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More crop per drop:
Improving our knowledge on crop water requirements for irrigation scheduling

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David le Maitre, Seb Dzikiti & Nebo Jovanovic

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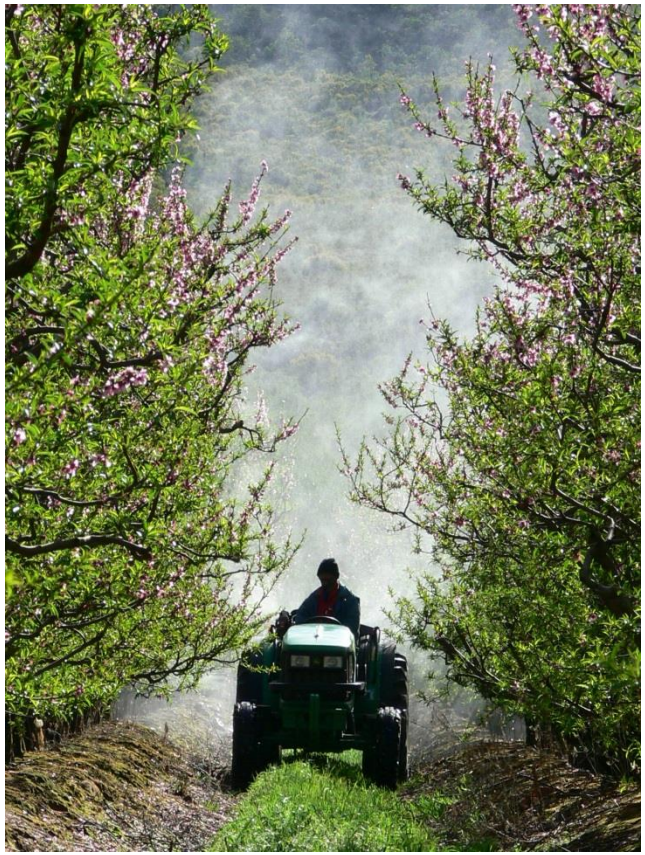
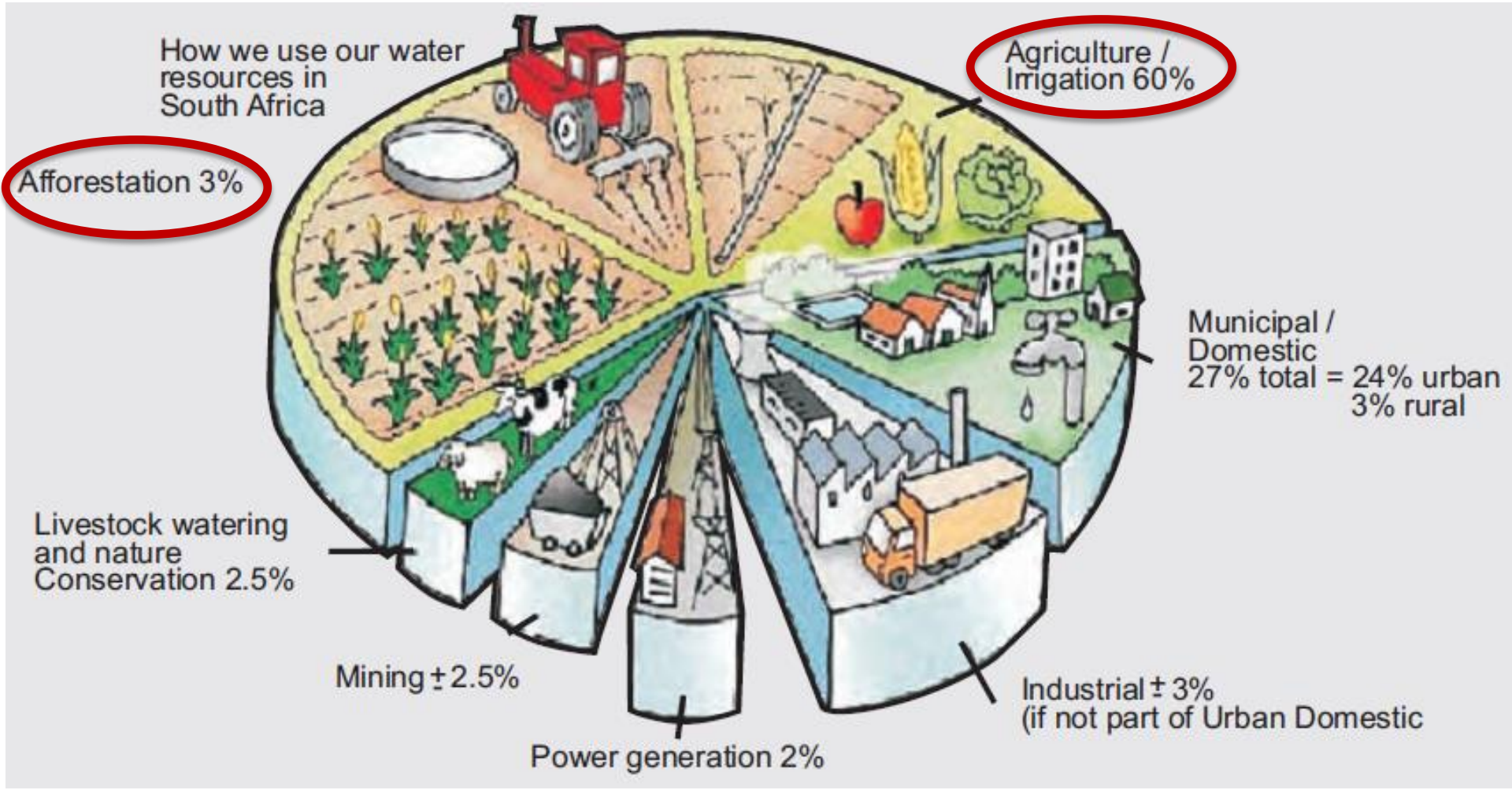
Introduction



