



Report card on sustainable natural resource use in agriculture

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

Supporting your success

Nutrient export (phosphorus)

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3 Baron-Hay Court South Perth WA 6151

Tel: (08) 9368 3333 Email: enquiries@agric.wa.gov.au

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Cover photo: Harvesting the wheat crop at Mingenew.

2.9 Nutrient export (phosphorus)

Key messages

Condition and trend

- While phosphorus (P) is a critical plant nutrient for profitable agriculture, its export in surface water run-off or leaching accelerates eutrophication in waterways.
- The export of nutrients used in agriculture was assessed as high to very high hazard for most of the coastal catchments.
- Algal blooms caused by excessive nutrients and organic matter in waterways are the major cause of fish kills and seagrass losses in rivers and estuaries across the south-west of WA.

Management implications

- A range of factors influence P export from agriculture, including fertiliser application method, storage, timing of application, rate applied and source, soil type and texture, slope, paddock fertility, connectivity to drainage, irrigation management, manure disposal and potential for erosion.
- Management practices that can reduce P export from paddocks include:
 - amending soils to increase low P retention capacity
 - using soil testing to inform decisions on fertiliser application rates
 - using perennial pastures to increase water and nutrient uptake and decreased erosion
 - accurately placing fertiliser
 - having fertiliser-free buffer zones close to waterways
 - using appropriate fertiliser for the soil type and the plant requirements
 - improving irrigation efficiency – replace flood with central pivot irrigation, recycle nutrients within irrigation systems
 - improving livestock management around feedlots and dairy sheds, and using effluent to offset nutrient inputs
 - licensing of agricultural point sources of nutrient discharge into catchment/estuarine systems
 - protecting and revegetating wetlands and waterways
 - adopting agricultural best management practices.

