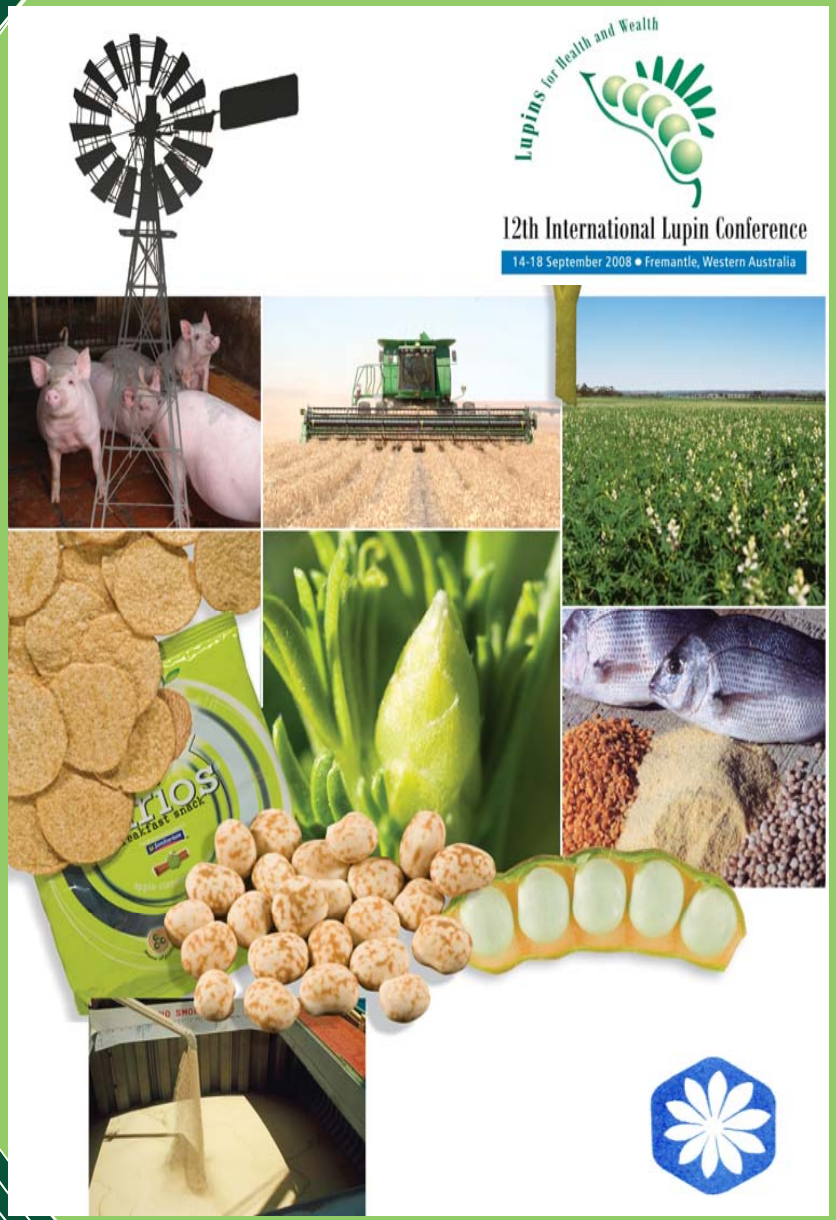


LUPINS

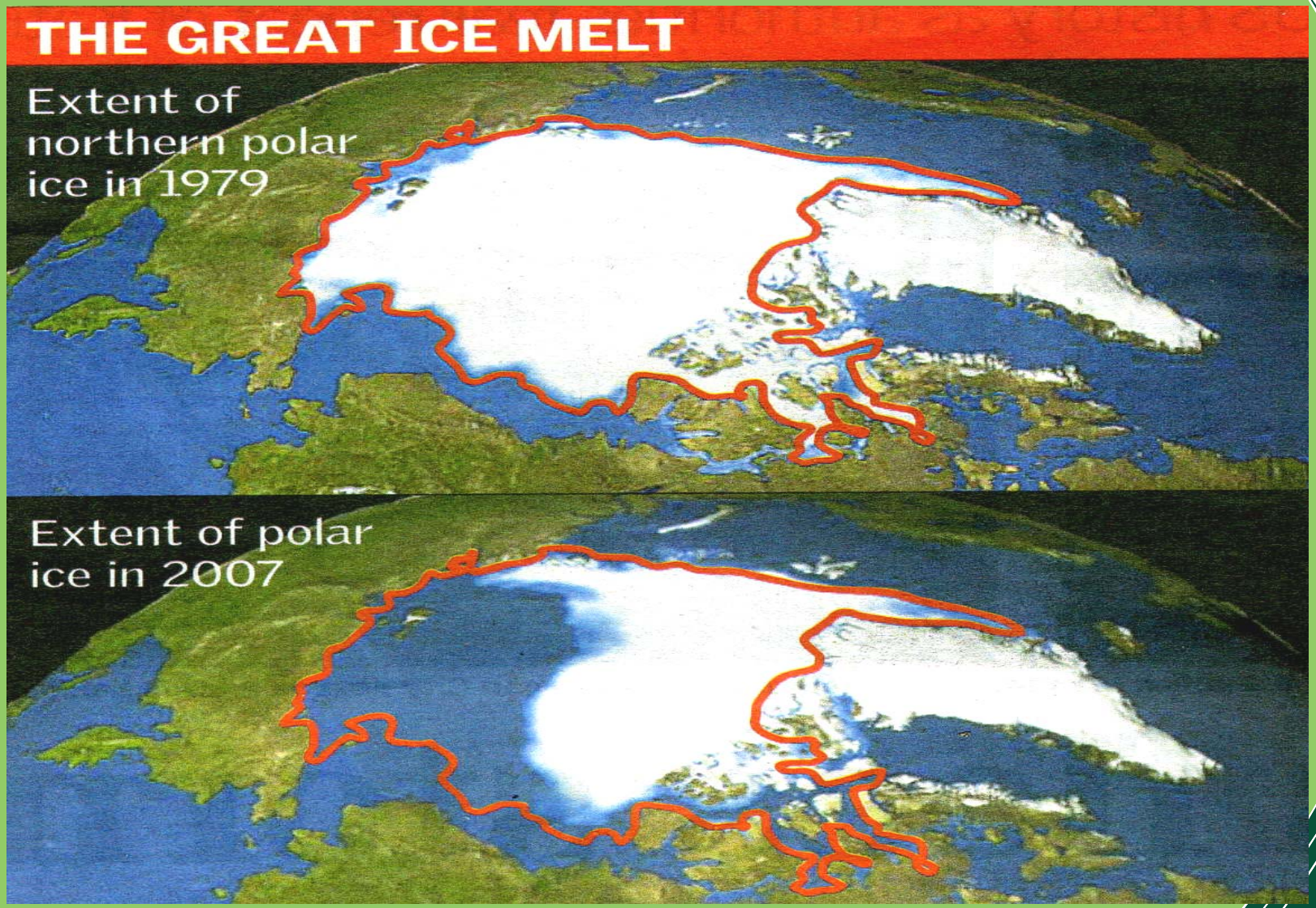
What we know and What we don't

Mark Sweetingham
Ross Kingwell

THE UNIVERSITY OF WESTERN AUSTRALIA
Achieving International Excellence

GOVERNMENT OF WESTERN AUSTRALIA
Department of Agriculture and Food

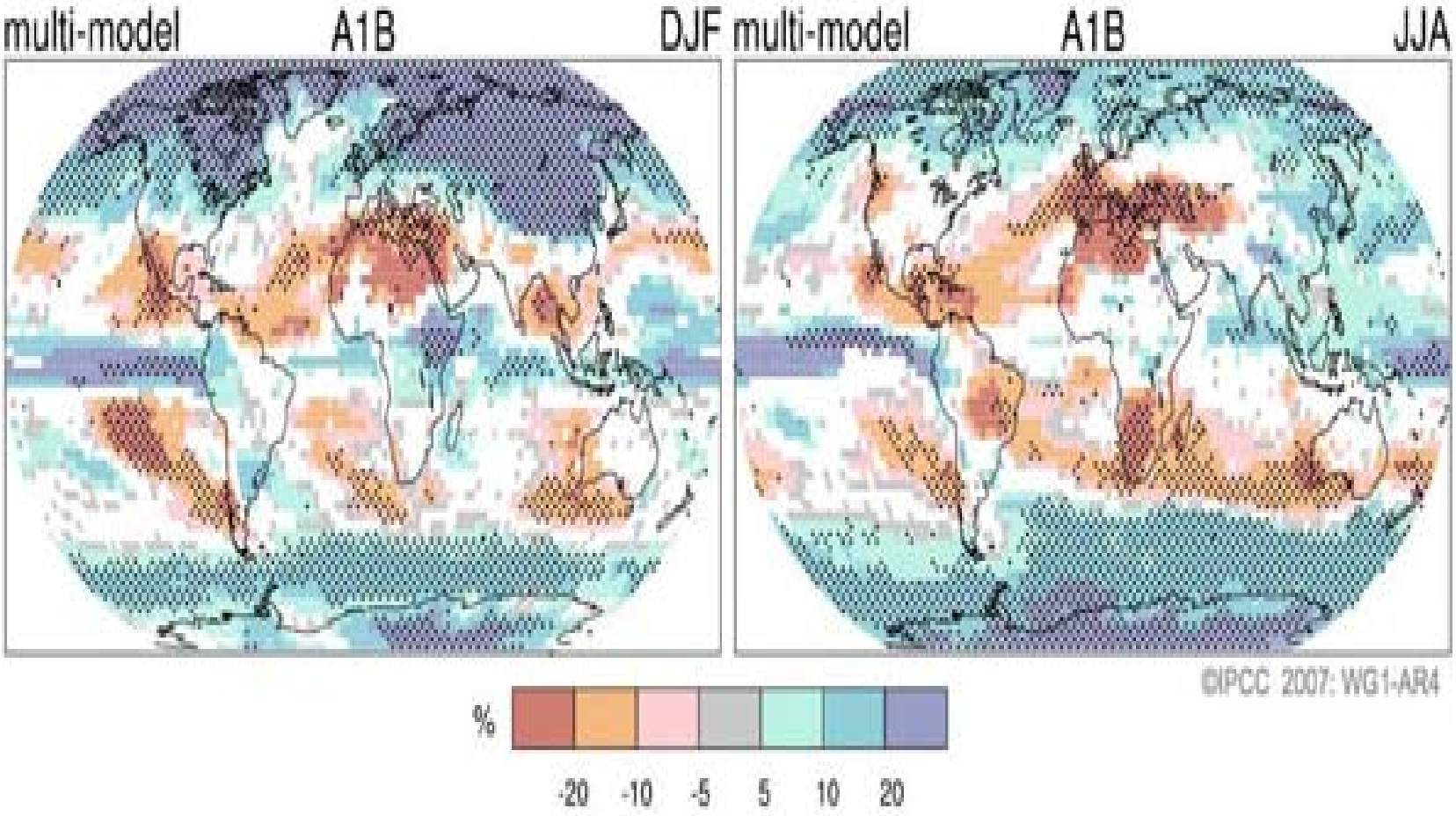
What we know:



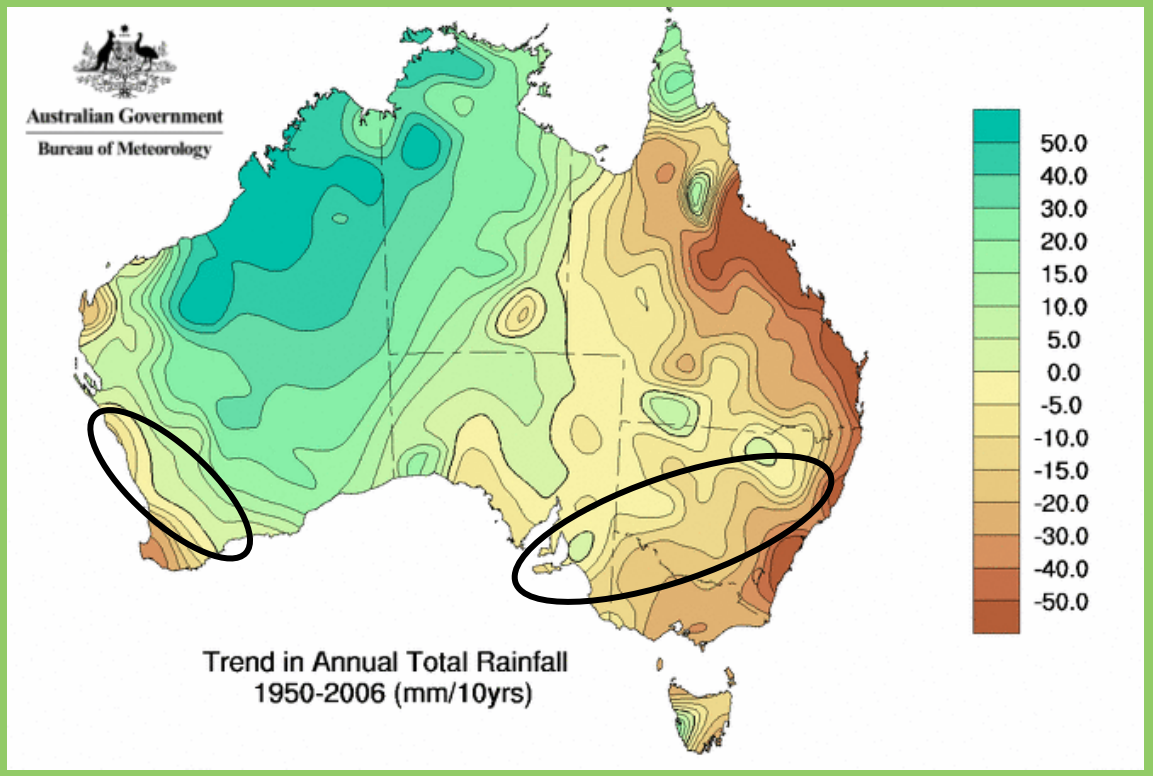
Source: NASA

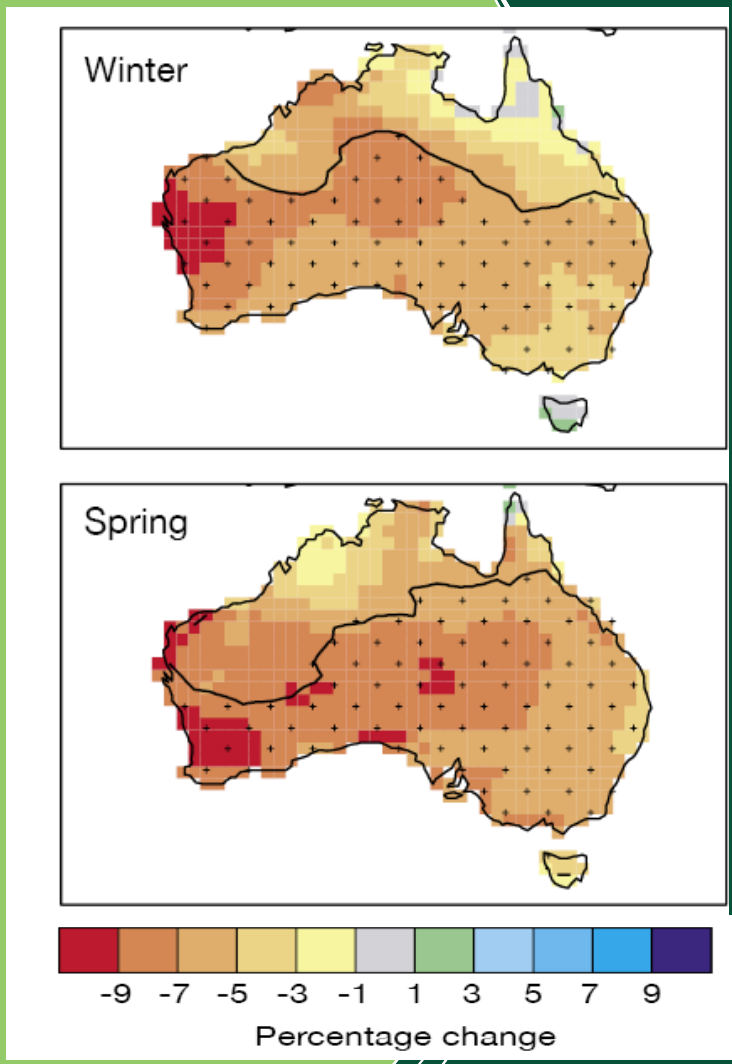
What is less certain:

Rainfall change under A1B emission scenario: 2050



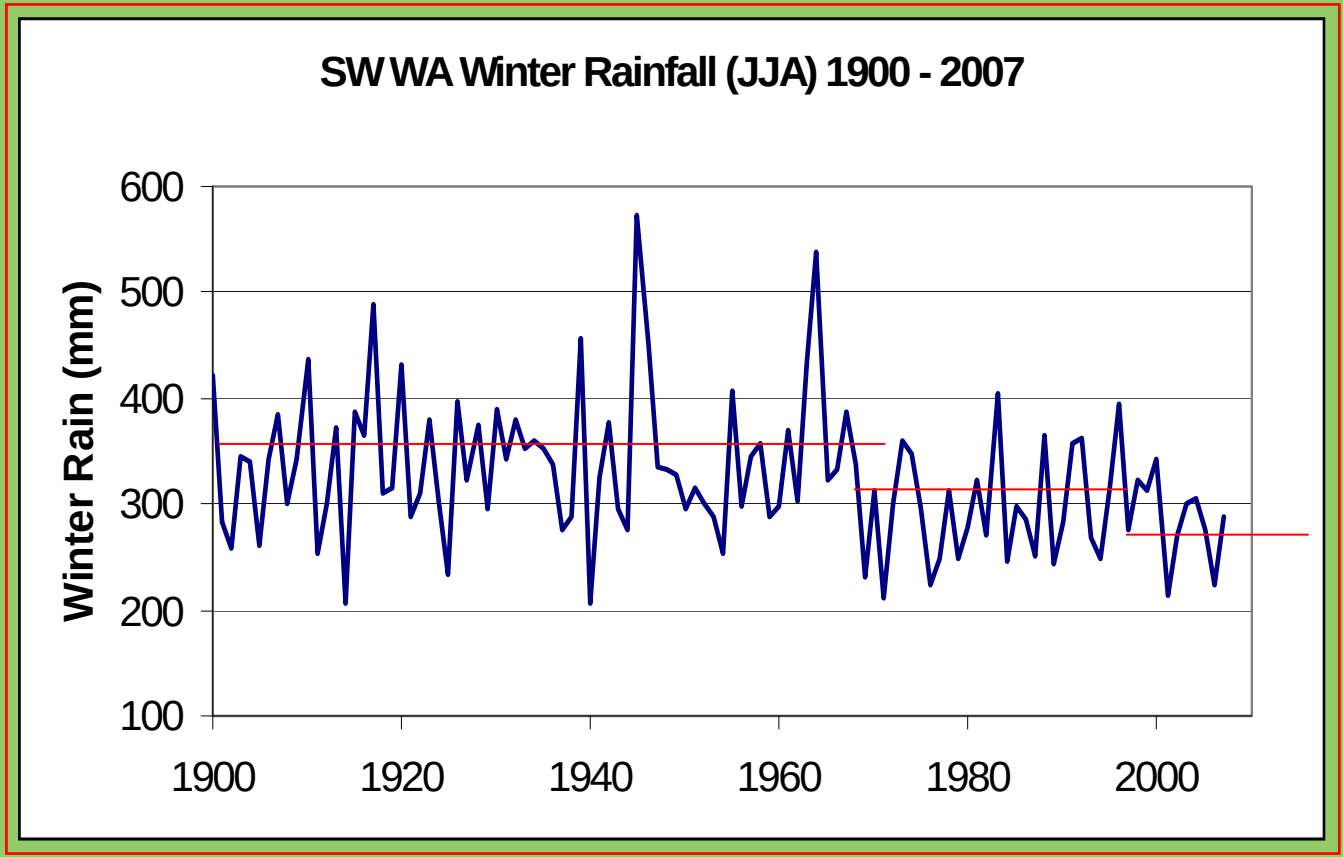
The Australian grain-belt has been drying





Significant decreases in winter / spring are ‘likely’ …

Normal seasonal variation remains greater



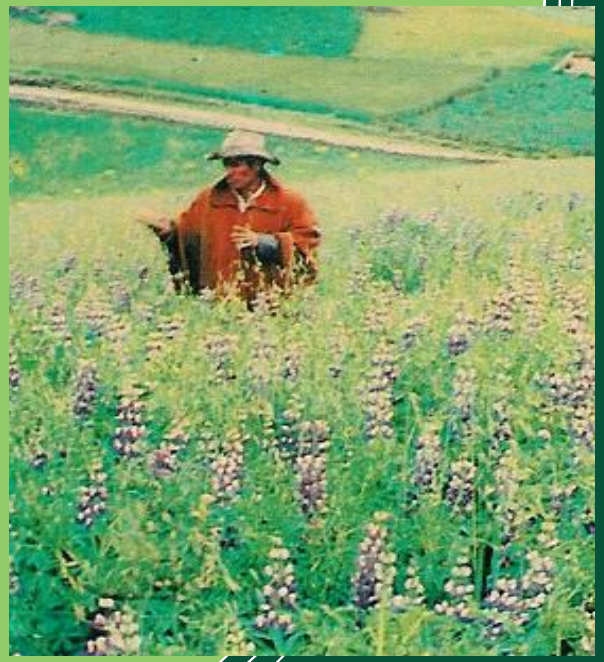
Genetic and agronomic improvements should keep pace with the average trend

An Ancient Crop

soil health improver

- **OLD WORLD**
  Mediterranean

- **NEW WORLD**
  Andean Highlands



A Traditional Food

- Egyptian, Greek, Roman
- Inca, pre-Inca

Bitter alkaloids removed by leaching

‘Nature’s Gift’

- about 280 annual and perennial spp.
- Increasing evolutionary, eco-geographical and physiological understanding

Genomic Tools

- Relatively dense map
- BAC libraries
- Markers for some important genes
- Comparative genomics with model legumes

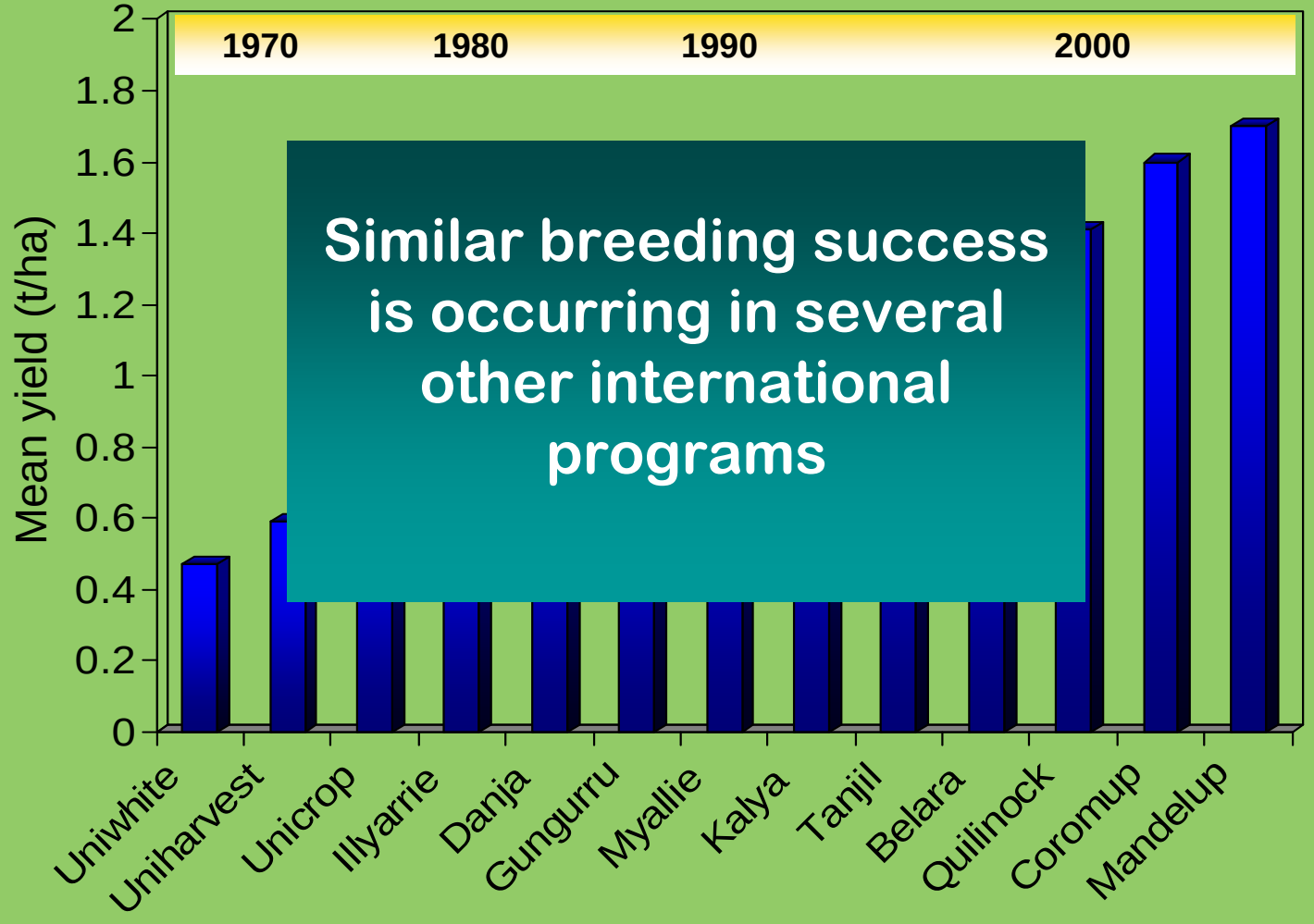
Combine knowledge to fully exploit this diversity

Enhancing Nature's Gift - domestication

- *L. luteus*
- *L. albus*
- *L. angustifolius*
- *L. mutabilis*
- *L. cosentinii*
- *L. atlanticus*
- *L. pilosis*
- *L. polyphyllus*

- low alkaloids
- non-shattering
- soft seeded

Breeding success - (*L. angustifolius*) in WA



39 trials over 14 locations (1997-2003)

Creating a super-lupin ? - interspecific crosses

	2n	
L. angustifolius	40	
L. luteus	52	*
L. albus	50	
L. luteus	52	****
L. hispanicus	52	
L. atlanticus	38	
L. cosentinii	32	***
L. pilosis	42	
L. mutabilis	48	****
New world *spp*	48	

Recombine traits for
- **adaptation**
- **disease resistance**
- **grain quality**

GM Enhancement

- **Herbicide tolerance**
- **Grain quality**

Technology issues

- Relatively high costs
- Limited access to IP (genes)

