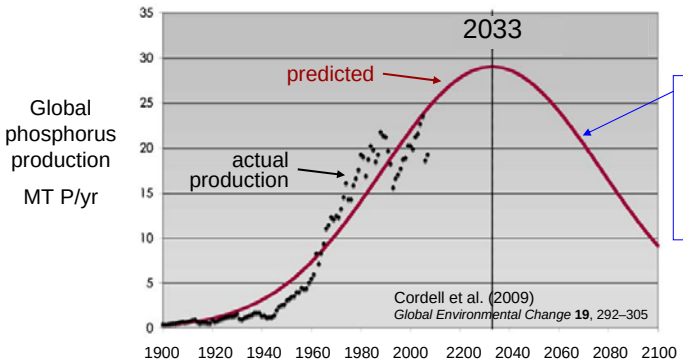
Dr Richard Simpson, CSIRO

Phosphorus

the current global situation, P-efficiency in Australian agriculture, threats & opportunities for grazing businesses.

Current global P supply situation

(i) Will there be a peak in the global supply of P in the near future?



"Hubbert Linearisation"

- recognises that finite resources become more difficult to extract as they are depleted.

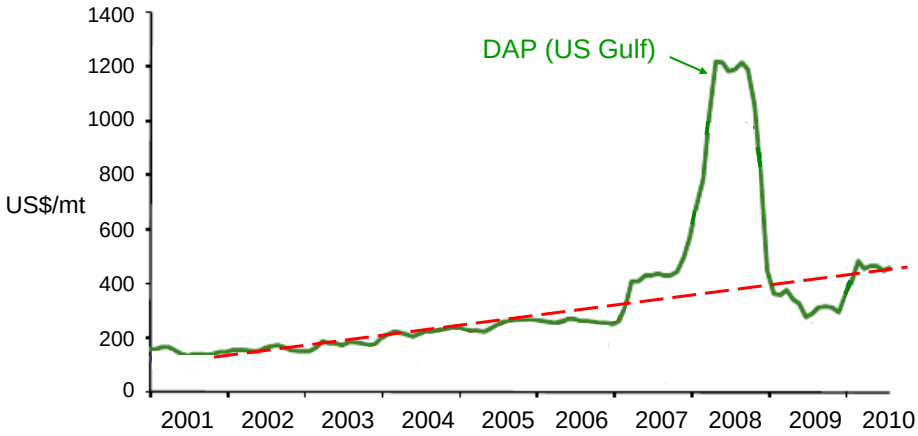
- the 'peak' indicates the time at which prices will escalate.

(ii) Global P-reserves re-analysed by IFDC September 2010 (Van Kauwenbergh 2010)

- Global P-reserves now estimated to be **4-fold larger** than previously thought
- Increase almost entirely due to re-assessment of Moroccan reserves
- "Peak-P" … now "several decades" away (?)
- Interesting geo-political supply situation will emerge over next ~30 years

the cost of P-fertiliser is likely to continue to rise

This price trend was predicted accurately (1988) by estimating costs of mining new sources of P-rock

