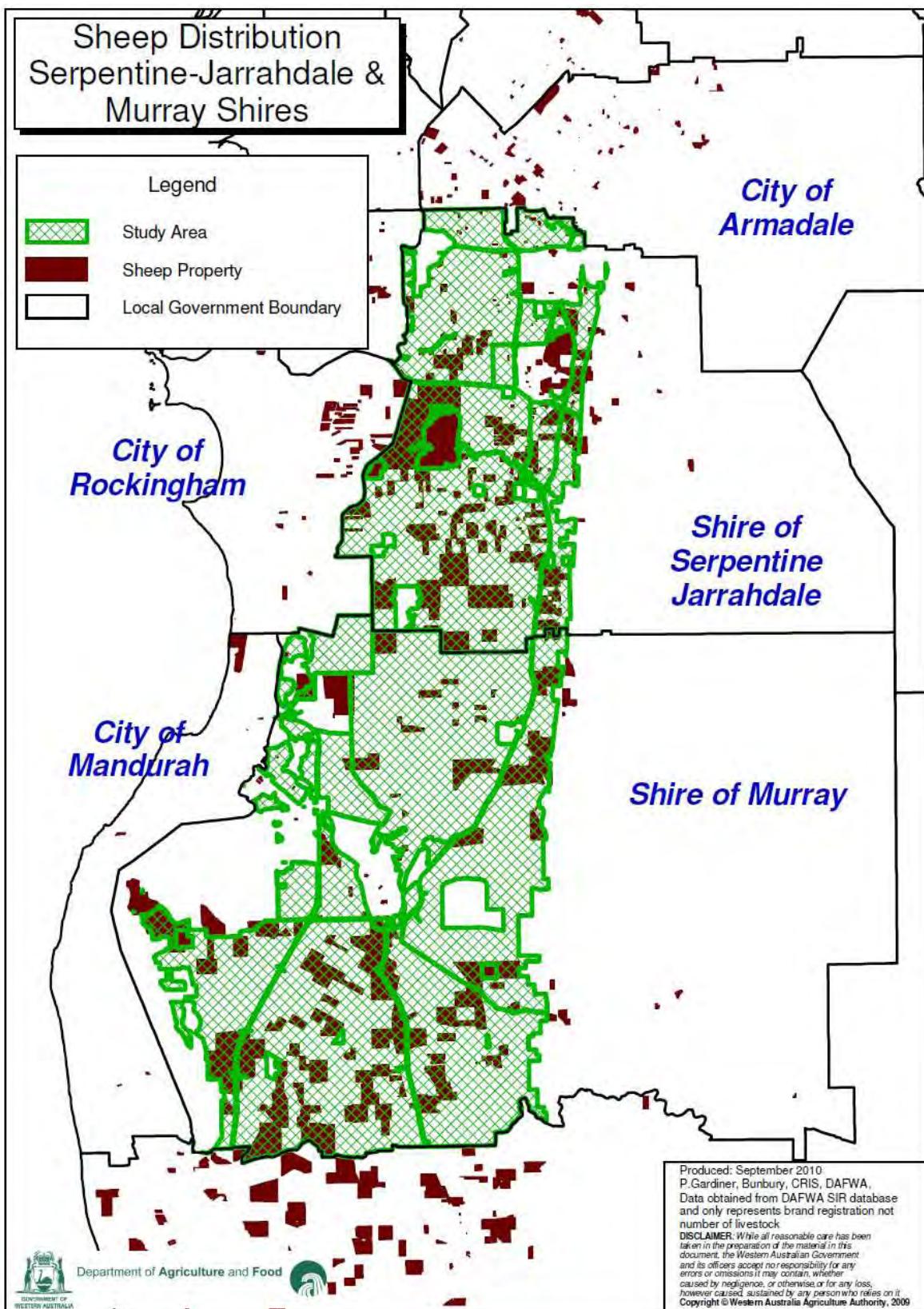


Figure 23 Sheep properties based on brands (the number of sheep is not considered)

Two potential industries are citrus and Chinese red dates. No cultural or economic analysis for these industries has been undertaken.

Citrus

There are currently no plantings of citrus on the Palusplain. Citrus require at least 30 cm of free-draining soil with a pH between 5.5 and 6.5 (1:5 soil: water). Spearwood Sands are suitable for citrus production as are parts of the Pinjarra Plain where there is good soil depth. Bassendean Sands are moderately suitable for citrus production, while parts of the Pinjarra Plain where soils are heavy (moderate to heavy clays) and drainage is poor are unsuitable. Nutrient export is a risk; however, the crop requires much lower levels of nutrients than most vegetable crops. Figure 32 (Section 6.2) shows areas outside the Palusplain wetland, but within the study area, with moderate to high land capability for perennial horticulture, which could include citrus if water supplies were available.

Chinese red dates (jujube)

Chinese red dates may suit the better drained soils of the study area (Figure 32, Section 6.2). They thrive in warm to hot dry climates, withstand extremes in temperature, prefer gravelly, well-drained soils but will perform well in a wide range of soils, and require a small amount of winter chill to set fruit. Trees appear to fruit well with little or no fertilisation, have no serious disease, insect or nematodes pests and low water requirement over summer months (Department of Agriculture and Food 2008).



Photograph 1 Chinese red dates (Department of Agriculture and Food 2008)

Conclusion

Proximity to markets, potential for on-farm and roadside sales, and boosting of tourism suggest that niche agricultural industries have capacity to expand. Such industries will require suitable landholdings and water near suitable infrastructure. A mix of landholding sizes, including areas greater than 40 ha, would be preferred. Suggestions from the community workshop included zoning for agricultural production, such as creating hubs for niche production. As with all land uses on the Palusplain, niche agricultural uses will need to manage nutrients to minimise export to waterways and wetlands.

3.11 Agri-food processing

Economic

An agri-food processing precinct is intended to be developed as a community of enterprises seeking enhanced environmental and economic performance from co-location. The key goals of such a precinct include:

- reduced resource consumption
- decreased environmental impact and improved environmental quality
- increased productivity and innovation through technology development, research and enterprise development

- increased strategic employment opportunities and improved quality of life for the community
- increased export opportunities
- enhanced business success through increased synergies, reduced raw material cost, decreased energy consumption, and minimised waste treatment and disposal.

An excellent example is the co-location of a piggery, composting industry and mushroom grower industries value adding from each other at a site east of Mandurah. As well as employing 70 people on-site, this development contributes to employment across the supply chain and to the local economy of the Peel region. The compost business also converts by-products of many other food industries from across the metropolitan region to composted organic products.

Proposals could be considered to establish a cluster of businesses either adjoining or in proximity to the existing businesses. There is a growing demand for land for these types of industries. These uses are compatible with proposed industrial land and airfield uses to the west and south, and could act as a buffer between urban and rural uses.

The levels of investment already committed within these activities, combined with the maturity of the current businesses and their networks, act as a strong catalyst to attract additional agri- and bio-industrial enterprises, particularly those that will benefit from industrial symbiosis, those that require waste management technology, and those that require a secure and proximate metropolitan location.

Environmental

Modern agri-food processing is designed to be a closed-loop system that exports its wastes. Figure 24 shows the possible nutrient flow for leaky animal and intensive industry, processing and composting which would be addressed in closed-loop systems.

Social

The community consultation suggests that there is interest in co-locating synergistic industries, with an agri-food processing precinct identified as a potential driver.

Conclusion

There is significant potential for the co-location of synergistic industries close to population centres and with good infrastructure. Examples are closed-loop agriculture production systems close to composting and possible algae production facilities. Such systems are now being designed into new cities and developments in China and elsewhere. Developments could be designed with complementary wetlands that would also serve as buffers. It will be important that such developments are well-managed, closed-loop systems to reduce risk of nutrient export.

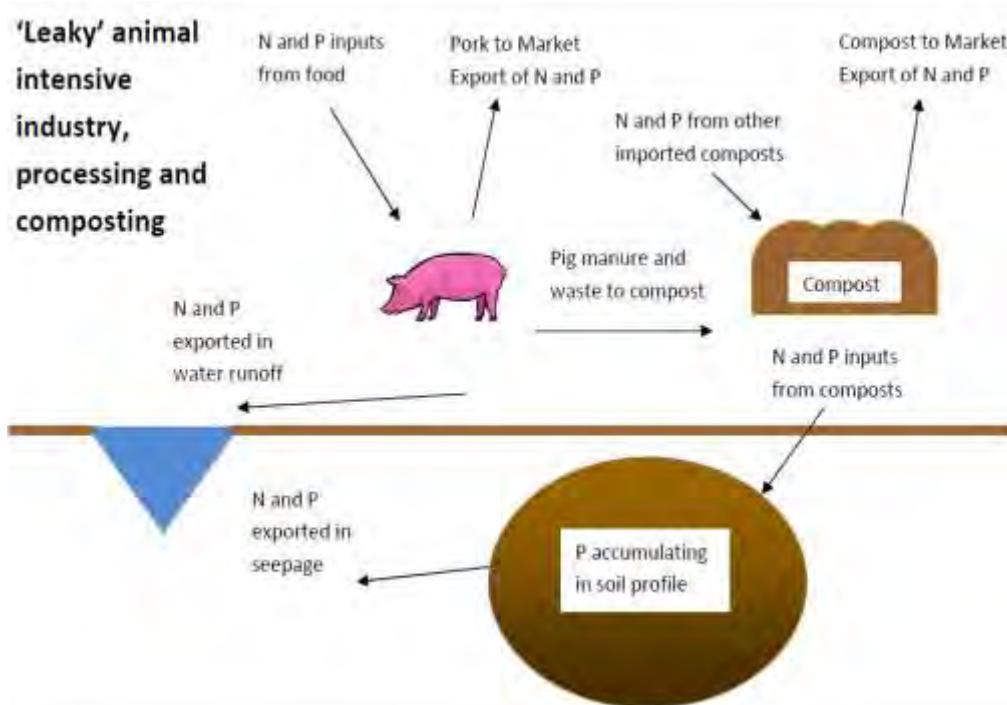


Figure 24 Possible nutrient flow for leaky animal and intensive industry, processing and composting

3.12 Energy industries

There is potential for wind, solar and timber industries for energy production. There is no economic or social information available. From the community consultation, it appears that there is interest in industries that add to the income base if they complement current activities.

Tree farming

Firewood

There is one firewood enterprise based on plantation timber at Coolup. Further development of such industries would have a significant environmental benefit. However, this market may be limited as burning firewood is recognised as a significant cause of air pollution in urban areas and is not a preferred heating source. The Environmental Protection (Domestic Solid Fuel Burning Appliances and Firewood Supply) Regulations 1998 restrict the sale of green firewood in the Perth Metropolitan Region. Green firewood is classified in the regulations as wood with more than 20 per cent internal moisture content.

Integration of tree farming for firewood and other uses has great potential to improve water balances and provide shelter. It is uncertain if there is a significant influence on nutrient export.

Carbon sequestration

Tree growing for carbon sequestration could be possible as a complementary land use when a carbon market is established, although land prices and the potential returns from other industries, may not make this a preferred area for carbon planting investments.

Wind farms

Average wind speed on the Palusplain tends to be below 6 knots, which is less than the average wind speed (greater than 10 knots) required for commercial applications. However, some landholders may consider small installations for supplementary energy. Considerations for commercial applications will be the effect of a proposal on:

- landscapes, views, visual characteristics and skyline
- local amenity, including shadow flicker, blade glint and noise
- local flora and fauna, effects on avian safety and environmental values
- economic benefits to local and regional areas
- potential impacts on aircraft, with Jandakot Airport in the vicinity.

More information about planning for wind farms is contained in the Western Australian Planning Commission's Planning Bulletin 67 *Guidelines for wind farm development* and the *Draft National wind farm guidelines* <<http://www.ephc.gov.au/taxonomy/term/25>>

Solar

The Palusplain, with its flat topography and proximity to major power infrastructure corridors and end users, has potential for solar power generation. However, this potential may be limited by the average number of clear days per year. Retaining significant areas in large lots would increase the potential for establishing solar power farms because land prices will be lower and buffers can be established if required. Visual landscape assessments would be required to ensure these would not impact adversely on the rural amenity.

Conclusion

Alternative energy industries could be important in the future. Tree farming for harvesting is compatible with normal agriculture but wind and solar energy farms may require significant buffers and locations that are in close proximity to a suitable electrical grid. Retaining large lot sizes, preferably greater than 100 ha, will facilitate the future development of such industries.

4. Impact of urban, rural residential and rural small holdings

The southern Perth metropolitan and Peel region has experienced significant demand for land use change from agricultural to urban, rural residential and rural small holdings. This demand is driven by urban sprawl and desire for a 'tree change'. It is the Western Australian Planning Commission's policy that subdivision of rural and agricultural land for closer settlement should be properly planned through the preparation of regional and local planning strategies. In the absence of these, existing large rural lots should be retained and fragmentation of rural land and loss of rural character through incremental subdivision should not be permitted.

Serpentine–Jarrahdale Shire has a minimum lot size of 40 ha in its rural zone under the Town Planning Scheme amendment of June 2009. In 2007, this shire had a total of 37 700 ha rural zoned land and the Murray Shire had a total of 76 600 ha rural zoned land. A lot size analysis for the agricultural zone of the two shires for 1992 and 2008 shows a large increase in the total area of lots of less than five hectares and a reduction in total area of lots greater than 60 ha (Figure 25 and Figure 26). There has been significant increase in small lots near the towns of North Dandalup, Ravenswood, Pinjarra and Coolup, and near the Peel–Harvey Inlet (Short et al. in prep.).

