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### The balancing act

David Weaver

*Department of Agriculture and Food, Western Australia*

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## The balancing act

David Weaver<sup>1\*</sup> and Simon Neville<sup>2</sup>

<sup>1</sup> Department of Agriculture and Food, 444 Albany Hwy, Albany, WA, 6330.

<sup>2</sup> Centre for Ecohydrology, University of WA

\*E-mail: [dweaver@agric.wa.gov.au](mailto:dweaver@agric.wa.gov.au)

<sup>2</sup> Ecotones and Associates, 9 Bell Rd, William Bay, Western Australia 6333.

### 1. Introduction

Nutrient management is as much a global issue as a local one with a balance required between economics and environment, inherent biological limitations and expectations of nutrient use efficiency, and traditional fertiliser practices and actual enterprise nutrient requirements.

The concept of nutrient balance depends on context and scale. Nutrient balance can be considered at a global scale, where issues of nutrient stocks, cycles, depletion and transfer of a particular element are important. For a single farm enterprise, nutrient balance might be considered in terms of phosphorus (P) inputs into and outputs from the enterprise. This is commonly known as a farm-gate nutrient balance, where the difference between inputs and outputs is nutrient surplus, and the conversion of inputs to outputs is nutrient use efficiency. Equally, a farm might consider nutrient balance in terms of the balance of nutrients within a particular soil, paddock, or crop where some nutrients are in sufficient supply and others are deficient.

This paper will consider these aspects of nutrient balance, and will indicate where these imbalances exist as a basis for improvement.

### 2. Global issues

Global nutrient cycles and transfers have changed since the industrial revolution. Prior to this era, humanity was intimately involved in agricultural production through the utilization of wastes. Since human requirements for nutrients such as P are quite low, these pre current era cycles could be considered closed and sustainable<sup>1</sup>. Since the industrial revolution, global nutrient cycles have altered with the discovery of phosphate rock and commercial fertilizer manufacture. Now more than 50% of humanity is urbanized and disconnected from food production. Major nutrients such as N, P and K recycle in nature, but human intervention has now created a mainly linear, non-recycling, open ended system (Figure 1). Recycling of farm nutrients (such as by the use of sewage sludge in farming) is limited in Australia, and most of these finite resources now enter the ocean. This cycle would only be sustainable if raw materials were in infinite supply, or if elements discharged to deep ocean sediments

could be recovered easily. Unfortunately neither of these is true, as indicted by recent assessments of phosphate rock reserves by the USGS in 2005 (Figure 2).

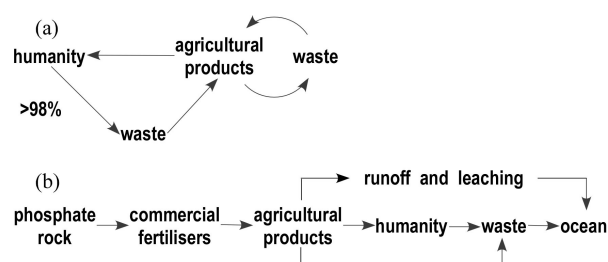


Figure 1. Pre (a) and post (b) industrial revolution P cycles

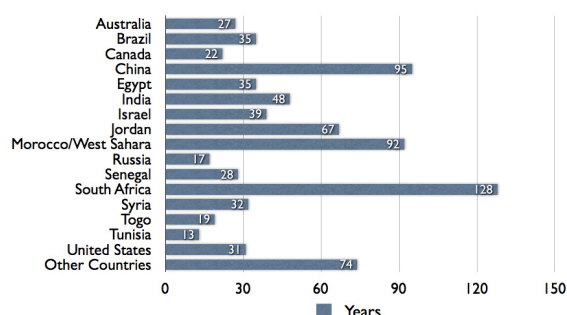


Figure 2. Years of extraction of phosphate rock remaining based on reserves at 2005 and a 2% annual increase (USGS, 2005).

### 2. Inherent landuse issues

Over the past 20 years or so, much effort has been devoted to recommendations and plans that aim to enhance nutrient use and overall environmental performance of agriculture. But what improvements can we reasonably expect? Recent farm-gate nutrient budgets for WA farms (Figure 3), whilst showing some variation, are in line with international work and highlight the inherent biological limitations of converting nutrients into products. Cropping systems show the best conversion of input nutrients to outputs of around 60-70%, whilst animal grazing systems are typically between 10-30%. With these systems, nutrient loss to the environment seems inevitable. Figure 4 also shows the inherent inefficiency of nutrient use, with a high proportion of N or P input expressed as nutrient surplus. It also indicates that higher surplus will result from higher inputs.

<sup>1</sup> "for an unspecified long period of time."

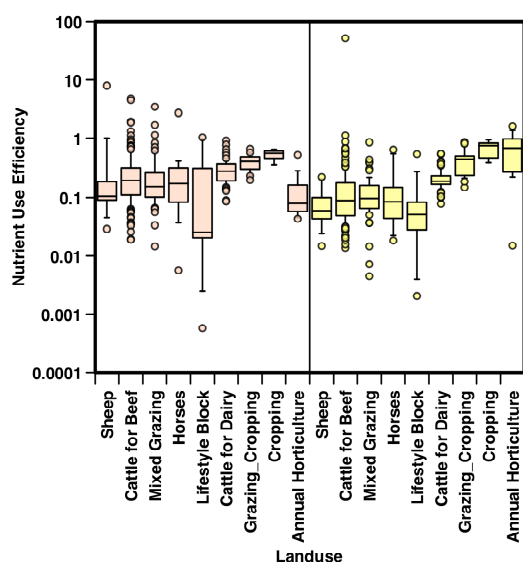


Figure 3. Box and whisker plots showing the variation in P use efficiency (left pane) and N use efficiency (right pane) across landuses. Boxes show 25th, 50th and 75th percentiles. Whiskers extend to 10th and 90th percentile and points show outliers. A value of 1 on the y-axis is 100%

