El fuego sagrado de la innovación

El Cuarto Elemento

XVIII Congreso Aapresid


Agriculture
Water
Catchment Management

Agriculture
Water
Catchment Management

John Williams
Natural Resources Commission

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Bob Mc Cown, Ray Isbell, Pat Walker, David Smiles


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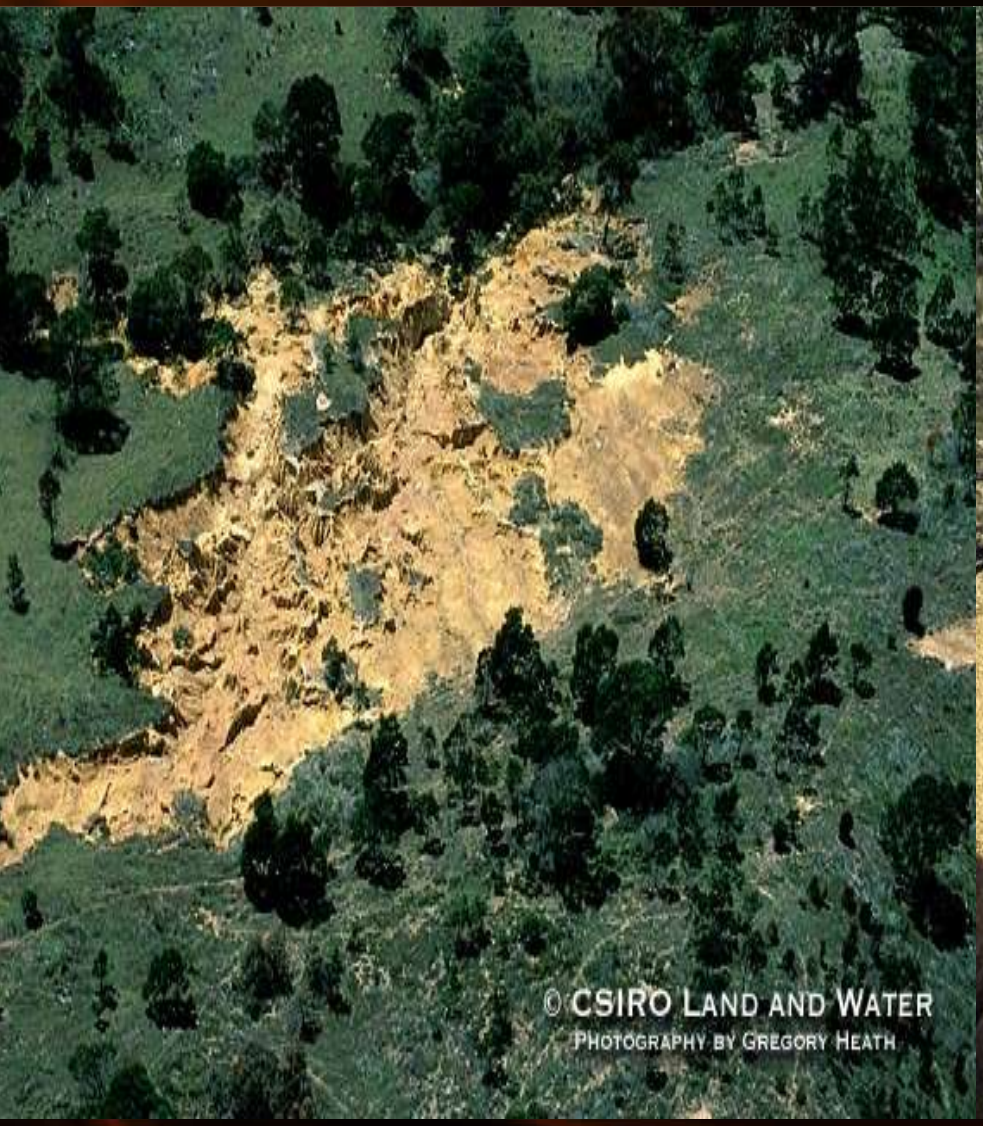
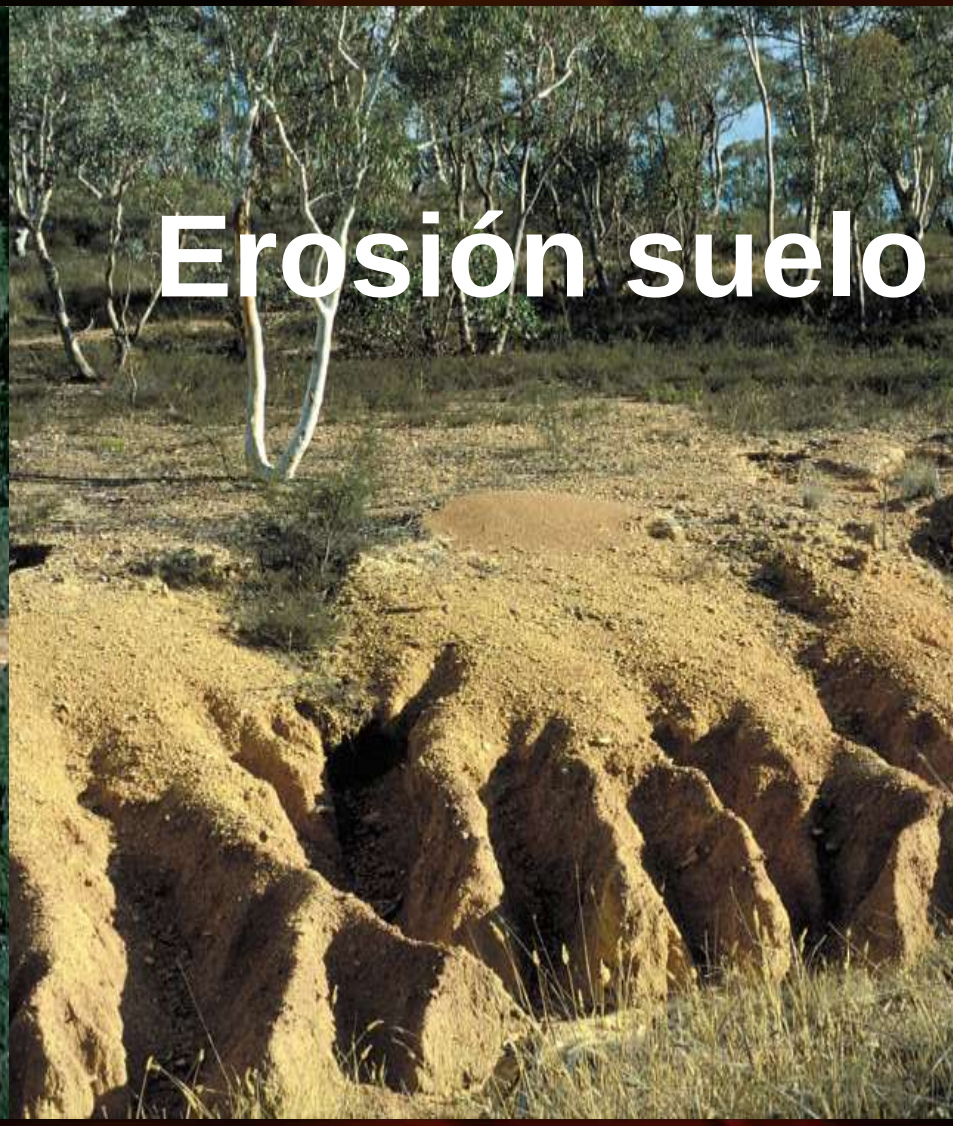
Damage to Environmental Assets

- soil nutrient depletion
- soil acidification
- soil structural decline
- soil biological decline
- dryland and irrigation salinization
- wind and water erosion
- contamination with residues of agricultural chemicals

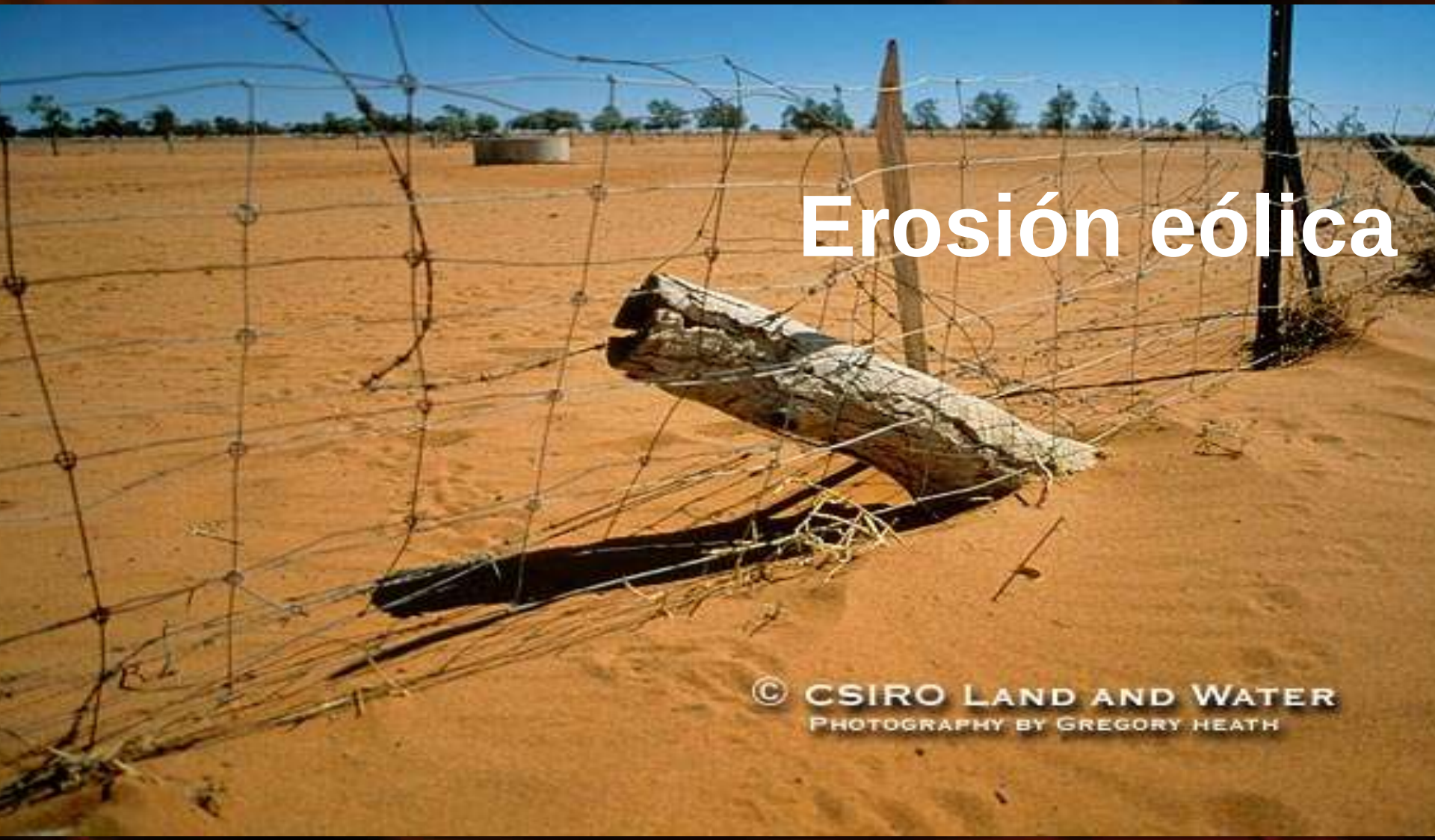
Damage to Environmental Assets

- loss of habitat and biodiversity
- river processes and environmental flows
- nutrient, salts and pollutants to wetlands, rivers and water bodies
- contamination of groundwater with nutrients, salt and pollutants
- riparian, remnant vegetation damage and rural tree decline
- decline in native pastures and environmental value of rangelands





Erosión suelo


Erosión eólica
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Salinidad
© W van Aken, CSIRO

Salinidad


Salinidad
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6 November 2002
Riverina

6 November 2002
Riverina….10 minutes later

Loxton SA: Annual Rainfall 273mm
2002 – 106mm (Decile 1)

Sequía en 2002

2002: - Excessive Cultivation
- no stubble protection
- crop lost this year
- soil and nutrients lost
- major restoration required

Cultivo excesivo

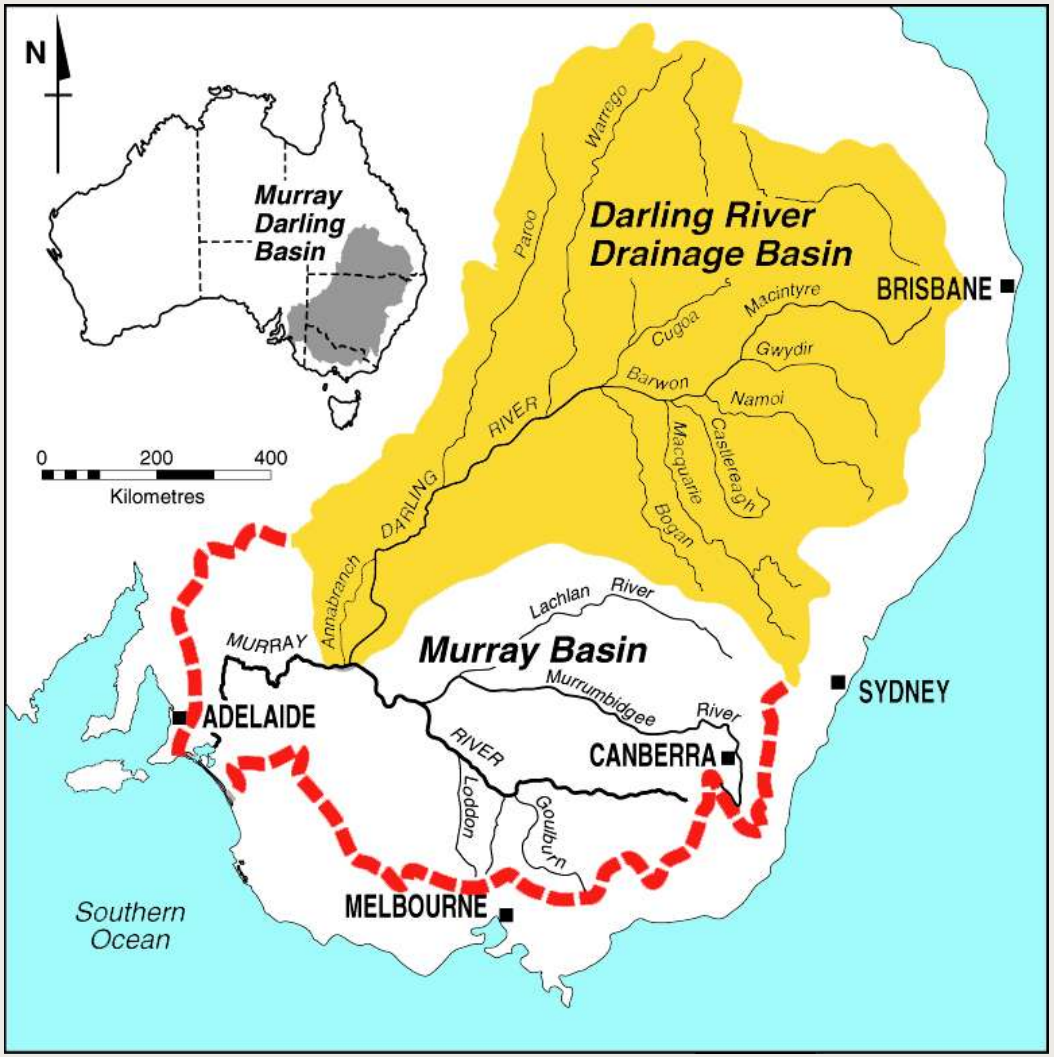
Courtesy David Roget of CSIRO

Waikerie SA: **Annual Rainfall 252mm**
2002 – 110mm (Decile 1)

Sequía en 2002
Cultivos intensivos con labranza cero

2002:
- **Intensive Cropping with Zero Tillage**
- **some crop (cash flow)**
- **crop lost this year**
- **stable soil (this years crop and last years stubble)**
- **ready to crop next year**

Courtesy David Roget of CSIRO


N
Murray
Darling
Basin
0
200
400
Kilometres
Darling River
Drainage Basin
Warrego
Paroo
Macintyre
Cugoa
Gwydir
Barwon
Namoi
RIVER
DARLING
Macquarie
Castlereagh
Bogan
Annabranch
Lachlan River
MURRAY
Murray Basin
Murrumbidgee River
RIVER
Loddon
Goulburn
BRISBANE
SYDNEY
ADELAIDE
CANBERRA
MELBOURNE
Southern
Ocean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Photography by Gregory Heath

El Cuarto Elemento
XVIII Congreso Aapresid


No sé qué hacer!
. . .

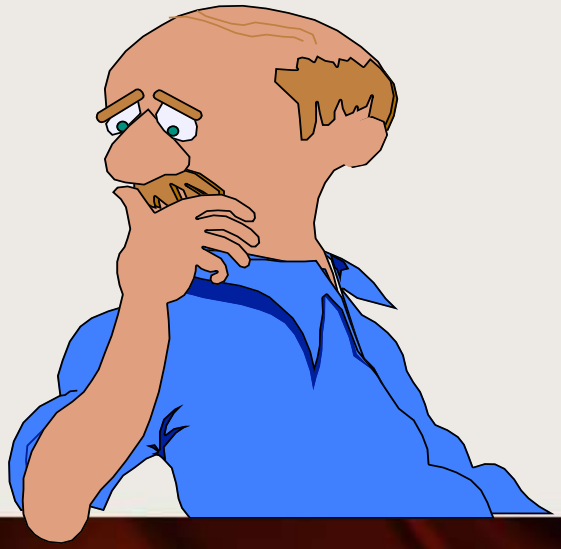
Entonces, ¿cuál el problema?