Background:

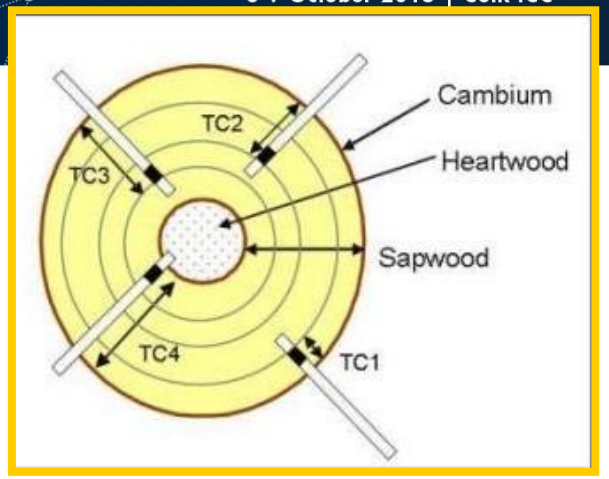
- Food security = water security
- Increasing pressure on water resources in SA (population & economic growth, climate change, dilution capacity for water quality)
- Economic importance of agriculture and forestry to SA (GDP & value add / jobs)
- Significant water use by irrigated agriculture, forestry & invasive alien plants
- Varies by crop type, irrigation vs dryland, rainfall region, tree species, riparian / upland
- How to produce more “crop-per-drop?”
- Measure to manage