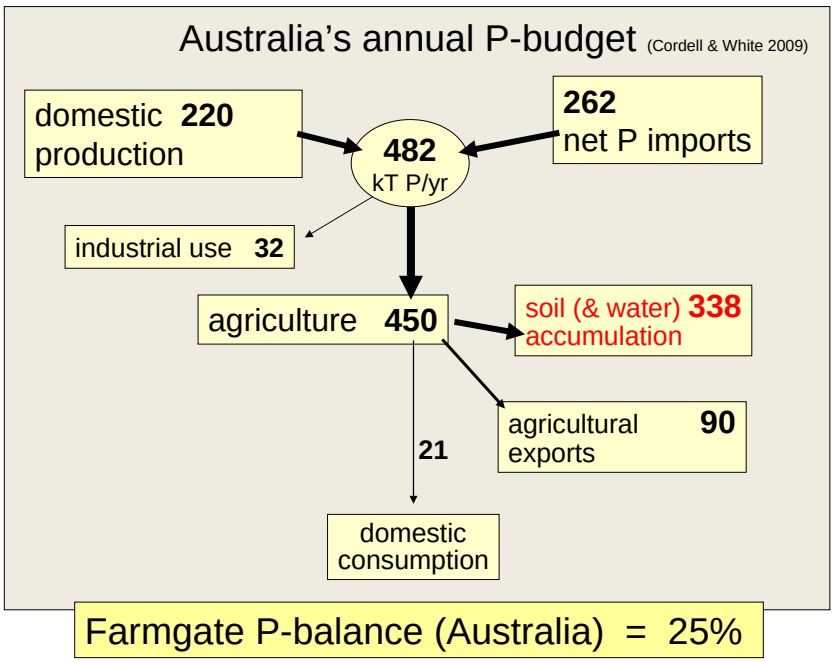


Monthly average fertiliser prices (fob, bulk) Source: IFDC (2010)

Opportunities to reduce the amount of P applied to pastures

"P-balance efficiency (%)"

$$= \frac{P_{output\ (products)}}{P_{input\ (fertiliser)}} \times 100$$



P input in fertiliser and export in products for major agricultural industries

McLaughlin et al. 1992

Product	P applied in fertiliser (Kt)	P in harvested product (Kt)	P-balance efficiency
Wheat	85	42.2	50%
Barley, Oats	35	15.8	45%
Sorghum, maize, rice	8	4.3	54%
Fresh fruit	6	0.4	7%
Vegetables	8	1.3	16%
Wool, meat, milk, live animals	179	35.8	20%

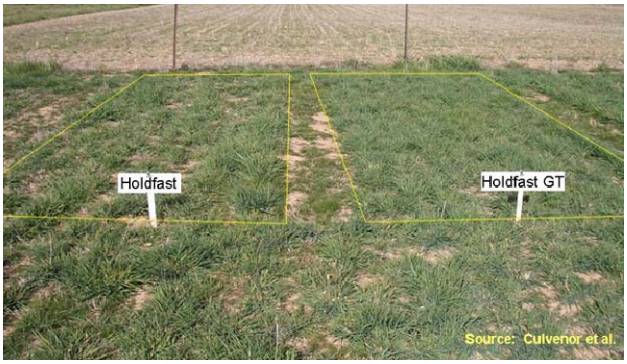
Well-managed grassland systems have low P-balance efficiency

1992

Options for lifting the efficiency of P-use in Australian agriculture

(1) Increase productivity at current P input levels

"Holdfast GT" a new cultivar of phalaris bred to withstand grazing pressure and to persist whilst carrying higher stocking rates. This cultivar will improve production per kg of P-fertiliser used.



Scope to improve the efficiency with which P-fertilisers are used

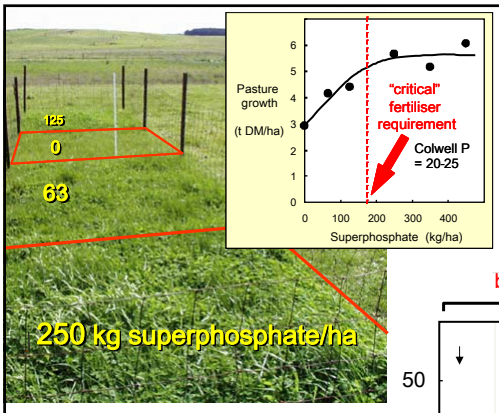
(2) Decreased P-input for current productivity

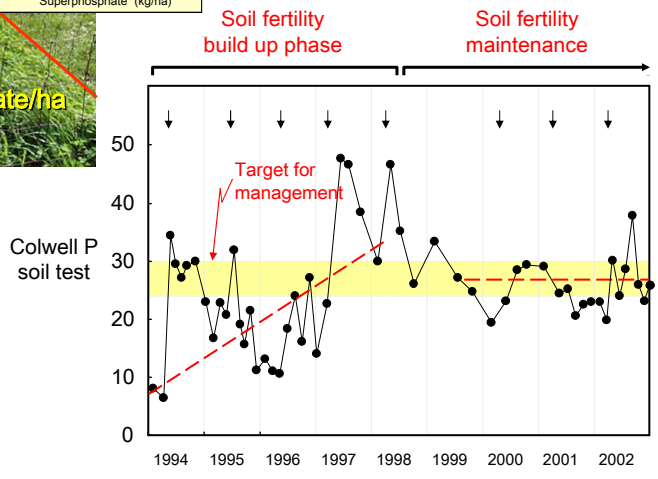
(a) **Critical P concentrations (whole shoots) - key pasture species (g/kg DM)**