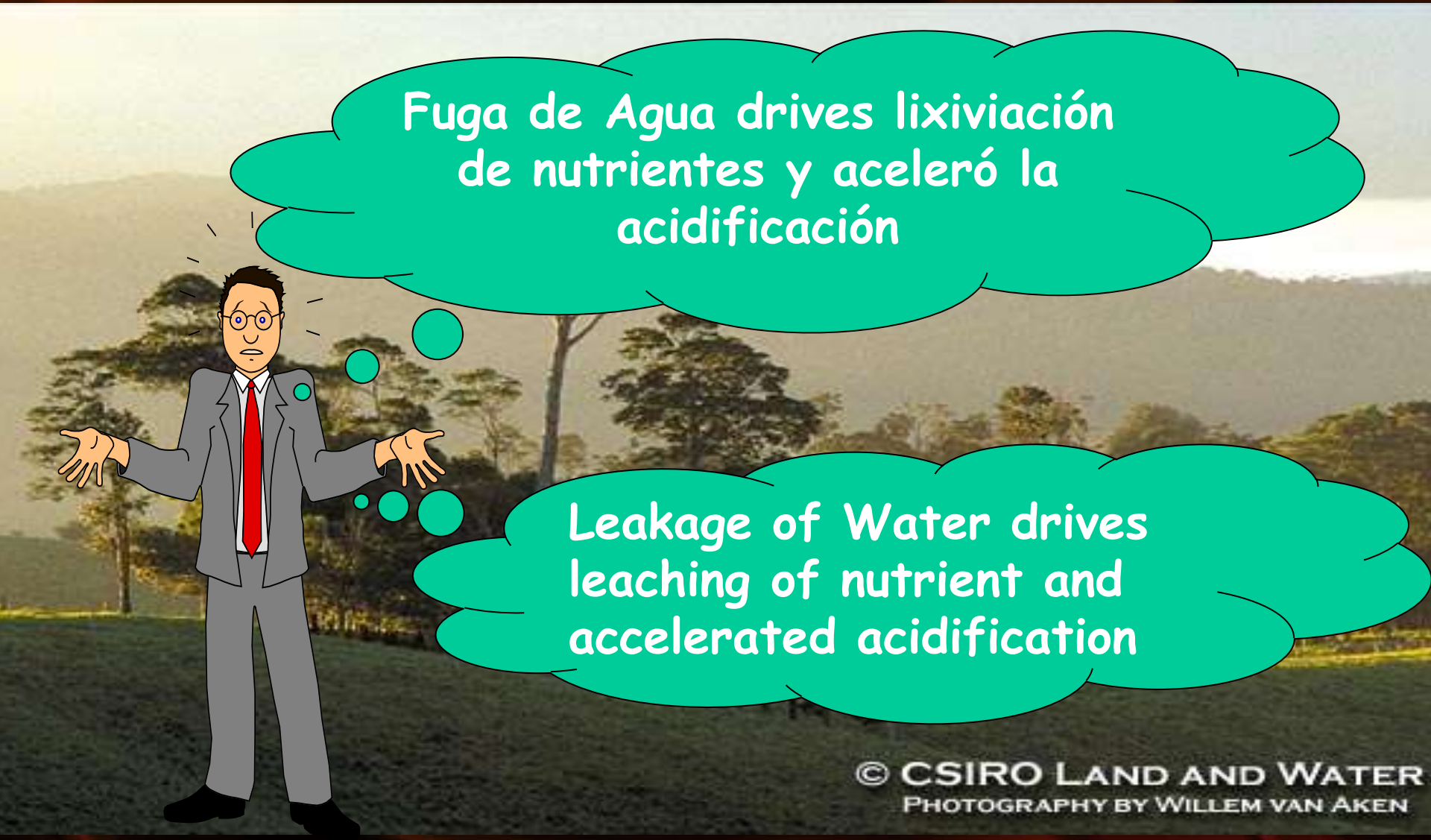
The Australian irony

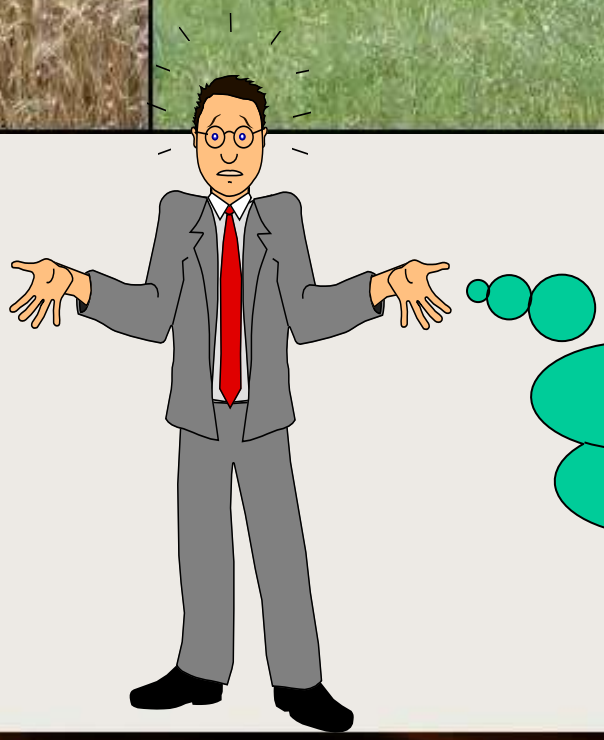
- **whilst our Agricultural productivity is constrained by lack of water and nutrients**

- **fundamental cause of much of our land degradation is an excess of water and loss of nutrients at key periods of the year.**

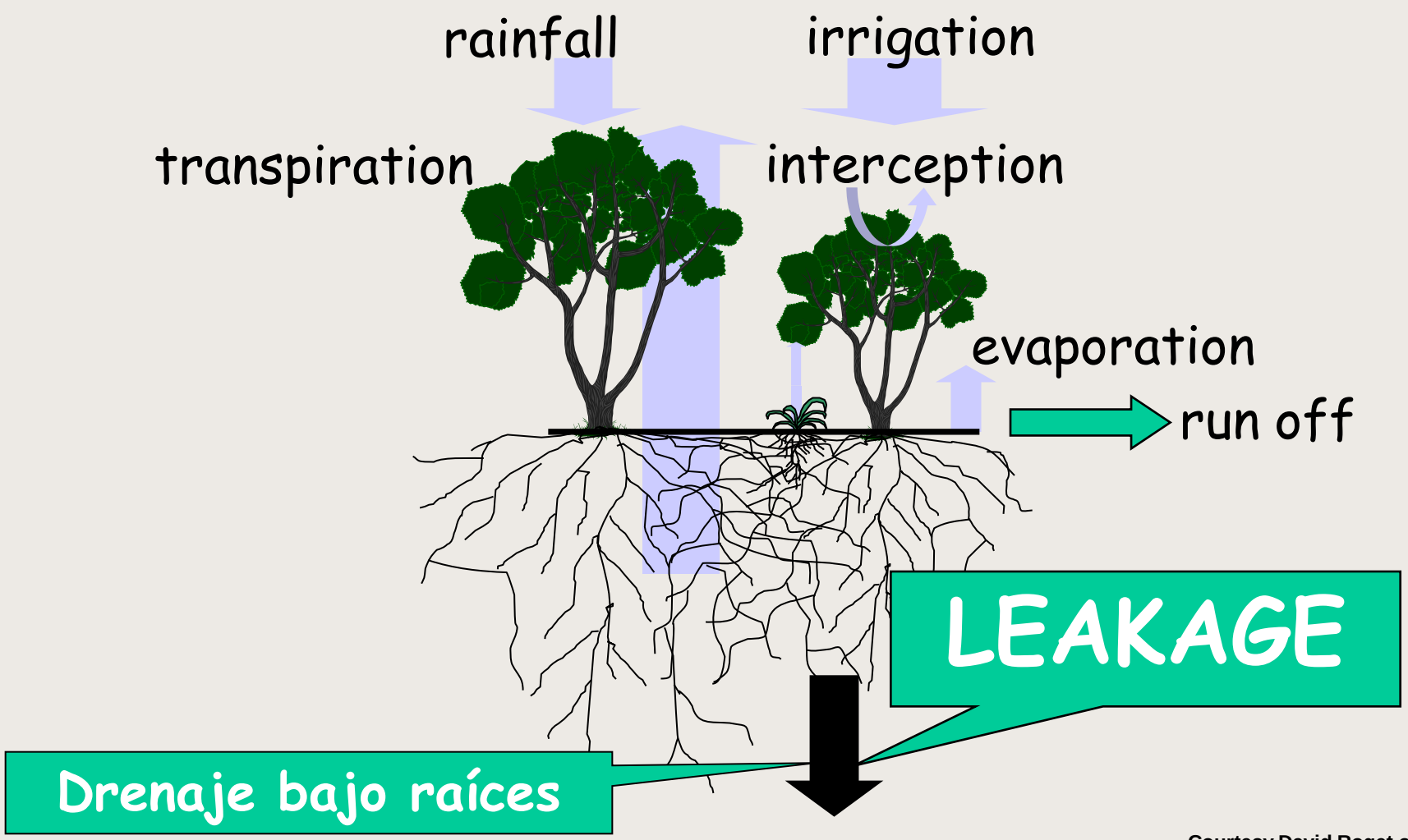
An essential design criteria of sustainable farming is to ensure that present-day flows of water, nutrient, carbon and energy match the magnitude of these flows that evolved to suit the way our landscape functions.




Fuga de Agua drives lixiviación de nutrientes y aceleró la acidificación
Leakage of Water drives leaching of nutrient and accelerated acidification
© CSIRO Land and Water
Photography by Willem van Aken



Science to calculate
& measure flows
in Agro-ecosystems



Courtesy David Roget of CSIRO

Bristow et al., 1986 J Agric & For Meteor,36,193-214

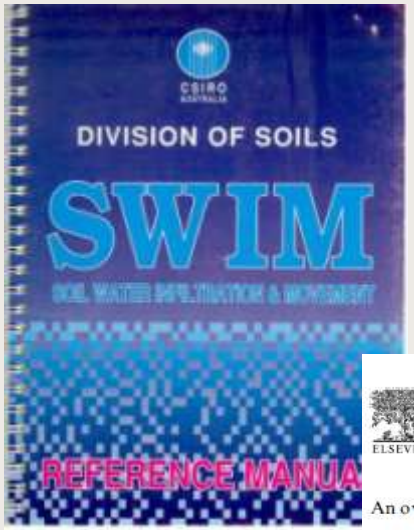
TABLE II

Cumulative precipitation, and simulated evapora
period 1 September 1981 to 31 August 1982.

	Residue-covered surface (m)	Bare (m)	rface
Precipitation	0.645	0.645	
Evaporation	0.300	0.475	
Drainage	0.270	0.097	
Storage	0.073	0.071	

Drenaje bajo raíces

mulch/residue
can increase drainage and leakage



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Europ. J. Agronomy 18 (2003) 267–288

European Journal of Agronomy

An overview of APSIM, a model designed for farming systems simulation

B.A. Keating [a,*], P.S. Carberry [a], G.L. Hammer [b], M.E. Probert [a], M.J. Robertson [a], D. Holzworth [a], N.I. Huth [a], J.N.G. Hargreaves [a], H. Meinke [b], Z. Hochman [a], G. McLean [b], K. Verburg [c], V. Snow [c], J.P. Dimes [a,d,e], M. Silburn [e], E. Wang [b], S. Brown [a], K.L. Bristow [c], S. Asseng [f], S. Chapman [b,f], R.L. McCown [a], D.M. Freebairn [e], C.J. Smith [c]

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[b] Department of Primary Industries/APSRU, Toowoomba, Qld, Australia
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Abstract

The Agricultural Production Systems Simulator (APSIM) is a modular modelling framework that has been developed by the Agricultural Production Systems Research Unit in Australia. APSIM was developed to simulate biophysical process in farming systems, in particular where there is interest in the economic and ecological outcomes of management practice in the face of climatic risk. The paper outlines APSIM's structure and provides details of the concepts behind the different plant, soil and management modules. These modules include a diverse range of crops, pastures and trees, soil processes including water balance, N and P transformations, soil pH, erosion and a full range of management controls. Reports of APSIM testing in a diverse range of systems and environments are summarised. An example of model performance in a long-term cropping systems trial is provided. APSIM has been used in a broad range of applications, including support for on-farm decision making, farming systems design for production or resource management objectives, assessment of the value of seasonal climate forecasting, analysis of supply chain issues in agribusiness activities, development of waste management guidelines, risk assessment for government policy making and as a guide to research and education activity. An extensive citation list for these model testing and application studies is provided.

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Keywords: Farming systems modelling; APSIM; Simulation model

1. Introduction

Agricultural Production Systems Simulator (APSIM) is a modelling framework that allows

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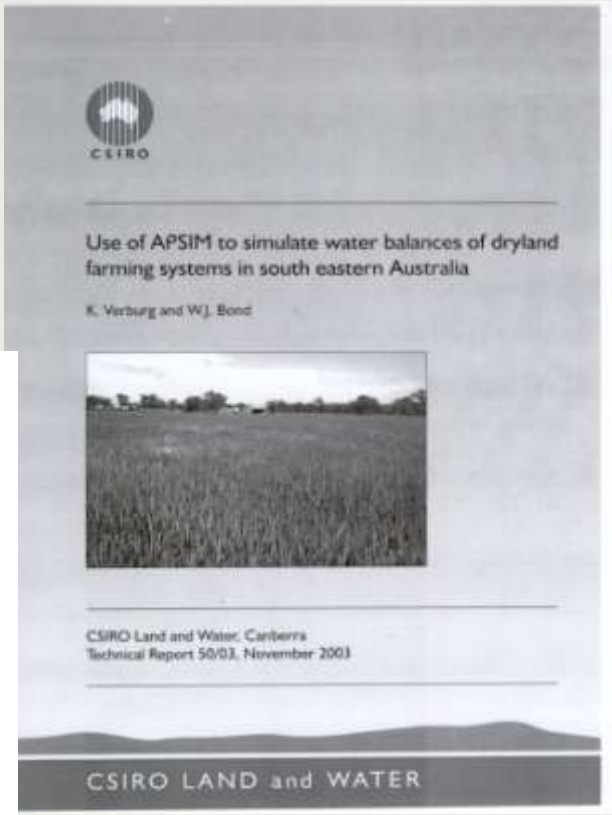
PII: S1161-0301(02)00108-9



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Agricultural Systems **50** (1996) 255–271
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0308-521X(94)00055-7

APSIM: a Novel Software System for Model Development, Model Testing and Simulation in Agricultural Systems Research

R. L. McCown, G. L. Hammer, J. N. G. Hargreaves,
D. P. Holzworth & D. M. Freebairn

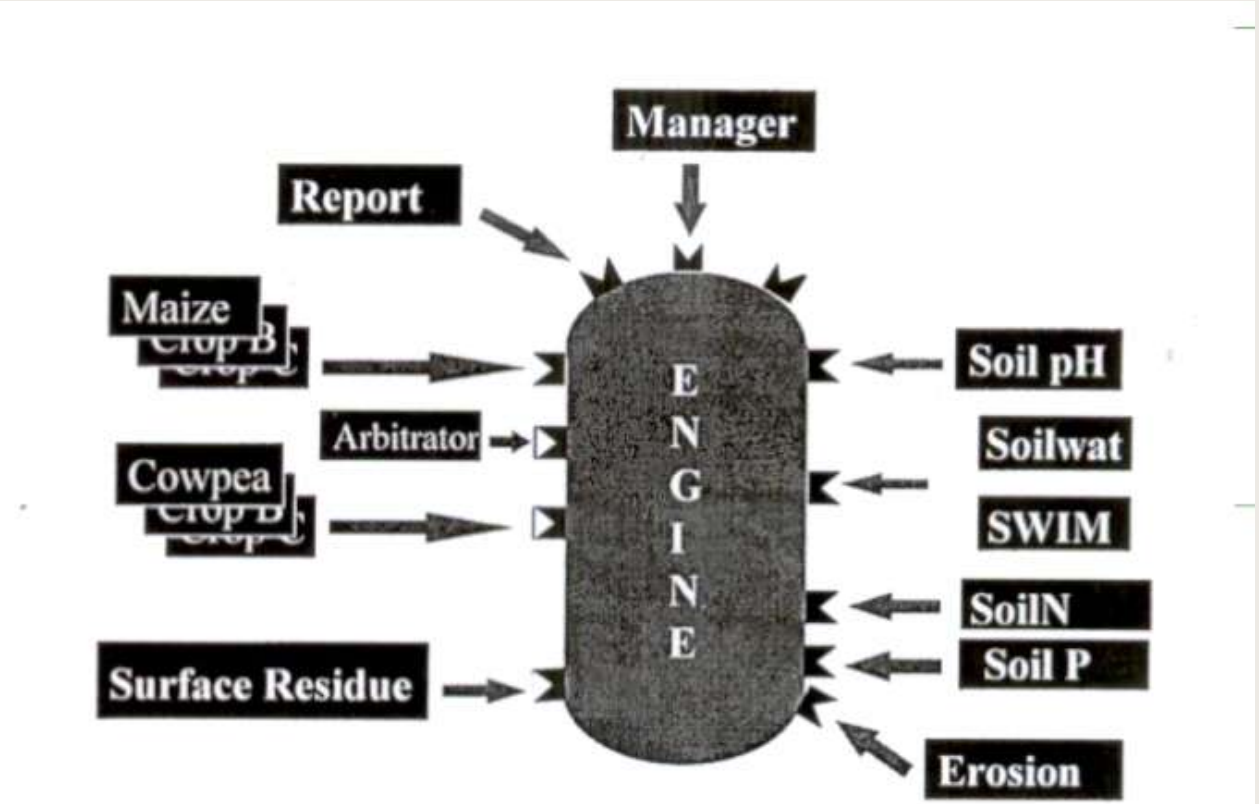


Fig. 1. Diagrammatic representation of the APSIM simulation

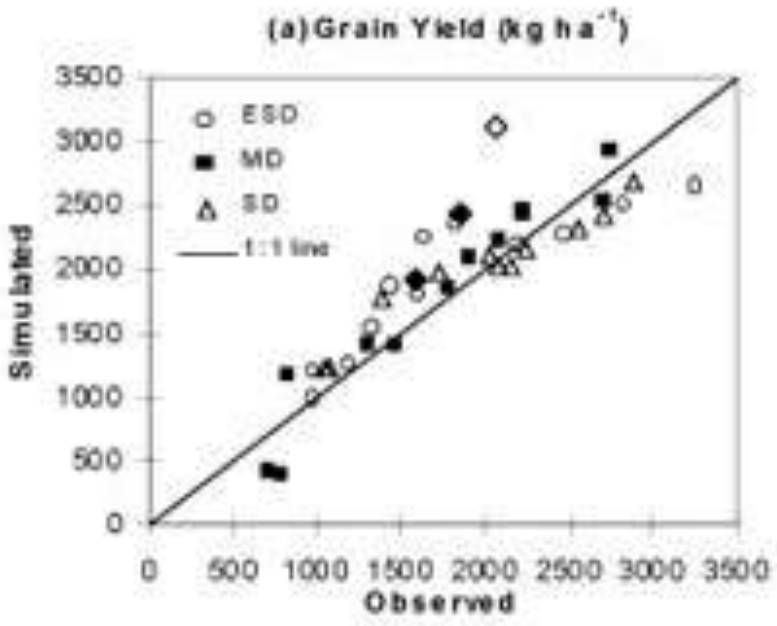
Keating et al., (2003)-Europ. J. Agronomy 18:267-288

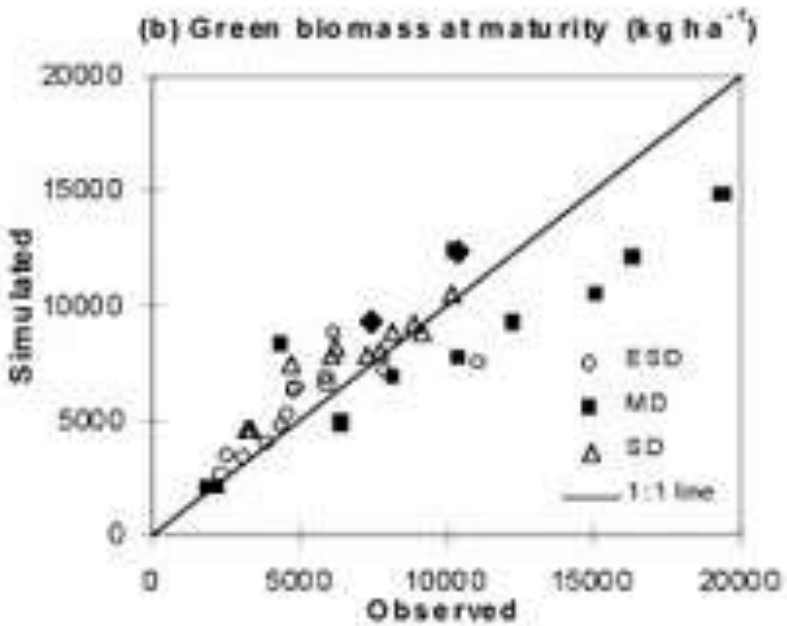
TABLE 1
List of Current APSIM Modules and Their Origins