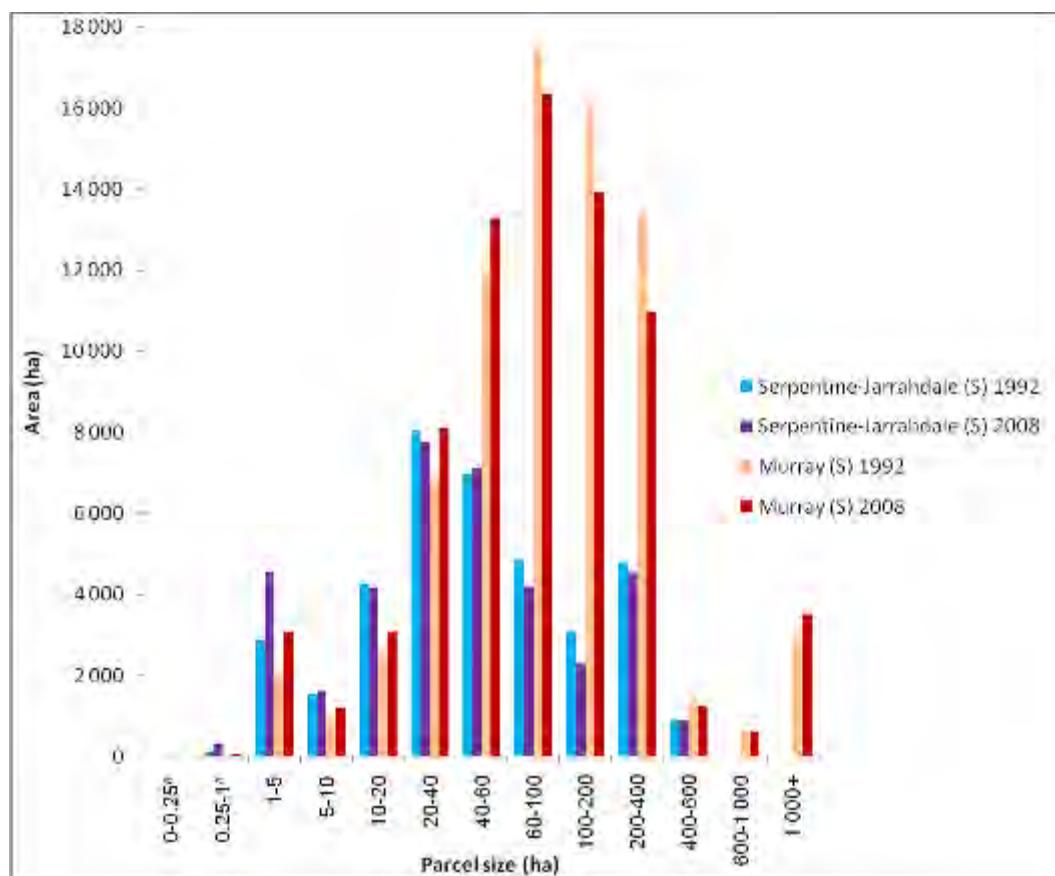


Figure 25 Total area (ha) per lot size category for Serpentine–Jarrahdale and Murray Shires (rural zone)

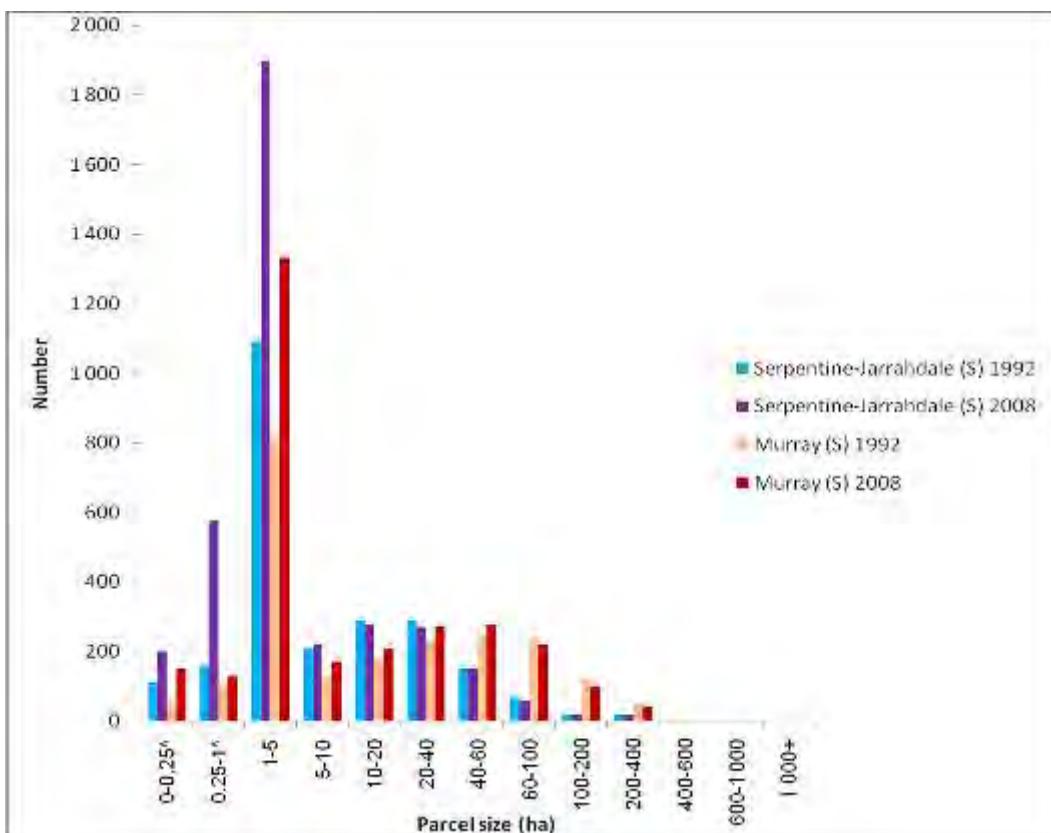


Figure 26 Total number of lots per size category for Serpentine–Jarrahdale and Murray Shires (rural zone)

Urban, rural residential and rural small holding developments are very high nutrient exporters compared to non-irrigated beef production and it is not easy to control fertiliser and other nutrient inputs (Figure 27 and Figure 28). The implication on the nutrient balance of changing from agricultural uses to such uses needs to be considered when planning for these developments. The Environmental Protection Authority (2008) states that best practice urban development can reduce nutrient export through:

- reticulated sewerage or alternate treatment units
- urban soil amendment with bauxite residue (not yet commercially available), loams, clays or crushed limestone applied to the lots as a soil amendment or as part of the subsoil fill
- water sensitive urban design water retention measures. On highly leaching soils, these will only work with the addition of soil amendments. Soil amendments will have to be reapplied as their nutrient absorption capacity is fully taken up and reapplication may become problematic when the land is fully developed.

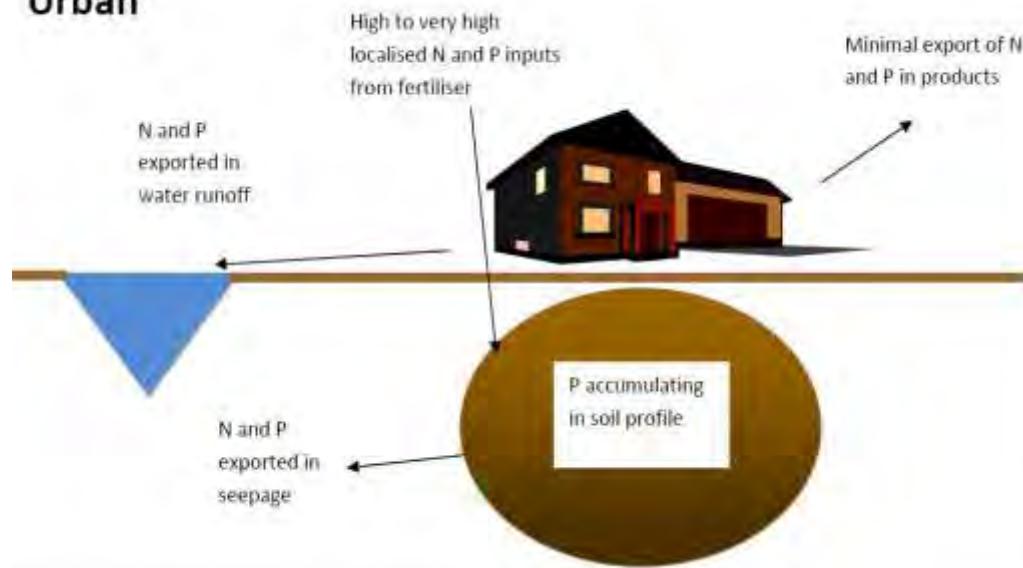
Urban

Figure 27 Possible nutrient flow for urban land use

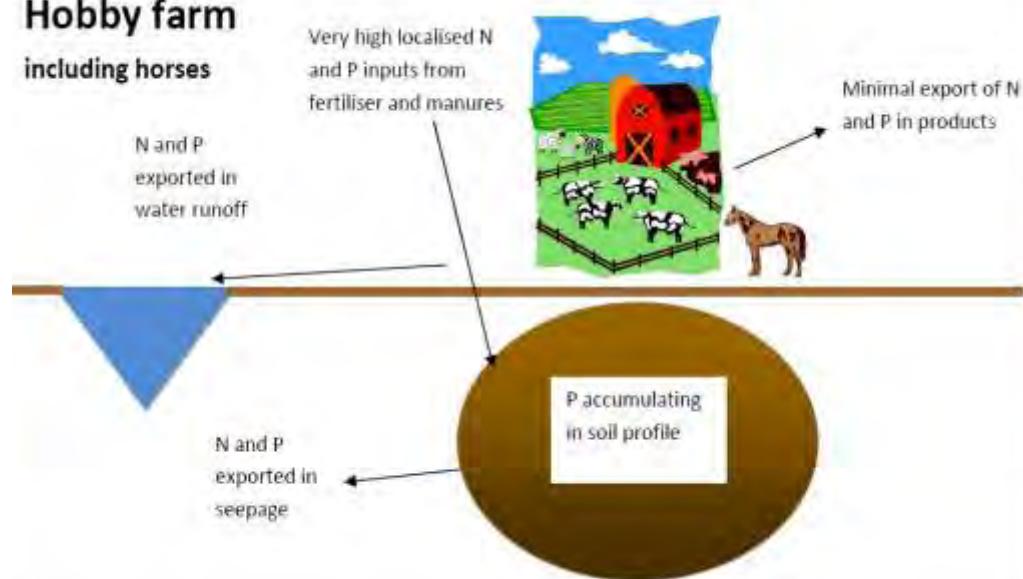
Hobby farm including horses

Figure 28 Possible nutrient flow for rural small holdings and hobby farms

5. Strategies and information to reduce nutrients

A key focus for land use planning is to balance economic, social and environmental issues and ensure that land uses are compatible with land capability. Through development controls, legislation and regulations, the process of land use and land development may be effectively managed.

Once a land use is in place, a number of catchment management solutions can be applied to reduce nutrient inputs into the wetland systems, including fertiliser management, soil amendments, perennial pastures, effluent management and riparian management. The Environmental Protection Authority (2008) recommends 13 best management practices to reduce phosphorus in the Peel–Harvey region:

- rural and urban fertiliser management
- rural and urban soil amendments
- sewage management in existing homes, dwellings and wastewater treatment plants
- zero discharge for licensed agricultural premises
- improve other agricultural practices through perennial pastures
- effluent management and irrigation management
- reafforestation of agricultural lands (farm forestry)
- connect new developments to reticulated sewerage or alternative treatment unit
- measures incorporated into local planning policies, strategies, planning conditions and state policies
- water sensitive urban design
- drainage reform
- wetland and waterway protection
- revegetation.

5.1 The Fertiliser Action Plan

The Fertiliser Action Plan (FAP) has been established by the WA Government to improve the use of fertiliser because fertilisers are often applied liberally and without testing for minimum requirements. For more information refer the [Fertiliser Action Plan](#) page on the DAFWA website.

The FAP recommends anyone purchasing phosphorus-based fertilisers in the FAP policy area, which includes the Palusplain, to only do so on advice from a FertCare-accredited advisor following soil testing.

On the Palusplain, it is difficult to achieve the critical phosphorus levels on the poorest soils because significant areas are classified as phosphorus deficient compared to the standards, even though they have been fertilised for 50 years. There are also pH requirements to meet, with a minimum pH of 5.5 recommended (Gourley et al 2007).

The current focus for the FAP is beef producers because they represent the highest overall contribution of phosphorus into coastal estuaries despite exporting relatively low phosphorus per hectare. The approach is to encourage all farmers to use alternative fertilisers and maintain critical phosphorus levels for plant growth. Even with full adoption of this approach,

modelling indicates that the best possible outcome will be a reduction in phosphorus load of less than 10 per cent. Therefore, despite best fertiliser management, at least 90 per cent of the phosphorus load will remain. Even though a 10 per cent reduction is modest, it is an important early reduction in phosphorous load which will enable other actions, such as soil amendments and buffers, to be more effective in creating further reductions.

The DAFWA website contains free information products to assist farmers make better decisions about fertiliser application to achieve economic and environmental outcomes. These are the 'Soil productivity and nutrient assistant' (SPANA) and the 'Making \$ense of fertiliser' DVD which is available from DAFWA offices.

5.2 Soil amendments

There is a range of potential soil amendments that can help in phosphate binding and improve soil quality and productivity. This project did not investigate the full range of potential amendments or how they could be used in combination; however, some information on Alkaloam® and bio-solids is provided. Further research is required to determine the potential for use of a range of recycled materials from urban and industrial sources.

Alkaloam®

Alkaloam®, which is also referred to as 'red mud' or 'bauxite residue', is the registered trademark for Alcoa-produced red mud. There is potential for Alkaloam® to be used in the Peel-Harvey catchment to reduce phosphorus leaching into waterways and to improve agricultural productivity. Alkaloam® has benefits such as high sorptive capacity (ability to adsorb a range of elements and heavy metals), phosphorus retention and can increase soil pH (Harris & Howard 2010)

Currently Alkaloam® is approved as a product for defined uses in a defined area; it does not have approval as a generic product. The current approval mechanism for its use in the Peel-Harvey catchment is under Part 4 of the *Environment Protection Act*, via a Public Environmental Review.

Other soil amendments

The Water Corporation is working to develop other soil amendments from waste materials. One development is a combination of lime-ameliorated bio-solids from sewerage treatment. The lime is from brick manufacture and the clay is surplus extracted as part of land fill. Lime-amended bio-solids have potential to provide nutrients and help improve soil water and nutrient-holding capacity.

