



# Phosphorus management of beef cattle in northern Australia

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# Contents



<b>Acknowledgments</b>	ii
<b>Key messages for managing phosphorus nutrition</b>	iv
<b>1. Why feed phosphorus?</b>	<b>1</b>
<b>2. Who should feed phosphorus?</b>	<b>3</b>
<b>3. What phosphorus to feed?</b>	<b>7</b>
<b>4. When to feed phosphorus</b>	<b>9</b>
<b>5. How much phosphorus to feed</b>	<b>10</b>
<b>6. How to feed phosphorus</b>	<b>14</b>
<b>7. Plants and phosphate fertiliser</b>	<b>16</b>
<b>8. Economics of phosphorus supplementation</b>	<b>18</b>
<b>9. Case studies</b>	
<b>9.1. Werrington Station, Georgetown, Qld</b>	<b>20</b>
<b>9.2. Granville, Jericho, Qld</b>	<b>22</b>
<b>9.3. Tara Station, Cloncurry, Qld</b>	<b>24</b>
<b>9.4. Watson River, Cape York, Qld</b>	<b>26</b>
<b>9.5. Kidman Springs, VRD, NT</b>	<b>28</b>
<b>9.6. Napier Downs, Kimberley, WA</b>	<b>29</b>
<b>9.7. Yardoogarra, Broome, WA</b>	<b>31</b>
<b>Appendices</b>	
<b>Appendix 1. Regional vegetation types</b>	<b>33</b>
<b>Appendix 2. Total phosphorus requirement</b>	<b>36</b>
<b>Appendix 3. Faecal NIRS analysis</b>	<b>37</b>
<b>Appendix 4. Blood phosphorus analysis</b>	<b>38</b>
<b>Appendix 5. Fluoride levels</b>	<b>39</b>
<b>Appendix 6. Analysis laboratories</b>	<b>41</b>
<b>Appendix 7. Sources of phosphorus</b>	<b>42</b>

## Key messages for managing phosphorus nutrition

In many of regions of northern Australia, phosphorus (P) is a serious nutritional limitation to cattle production, reducing its efficiency and profitability.

Some general principles can be applied to strategies and practices when feeding phosphorus to beef cattle.

- The animals that need phosphorus most are growing stock, late-pregnant heifers and cows, and lactating cows.
- Deficient animals respond best to P supplement when their diet has adequate protein and energy. This is why P supplementation is most effective during the wet season.
- Signs of acute phosphorus deficiency include bone chewing, broken bones, peg-leg, poor body condition of breeders and botulism.
- There are no simple diagnostic tests for the P status of cattle. Blood and faecal P are the most useful indicators.
- If P is fed over the wet season on deficient country:
  - young growing stock can increase their growth by 30–40kg/year
  - breeders can increase weaning rates by 10–30%
- Deficiency is related to soil P status. As a general rule, where soil P levels:
  - are deficient (5mg/kg or less), all classes of stock are likely to respond to feeding P
  - are marginal (6–8mg/kg), young breeders are likely to respond to feeding P
  - exceed 8mg/kg, the economic benefit from feeding mature cows diminishes.
- Responses to P supplement may be lower if animals running on P-deficient country have access to adjacent areas of high-P soils, such as frontage country.
- Supplements should be compared on the cost of their P content, on the practicality of feeding out and on whether the animals will be able or willing to eat target amounts.
- A typical wet season loose-mix P supplement should contain at least 8% P; a typical dry season supplement will contain 2–4% P and also non-protein nitrogen (eg urea).
- On deficient country, lowering the stocking rate will not reduce the need to feed phosphorus.
- Where the native pasture on deficient country contains sufficient stylo, cattle may respond significantly to P supplement during the dry season because of the extra protein in their diet.
- Because cattle eat more pasture when P supplements are fed, stocking rates should be reduced to avoid overgrazing.
- The economic benefits from feeding P are maximised when done in conjunction with other aspects of good herd management.

# 1. Why feed phosphorus?

Cattle need phosphorus (P) for almost every vital function of the body. It is used for building bones and teeth, metabolising fat, carbohydrates and protein, producing milk and for efficient feed utilisation.

The problem of phosphorus deficiency arises because most soils in northern Australia are deficient in phosphorus and cattle cannot get sufficient P from the pasture.



Typical P-deficient country in northern Australia

The animals that need phosphorus most are the young, which need it for their growing bones; first-calf heifers, which need it for growth, pregnancy and lactation; late-pregnant breeders, which need it for the growing foetus; and wet cows, which need it for milk production.

## Poor performance and broken legs

A phosphorus-deficient animal will eat less pasture and this depresses its productivity. Phosphorus deficiency results in poor appetite and feed intake, poor growth, high breeder mortality, reduced fertility and milk production, bone breakage and, in severe cases, bone deformities. Added to this poor performance is an increased risk of deaths from botulism when cattle chew bones in their craving for the mineral.

The animals that need phosphorus most are the young, first-calf heifers, late-pregnant breeders and wet cows.

## Urea-based supplement is well known

Many producers routinely feed urea-based supplements during the dry season because the loss of body condition in their stock from protein deficiency becomes obvious.

Not so obvious is that large responses can be obtained by providing phosphorus to growing cattle eating green grass during the wet season on P-deficient country.

## Depleting phosphorus body reserves

Phosphorus deficiency is not generally like an acute disease where the clinical signs are obvious. Cattle can store phosphorus in their bones and mobilise it when they need it. A 400kg breeder with full P reserves may be able to mobilise 600g of P initially—but her reserves will soon be depleted because each litre of milk contains 1.1–1.2g of phosphorus. In P-deficient country, animals that have full bone-P reserves may not suffer from depressed appetite or depressed productivity for as long as three to five months.

## Marginal phosphorus deficiency

Not every animal on P-deficient country is severely P-deficient. Some have only a marginal deficiency because the soils and thus the pasture have moderate levels of phosphorus; even those on deficient country may be able to build up their phosphorus reserves if they also have access to areas of more P-rich soil. Moving cattle between lighter country and adjacent P-rich frontage country, for example, will reduce the level of supplementary P required—and, with good management, avoid overgrazing the P-rich country.

## Reduce herd numbers if feeding P

Feeding a phosphorus supplement to P-deficient cattle will increase feed consumption by 10–60%. Branding rates and growth rates will also increase, as will herd numbers, thus increasing total grazing pressure on the pasture. To avoid overstocking, more unproductive females will need to be sold; breeder numbers can be reduced by up



More and bigger calves, and heavier steers and heifers with P supplements

to 30% while still producing the same number of calves.

The sale of extra cows may soon pay for the initial costs of feeding the supplement. Feeding P requires investment in infrastructure such as troughs, storage and maybe wet weather access roads in the first year, and a recurring cost of supplement and its delivery.

It is often difficult for a beef producer to determine the direct economic impact of feeding phosphorus supplement because the supplementation is often introduced at the same time as other improvements in herd or station management, and some production benefits are not immediate. However, economic analysis of herd performance on deficient country has shown that supplementation is well worthwhile, even when the price of phosphorus increases substantially. Indeed, the question is whether enterprises running cattle on P-deficient country can remain economically viable

without feeding phosphorus.

### Phosphorus in herd management

Feeding phosphorus supplements is only part of good general property and herd management.

Maintaining breeders in good condition is critical for herd fertility, high branding rates and heavy weaning weights. Correcting a P deficiency is one aspect of increasing productivity. To be effective, supplementation needs to be carried out in conjunction with other aspects of good management—otherwise money is likely to be wasted.

For northern Australia, the most important aspects of management to be considered along with P supplementation are:

- botulism vaccination
- matching time of calving to peak pasture nutrition
- culling unproductive breeders to save on the cost of supplement and reduce grazing pressure
- maintaining pasture condition by stocking appropriately
- weaning early in the year to allow the breeding cow to regain condition before the next calving
- matching type of country to the class of stock (weaners, growing replacement heifers and first-calvers need the best

Lowering the stocking rate will not reduce the need to feed phosphorus. The cost-effective solution is still to feed phosphorus along with a well-managed pasture.

Table 1.1. Likely benefits of feeding P supplements to cattle grazing native pasture and stylo-based pastures growing on P-deficient soils in northern Australia

	Acutely deficient	Deficient	Marginal
Typical soil phosphorus ( $P_{B \text{ mg/kg}}$ )	<4	5	6–8
<b>Likely weight response to P supplement by growing cattle (kg/year)</b>			
Native pasture	30–40	20–40	0–20
Stylo pasture	45–70	40–60	0–40
<b>Likely response to P supplement by breeder cattle grazing native pastures</b>			
Increased weaning rate (%)	10–30	10–20	0–10
Increase in calf weight at weaning (kg)	10–20	5–15	0–10

$P_{B \text{ mg/kg}}$  = bicarbonate extractable phosphorus

## 2. Who should feed phosphorus?

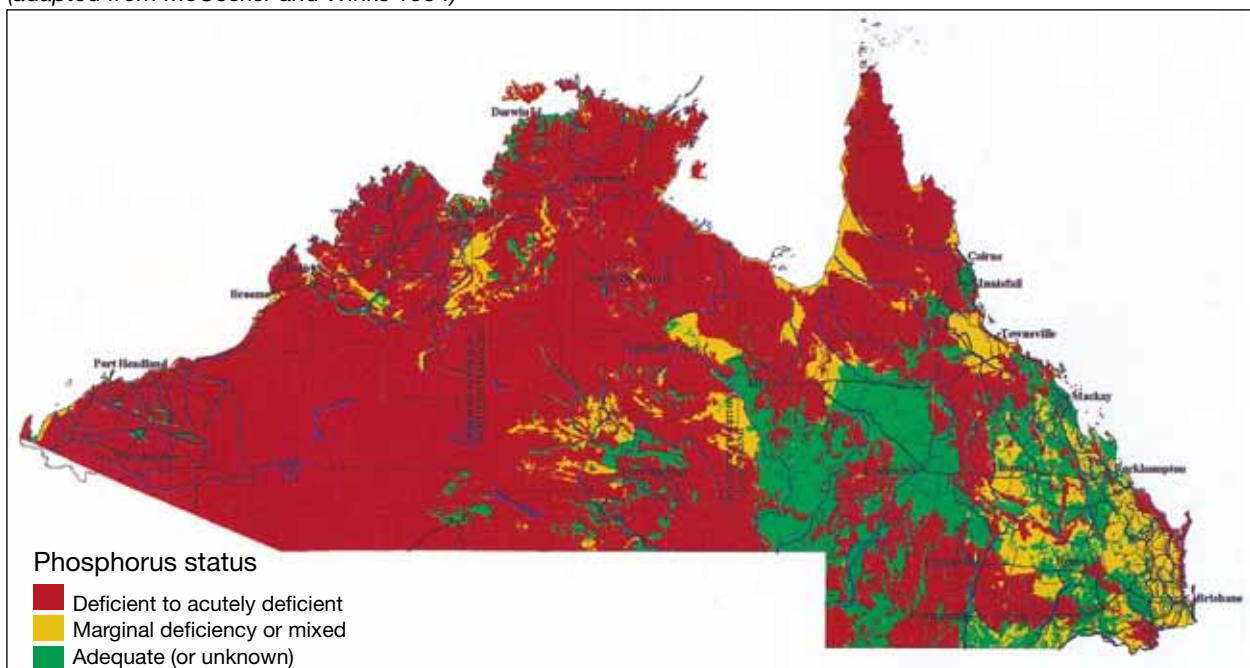
The decision on whether to feed phosphorus to cattle should take a systematic approach. No single test is totally conclusive, and phosphorus deficiency might be confounded with other problems. Before feeding a phosphorus supplement, a manager should work through a series of questions such as:

1. Is the district generally known to be P deficient? – Ask the local technical advisers, look at maps of soil phosphorus levels. Have the soils on the property been sampled and analysed for their P levels?
2. Do the stock show any clinical signs or other symptoms of P deficiency? – Do they chew old bones, show peg leg, sometimes break bones or die of botulism?
3. Are the animals performing as expected? – Are their rates of growth and reproduction, and body condition unacceptably low?

If the answers suggest the possibility of P deficiency, the next stage is for more detailed investigation. This could involve trial feeding a group of potentially responsive animals or analysing their blood or faeces.

This chapter describes these steps in more detail.

Figure 2.1. Map showing general extent of phosphorus deficiency over northern Australia (adapted from McCosker and Winks 1994)



### Which soils are P-deficient?

Everyone managing cattle on soils that are marginally or severely deficient in phosphorus should be aware of the potential problem.

Large-scale soil or vegetation maps show that much of northern Australia is deficient in phosphorus (Figure 2.1) but, at this scale, maps cannot define small pockets of soil with adequate or even high levels of phosphorus.

Over the decades, thousands of soils have been sampled and analysed, and their P status has been categorised.

### Soil analyses

Soil P\* levels are expressed as milligrams per kilogram (mg/kg) (previously parts per million or ppm) of dry soil.

For beef production, soil P levels with:

- 5mg P/kg or less are considered deficient to acutely deficient
- 6–8mg P/kg are marginal
- more than 8mg P/kg are considered adequate.

\*Levels refer to bicarbonate extraction P.

In general, all cattle grazing continuously on land with soils having 5mg P/kg or less are at risk, and will respond immediately to P supplement during the wet season.

All cattle grazing continuously on land with soils having less than 5mg P/kg will respond immediately to P supplement.

### Land types on your property

Vegetation is often a useful indicator of the level of phosphorus in soils and thus of deficiency in pasture and cattle.

The main vegetation–soil associations across northern Australia and their probable phosphorus status are listed in Appendix 1.



Nearly all soils with termite mounds are P-deficient –but not all P-deficient soils have termite mounds.

Some soils can be classified generally; for example, in north Queensland, deep sands are acutely P deficient while all other land types are deficient to marginal. Goldfields, frontage, Mitchell grass downs and basalt soils may be marginal or adequate.