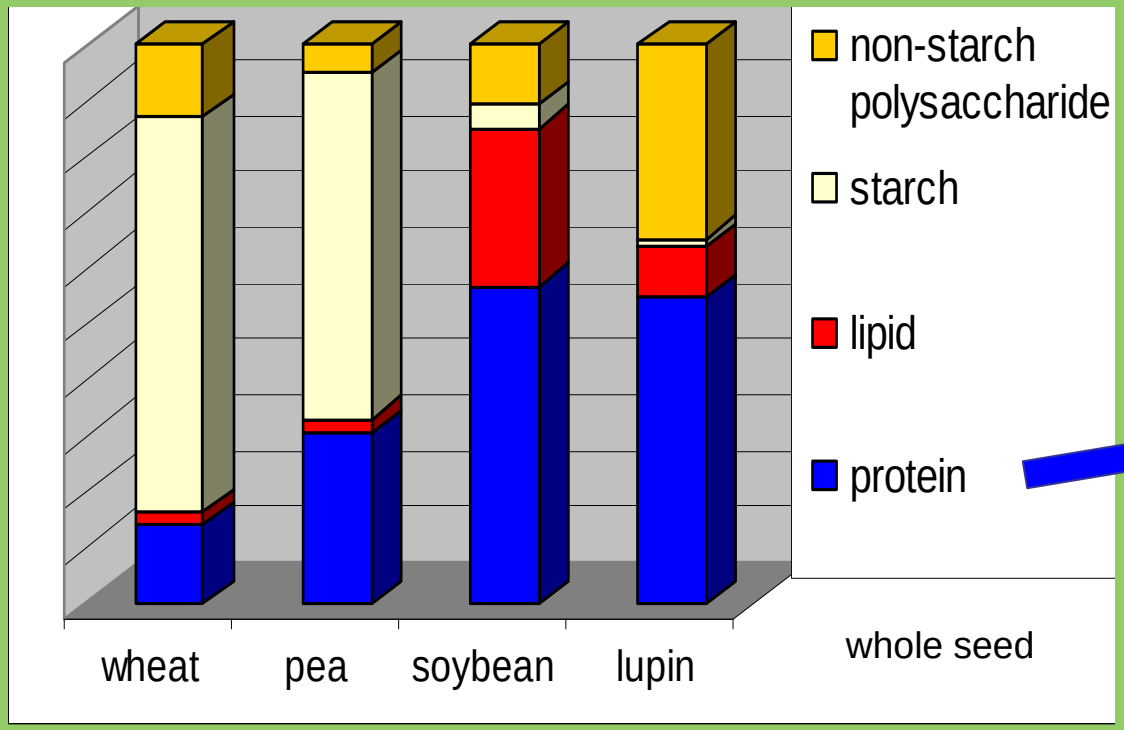
Market issues

- GM soy feed markets ☑
- Food markets ☒

Unique composition

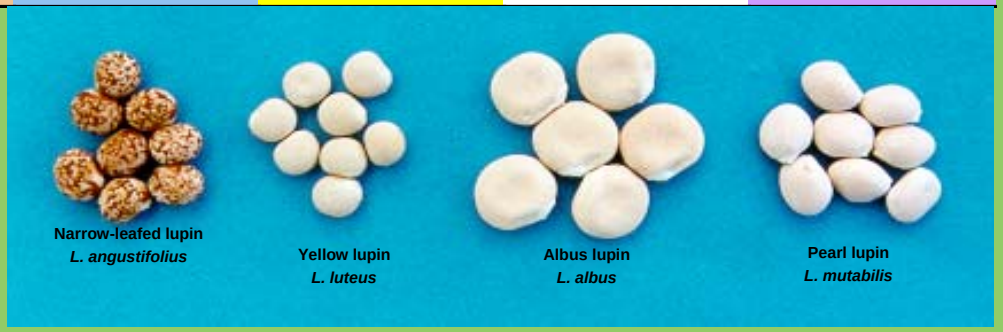
(*L. angustifolius*)

- High protein
- High crude & dietary fibre
- Low fat
- Virtually no starch



Other lupin species

	Soybean	Narrow-leafed	Yellow	Albus	Pearl
Crude protein	40	32	38	36	43
Total Lipid	20	6	6	9	17
Methionine	0.52	0.22	0.27	0.24	0.28
Cysteine	0.60	0.42	0.88	0.49	0.68
Lysine	1.75	1.46	2.07	1.58	1.49



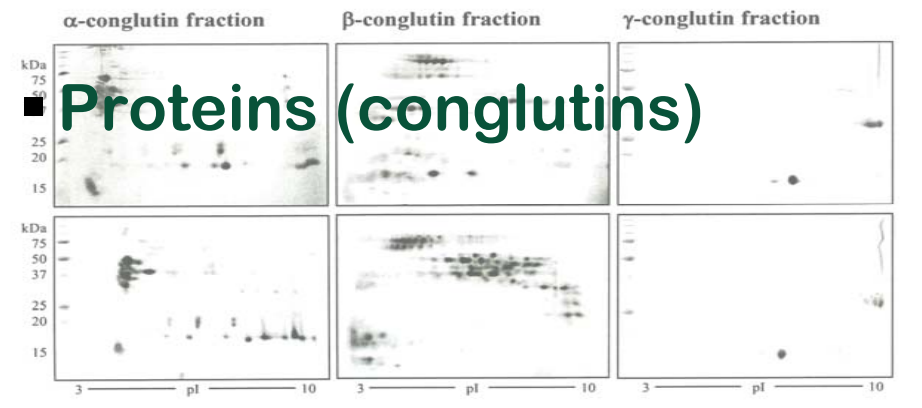
RICH IN

- arginine
- carotenoids (lutein)

LOW IN:

- trypsin inhibitor
- lectins
- isoflavones

Functional ingredients in food systems



- Proteins (conglutins)
- Hydrocolloids (gums) – hydrophilic polymers used for thickening and gelling

rhamno-galacturonan

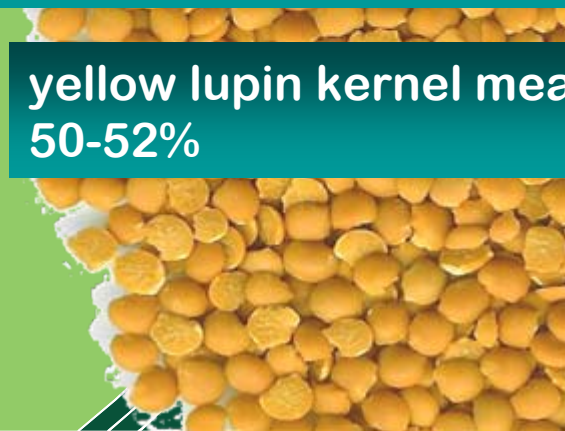
Cultivar differences

typical protein content (as received basis)

Variety	Protein %	Oil %
Belara	31.6	6.1
Mandelup	32.3	5.7
Tanjil	32.6	5.7
Kalya	33.2	5.4
Merrit	33.6	5.6
Quilinock	33.6	5.2
Myallie	34.1	5.0
Coromup	34.5	5.8