5.3 Catchment approaches

Figure 29 and Figure 30 show possible drainage and nutrient management practices in agricultural systems that can be used to complement the Fertiliser Action Plan. They are concepts only and the relative merits in removing and holding nutrients requires further research. The key features are:

- Fencing to prevent livestock from entering waterways to reduce the direct nutrient input into the waterways (Weaver et al. 2008).
- Spreading of ironstone gravels within drains to adsorb phosphates. This practice has not been adequately tested and is not proven. However, spreading smaller gravels within the drains offers a larger surface area and greater sorptive potential (Weaver et al. 1992).
- Revegetating and harvesting streamside vegetation. This practice has been found to not reduce nutrients in-stream because nutrients travel freely in solution and revegetation

reduces the clay content of surplus water enabling efficient export. Streamside vegetation is also attractive to stock for shelter and may work against nutrient reduction by concentrating nutrients in areas close to drainage channels and streams (Weaver 2010).

- Revegetating, reforesting and harvesting away from the streamside may encourage stock away from drains and streams increasing opportunities for in situ nutrient use.
- Spreading drain sludge when drains are cleaned may reduce nutrients rapidly re-entering streams in soil erosion events.
- Adding phosphate-binding soil amendments. There are also a number of soil amendments that improve soil qualities and act to adsorb and slowly release nutrients.
- Planting perennial pastures which can be effective in using nutrients from deeper in the soil profile. They may be best located away from streams and drains to encourage stock away from direct nutrient export areas.
- Holding back water in drains and natural and created wetlands in a manner that avoids flooding and maximises deposition of suspended soil particles and biological activity consuming nutrients within drains.
- Developing and incorporating removable/recyclable, phosphate retention filters in drains. This concept is currently in development for trialling by the Water Corporation.
- Reviewing the Water Corporation's three day (drainage) rule as a potential to retain the nutrients, thereby reducing the amount of nutrient going into the lower rivers and estuary. Investigations will be required to achieve both satisfactory drainage and maximum nutrient retention.

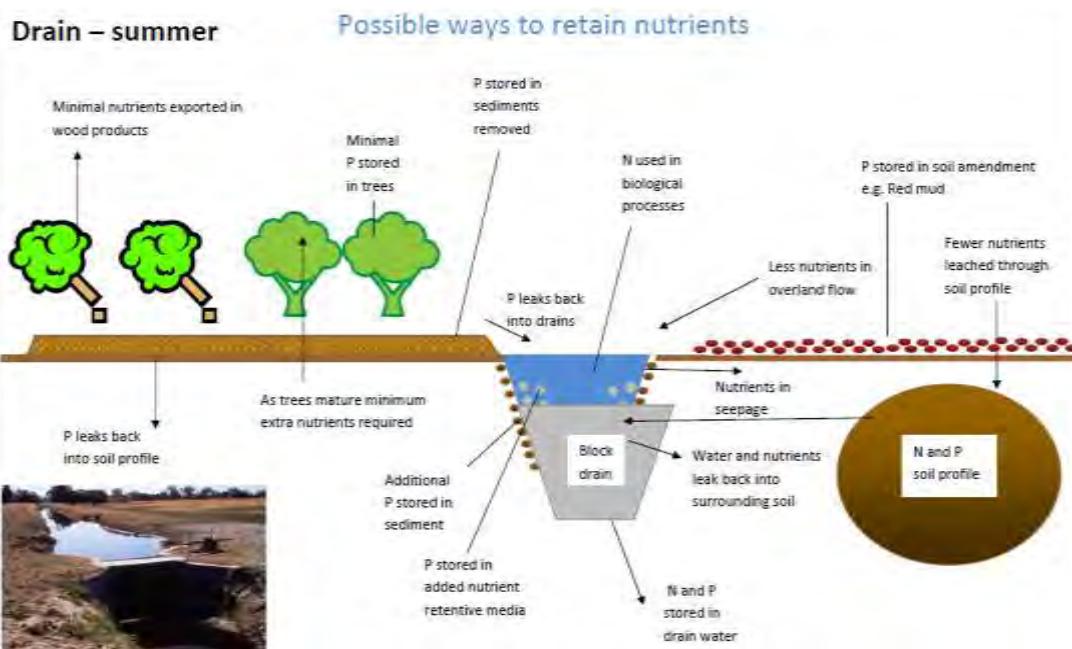


Figure 29 Possible ways to retain nutrients in summer

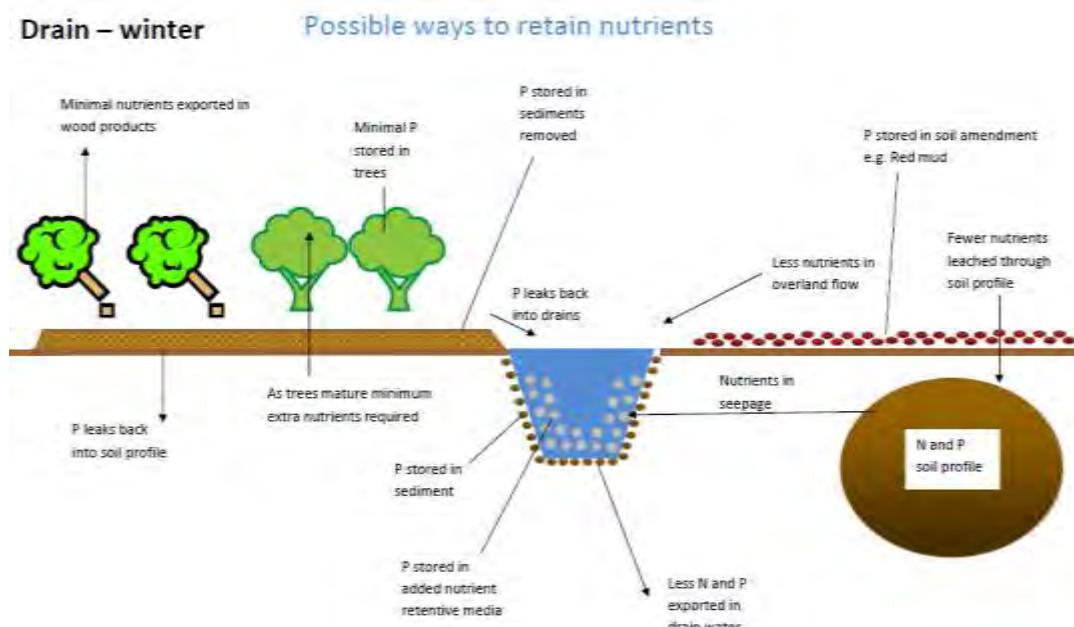


Figure 30 Possible ways to retain nutrients in winter

5.4 Information gaps

Through catchment-based research, there is now an improved understanding of nutrient pathways on the sandy soils of the Swan Coastal Plain. In particular we have learnt which industries are the main contributors and that urban residential uses can be high nutrient contributors compared with standard grazing practices such as beef. We have also found that revegetation along streams is effective in cleaning the water of sediment but it is not effective in reducing in-stream nutrients.

The effectiveness of many of the measures to improve nutrient use and reduce nutrient export are yet to be demonstrated in the long-term and require trialling and monitoring. A well-resourced, multi-agency, long-term assessment of existing and proposed nutrient management practices needs to be developed covering both urban and rural interventions. Developments using these practices need to put in place monitoring infrastructure as well as the means to pay for sustained monitoring. Since methods using soil amendments can have a limited life, any monitoring has to be long-term and initially designed to be over at least 20 years.

6. Land use planning to reduce future nutrient inputs

This section describes the layers of spatial data and information that can support nutrient-sensitive, land use decision-making on the Palusplain and the use of these layers to establish conceptual land use options.

Key layers of information to consider for analysing potential for different land uses are:

- phosphorus retention index (PRI)
- phosphorus export hazard
- land capability for annual and perennial horticulture, and grazing
- acid sulphate soils
- land elevation
- waterlogging hazard.

It is also necessary to consider lot size availability, separation distances from other land uses, infrastructure availability and stocking rates.

6.1 Phosphorus retention and export hazard

In planning for land use on the Palusplain, mapping of PRI and phosphorus export hazard are key datasets (Figure 8 and Figure 11). Potential nutrient-exporting land uses should be avoided on areas with low PRI soil (less than 5), unless soil amendments are used. Similarly, such uses should be avoided on land with a high to extreme hazard rating for phosphorus export hazard.

As well as areas of low PRI and high to extreme phosphorus export hazard, the proximity of a land use in relation to the waterways impacts on water quality. A beef property close to the estuary will result in a worse outcome for the estuary than a beef property far from the estuary. Assimilation or absorption of nutrients on a catchment-scale is an important factor not included in export risk assessments which look at edge of paddock losses, not losses as seen by the estuary (Table 2). The highest nutrient-exporting land uses should be located as far from the estuary as possible to increase the potential for nutrient assimilation prior to entering waterways and the estuary.

Areas of soils with high capacity to export nutrients, particularly close to the estuary, streams and drains, could be considered as priorities for commercial or non-commercial revegetation.

6.2 Land capability mapping

Land capability refers to the ability of land to support a type of land use without causing damage. Land capability mapping is a base measure of the capability of the existing soils for a particular land use. The mapping is based on proportional mapping, so data is displayed as proportions.

Land assessed as having very high or high capability has very few or minor physical limitations affecting the productive use, and negligible or minor risk of land degradation associated with that land use.

Land assessed as moderate or fair capability has moderate physical limitations which require careful planning and conservation measures to ensure the land remains productive and/or

degradation doesn't occur. Depending on the type of limitations, moderately capable land could be as productive as highly capable land but will require a higher level of management input and costs to overcome its limitations.

Low or very low capability land has increasing physical limitations to land use from high to severe and is generally considered unsuitable for the specified land use without a high level of management input.

Generally, agricultural development should focus on areas with high land capability for that land use. Moderate capability land can be used if the limitations can be ameliorated over the long-term. Limitations to land uses can be minimised by employing measures such as soil amendment on low PRI soil, fill for waterlogging soils or specialised drainage for areas subject to inundation. Another approach is to introduce new land uses which are less affected by the limitations.

Land capability mapping can be used to guide the location of soils-based agriculture (annual and perennial horticulture, and grazing). The mapping only accounts for limitations associated with soil and landscapes, such as flood hazard, land instability, pH and phosphorus; it does not consider other factors such as availability and quality of water supplies, climatic risks such as frost or heat stress, or socio-economic factors (van Gool et al. 2005). Table 5 contains the area for each land use in the study area and its land capability ratings.

Table 5 Area (to the nearest 100 ha) of land use and its land capability rating

Land capability ratings	Annual horticulture (ha)	Perennial horticulture (ha)	Grazing (ha)
> 70% of land has high capability	2 300	500	3 900
50–70% of land has high capability	3 600	5 100	4 400
> 70% of land has moderate to high capability	17 300	26 200	58 100
50–70% of land has moderate to high capability	17 600	6 100	5 900
50–70% of land has low capability	18 000	3 600	900
> 70% of land has low capability	47 800	65 200	33 600

Land capability for annual horticulture

Land capability for annual horticulture is assessed on the production of irrigated horticultural crops from plants with a short-term life cycle (typically one year). Crops include annual fruits, vegetables, commercial turf production and cut flowers. The assumptions for mapping this land use are: crops are grown commercially; crops are shallow-rooted (most only use the top 50 cm of soil); crops are irrigated using sprinkler or trickle systems; mechanised cultivation is used; fertilisers and herbicides, fungicides and/or pesticides are used; and there is crop rotation (van Gool et al. 2005).

Because of the nutrient export risk, only land with high capability should be used and even then, good soil, water and nutrient management including soil amendments, would be required. Locations far removed from water bodies will reduce environmental risks (Figure 31).

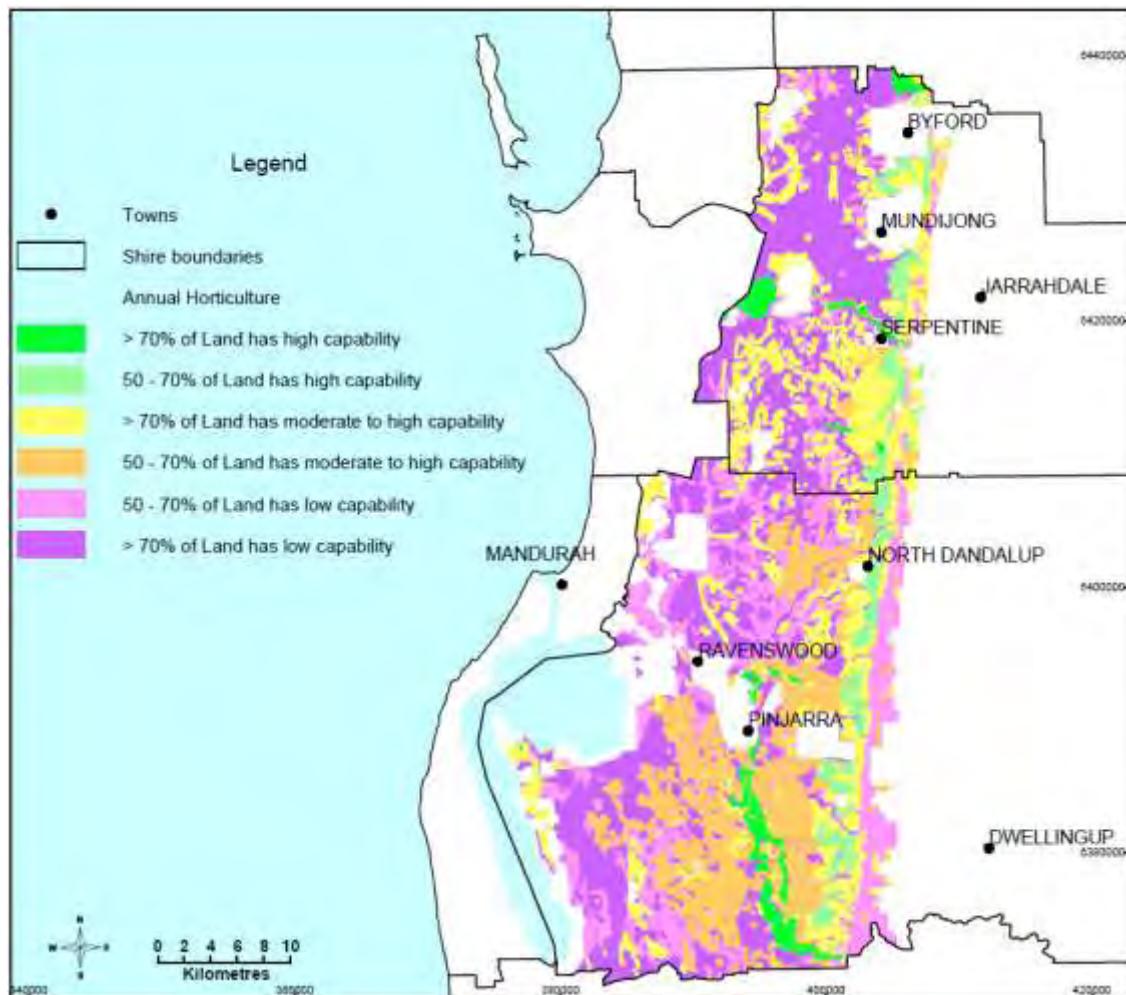


Figure 31 Land capability map for annual horticulture

Land capability for perennial horticulture

Land capability for perennial horticulture is assessed on the production of irrigated horticultural crops from plants with a long life cycle, such as orchard and vineyard crops. Although the plants are perennial, crops are harvested annually. The assumptions for mapping this land use are: crops are grown commercially; crops are deep-rooted (roots extending to 100 cm or more); crops are irrigated using drip, micro-jet or mini-sprinkler systems; mechanised cultivation is used; fertilisers and herbicides, fungicides and/or pesticides are used; weeds are controlled by mowing, slashing or sprays; and machinery access is available (van Gool et al. 2005).