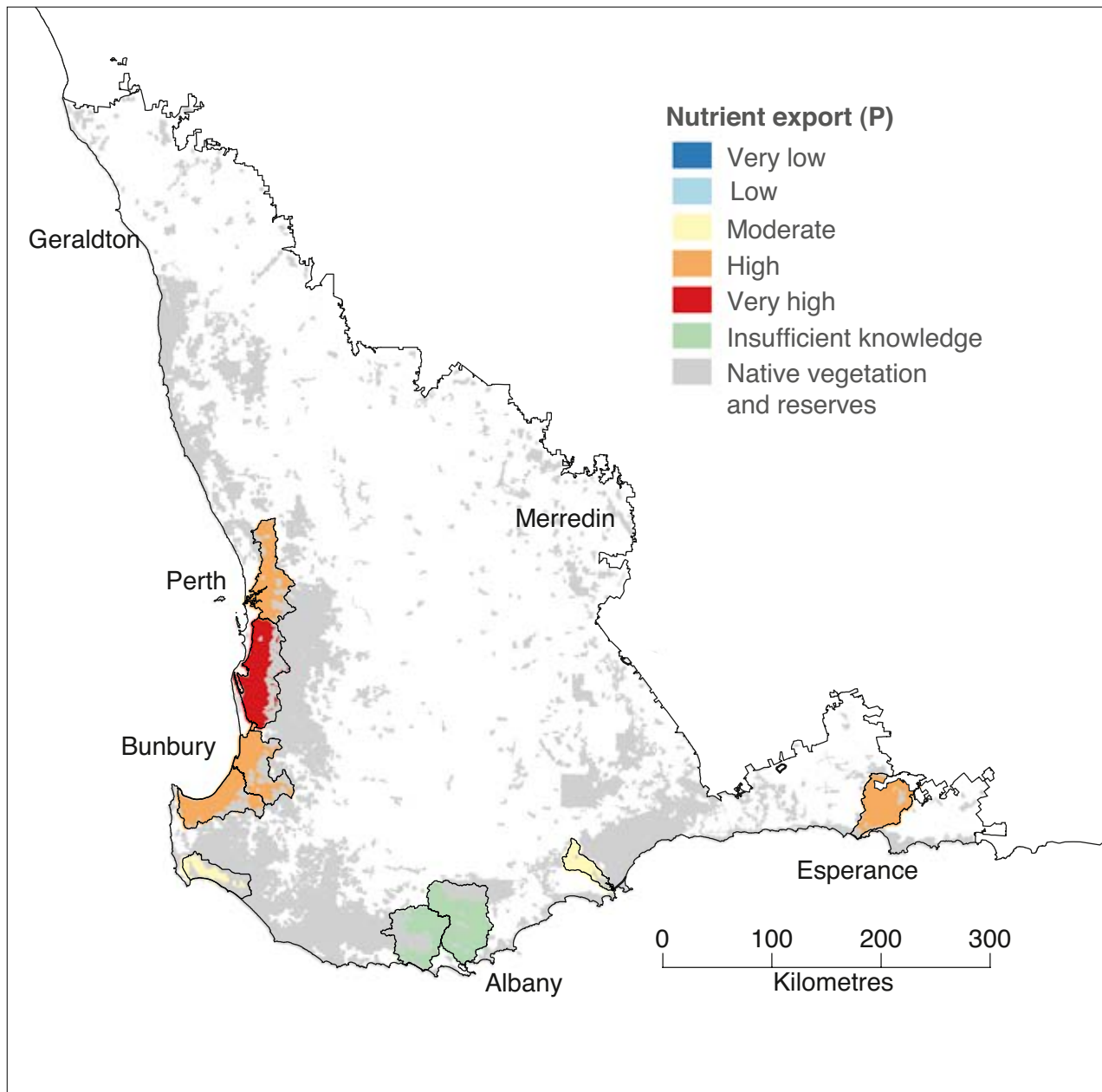


Figure 2.9.1 Resource hazard summary for nutrient export (P) in selected catchments.

Table 2.9.1 Resource status and trend summary of nutrient export (P) in selected catchments

Catchment/system	Summary	Hazard and trend					Confidence	
		Very high	High	Mod	Low	Very low	In risk impact of agriculture	In trend
1 Swan–Canning System	The main sources of nutrients are agriculture, predominantly from cattle grazing in the Ellenbrook sub-catchment, and urbanisation.							
2 Peel–Harvey System	The main source of P is agriculture, particularly from broadacre dryland grazing of cattle. The estuary condition has improved with the construction of the Dawesville Channel; however, algal blooms and fish kills now occur in the lower reaches of major rivers.							
3 Leschenault Catchment	The main nutrient losses originate from diffuse sources, including broadacre beef and dairy grazing and dairy sheds near streams. All monitored sites in the estuary and catchment exceed target levels.							
4 Vasse–Geographe Catchment	Most of the nutrient loads come from broadacre grazing of beef and dairy cattle. Upstream tributaries and wetlands have poor water quality.							
5 Scott River Catchment	Agricultural land use is changing from dryland grazing to more intense irrigated dairy enterprises, resulting in an increasing nutrient impact.							
6 Wilson Inlet Catchment	The main diffuse sources of nutrients are beef and sheep grazing with broadacre cropping. Phosphorus concentrations in tributaries are increasing.	Insufficient data for full assessment						
7 Oyster Harbour Catchment	Most of the nutrient loads come from diffuse agricultural sources in higher rainfall areas supporting grazing enterprises.	Insufficient data for full assessment						
8 Bremer Catchment	Most of the nutrient loads come from broadacre grazing and cropping.							
9 Lake Warden Catchment	Most of the nutrient loads come from diffuse agricultural sources, particularly broadacre grazing and cropping enterprises, and some farm forestry practices.							

Hazard grades	Nutrient export hazard grades matrix						Recent trends	Confidence
	Agricultural contribution to P load	Significance of phosphorous load (P load above target)						
Very low							Improving	Adequate high-quality evidence and high level of consensus
Low								
Moderate	>75%	Moderate	Moderate	High	Very high	Very high	Stable	Limited evidence or limited consensus
High	50–75%	Low	Moderate	Moderate	High	High		
Very high	25–50%	Low	Low	Moderate	High	High	Variable	Evidence and consensus too low to make an assessment
	<25%	Very low	Low	Low	Moderate	Moderate		

Overview

This chapter assesses the phosphorus (P) export from agriculture across nine coastal plain catchments, covering 27 600 km² (2.76 million hectares) of the south-west of WA. Plant nutrients are required for productive agriculture; however, on the predominantly sandy soils of these nine catchments, there is significant risk that excess P will be exported to rivers and estuaries downstream.

Sources of P from agriculture can be broadly classified as diffuse (coming from a wide area) or point (localised discharge, such as from a pipe) and include:

- broadacre grazing on fertilised pasture land (cattle and sheep)
- cropping on arable land
- intensive livestock industries (dairies, feedlots and stock holding yards, piggeries, poultry farms)
- orchards and intensive horticulture.

Export of P from agriculture, urban and industrial sources has contributed to nutrient enrichment of streams, rivers and estuaries, resulting in water quality problems (eutrophication), such as algal blooms, occasional fish kills, odours from decaying algae, and potential accumulation of toxins in shellfish.