Kernel meals

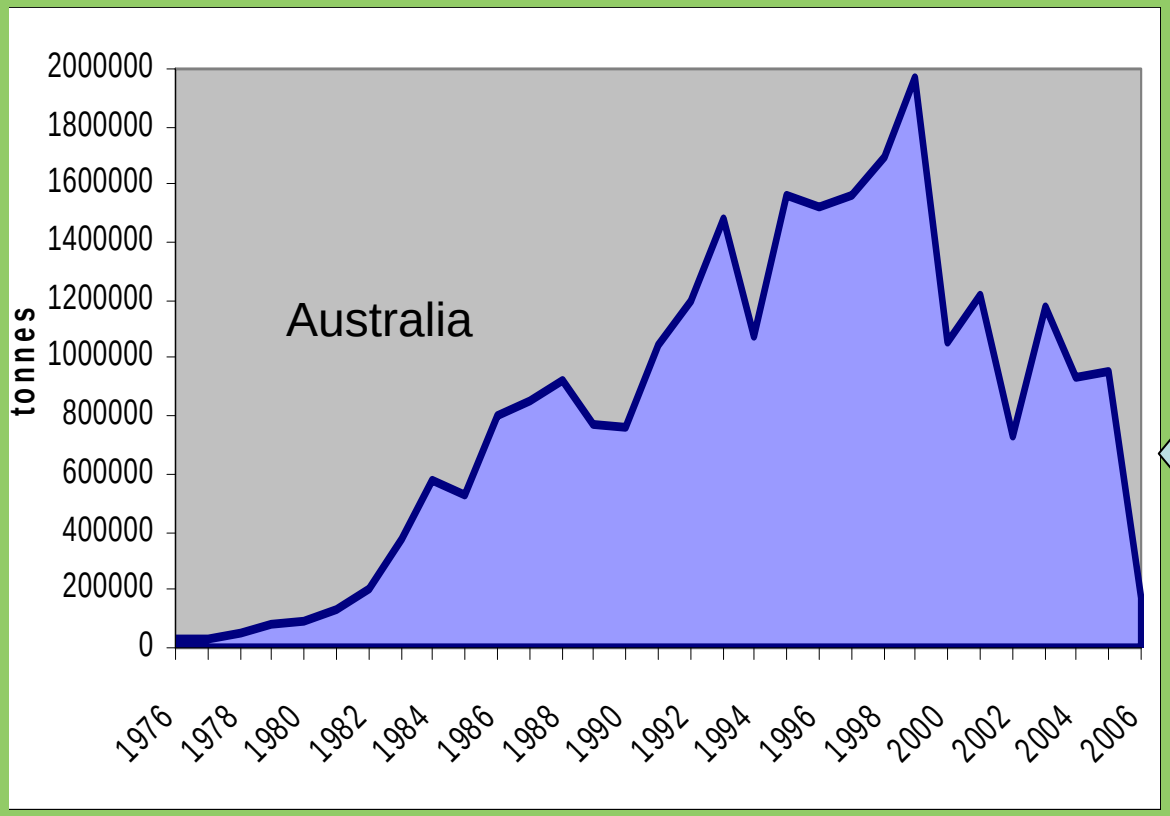
- **Belara 40.5 %**
- **Coromup 45.9%**



yellow lupin kernel mea
50-52%

BUT , first things first …
premium markets require continuity of supply

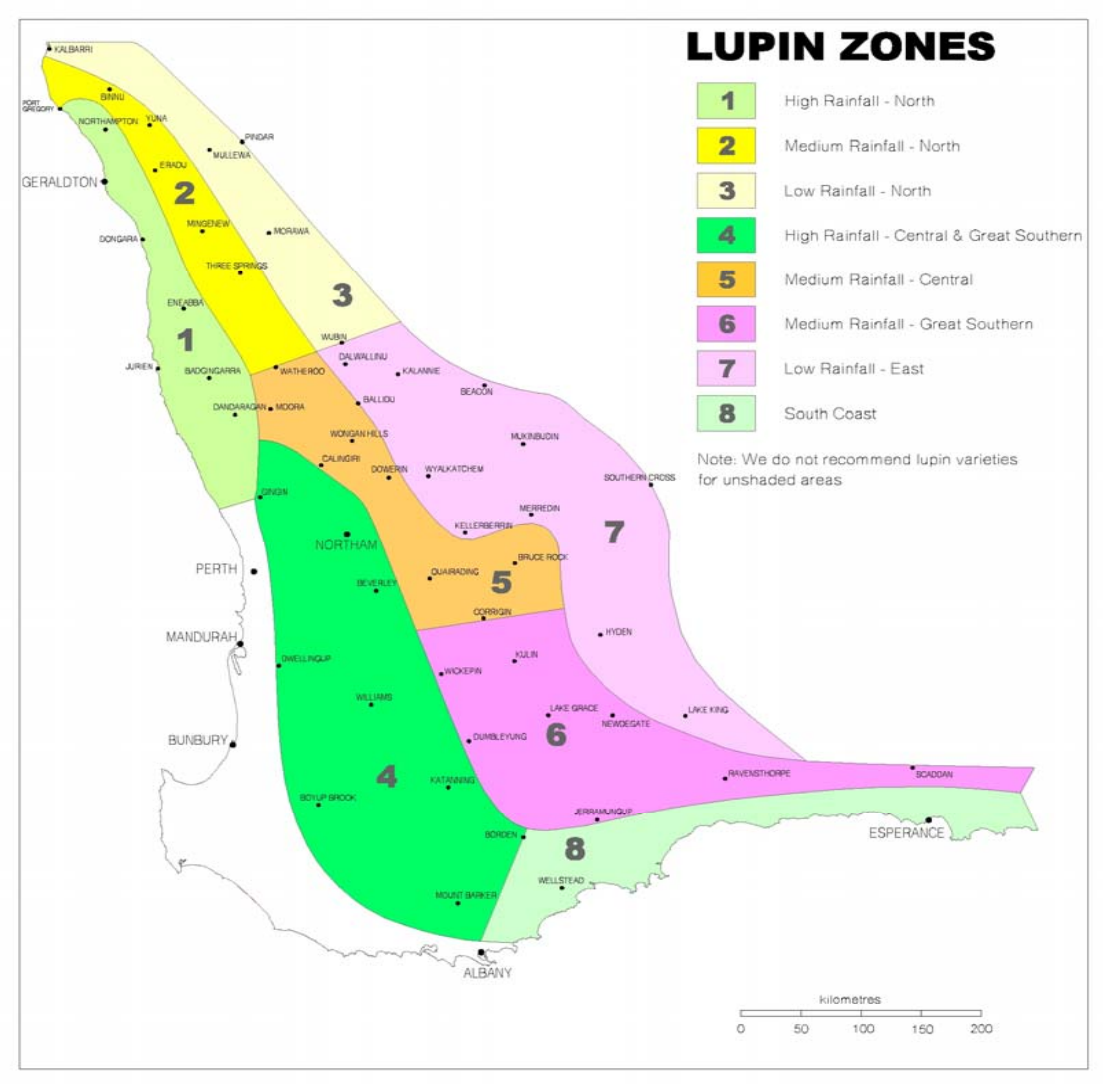
Lupin Production 1976-2006



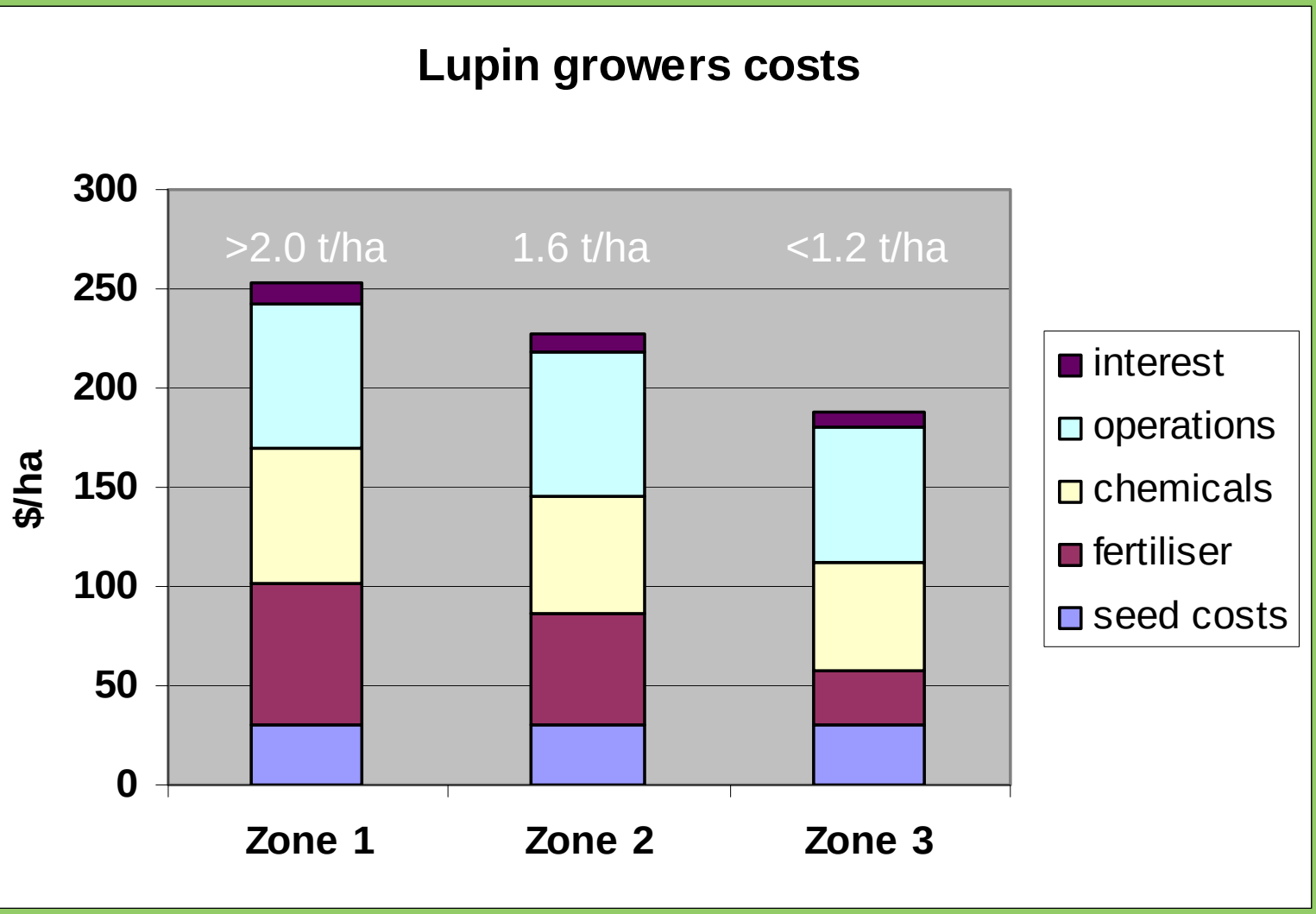
2008

- relative profit
- weeds
- dry seasons, late opening rains

Biggest decline in the lower rainfall zones



AREA SOWN 1999 to 2004	
ZONE	**% drop**
1:	10%
2:	15%
3:	65%
4:	15%
5:	45%
6:	50%
7:	70%
8:	20%



Source: Planfarm (2005)