Because of the nutrient export risk, only land with high capability should be used and good soil and nutrient management, including soil amendments, would be required. Moderate capability land should only be used if the constraints can be ameliorated over the long-term and locations are far removed from water bodies (Figure 32).

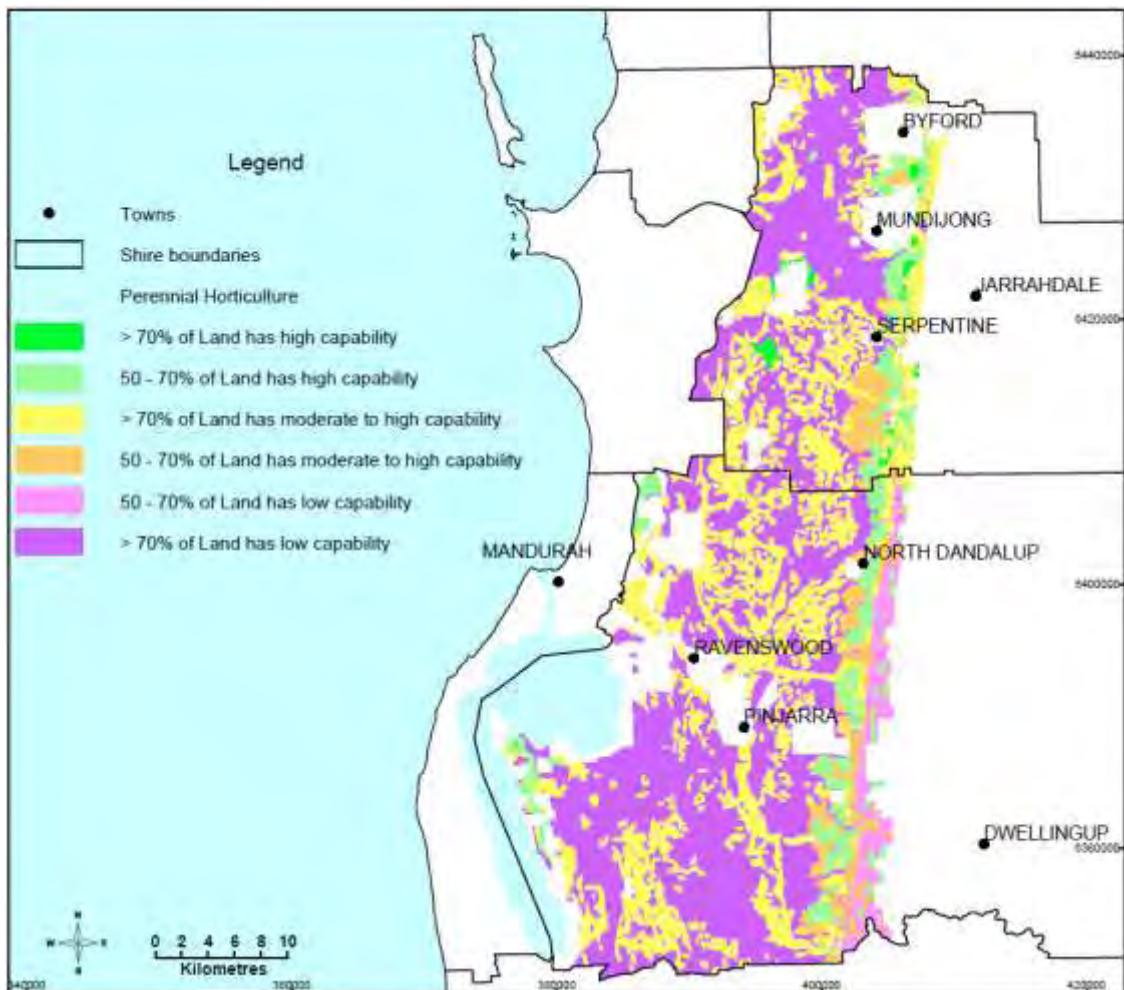


Figure 32 Land capability map for perennial horticulture

Land capability for grazing

Land capability for grazing is assessed on the grazing of sheep and cattle on broad-scale, dryland (non-irrigated) pastures in agricultural areas receiving an average annual rainfall of more than 350 mm. The assessment does not apply where supplementary feeding and wind breaks are used (van Gool et al. 2005).

Moderate capability land should only be used if the constraints can be ameliorated over the long-term (Figure 33).

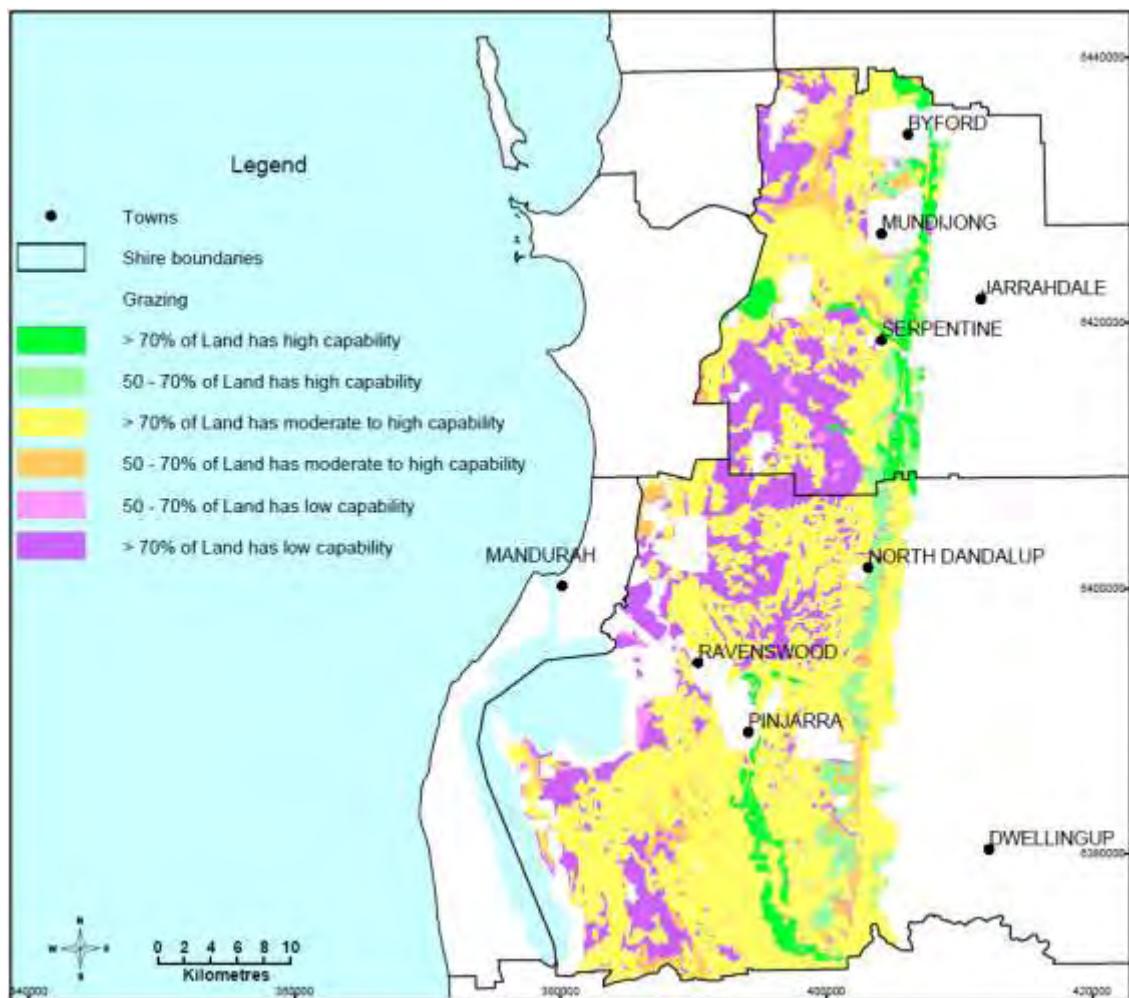


Figure 33 Land capability map for grazing

6.3 Lot size distribution

Lot size distribution has a significant impact on potential future agricultural land uses. Two trends are operating: most agricultural industries are moving to bigger, more specialised operations as a means of improving efficiency; and new industries cannot be attracted unless lots of sufficient size, which are priced to reflect their agricultural values, can be purchased.

It is also recognised that the numbers of small landholders with niche products are increasing. There is potential for further increases in small-scale production with the growth of farmers' markets and the potential for a cooperative to pool product and markets.

Over the 1992–2008 period, there was a substantial reduction in the number of large lots and a corresponding increase in the number of small lots. The implication of this change is that for the Palusplain to attract future agricultural industries, the remaining larger lots need to be retained.

However, across the south-west of WA, large rural lots continue to be subdivided (Short et al. in prep.). If this trend continues, opportunities for new, large-scale agricultural enterprises will diminish, as will opportunities to adapt to climate change, increased energy costs and increasing populations. In some areas, there is justification for subdividing agricultural land. But large lots are more likely to maintain land prices at agricultural market levels and reduce likelihood of lifestyle ownership. They also maintain agricultural options for the future should market signals change.

Figure 34 shows the current lot (parcel) size distribution which highlights the location of large lots (200–2000 ha) across the study area. The current distribution of rural properties shows that many properties consist of multiple lots (Figure 35). In traditional farming areas, aggregates of lots allow farm build-up for increasing efficiency and scale of production. In peri-urban situations, such aggregation of lots in single properties may also mean a landholder has purchased multiple lots as an economic investment.

There are very few areas with large lots remaining which have a moderate to high capability for annual horticulture (Figure 36). It will be important to retain the large lot sizes in these areas for future horticultural developments. Figure 37 shows the lot size and potential areas for perennial horticulture and Figure 38 shows the distribution and size of lots with moderate to high capability for grazing.