### Consult others

Seek more information about your soils and possible deficiency from your local beef adviser or consultant, discuss the problems and experiences with your neighbours and feed suppliers.

### Animal performance

In general, it is easy to identify where cattle are acutely deficient. It is more difficult with marginal P deficiency which may result in poor weight gains of young stock and poor body condition and fewer calves in breeders.

A number of symptoms or clinical signs may indicate a P deficiency, but not all are specific to it. Their presence does not necessarily confirm P deficiency.



It is usually easy to identify when cattle are severely deficient.

Poor overall performance may be because of heavy stocking and a shortage of feed, limited energy and protein in the diet, poor weaning management or disease. These factors also need to be addressed by reducing herd numbers and focusing on that part of the herd with the highest potential returns.

Thus a number of factors must be considered to make the decision to feed phosphorus.

Poor performance may not result solely from a shortage of P; it may be due to other management issues.

### Clinical signs

Clinical signs include peg-leg, especially in drier years; broken bones which often occur when working the cattle in yards; bone chewing and other forms of depraved appetite (pica) such as chewing on stones, polythene pipe or horns.



Bone chewing probably indicates P deficiency—but may also be caused by severe protein deficiency.

### Signs of severe P deficiency

Bone chewing, broken bones, peg-leg, pica, poor body condition of breeders and botulism indicate phosphorus deficiency.



*Sudden death is more likely due to botulism than snake bite in P-deficient country!*

### Trial feeding

Trial feeding a group of potentially responsive cattle and comparing their performance against a similar group of unsupplemented animals can help diagnose P deficiency. Feeding phosphorus during the wet will give immediate responses in weight gain and reduced mortality if the deficiency is acute or even marginal.

First-calf heifers are most responsive, but deficient steers and heifers will also respond in the first season of feeding.

### Diagnostic tests for phosphorus

There are no simple and completely reliable diagnostic tests for the P status of grazing cattle.

### Soil testing

Soil samples can be analysed for phosphorus levels. Soil analysis may help to define which paddocks or land types on the property are deficient and which have P levels high enough to allow the breeders to replenish their bone phosphorus.

Sampling has to be done correctly across the land type or the results may be difficult or impossible to interpret usefully. Sampling should be carried out by someone with the necessary skills.

### Pasture sampling and testing

Analysis of forage is generally of little use at the property management level because of the large variation between soil types, between pasture species and between different parts of the same plant. Even pasture samples plucked by hand will not represent what the animal is selecting.

Analysis of forage in the paddock is generally of little use in determining P deficiency in cattle.

### Animal testing

Discuss the value of sampling your animals and any interpretation of results with your cattle husbandry adviser, consultant or veterinarian.

**Blood samples** – Blood samples taken at the end of the wet season from non-lactating animals are accurate, but this may be impractical, and analyses are expensive.

**Dung samples** – Dung samples taken from unsupplemented animals in the middle of the wet season (eg February) will help build a picture of their dietary P status.

### Blood phosphorus concentration

Blood P concentration of samples taken at the end of the wet season can indicate P deficiency in a growing animal such as a steer or a heifer before first pregnancy, but blood tests are of limited value in the lactating cow.

With the lactating cow, better diagnoses can be achieved by:

- faecal sampling
- grazing young steers or heifers with the breeders through the wet season and blood sampling these as a sentinel group.

Expected responses to P supplementation of growing animals based on blood P concentrations are shown in Appendix 4.

Because there are different methods of collecting and preserving blood, results from the analyses should be discussed with a specialist.

### Faecal analysis

The P concentration in the diet of grazing cattle can be estimated from the P concentration of the dung in unsupplemented animals.

Current dietary P status (deficient or adequate), relative to the P requirement based on energy status, can also be calculated from analyses of the dung of cattle grazing tropical pastures.

Cattle tested must not have eaten P supplement for at least a week before the test sample is collected. If cattle are being fed P supplement, removing the supplement for at least a week (preferably two weeks) should allow faecal P concentrations to return to levels in the absence of P supplements.



Collecting samples of fresh dung for faecal NIRS

### Faecal P with Faecal NIRS

The ratio of faecal P to metabolisable energy in the diet is currently the most reliable indicator of whether the diet provides sufficient P for the grazing animal without mobilisation of any body P reserves.

Since the amount of P needed depends on the amount of energy the animal is consuming, its need for P can be estimated from the ratio of the P concentration in faeces and the level of dietary energy.

The energy (ME) level of the diet is calculated from the dry matter digestibility (DMD) as estimated using faecal near infrared spectroscopy (F.NIRS).

Calculation of the P requirements of lactating cows requires allowance for their need for higher levels of energy and the large amount of P in their milk.

Estimates of the need for supplementary P for growing cattle and for lactating cows are given in Appendix 3.

Table 2.1. Typical threshold values of dietary P status, using blood and faecal analysis, relative to soil P concentrations

	Acutely deficient	Deficient	Marginal	Adequate
<b>Soil P (<math>P_B</math> mg/kg)</b>	<4	5	6–8	>8
<b>Blood P (growing cattle)</b>				
Blood inorganic P (mg/L) in tail blood	<25	25–35	35–50	>50
<b>Faeces</b>				
Growing cattle				
Diet (mg P/kg faecal DM)/(MJ ME/kg diet DM)	<70	70–120	120–170	>170
Faeces (mg P/kg faecal DM)/(MJ ME/kg diet DM)	<160	160–240	240–340	>340
Lactating breeders (5kg milk/day) <sup>1</sup>				
Diet (mg P/kg faecal DM)/(MJ ME/kg diet DM)	<90	90–165	165–230	>230
Faeces (mg P/kg faecal DM)/(MJ ME/kg diet DM)	<190	190–300	300–410	>410

<sup>1</sup>These values assume no mobilisation of P from body reserves. When lactating cows are mobilising large amounts of P from body reserves, the thresholds will be comparable to those for growing cattle. (See Appendices 2, 3 and 4.)

## 3. What phosphorus to feed?

If stock have not been fed P supplement before, small quantities of various forms of phosphorus can be fed during the wet season and intakes recorded to determine which source is most acceptable. There is no universal formula that suits all properties, and different formulations may be more effective. Phosphorus content and prices for proprietary and home-mixed supplements should be compared.

### Phosphorus and phosphates

Phosphorus is generally fed out as calcium phosphate, which contains about 21% elemental P.

### Proprietary P supplements

Read the labels. Phosphorus will be listed as one of the nutrients but cattle may not eat enough to meet their needs of supplementary P.

The amount of P that an animal will eat will depend on:

- the percentage of phosphorus in the supplement
- the amount of supplement eaten (its palatability, and hardness if it is a block)
- the phosphorus already in their diet
- the balance with other nutrients, such as energy, protein and calcium, in the supplement and the pasture.

### Calculating cost of P in a supplement

Supplement prices should always be compared on the cost per tonne of the nutrient to be fed, not on a cost per tonne of product. The cost of phosphorus can be calculated as in the example below.

Cost of supplement

= \$750/tonne (= \$0.75/kg)

Phosphorus content of supplement

= 5%

Weight of phosphorus per tonne of supplement

= 50kg

Thus the cost of 50kg phosphorus is

$\$750 \div 50\text{kg} = \$15/\text{kg P}$

or 1.5 cents/g P

### Soluble P for water medication

When P is supplied to cattle through medicated water, it must be added to the water supply in a soluble form.

The pH of the water influences the most suitable source of P. For water with neutral pH, technical grade MAP is cheapest whereas the alkaline technical grade DAP may increase urea breakdown; urea phosphate may be used in alkaline water. All water-soluble forms of P have a higher cost.

For more information on suitable forms of P, read the MLA book *Water medication: a guide for beef producers* (2005).

### DIY loose lick recipes

Two typical wet season mixes are:

- 50% salt, 50% calcium phosphate
- 50% salt, 40% calcium phosphate, 10% sulphate of ammonia

Phosphorus supplements may include:

- **Phosphorus** – Calcium phosphates contain about 21% P.
- **Salt** – Salt can be used either as an attractant to get animals to eat the supplement or to restrict intake.
- **Sulphate of ammonia** – Sulphate of ammonia (eg GranAm™) reduces palatability but may be included as a source of sulphur if feeding urea. Some producers add 5–10% urea, with the salt reduced proportionally, towards the end of the wet season when the protein content of the forage is declining.

### Supplement additives

**Lime** – Lime (calcium carbonate) is often added to licks to:

- act as a hardening agent to prevent rain damage during the wet season
- balance phosphorus and calcium.

Adding lime may exacerbate any P deficiency as mature tropical pastures already have a high ratio of calcium to phosphorus (see note on calcium).

**Cement** – Cement powder is sometimes added to phosphorus licks or in homemade blocks as a hardening agent. This is not recommended as it may contain unacceptable levels of heavy metals. Any use of cement powder in licks must be identified in a vendor declaration.

**Molasses or protein meal** – Although normally included in dry season licks, molasses or protein meal may sometimes have to be added to wet season licks to encourage their consumption—molasses where there are other sources of natural salt, or protein meal, for example in mulga country.

Other ingredients are often added to licks to improve palatability and animal productivity. But they usually increase the cost of the lick, provide little additional nutrients and may even make a lick less palatable. They should be used with caution.

### Other minerals and elements

**Calcium** – Adding calcium (Ca) will bring the calcium to phosphorus balance in the supplement closer to an ideal ratio of 2:1. But as most pastures in northern Australia have high Ca:P ratios, adding extra Ca may reduce feed intake and prevent the animals from mobilising bone reserves of P.

Ca deficiency is rare in northern Australia but could occur on acid, sandy or peaty soils.

### Some potential problems

**Cadmium** – Cadmium is a heavy metal toxic to animals. It accumulates in the liver and kidney, and high intakes cause many health and productivity issues. Phosphate fertilisers that are not registered for livestock feeding may contain high levels of cadmium, and must not be fed to stock.

**Rock phosphates** – Rock phosphates are neither suitable nor registered for feeding to livestock because of their high levels of fluorine and heavy metals.

**Meat and bone meal** – Feeding meat and bone meal to cattle or other livestock is illegal in Australia.



Lime is sometimes added as a hardening agent in half-tonne bags that are put out for the entire wet season.

### Fluorine (F)

Fluorine (measured as fluoride) interferes with phosphorus absorption because it is absorbed more rapidly. High fluorine in the diet can cause problems seen as:

- reduced feed intake and weight loss
- scouring and listlessness
- abnormal bones and teeth

and, over a prolonged period, it can kill stock.

The maximum level of fluorine consumed should not exceed 1mg/kg bodyweight from all sources. In past decades, feeding phosphate fertiliser with high F content as a supplement could create problems in areas where bore water also had high F levels. As P supplements now have much lower levels of fluoride (see Appendix 7), the problem comes only from the bore water.

High fluoride levels are found in a number of bores across Queensland and in Central Australia (see Appendix 5 for maps). Beef producers in these regions should have their bore water analysed.

Bores with fluoride levels greater than 3mg/L will adversely affect animal performance, while evaporation along bore drains can dramatically concentrate fluoride.

Young growing animals and lactating breeders should not be run in paddocks where bore water fluoride levels are high. Other stock should not be run in these paddocks for the long term; dam water is preferable to high-F bore water.

Feeding extra phosphorus will not counteract high fluoride in the diet.

## 4. When to feed phosphorus

Animals need phosphorus throughout the year to maintain basic body functions. The amount of P to be fed as a supplement depends on the level of deficiency, the balance of nutrients and the animal's stage of production.

Animals suffering from P deficiency will respond to P supplement best when their diet has adequate protein and energy. In northern Australia, that usually occurs during the wet season when they are growing or lactating.

### Feed P when the grass is green

The need to feed P through the wet season is often misunderstood by producers who think that cattle do not need a supplement when the grass is green and the cattle are gaining some weight.



*Feed P when pasture quality and quantity is high.*

As the pasture matures into the dry season and its protein and digestibility levels drop, cattle growth rates decline and phosphorus becomes less limiting in the diet. Some phosphorus should be included in dry season supplements for breeding cattle during the late dry season because most are likely to be in late pregnancy or even in early lactation. P supplement will be beneficial to any cows lactating during the dry season but supplementary N should also be provided in dry season P supplements.

A typical supplementary mix may include 10% phosphorus (50% phosphate) in the wet season and 2–4% (10–20% phosphate) in the dry.

### Practical problems in the wet

Practical problems often make it more costly to put out supplements in the wet season than during the dry season. Paddocks may be inaccessible for weeks on end, and supplements need to be kept dry or be resistant to rainfall. Feeding phosphorus through water medication is less reliable where cattle can drink from creeks or natural water holes.

Fortunately, because the animal can recycle and metabolise the mineral from its bones in the short term, a constant and regular delivery of supplementary P is not as critical as with other nutrients.

While it may be best to deliver supplement weekly during the wet, this may not be practical for many producers. Some have devised ways of distributing supplement regularly; others may have to put out a larger quantity before the rains, topping up if possible during occasional dry spells as the season progresses.

Putting out a large amount of phosphorus supplement in the late dry season may be less desirable than providing it regularly over the wet season, but it should go a long way towards meeting the animals' wet season requirements. It will provide P to heavily pregnant or lactating breeders, and help to preserve bone reserves for later use.



*Dry-season urea-based supplements that contain some phosphorus will benefit heavily pregnant and lactating cows.*

## 5. How much phosphorus to feed

Growing or breeding cattle need to eat large quantities of feed for their intake of energy.

The amount of feed, and hence P needed, varies with the animal's weight, age, growth, pregnancy or lactation status. The primary effect of P deficiency in cattle is to depress forage intake so that the animal cannot eat enough to meet its energy requirements and, as a consequence, productivity is depressed.

### Animal dietary requirements

The dietary amounts of P that the animal's body needs vary.