Group	*APSIM module*	*Original model*	*Reference*
Crop	Cotton[a]	OZCOT	Hearn & Da Rosa, 1985
	Cowpea	ASPIM-Cowpea	Adiku *et al.*, 1993
	Maize	AUSIM-Maize	Carberry & Abrecht, 1991
	Peanut	QNUT	Hammer *et al.*, 1992
	Sorghum	QSORG	Hammer & Muchow, 1991
		AUSIM-Sorghum	Carberry & Abrecht, 1991
	Sunflower	QSUN	Chapman *et al.*, 1993
	Wheat1	Woodruff-Hammer	Hammer *et al.*, 1987
	Wheat2	CERES-Wheat	Ritchie *et al.*, 1988
Tropical grass pasture	GRASP[a]	GRASP	McKeon *et al.*, 1990
Temperate pasture	GRAZPLAN[a]	GRAZPLAN	Moore *et al.*, 1991
Soil water	SoilWat	CERES	Ritchie, 1985
		PERFECT	Littleboy *et al.*, 1992
	APSWIM[a]	SWIM	Ross, 1990*a*
Soil nitrogen	SoilN	CERES	Godwin & Jones, 1991
Soil erosion	Erosion	PERFECT	Littleboy *et al.*, 1989

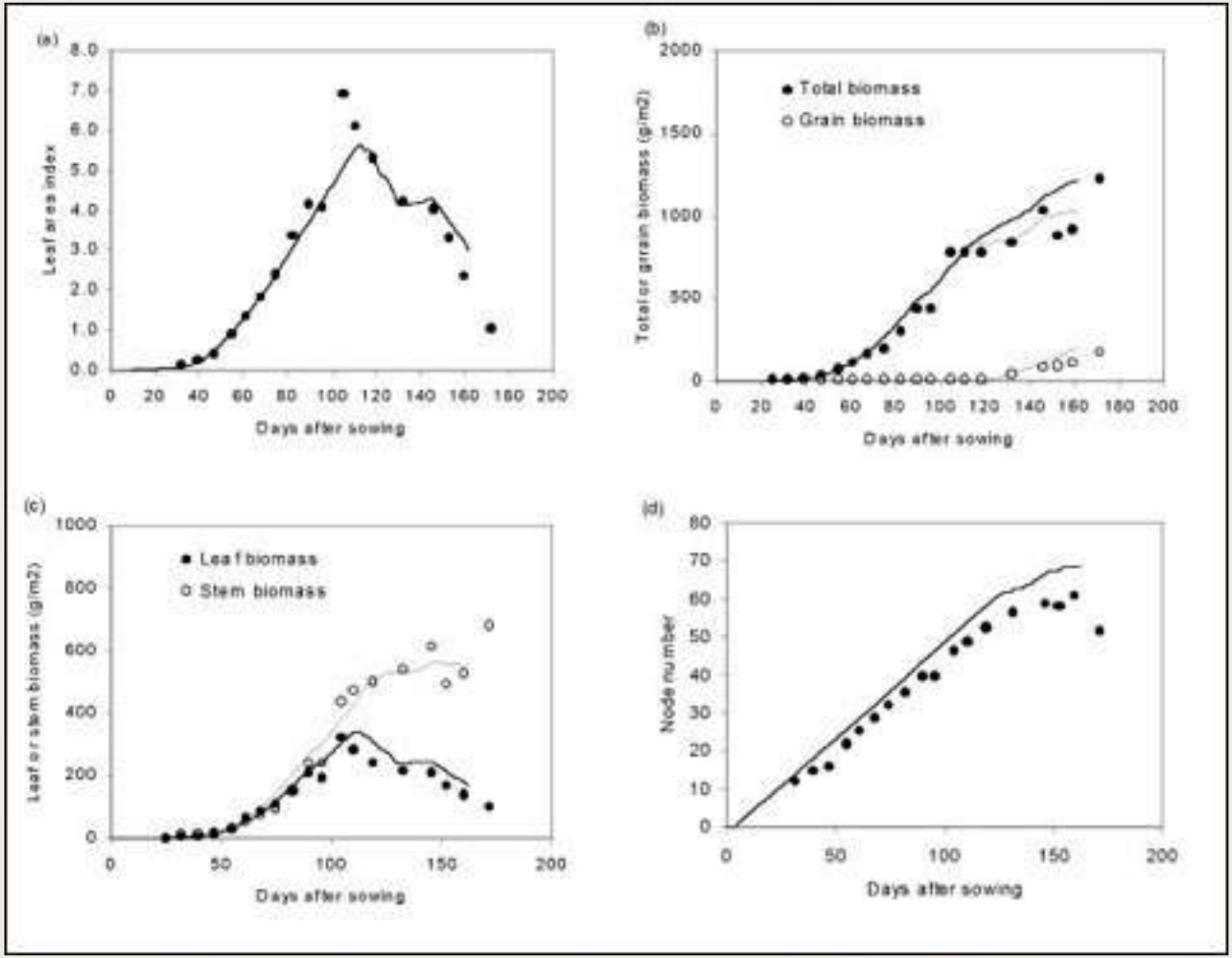
[a]Intellectual property remains that of the original developer.

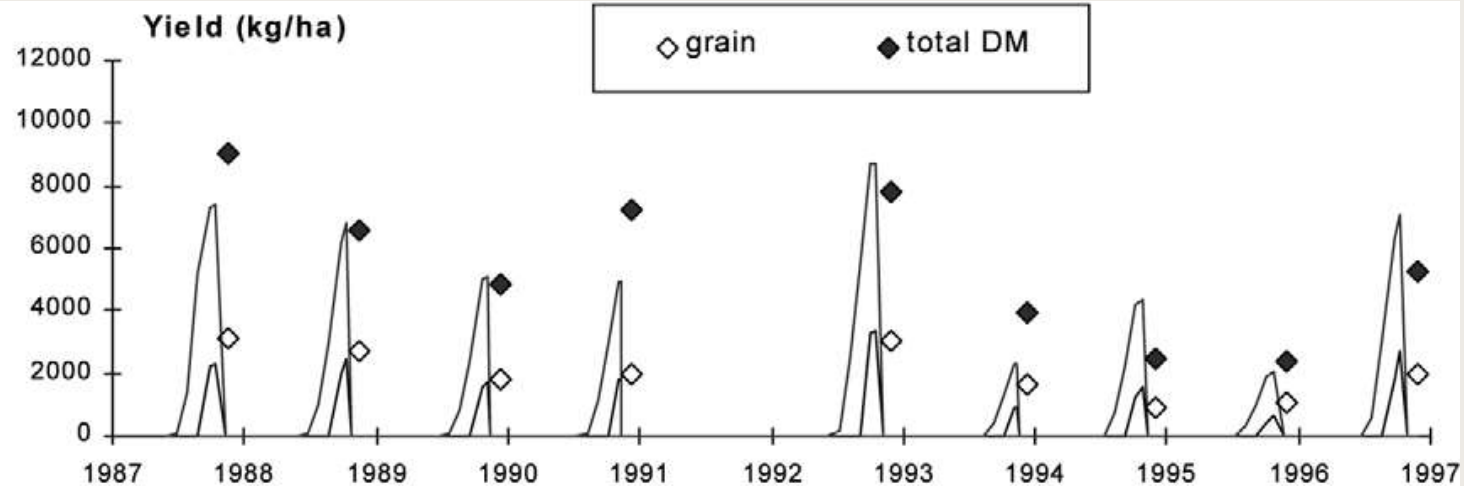
Agricultural Systems 50 (1996) 255-271

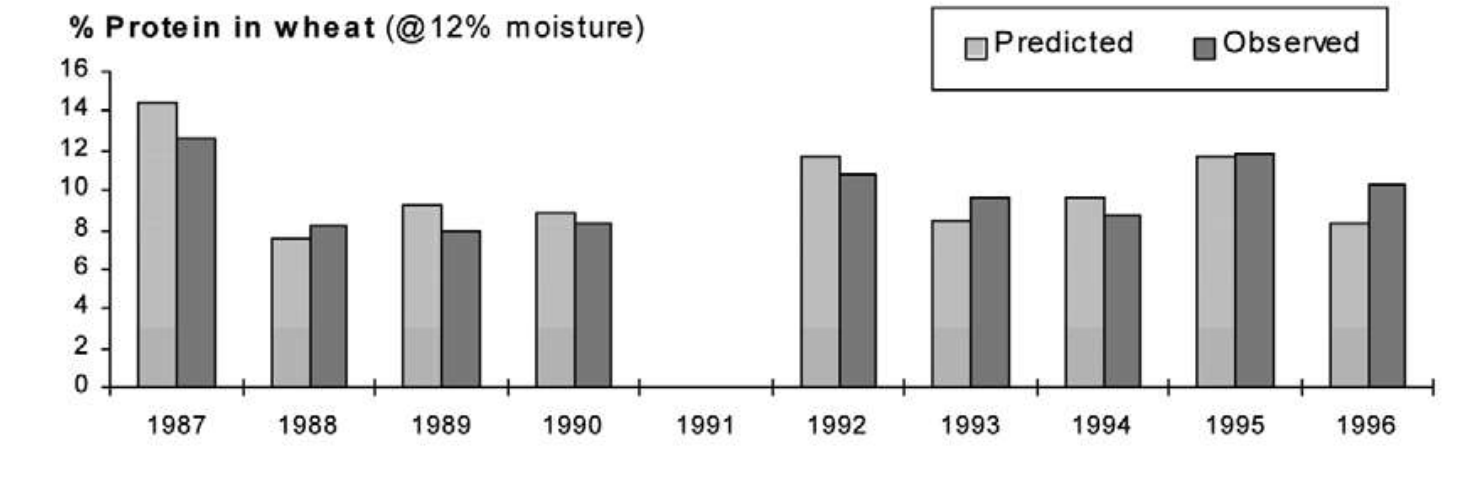




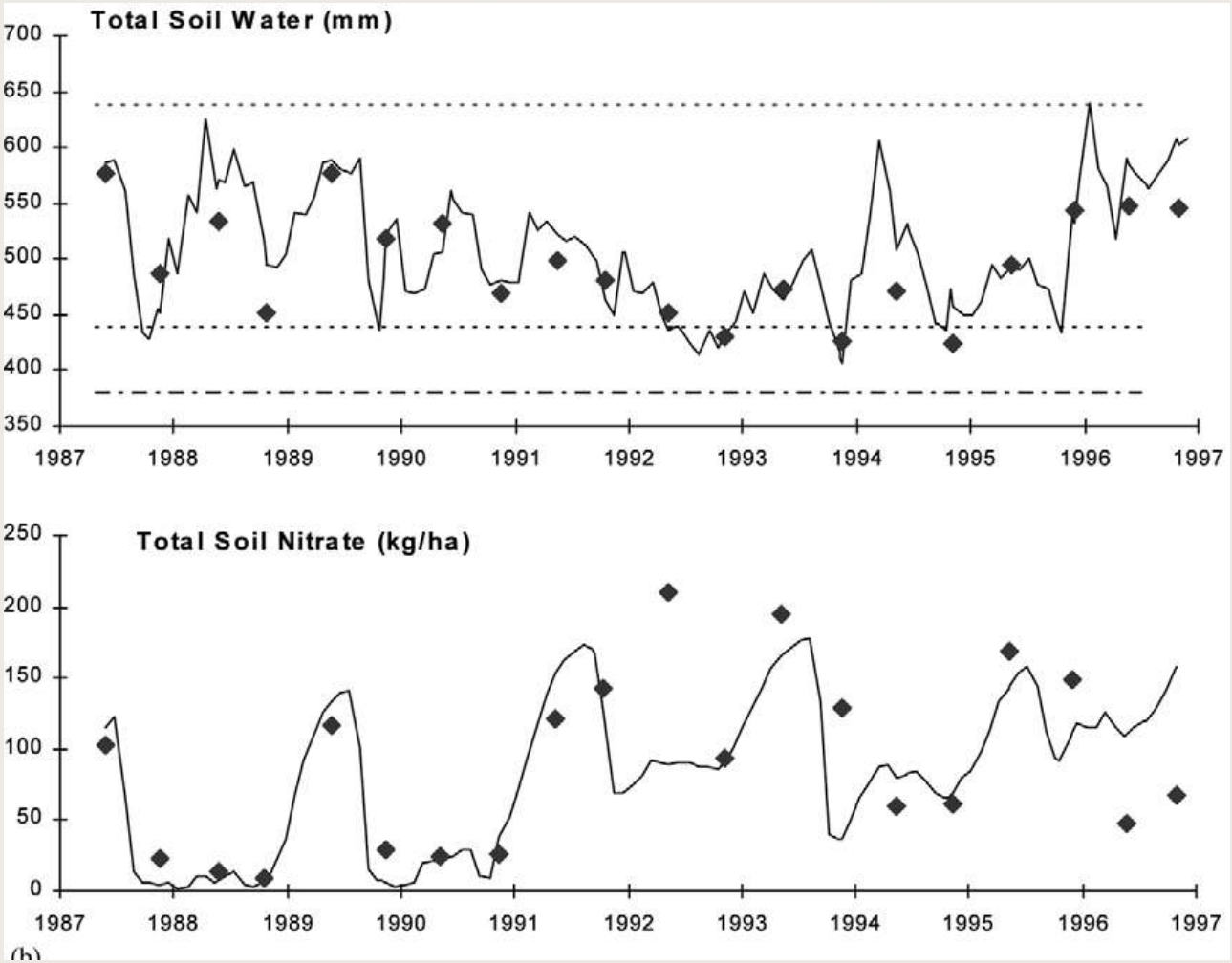
http://www.icrisat.cgiar.org/what-we-do/agro-ecosystems/aes-rb-pigeonpea.htm


(a)
Leaf area index
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0 20 40 60 80 100 120 140 160 180 200
Days after sowing
(b)
Total or grain biomass (g/m2)
2000
1500
1000
500
0
Total biomass
Grain biomass
0 20 40 60 80 100 120 140 160 180 200
Days after sowing
(c)
Leaf or stem biomass (g/m2)
1000
800
600
400
200
0
Leaf biomass
Stem biomass
0 50 100 150 200
Days after sowing
(d)
Node number
80
70
60
50
40
30
20
10
0
0 50 100 150 200
Days after sowing





Keating et al., (2003)-Europ. J. Agronomy 18:267-288



Keating et al., (2003)-Europ. J. Agronomy 18:267-288

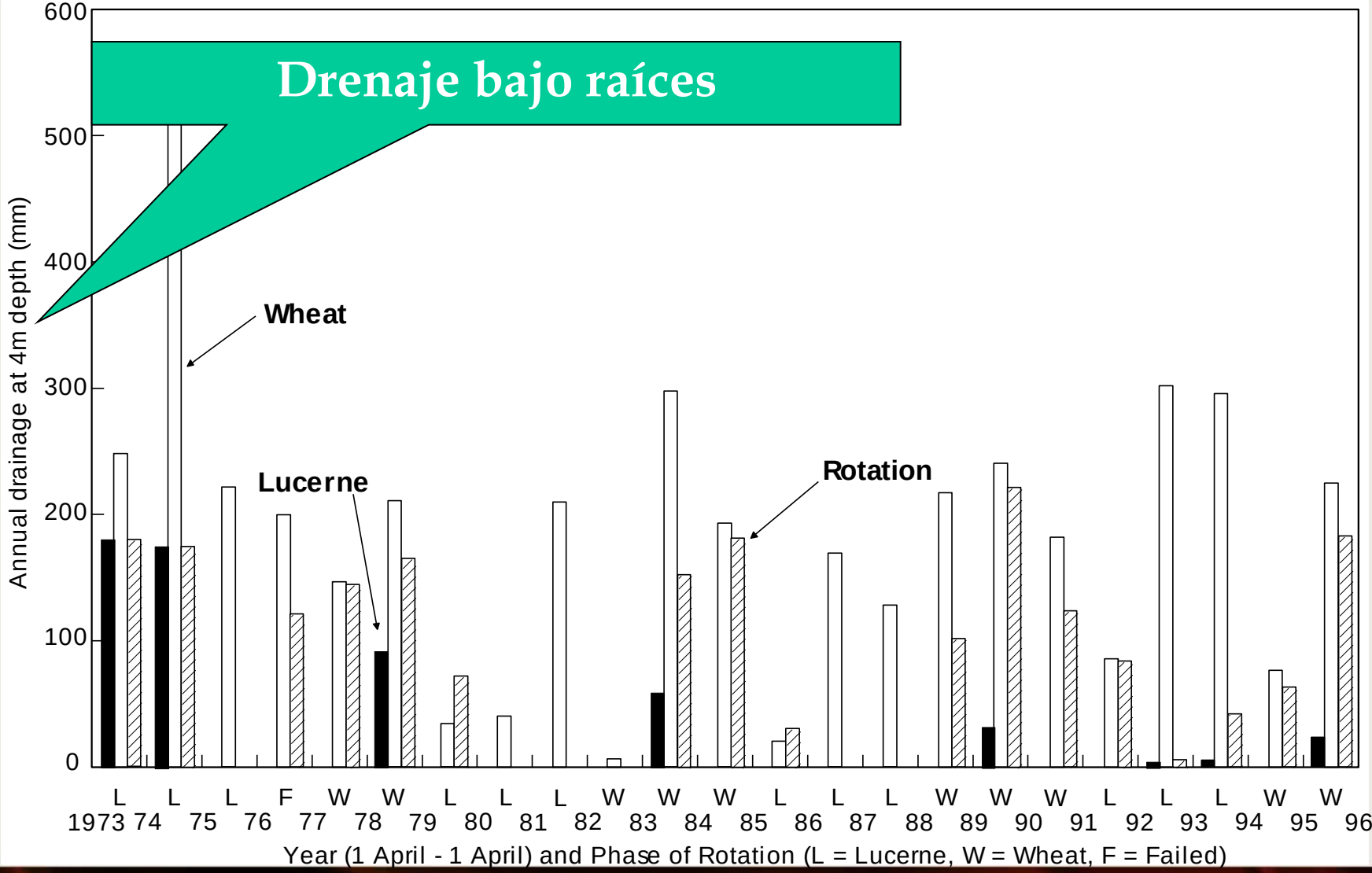
Drenaje bajo raíces

Table 1. Compari[illegible]of simulated average annual water balances in a Red Kande[illegible]l at Wagga Wagga (1973-1996) for the scenarios of continuous [illegible]heat, lucerne fodder crop and a three year lucerne/wheat rotation

System	Rain (mm)	Runoff (mm)	ET (mm)	Drainage at 4m (mm)	Drainage at 1m (mm)
Wheat	611	15	411	185	223
Rotate	611	15	507	89	181
Lucerne	611	15	579	25	134

(Source: Dunin, Williams, Verburg & Keating 1999)