Water quality improvements plans (WQIPs) have assessed and modelled the magnitude of P from different sources and suggested ways to reduce nutrient export.

The export of P from agriculture is assessed qualitatively by combining the relative magnitude of agriculture's contribution, and the magnitude of the over-supply of P to waterways.

The coastal soils have a low capacity to retain nutrients. Any land clearing for productive agriculture increases nutrient run-off (Brearley 2005). Nitrogen and P are exported in solution or bound to soil particles in surface run-off from clay soils and both surface and sub-surface flow

(leaching) in sandy soils, when saturated with water (Summers et al. 1999). Soluble P is more likely to be exported from sandy soils through leaching and run-off and from clay soils in run-off when the soil surface is saturated with P.

Increased rainfall increases nutrient export. On the other hand, reduced rainfall magnifies the impact of lost nutrients because it results in modified catchment hydrology. Winter river flows have generally decreased in recent years, reducing the amount of nutrients and organic matter flushed out to the ocean. Instead they accumulate in the sediments of waterways. In summer, saline water moves further upstream, often remobilising nutrients stored in the sediment.

Summer storms may become more frequent in the future. These stimulate nutrient export and re-suspend stored nutrients during periods of warm temperatures, further exacerbating the potential to create algal blooms (Giller and Malmqvist 1998; Chuwen et al. 2009).

Assessment method

This chapter reports on the hazard of P being exported from agriculture within specified catchments, which may affect the condition of waterways and water bodies lower in the catchment (Figure 2.9.2). It does not report directly on the condition of the waterways and water bodies – this information is reported elsewhere in WQIPs and other published sources.

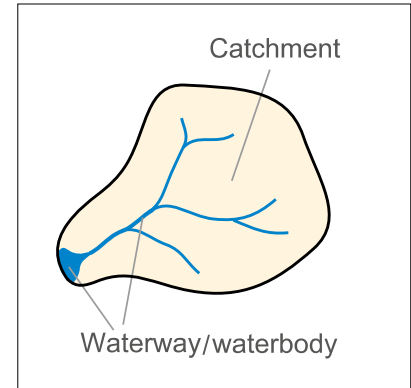


Figure 2.9.2 The spatial relationship between the hazard of nutrient export in the catchment and the waterways and water bodies that may be affected.

For this assessment, P has been used as a key indicator of nutrient export in the catchment. The data from the WQIPs and other published sources were used to determine the:

- percentage of exported P contributed by agriculture in each of the catchments
- significance of this P contribution to the downstream environment
- condition of the catchment in terms of current and target P loads.

A matrix integrating the contribution from agriculture and the significance of this contribution was used to qualitatively assess the hazard of P export (Table 2.9.2).

Table 2.9.2 Matrix to determine hazard grades for P export

Agricultural contribution to P load	Significance of P load (P load above target)				
	Very low (<30%)	Low (30–60%)	Moderate (60–90%)	High (90–120%)	Very high (>120%)
>75%	Moderate	High	High	Very high	Very high
50–75%	Low	Moderate	High	High	High
25–50%	Low	Low	Moderate	High	High
<25%	Very low	Low	Low	Moderate	High

A case study of the Peel–Harvey catchment (below) outlines the data, analysis and interpretation of various agricultural sources of P.

Status and trend

Agriculture’s contribution to P input into the catchments examined, ranges from 45 to 99%. While the catchments with predominantly agricultural land use provide the highest percentage contribution to the P load, the quantity of P is also an important consideration. The highest percentage contribution occurs in the Lake Warden Catchment because broadacre farming is the dominant land use. Catchments in more populated areas (e.g. Swan–Canning, Peel–Harvey, Leschenault and Vasse–Geographe) are receiving an increased contribution from urban sources (Figure 2.9.3).

Excessive P load is common across all of the catchments on the Swan Coastal Plain where agriculture is dominant (Table 2.9.3). However, assessment of the Swan–Canning System demonstrates that even where agriculture is not the dominant contributor of P, the significance of the P load is still high.

Nutrient audits have also shown that the conversion of agriculture to urbanisation leads to increased nutrient inputs. All of the coastal catchments have both intensifying agricultural practices and areas of increasing urbanisation. Therefore, future changes in land use changes should incorporate best practice water quality management.

Figure 2.9.3 Phosphorus export risk and source separation.