Growing cattle need about 9g P/kg liveweight gain for muscle and bone; breeding cows need P for the growing foetus and to produce milk (1.6g P/kg milk produced). The young suckling calf needs a large amount of P because it is growing fast, and gets it in milk from the mother. Thus the lactating cow becomes the animal most susceptible to P deficiency.

The amount of P needed increases greatly for high growth rates; a steer growing on good pasture during the wet season will need more than twice as much P as it does when maintaining weight over the dry season (see Table A.2.1 in Appendix 2).

Steers often have high weight gains during the early wet season, particularly if they are in compensatory growth after the dry season.

For example, a 400kg steer needs 7g P/day to maintain weight but would need 22g P/day if gaining 1.2kg/day; the required concentration of P in the diet would need to increase from 0.9g to 1.5g P/kg dry matter (DM).

The importance of providing P to a cow during lactation can be seen by comparing the requirements for the 400kg growing steer with those of a lactating cow gaining some weight. Producing 5kg milk per day will increase P requirements by about 8g P/day, and if the cow is also gaining 0.3kg/day, her diet will need the P concentration to increase from 1.2 to 1.7g P/kg DM.

Conversely, a dry cow losing weight would need little dietary P.

### Estimating animal phosphorus status

Evaluation of the dietary P status of grazing cattle, and more specifically whether a response to supplementary P can be expected, is difficult—as explained in Chapter 2. Factors include: how much P the animal requires for immediate productive purposes; how much P is absorbed from the diet; and how much P is available from mobilisation of body stores of P.

### Phosphorus sources

An animal can obtain its phosphorus requirements:

- from pasture
- by mobilising (drawing on) body reserves
- from a supplement.

### Phosphorus from pasture

The concentration of P in a plant depends on:

- the soil in which it is growing
- plant species (grasses, browse, legumes)
- plant parts (younger leaves have higher P concentration than old leaves or stems)
- season of the year, the maturity of the plant and rainfall patterns.

Cattle can digest, absorb and use about 75% of the phosphorus in the forage.

In fairly homogenous land systems with high P levels (such as most basalt or brigalow), general recommendations can be made with confidence. However, where P is marginal or deficient overall, grazing patterns are likely to be more important as even small areas of high-P soils such as on river frontage may provide a large proportion of dietary P.

The amount of P in the diet can be assessed through faecal analysis. As long as the cattle are not being fed a phosphorus supplement, a faecal phosphorus analysis (using wet chemistry) will estimate P concentration in the diet (see Chapter 2 and Table A.4.1).

### Phosphorus from body reserves

When P is lacking in the diet, cattle, and especially breeders, can mobilise bone P reserves built up while on a high P diet.

Similarly, when an animal is losing weight it can use some of the P in the tissue which is mobilised during this process (about 1.2g P/kg soft tissue). Thus a dry cow losing weight needs little P from the diet. However, a late-pregnant cow, without access to P supplement, grazing mature, very low P pasture during the dry season can only meet the demands of the foetus for P by mobilising her body P reserves.

Cattle that have been grazing high P country contain 7–8g P/kg liveweight, with about 80% of this in bone.



*The bone of these breeders with access to frontage country may well be filled (replete) with P.*

A 400kg breeder has about 3,000g P in her body, and 20–30% of this (about 600g P) can be mobilised under severe P deficiency. Large amounts of P can be mobilised initially but the rate will decline with time as bone reserves become depleted. A breeder with adequate bone phosphorus might mobilise 10g P/day for the first four weeks of lactation when the demand for P is high, and then 5g P/day for the next eight weeks.

The cow uses this P mobilised from body reserves more efficiently than P in the diet, and this adds to its value.

P mobilised from bone reserves during late pregnancy and lactation will have to be replaced at some later time during the annual cycle if the cow is to have adequate body P reserves for the subsequent pregnancy and lactation. This may not be possible for cows grazing low-P pastures and producing a calf each 12 months. The breeder that calves every 18 or 24 months, as often occurs in northern Australia, will have a greater

opportunity to replenish its body P reserves without supplementation—but at the expense of herd productivity and profitability.

Early weaning will stop the lactation drain on the cow's body reserves of P and, depending on post-weaning dietary P status, may allow her to partly or fully replenish her reserves before the next calving.

### Phosphorus from supplement

The amount of P supplement needed is the difference between the total requirement and the amounts the animal obtains from the pasture and (in the short term) by drawing on bone reserves.

The amount will depend on the target growth rates of the different classes of cattle (Table 5.2), and needs to be considered in relation to the annual cycle as well as over the short term.

As with most nutrients, an animal responds strongly to P supplements when very deficient, and less so as it approaches adequacy; often the economic optimum amount is less than the maximum animal response.

If animals are eating only a small quantity of lick, it must have a higher phosphorus content; if they are eating plenty, the phosphorus concentration can be decreased to reduce the overall cost or intake restricted by decreasing palatability (Table 5.1). Higher P concentration will reduce the costs of transport and handling but may reduce intake through lower palatability.

**Table 5.1. Can they eat sufficient lick to get enough P?**

Target intakes of P (g P/head/day)	% P in lick	Required intake of lick (g/head/day)
<b>Deficient areas</b>		
6	2	300
6	5	120
6	10	60
6	15	43
<b>Acutely deficient areas</b>		
10	5	200
10	10	100
10	15	66

In P-deficient country, wet season lick should contain at least 8% phosphorus.

Table 5.2. Approximate amounts of **supplementary P** needed (g/day) by growing steers and heifers, and pregnant or lactating breeders

Class of animal	Weight (kg)	Target weight gain (kg/day)	P supplement (g/day) needed to achieve target weight gains			
			Acutely deficient	Deficient	Marginal	Adequate
Steers and heifers	200	0	2	1	Nil	Nil
Steers and heifers	200	0.3	4	3	1	Nil
Steers and heifers	200	0.6	6	4	1	Nil
Steers and heifers	200	0.9	8	5	2	Nil
Steers and heifers	200	1.2	10	7	2	Nil
Steers and heifers	400	-0.3	2	Nil	Nil	Nil
Steers and heifers	400	0	3	2	1	Nil
Steers and heifers	400	0.3	5	4	1	Nil
Steers and heifers	400	0.6	7	5	2	Nil
Steers and heifers	400	0.9	9	6	2	Nil
Steers and heifers	400	1.2	11	8	3	Nil
Pregnant breeders <sup>1</sup>	400	-0.3	3	2	1	Nil
Pregnant breeders <sup>1</sup>	400	0	5	3	1	Nil
Pregnant breeders <sup>1</sup>	400	0.3	7	4	1	Nil
Pregnant breeders <sup>1</sup>	400	0.6	9	6	2	Nil
Pregnant breeders <sup>1</sup>	400	0.9	11	8	3	Nil
Pregnant breeders <sup>1</sup>	400	1.2	14	10	5	Nil
Lactating cows <sup>2</sup>	400	-0.3	7	5	2	Nil
Lactating cows <sup>2</sup>	400	0	9	6	2	Nil
Lactating cows <sup>2</sup>	400	0.3	11	7	2	Nil
Lactating cows <sup>2</sup>	400	0.6	12	9	3	Nil

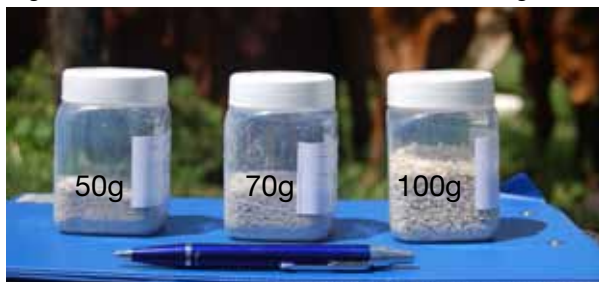
<sup>1</sup>Late pregnant breeders, last three months of pregnancy.

<sup>2</sup>Lactating cows, producing 5kg milk/day.

Note 1: These estimates assume nil mobilisation of P from body reserves. Breeders that can replenish their body reserves by grazing on high-P country may mobilise 5g P/day, and will require less P supplement.

Note 2: Target weight gains represent the potential daily weight gain based on the nutrient content of the diet when P is not limiting.

*Intake of supplement required for a breeder on acutely deficient country will depend on the P concentration. Higher concentration will reduce cost of handling but could actually reduce intake through lower palatability.*



Intake **per day** of supplement with 21% P, 15% P and 10% P respectively from left to right.



Required intake **over the wet season** of supplement with 21% P, 15% P and 10% P respectively.

### Calculating phosphorus need from F.NIRS

The ratio of faecal P to metabolisable energy in the diet determined from analysis of dung samples is currently the most convenient indicator of dietary P status of the animal from pasture (see Appendix 3).

Table A.3.1 in Appendix 3 shows the large amounts of P required per day for high weight gain and for milk production, and the necessary ratio of faecal P to metabolisable energy (ME) at various levels of production (ME is correlated to DMD).

### Likely responses to P supplement

Whether and by how much cattle will respond to phosphorus supplements during the wet season will depend upon:

#### - whether P is the most-limiting nutrient

In northern Australian pastures, nitrogen (protein) and available energy are almost always most limiting during the dry season. Thus, growing cattle grazing native grass pasture may respond to P supplements during the wet and early dry seasons, but show no weight gain response from the middle of the dry season through until the seasonal break.

An exception may be where cattle are grazing stylo-based pastures on low P country, and thus where the protein and energy content of the pasture may be maintained well into the mid or even late dry season. In north Queensland, steers on native pastures with stylo can gain an additional 30–60kg a year with P supplement.



*Stylo pastures maintain their protein value into the dry season allowing cattle to respond well to P supplement.*

#### - availability of sufficient pasture

Responses to P supplements during the wet season generally occur because the animal eats more pasture (10–30%, even up to 60%, more).

When P supplements are given, the forage is no more digestible or more efficiently used by the animal; the animal obtains more energy because it is eating more pasture. Thus grazing cattle will respond to P supplement only when there is sufficient pasture.

#### - the P body reserves of the animal

An animal that is mobilising P reserves is usually alleviating a dietary P deficiency and can therefore be expected to have a lesser response to P supplement than an animal with lesser P reserves available for mobilisation. Nevertheless, at such times, P supplement can be expected to reduce or eliminate the net mobilisation of P reserves and so maintain the reserves for later use when demand for P may increase. Whenever breeders deplete their reserves of P to alleviate a dietary P deficiency, those reserves will obviously need to be replenished before the next reproductive cycle.

Estimating the direct responses to phosphorus supplementation in breeder herds is difficult because other aspects of management, such as weaning strategy, stocking rate and grazing pressure, are usually changed at the same time. Young heifers and steers will show immediate benefits, cull cow weights will improve.

Changes in breeder management often take several years to affect cattle output and sales through the number of weaners and weaning weights, and through reduced cow mortality.

## 6. How to feed phosphorus

Phosphorus can be fed to cattle during the wet season as:

- loose mix in the open
- loose mix under shelters
- blocks
- medicated water.

The choice of which form to feed is a balance of cost and practicality, and this will differ between properties and regions. For many producers, blocks are the easiest form to handle in the wet, and the proprietary blocks are weather-proof—they are also the most expensive. Some proprietary mixes are available in tonne and half-tonne bulk bags or in more-easily handled 25kg or 50kg bags.

While some properties successfully feed wet season mixes without shelter, wetting may greatly reduce palatability, and lead to leaching of soluble P (and of salt) in higher rainfall regions.



Hard blocks last well in the wet but may restrict intake.



Half-tonne bags need lifting equipment.



Small bags that can be left in the paddock

### Water medication

Water medication is generally less effective in the wet season as cattle usually have access to surface water. While some cattle have been observed to walk through standing water to get to their regular trough, most may miss out on supplement just when they need it most.

Table 6.1. Advantages and disadvantages in methods for feeding out supplements

Loose lick	Blocks	Loose lick in bulk bags
Need lick sheds/covered troughs	Weather resistant in most cases	Reasonably weather resistant
Lower cost/kg of P	Higher cost/kg P	Lower cost/kg of P
Recipe can be changed to achieve target intakes	Set recipe	Recipe cannot be changed quickly to achieve target intakes
Difficult to put out full wet season requirements	Can be distributed in paddocks before onset of wet; flexible distribution	Can be distributed in paddocks before onset of wet
More labour intensive	Less labour intensive	Needs suitable lifting gear
Can be spoilt by storm rain	Storm resistant	Can be spoilt by prolonged rain
Can increase P% to reduce freight cost/tonne of P	More expensive to freight as P% is usually lower	Can increase P% to reduce freight cost/tonne of P

## Feed troughs

Troughs have been made from a wide variety of materials and products. Plastic troughs do not corrode but may be expensive; hollowed tree trunks are cheap and durable. Others use old metal drums, tractor tyres cut in half, even steel wheel rims from large mine machinery.

## Shelters

Home-made supplement shelters can be cost-effective, but need to be sturdy because the salt in supplement mixes will rust out flimsy steel shelters within a few years. Lightweight shelters tend to be damaged by cattle or by heavy gusts of wind.

## Choosing sites

Managers need to plan the physical and logistical aspects of both wet and dry season feeding, including the location of feeding sites, their access during the wet season and the method of delivery, as well as suitable troughs and shelters.

Feeding sites should be selected on:

- Soil type—can it take heavy trampling around the trough; what is the P status of surrounding country?
- Access—for efficient distribution and for checking consumption.
- Flexibility—movable feeders can be shifted to encourage animals to use various parts of a paddock and so relieve the pressure on conventional feeding areas.
- Location of watering points—placing licks away from watering points can encourage more even grazing patterns.

As P supplements must be available throughout the wet season, supplies have to be either replenished regularly during the wet or an adequate supply (to last up to 12 weeks) put out before the wet and protected from the weather. Alternatively the supply can be stored in a remote shed or shipping container, or in a loft under the lick shed's roof.

Some producers use 4WD quad bikes to deliver the supplement or to visit sites to monitor and feed out stored supplements. Some practical ideas are described in the case studies provided later in the book.