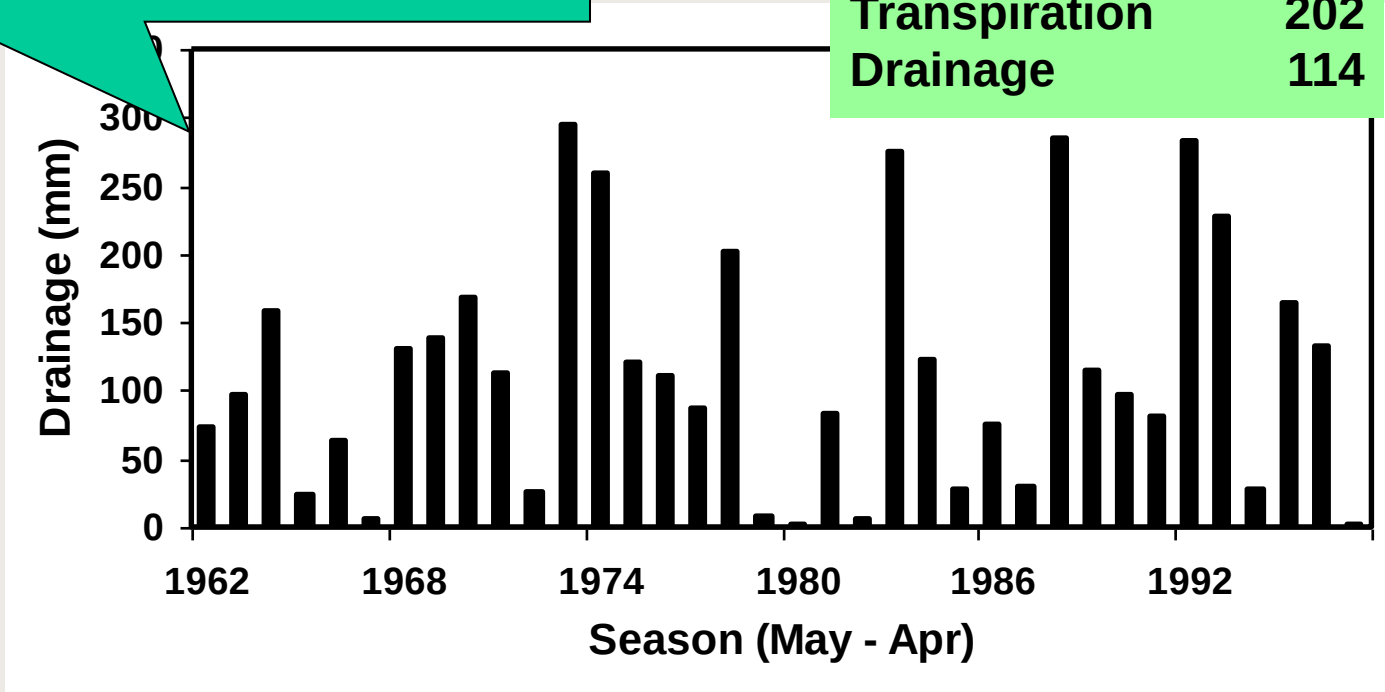
Drenaje bajo raíces



Average water balance - wheat

Drenaje bajo Raíces

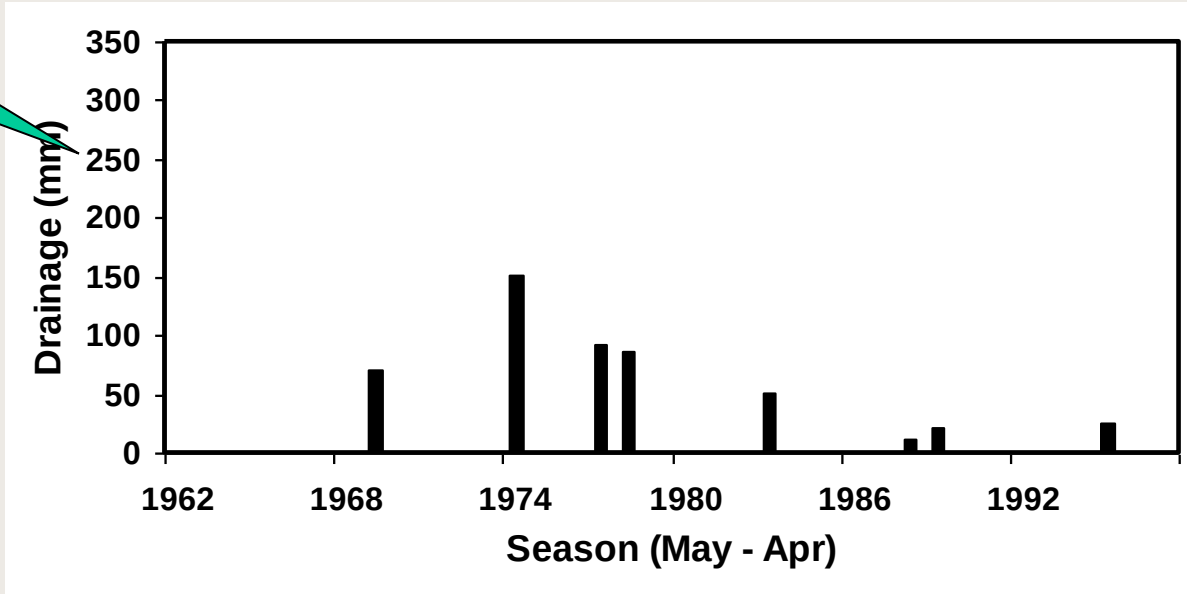
Rain	591 mm
Evaporation	278
Transpiration	202
Drainage	114



From: Verburg, Keating and Smith et al. (1999)-RAAL Workshop Perth

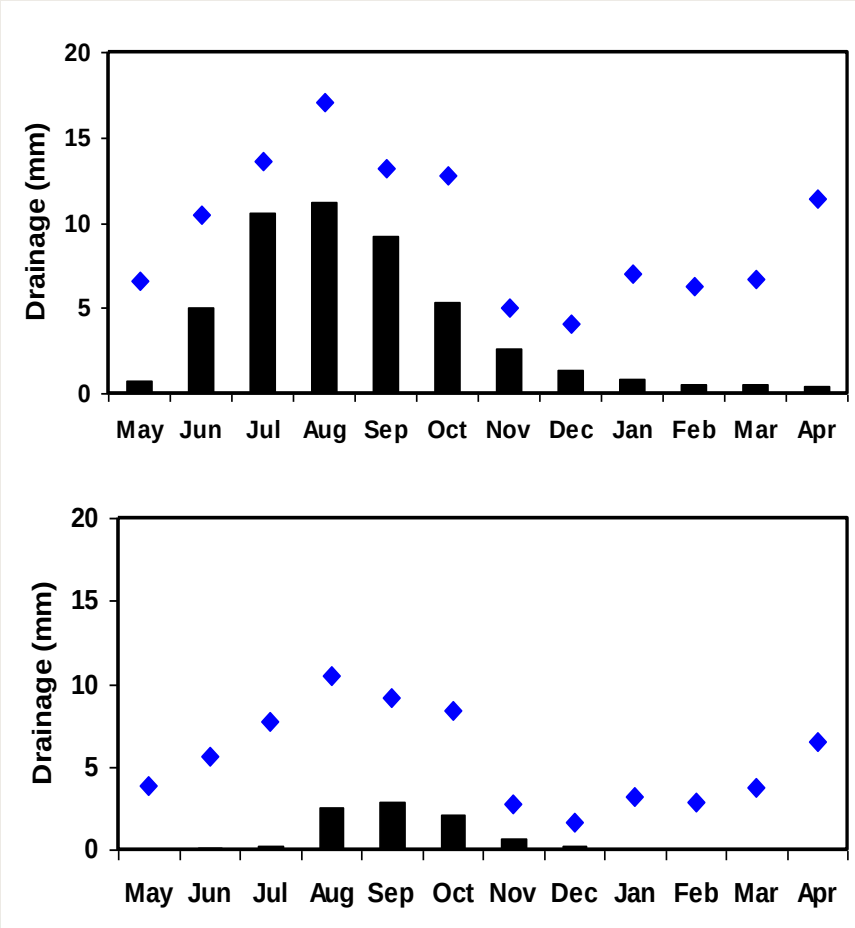
Drenaje bajo Raíces

	1st	2nd	3rd	CW
Rain	591	591	591mm	591 mm
Evaporation	336	269	303	278
Transpiration	290	314	212	202
Drainage	81	14	16	114
D Storage	-116	-6	+60	



From: Verburg, Keating and Smith et al. (1999)-RAAL Workshop Perth

Drainage Patterns

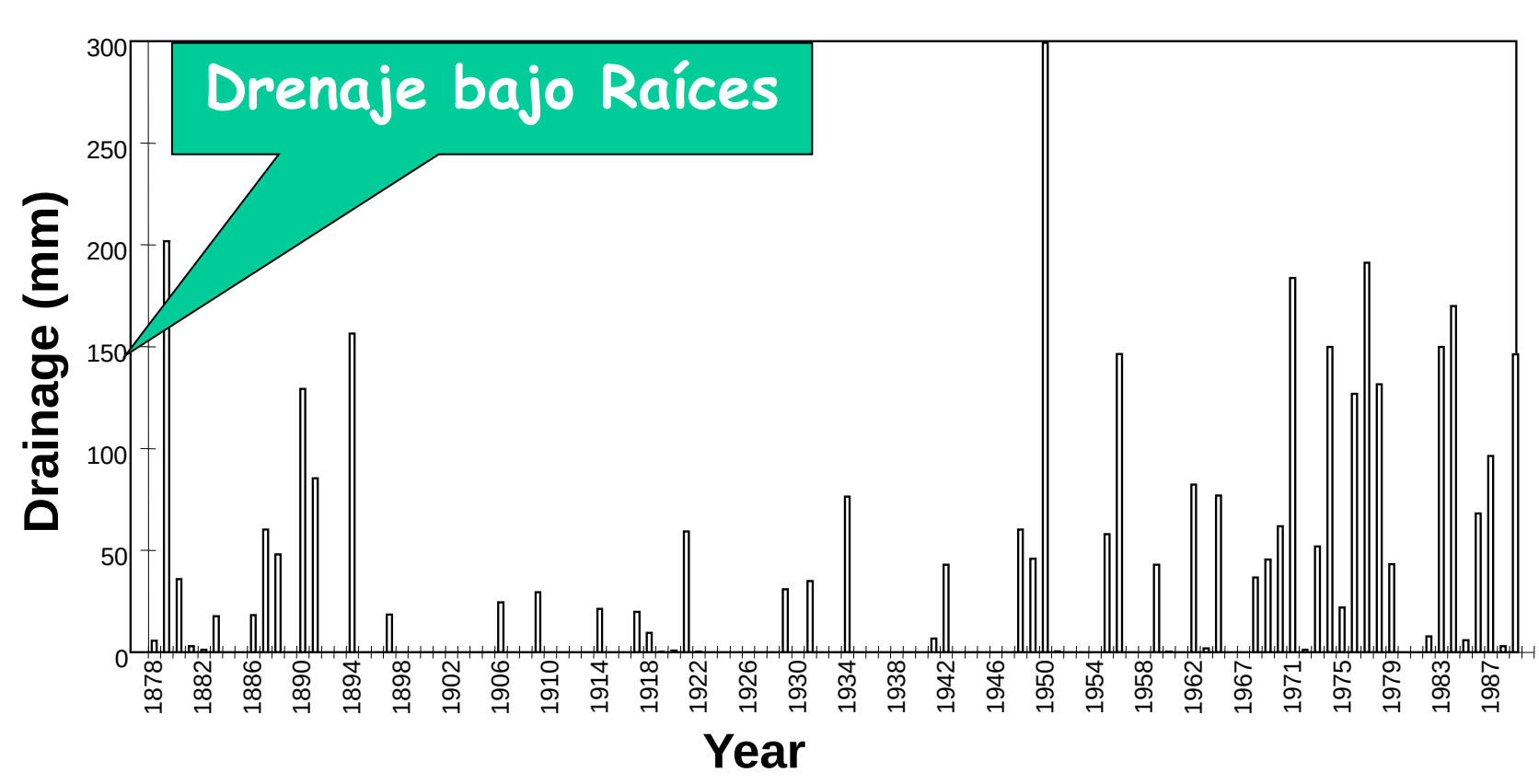


Continuous wheat

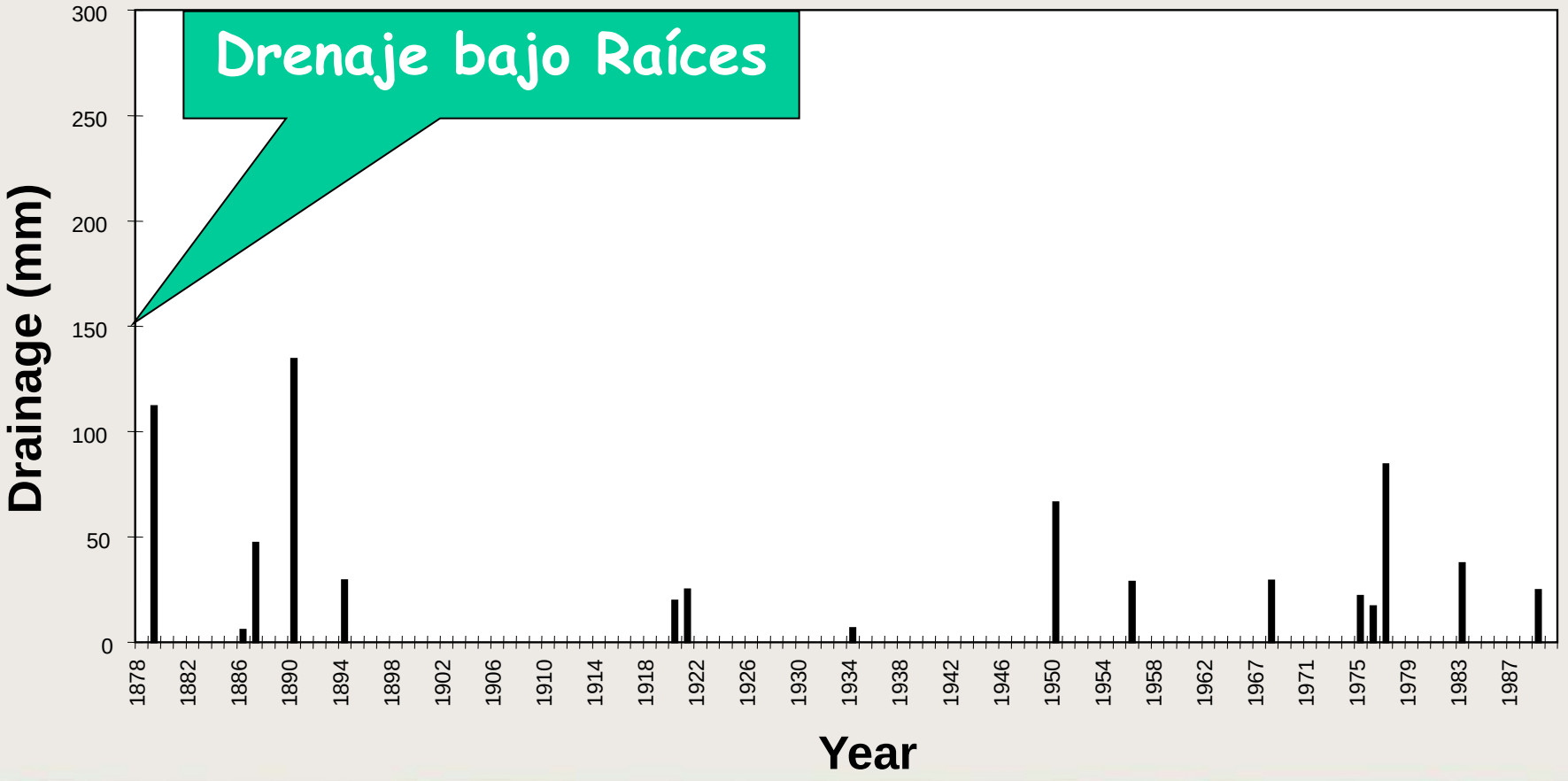
Rotation with Lucerne removed in December

From: Verburg, Keating and Smith et al. (1999)-RAAL Workshop Perth

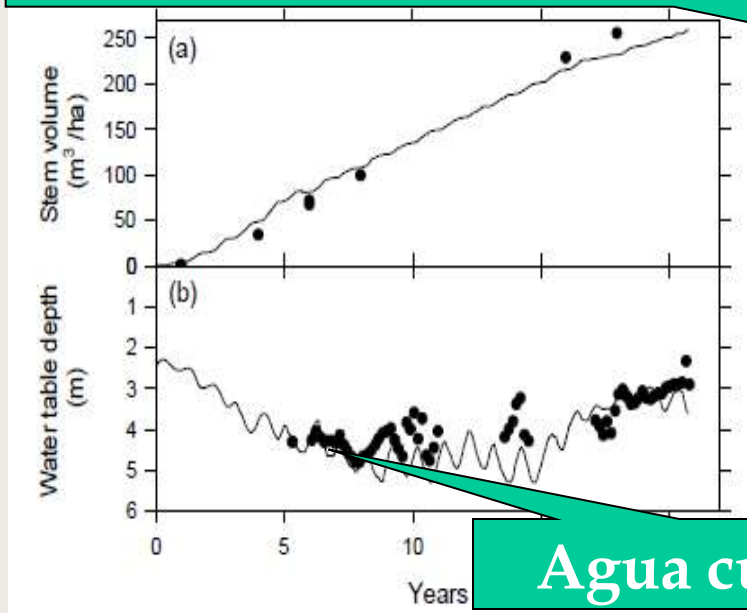
Simulated Deep Drainage for 100 years at Gunnedah under Wheat/Long Fallow/Sorgham Rotation (Cresswell & Keating, 1996)

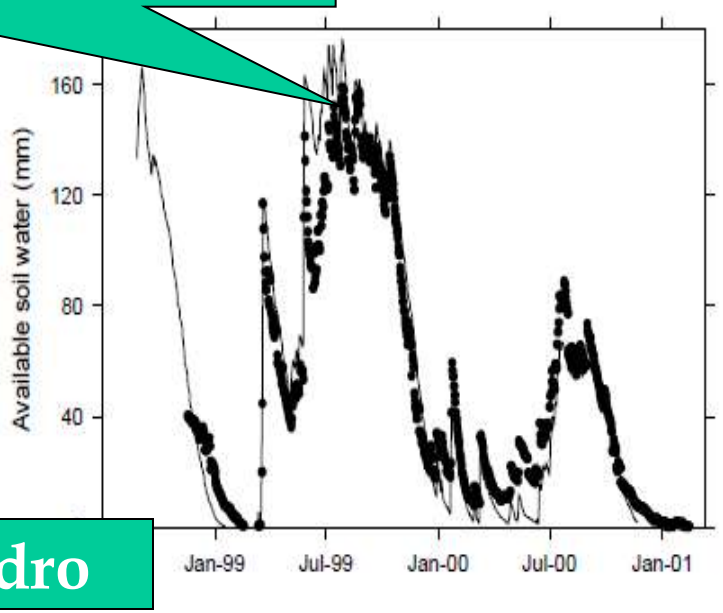


Simulated Deep Drainage for 100 years at Gunnedah under Wheat/Sorgham Opportunistic Rotations



Suelo el almacenamiento de agua





Agua cuadro

Figure 3. Stem volume (a) and water table depth (b) data for *E. grandis* grown over a shallow groundwater table at Kyabram. Observed data shown as symbols and simulations results as lines.