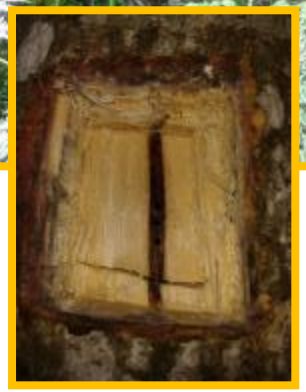
Water use by sector



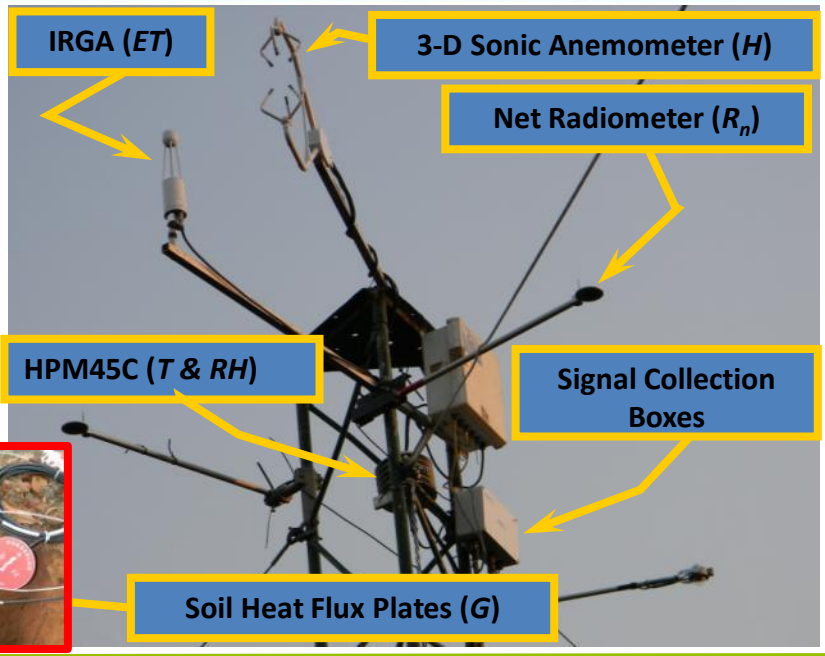
- Source: Dept. Water and Sanitation, NWRS-2.

Measuring water use
Transpiration (tree)





Measuring water use
Total evaporation (forest / orchard)



$$R_n - G - H - LE = 0$$
$$LE(ET) = R_n - G - H$$

Modelling

Use of models to simulate ET from trees & canopy surfaces – calibrated & verified with seasonally observed data

Remote sensing & earth observation

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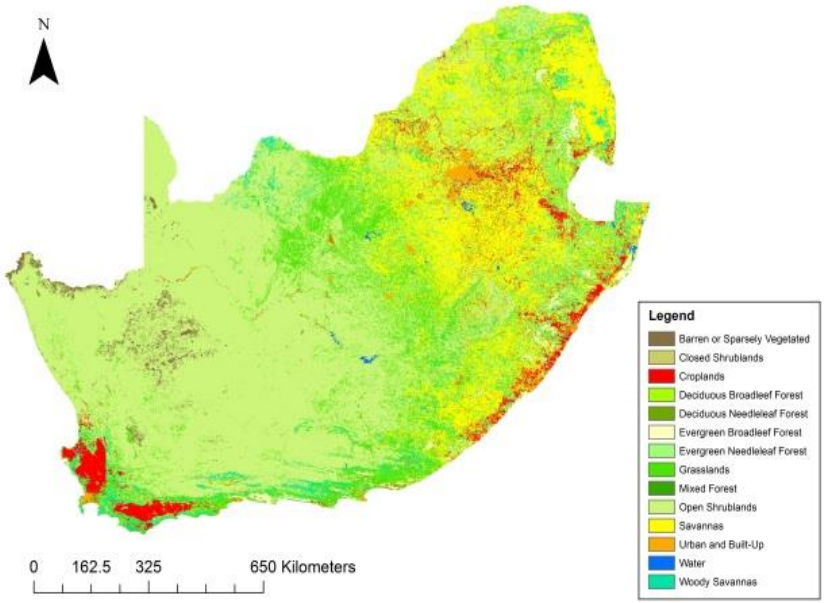