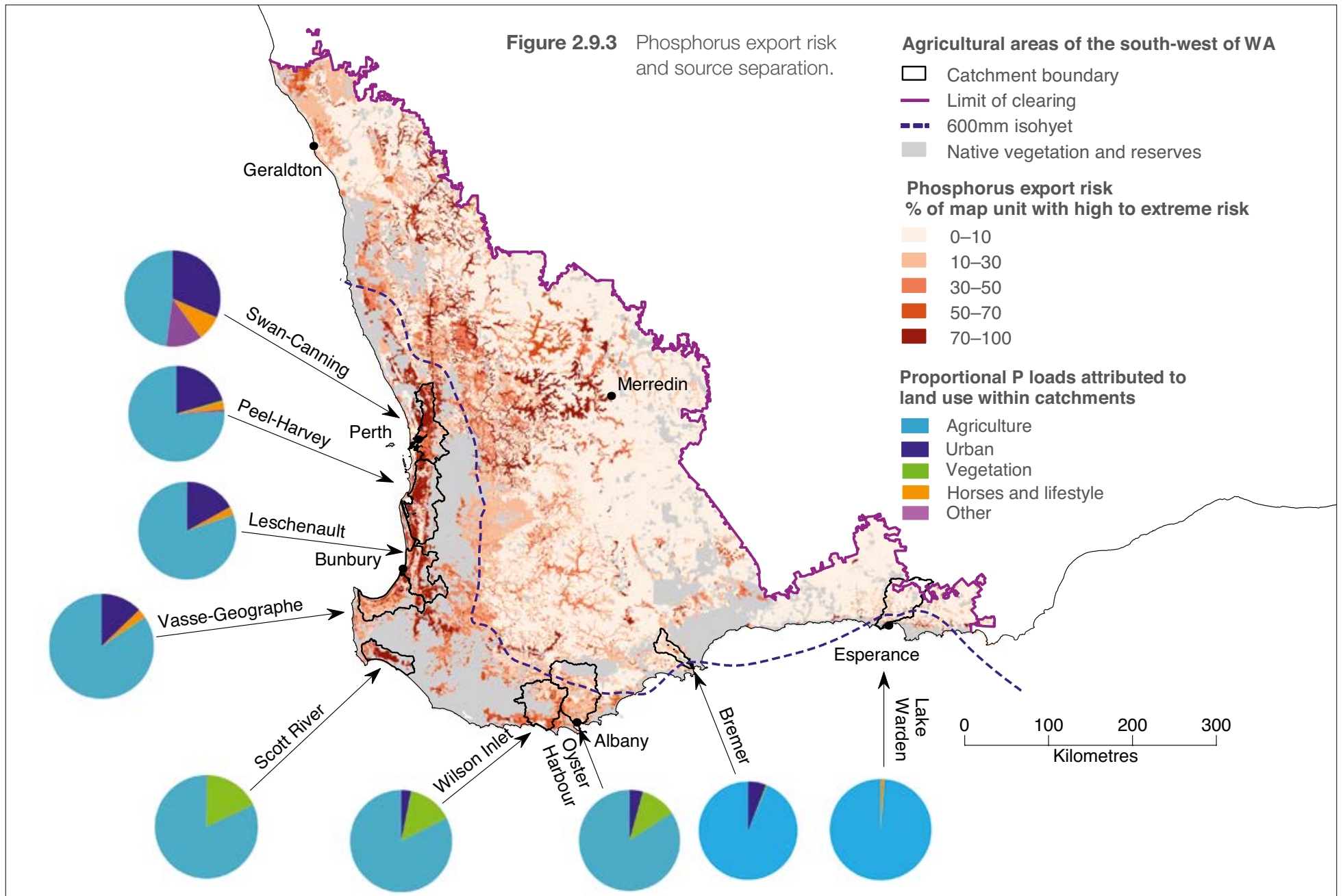


Table 2.9.3 Phosphorus significance (loads) and agricultural P source

Catchment	Catchment area (km ²)	Current P load (t/year)	Target P (t/year)	% P over target*	Agricultural P source (%)					
					Beef/sheep	Cropping	Dairy	Horticulture	Other	Total (%)
Swan–Canning System	2 090	26	12	117	33	–	–	11	1	45
Peel–Harvey System	11 930	145	75	93	50	2.7	10.1	13.6	6.8	82.7
Leschenault Catchment	1 981	27.8	10.7	160	43	–	31	0.7	–	74.7
Vasse–Geographe Catchment	2 000	53	20	165	32	–	25.4	5.7	<1	63
Scott River Catchment	700	11	8	38	33	–	45	–	<1	84
Wilson Inlet Catchment	2 379	13	–	–	60	–	11	10	2	82
Oyster Harbour Catchment	3 780	23	–	–	67	2	4	–	11	84
Bremer Catchment	680	1.2	0.95	26	94.4	–	–	–	–	94.4
Lake Warden Catchment	2 132	2.6	1.4	86	49	51	–	–	–	99

* % P over target = (current P load – target P = P in excess divided by target P)

Notes: Data for the Swan–Canning and Peel–Harvey systems, and Leschenault, Scott River and Wilson Inlet catchments were obtained from their current water quality improvement plans.