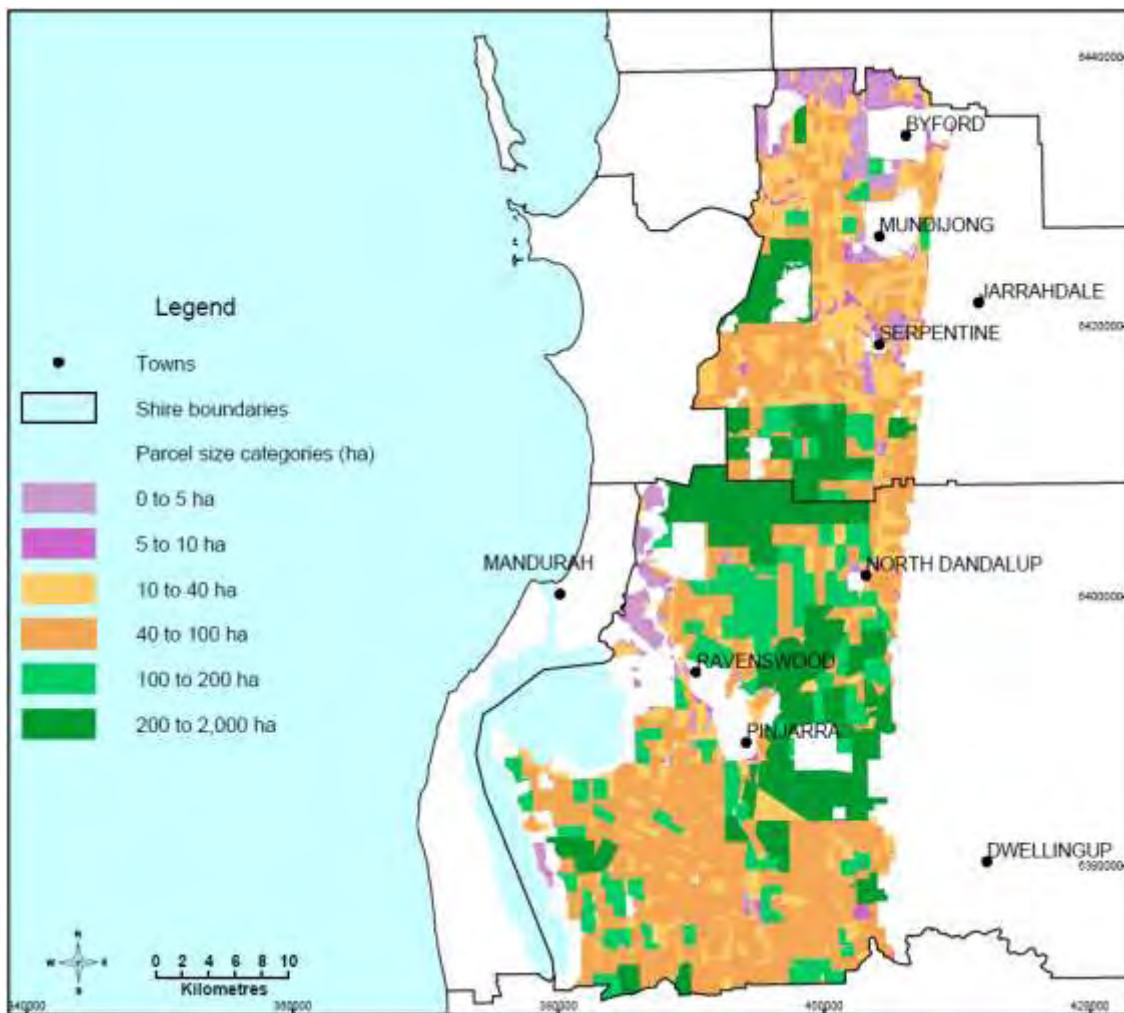


Figure 34 Lot (parcel) size categories

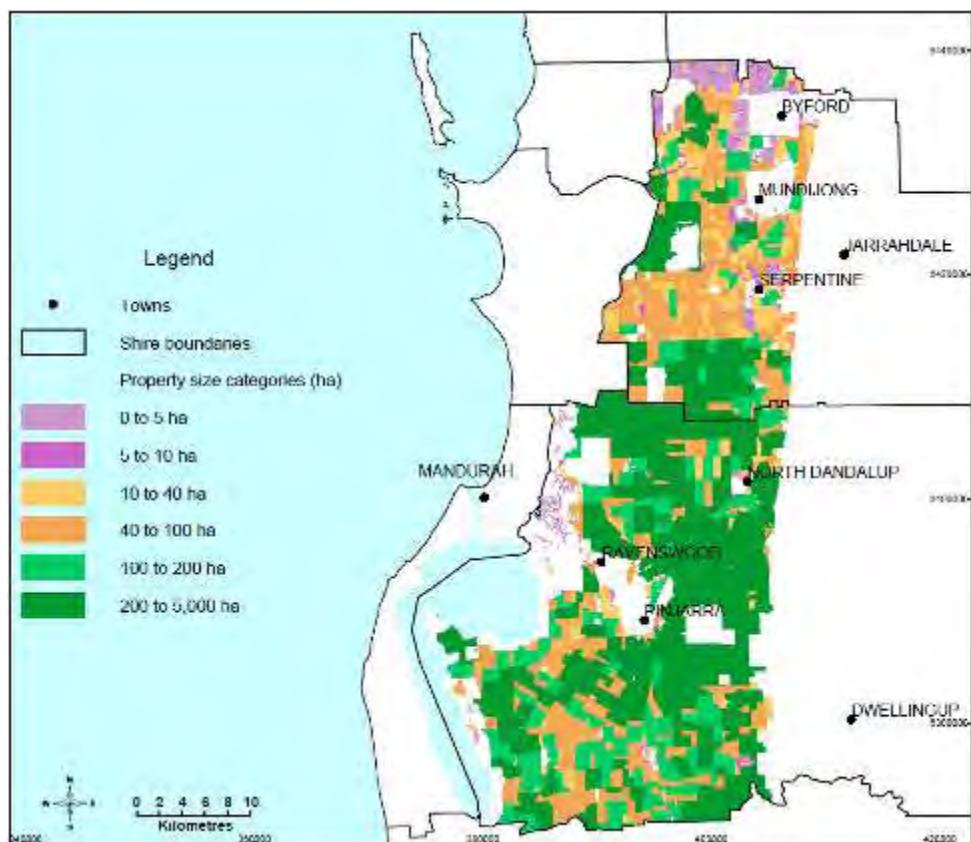


Figure 35 Property size categories

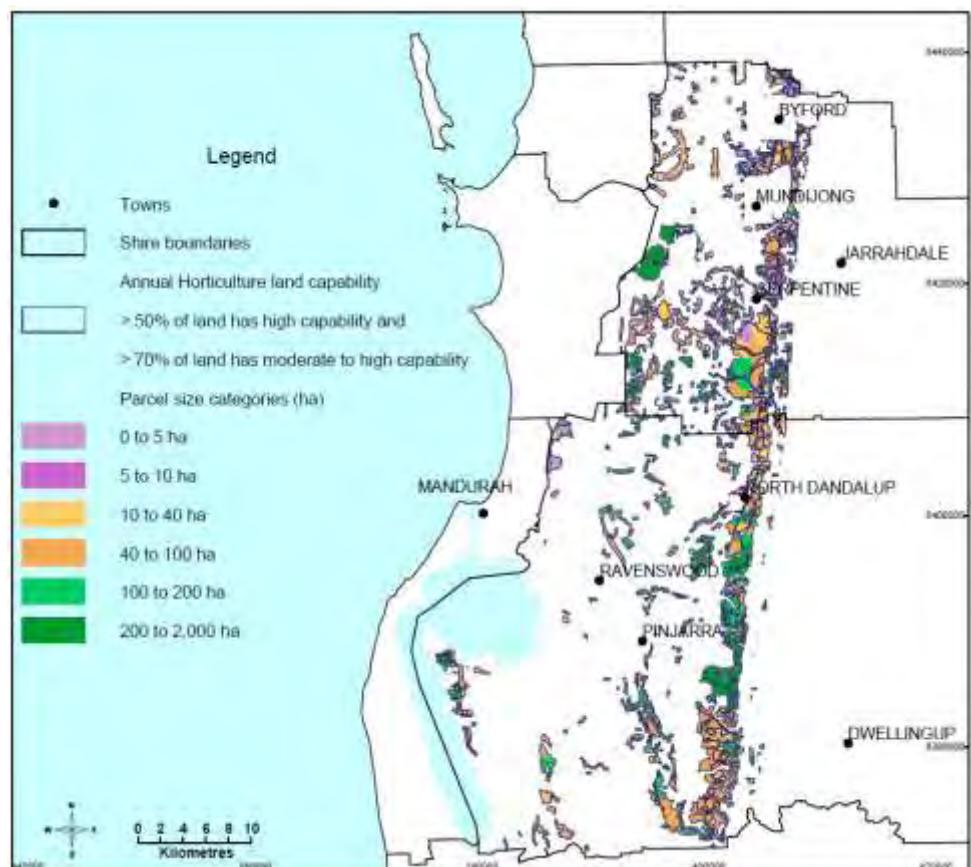


Figure 36 Lot size distribution on land with a moderate to high capability for annual horticulture

Potential rural land uses on the Palusplain

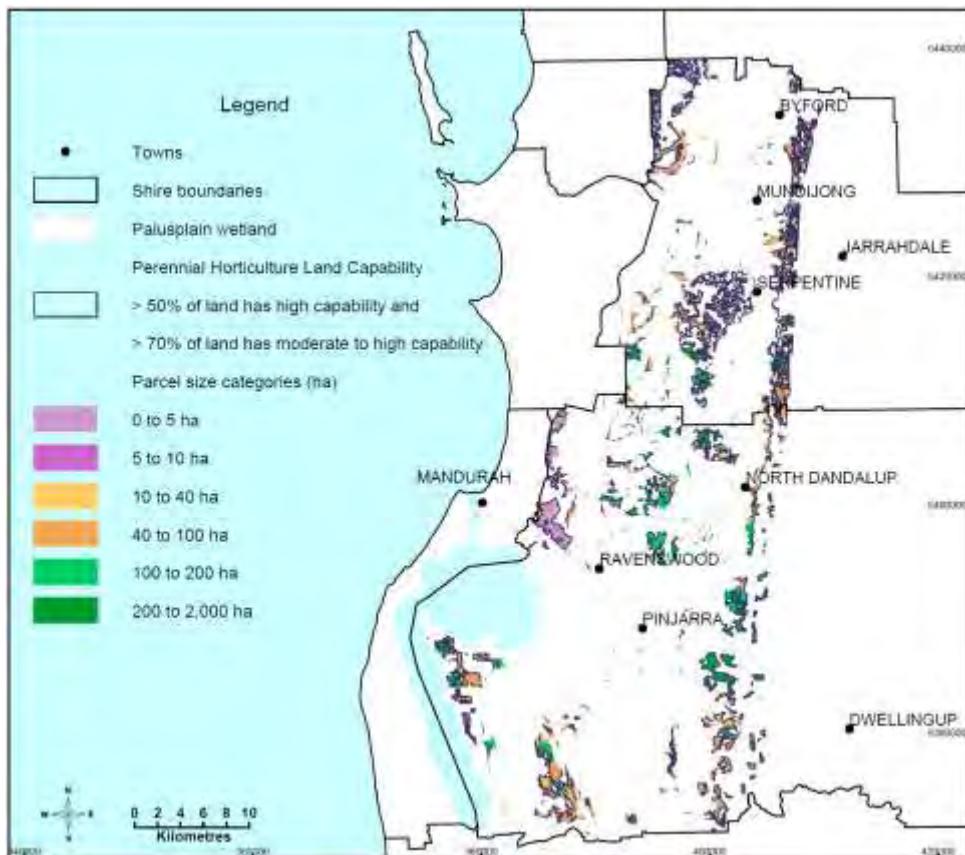


Figure 37 Lot size distribution on land with a moderate to high capability for perennial horticulture

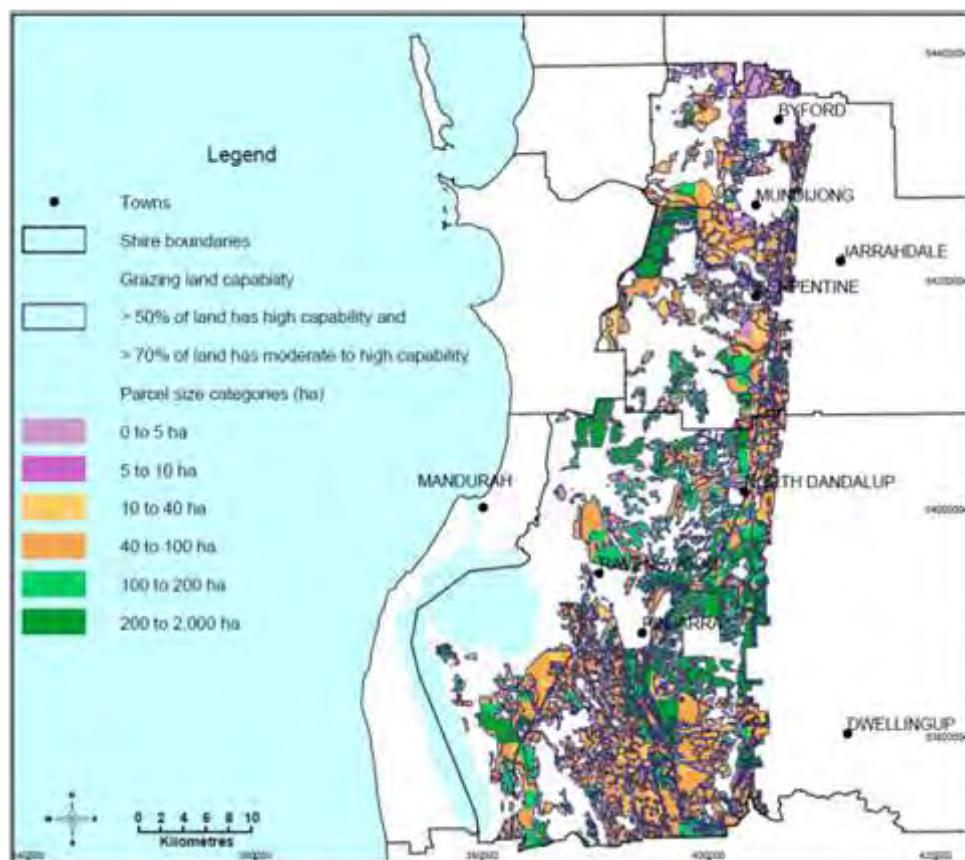


Figure 38 Lot (parcel) size distribution on land with a moderate to high capability for grazing

6.4 Pilot study for poultry

DAFWA is developing a spatial analysis tool to identify parcels of land suitable for intensive agricultural production (G. Doncon (DAFWA) 2010 pers. comm.). To test this methodology, a pilot study to identify sites suitable for a poultry hatchery was undertaken in the Serpentine–Jarrahdale and Murray Shires. Draft maps from this study highlight lots which may be suitable for a hatchery based on specific selection criteria (Figure 39). The maps indicate areas likely to be preferred but do not rule out other areas based on commercial and other considerations. Using different criteria may highlight different areas.

To generate these maps, each land parcel (lot) is assigned a set of attributes, such as distance to water mains, powerlines, towns and ports, which are determined by the requirements of the land use and through stakeholder consultation. The spatial tool can also incorporate exclusion zones, such as land precluded by legislation, industry specific guidelines and environmental guidelines, which were considered in the study; however, the study may not have included all factors required for a complete industry analysis and more detailed investigations are recommended.