*Troughs and shelters – many and varied. Shelters reduce leaching of soluble P under heavy rainfall.*



*Troughs should be placed on higher ground or a pad built up to provide good drainage.*

# 7. Plants and phosphate fertiliser

Phosphorus can be applied to the soil to correct the deficiency in plants. This will improve plant growth, raise the phosphorus concentration of the plants and hence improve the grazing animal's diet and production.

## Superphosphate

Much superphosphate, as single super (9% P and 11% sulphur) or as triple super (20% P) has been applied to southern and some tropical pastures over the past century.



*Superphosphate is applied to pastures only in high-rainfall areas capable of heavy stocking rates.*

The current cost of phosphates means that economics restrict the application of superphosphate in northern Australia to all but tropical legume-based and grass pastures in the more coastal regions. Here, higher rainfall and related vigorous plant growth can allow the cost of applying superphosphate to be recovered. The extra grass and legume growth allows stocking rates of more than 1.5 animals per hectare producing 300–360kg of liveweight gain per hectare per year (Table 7.1).

**Table 7.1. Response to application of superphosphate fertiliser by animals grazing grass–legume pastures in higher rainfall regions**

Queensland region	Stocking rate (AE/ha)		Weight gain (kg/AE/yr)	
	No P	+ super	No P	+ super
Wet coast	1.3	1.8	125	165
Tablelands	1.2	1.5	145	230

## Legume pastures respond to P

Superphosphate is applied to grass–legume pastures because it can double or triple pasture yield, and greatly improve pasture quality.

Phosphorus improves the mineral concentration in the legume leaf, but also the sulphur in superphosphate allows the *Rhizobium* bacteria in the legume's root nodules to fix more nitrogen from the atmosphere. This nitrogen is used by the plant to grow more vigorously while raising the protein content of the legume leaf.

The protein is ingested by the animal and improves its growth rate. Some of it is returned to the soil through dung and urine, and through leaf fall, to boost grass growth. Thus superphosphate boosts total pasture growth and total animal growth.

## Sown pastures

Generally superphosphate is applied to pastures sown with improved species of grass and legumes, but is also applied to pure grass pastures that are heavily fertilised with nitrogen.

Forage legumes such as the trailing siratro and centro need moderate levels of soil P (eg 8–10mg P/kg) to grow well and persist. Amarillo forage peanut will persist under lower levels of soil P but still respond vigorously to superphosphate.



*Vigorous growth of the forage legume Amarillo peanut with application of superphosphate*

On the Atherton Tableland, soil levels of 30mg P/kg are recommended for highly productive pastures.



*Steer grazing signal grass–legume pasture fertilised with superphosphate*

### Legumes in native pastures

Native pastures are often oversown with hardy legumes such as the stylos. Seca and Verano stylo will grow in soils with marginal to low soil P (eg 4–6mg/kg).



*Seca stylo oversown into speargrass*

These legumes may be neglected by cattle when there is ample green grass leaf available but are grazed at the end of the wet season and into the dry season to provide extra protein in the diet.

Although the stylos will respond to superphosphate with better growth and higher concentrations of nitrogen and phosphorus in the leaf, superphosphate application is rarely economical once stocking rates are lower than about a beast to four hectares. At lower stocking rates, feeding the phosphorus directly to the animal through supplementation over the wet season shows a better economic response.

### Response to P supplement in wet and dry

Cattle on stylo pasture respond well to P supplement over the wet season when green grass is available. Cattle on pastures with sufficient stylo content will also respond to supplementary phosphorus during the early to mid dry season because their diet now has adequate protein and energy for growth.



*Steers grazing speargrass–stylo pasture may respond to P supplement during the early to mid dry season.*

### Loss of grasses

Oversowing stylos into native pastures may allow cattle to remain in good condition at considerably higher stocking rates than those on native grass-only pastures.

High stocking rates, aided by P supplement, can result in the loss of the more palatable grasses in a native pasture, resulting in an unstable stylo-dominant pasture with little or no grass.



*Legume and P supplement can allow overgrazing, loss of productive grasses and legume dominance.*

This may be reversed by reducing the stocking rate, burning at the end of the dry season and wet season spelling or even by applying superphosphate to boost grass growth.

## 8. Economics of phosphorus supplementation

Case studies in this book describe beef production systems incorporating phosphorus supplementation; however, it is generally difficult to isolate the actual benefit of the P supplementation on a property because other management changes can also contribute to the improved productivity.

To look at the effect of P supplement itself requires economic analyses in which other management changes such as weaning strategies, better genetics or infrastructure improvements remain constant.

The economics of P supplementation to correct phosphorus deficiency in north Queensland have been analysed using the BreedCow economic model (Tables 8.1 and 8.2).

### Croydon region, Qld (2011)

An analysis in 2011 used beef herd data from the acutely phosphorus-deficient Croydon area in the Gulf region along with productivity gains derived from the results of research and from practical experience.

### Assumed responses to P supplementation

#### State 1. No P in the wet season

A weaner lick (25% urea + 20% CSM, 10% GranAm™, 34.5% salt, 10% MDCP, 0.5% trace elements) fed at 100g/day from June to November (180 days dry season) would cost \$12.78 per weaner, while yearling heifers and steers (150g of lick/day for 150 days) would cost \$15.98 per head.

Breeders fed a mix (30% urea, 33.5% salt, 12% CSM, 14% GranAm™, 10% MDCP, 0.5% trace elements) would eat 150g/day for 180 days costing \$19.17.

#### State 2. With P supplement (10% P) in the wet season

Wet season lick at 9.6% P (46% MCDP, 10% lime, 8% GranAm™, 0.5% trace elements, 24.5% salt, 10% urea, 1% sulphur) costs \$775/tonne on property.

Breeders would eat 100g/day for 150 days = 15kg/head costing \$12.52; weaners would eat 50g/day costing \$6.26, yearling heifers and all steers cost \$9.39/head.

The herd with no P supplement (but some dry season urea-based lick) was of 4,000 adult equivalents (AE) or 6,032 head including weaners. The 2,944 breeders were mated to wean 1,276 calves. Steers were turned off at 42 months of age at an average live weight of 350kg.

For the supplemented herd, the total AE was 10% lower (3,600 AE) to account for the increased appetite of P-supplemented cattle.

In this herd of 4,828 head, 2,411 females (now 18% fewer) were mated to wean 1,287 calves. Total cattle number was reduced by more than the 10% AE reduction since the supplemented cattle are heavier.

Steers are now turned off a year earlier at 30 months of age at 360kg live weight.

Capital costs of \$22,000 include ten lick sheds erected using station labour and bush timber for \$1,000 each, and three second-hand shipping containers at \$4,000 each.

Depreciation and interest on the capital expenditure, written off over 20 years at 8% interest, would be \$2,240 per year.

On-going costs for labour at \$3,200 per year were for one day per week over 22 weeks (150 days) at \$150/day. Vehicle costs at 50km per run once a week for 22 weeks, at 70 cents/km are \$770/year.

Any benefits through reduced labour from quieter cattle and easier mustering are not included as both herds get dry season supplement.

The modelled output for herds with and without P supplement is shown in Table 8.1 with the costing in Table 8.2.

In this acutely-deficient district, feeding phosphorus supplementation nearly doubled the gross margin per AE (from \$57 to \$103/AE). The herd gross margin was improved from \$228,300 to \$371,700.

### Conclusion

Supplementing breeding and growing herds with phosphorus provides a good return on investment, and should be continued even with significant price rises in the cost of phosphorus.

Failure to supplement P on acutely phosphorus-deficient country is likely to make an enterprise uneconomical.

Table 8.1. Effect of P supplementation on herd output in the Croydon region, Queensland

	No P	With P
Adult equivalents (AE)	4,000	3,600
Total cattle	6,032	4,828
Breeders mated	2,944	2,411
Calves weaned	1,276	1,287
Weaning/cows mated	43.33%	53.37%
Breeder deaths	7.86%	4.18%
Female/total turn-off	37.24%	45.87%
Male turn-off	350kg @ 42 months	360kg @ 30 months
Average cow turn-off weight	400kg	420kg
Dry season supplement – breeders	\$19.17	\$19.17
Dry season supplement – heifers and steers	\$15.98	\$15.98
Wet season (P) supplement – breeders	Nil	\$12.52
Wet season supplement – heifers and steers	Nil	\$9.39
Gross margin/AE	\$57.15	\$103.26
Herd gross margin	\$228,299	\$371,738
Benefit from P supplement		\$143,439

Table 8.2. Financial costs and benefits from supplementation with phosphorus in the Croydon region, Queensland

Required capital expenditure	\$22,000
Capital amortisation over 20 years @ 8% interest	\$2,240
Additional labour @ \$150/day	\$3,200
Vehicle cost @ 70¢/km	\$770
Total new fixed costs	\$6,210
Advantage to P supplement net of new fixed costs	\$137,229/yr
Advantage per AE (on initial 4,000 AEs)	\$34.31

## 9. Case studies

### 9.1. Werrington Station, Georgetown, Qld

The Lethbridge family (Lux and Linley and son Russell and wife Donna) own Werrington Station, 19,500ha of mainly eucalypt woodland approximately 125km south-east of Georgetown.

Werrington Station carries most of the breeders (2,500 out of a total herd of 9,000–10,000 head) but is run in conjunction with 'Rainmore', 28,000ha of buffel grass on brigalow country south of Alpha, and other agistment on forest and downs country.

Werrington (average rainfall 700mm) has soils of varying fertility. Phosphorus levels are generally deficient: sandy country at 2–3mg/kg, decomposed granites 3–4mg/kg, red earths 2–4mg/kg, black soils 3–6mg/kg and Goldfield soils 7–8mg/kg.



Breeders run on hard phosphorus-deficient iron bark country on Werrington Station.

Each paddock is spelled for 4–5 months over the wet season every second year, with weaner paddocks spelled every year, and no burning for over 30 years. Some country has been oversown with Seca and Verano stylo and Wynn Cassia.

#### Herd management

Breeders have been control-mated to drop calves over the September to November period. All animals are vaccinated for botulism.

#### Supplementation

Breeders get both dry and wet season supplement. After the first frosts, weaner heifers get six months of the dry season supplement of M8U plus 1% P and 8% copra meal.

Wet season phosphorus supplement (9.1% P) is made up of 44% Kynofos™, 35% salt, 8% urea, 7% limestone, 4% GranAm™, 2% sulphur with 0.5% Rumigro™ vitamin and mineral mix, and costs \$865/tonne delivered (2012). Target intakes are 7–8g P/head/day for breeders and heifers and 4g/head/day for steers. When fed for 100 days over the wet season, this supplement costs \$7–8 per breeder.

Russell says, "In earlier days, some phosphorus was fed haphazardly during the wet season. Later we decided to get serious on phosphorus feeding and stopped trying to mix our own and got our recipe commercially mixed, and concentrated on getting recipes and intakes right."

"We soon noticed a 15–20kg advantage in the dressed weight of cull cows and a 15% branding advantage across the Werrington cows."



When breeders were fed phosphorus supplement in a trial, the branding rate increased by 15%.

"Feeding phosphorus maximises weight gains of the breeders over the wet resulting in higher condition scores at calving. To maintain branding rates, our cows must calve in condition score 3 or above. Phosphorus feeding over the wet is the key to achieving these condition scores."

"We now put out wet season phosphorus in half-tonne fertiliser bags; all supplement is put out before the wet, away from permanent waters."



All P supplement is put out in half-tonne bags before the wet season. Lux Lethbridge checks consumption of supplement in the late wet season.

“We estimate the net benefit of phosphorus is about \$130,000 a year without counting ease of mustering and the benefits of quieter cattle.”

### Werrington economic modelling

Without phosphorus supplementation, weaning rates (except for first-calf heifers) are assumed to be reduced by 15%, breeder death rates increase from 1.5% to 3.0%, only a portion of empty cows can be sold, and cow culling age has to be increased from 10 to 11 years. Mature cow weights (paddock and slaughter) are reduced by 40kg, and calf weight at five months is reduced from 150 to 130kg. Weaners are still supplemented.

These assumptions for the effect of P, especially its impact on breeder mortalities, may be conservative. No allowance has been made for the benefits of reduced mustering cost.

Net turn-off is calculated as total sales less purchases (bulls), divided by cattle carried for the whole year. The ‘Breeders’ columns in Table 9.1.1 can be compared since both are modelled to turn off weaner steers.

Table 9.1.1. Economic modelling across all properties showing benefits of feeding P supplement to breeders

	Breeders no P	Breeders + P
Adult equivalents	6,635	6,635
Breeders mated	4,763	4,129
Calves weaned	2,970	2,993
Weaning %	62%	72%
Net turn-off %	37%	41%
Steer turn-off age	Weaners	Weaners
Steer price (net)	\$250	\$289
Female price	\$499	\$546
Husbandry cost/AE	\$32	\$42
Gross margin/AE	\$116	\$132
Total GM	\$767,750	\$878,900

Similar numbers of steers are available to transfer to the fattening property (half of 2,993 or 2,970 respectively), though the unsupplemented steers are lighter and this may affect the profit performance of the fattening property.

P supplementation increases breeder gross margin (GM) by \$16.76/AE, or \$111,150 overall.



Feeding P supplement to the breeding cows helped produce this mob of healthy weaners.

## 9.2. Granville, Jericho, Qld

Glenn and Natalie Williams own 'Granville', 54km north-east of Jericho in the Desert Uplands, a region notorious for its low phosphorus soils. The property consists of 7,400 hectares of box and ironbark country, mostly on 'Texas sand' soils but with some black soil over red sand carrying significant areas of buffel grass. Some of the country, especially the swampy areas, is in good condition.

### History

When the Williams purchased 'Granville' in 1995 it consisted of two paddocks, power, no house, three silted-up dams and one bore. Productivity figures included:

- 9% mortality, partly because watering points were too far apart
- 52% conception rates
- 150kg average weaning weight (ranging from 100 to 250kg).