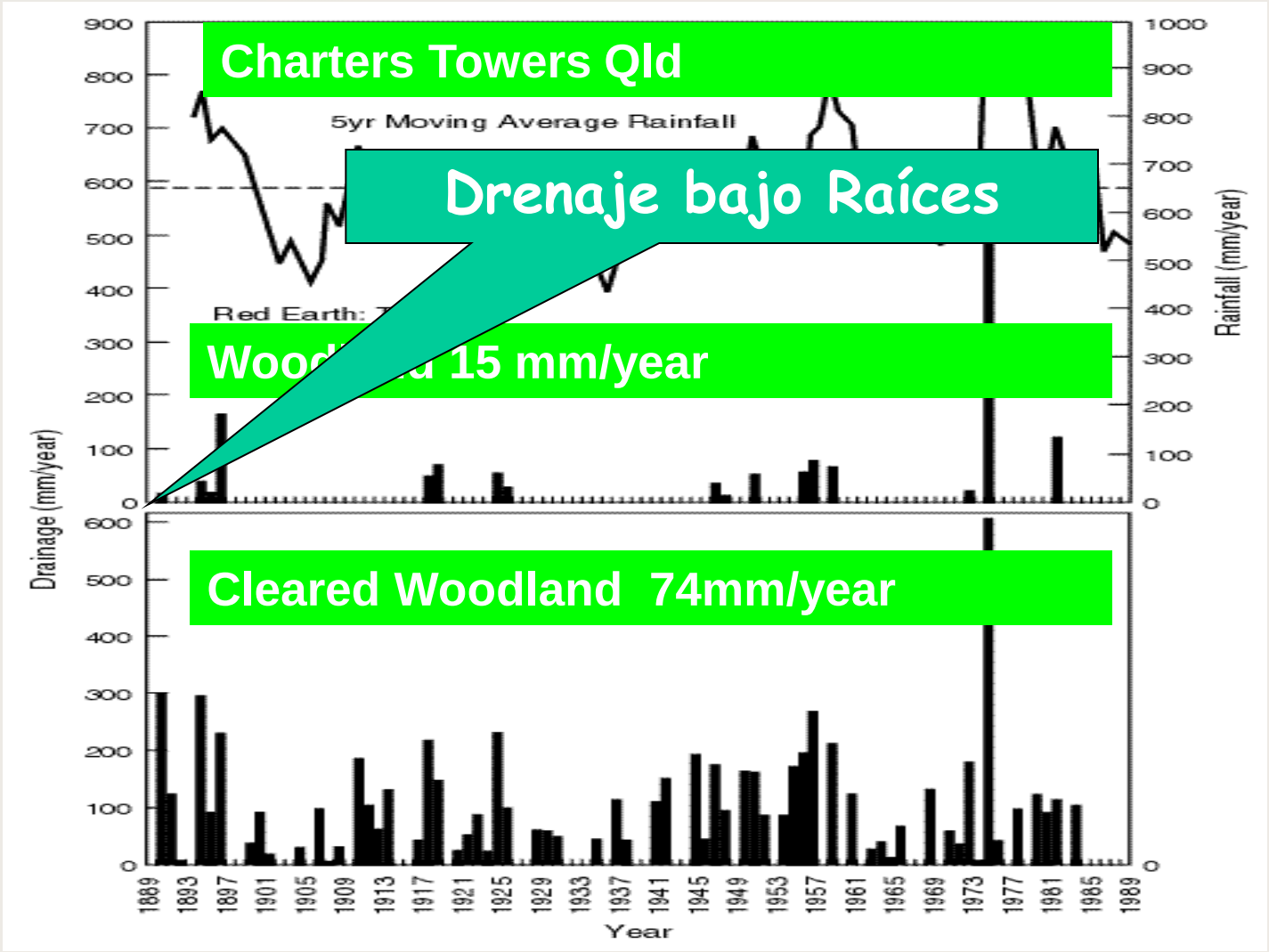
Figure 4. Data (symbols) and simulation results (lines) of plant-available soil water storage to a depth of 4.5 m at Moora under *Banksia* woodland.

Integrating a Forest Modelling Capability into an Agricultural Production Systems Modelling Environment - Current Applications and Future Possibilities

N. I. Huth[a], V. O. Snow[b] and R. A. Keating[a]

[a] CSIRO Sustainable Ecosystems/APSRU, 120 Meiers Road, Indooroopilly, Brisbane Qld 4068, Australia. (neil.huth@csiro.csiro.au)

[b] CSIRO Land and Water, GPO Box 1666, Canberra ACT 2601, Australia.


Charters Towers Qld
5yr Moving Average Rainfall
Drenaje bajo Raíces
Red Earth:
15 mm/year
Cleared Woodland 74mm/year
Drainage (mm/year)
Rainfall (mm/year)
Year
900
800
700
600
500
400
300
200
100
0
1000
1889
1893
1897
1901
1905
1909
1913
1917
1921
1925
1929
1933
1937
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1945
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1953
1957
1961
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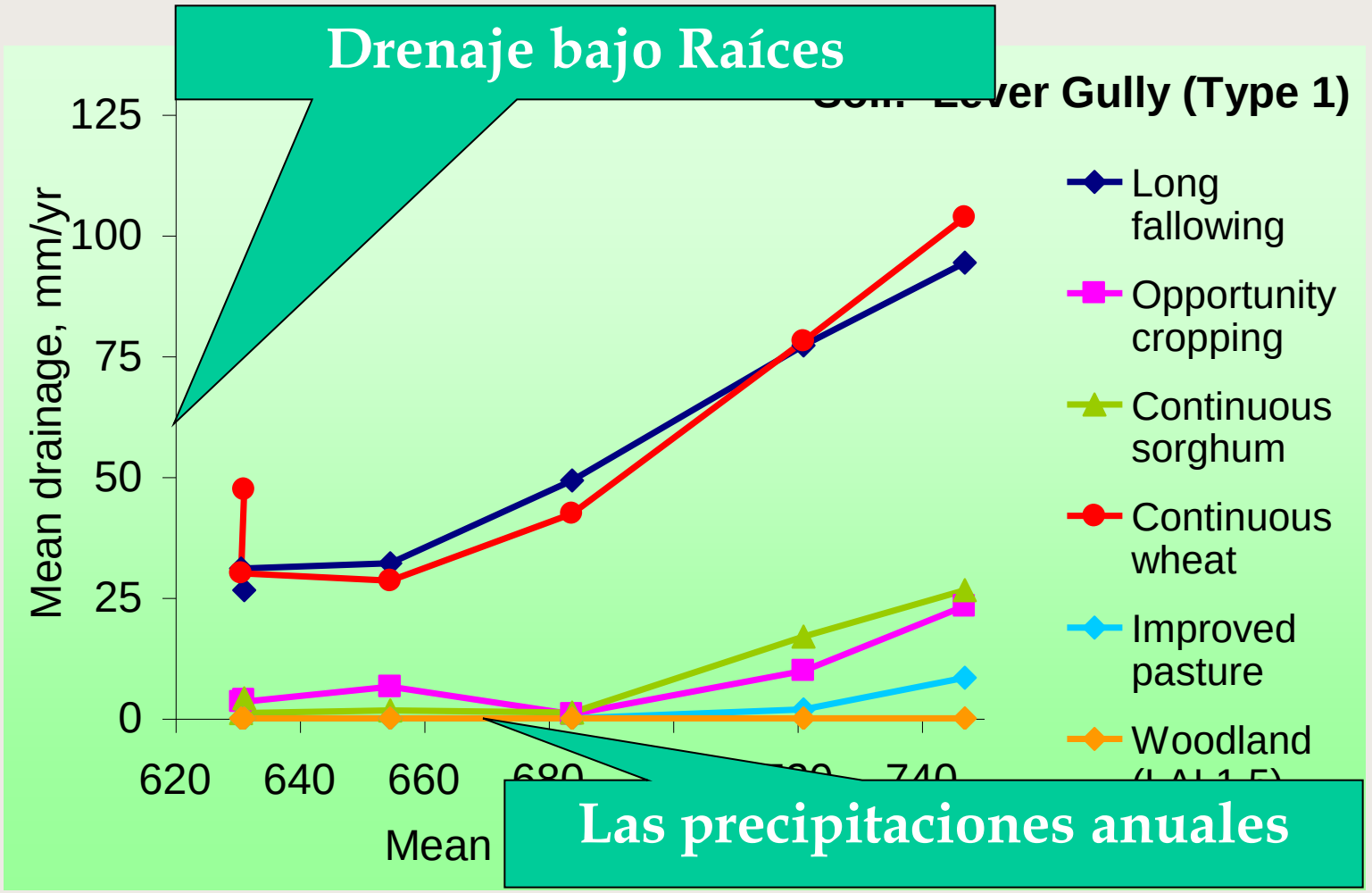
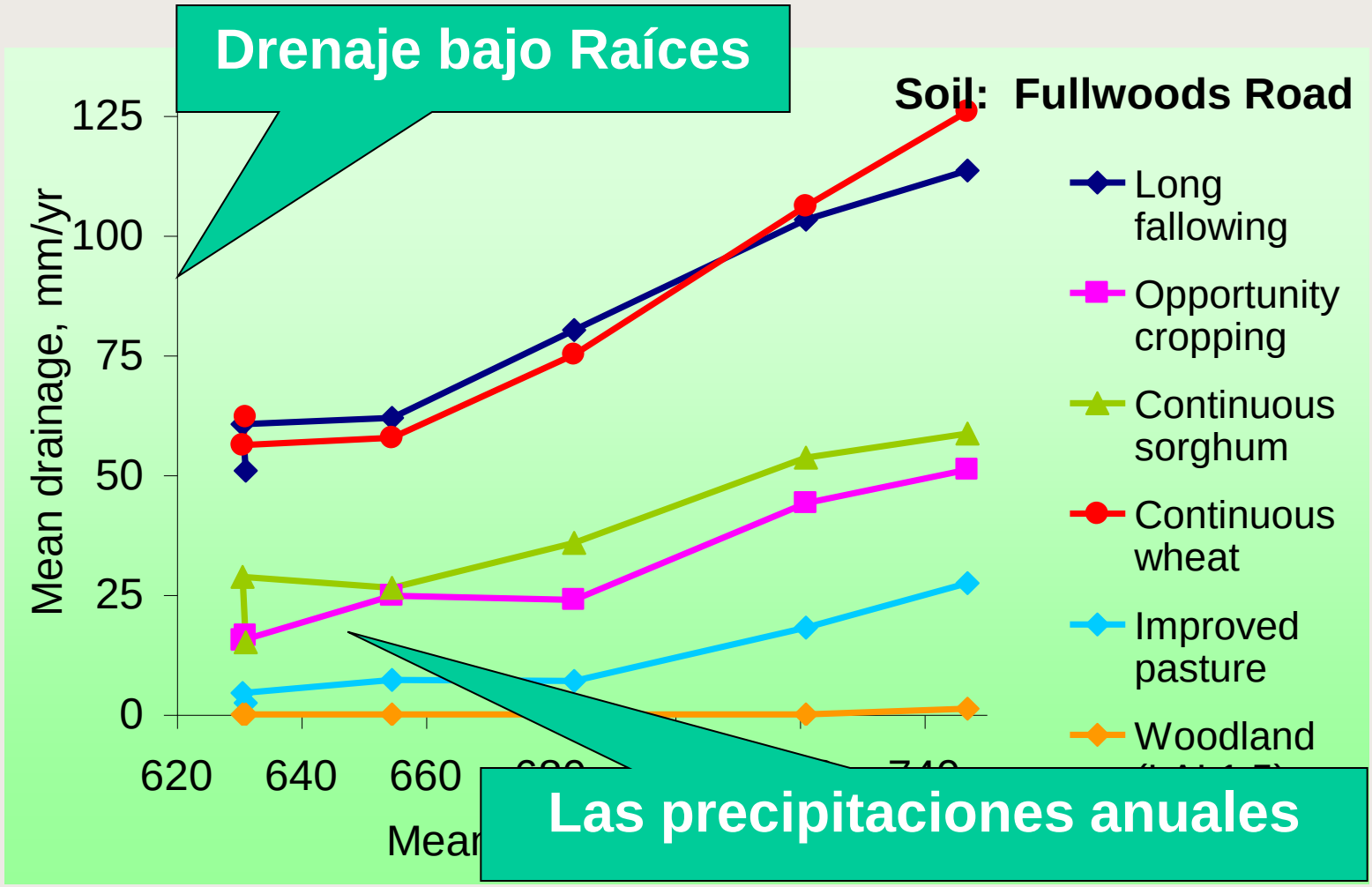
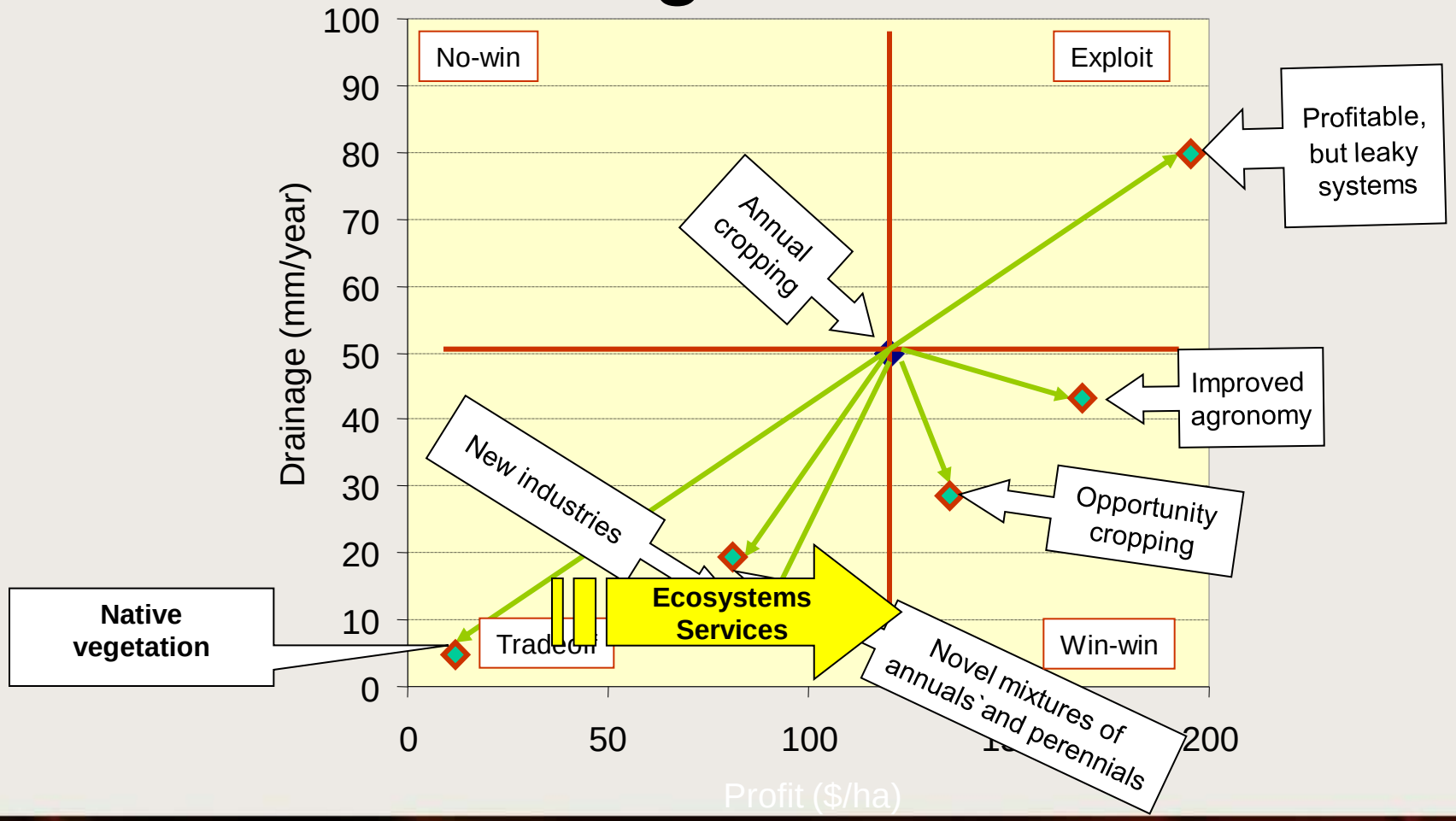
1969
1973
1977
1981
1985
1989


Drenaje bajo Raíces
Mean drainage, mm/yr
125
100
75
50
25
0
620
640
660
Mean
Long fallowing
Opportunity cropping
Continuous sorghum
Continuous wheat
Improved pasture
Woodland
Las precipitaciones anuales

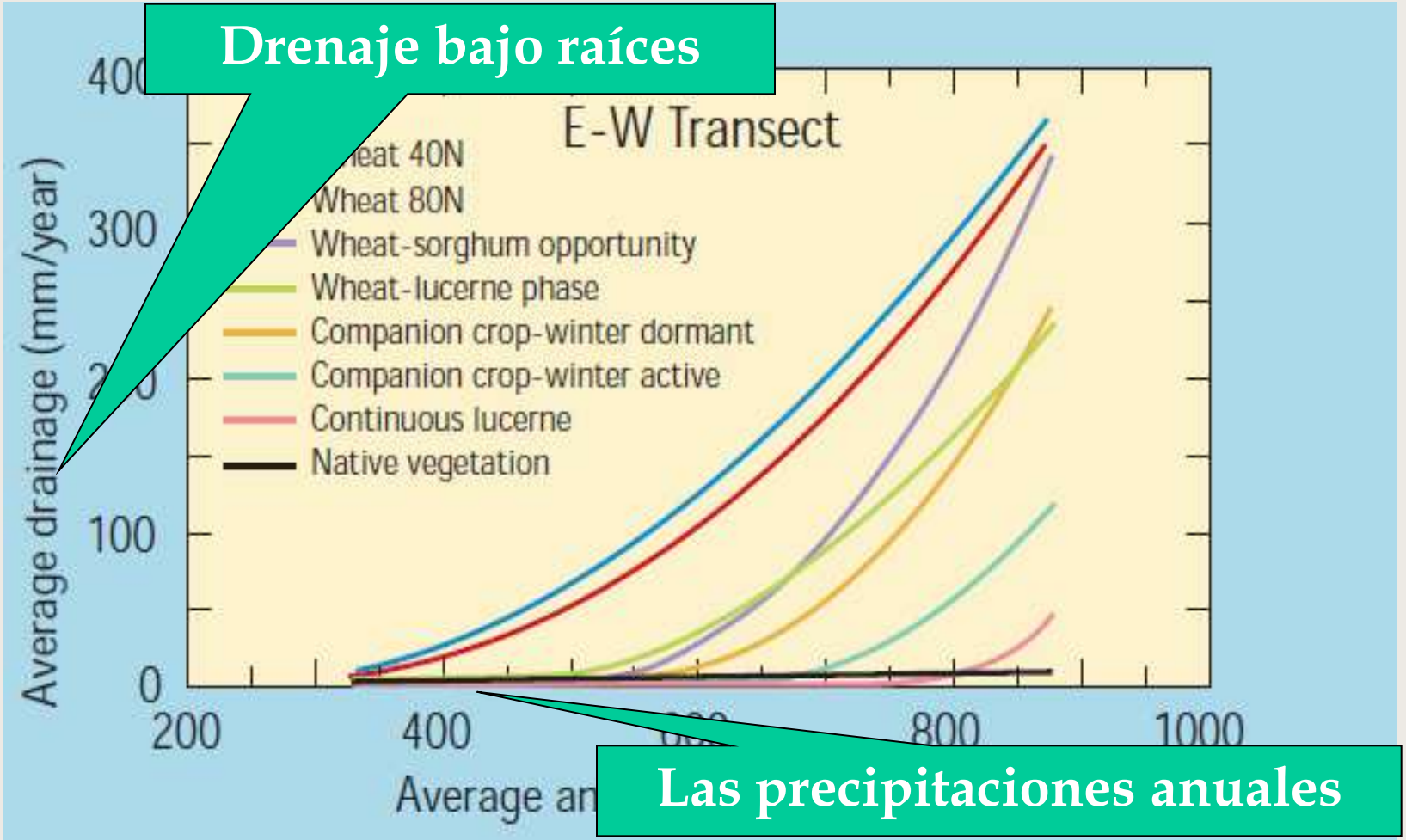

Drenaje bajo Raíces
Soil: Fullwoods Road
Mean drainage, mm/yr
125
100
75
50
25
0
620
640
660
Long fallowing
Opportunity cropping
Continuous sorghum
Continuous wheat
Improved pasture
Woodland
Las precipitaciones anuales