Medicago murex / polymorpha / truncatula	annual medics	**2.6 - 3.5**
Trifolium repens / subterraneum	white clover / subterranean clover	**2.5 - 3.2**
Medicago sativa	lucerne	**2.1 - 2.6**
Phalaris aquatica	phalaris	**1.8 - 2.0**
Lolium perenne	perennial ryegrass	**2.0 - 2.5**

(b) **Recommended P allowances for sheep**

	Weight (kg)	Weight gain (g/d) or other condition as specified	Intake (kg DM/d)	P intake (g/d)	P concentration of diet required (g/kg DM)
Growing weaner sheep	20	100	0.61	1.28	**2.1**
	20	200	0.95	2.37	**2.5**
	40	100	0.97	1.53	**1.6**
	40	200	1.45	2.66	**1.8**
Adult sheep	50	0	0.69	0.6	**0.9**
Pregnant ewe	50	week 21 of gestation	0.96	3.99	**2.0**
Lactating ewe	50	1.7 kg milk/d	1.77	5.31	**3.0**





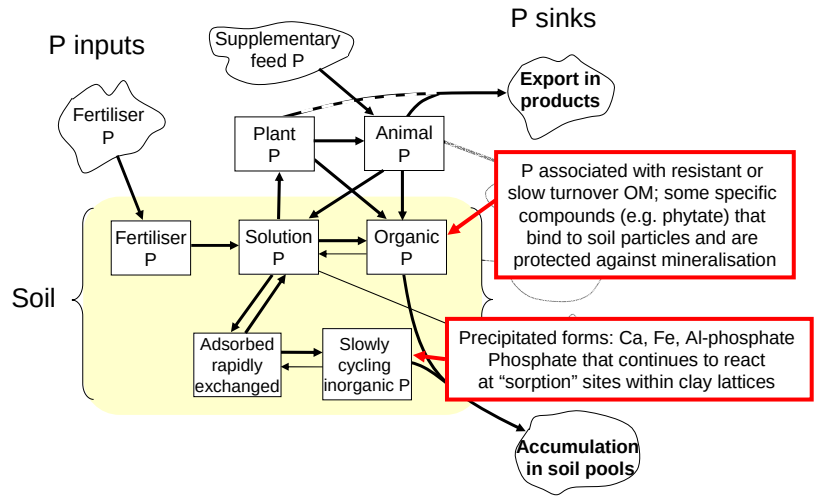
P-budgets: farm systems maintained with 'stable' plant-available P levels

(kg P/ha/year)

	P input	=	P waste dispersal	+	P leaching & erosion	+	P soil accumulation	+	P export
wool production, Canberra, ACT Simpson et al. 2010	9.8*								1.9
wheat-sheep rotation (wwww-pp) Wagga, NSW Helyar et al. 1997	11.8								7.2
grazed annual pasture, Willalooka, SA Lewis et al. 1987	9.2								1.2

* input for stable soil fertility after drift in Olsen P accounted for

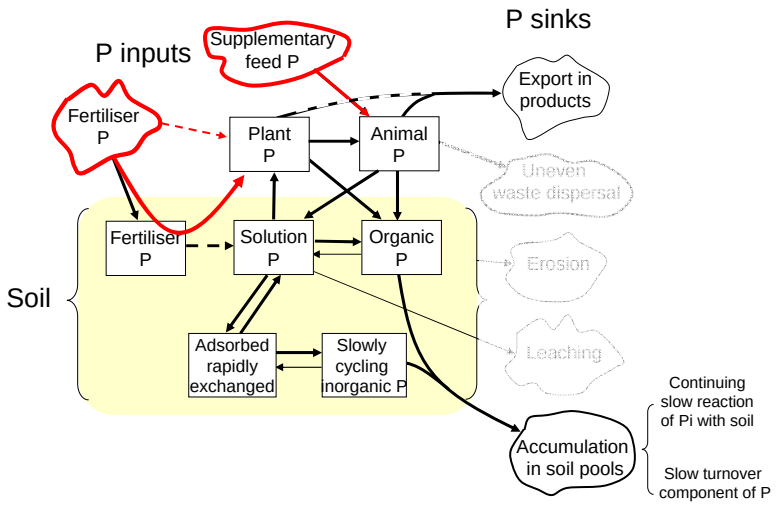
$P_{input} = P_{export} + P_{waste\ dispersal} + P_{leaching\ \&\ erosion} + P_{soil\ accumulation}$