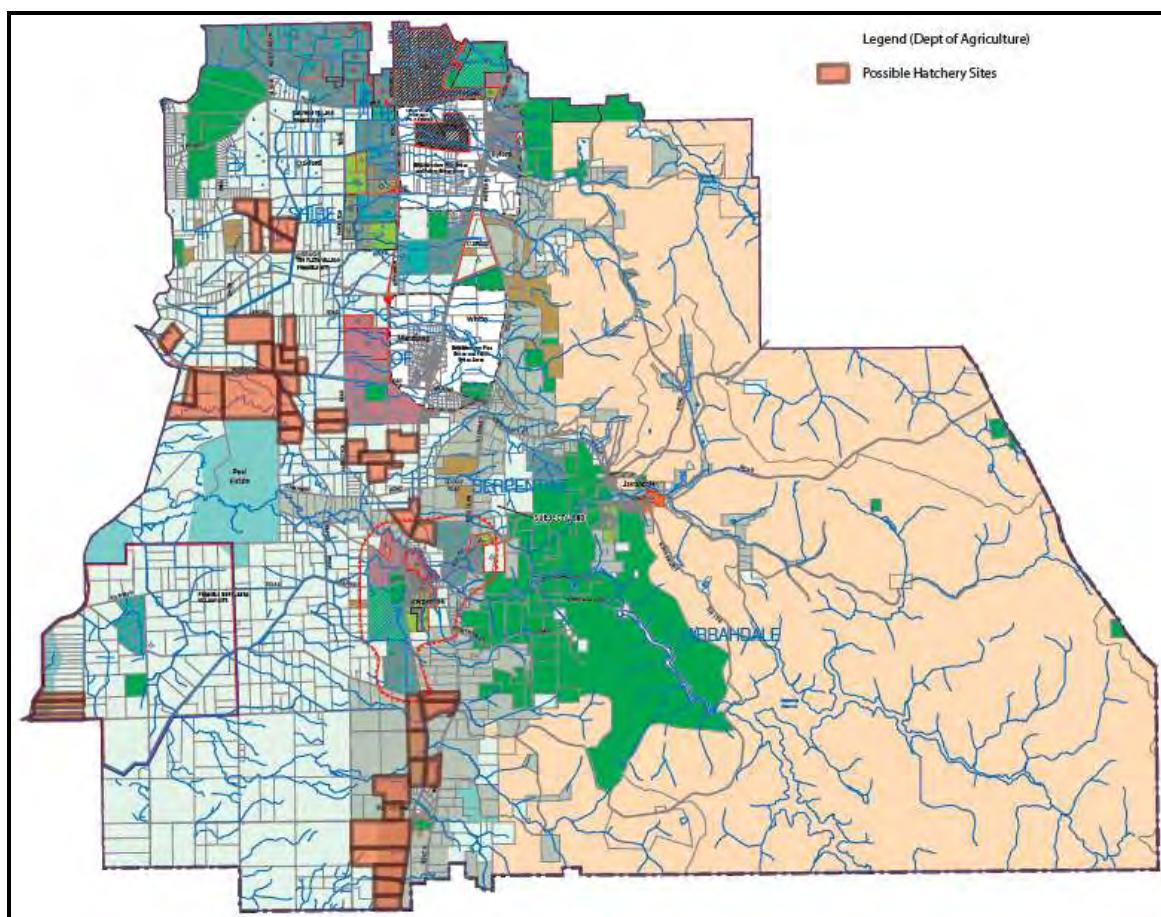


Figure 39 Possible poultry hatchery sites () for Serpentine–Jarrahdale Shire, overlaid on the rural strategy map

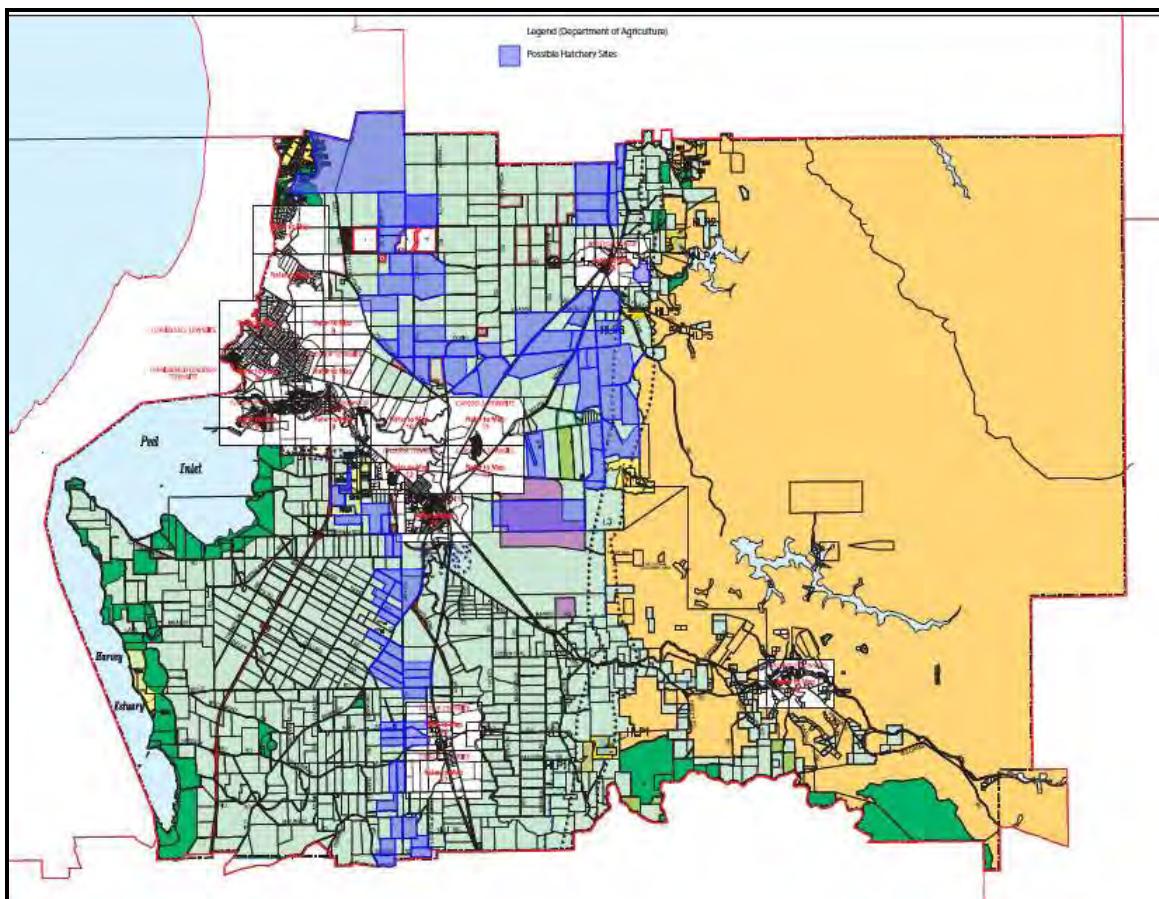


Figure 40 Possible poultry hatchery sites (■) for Murray Shire, overlaid on the town planning scheme map

6.5 Infrastructure requirements influencing industry location

The Palusplain has significant infrastructure advantages with three-phase power, natural gas and electricity transmission easements throughout the area, although some easements restrict land use potential (Figure 2). The availability of this infrastructure is an important consideration for potential agri-businesses.

Landholders consulted in the project reported that the road network, particularly the statutory limits on truck size on many roads, increases the cost of bringing in soil amendments, such as composts and bio-solids. The Murray Shire has withdrawn agreement for Class 2 and 3 Restricted Access Vehicles (all multi-trailer permit vehicles) to use the Old Bunbury Road, East Coolup Road and Burnside Road. The Serpentine–Jarrahdale Shire has withdrawn agreement for these vehicles to use Watkins Road and Mundijong Road between South Western Highway and Lightbody Road. Co-location of industries requiring large trucks could provide an economic incentive to upgrade the road network to those locations.

6.6 Planning for development hubs

Agricultural development hubs could be designed to encourage intensive, small landholder agricultural initiatives and closed-loop intensive agriculture, such as poultry and hydroponics, and agri-industry development.

A suggestion from the consultation was to locate hubs higher in the local landscape and/or in areas that can be built up through excavation of adjacent areas, which would require environmental approval. These hubs could be designed for compatible land uses with tight development controls. Such opportunities include:

- landholdings established around the concept of environmental repair
- collection of niche agricultural enterprises
- compatible agri-businesses, such as poultry, composting, mushrooms
- industrial uses requiring significant buffers.

Developing the concept will involve detailed landscape analysis to locate slightly higher areas where development can be focused to achieve both environmental and economic benefits. These areas may be built up by borrowing from surrounding lower areas which then become wetlands. These wetlands must be slow, flow-through systems so there is increased capacity for nutrients to be retained in situ but enough flow to prevent build-up of nutrients and resultant eutrophication.

It will be important to determine acid sulphate soil risk and not undertake activities that expose such soils to drying regimes (Figure 41). The elevation map and waterlogging map provide an indication of landform and areas of locally elevated ground available (Figure 42 and Figure 43, Table 6). However, a detailed study is needed to identify areas of locally higher elevation, which would be a significant project because the data is currently not in a suitable form and the analysis is complex.

6.7 Buffers and separation distances

Land use planning should ensure that land uses are not encouraged where they may sterilise agriculture and agri-industry operations in the future because of conflicts of land use. This project presents an opportunity for appropriate buffers for potential agricultural and co-located synergistic industries to be considered when planning. However, this project was not designed to undertake detailed zoning and therefore it is appropriate to refer to the *Guidance for the assessment of environmental factors Western Australia* (Environmental Protection Authority 2005).