Data for the Oyster Harbour Catchment was obtained from Master (2007).

Data for the Lake Warden Catchment was obtained from DAFWA (2009).

Data for the Bremer Catchment was obtained from DAFWA (2008).

Discussion and implications

Phosphorus is an essential element for plant and animal growth and many of WA's agricultural soils were originally amongst the most P deficient in the world (see Chapter 2.8). While P is critical for profitable agriculture, its export through surface water run-off and leaching increases the chance of algal blooms in receiving water bodies. In addition, organic matter flowing from the landscape to receiving water bodies depletes dissolved oxygen during decomposition. These two factors increase the likelihood of water quality problems. The degree of impact depends on characteristics of both the source and transport. Some of these source and transport factors can be managed to reduce the risk of export (Figure 2.9.4), while others are inherent to the landscape or the environment and are beyond the control of land managers.

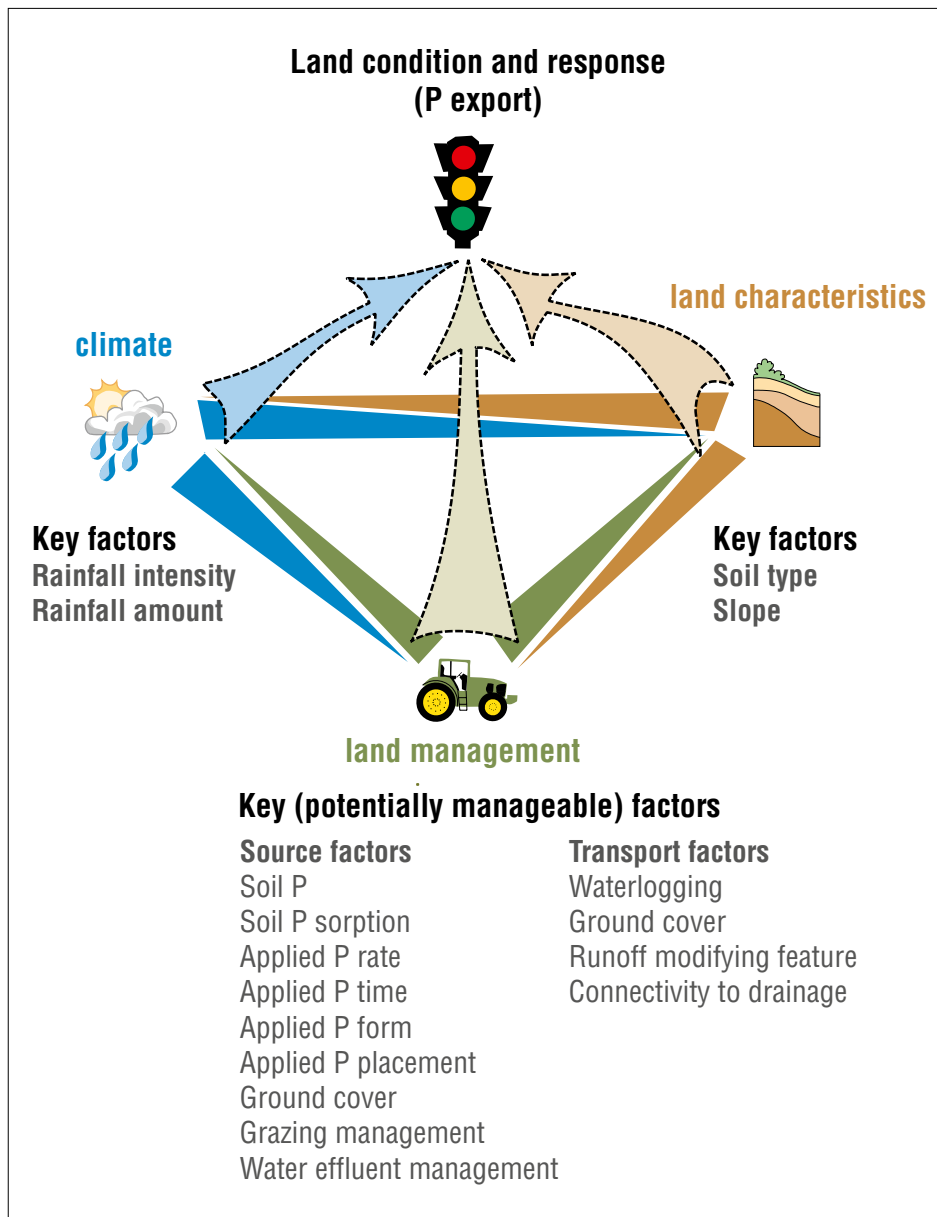


Figure 2.9.4 Factors that may influence P export. The potentially manageable factors fit within the land management driver.

Fertiliser management

Fertiliser management is estimated to reduce P export by around 10%. The efficiency with which stored and fertiliser nutrients are used by plants can be improved by the following:

- Test soil and plant tissue to establish and monitor plant nutrient requirements. Ensure that critical soil test values are reached but not exceeded.
- Use slow release, low water soluble P fertilisers where appropriate (in low P retention index soils).
- Avoid applying fertiliser prior to the break of season and stagger applications to meet plant requirements.
- Calibrate fertiliser spreaders to ensure the application rate is correct and expenditure on fertiliser is minimised.
- Avoid application immediately prior to heavy rainfall.
- Ensure fertiliser and manure is stored on a hard standing and under cover away from rain.
- Ensure soil pH is corrected to allow maximum use of stored soil nutrients and applied fertiliser.

Soil amendments

Applying soil amendments to soils with low P retention capacity should reduce P export by about 40%. Soil amendments may consist of mining or other by-products that add clay minerals to the soil. These increase nutrient retention, overcome non-wetting characteristics, raise soil pH and increase pasture production.

Perennial pastures

The deeper roots of perennial pastures increase water use and access nutrients from greater soil depths, as well as reducing erosion risk. However, recent research suggests that perennial pastures and grasses may reduce the amount of nitrogen, but not P, exported off-site. Perennial grasses have a lower P requirement than clovers. Nutrient response curves are needed for perennials so that their effectiveness to reduce nutrient loss can be established.

Irrigation management