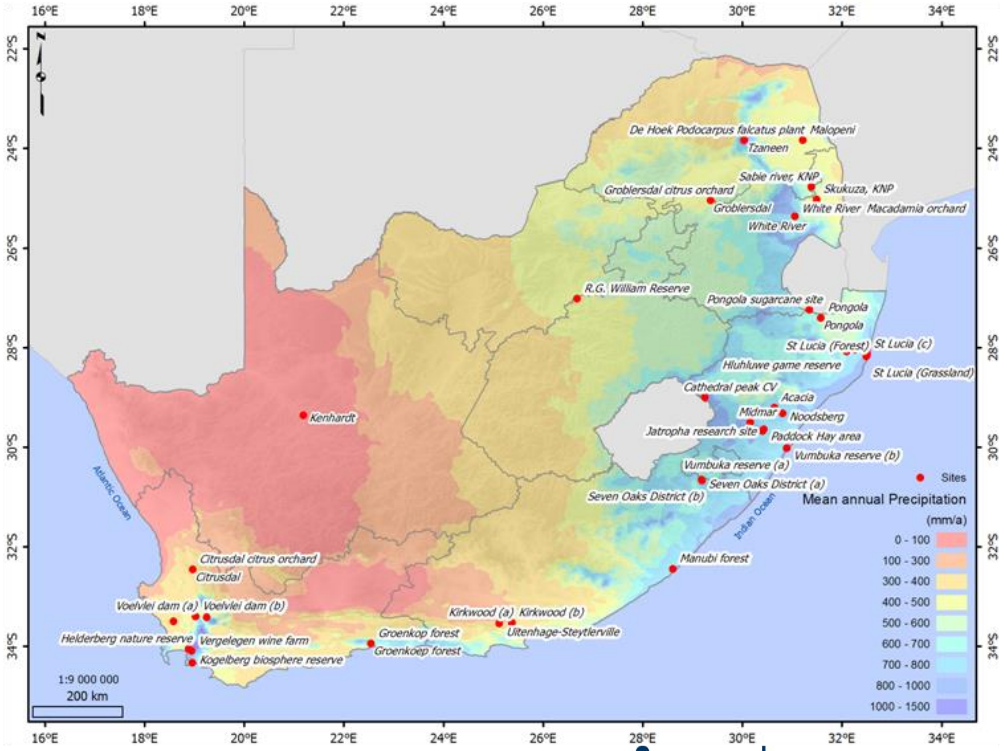

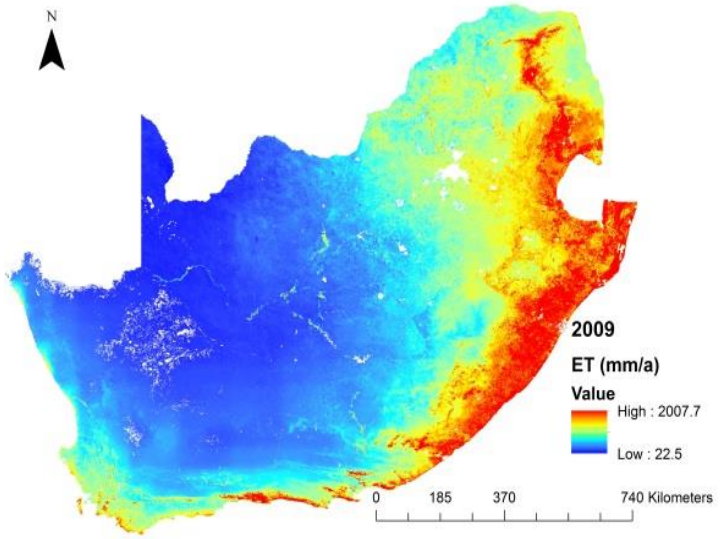

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Irrigated agriculture

Water use of fruit tree orchards