Problems experienced in their cattle included peg-leg, bone-chewing, some botulism, weak breeders at calving and 5% mortality rate due to prolapse.

In 1999, after attending a Grazing for Profit workshop, they began pulling about 1,600 hectares a year and planting Seca, Verano and Amiga stylo and buffel grass.

By 2002/2003, they had built their herd up to 3,000 head but had to almost totally destock in 2004 after the droughts of 2002 and 2003.

### Infrastructure

There is now a house with power, an excellent set of cattle yards, two sub-artesian bores, 74 water troughs, 137km of 63mm high-pressure poly pipe, and thirty-four 34,000 litre tanks. Four dams are fenced off so that all cattle are supplemented through their drinking water.

### Pasture and grazing management

Cattle are rotationally grazed on average every five days through 25 paddocks, with forage budgeting. Some 860 breeders are run in an 11-paddock rotation.

The Williams like to ensure that they always have three months' feed in front of the cattle



Cell grazing through 25 paddocks, with P through water medication.

but says Glenn, "The goal posts are shifting as rules change, as pasture changes and according to need, for example fattening versus breeding".

At the end of the growing season, the Williams do a pasture budget over the whole property, aiming for 2,400kg DM/ha at the end of the dry season. The budget estimates pasture quantity and quality (using F.NIRS), and they adjust their LSUs accordingly at the end of April.

They burn strategically every year if there is enough dry matter but not if agistment rates are high. Glenn says, "Tree suckers are getting a go-on so the pressure to burn is building."

Since 1997, Glenn and Natalie have rehabilitated much of the country from poor and degraded condition to A condition, and with the pasture improvement they can now run 30% more cattle. The return per adult equivalent has doubled to \$200.

### Supplementation

#### Before – dry lick only

Glenn and Natalie used to feed dry lick with urea during the dry season and phosphorus during the wet season, putting out the phosphorus to breeders six to eight weeks before the start of calving, and then right through the wet season. They did not have the previous data to measure the productivity response but the aim was to feed dry lick year round at a cost of 22 cents/kg beef produced. However, supplementation with lick was the

highest variable cost after fuel, and the cost kept going up.

They also had problems getting dry lick out during the wet season, and in shifting troughs when rotating cattle between paddocks. It took four hours to move the cattle from one paddock to the next and then the rest of the day to move the lick troughs. Glenn also reckoned that only 60–70% of their cattle were eating dry lick.

### After – with water medication

All cattle are now supplemented through a water-nutrient dispenser at troughs, with no more access to the dams. The water nutrient dispensers ensure that all animals receive supplement and allows Glenn to adjust intake levels based on diet quality monitored using faecal NIRS.



Glenn checks the automatic nutrient feed.



Soluble form of P for water medication

All breeders are provided with lick all year round. The cost previously was \$1.05/head/week for wet and dry season licks, regardless of whether a cow is wet or dry.

Feeding dry lick and wet-season P has allowed the Williams to move from continuous mating to controlled mating with reconception rates in their first-calf breeders of 60–70%.

All northern cattle coming onto agistment are fed up to 140g phosphorus lick/day for 3–4 weeks even if their normal requirement is only 50g/head/day to ensure that any phosphorus lost through a pre-existing phosphorus deficiency is replaced.

Overall responses to P supplement (and to pasture improvement and breeder management) can be demonstrated in Table 9.2.1. Breeders were initially given P-medicated water during the wet season (or dry P lick if they could drink from surface water) and subsequently given P and N through water medication throughout the year (with surface water fenced off).

Table 9.2.1. Effects of various P supplementation regimes on productivity

	Weaning weight (kg)	Cull cow* weight (kg)	Increased conception
No dry season P	150	350	
P all wet season and two months before calving	180		
P all year round	210	550	11–15%

\*Cull cow – either weaners' mother condition or PTIC

Mortality has dropped from 5% to 1% with year-round supplementation.

The current cost of feeding is 45¢/LSU/week (LSU = 400kg animal maintaining weight).

### Vaccinations

Bulls are vaccinated for vibriosis, 3-day, botulism, pestivirus and 7-in-1, and given a worm drench. Breeders are vaccinated for botulism, vibriosis and leptospirosis.

The Williams no longer use HGP's because they felt that their cattle did not present well if they had a HGP during a dry season with poor nutrition.

### Weaner management

In the year after weaning, young stock are now gaining 200kg through improved pasture and strategic phosphorus and dry season supplementation. Previously, the weaners were gaining 130kg a year.

## 9.3. Tara Station, Cloncurry, Qld

Tara Station, near Cloncurry, has been in Dan Lynch's family for generations. Tara is a 14,000ha property comprising 90% black soil and 10% red country. Most paddocks have some hard ridges that are important during the wet season. The black soil carries Mitchell grass and Flinders grass whereas pulled country has been seeded to buffel. The red country with hard ridges has silverleaf box and spinifex.

When Dan took over from his father in the late 1990s he realised that the current grazing practices were not sustainable.

Controlled mating tightened the calving window, and culling all empty breeders increased breeder efficiency allowing him to stop feeding dry season supplements.

Instances of peg-leg at a neighbour's property started Dan hand-mixing his own phosphorus lick for a wet season supplement.

### The herd

The total herd is about 4,000 mainly Brahman breeders and heifers, with 2,000 of these running on a nearby agistment block of silverleaf box and spinifex country. Paddocks on both properties are grazed in rotation, with Tara having 42 paddocks averaging 365 hectares and with two to four watering points in each.

About 2,700 calves are branded. Males are turned off at 17 months weighing 370kg to whatever market is paying best. This is mostly live export, but could be to southern markets. Cull females are sold direct to meatworks in either Townsville or Rockhampton.

### Management and supplements

After weaning, steers are given phosphorus supplement during the next wet season and then sold at about 17 months. All heifers receive wet season P, with replacements seasonally mated at two years of age. Bulls go into the breeder herd in mid-January and come out on the pregnancy test muster in May or June. All empty cows are culled so few reach old age.

All breeders and bulls are vaccinated with C and D botulism each year.

### Present supplementation

Dan finds that getting as much phosphorus as possible into the breeders during the wet, along with controlled mating, reduces the need for costly dry season supplements. Now he provides dry season supplements only in bad years, for example, he fed 0.8–1g urea per litre of water delivered through water medicators in 2010 when rain spoiled the dry grass.

In response to chronic peg leg and bone breakages, Dan started using a cement mixer to make his own P supplement, and he fed his mix of Ferafos™, salt, lime and a true-protein source to cattle during the dry season. He then got a local feed merchant to mix the recipe for him.

Feeding the mix during the dry season gradually evolved to a wet season supplement. Work with the local feed merchant has led to the current mix of 48% Kynofos™, 10% urea, 5% sulphur, 20% salt, 4% lime, 12% cottonseed meal plus 1% mineral mix.

He starts feeding his P supplement two to three weeks after the start of the wet (50mm of rain in 2 days)—usually the second or third week in January. He has noticed that the cattle start looking for the P supplement two weeks after feeding on green grass.



*P supplement is put out two to three weeks after the start of the wet season. Cattle start looking for it about two weeks after eating green grass.*

Breeders start eating 100g per head per day for two to three weeks but then drop to 60g per day. Weaners start at 60g per head per day and then drop to 40g per day.

Dan keeps feeding wet season P until pasture quality drops below 6% crude protein with a dry matter digestibility of 55% – as determined by F.NIRS dung samples taken every two months.

The plastic supplement troughs are not covered because it would make them too heavy and awkward to shift all the time. The plastic troughs are light and can be easily shifted on the quad bike.



*Shallow plastic troughs are easy to move but cows and calves can sometimes dung in them.*

Each week at Tara, Dan puts out five to six days' supply of lick (four 25kg bags per trough) in two small plastic troughs at each water. He uses a quad bike to carry at least four bags—two on the front, two on the back—and has made a metal frame to allow him to stack four or more plastic troughs on the back when needed.

On the agistment property, he puts out a month or more supply of lick at a time into larger plastic troughs with holes in the bottom. He keeps an eye on the weather using Rainman and the Bureau of Meteorology website and puts out what he thinks will last until the rain. The amount going into the troughs changes depending on the weather.

He says that it is not too big a problem as he has to go to only two or three paddocks to feed the entire herd due to the regular rotations. This may take a day in the Toyota in dry weather but two days in the wet using the four wheeler.

In big wet years such as 2009, he had trouble getting lick out when it rained for over a month, but put it out as soon as possible and did not notice any change in production.

All lick loads are logged on a whiteboard in the shed and consumption monitored.

### **Tara gross margin modelling**

The Tara operation was modelled using Dan's good data for weaning and death rates and sale weights. These represented averages over the 10 years since the current management system was implemented. The benefit of feeding the phosphorus supplement cannot be separated from the other changed practices.

Modelling is based on a herd size of 6,000 adult equivalents, based on 4,067 females mated (including heifers), 3,055 retained after sales (mostly on pregnancy test), producing 2,667 weaners. Modelled turn-off is 1,320 steers aged 17 months and 1,255 surplus cows and heifers.

The calculated gross margins (GM) and adult equivalents (AE) are shown in Table 9.3.1. The breakup of GM between breeders and steers is based on an assumed transfer value of weaner steers (1,320 at 154kg at 5 months) of \$257/head net.

**Table 9.3.1. Gross margins for feeding components of the herd**

	Herd	Breeders	Steers
Total AE	6,000	5,321	679
Total GM	\$1,022,620	\$683,465	\$339,155
% of herd	100%	89%	11%
% of GM	100%	67%	33%
GM/AE	\$170.44	\$128.45	\$499.30

The marked disparity of GM/AE between the breeding and fattening parts of the enterprise is consistent with all previous similar modelling, with the high return on the steers being aided by the low AE rating (0.51) on account of their light weight.

These results represent a combined return to a number of husbandry practices including seasonal calving (reducing the need for supplementation), and careful control of nutrition through grazing management, F.NIRS analysis and wet season P supplementation.

## 9.4. Watson River, Cape York, Qld

Cameron and Doreen Quartermaine own 'Watson River', 89,000 hectares on Cape York south of Weipa. They run 6,000 head mainly on native pastures but with 325 hectares of improved grasses and legumes on cleared country. The soils are grossly phosphorus deficient.



*Cameron and Doreen Quartermaine manage some of the most difficult country in Queensland.*

Only half of the total area has been developed with nine main paddocks, 31 lick sheds and four shipping containers as wet season lick depots. Getting around to deliver 50 tonnes of supplement during a monsoon season that drops 1,500mm of rain is challenging.



*Flooded creeks during the monsoon make distribution of P supplement difficult on the Cape York Peninsula.*

### Herd husbandry and supplement

Breeders and heifers are vaccinated for botulism. Cattle are mustered by picking up mobs from each lick trough. The lick feeding, combined with culling for temperament, has resulted in quiet cattle, and the lick sheds are in a reliable location to collect cattle.

Weaning rates on Watson River are around 70%, and breeder losses are normally 1% but up to 2.5% in bad years. Lick for the main group of weaners costs \$28.37/head, while feeding smaller weaners costs \$75.40/head.

All stock get P supplement over the wet season (about 120 days) but dry season urea licks are fed only in tough years as it costs \$7.88/breeder. The cost of dry season supplementation is greatly reduced through an effective wet season P feeding program. Weaners are trained to eat wet and dry season lick.

The wet season supplement (14% P) is 67% DCP, 23% salt, 5% GramAm™, 2% each of lime and molasses and 0.5% premix. Target intake is 70g/head/day for breeders and heifers and 35g for steers.

The aim is to deliver 70g of lick/head/day over 120 days across the whole property. In the 2009/2010 wet season, 50 tonnes of supplement at \$919/tonne (\$789/tonne lick plus \$130/tonne freight) cost a total of \$44,450. Over the whole herd, the cost/AE is \$11; cost/head is \$7.40.



*Lick troughs shelters are substantial and include back-rubbers.*

Lick troughs are sheltered from the rain by substantial sheds built of bush timber (Cooktown ironwood) and corrugated iron, with backrubbers (for buffalo fly control) under the same roof.

Bulk supplies of lick and backrubber chemicals are stored in the paddock in shipping containers. Each container can hold about 14 tonnes of wet-season supplement, and is filled well before the start of the wet season—usually in November.



Bulk supplies are stored in the paddock in shipping containers with troughs inspected and replenished using quad bikes.

Quad bikes are used to replenish lick troughs and backrubbers on a weekly basis, but Cameron has had to build bridges over the numerous creeks to get around during the wet season.



Bridges on Watson River to cross the numerous flooded creeks to feed phosphorus.

Cameron explains the importance of feeding phosphorus, *“In the mid-90s, we fed a bad batch of lick that our cattle refused to eat. This immediately resulted in peg-leg, higher deaths the following dry and noticeably less calves the following season. We also observed*



High troughs reduce contamination with dung.

*increased deaths as surviving calves chased any surviving cows for milk.”*

*“We have always been convinced about the cost-effectiveness and production benefits of feeding P, but that experience reinforced that P supplementation is a must for all cattle in our country—every year.”*

*“We believe that stopping the P supplement would increase breeder losses from 3% to 8–10%, the heifers would not conceive until three years of age (currently two), and from then on would wean about 45%—which leaves almost no scope for heifer sales. All cattle would gain 40kg less in the wet season and even the best fat cows would be about 340kg which would carry a price/kg penalty.”*

*“Wet season P increased our bottom line by at least \$60,000 from more calves, less deaths and better weights. On top of this, there are huge savings on mustering and cattle handling costs as cattle are quieter and can be collected from lick points.”*



P supplement makes for quiet cattle that are easier to muster in the heavily timbered country.