Improvements in efficiency by moving from flood irrigation to more water use efficient systems, such as central pivot sprinklers, should reduce P export.

Effluent management

Improved effluent management from dairy sheds is estimated to reduce P export by less than 5% because only 10–15% of nutrients are derived from the vicinity of the dairy shed and effluent ponds. In contrast, 85–90% of animal excreta are deposited directly onto pastures, whereupon it becomes a diffuse nutrient source (Keipert 2008). Nutrients in effluent can be captured and irrigated onto pasture or timber lots, replacing bought-in fertiliser. Manures also contain bacteria that are a risk to water quality if not managed appropriately (URS 2005). Dependent on the scale and location of an intensive animal operation, licensing of agricultural discharges may lead to reduced nutrient export.

Riparian buffers

Protection and revegetation of wetlands and waterways has long been advocated as a nutrient control measure. However, research in the south-west of WA has shown that in catchments with sandy soils, sub-surface flow is the dominant pathway of P export. In this situation, buffers reduce P export by less than 5%. Fenced riparian buffers physically separate stock from streams, preventing fouling of waterways and erosion of banks, thus reducing sediment loss. Fenced buffers may also reduce the chance of direct fertiliser application on streams.

Governance

The Fertiliser Partnership provides a coordinated approach by government, the fertiliser industry, fertiliser user groups, and peak non-government organisations and other partners, to voluntarily engage in developing improved practices and products for industry and consumers (fertiliserpartnership.agric.wa.gov.au).

The partnership recognises:

- the value and importance of maintaining and improving the health of aquatic environments for the benefit of current and future generations of Western Australians
- the production of agricultural goods and services is essential to society
- the enjoyment of household gardens, parks, and recreational grounds is central to the lifestyle of Western Australians.

Reduced nutrient export can only be achieved through collaborative effort with, and involvement of, the broad community. The partnership aims to foster a cooperative working relationship to reduce fertiliser nutrient loss to aquatic environments.

The Fertiliser Partnership has an aspirational goal of reducing nutrient loss by 50% by applying the following strategies:

- develop and promote low P fertiliser products
- develop and promote best practice fertiliser use and management in broadacre agriculture (grazing), horticulture and other related commercial activities and urban land use applications
- develop and promote best practice based on relevant, accredited programs and advisors
- research, develop and trial nutrient-binding soil amendment products to improve nutrient use efficiency and reduce nutrient loss to waterways
- develop and promote educational material on fertiliser use efficiency.