Western Australia - Weeds

- Herbicide resistance in reduced tillage systems

wild radish
Raphanus raphanistrum

annual ryegrass
Lolium rigidum

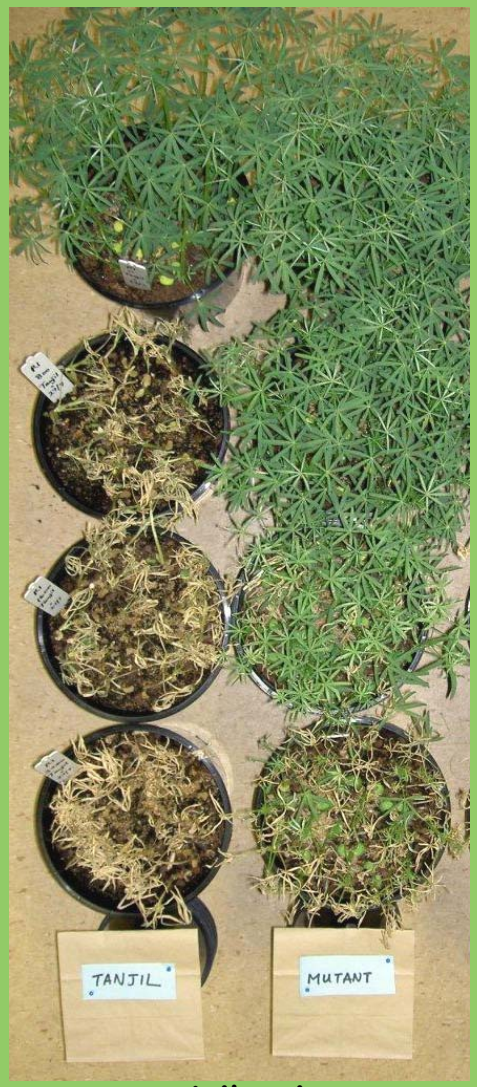
Smarter use of old and new chemicals

Burning header trails

- without risk of wind erosion

Novel herbicide resistance

mutation breeding

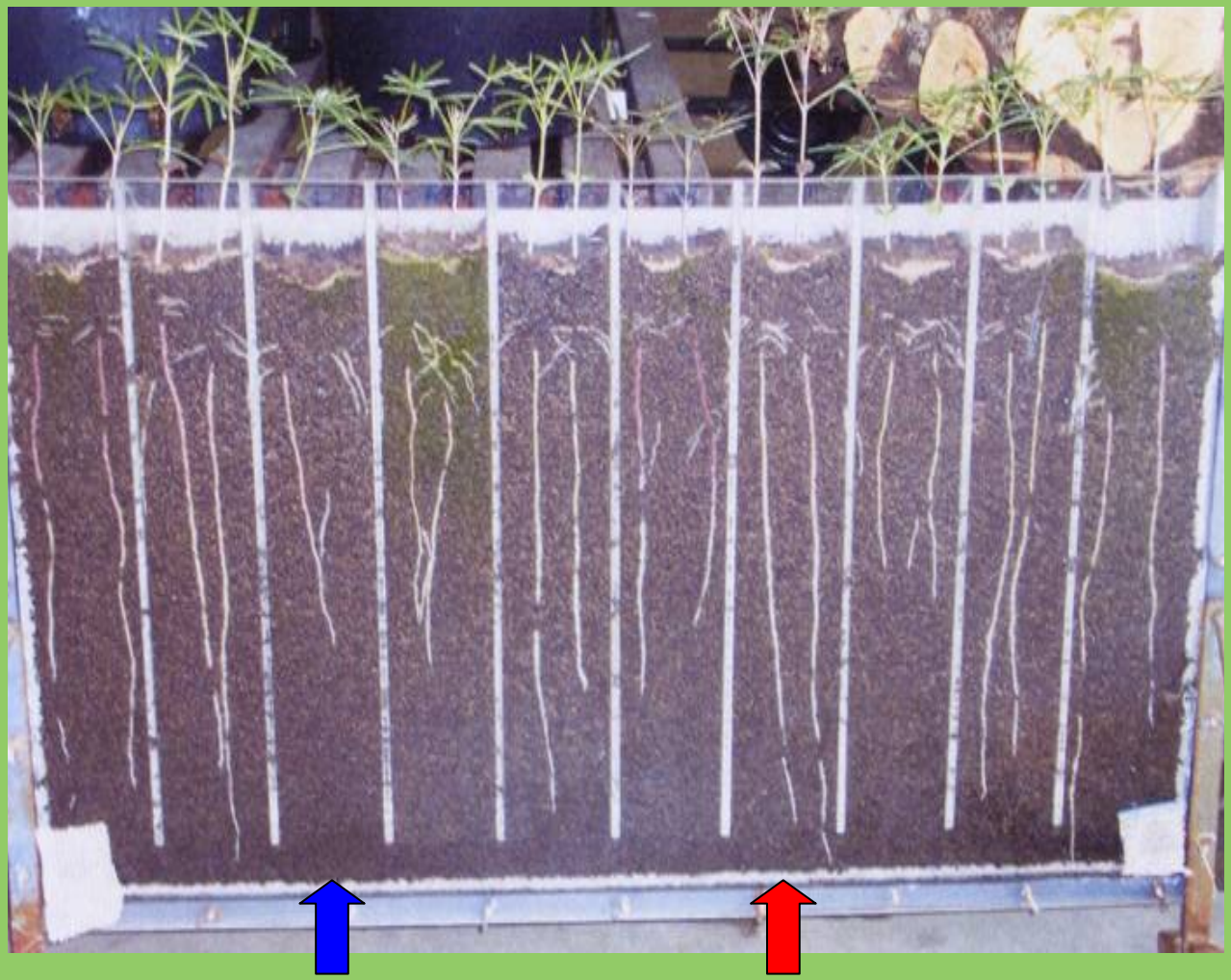


metribuzin

GM

Seedling vigour

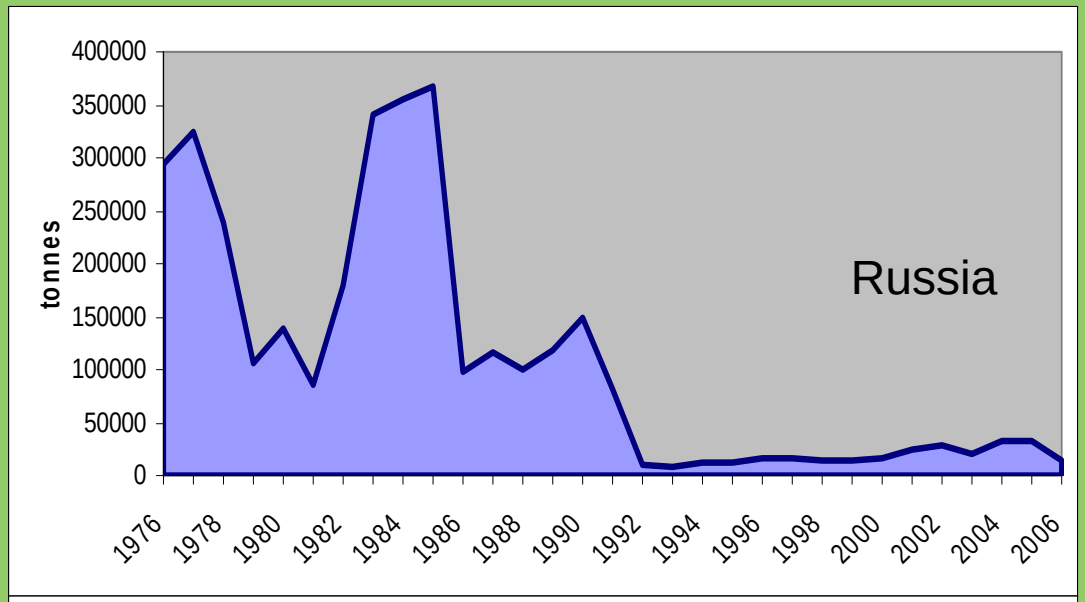
more competitive with weeds

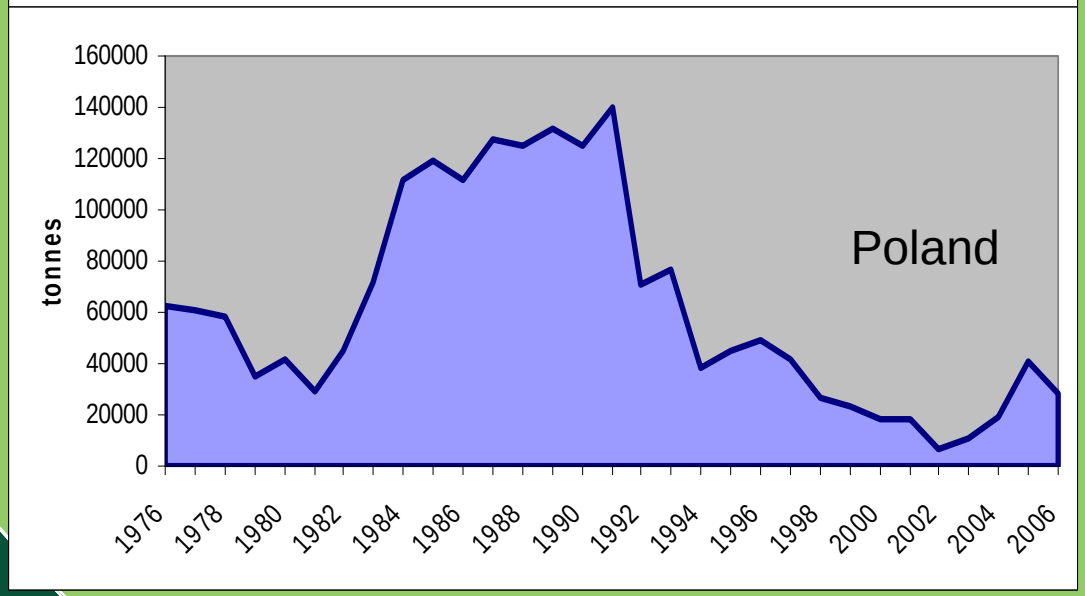


Australian cultivar Russian breeding line

Jon Clements

Lupin Production 1976-2006

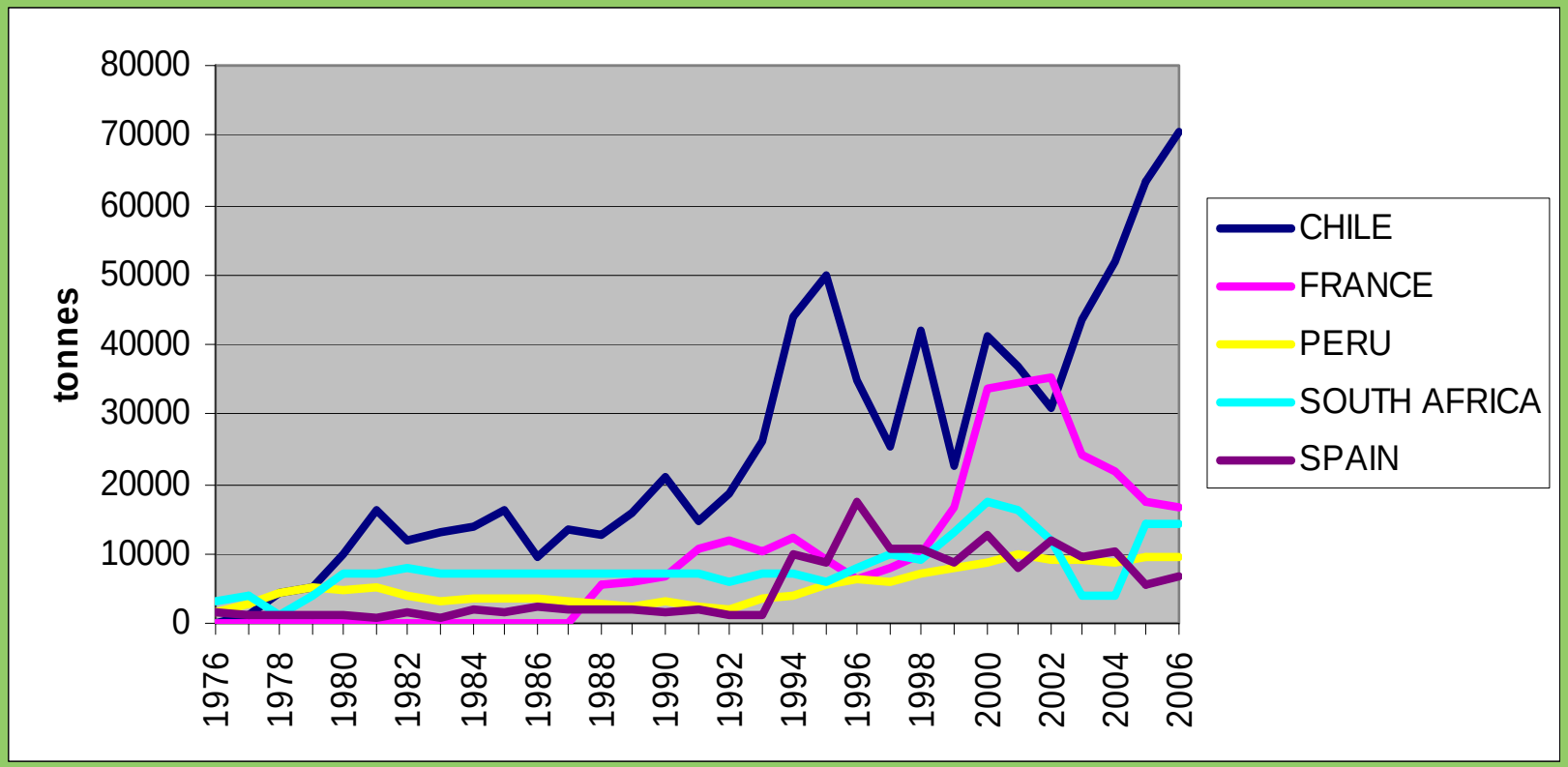




A more market-orientated agricultural sector

- relatively less profitable compared to other crops
- anthracnose

Lupin Production Trends 1976-2006



FAOSTAT

Biosecurity

Anthracnose – *Colletotrichum lupini*

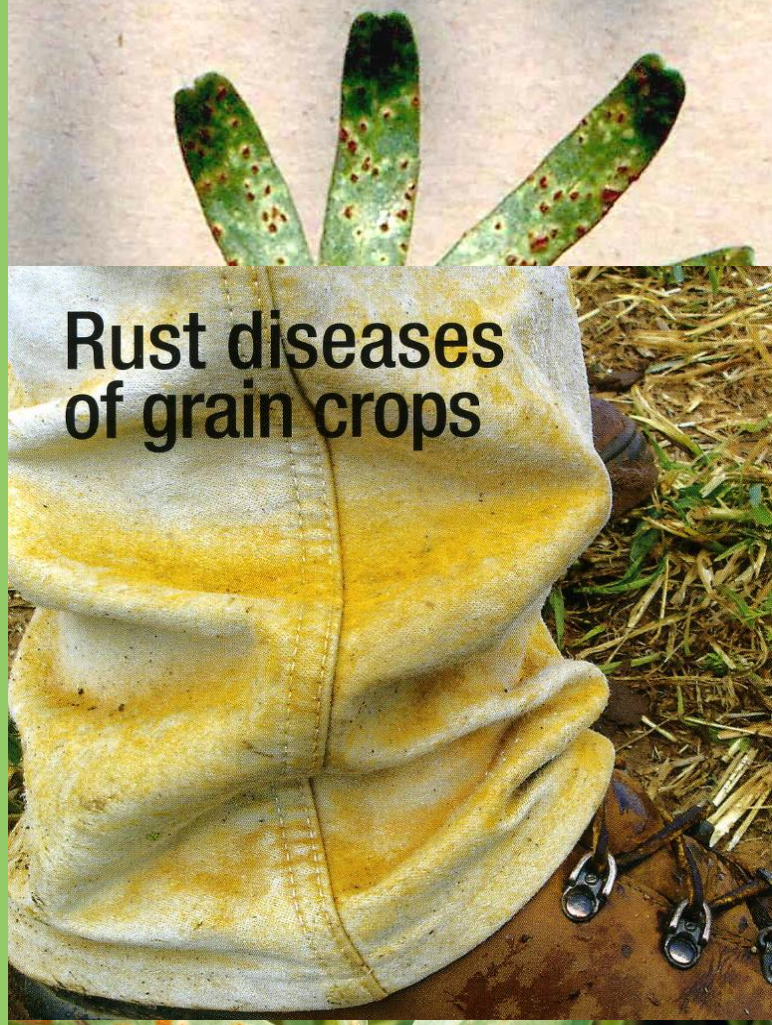
Readily moved around the world with seed

Biosecurity

some pathogens and pests not yet globally distributed:

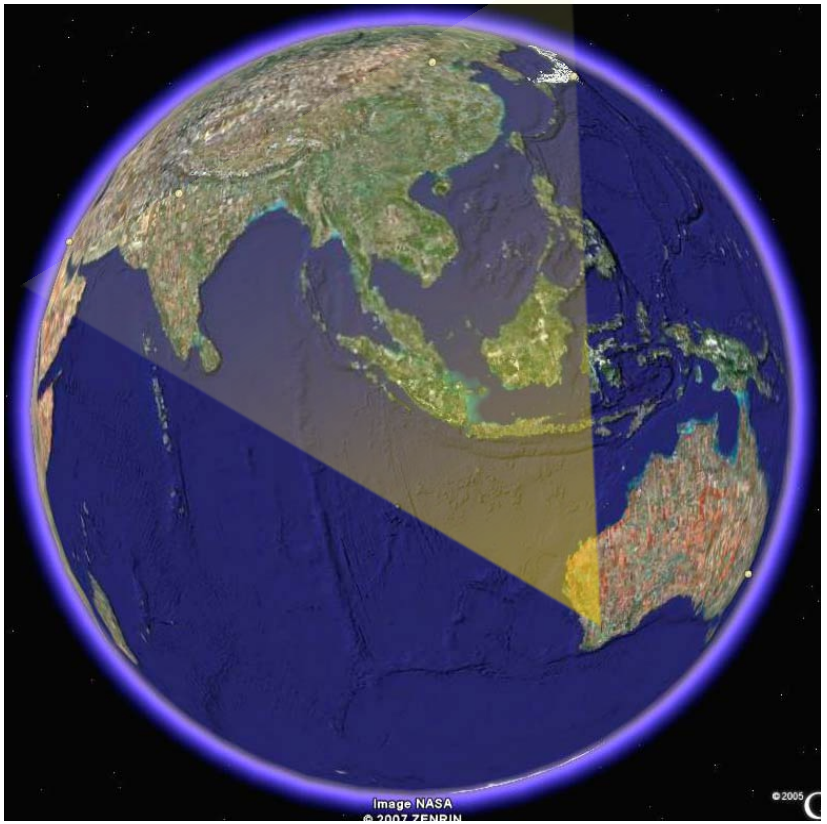
- *Sitona lineatus*
- *Macrosiphum albifrons*
- *Phoma lupini*
- *Uromyces spp.*
- *Fusarium* wilt
- strains of BYMV
- strains of *C. lupini*

All of us are potential vectors

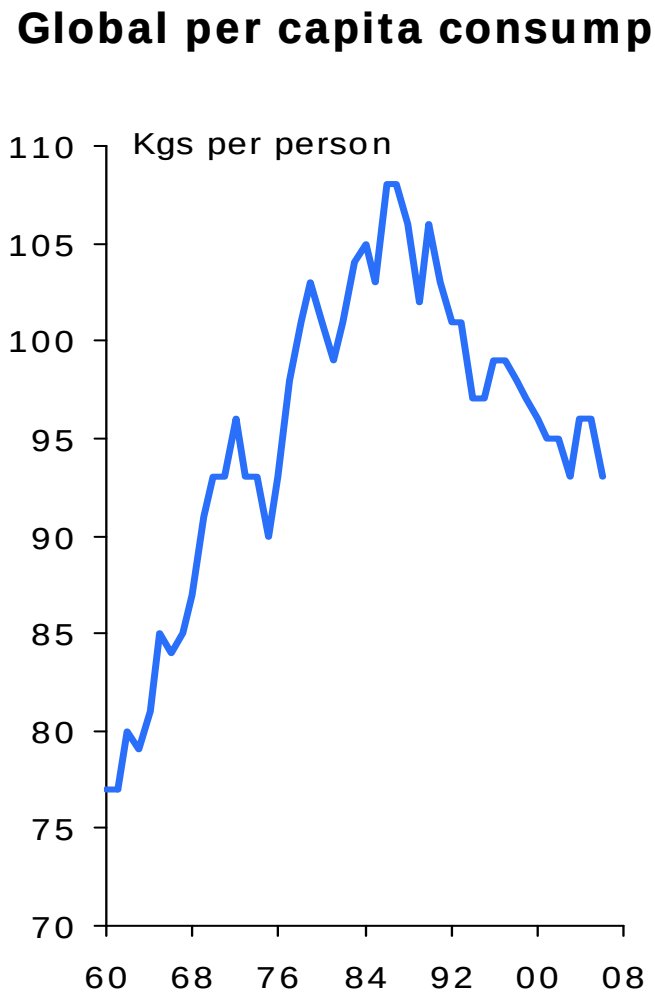


Genuine increasing global demand for plant protein

- for food and feed
- Asian mega-economies (India, China)
- meat consumption
- aquaculture