## 9.5. Kidman Springs, VRD, NT

Rohan Sullivan managed the Northern Territory Government Kidman Springs Research Station in the VRD, about 220km south-west of Katherine, before managing his own family property Cave Creek, at Mataranka, 100km south of Katherine. In this case study, Rohan tells how he implemented successful year-round supplementation programs on both properties and the results he has observed.

Both operations graze native pasture with Kidman being on Emu red earths, Kununurra cracking clays and Kidman earths, and Cave Creek (1,250 square km) on savannah woodlands with sandy red soils and some black soil creek frontage. Both have continuous mating with twice yearly weaning. Both operations vaccinate annually against botulism.

### Changed management

In 1990, a new management package at Kidman Springs included year-round supplementation of breeders. Animals were fed a dry lick mixture of Kynofos™, sulphate of ammonia and salt during the wet, with urea added over the dry season. The target consumption of 100g/breeder/day in the dry and 50g/day in the wet worked out at \$24/head/year. The change from dry season lick to wet season lick was made when there was a noticeable 'green pick'. Wet season access around Kidman was good so lick was distributed weekly into troughs under shelters, and this prevented cattle from gorging themselves.

Rohan noticed a remarkable difference in the cattle, under the new management system. *"It is difficult to pin point exactly what difference the wet season supplement made, but the whole change in management program saw breeder mortality reduce from 12 to 4%. Cows were stronger and were able to feed out further from watering points. After 18 months, weaning rates had increased from 50 to 80% and average weaning weights had increased by 30kg."*



When Rohan moved to his family-owned property Cave Creek, he decided to continue the supplementation program he had used at Kidman.

*"The results I observed at Kidman were phenomenal, it was enough to convince us to use lick when we bought Cave Creek."*

At Cave Creek, Rohan uses a loose mix similar to that used at Kidman, with the same budgeted consumption rates and an annual cost of \$20/head. Animals are fed salt for a couple of weeks before starting dry season supplementation to stop animals from gorging when the first dry season lick is put out. Dry season supplement is distributed weekly on the bore run.

Cave Creek has reduced access during the wet, so most supplement is put out in tractor tyres after the first few storms.

*"A neighbour put his lick out in bulk bags last wet and just cut slits in the top of the bag. The lick lasted all wet and was protected well from weather, I think I will try this next wet."*

Rohan comments, *"Although feeding lick is costly, I don't think we would survive as a cattle business without it. We have always fed supplement on Cave Creek so it is difficult to know exactly what the benefit is, but I am sure our mortality would be higher and our weaning rates would not be near what they are. The other benefit I see is that it keeps our cattle quiet, and I don't think you can put a value on that."*

## 9.6. Napier Downs, Kimberley, WA

Peter Leutenegger owns and manages Napier Downs, some 135km north-east of Derby in the Kimberley region of Western Australia. Napier Downs has a mix of land systems ranging from black soils with some bauhinia species to lighter ‘pindan’ country with eucalypts and acacia.

### Herd management

The main cattle enterprise is breeding high-grade Brahmans for live export markets.

Breeders are generally mustered twice each year with calves branded and weaned at each muster, with an average weaning rate of 72%.

### Supplementation

While cattle show no symptoms of phosphorus deficiency on most of Napier Downs, breeders, and especially calves, running in the Hawkstone and Limestone paddocks on a mix of black soils and pindan country did not perform as well as could be expected. Providing a dry-season supplement of urea-based blocks that included some P in these paddocks during 2006 improved breeder performance but cattle still chewed bones and some were showing lameness.

Wet-season supplementation with phosphorus blocks was introduced in these two problem paddocks in the 2007–08 wet season.

*“My observations are that cows are healthier and heavier, and the same for the weaners”*, says Peter.

Branding records of the 2,000 breeders running in these paddocks indicated higher branding rates.

### P supplement system

After significant rainfall, access to these paddocks is restricted because of the areas of black soil and some watercourses. As a result, sufficient 100kg phosphorus (Phosrite™) blocks to last for several months are put out, usually in late November; they appear to handle the weather well. Because cattle in these areas are supplemented with urea-based (Uramol™) blocks from about mid-year, intake



*100kg phosphorus blocks are put out in late November, and last for the whole wet season.*

of phosphorus blocks is not great at the end of the dry with cattle generally preferring the softer and more palatable Uramol™ blocks. Intake of phosphorus increases through the wet season in February and March.

*“The blocks put out at sites away from the waters usually last all the wet and often are not eaten until towards the end of the wet season”*, says Peter.



*Cattle prefer the softer and more palatable urea-based blocks initially but go for the phosphorus blocks in February and March.*

During the 2009–10 growing season, consumption of phosphorus blocks averaged 120g a day over January to March. This intake provided about 6g P/head/day for the 2,000 head at a cost of approximately \$18.60 a head. Urea-based Uramol™ blocks (3.6% P) fed during the 2009 dry season were consumed at a rate of about 140g/head a day, and provided about 40g of urea and 5g P/head/day at a

cost of approximately \$27.50 a head. Thus the total cost of supplement for the year was \$46 a head.

Phosphorus has been tried on other areas of Napier Downs with varying consumption.

*“I fed it to some other cattle as well. The other areas where we fed Uramol™ and Phosphrite™ are not as deficient. Cattle ate the Uramol™ blocks, but did not gorge them as they can do in the problem paddocks. They hardly touched the Phosphrite™ in the wet and are just nibbling at it now (September 2010). The only area that the Phosphrite™ was cleaned up, and they are still looking for it, is near the limestone range where cattle water on a spring.”*



*Hard P blocks chewed by cattle last the whole wet season but may restrict intake of P.*

### Napier Downs economic modelling

The performances of the 2,000 cow herd in the P-supplemented area before and after supplementation were compared using the Breedcow herd model. Branding rates recorded in 2005 are compared with the average of the branding rates recorded for the same area over 2007–2009. Female sales as a percentage of total sales averaged over three-year periods for the whole station were used to indicate likely female death rates before and after supplementation.

Breedcow outcomes are summarised in Table 9.6.1. Results are presented as a fixed number of breeders (2,000 head) and as adult equivalents (AE) in each of the before P and after P scenarios. AE represents the same stocking pressure from the slightly different herd compositions resulting from a more efficient supplemented herd.

This modelling indicates a 30% increase (\$121) in gross margin per AE (net sales less per head costs/AE) for the 2,000 breeders supplemented, and reflects a combination of more weaners from better reproductive rates, slightly fewer deaths and more valuable males and surplus females.

The response to P supplement alone cannot be separated from the combination of dry season urea and phosphorus and phosphorus during the growing season, but is clearly worthwhile.

Table 9.6.1. Modelled benefits from feeding P supplements to breeders

Category	No P supplement	+ P supplement	AE (+ P supplement)
No. of breeders	2,000	2,000	1,900
AE	3,125	3,300	3,125
Wean % (from records)	64	82	82
Weaners	1,285	1,555	1,475
Females sold	360	575	545
Males transferred	640	780	735
Female sales % (from records)	36	42	42
Female sale price (2009/10)	\$455	\$505	\$505
Male weaner price	\$200	\$250	\$250
Net sales	\$293,000	\$484,000	\$459,000
Direct costs (excluding bulls)	\$17,000	\$115,000	\$109,000
Gross margin (GM)	\$252,000	\$345,000	\$327,000
GM/AE	\$80.67	\$104.65	\$104.65

## 9.7. Yardoogarra, Broome, WA

'Yardoogarra' is on the coast south-west of Broome. The 72,000 hectare property is mostly phosphorus-deficient red sandy loam 'pindan' country, with 5,000 hectares of highly productive marine plain. Breeders are run on the pindan; weaners, heifers and sale cattle run on the coastal plains.

John and Tricia Grey have been on Yardoogarra since 1969. All breeders had some access to good-quality grazing on the coastal plain country up to 1986, after which they were confined solely to the pindan country.

### Herd management

Breeders were control-mated each year, bulls in from mid-February to June, from 1990 to 1999. P supplement was introduced to overcome a lameness problem. Control mating was discontinued in 2000.

Excellent cattle records are maintained on Yardoogarra and indicate an average weaning rate of 56% over the last five years. Female sales as a percentage of total sales averaged over the same period were 44%.

### Supplementation

John comments, *"By the second year on the pindan, it was apparent we had a problem with lameness and thrift in lactating cows. A neighbouring property had similar problems and together we drifted into supplementation starting with salt, urea and MAP-DAP mixes."*

Early on, fertiliser-based supplements markedly reduced peg leg and, although *"cows were certainly stronger at the end of the year"*, it did not eliminate lameness.

### High fluorine

This persistent lameness was eventually diagnosed as damage to smooth surfaces of joints caused by an excess of fluorine. Fluorine in most of the bore waters at Yardoogarra was exacerbated by the fluorine from the MAP-DAP. As a result, John switched to mono dicalcium phosphate (MDCP) as Kynofos™ in 1992.

He started purchasing Kynofos™ in 21.5-tonne container lots, initially delivered by ship

to Broome, but later containers have been trucked from Fremantle and off-loaded on the property. Around 10 tonnes of Kynofos™ are fed each year so one container lasts for two years.

The price of Kynofos™ consignments delivered to Yardoogarra in 21.5 tonne container lots increased from \$892/tonne in 2006 to \$1,334/tonne in 2009. Because of the price increase, only 10 tonnes were purchased in 2008.

### Supplement mixes

High-grade Brahman breeders are run on the pindan country of Yardoogarra at a stocking rate of one breeder per 40 hectares, and are supplemented all year with home-mixed supplements of Kynofos™, salt, urea and sulphate of ammonia. The recipe is varied from time to time to achieve target intakes. Urea is not added during the wet.

Kynofos™ provides 40% of the supplement in the wet season and 20% in the dry season. Supplement is mixed on the station and fed out in troughs as a loose mix every three to four days throughout the year.

When there is green feed (usually December to May), the target intake is 8g P/head/day, but 4g/head/day during the dry. Consumption during 2009 averaged almost 6g P/head/day.

The cost of total supplement fed averaged over the almost six years (2005–2010) (including the high price for P and urea in 2008–09) was around \$19.50/breeder/year or \$1.60/month, with the phosphorus component costing around \$14 a year.

### Cattle response

As supplements containing at least some P have been fed for over 20 years, it is not possible to clearly determine cattle performance before P was fed. Records averaged over five years from 1991 (Kynofos™ introduced in 1992) indicated an average weaning rate for that period of around 49%.

These records indicate that while weaning rates are not 'spectacular', they are accurate and have improved over time. The percentage of

females sold indicates that female death rates are low, and reflect effective supplementation and management on the grossly P-deficient pindan country.

*“By feeding phosphorus in our pindan country, we have eliminated the problem of lameness in our breeders, and we are confident that cows can now raise a calf and remain healthy.”*

### Yardoogarra economic modelling

The Breedcow herd model was used to compare the performance of a 1,000-cow herd before and after supplementation. Inputs into this model have been based on animal performance and sale price information provided by John and Tricia Grey at Yardoogarra in 2010 and information and experience from other sources (Table 9.7.1).

#### Modelling assumptions

1. ‘Current performance’ is based on recorded weaning rates, percent female sales averaged for the period 2002–03 to 2008–09, and 2009 turn-off weights and prices.
2. ‘Before P’:
  - Weaning rate 49% – indicated from Yardoogarra 1990 records.
  - Breeder death rate up to 9% – based on female sales and weaning rate.

- Female sales as percentage of total sales reduced to 39% – see below.
- Prices reduced by about 10% – to reflect lower sale weights of unsupplemented cattle at the same age.

While the breeder death rates ‘before’ are estimates, a recent survey in the Kimberley recorded female sales as 38% of total sales averaged over two years. This indicates that 39% female sales is realistic for P-deficient country in this region.

Breedcow modelling outcomes are summarised in the table below. Results are presented as a fixed number of breeders (1,000 head) and as adult equivalents (AE) in each of the before P and after P scenarios. AE represents the same stocking pressure from the slightly different herd compositions resulting from a more efficient, supplemented herd.

While the exact economic response to supplement is difficult to determine accurately, the response in the gross margin (approximately 25% increase per 1,000 breeders) indicated by the Breedcow modelling confirms the opportunity to improve enterprise profitability on P-deficient country.