Recommendation

Reducing P export from agricultural land needs engagement across the sector and the Fertiliser Partnership provides a framework to engage government, industry, agri-food sector and the community to achieve the balance between applying enough P for profitable agriculture and minimising off-site impacts of excess P.

Case study – Peel–Harvey System

Background

The Peel–Harvey estuary is the largest inland water body in the south-west of WA (Brearley 2005). The catchment for the estuary includes the Serpentine, Murray and Harvey rivers, and has an area of about 11 900 km² (Jakowyna 2000). Two channels connect the estuary to the ocean – the natural Mandurah Channel and the man-made Dawesville Channel.

About three-quarters of the coastal plain in this system has been cleared of native vegetation. East of the Darling Scarp are forests dominated by *Eucalyptus marginata* (Jarrah). All rivers except the Murray are dammed. Further east, the plateau is mostly cleared for wheat and sheep production (Jakowyna 2000). The Peel–Harvey System is considered ecologically significant under Ramsar convention guidelines (ramsar.org) and it is also an internationally significant water body for migratory and resident waterbirds.

Clearing for agriculture caused rises in groundwater that compounded natural flooding. To alleviate the increased flooding of low-lying lands on the Swan Coastal Plain actions such as the creation of a system of drains, the removal of fringing foreshore vegetation, de-snagging and straightening of rivers and draining of swamps was undertaken (Bradby 1997). This change in the hydrology of the system resulted in increased, direct export of nutrients from the catchment to the estuary.

Before the construction of the Dawesville Channel, the system received limited flushing from tidal exchange, leading to increased retention of nutrients in the estuary. Daily tidal exchange was 16% before the channel was constructed; it has since increased to about 50%.

Land use practices in the catchment have contributed to nutrient enrichment for many years, resulting in large accumulations of macroalgae and toxic blue-green microalgae (*Nodularia spumigena*) (Water and Rivers Commission 2004). Concern for prolonged water quality deterioration in the estuary led to the construction of the Dawesville Channel in 1994 along with weed harvesting and continuous condition monitoring. The channel provided the estuary a symptomatic

treatment through increased salinity, which controlled the growth of toxic blue-green microalgae.

Condition and trend

The Dawesville Channel has been relatively successful in improving water quality, though the major rivers in the upper catchment still show signs of deterioration. Work is therefore still required to reduce nutrient discharge from agriculture. The increase in tidal flushing of the estuary with sea water has had some negative impacts on fringing vegetation and aquatic/terrestrial biodiversity of local flora and fauna, as well as dramatically increasing problems associated with mosquitoes.

Agriculture is the dominant land use in the system. Beef cattle and sheep grazing, and hay and pasture production, using clover and ryegrass-based pastures, are the most common activities, along with horticultural enterprises. Agriculture collectively contributes about three-quarters of the annual P to the estuaries. Phosphorus export from native vegetation, including conservation areas, which occupy about three quarters of the system, is very low. Figure 2.9.5 shows the spatial extent of P export risk from the system using the methodology described by van Gool et al. (2005), broad land use categories and nitrogen and phosphorus loads attributed to these land use categories.

Discussion

The flat landscape of the system, with sandy surfaces on top of impermeable layers of ironstone or clay, inherently leads to high run-off. Clover-based pastures are predominantly grown on deep sandy soils with shallow watertables within the western parts of the system along the southern Harvey sub-catchment. These are at risk of exporting high levels of nutrients into the Harvey Estuary.

The central Murray sub-catchment has shallow watertables and is hydrodynamically linked to both estuaries. Grazing and cropping are the major agricultural enterprises and these enterprises need to adopt management practices to restrict diffuse sources of nutrients entering the waterways through groundwater discharge. The western area of