Potential rural land uses on the Palusplain

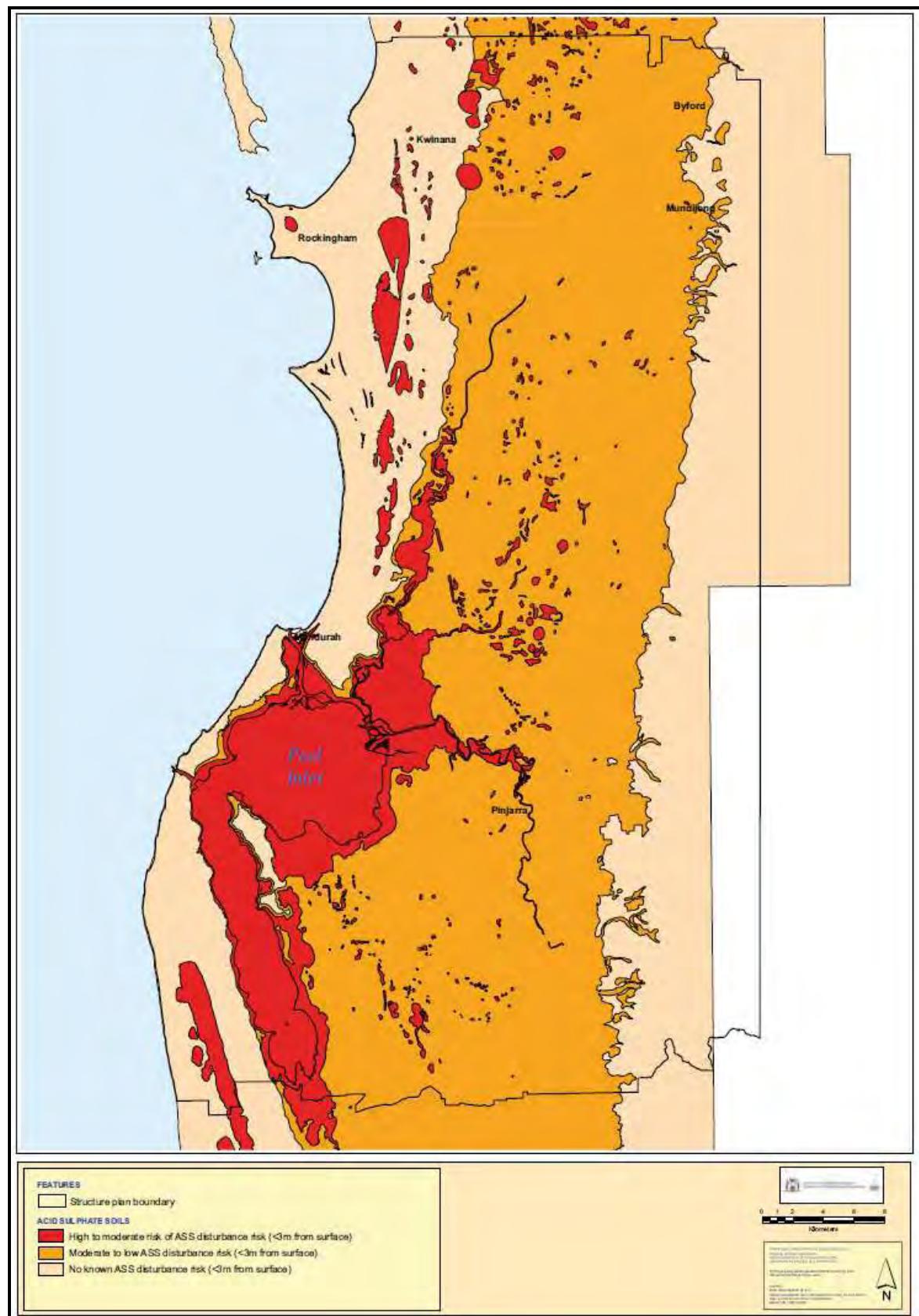


Figure 41 Risk of acid sulphate soils

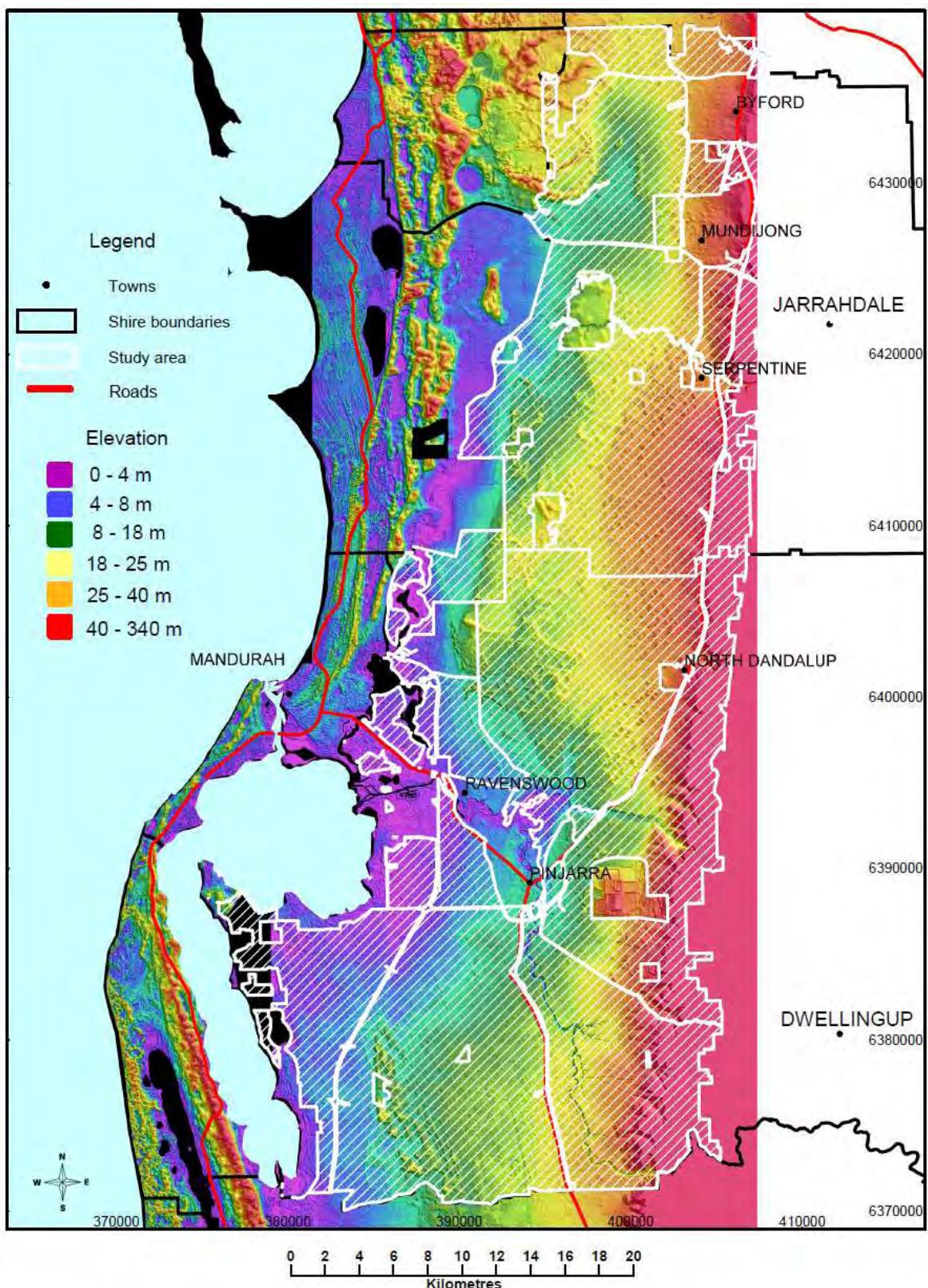


Figure 42 Elevation map

Potential rural land uses on the Palusplain

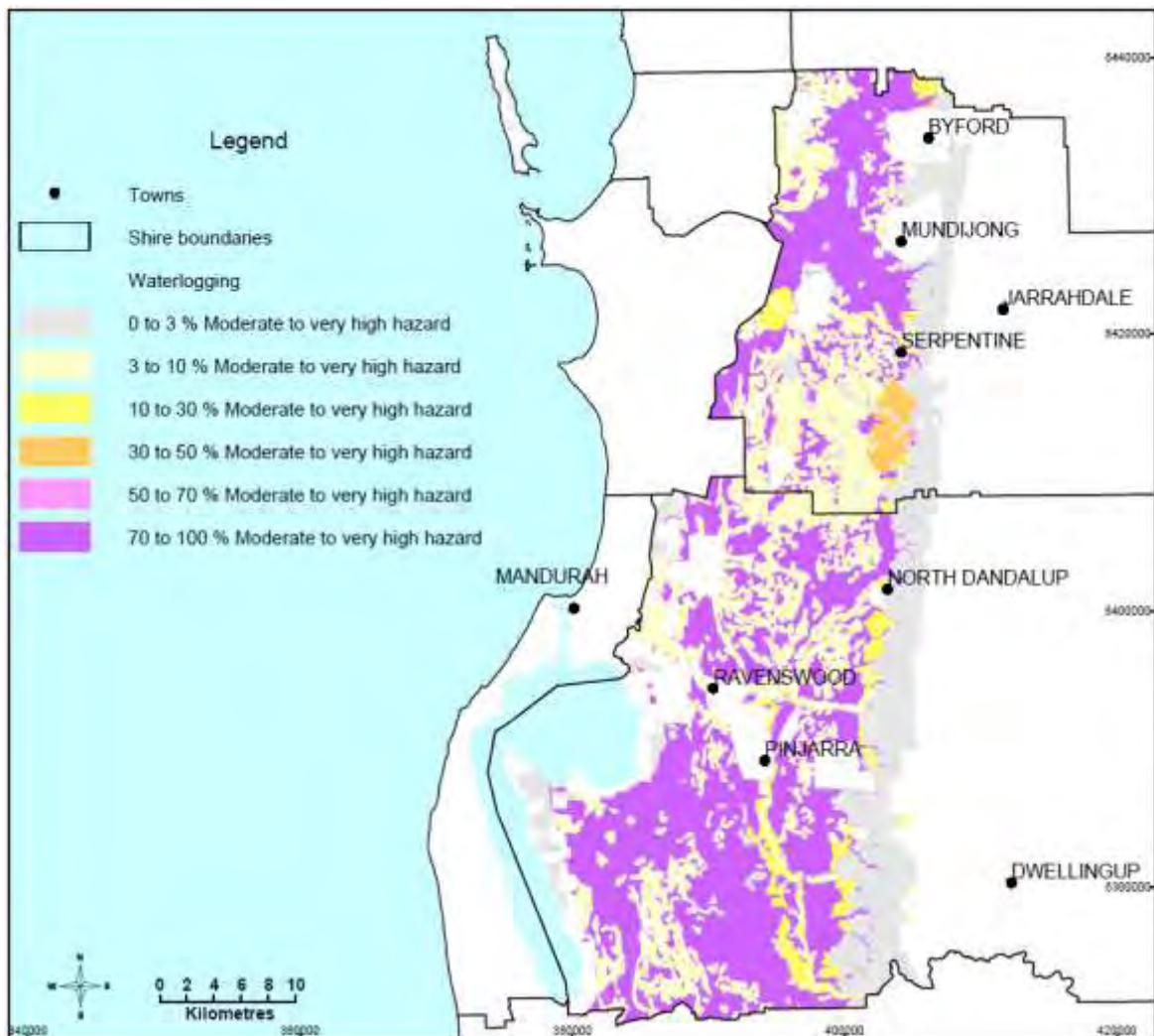


Figure 43 Waterlogging map

Table 6 Area (rounded to nearest 100 ha) of waterlogging hazard, related to Figure 43

Waterlogging hazard	Area (ha)
0–3% moderate to very high hazard	18 000
3–10% moderate to very high hazard	18 400
10–30% moderate to very high hazard	9 600
30–50% moderate to very high hazard	1 500
50–70% moderate to very high hazard	0
70–100% moderate to very high hazard	5 900

6.8 Findings from nutrient-sensitive, rural landscape planning

This project found that:

- If recycled water becomes available for agricultural use, there are prospects for expanding the Harvey Irrigation Scheme in the south and east of the study area because these areas have a combination of suitable land capability and large lot sizes.
- Under current management regimes, all soil-based agricultural and urban land uses contribute high levels of nutrients into the Palusplain wetland system. The widespread adoption of suitable soil amendments and other strategies to adsorb or export nutrients could reduce the nutrient impacts from agriculture.
- Areas with moderate to high capability for horticulture and grazing, and large lot sizes (100 ha or greater) should be considered for future agricultural and agri-business development. These are mainly located in the east of the study area.
- There is potential for locating agricultural development hubs on areas of higher ground or building areas of higher ground by excavating adjacent land which then become wetland systems. These areas could be developed for niche agricultural production with tourism-type activities and production for local markets encouraged. Retaining larger lots (40 ha or greater) is preferred to ensure that commercial and semi-commercial land uses locate here rather than lifestyle land uses.
- For a number of land uses, such as dairy, poultry and hydroponics, retaining large lot sizes and buffers is recommended to encourage these larger-scale operations.
- There is potential for agri-food processing operations to co-locate east of Mandurah where large lot sizes and suitable separation distances from urban development remain.

7. A way forward for the Palusplain

A community workshop was held on 13th May 2010, with about 50 attendees from a wide range of organisations including landholders, community groups, government, council and industry. The purpose of the workshop was to identify opportunities and barriers to continued agriculture and future rural land uses. The workshop created a vision for the Palusplain which is captured below and in Figure 44.

The Palusplain supports a strong, diversified and sustainable economy, as a food bowl for Perth, set in an environment that maximises biodiversity and nutrient retention and supported by clear, consistent integrated governance.

The key elements are:

- Governance—integrated government approaches based on clear, consistent and strategic policies.
- Environment—native vegetation retained and enhanced to maximise biodiversity complemented by waterways and wetlands designed to retain nutrients with more efficient grazing, focus on carbon retention and high integration of rural production and recycling.
- Social/cultural—the Palusplain is a food bowl for Perth based on organic and niche, gourmet, artisan, cooperative and diversified production with settlement and specific uses in hubs surrounded by productive and conservation lands.
- Economic—a strong, diversified and sustainable economy based on the comparative advantage of its agriculture, light industrial, bio-industry, agri-tourism, rural recreation and retirement land uses and employment opportunities.

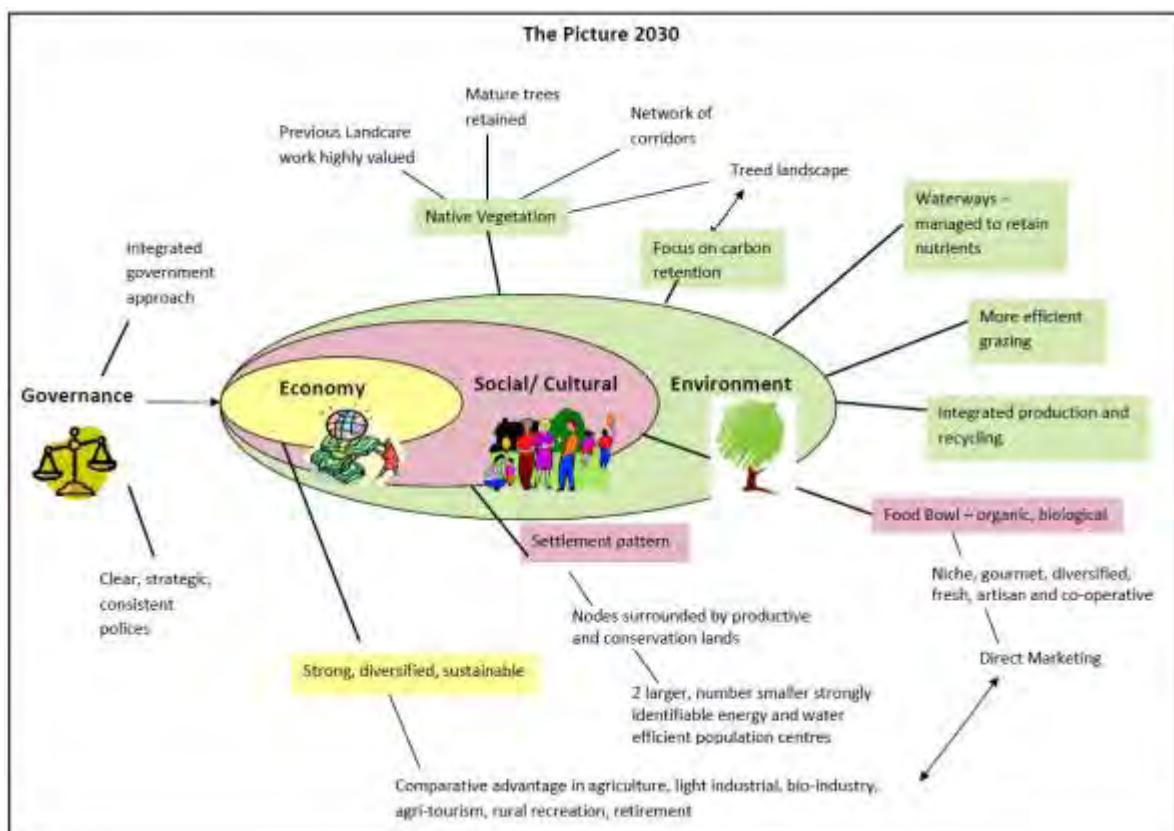


Figure 44 Key features of the vision for the Palusplain, created from the community workshop

Agriculture Western Australia (1998) outlined very similar thinking 13 years earlier:

Socially relevant agriculture in the urban fringe needs a different look and feel to become attractive as an amenity. It's more a day trip feel – a cross between an open market and a farm visit. So you need roadside vendors selling vegies, organics, flowers which can come from an integrated, village-feel agricultural system – mixed with amenities like farm visits with some participation and rural flavour refreshment places, etc. Demonstration trailing a mini system in Peel would be good ("Peel off the city and spend the day in the Peel").

The community workshop suggested ways to achieve the vision (Figure 45). The key features are:

- Governance—to be based on whole of government and community long-term strategic planning with integrated policies covering economic, nutrients and production.
- Environment—it will be important to appreciate climate change and enhance the natural assets with land uses and drainage managed for minimising nutrient export through using nutrient-adsorbing residues and waste water removed from the system for reuse.
- Social/cultural—create a strong awareness of the region, climate change and appreciation for local food with local branding, farmers markets and food tours set in an environment where wetlands and natural vegetation surround hubs of settlement and agri-business.
- Economic—world's best practice in agriculture is achieved through research and nutrient management with shorter supply chains achieved through farmers markets and related initiatives, supported by local branding and food trading, supported by the carbon economy.