Table 9.7.1. Modelled response to P supplement at Yardoogarra

Description	No P Supp	+ P Supp	AE + P Supp
No. of breeders	1,000	1,000	950
(AE)	1,700	1,800	1,700
Wean %	49	56	56
Weaners	505	570	540
Females sold	155	225	215
Males sold	240	280	265
Female sales %	39	45	45
Female sale price	\$450	\$500	\$500
Male price	\$540	\$595	\$595
Net sales	\$201,000	\$277,500	\$262,000
Direct costs (excluding bulls)	\$13,500	\$46,500	\$44,000
Bull replacement	\$12,500	\$12,000	\$11,334
Gross margin	\$175,000	\$219,000	\$207,000
\$ response to P		\$44,000	\$32,000

# Appendix 1.

## Regional vegetation types

Table A.1.1. The phosphorus status of soils based on vegetation types

Soil-vegetation	Distinguishing features	P status
<b>Southern Queensland</b>		
Wallum	Coastal lowlands; sandy loams with clay subsoil; open forest of bloodwood to tea-tree and <i>Banksia</i> ; also deficient in other essential minerals	Deficient
Darling Downs	Highly fertile brown, red and black cracking clays	Adequate
Traprock	Uplands around Stanthorpe; eucalypt woodland on shallow dense loams	Marginal to deficient
<i>Aristida-Bothriochloa</i>	Sandy surfaced duplex soils supporting eucalypt-acacia woodland	Marginal to deficient
Brigalow-belah	Deep grey, brown and red cracking and non-cracking clays	Adequate
Mitchell grass	Rolling downs, floodplains and channels	Variable
Poplar box woodlands	Red and brown soils with distinct B horizons; poplar box, silverleaf ironbark	Marginal to adequate
Poplar box-mulga	Sandy to loamy red earths supporting mulga with some poplar box	Deficient
Cypress pine-bull oak, ironbark	Sandy loams, deep sands and shallow hard-setting clay loams	Deficient
Black speargrass (a) Spotted gum ridges	Spotted gum, wattle, narrowleaf ironbark	Deficient
(b) Steep ironbark slopes	Narrowleaf ironbark on podzolic soils derived from granite	Marginal to adequate
(c) Lower ironbark slopes	Silverleaf ironbark	Adequate
(d) Blue gum flats	Alluvial and basaltic flats	Adequate
(e) Basaltic soils	Grey, brown and black cracking clays	Adequate
<b>Western Queensland</b>		
Mitchell grass downs and flooded alluvials	Open grasslands; grey and brown cracking clays	Variable
Mulga	Mulga with poplar box, gidyea, sandalwood	Deficient
Gidyea	Gidyea scrub often sown to buffel grass	Adequate
Spinifex	Spinifex and wire grass; shallow, gravelly sands to loams and earths	Deficient
Channel country	Intermittently flooded channels and floodplains	Adequate
<b>Central Queensland</b>		
Flood plains	Coolibah, poplar box and bluegum over speargrass	Adequate
Queensland bluegrass	Open grasslands on cracking and non-cracking clays	Adequate
Brigalow-softwood scrub	Duplex to cracking clays	Adequate

Soil–vegetation	Distinguishing features	P status
Black speargrass; <i>Aristida-Bothriochloa</i>		
(a) On red-brown soils developed on granite	Silver and narrowleaf ironbark on duplex soils and structured earths with red-brown clay subsoils; rolling country	Adequate
(b) Shallow soils on volcanic rocks and granites	Rolling to steep mountains carrying narrowleaf ironbark, lemon-scented gum and brush box on shallow skeletal soils and shallow duplexes	Adequate
(c) Duplex soils on sedimentary and metamorphic rock	Undulating eucalypt woodlands with narrow and silverleaf ironbark, poplar box and gum-topped box; duplex soils with heavy clay subsoils	Marginal to deficient
(d) Yellow duplexes on granite	Sandy-surfaced soils with yellow clay subsoil; silverleaf ironbark, gum-topped box, poplar box, sandalwood	Deficient
(e) Red and yellow massive earths	Level to undulating plateaus and plains; narrow and silverleaf ironbark woodlands with wattles, quinine and ash; desert and pitted bluegrass, wiregrass with spinifex in the north-west	Deficient
(f) Shallow soils on hills and mountains	Rolling to steep mountains; ironbark, lancewood, bendee, rosewood and wattles	Deficient
Saltwater couch pastures	Along coastline; saline non-cracking soils	Adequate
Blady grass pastures	Bloodwood, stringy bark, poplar gum and teatree; variable soils	Variable, marginal to deficient
<b>Northern Queensland</b>		
Red, grey and yellow earths	Sandy to hard-setting; termite mounds common; eucalypts, teatree, wattles; much of Peninsula, west and south of Charters Towers	Deficient
Sandy soils	On coast; teatree, stunted eucalypts; Croydon sandy forest, cypress pine	Deficient
Bluegrass–browntop plains	South of Gulf of Carpentaria, open grasslands with eucalypts in water courses; grey to brown self-mulching soils	Marginal
Red and yellow duplexes	West and south of Charters Towers, coastal strip south of Townsville; ironbark, poplar gum, bloodwood	Marginal
Georgetown granites	Around Georgetown; grey box, lancewood, bloodwood, ironbark	Marginal to adequate
Frontage country	Alluvial soils along main streams	Adequate
Basalt country	North-west of Charters Towers; ironbark; deficient in salt and sulphur	Adequate
<b>Northern Territory (south)</b>		
Spinifex	Sand plains and sandy rises; sparse shrubs of blue mallee	Deficient
Mulga	Dense forests to open woodland on red earth plains and alluvial plains	Deficient
Bluebush/saltbush	Southern bluebush and bladder saltbush with mulga, Georgina gidyea and myall	Adequate
Gidyea	Georgina gidyea on sandy plains and shallow gravelly loams	Adequate
Mitchell grass	Cracking clay soils with Mitchell grass along the bases of the ranges and with open woodland of Georgina gidyea	Variable
Flooded country	Channels and floodplains; coolibah, river red gum	Adequate

Soil–vegetation	Distinguishing features	P status
<b>Northern Territory (north)</b>		
Tallgrass pastures	Eucalypt woodland, sorghums, giant speargrass, ribbon grass; sandy to stony skeletal soils and red and yellow earths	Deficient
Midgrass pastures	Low eucalypt woodland, <i>Aristida</i> and ribbon grass on yellow earths; north of Mitchell grass plains	Deficient
Shortgrass pastures	In Victoria River basin, calcareous loams; bloodwood, southern box woodland with <i>Enneapogon</i> , <i>Aristida</i>	Marginal
Spinifex	Curly spinifex in Arnhem Land, Gulf, VRD and Barkly Tableland	Deficient
Mitchell grass	Barkly Tableland and VRD; black soil plains grading into coolibah woodlands; deficient in sodium and sulphur	Deficient; variable towards Qld border
Saltwater couch pastures	Coastal saline flats of loams or grey clays merging into fringing salt pans	Adequate; adjacent country deficient
<b>Western Australia (Kimberley)</b>		
Pindan	Curly spinifex and ribbon grass; red and yellow sands with low scrubby woodland	Deficient
Spinifex	Curly and soft spinifex with eucalypt open forest	Deficient
Tallgrass pastures	Ribbon grass, kangaroo grass, cane grass and black speargrass under eucalypt woodland	Deficient
Midgrass pastures	Ribbon grass, bluegrass, brown top, kerosene grass, wire grass under low eucalypt woodland	Deficient
Shortgrass pastures	Ribbon grass, <i>Enneapogon</i> , curly spinifex under open eucalypt woodland of bloodwood and southern box	Marginal
Mitchell grass	Black soil plains in eastern Fitzroy basin, extending north-west into the Meda and May River basins; deficient in sodium	Marginal
Frontage	On levees of major rivers – Fitzroy and Ord and tributaries; ribbon grass, bluegrass, sorghum under open eucalypt woodland	Adequate
<b>Western Australia (Pilbara)</b>		
Spinifex	Hard and soft spinifex on rocky outcrops and sand plains with scattered <i>Acacia</i> shrubs	Deficient
Mulga	Shrubland of mulga, sandalwood and cassia with <i>Aristida</i> and sparse annual grasses	Deficient
Bluebush/saltbush	On hard-setting loams over red clays in low shrubland; sparse seasonal grasses	Marginal
Coastal plains	Tussock grasslands; Roebourne plains and buffel grasses	Marginal
Mitchell grass	Fortesque flood-out country and on basaltic soils in Chichester and Hammersley Ranges	Adequate
Frontage	On levees of rivers and streams	Adequate

## Appendix 2. Total phosphorus requirement

Table A.2.1. Approximate amounts of **total P** needed in the diet by steers and heifers, breeders in late stage of pregnancy or lactating

Class of cattle	Weight gain (kg/day)	Milk (L/day)	Total P needed (g P/day)
Growing cattle (steers and heifers)			
200kg	0	-	4
200kg	0.3	-	7
200kg	0.6	-	11
200kg	0.9	-	14
200kg	1.2	-	18
400kg	-0.3	-	4
400kg	0	-	7
400kg	0.3	-	10
400kg	0.6	-	14
400kg	0.9	-	18
400kg	1.2	-	21
Late pregnant breeders (last three months)			
400kg	-0.3	Nil	6 <sup>1</sup>
400kg	0	Nil	9 <sup>1</sup>
400kg	0.3	Nil	13 <sup>1</sup>
400kg	0.6	Nil	17 <sup>1</sup>
Lactating breeders (producing 5L milk /day)			
400kg	-0.3	5	13 <sup>1</sup>
400kg	0	5	17 <sup>1</sup>
400kg	0.3	5	20 <sup>1</sup>
400kg	0.6	5	23 <sup>1</sup>

<sup>1</sup> Assumes no mobilisation of P from body reserves. This mobilisation could be up to 4g P/day during late pregnancy, 10g P/day during early lactation and 4g P/day during mid lactation.

## Appendix 3. Faecal NIRS analysis

Table A.3.1. Estimated phosphorus requirements of various classes of cattle and threshold values for adequacy of dietary P based on research results currently available

Class of cattle	Diet DMD from F.NIRS (%)	Expected weight gain (kg/day)	Diet P required (g/day) <sup>1</sup>	Required faecal P (g P/kg faecal DM)	Required faecal P/diet ME (mg P/MJ ME) <sup>2</sup>
<b>Growing cattle (steers and heifers)</b>					
200kg	50	-0.3	1	0.8	110
200kg	52	0	4	2.1	280
200kg	54	0.3	7	2.9	380
200kg	56	0.6	11	3.4	430
200kg	58	0.9	14	3.8	460
200kg	60	1.2	18	4.2	480
400kg	50	-0.3	4	1.5	220
400kg	52	0	7	2.1	290
400kg	54	0.3	10	2.5	330
400kg	56	0.6	14	2.8	340
400kg	58	0.9	18	3.0	360
400kg	60	1.2	21	3.2	370
<b>Late pregnant cows (last three months)</b>					
400kg	50	-0.3	6	2.2	310
400kg	52	0	9	2.7	370
400kg	54	0.3	13	2.9	380
400kg	56	0.6	17	3.1	390
400kg	58	0.9	20	3.3	400
<b>Lactating breeders (producing 5L milk/day)</b>					
400kg	50	-0.6	10	2.9	460
400kg	52	-0.3	13	3.1	440
400kg	54	0	17	3.3	420
400kg	56	0.3	20	3.5	410
400kg	58	0.6	23	3.6	390

<sup>1</sup> Any net mobilisation of P from body reserves will reduce these required amounts.

<sup>2</sup> Ratio of faecal P: Diet ME (mg P/kg faecal DM divided by the diet ME) – the concentration of P in faeces to the ME of the diet at which dietary P requirements should be met. If the value is lower than the value in the table, the animals should respond to supplementary P.

The faecal P concentration, and the ratio of faecal P to metabolisable energy (ME) in the diet, can indicate whether the diet provides sufficient P without mobilisation of any body P reserves.

However, the correlations between concentration of P in the diet and in the faeces and the correlations between DMD, DM intake and weight gain have not yet been validated for many land systems and, in some

circumstances, there has been no response to a P supplement although the faecal P test indicated a deficiency.

Other complicating factors are that cattle should not have been fed P supplement in the two weeks before sampling and that they have adequate pasture.

Thus the results of faecal P and NIRS analyses are best interpreted by a cattle nutritionist with specialised knowledge.

## Appendix 4. Blood P analysis

Table A.4.1. Likely weight changes in steers or non-lactating heifers or cows relative to blood P concentrations and different diet digestibility levels

Blood (mg P/litre)	Diet DMD (%)	Potential weight gain (kg/day)	Likely response to P supplement
<25	<50	Wt. loss	None
<25	55	0.5	High
<25	>60	>1.0	Extremely high
25–35	<50	Wt. loss	None
25–35	55	0.5	Moderate
25–35	>60	>1.0	Very high
35–45	<50	Wt. loss	None
35–45	55	0.5	Low
35–45	>60	>1.0	High
45–55	<50	Wt. loss	None
45–55	55	0.5	None
45–55	>60	>1.0	Moderate
>55	Any DMD	–	None

Note 1. The values in Table A.4.1 are for whole blood inorganic P sampled from the caudal (tail) vein. Blood can be analysed as 'plasma inorganic P' (PIP) or 'blood inorganic P' (Bi or BIP). The concentration in plasma will be about 30% higher than in whole blood.

Note 2. On-farm blood sampling will usually be from the caudal (tail) vein. P concentration of blood from the jugular vein (neck) will be about 15% lower.

Note 3. Diet DMD% and expected weight gain can be estimated from faecal NIRS analysis.

Note 4. Potential weight gain based on the DMD and assuming sufficient protein and mineral intake.

Blood phosphorus concentration is likely to give the best indication of the P status of a growing animal, but cannot be applied to a lactating cow. The results of blood P analyses must be interpreted by a nutrition specialist.

The better the quality of the diet, the greater the expected weight gain and thus the higher the blood BIP needed for the animal to be in adequate P status.

For a given low to moderate BIP (eg 25–45mg P/litre), the better the quality of the diet available, the greater the expected P deficiency and the greater the response to P supplement.

For cattle grazing good wet season pastures, a BIP of 25–35mg P/litre generally indicates P deficiency, and P supplementation should give an additional 0.3 to 0.5kg of weight gain/day. With a BIP below 30mg P/litre, the animal is probably acutely deficient and the response would be even greater. Less response can be

expected if the BIP is in the range 45–55mg P/litre and no response if the BIP exceeds about 55mg P/litre.

It is more difficult to interpret the BIP concentrations from lactating cows. The cow may be maintaining acceptable productivity in terms of their body condition and calf growth by mobilising body P reserves. This will be satisfactory if the cow can replenish body P reserves later after weaning. If BIP falls below about 30mg P/litre, voluntary intake of forage may decrease, and there should be some response to P supplement. However there may be little or no response in reproductive performance if other management of the breeder herd is good. For example, rigorous early weaning will give cows good opportunity to replenish body P reserves before pasture quality (and pasture P concentrations) decreases as pastures mature into the dry season.