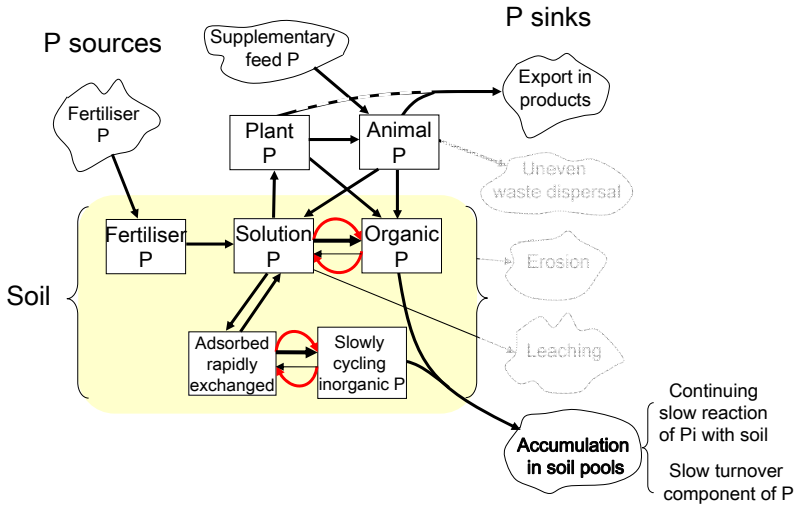
P-input (fertiliser) strategies

- By-pass the soil; foliar fertilisers, supplements — Some impacts possible but will be limited at best
- Banding; fluid fertilisers (alkaline/calcareous soils) — Cropping option
- Controlled release; P supply matched to plant requirements
- Granule coatings that may reduce Ca, Al, Fe reactions with P
- Subsurface (self-) placement