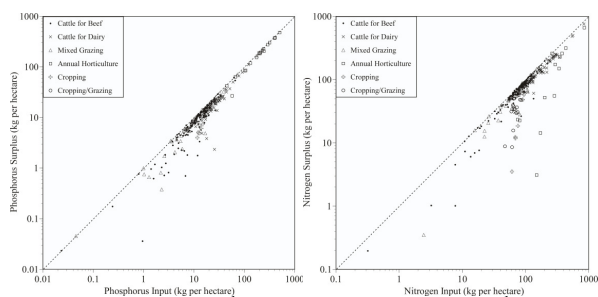


Figure 4. Surplus ( $\text{kg ha}^{-1}$ ) as a function of input ( $\text{kg ha}^{-1}$ ) for Cattle for Beef, Cattle for Dairy, Mixed Grazing, Annual Horticulture, Cropping and Grazing/Cropping. Phosphorus (left) and Nitrogen (right). 1:1 line shows 100% of input as surplus

Figure 5 plots P outputs as a function of P inputs, and shows that greater P use efficiency can be achieved with lower inputs (“sub optimum zone”). This needs to be balanced against potentially lower production, resultant economic issues, and possible environmental issues associated with poor ground cover. In contrast with this we see that in the “overshoot” zone of Figure 5, as inputs increase above a threshold of around  $45 \text{ kgP ha}^{-1}$ , outputs increase at a lower rate than the optimum zone, whilst surplus and inefficiency increase rapidly. In the central zone – the “optimum” zone – the trend is for increasing nutrient inputs to achieve increasing outputs, and increasing nutrient use efficiency, and therefore limited increases in surplus. This seems counterintuitive, given the trends in the sub optimum and overshoot zones, and the general findings of inherent biological inefficiency (Figures 3 and 4). It may be that in the optimum zone a range of other deficiencies and issues (K, S, pH) have been addressed to some degree, and this has assisted to increase outputs at a faster rate for the same level of input.

### 3. Internal nutritional balance issues

Soil data (23000 samples) collected in the Peel Harvey and Albany catchments showed that around 60% of the soils either had high P status or would not respond to applications of P. Within this high P status group, numerous other issues existed, including key nutrient

deficiencies (Table 1).

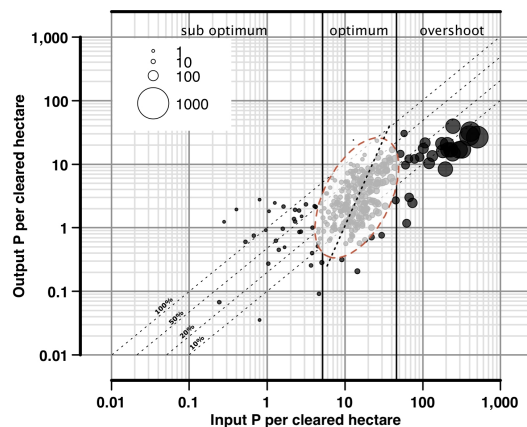


Figure 5. P output ( $\text{kg ha}^{-1}$ ) as a function of P input ( $\text{kg ha}^{-1}$ ) for Cattle for Beef, cattle for Dairy, Mixed Grazing, Cropping, Grazing/Cropping and Annual Horticulture. Surplus ( $\text{kg ha}^{-1}$ ) shown by circle size. Dotted lines show Nutrient Use Efficiency. Trendline and 95% confidence ellipse shown for optimum zone.

Table 1. Percentage of high P status soil samples that have other nutritional or soil chemical issues

Issue	%
Potassium deficiency	27
Sulphur deficiency	65
Potassium and Sulphur deficiency	21
Soil Acidity	45

With the large proportion of high P status soils, it is likely that issues other than P are often limiting production and P outputs in products, and therefore limiting nutrient use efficiency. Some farmers already realize this and apply compound fertilizers and soil amendments to address these issues. Amongst a range of climatic, environmental and management factors, the variability of data points in Figure 5 may also be a reflection of the variability in individual approaches to nutrient management. The data in the optimum zone in Figure 5 will capture the farmers who recognize the importance of nutritional balance within their farming system (and some who don't), and hence the general trend within the data is for nutrient outputs and nutrient use efficiency to go against the trend and increase with increasing inputs. This means that nutrient surplus in this zone, assuming that nutritional balances are right, increases less than it would otherwise. Whilst the relationship between nutrient surplus and input is strong (Figure 4) and indicates greater input leads to greater surplus, there may be some scope to limit the impact that additional inputs have on surplus (up to a limit defined by the optimum zone), if other nutritional factors are optimized.

### 4. Conclusions

We are approaching a period where conventional nutrient sources are likely to become more scarce. It is imperative from economic and environmental perspectives to examine nutrient balance at all scales, from within the farm to the global scale. Treating conventional nutrient sources as a renewable resource needs to be re-examined. At the large scale, this may require reclaiming nutrients from wastes (eg sludges). At the farm scale, this will require careful examination of the factors affecting the efficiency of nutrient utilisation, down to a paddock scale balancing of nutrients essential for agriculture.