Profit – drainage matrix



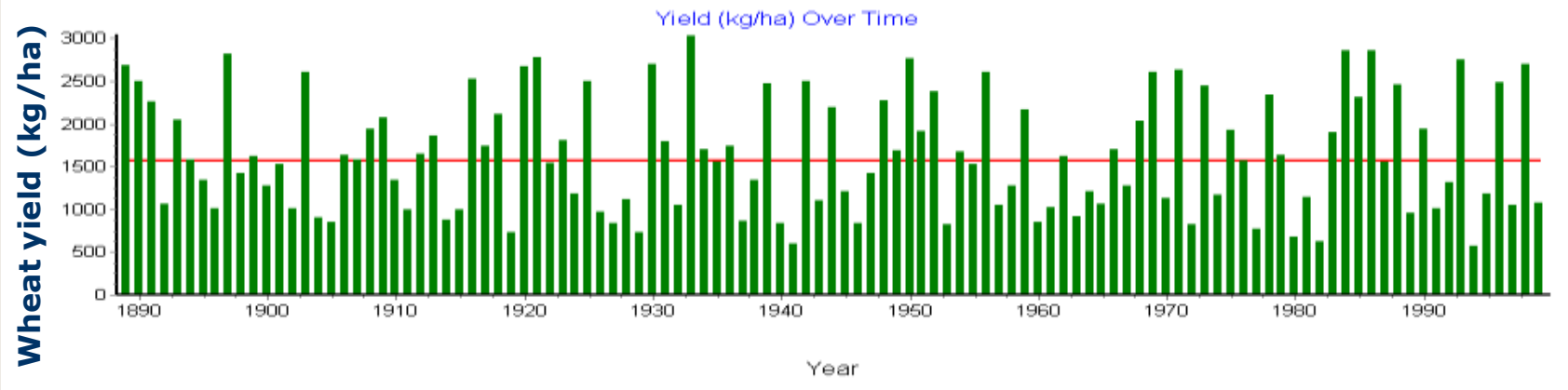

LAND STEWARDSHIP
Ecosystem Services through Land Stewardship Practices: Issues and Options
LAND STEWARDSHIP
Market-like Policy Options

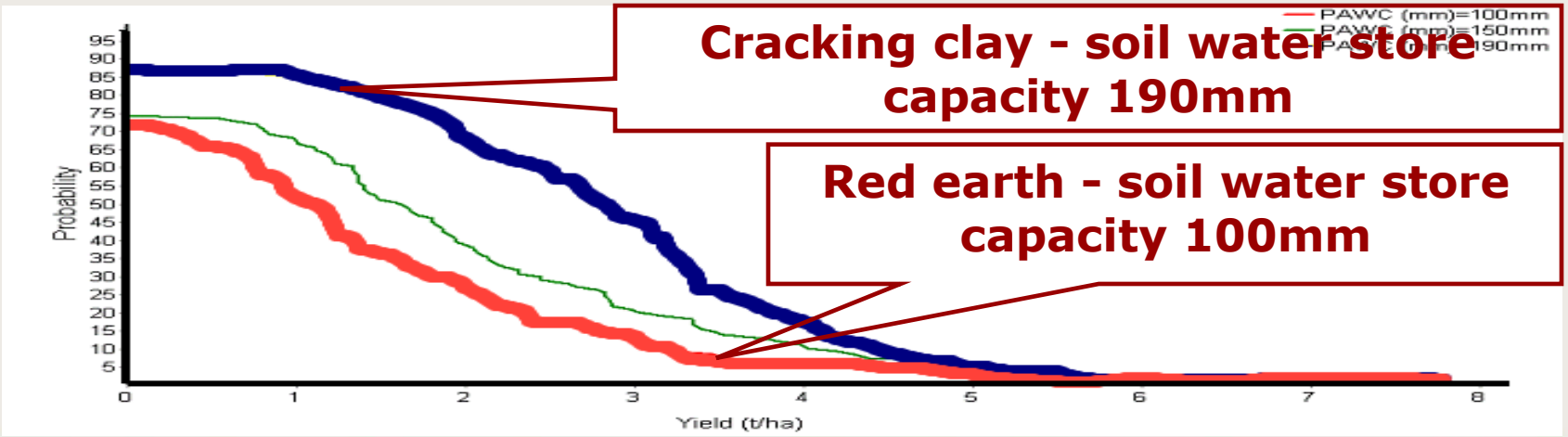

Murray-Darling Basin
Brisbane
Sydney
Canberra
Adelaide
Melbourne



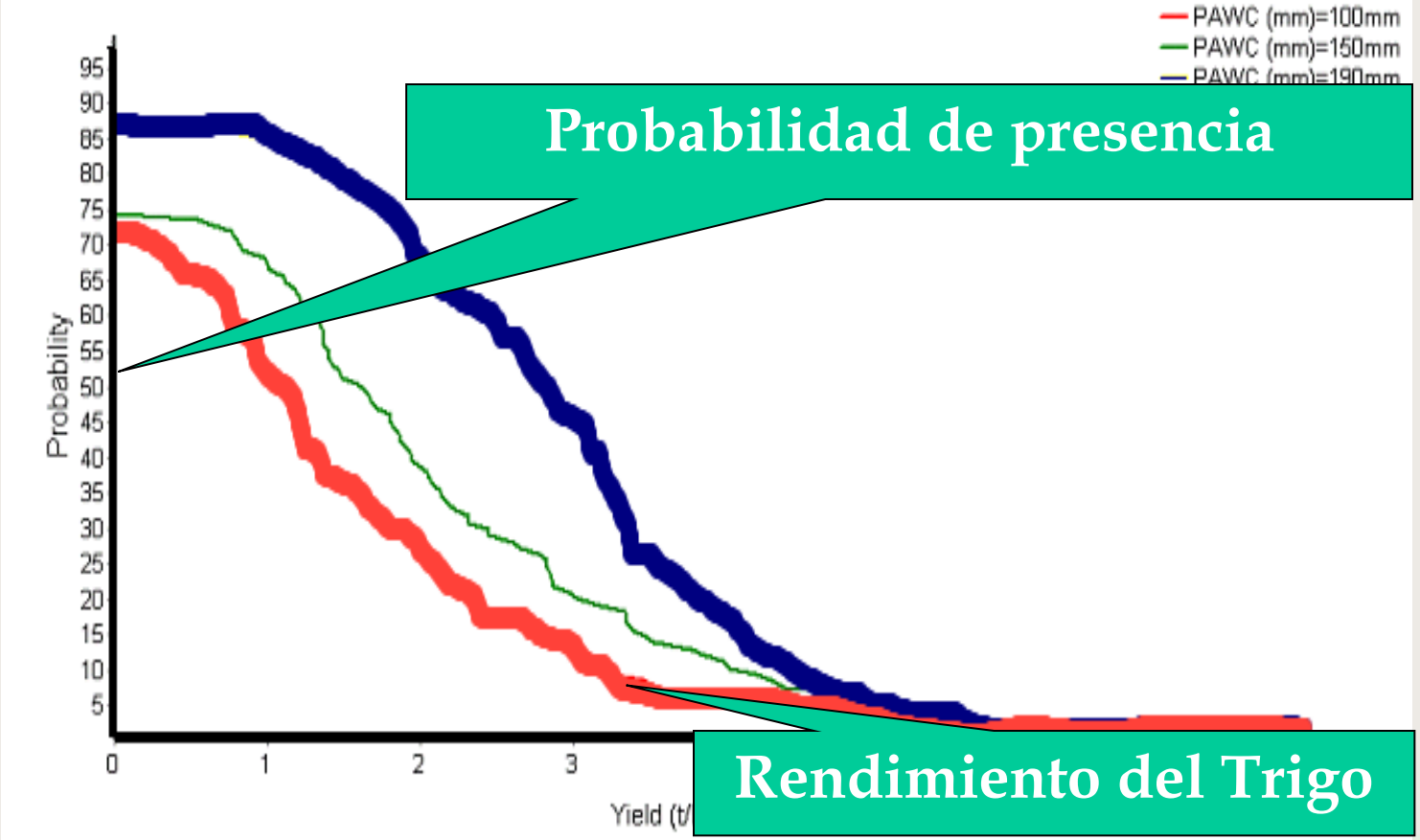
http://www.clw.csiro.au/publications/general2003/revolution/index.html

Wheat Yield

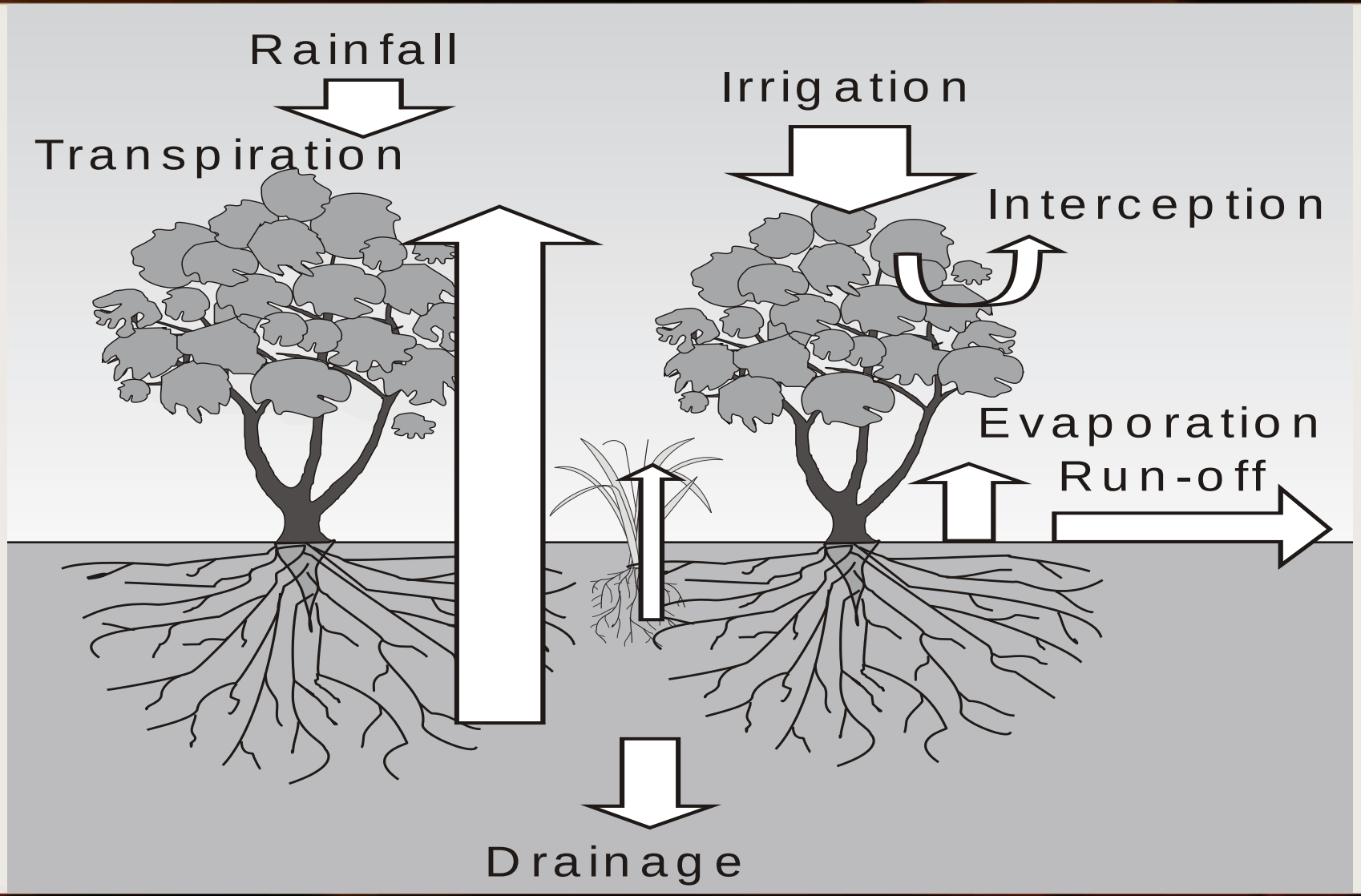

Yield (kg/ha) Over Time
Wheat yield (kg/ha)
3000
2500
2000
1500
1000
500
0
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
Year

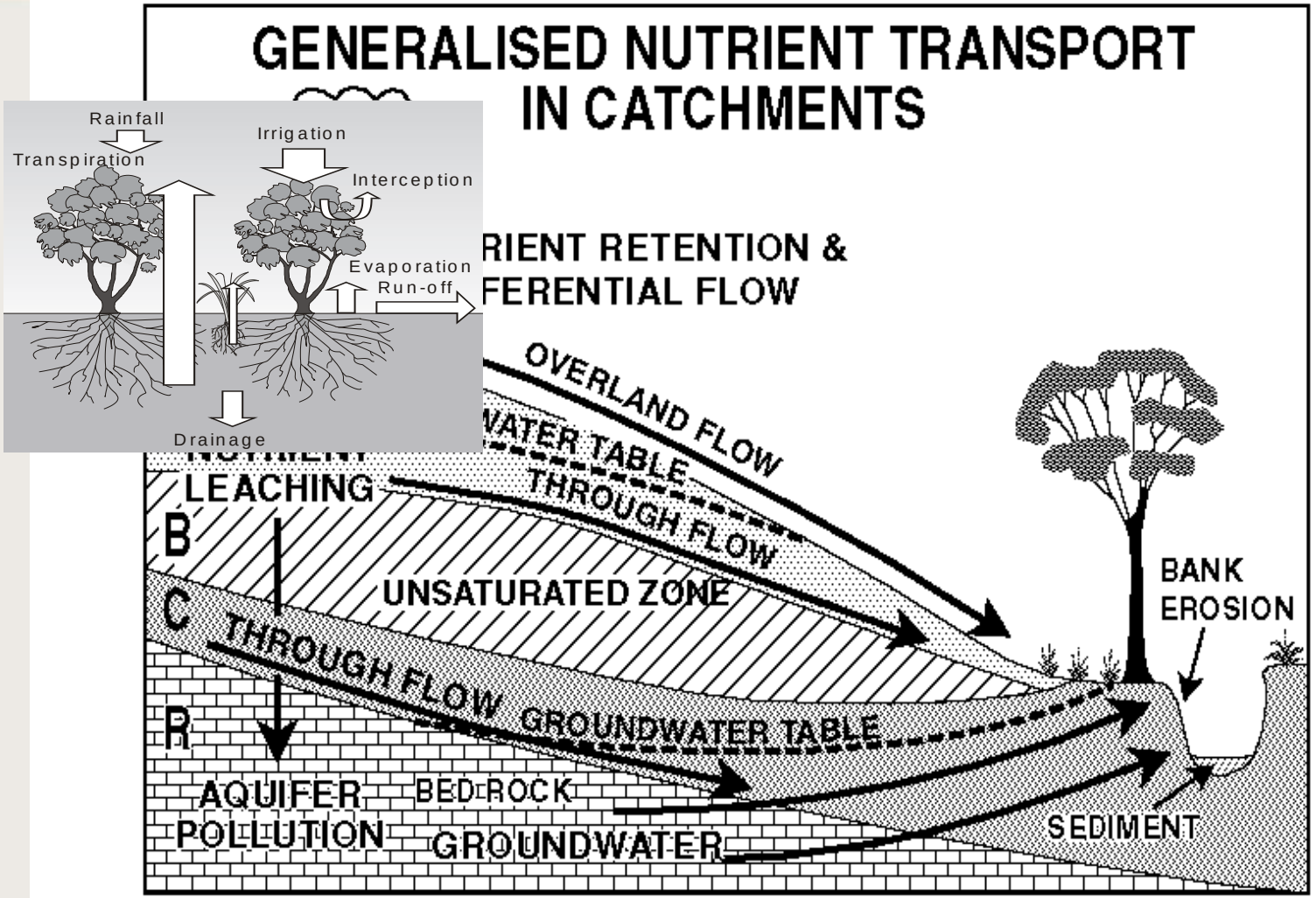

PAWC (mm)=100mm
PAWC (mm)=150mm
PAWC (mm)=190mm
Probability
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
Yield (t/ha)
Cracking clay - soil water store capacity 190mm
Red earth - soil water store capacity 100mm

Risk assessment of current dryland farming
Using historical climate and climate change data

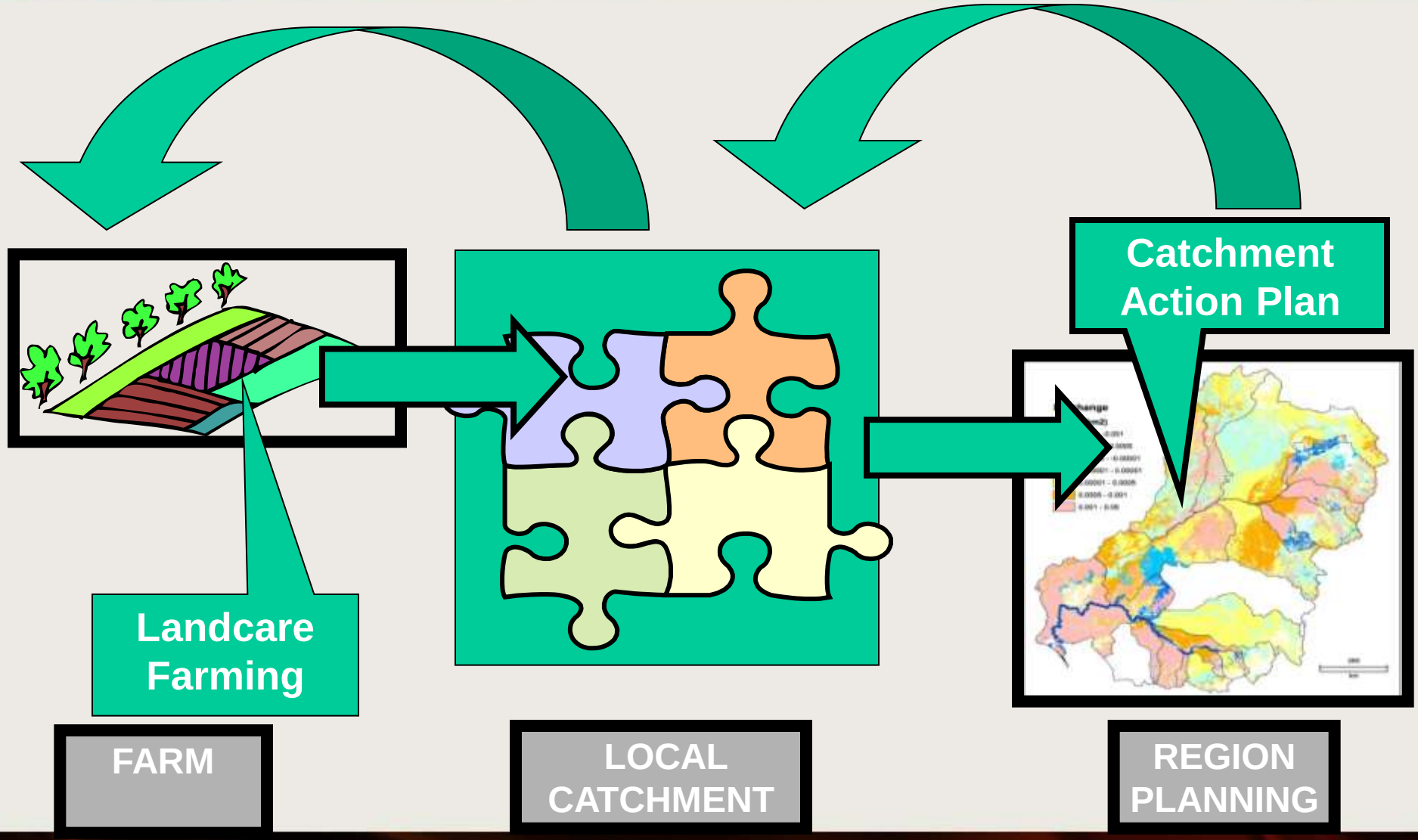



Enlace corrientes en la agroindustria ecosistema a aquellos en paisaje
Link flows in agro-ecosystem to those in landscape
© CSIRO Land and Water
Photography by Willem van Aken


Rainfall
Irrigation
Transpiration
Interception
Evaporation
Run-off
Drainage



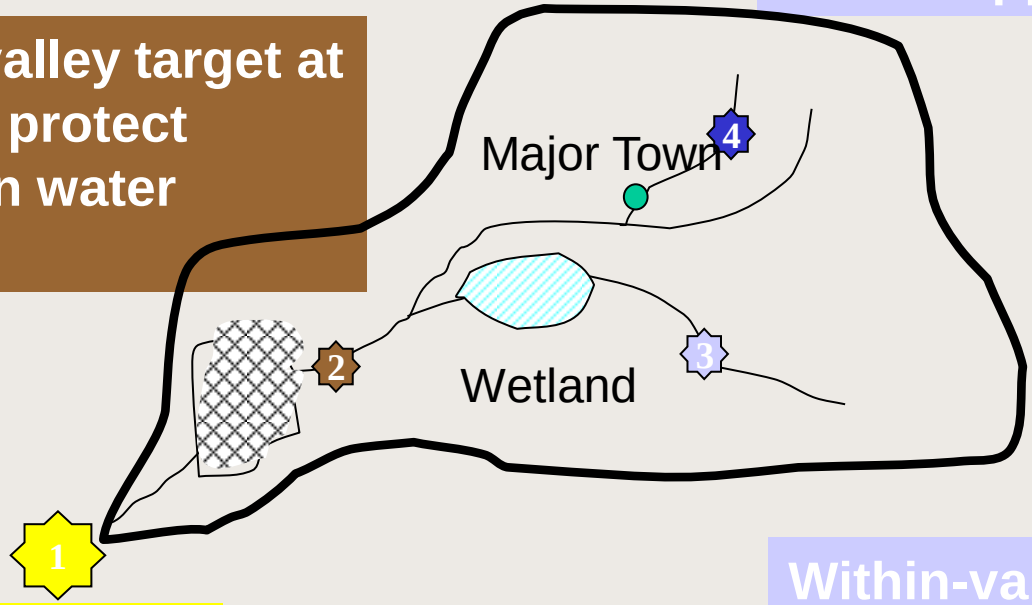
Williams, figure 2.