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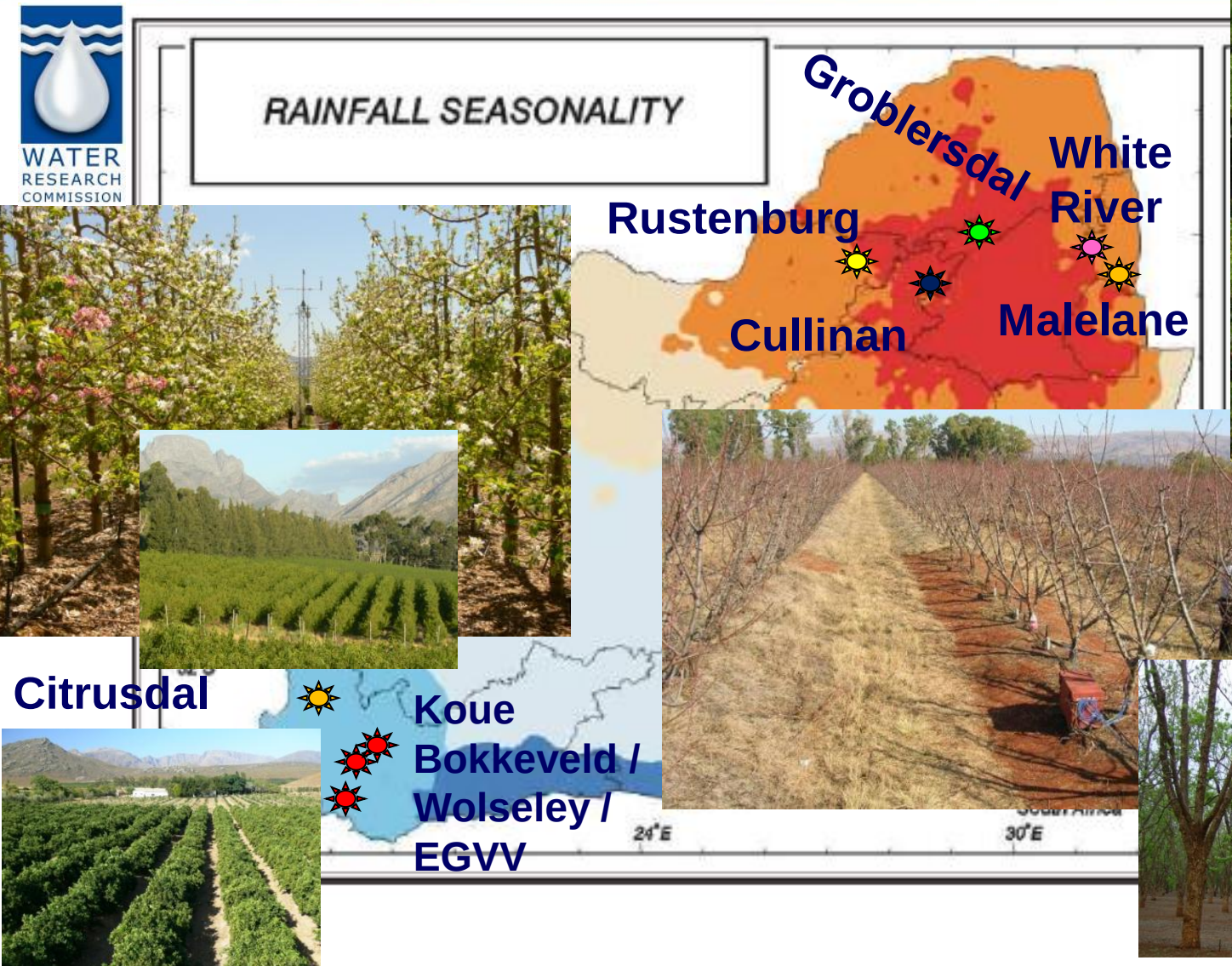
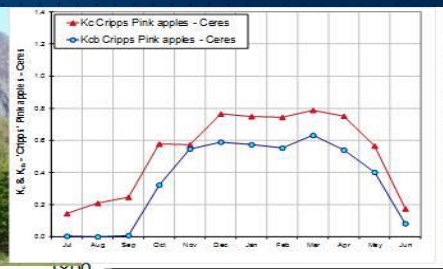
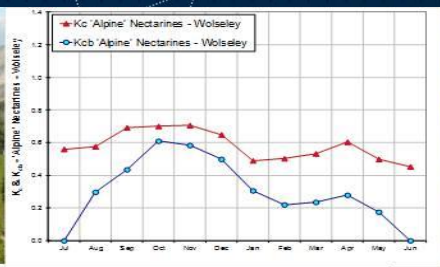
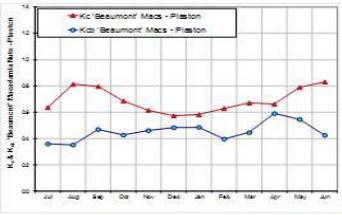
WATER RESEARCH COMMISSION