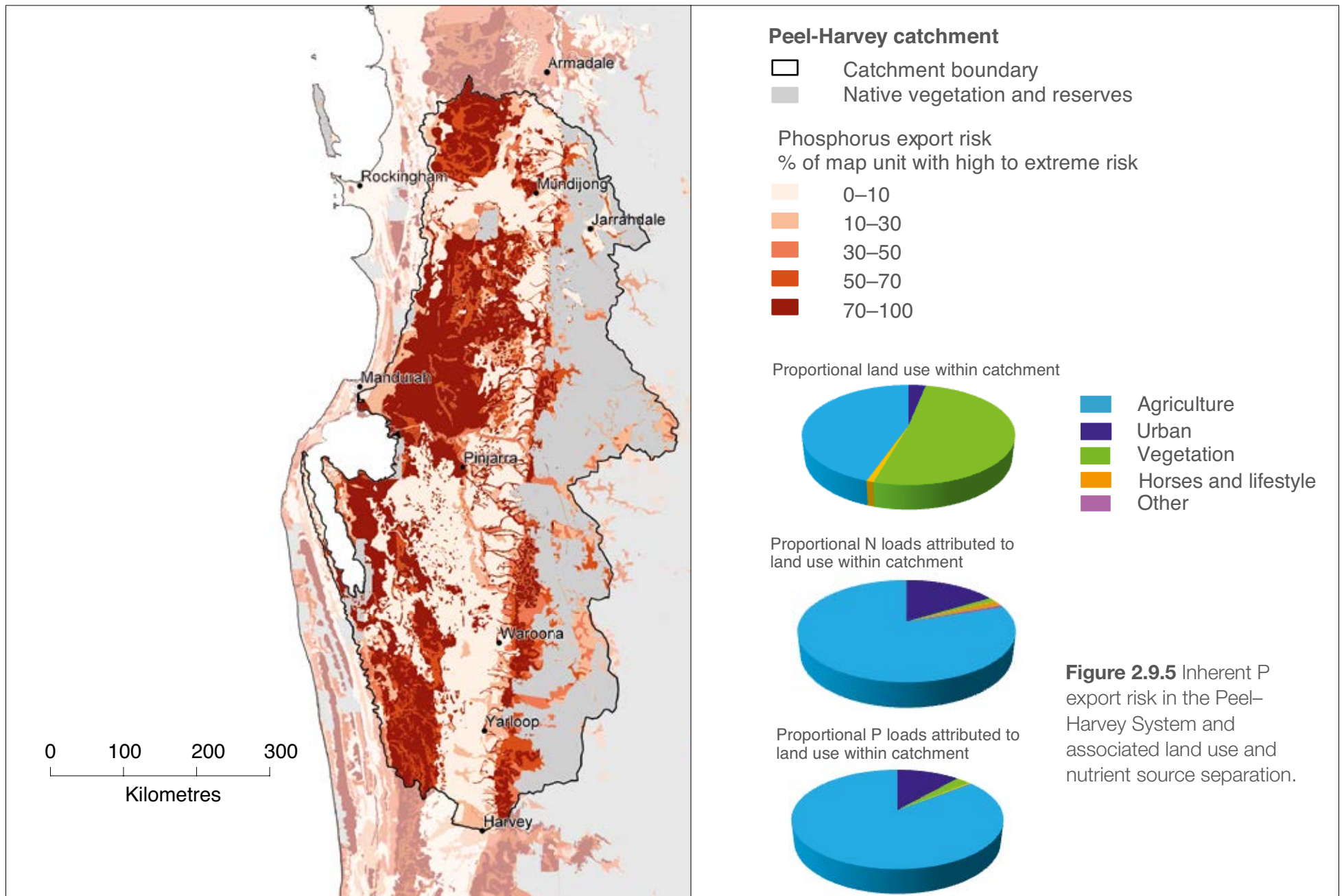


Figure 2.9.5 Inherent P export risk in the Peel-Harvey System and associated land use and nutrient source separation.

the northern Serpentine sub-catchment is characterised by deep sandy soils adjacent to the Peel Inlet. Land managers and planners in this area need to adopt management practices to mitigate the high risk of exporting P into the estuary.

The inherently high risk of P export, coupled with agricultural systems that require high fertility and have altered the hydrology that encourages discharge, have resulted in conditions that are extremely conducive to nutrient loss in the Peel–Harvey System. Despite decades of nutrient input from various land uses leading to a significant organic store in the estuary, the increased tidal exchange from the construction of the Dawesville Channel has improved water quality. However, increases in urbanisation and potential intensification of agricultural practices may further contribute to deterioration of water quality in the upper catchment tributaries.

The off-site impacts of agricultural nutrients, particularly P, continue to be a concern. Government, land managers and planners have the opportunity to encourage the adoption of management practices that reduce the risk of exporting nutrients into the Peel–Harvey estuary.

The response to the water quality impacts has included catchment management measures, weed harvesting, and in 1994, the construction of the Dawesville Channel. In more recent years, projects focused on water quality improvement have included:

- Lake Mealup recovery plan
- stormwater retrofits
- Kentish Site graded banks trial
- Buchanan’s Drain and Coolup D Drain phosphorus retention trials
- revegetation of 23 ha of priority riparian areas.

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