Catchment
Action Plan
Landcare
Farming
FARM
LOCAL
CATCHMENT
REGION
PLANNING

Examples of Targets for a Catchment

Within-valley target at site 4 to protect town water supply

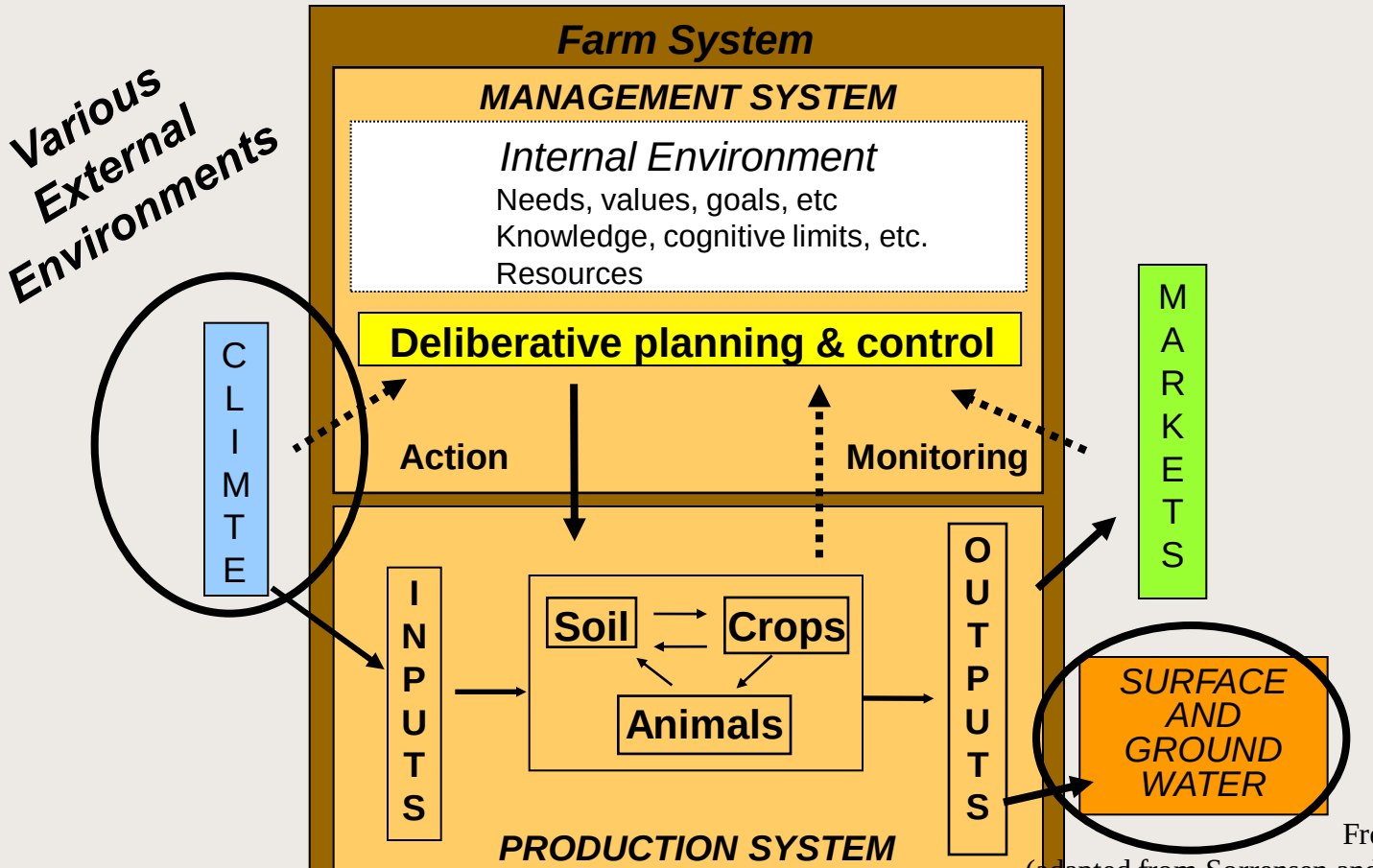
Within-valley target at site 2 to protect irrigation water supply



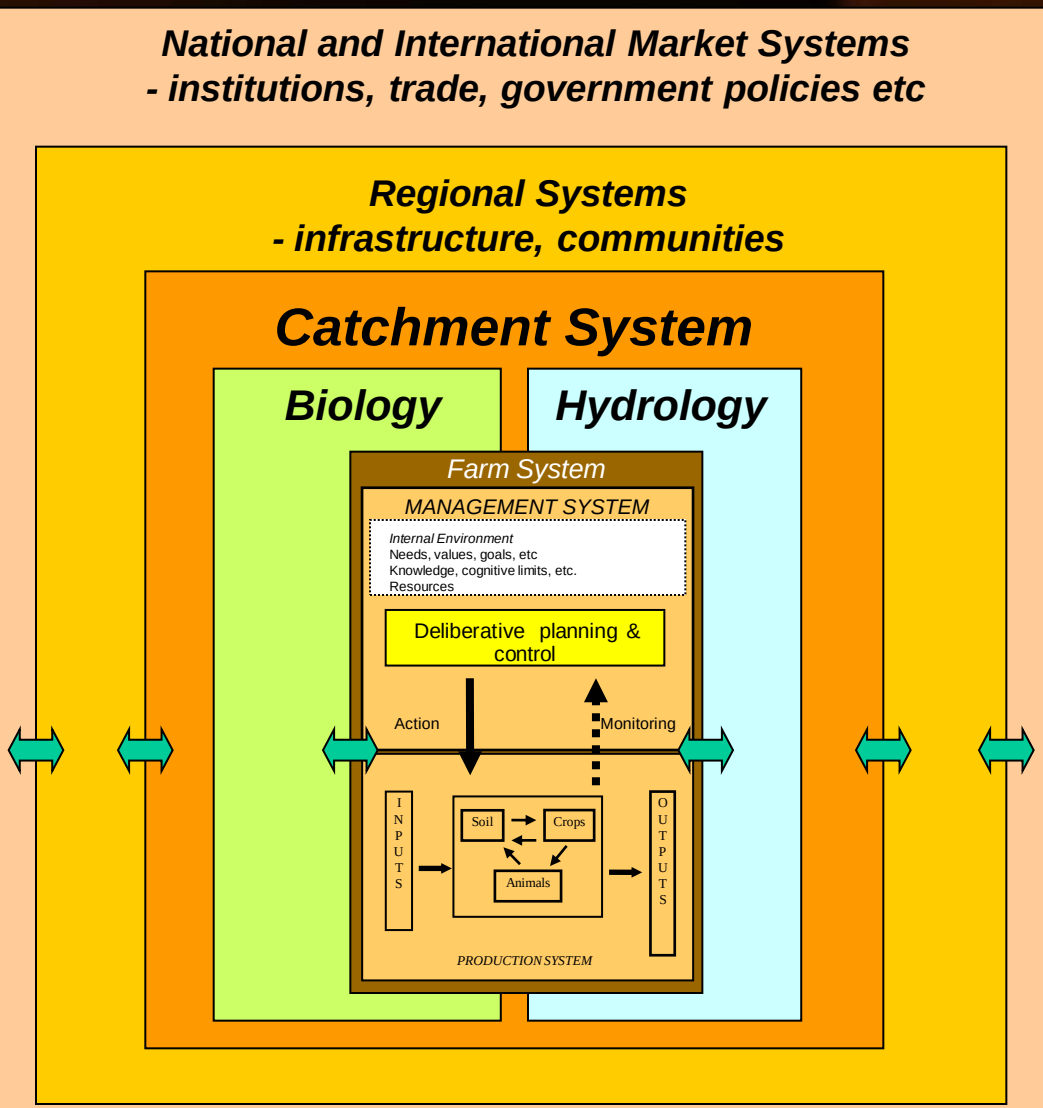
End-of-valley target at site 1 to protect Basin health

Within-valley target at site 3 to protect wetland ecosystem

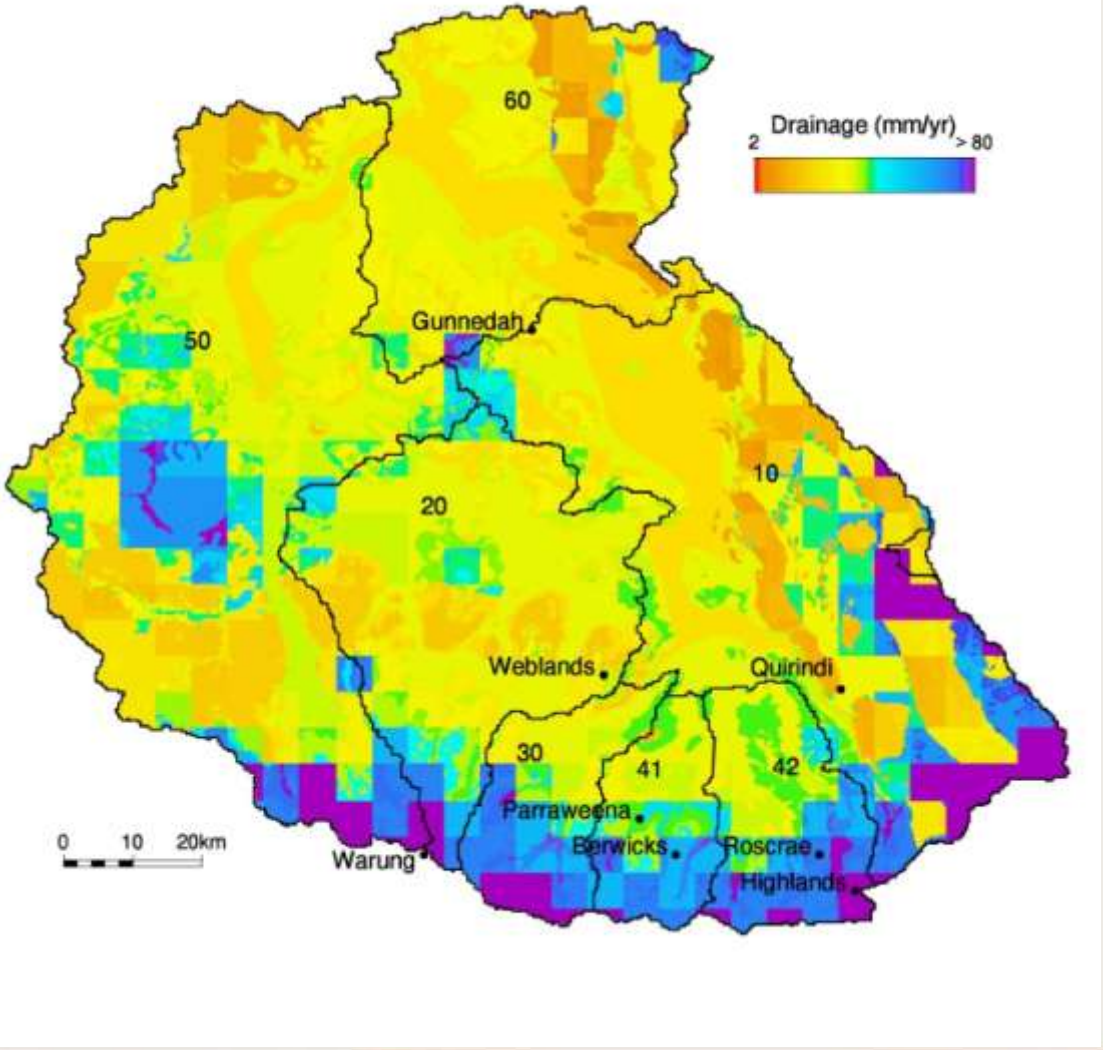
Field and farm practice



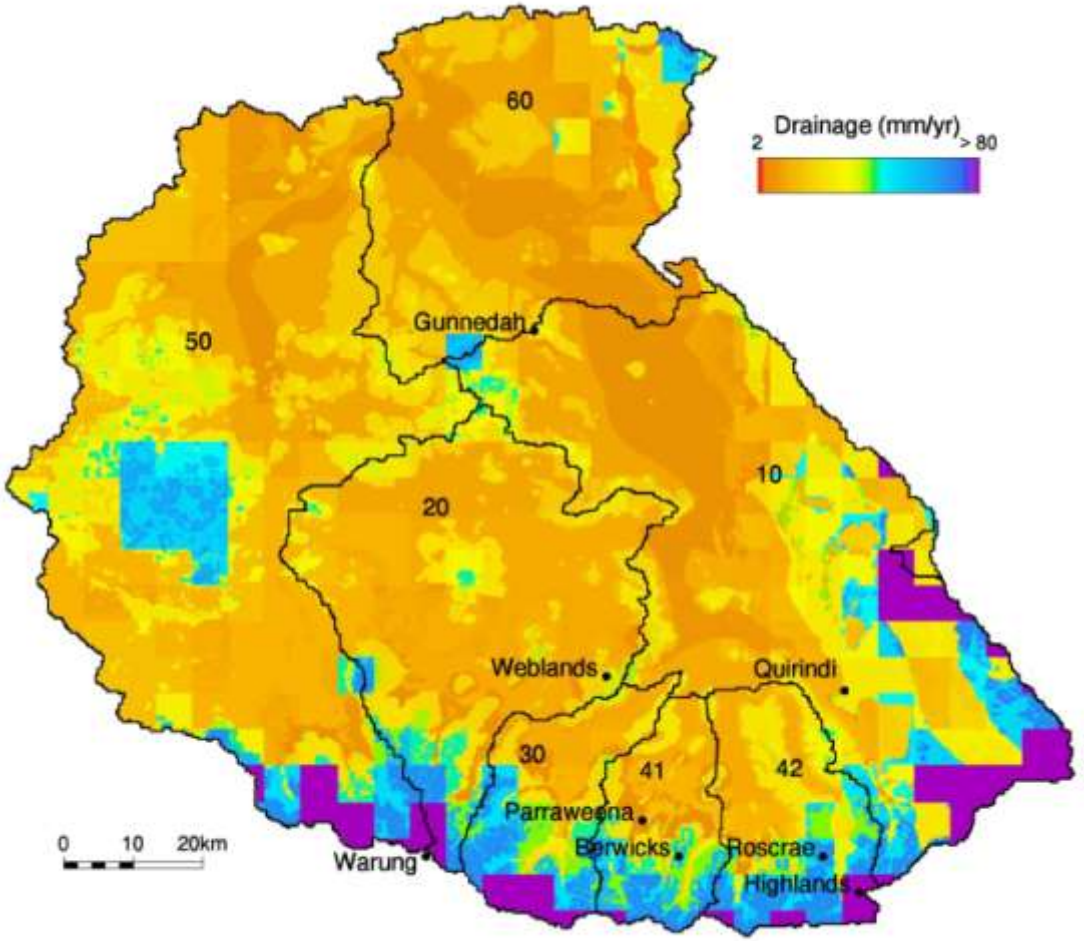
From McCown, 2
(adapted from Sorrensen and Kristensen, 19


National and International Market Systems
- institutions, trade, government policies etc
Regional Systems
- infrastructure, communities
Catchment System
Biology
Hydrology
Farm System
MANAGEMENT SYSTEM
Internal Environment
Needs, values, goals, etc
Knowledge, cognitive limits, etc.
Resources
Deliberative planning & control
Action
Monitoring
INPUTS
Soil
Crops
Animals
OUTPUTS
PRODUCTION SYSTEM


Australia
Darwin
Murray-Darling Basin
Brisbane
Liverpool Plains
Perth
Adelaide
Sydney
Canberra
Melbourne
0 Scale1000 km
Hobart