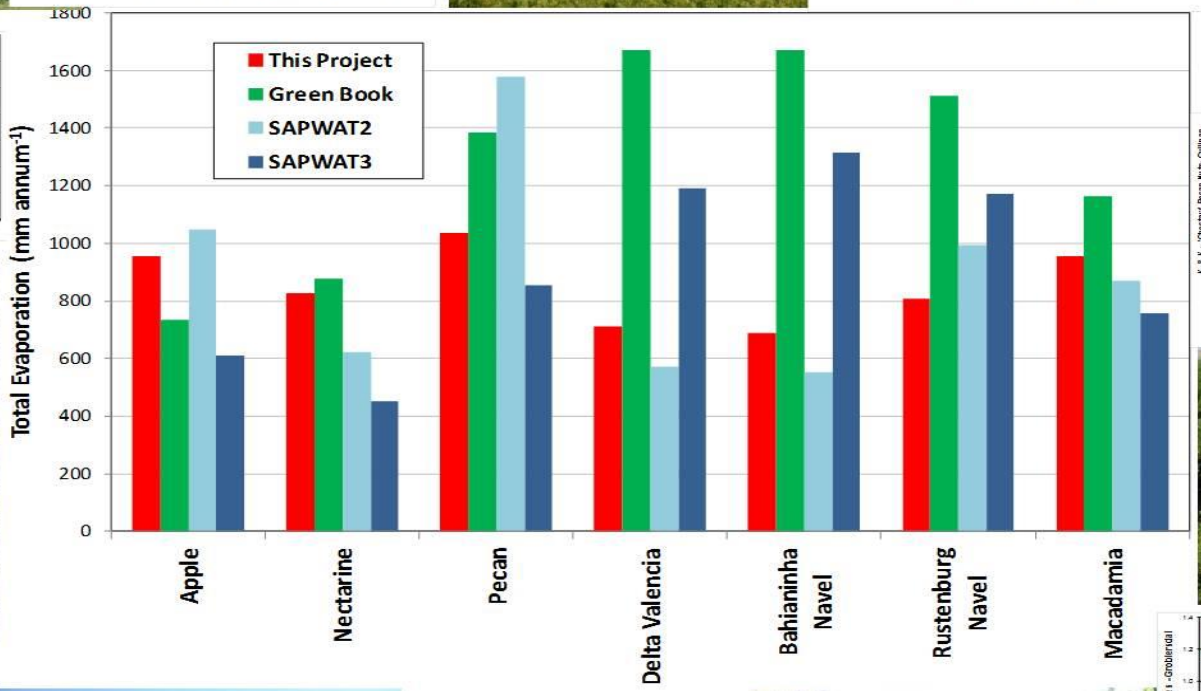


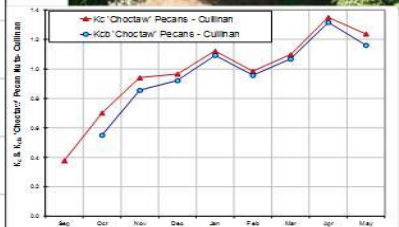
Results

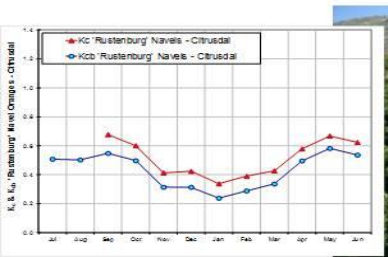

Kc Cripps Pink apples - Ceres
Kcb Cripps Pink apples - Ceres


Kc 'Alpine' Nectarines - Wolseley
Kcb 'Alpine' Nectarines - Wolseley

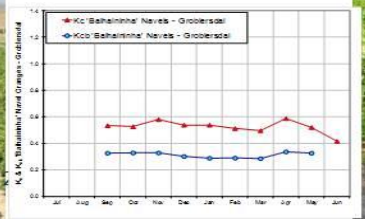

Kc 'Beaumont' Macs - Pleiston
Kcb 'Beaumont' Macs - Pleiston

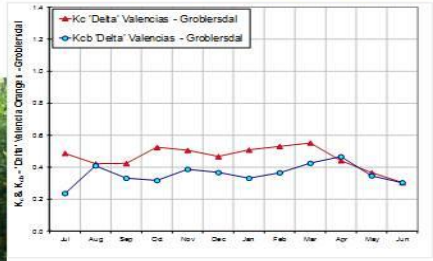

This Project
Green Book
SAPWAT2
SAPWAT3
Total Evaporation (mm annum-1)
1800
1600
1400
1200
1000
800
600
400
200
0
Apple
Nectarine
Pecan
Delta Valencia
Bahianinha Navel
Rustenburg Navel
Macadamia