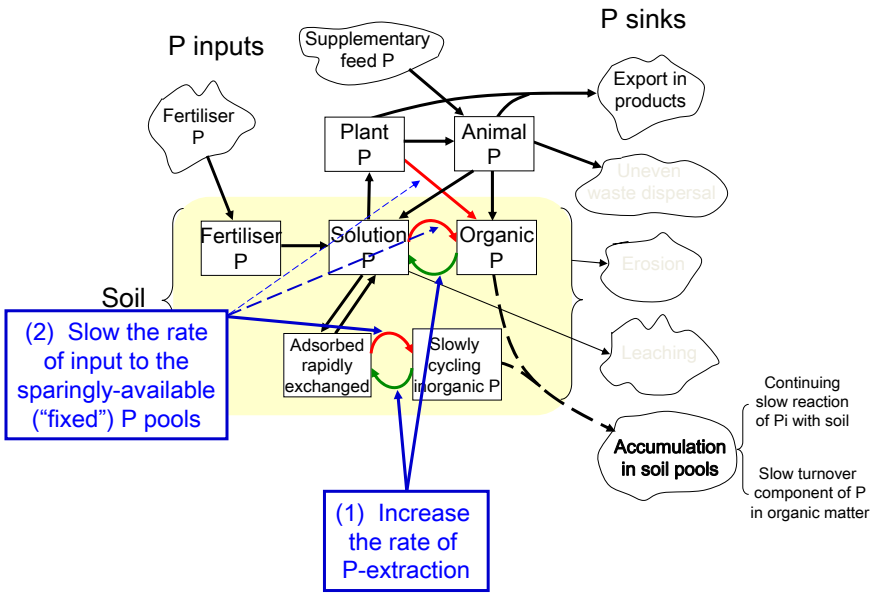
Pasture impacts are possible



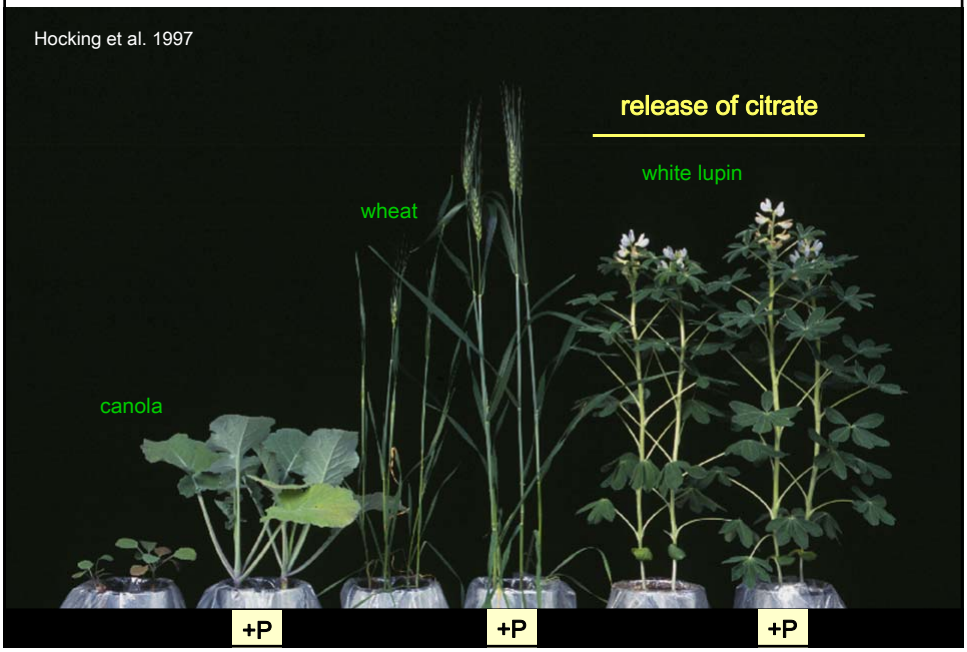
Accumulation of phosphate (Pi) & organic-P (Po) in soil



Two main options:



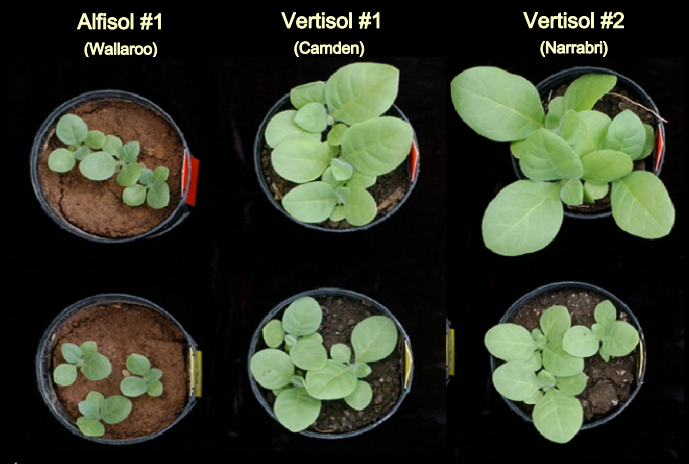
Increased Pi-extraction: organic acid secreting plants



Increased Po – extraction:

expression of a microbial phosphatase in transgenic plants

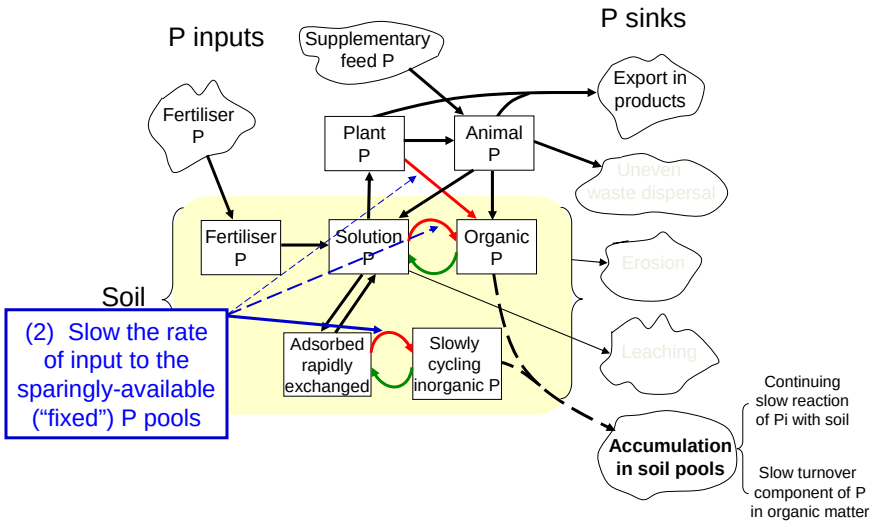
(George, Richardson et al. unpublished)



	Alfisol #1 (Wallaroo)	Vertisol #1 (Camden)	Vertisol #2 (Narrabri)
Total organic P (µg g^{-1})	211.4	214.7	215.8
Organic P (µg g^{-1}) (water extractable)	3.3	7.1	29.9

- response is a function of organic P availability

Reducing soil P accumulation



Rate of continuing reaction of phosphate with soil

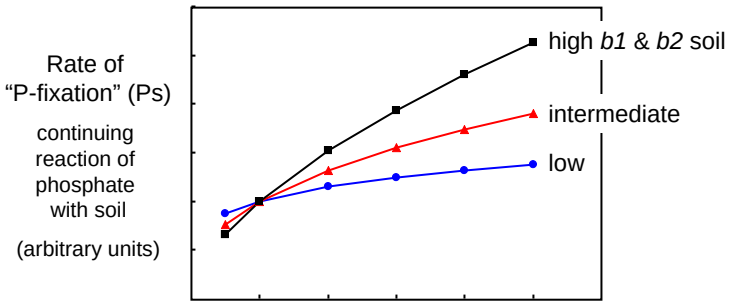
Phosphate concentration

Time

$$Ps = a \cdot C^{b1} \cdot T^{b2}$$

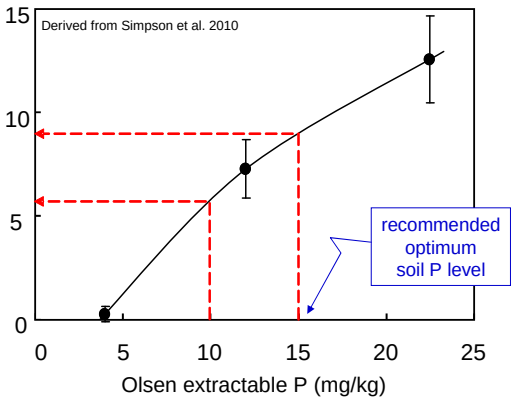
from Barrow (1980) *Aust J Soil Res*. **8**, 215-224

(laboratory incubations of phosphate with soils at elevated temperatures)



P accumulation in grazed paddocks managed with maintenance fertiliser inputs

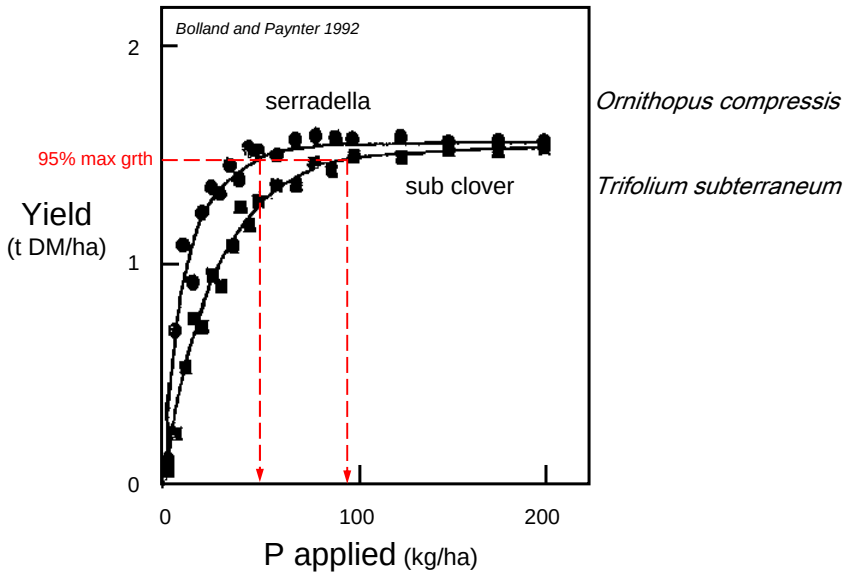
(kg P/ha/year)