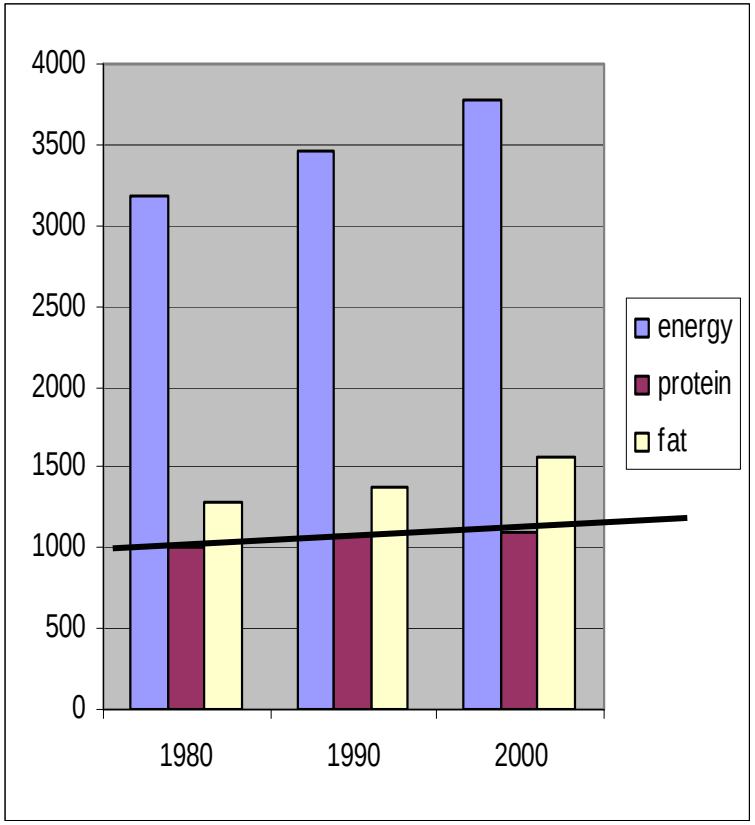


In contrast wheat consumption is declining

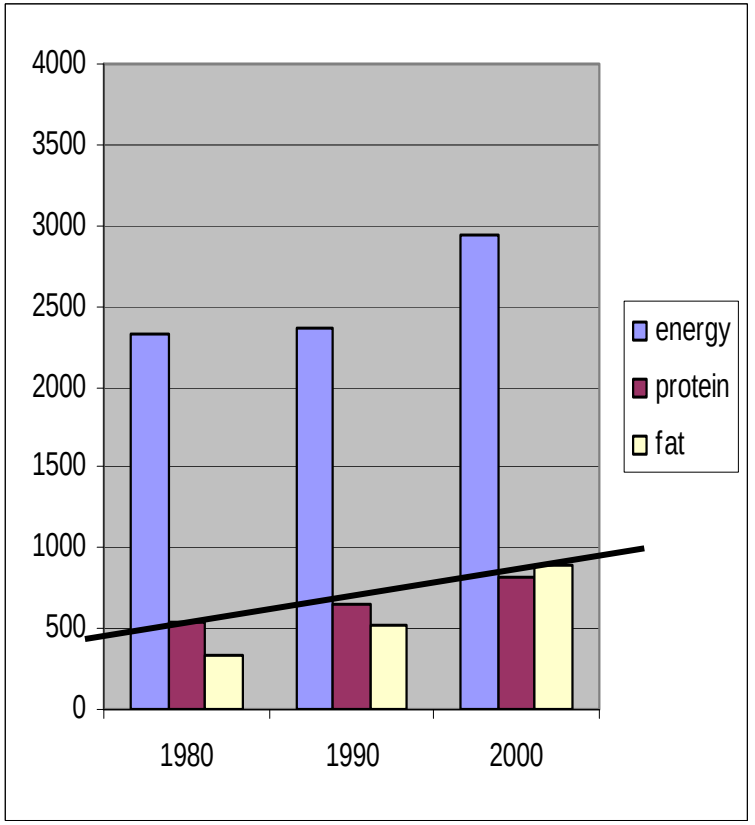


Saul Eslake, ANZ Bank

Per capita food intake



USA



China

Source: UN-FAO; USDA-ERS

Relevance for lupins

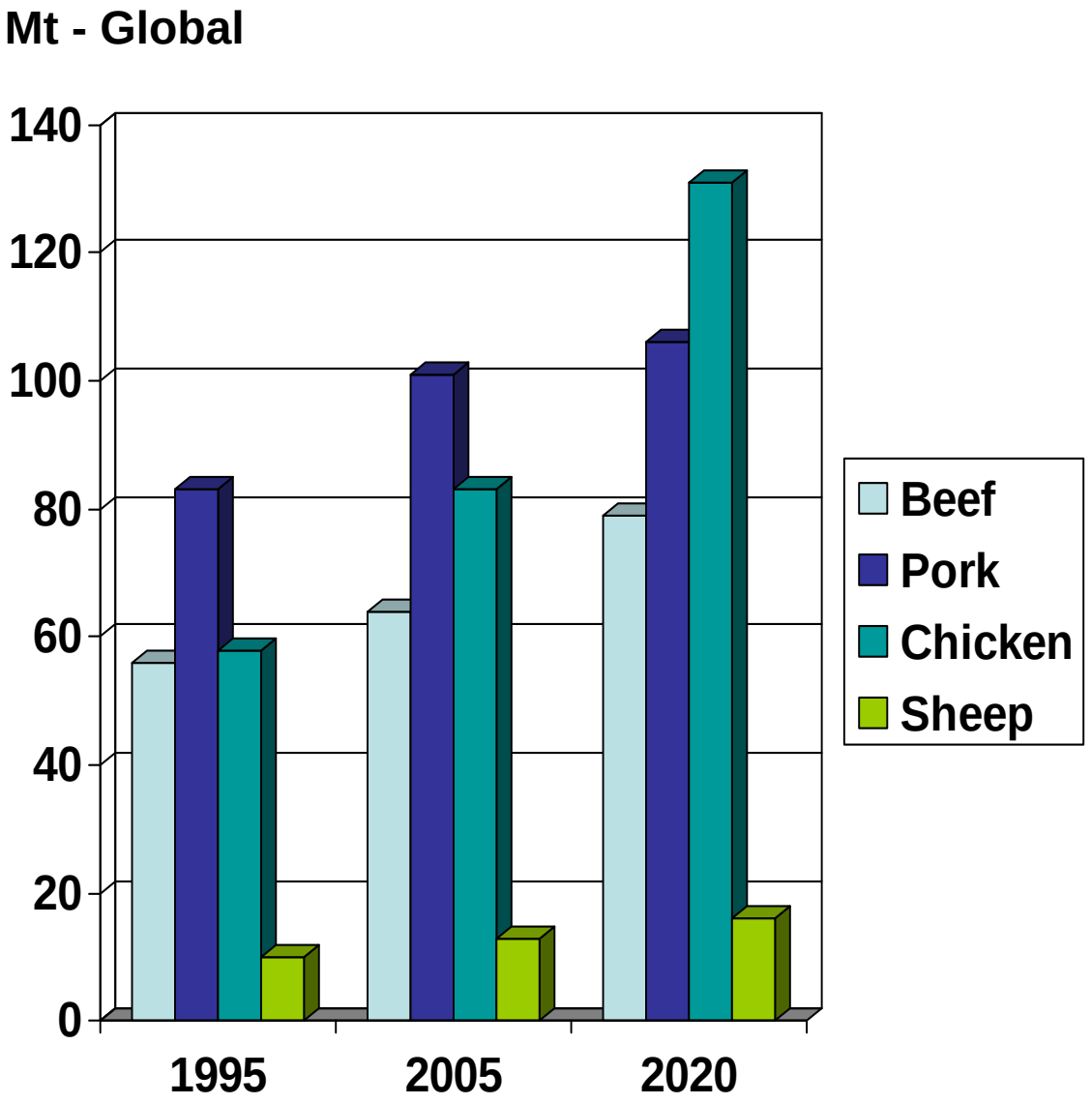
- Increased demand for feed grains (particularly protein meals)