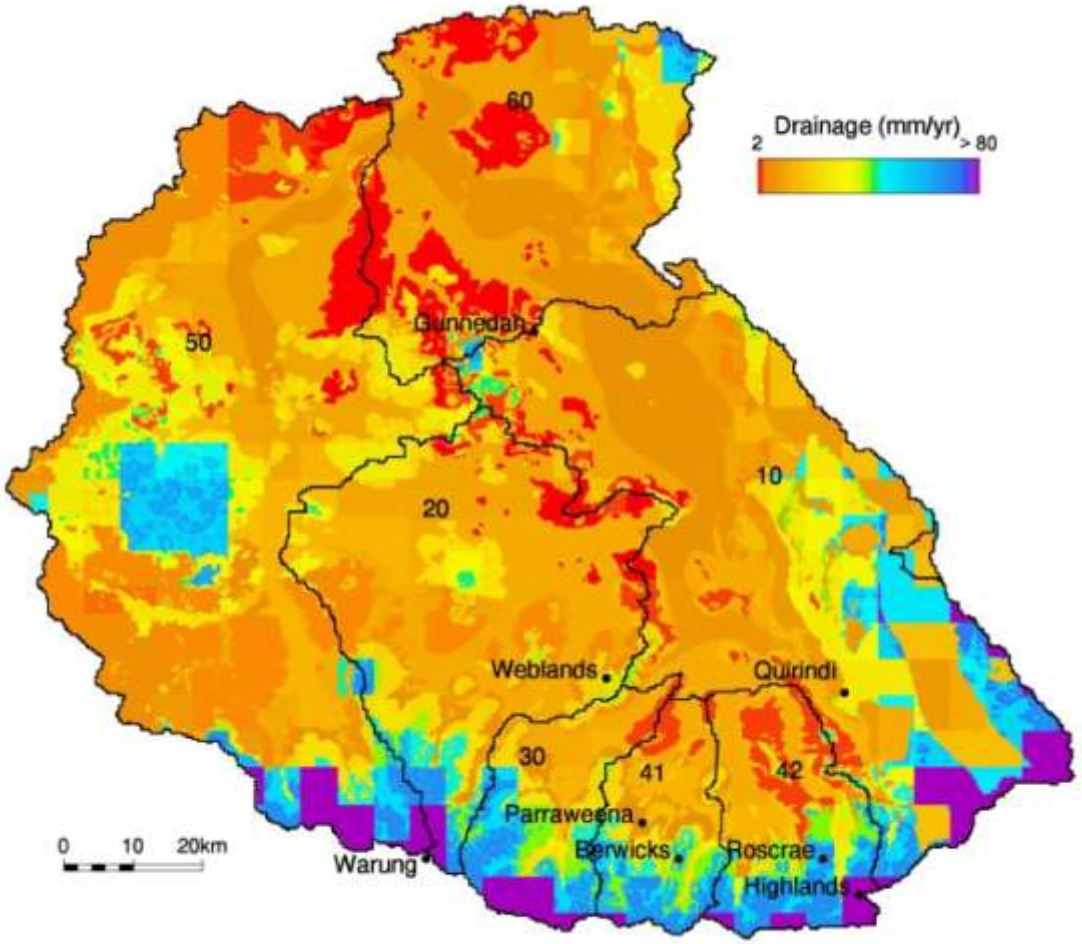


Estimated mean annual drainage with current land use

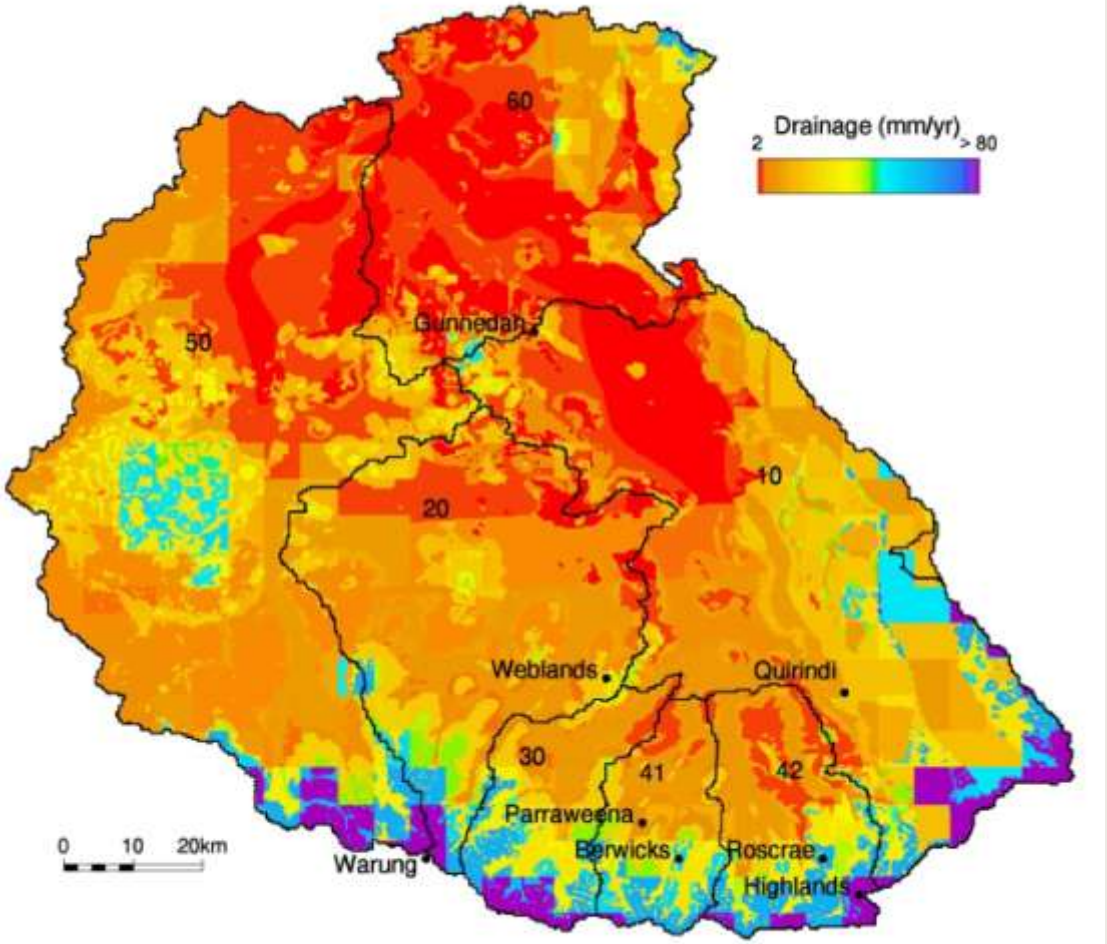


Estimated mean annual drainage with alternative cropping systems

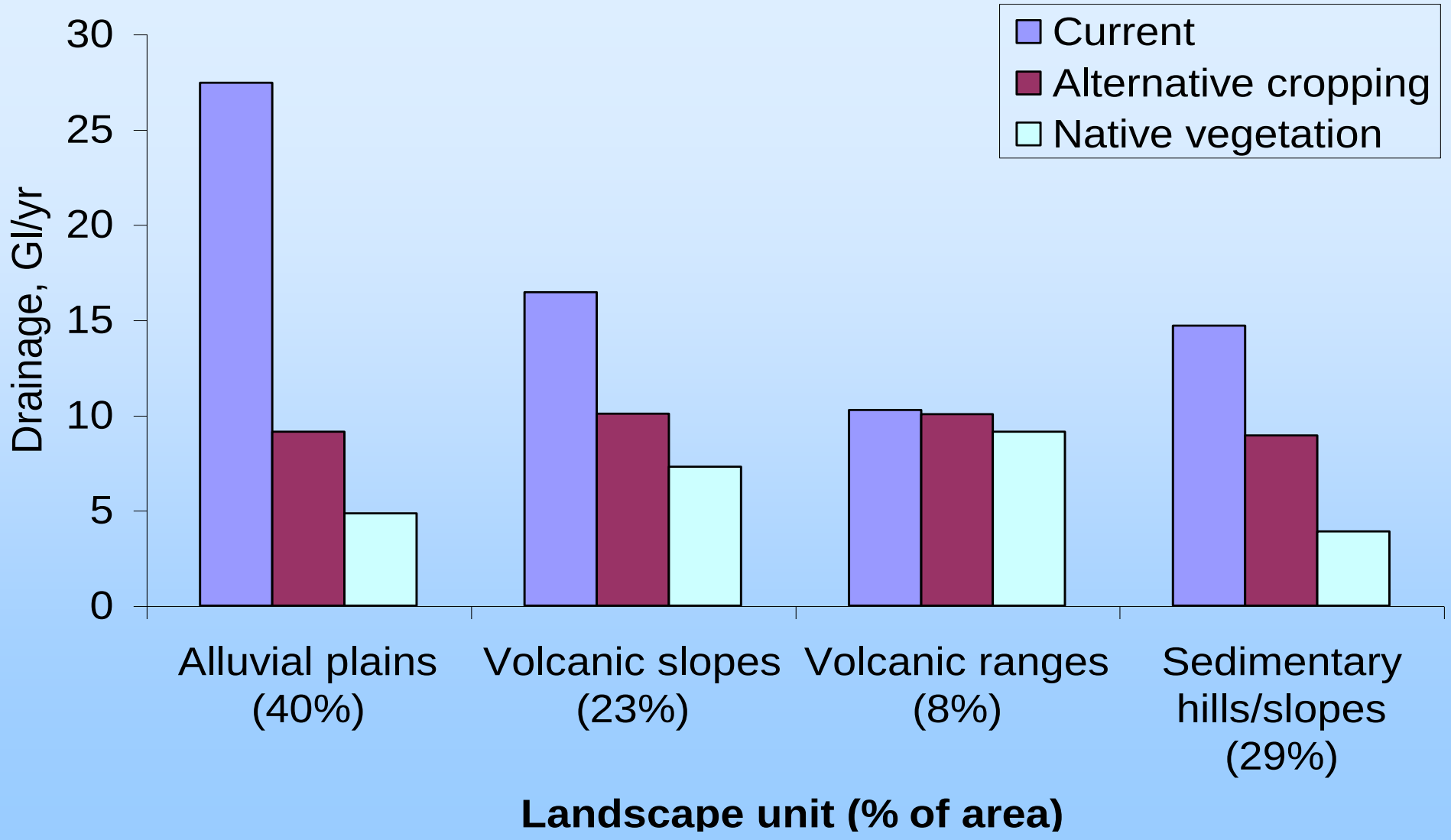
(opportunity cropping or continuous sorghum)



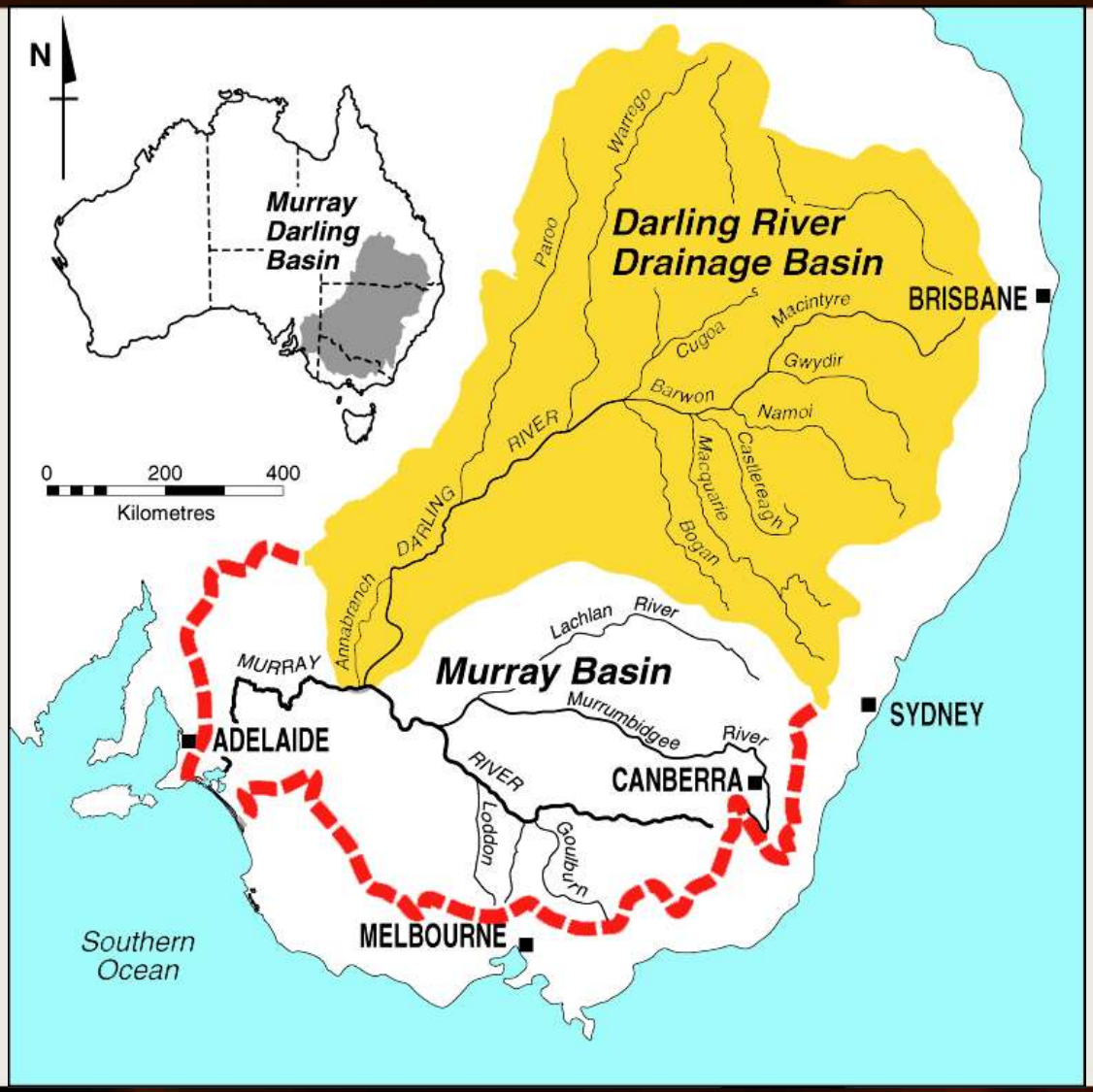
Estimated mean annual drainage with alternative cropping systems + forestry on sedimentary hills & slopes

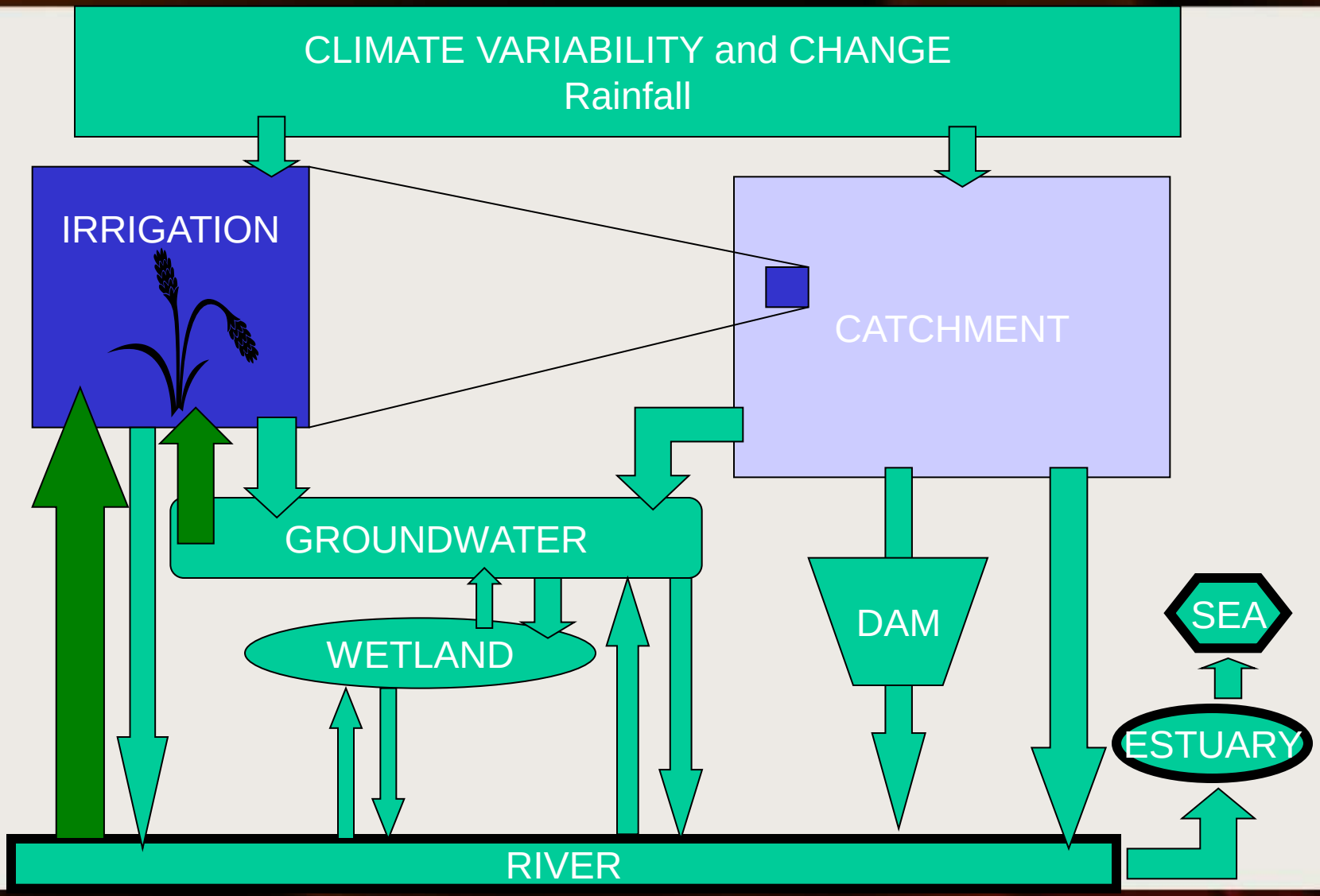


Estimated mean annual drainage with native vegetation


Current
Alternative cropping
Native vegetation
Drainage, Gl/yr
30
25
20
15
10
5
0
Alluvial plains (40%)
Volcanic slopes (23%)
Volcanic ranges (8%)
Sedimentary hills/slopes (29%)
Landscape unit (% of area)


Link flows in agro-ecosystem to those in landscape
© CSIRO Land and Water
Photography by Willem van Aken


N
Murray
Darling
Basin
0
200
400
Kilometres
Darling River
Drainage Basin
Warrego
Paroo
BRISBANE
Macintyre
Cuoga
Gwydir
Barwon
Namoi
RIVER
DARLING
Macquarie
Castlereagh
Bogan
Annabranch
Lachlan River
MURRAY
Murray Basin
Murrumbidgee River
SYDNEY
ADELAIDE
RIVER
CANBERRA
Loddon
Goulburn
MELBOURNE
Southern
Ocean


CLIMATE VARIABILITY and CHANGE
Rainfall
IRRIGATION
CATCHMENT
GROUNDWATER
WETLAND
DAM
SEA
ESTUARY
RIVER

Tension between water extraction and water for river health


© W van Aken, CSIRO

Ecosystem services

"…the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life"

Daily (1997)

Ecosystem services

OR?

Pollination as ecosystem service

native plants produce **nectar**

nectar feeds **bees**

bees **pollinate** crops at no cost to growers

sunflower

lucerne

clover

pumpkin

cherry

apple

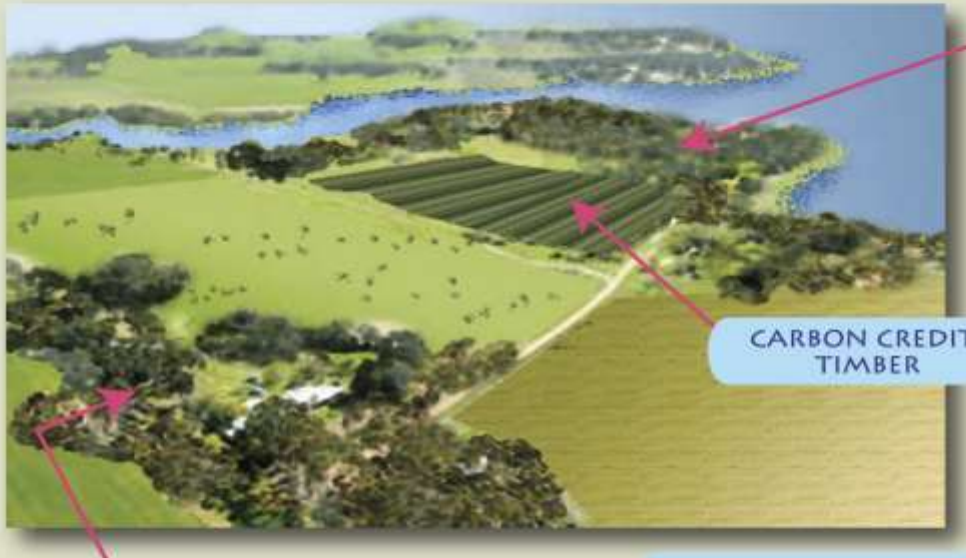
grapefruit

plum

apricot

All >70% dependent on pollinators

VALUE OF PRODUCTS: $1.2b pa



COMMODITY	BUSINESS SHARE %	CLIENT
WHEAT	40	WORLD MARKET
WOOL	15	WORLD MARKET
TIMBER	10	PULP WOOD, BIOMASS ENERGY, SPECIALTY TIMBER
CARBON CREDITS	7.5	STEEL MILL
SALINITY CREDITS	7.5	COST SHARING FOR CATCHMENT MANAGEMENT
WATER SUPPLY MANAGEMENT	15	WATER SUPPLY COMPANY
BIODIVERSITY CREDITS	3	PUBLIC/PRIVATE TRUSTS

The future form of sustainable agriculture

La forma futura de la agricultura sostenible

"…from little things big things grow"