Level at which soil P fertility was maintained

Soil fertility level (Olsen P) mg P/kg soil	P accumulation in paddock (kg P/ha/year)	Estimated fertiliser input (kg P/ha/year)	***Fertiliser saving* (%)**	P-balance efficiency (%)
15	9.2	~11.2		18%
10	5.8	~7.8	***~30%***	26%

P inputs are determined by the critical P of pasture legumes } serradella << sub clover = white clover < ann. medics



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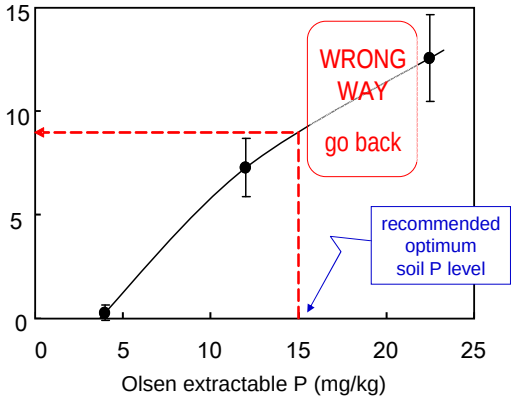
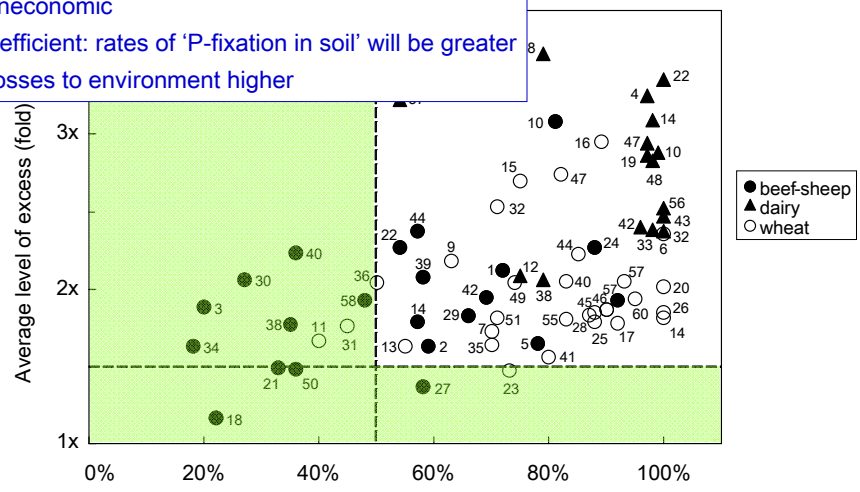


Level at which soil P fertility was maintained

- Uneconomic
- Inefficient: rates of 'P-fixation in soil' will be greater
- Losses to environment higher



Proportion of Colwell P test results from each location
that are above the critical level needed for max pasture growth

Pre-season soil tests (2009), points are district averages, only samples from acid soils and where clearly labelled with enterprise type; districts identified by postcode **Data courtesy of Incitec-Pivot**

Conclusions

- Peak P is not expected to occur "soon"
- Steady price increases for P-fertiliser are likely
- P-efficiency gains have stalled

***However*… the P-cost of grazing systems can be reduced**

(1) Promote targeted use of P-fertilisers

(2) Develop farming systems that operate at low available-P concentrations

(3) Research innovative fertiliser technology

(4) Develop novel plants (systems) that "extract" sparingly-available Pi & Po