- 8kg grain → 1kg beef
- 3kg grain → 1kg pork

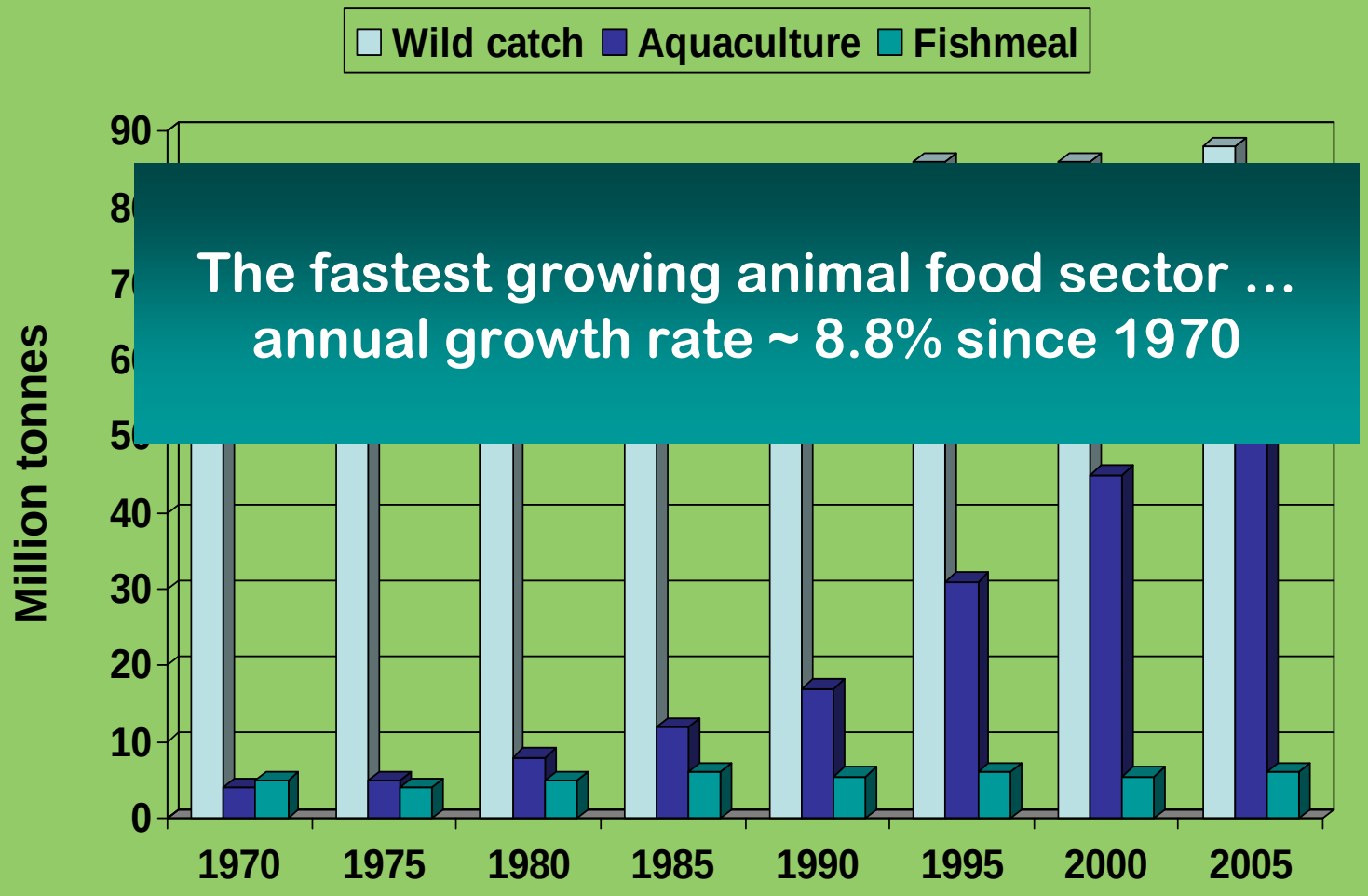
The Livestock Revolution

Feed grains demand

A 2nd Green Revolution



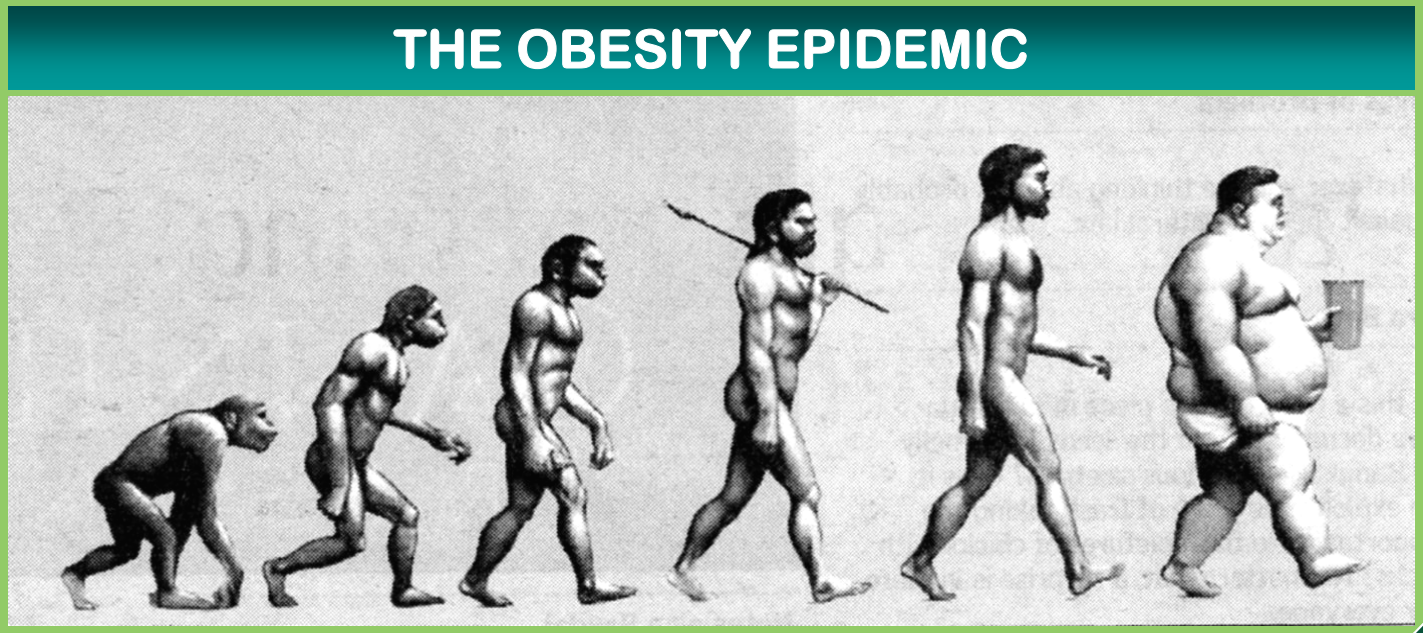
Annual fisheries production



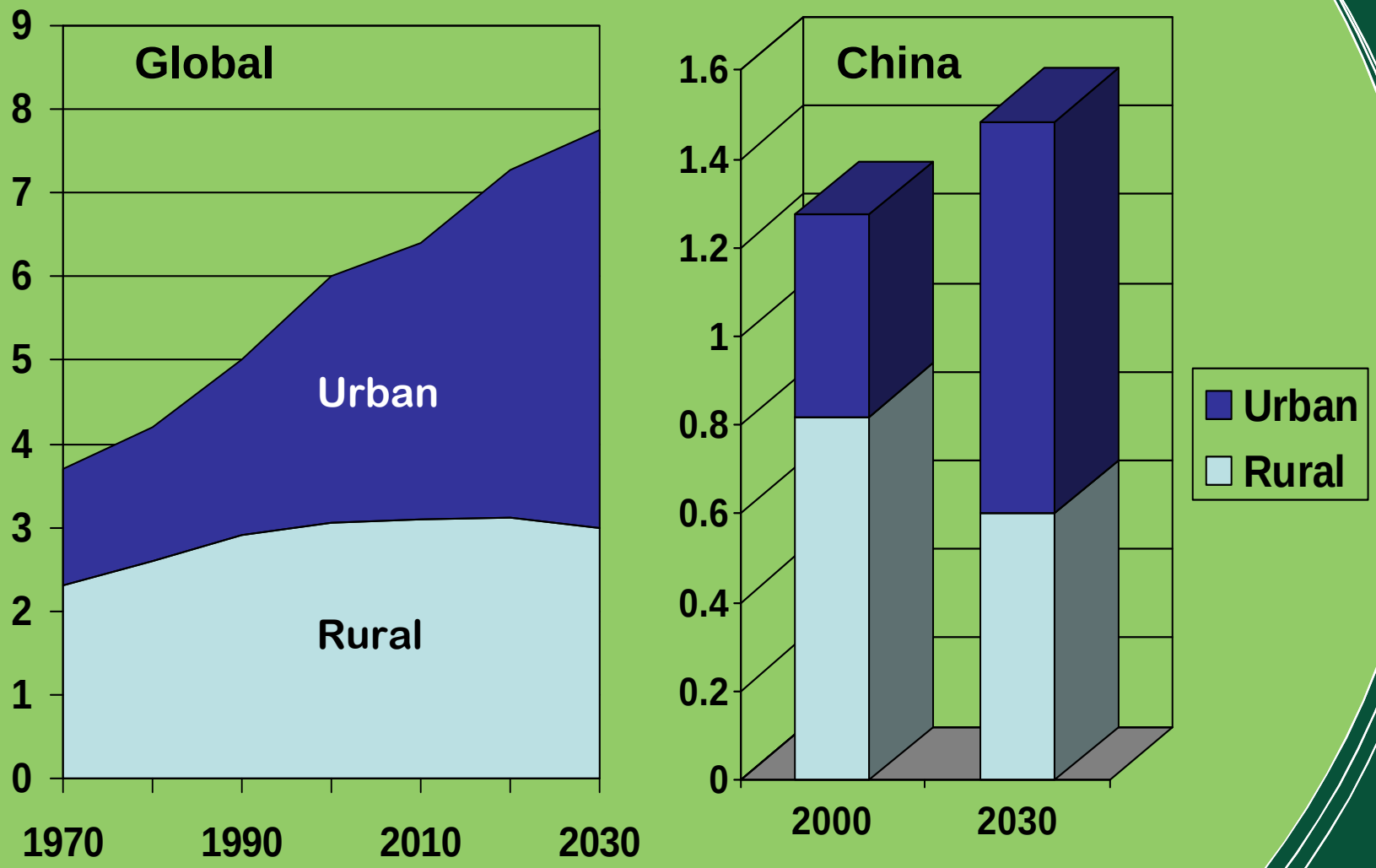
FAO, 2006; IFFO, 2006

Urbanisation - diet and lifestyle

- per capita income growth
- trade expansion and globalisation of food tastes
- decline in real food prices (until 2007)
- increased energy and saturated fat intake, reduced dietary fibre intake
- less physical activity



Urbanisation



FAO

More than 1 billion people are overweight, … 300 million are clinically obese.

- **mainly in Western countries**
- **rapidly increasing in developing countries (20% in some Chinese cities)**
- **childhood obesity in Australia and the US has trebled since 1980**
- **health cost to the US in 1997 was $120 billion**

Notable exception is sub-Saharan Africa

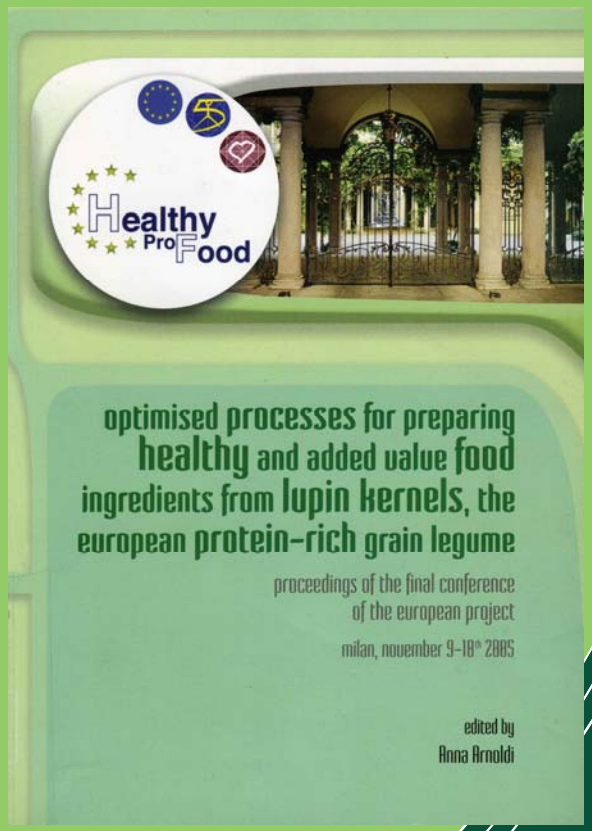
(WHO, 2003)

Diabesity

- a cluster of medical disorders that increase risk of:
  - Type 2 diabetes
  - Cardiovascular disease

Disorders include:
- impaired glucose tolerance
- insulin resistance
- high blood pressure
- elevated triglycerides
- increased LDL cholesterol
- decreased HDL cholesterol

Also increase the risk of:
- some cancers
- osteoarthritis
- respiratory difficulties
- infertility



Diabesity and lupin foods

- increases satiety
  - lowers energy intake, weight loss
- lowers blood glucose spike (low GI)
- lowers blood cholesterol
- lowers blood pressure

whole kernel

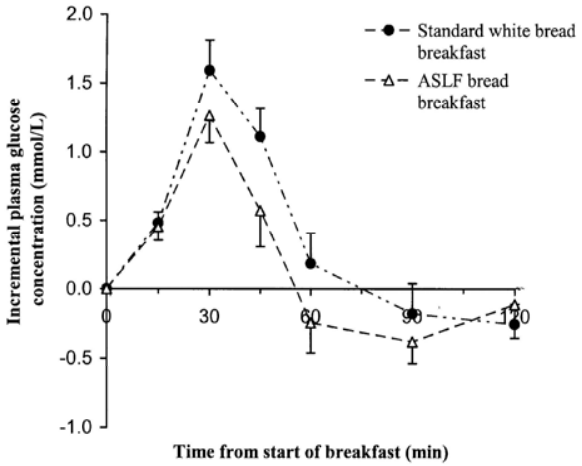
proteins

fibre

alkaloids

Animal model data

Limited human data



Over 500,000 tonnes of food consumed annually in Europe contains lupins (Fletcher, 2006)

Food Industry

Barriers to wider adoption

- Lack of processing knowledge
- Unclear ‘point of difference’
- Allergy risk
- Reliability and consistency of supply
- Taste (in some products)

Food companies needs a commercially competitive position

Global fertilizer price spike

THE WEST AUSTRALIAN

News

Farm costs soar as demand for food booms

JODIE THOMSON

Farmers' attempts to cash in on soaring global grain prices are being tempered by spiralling production costs as the world's growing appetite drives up the price of farm fertiliser and chemicals.

Growth in demand for food from China and India, combined with increased use of crops to produce biofuel, have increased demand for key farming factors.

WAFarmers president Trevor De Landgrafft said the cost of some farm budgets had almost doubled as farmers took into account increases in fuel, fertiliser, chemical, transport, labour and interest rates.

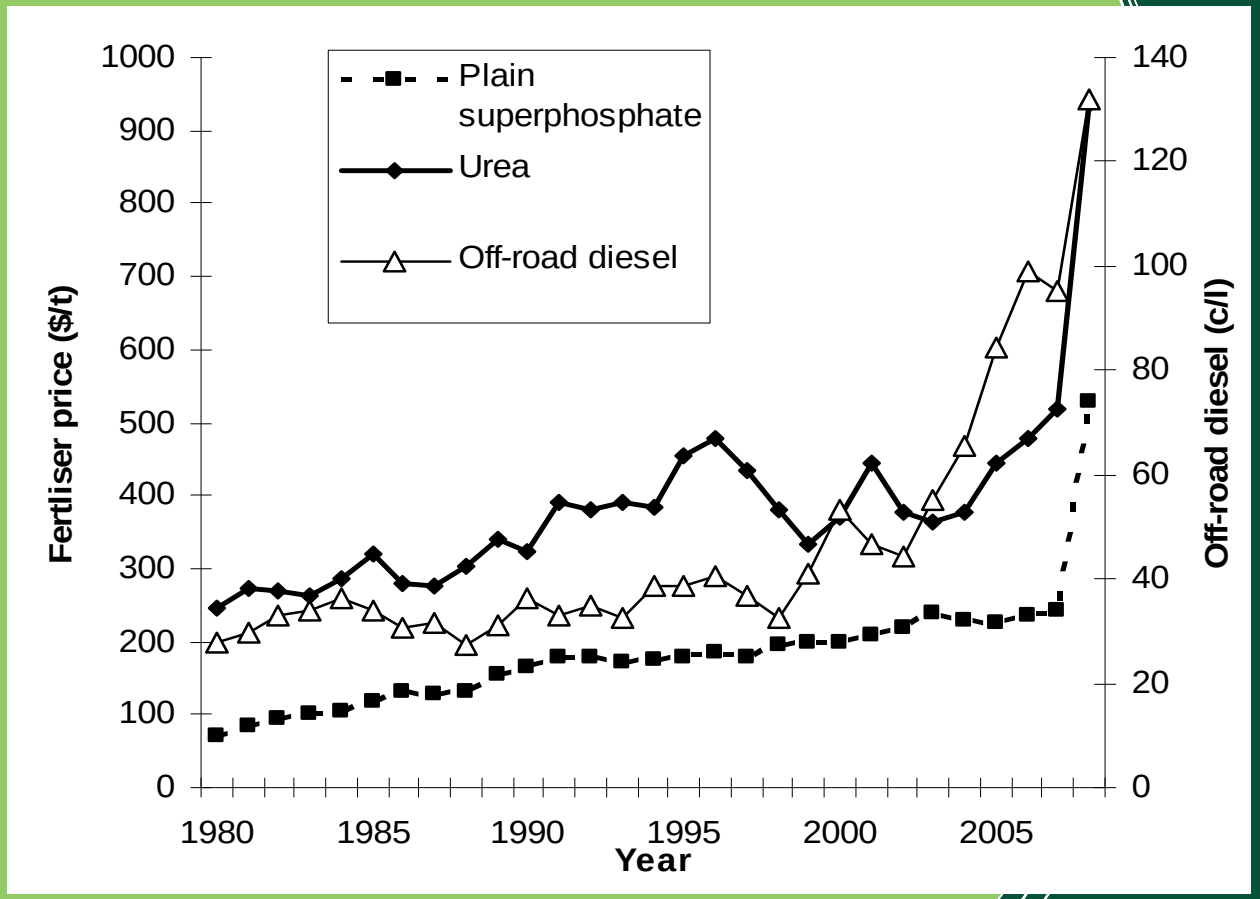
While high grain and oilseed prices were outweighing those increases, any.

He said farmers were budgeting about $28-$30 per crop hectare for fuel costs, compared with an average of about $22/ha over the past three years. Interest rate rises had been a big blow for those with substantial borrowings.

Even with the increased costs, expectations among Planfarm clients for 2008 were bullish. Most farm budgets were showing healthy surpluses even at conservative yield and grain price estimates.

Summit Fertiliser marketing executive manager Murray Browne said import costs had been driven up dramatically as stable world supplies of fertiliser failed to keep up with surging demand. This meant prices were kept high by the demand from major grain-growing nations.

Western Australian prices



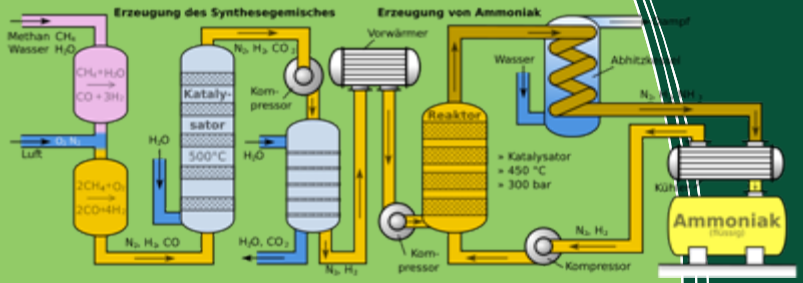
Nitrogen price is linked to energy cost

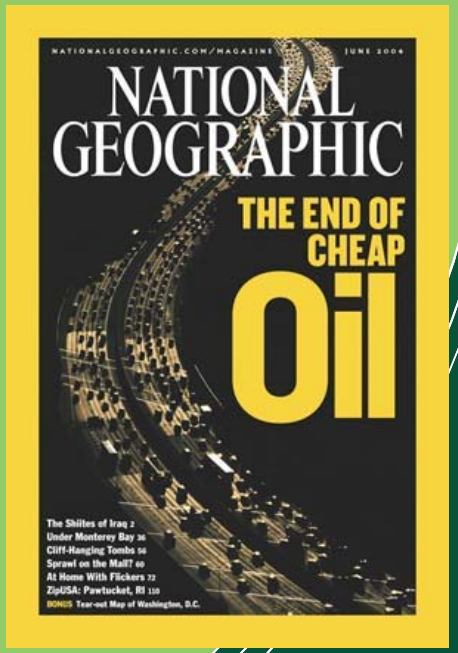
90% of the cost of manufacture of $N_2 \rightarrow NH_3$ is the cost of energy