## Appendix 5. Fluoride levels

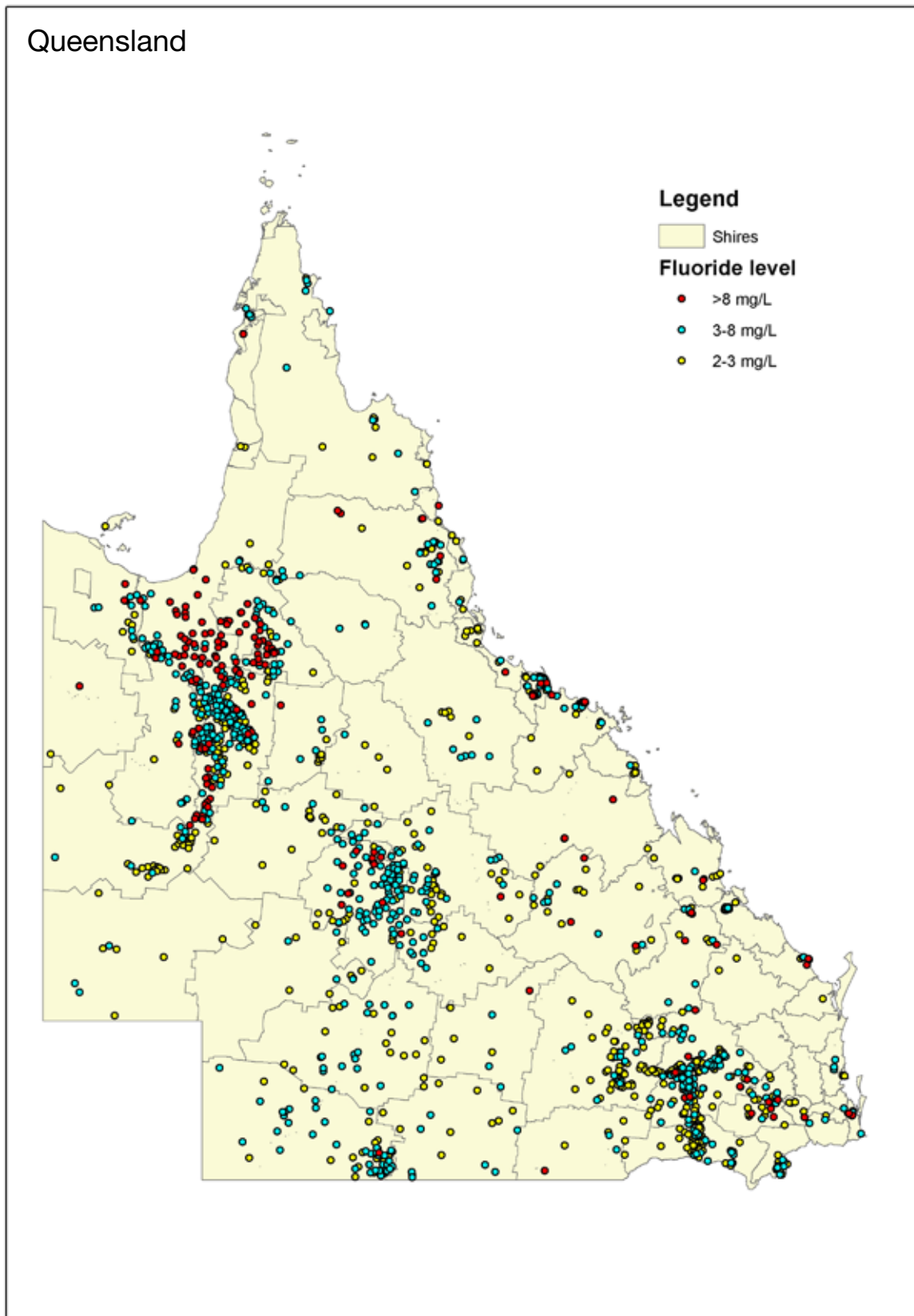


Figure A.5.1. Fluoride concentration of registered bores in Queensland. The bore water fluoride database points were provided by the Queensland Department of Natural Resources and Mines (2012). Bore with less than 2 mg/L not included.

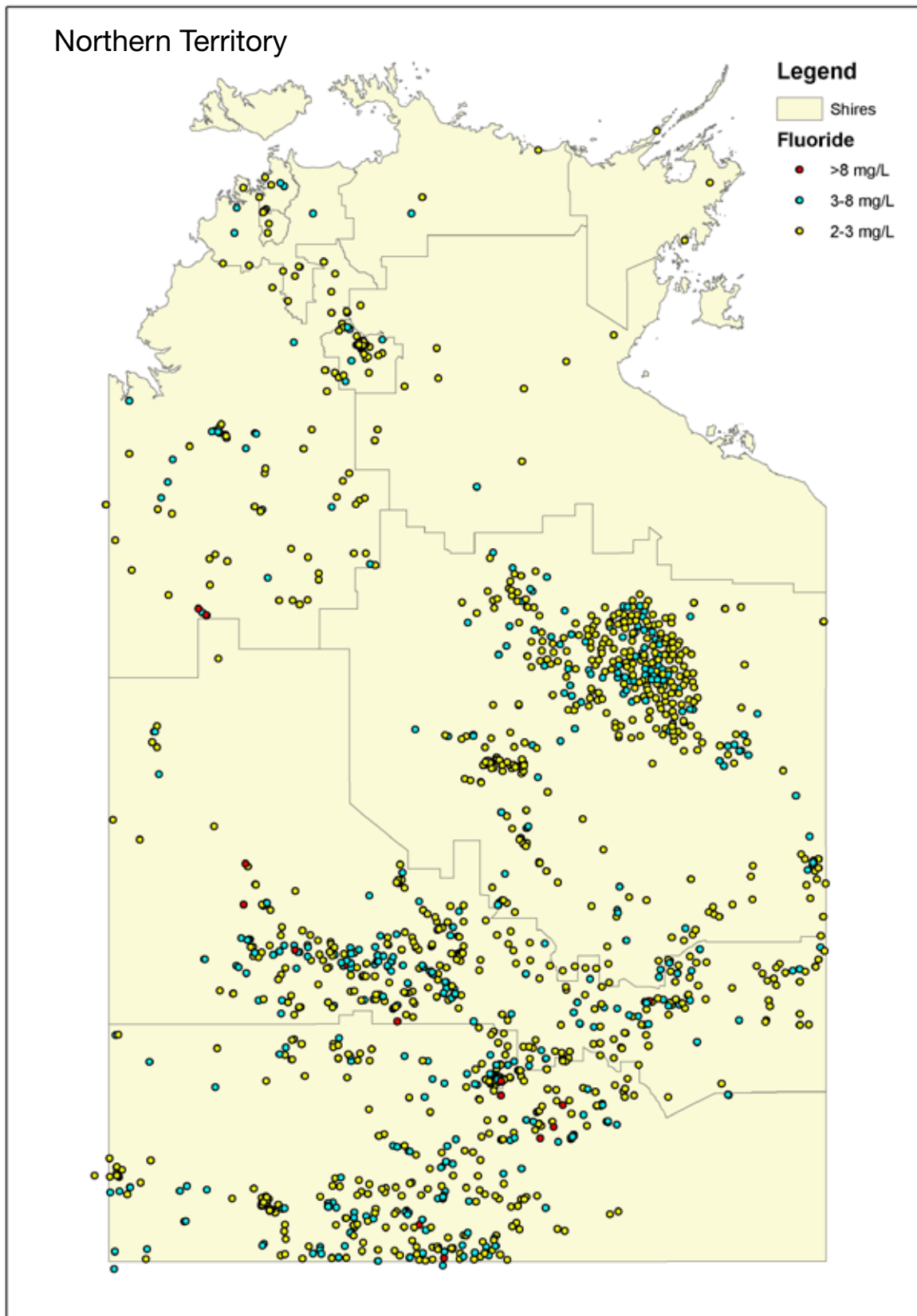


Figure A.5.2. Fluoride concentration of registered bores in the Northern Territory. The mapping is for point source data only and it should not be used to extrapolate potential fluoride readings over a wider area. Data supplied by Department of Natural Resources, Environment, The Arts and Sport (2012). © Northern Territory of Australia.

## Appendix 6. Analysis laboratories

### Analysis for blood phosphorus levels

#### Queensland

Queensland Biosecurity Sciences Laboratory  
Health and Food Sciences Precinct  
Specimen receipt (Loading Block 12)  
39 Kessels Road, Coopers Plains, Qld 4108  
Phone: (07) 3276 6062 (submission enquiries)  
Fax: (07) 3216 6620

#### Northern Territory

Berrimah Veterinary Laboratories  
Berrimah Farm, Department of Resources  
Makagon Road, Berrimah, NT 0828  
GPO Box 3000, Darwin, NT 0801  
Phone: (08) 8999 2249  
Fax: (08) 8999 2024

#### Western Australia

Animal Health Laboratories  
3 Baron-hay Court  
South Perth, WA 6151  
Phone: (08) 9368 3351  
Fax: (08) 9474 1881  
E-mail: clientsAHL@agric.wa.gov.au

### Analysis for Faecal NIRS

#### Queensland, NT and Western Australia

Symbio Alliance  
52 Brandl Street, Eight Mile Plains  
PO Box 4312, Eight Mile Plains, Qld 4113  
Phone: (07) 3340 5700  
Fax: (07) 3219 0333  
E-mail: admin@symboalliance.com.au

### Analysis for fluoride levels in water

#### Government laboratories

##### Queensland

Queensland Health Scientific Services  
Queensland Health Building  
147–163 Charlotte Street  
GPO Box 48, Brisbane, Qld 4001  
Phone: (07) 3234 0111

##### Northern Territory

##### Darwin

Department of Resources –  
Primary Industry, BAL Building  
Berrimah Farm, Makagon Road  
Berrimah NT 0828  
Phone: (08) 8999 2276  
Fax: (08) 8999 2111

##### Alice Springs

Arid Zone Research Institute  
South Stuart Highway,  
Alice Springs, NT 0870  
Contact: Laboratory Manager  
Phone: (08) 8999 2196  
Fax: (08) 8999 2191

##### Western Australia

Environmental Chemistry Laboratory  
Resources Chemistry Precinct  
Manning Rd, Bentley WA 6102  
PO Box 1250,  
Bentley Delivery Centre, WA 6983  
Phone: (08) 9422 9800  
Fax: (08) 9422 9801  
E-mail:  
EClabmanager@chemcentre.wa.gov.au

#### Website listing of private companies

[www.nata.asn.au](http://www.nata.asn.au)

# Appendix 7. Sources of phosphorus

Table A.7.1. Sources of phosphorus

Primary source of phosphorus	Name of compound	Physical form
<b>Calcium phosphates</b>		
	Monocalcium phosphate MCP	Grey powder/granule
	Monocalcium phosphate MCP	Pastel-white granular product
	Monocalcium phosphate MCP (Aliphos™)	
	Dicalcium phosphate DCP	Grey granule/powder
	Dicalcium phosphate DCP (Italphos™ Dical)	
	Tricalcium phosphate TCP (Multifos™)	Grey-white powder or granules
		Brown-grey granules
	Mono dicalcium phosphate MDCP	White-grey granules
	Kynofos 21™	Grey-green granule
	Monocalcium phosphate (Biofos™)	Grey granules
	Mono dicalcium phosphate (Aliphos™)	White/off white or grey granules
<b>Sodium phosphates</b>		
	Monosodium phosphate	Fine white powder
	Sodium tripolyphosphate	Viscous liquid
<b>Urea phosphate</b>	Urea phosphate	White crystals
<b>Monopotassium phosphate</b>	Monopotassium phosphate	White crystal
<b>Phosphoric acid</b>		
	Food grade	Colourless viscous liquid
	Technical grade	Colourless viscous liquid
<b>Ammonium phosphates</b>		
	Technical grade MAP (Liquifert P™)	
	Diammonium phosphate (DAP) technical/food grade	White crystalline
	Monoammonium phosphate (MAP)	Grey granule
	Diammonium phosphate (DAP)	White crystalline
<b>Superphosphates</b>		
	Single superphosphate	Grey granule
	Triple superphosphate	Grey granule
<b>Rock phosphates</b>	Rock phosphates	White/grey powders
<b>Animal by-products</b>		
	Bone char	Black granule
	Meat and bone meal	Brown powder
	Guano	
	Guano (Guano Gold™)	Dark brown granules

<sup>1</sup> The citric acid technique for measuring bioavailability is applicable to monogastric animals, but unknown for ruminants.

<sup>2</sup> weight/weight

%N	Chemical composition			mgF/gP	Bioavailability % P <sup>1</sup>	Origin/Comment
	%P	%Ca	%F			
	21–22	17–18	0.16	6.2–7.5		80% of P is water soluble
	22	16	0.20		98% (citric acid)	Good solubility in water
	22.9	16.65	0.10		99% (citric acid)	Conforms to current EC legislation
	16–21	21–23	0.07–0.19	1.2–9.1		Poor palatability
	18.1	29	0.14		99% (citric acid)	Conforms to current EC legislation
	18	30–34	0.18			
	18	30–34	0.18			Na 5.1%
	21	16–20	<0.18			
	21	16	0.18		97% (citric acid)	MCP:DCP 3:1
	21	15–18	0.16–0.21			
	21.9	21	0.13		99% (citric acid)	Low levels of heavy metals and dioxins; conforms to current EC legislation
	25			20ppm max		
	25.6	0	0	0		
17.5	19.25					
	22–23	0	0.06	2.7		Readily soluble
	25.5 min		0.001 max			
	26.5 min		0.001 max			
12	26.6					
21	23			50ppm max		
10	21.9					<b>Not to be fed to livestock</b>
18	46.5					<b>Not to be fed to livestock</b>
	8.8–9.6	20	1.95–2.36	204–266		<b>Not to be fed to livestock</b>
	20.7	15	2.28–3.16	114–155		<b>Not to be fed to livestock</b>
	13–17	49–54	2.2–4.1	151–276		<b>Not to be fed to livestock</b>
	10–14	20–28	0	0		<b>Not to be fed to livestock</b>
	3–6	4–15	0	0		<b>Not to be fed to livestock</b>
	5.7–5.9	27	0.005% w/w <sup>2</sup>			<b>Not to be fed to livestock</b>
	12	29			50% (citric acid)	Stockfeed grade with 10% silica



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[www.mla.com.au](http://www.mla.com.au)



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