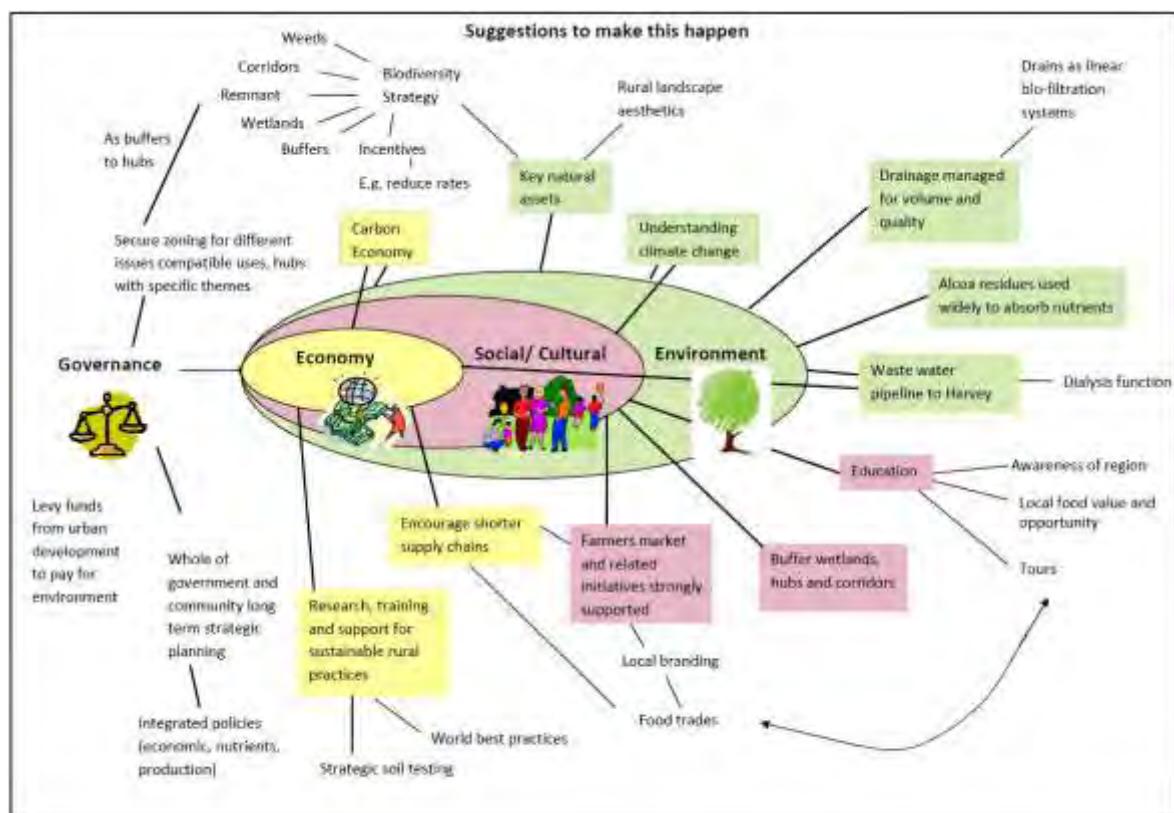


Figure 45 Suggestions from the community workshop for ways to achieve the vision for the Palusplain

8. Conclusions and ways forward

The vision developed through the community consultation in this project seeks to increase agricultural production and diversity while balancing environmental values. Land in the study area is under increasing pressure from growing populations and economies for more intensive development. The following is a summary of existing and potential land uses:

Livestock systems—Beef grazing is currently only marginally profitable for many growers and a high overall nutrient exporter. It is unlikely that known profitable beef farming systems will be adopted under a regime of lifestyle farmers and investors holding much of the land, with high land prices and generally small parcel sizes. Dairying is profitable with local markets but is a significant localised source of nutrient. Land prices and cost of conversion may be prohibitive for establishing profitable lamb enterprises. There could be potential for some niche goat and specialist species enterprises. For land-based agriculture to be sustainable, soil amendments are required to improve the soils and balance nutrient inputs.

Closed-loop agricultural systems, like poultry, have further potential and land has been identified for possible hatchery sites. Glasshouse and hydroponic closed-loop, intensive horticultural systems have the advantage of being located close to markets and infrastructure, but uncertain water supplies (quality and quantity) and frost and summer heat may limit establishment.

Intensive horticulture has potential in the east of the study area if alternative water supplies, such as recycled waste water, become available. This potential could replace some of the production lost in the Perth metropolitan region's Wanneroo Shire because of urban development. Even with best practice nutrient management, intensive soils-based, horticultural systems are high, net nutrient exporters and need to be located well away from sensitive land uses and water bodies.

Nutrient-sensitive spatial planning on the Palusplain has the potential to:

- use planning mechanisms to retain large lot sizes to encourage ongoing commercial agricultural use and provide opportunities for closed-loop intensive land uses and agri-food processing
- use planning mechanisms to provide the conditions that encourage land uses that have low, nutrient export potential
- apply conditions to development approvals that ensure that appropriate soil amendments are used so that there is a net reduction in nutrient export compared with the previous land use
- ensure that capacity is made available to provide funding for long-term monitoring of each development through a development contribution scheme
- support land use zoning that encourages redesign of the landscape to reduce nutrient export
- support remaining agricultural activities to achieve best practice nutrient management.

Mechanisms that improve income derived from agriculture, such as direct marketing (for example, farmers markets), value-adding and co-location of synergistic industries, will be important to provide landholders with increased capacity to manage nutrients.

This project has highlighted several opportunities for improving management of agricultural systems to reduce nutrient export:

- Phosphorus-fixing soil amendments, such as red mud, need to be approved for general use within the catchment.
- Planning and drainage management must encourage retention of water in the landscape to maximise nutrient use/retention.
- Monitoring of nutrient export is required as soil amendments will need to be replaced on a regular, possibly 20-year, cycle.
- Closed-loop agricultural systems, such as poultry and hydroponic/glasshouse horticultural systems, should be encouraged because they have lower nutrient export.
- High, point source nutrient loads, such as from feedlots, need to be managed at all scales of production.
- Development hubs on locally higher ground surrounded by wetlands may be suitable for closed-loop agricultural systems and small landholdings for niche production.
- A waste water/recycled water pipeline has the potential to provide an additional water supply that will allow the area of horticulture production to be expanded on suitable soils away from the Peel–Harvey Estuarine System.
- Agricultural hubs are required to have adequate buffers for co-locating complementary agri-food processing, such as Wandalup Piggery and Custom Composts.
- Water drainage practices that retain water for summer, as well as manage high rainfall periods and events, should be implemented.

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Appendix A State and regional planning context

The policy setting for planning in the Peel Region supports retaining the Palusplain study area for rural land uses. A number of state policies guide the local planning strategies, which govern land uses including rural zoned land, of the Serpentine–Jarrahdale and Murray Shires. This project provides information that will contribute to future revisions of these local strategies.

State Planning Strategy

The State Planning Strategy provides the basis for long-term state and regional land use planning, outlining the key principles which underpin the State Planning Framework including principles relating to the environment, community, economy, infrastructure and regional development (Western Australian Planning Commission 1997). The strategy includes the following vision for the Peel region:

In the next three decades the Peel region will continue to grow, with Mandurah being the major residential and commercial area. A series of lifestyle-based rural villages and development areas will be established. Emphasis will be placed on containing urbanisation, protecting estuarine and coastal areas and preserving the rural backdrop and environmental attributes to cater for lifestyle choices. The local economy will provide a range of employment opportunities for the expanded population, with significant areas of resource processing, mining, tourism, sustainable agriculture and other service industries. Peel will have strong and efficient inter-regional transport links, especially to the Perth and South-West regions.

Key strategies and actions arising from this strategy that are relevant to the study area are:

- identify and protect prime agricultural land, suitable for intensive and/or irrigated uses
- protect prime agricultural areas from rural residential uses
- manage the Peel–Harvey catchment to reduce nutrient levels.

Directions 2031 and Beyond

‘Directions 2031 and Beyond’ establishes a vision for the future growth of the Perth and Peel region, and provides a spatial framework to guide the detailed planning and delivery of housing, infrastructure and services necessary to accommodate the predicted growth (Western Australian Planning Commission 2010).

The study area contains the Peel and South East sub-regional planning area, as identified within Directions 2031. Key issues within Directions 2031 that are relevant to the agricultural land use in the study area are:

- South Western Highway—any future development along the South Western Highway will need to be carefully planned and managed to ensure that it does not compromise the regional transport function of this route.
- Landscape protection and urban design—there are a number of landscape protection and urban design issues that must be considered in future development in the sub-region, including natural landform and visual amenity, transit-orientated development opportunities, energy and water efficient design of urban areas, and any potential impact from sea level rise.
- Biodiversity—the environmental integrity of the Palusplain is critical to the long-term biodiversity of the region as it drains into the Peel–Harvey Estuarine System. While the area is still largely rural, proper management and planning is essential to ensure that the impacts from agriculture and urban activities are minimised.

*State policy***Statement of Planning Policy 2.1 Peel–Harvey Coastal Plain Catchment**

SPP 2.1 was prepared in response to the requirements of the Minister for the Environment, in consultation with the Minister for Planning, to ensure that land use changes within the Peel–Harvey catchment do not cause environmental damage to the estuary. The policy applies to all residential, commercial, industrial, rural and recreational land uses that fall within the portion of the Peel–Harvey catchment that lies on the Swan Coastal Plan.

The specific objectives in the SPP 2.1 which are relevant to agriculture are to:

- improve the social, economic, ecological, aesthetic and recreational potential of the Peel–Harvey Coastal Plain Catchment
- ensure that changes to land use within the catchment of the Peel–Harvey Estuarine System are controlled so as to avoid or minimise environmental damage
- balance environmental protection with the economic viability of the primary sector
- increase high water-using vegetation cover within the catchment
- reflect the environmental objectives in the Draft Environmental Protection Policy (Peel–Harvey Estuarine System) 1992
- prevent land uses likely to result in excessive nutrient export into the drainage system.

The provisions in SPP 2.1 are designed to ensure that the health of the Peel–Harvey Estuarine System is not adversely impacted by unsuitable land uses. The challenge is to achieve these environmental objectives whilst supporting innovations in agricultural activities.

It is important that all future land use changes meet the requirements of SPP 2.1 and that nutrient export can be managed not just as a condition of development but that controls can be maintained and enforced in the long-term.

Statement of Planning Policy 2.4 Basic Raw Materials

SPP 2.4 seeks to protect deposits of basic raw materials (including sand, clay, hard rock, limestone and gravel) from sterilisation through avoiding sensitive developments close to the resource. The protection of basic raw materials within close proximity to developing parts of the metropolitan region, is essential in keeping down the costs of land development and contributing to affordable housing, through the avoidance of excessive transport costs.

Statement of Planning Policy 2.5 Agricultural and Rural Land Use Planning

SPP 2.5 seeks to protect productive agricultural land from developments that may lead to its alienation or diminished productivity, whilst accepting the need for land for expanding urban areas and other uses of state significance.

Portions of the study area outside the Palusplain wetland were identified as potential development areas subject to additional and detailed investigation within the policy.

Statement of Planning Policy 2.9 Water Resources

SPP 2.9 provides guidance for the consideration of water resources in land use planning processes. There are a number of waterways, wetlands and water source protection areas within the study area.

Development Control Policy 3.4 Subdivision of Rural Land

DC 3.4 provides additional guiding principles for subdivision of rural land in order to achieve the key objectives of SPP 2.5. The policy specifies that the subdivision of rural and agricultural land for closer settlement (rural-residential and rural smallholdings) and more intensive agricultural uses should be properly planned through the preparation of regional and local planning strategies and provided for in local planning schemes prior to subdivision.

Region schemes

Under the Metropolitan Region Scheme and the Peel Region Scheme, the majority of the study area is zoned 'rural'. The purpose of the rural zone is 'to provide for the sustainable use of land for agriculture, assist in the conservation and wise use of natural resources including water, flora, fauna and minerals, provide a distinctive rural landscape setting for the urban areas and accommodate carefully planned rural living developments'.

Appendix B Soils of the Palusplain

The Swan Coastal Plain, which extends from Dongara to Busselton, has been formed from depositional material either from fluviaatile or aeolian activity (Hill et al. 1996). The Ridge Hill Shelf is a series of laterite covered spurs at the foot of Darling Scarp. The flat Pinjarra Plain is composed of alluvia of various ages. Moving west there is a series of sand dunes starting with the Bassendean, followed by Spearwood and then Quindalup Dune System near the coastline (McArthur 2004).

There are two main soil-landscape systems—Pinjarra Plain and Bassendean Dunes—and a number of smaller ones (Table B1). A soil-landscape system can be further broken down into soil groups (Table B2) (Schoknecht 2005). Table B3 shows some of the soil profiles found in the Serpentine–Jarrahdale and Murray Shires.

Table B1 Soil-landscape systems area for the agriculture zone

Soil-landscape System	Area (ha)
Pinjarra Plain	49 700
Bassendean Dunes	35 500
Forrestfield	10 800
Murray Valleys	7 600
Vasse System	1 700
Spearwood Dunes	1 100
Darling Plateau	300
Total	106 700

Table B2 Soil groups for the Murray and Serpentine–Jarrahdale Shires' agricultural zone (Schoknecht 2005)

Murray Shire		Serpentine–Jarrahdale Shire	
Soil group	Area (ha)	Soil group	Area (ha)
Semi-wet soils	19 200	Pale sands	8 400
Pale sands	14 700	Semi-wet soils	7 600
Deep sandy duplexes	5 400	Gravels	2 900
Shallow sandy duplexes	4 600	Clays and shallow loamy duplexes	1 800
Gravels	3 600	Deep loamy duplexes and earths	1 800
Clays and shallow loamy duplexes	2 900	Shallow sandy duplexes	1 600
Wet soils	2 500	Wet soils	1 500
Deep loamy duplexes and earths	2 200	Deep sandy duplexes	1 200
Saline	2 100	Saline	700
Coloured sands to sandy earths	1 300	Shallow and stony soils	600
Shallow and stony soils	1 100	Coloured sands to sandy earths	400
Bare rock	400	No information	200
No information	200	Bare rock	100

Table B3 Examples of soil profiles in the Serpentine–Jarrahdale and Murray Shires



Pale deep sand



Friable red/brown deep sandy duplex



Grey shallow sandy duplex



Duplex sandy gravel



Yellow/brown shallow loamy duplex



Brown loamy earth