35 gigajoules

↓

1 tonne of urea





Symbiotic Nitrogen Fixation

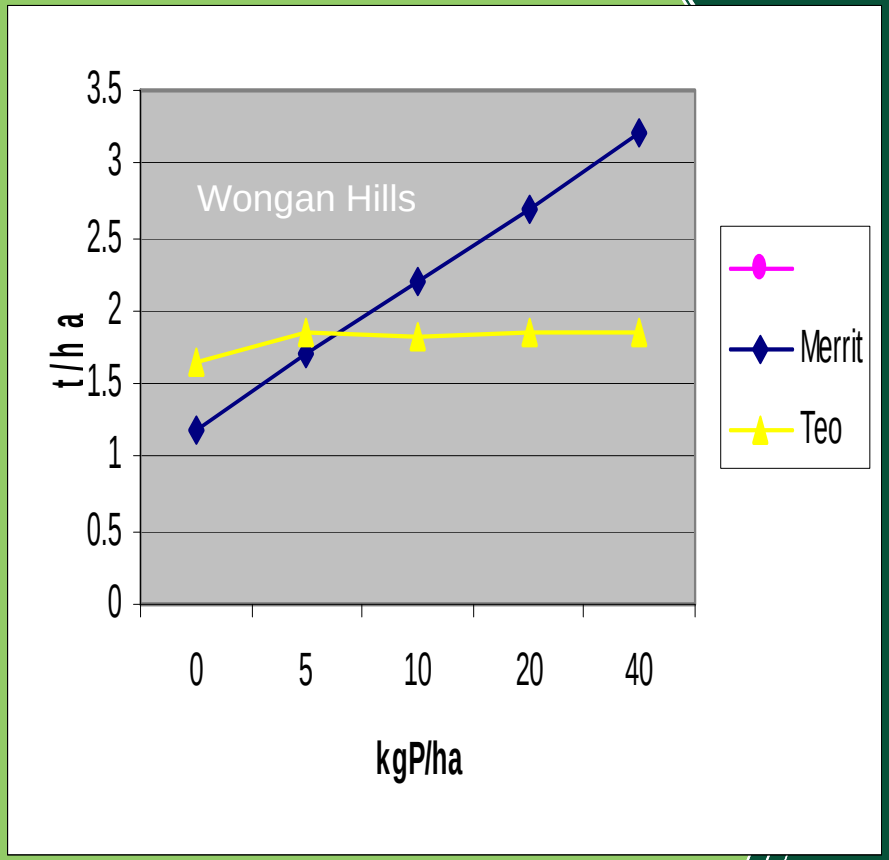
$N_2 \rightarrow NH_4^+$

Reduced carbon footprint

400,000 ha of lupins in WA in 2008 will fix ~ $120m worth of N

Phosphorus

- 40% of the world's arable land is limited by P availability
- the most commonly limiting nutrient for lupins in WA
- less than 20% of applied P is removed in the first year (complexed to cationic and organic fractions)
- *L. luteus* 'mines' the insoluble P better than *L. albus* which in turn better than *L. angustifolius*



Vance (2001)
Vance (2001)

Bolland *et al.* (2001)

MIDAS – bioeconomic model

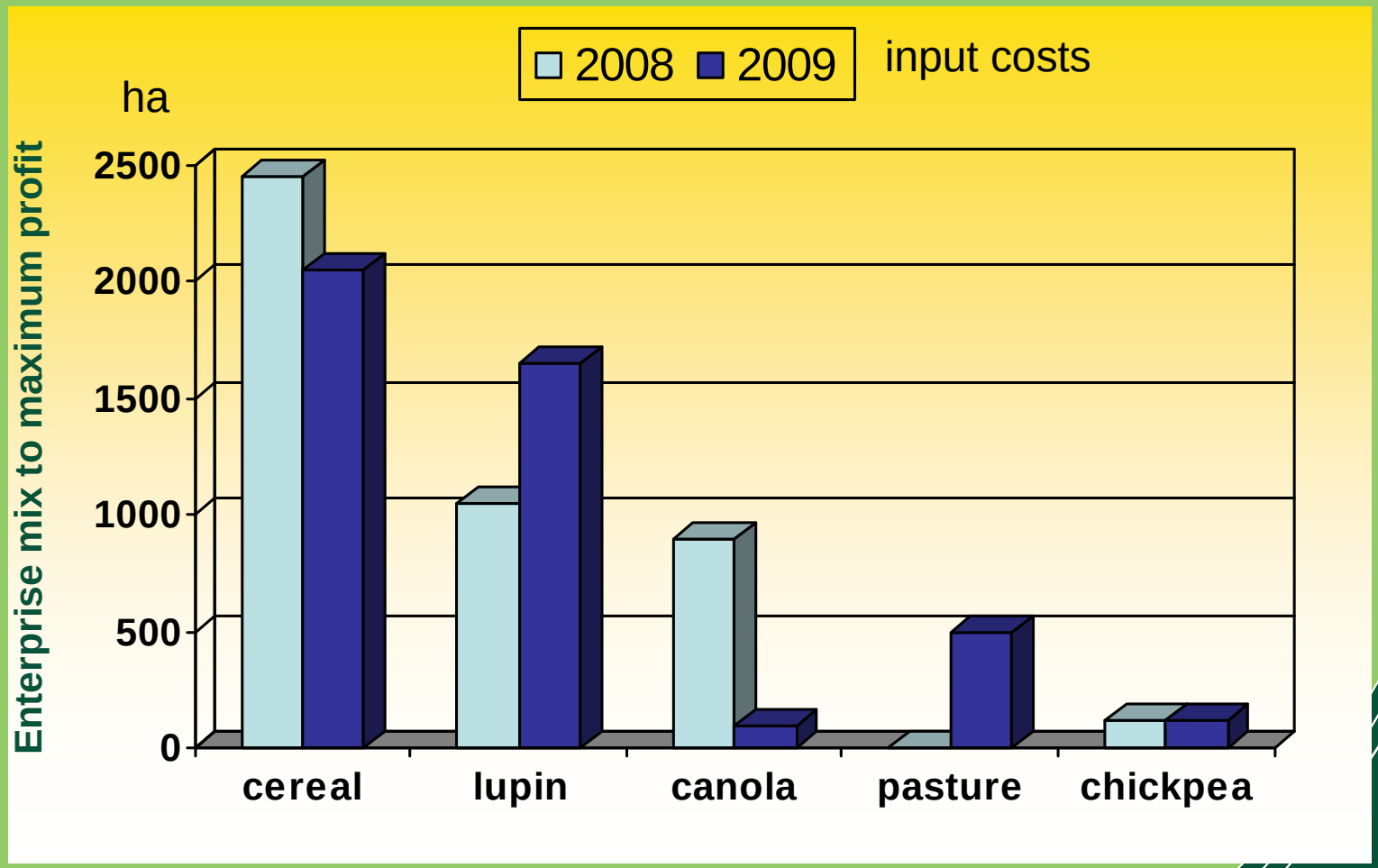
- Model of an
- Integrated
- Dryland
- Agricultural
- System

Optimises enterprise mix based on soil-type capability, cost and price of inputs and outputs

Kingwell and Pannell (1987)

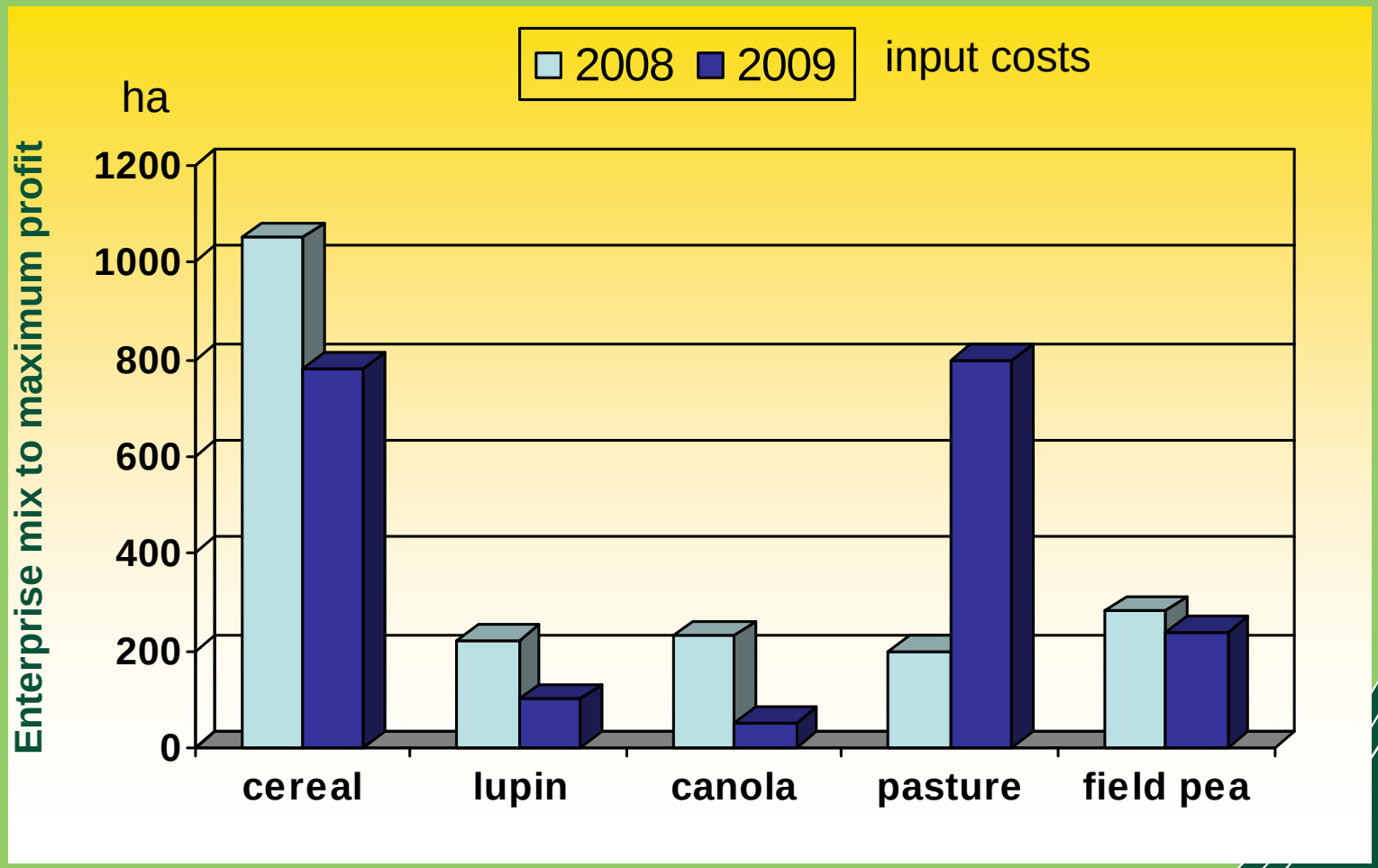
MIDAS optimisation (2008 grain prices)

'Geraldine' Farm - Mingenew assuming an average year



MIDAS optimisation (2008 grain prices)

Central wheatbelt farm – assuming an average year



The US soybean industry

the highest agricultural export earner in the US

1900s - introduced as a green manure

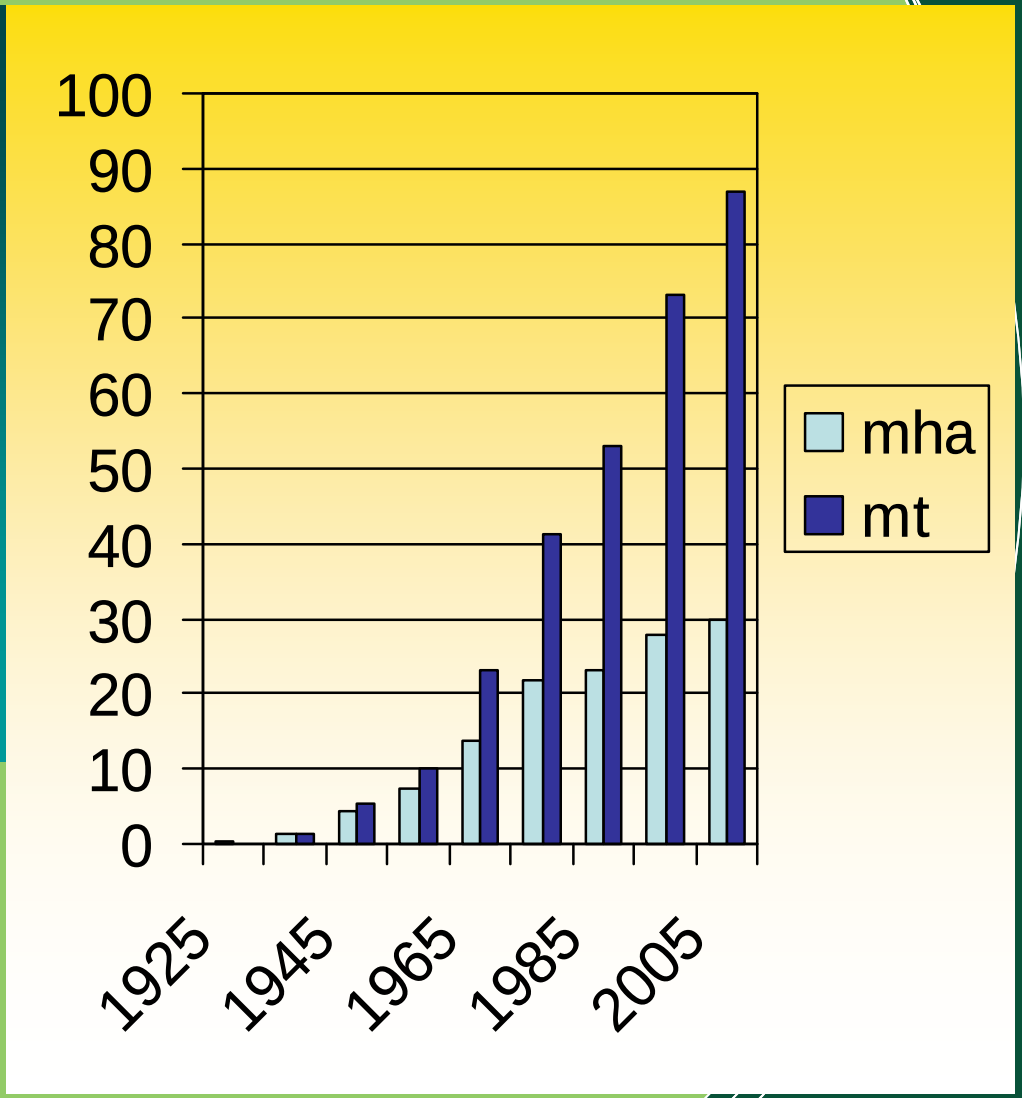
1930s - solvent extraction of oil

1970s - food and industrial product R&D

1980s - integrated production, processing & marketing

1990s - FDA health claims

2000s - GM



Define, and exploit the competitive advantage …

- in farm production systems
- for specific end-uses

www.lupins.org