Kc 'Choctaw' Pecans - Cullinan
Kcb 'Choctaw' Pecans - Cullinan


Kc 'Rustenburg' Navels - Citrusdal
Kcb 'Rustenburg' Navels - Citrusdal

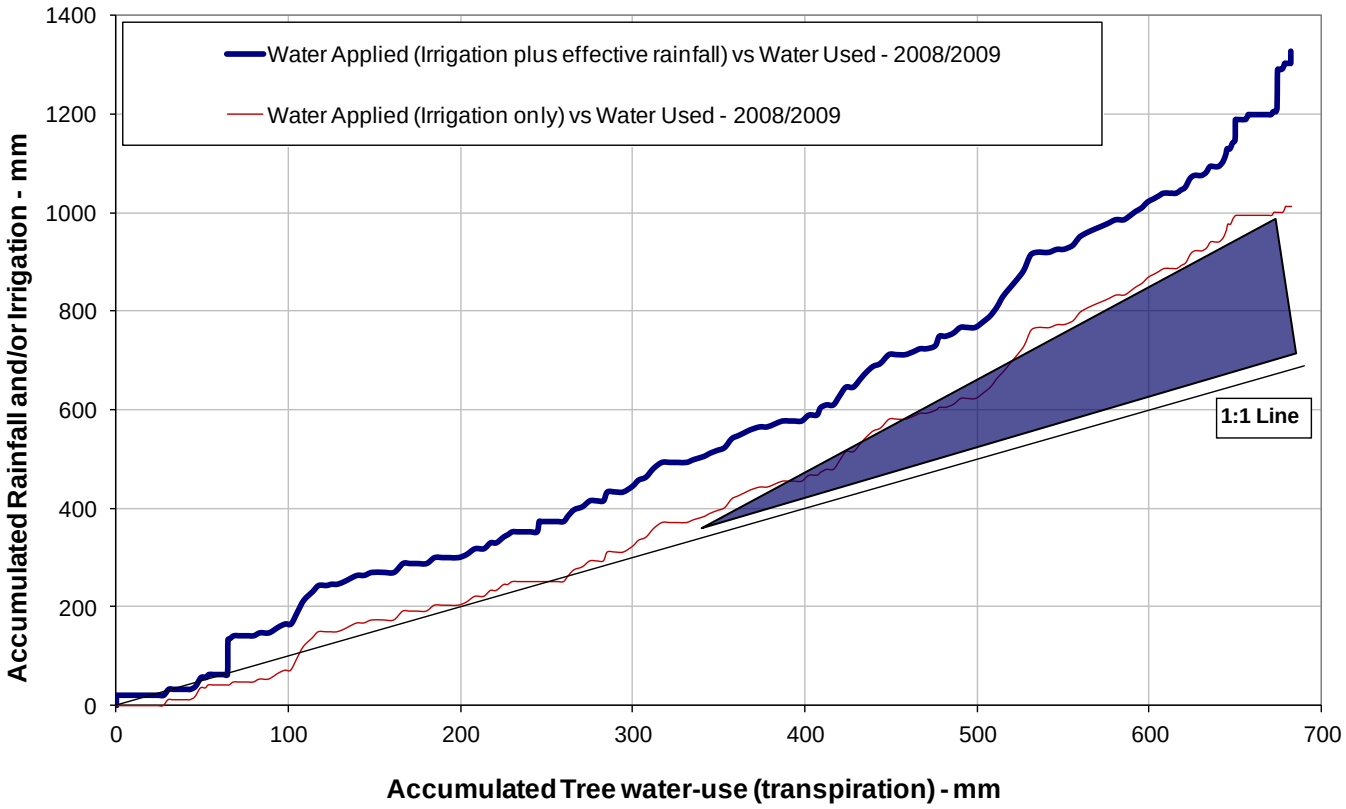

© CSIR


Kc 'Bahianinha' Navels - Groblersdal
Kcb 'Bahianinha' Navels - Groblersdal

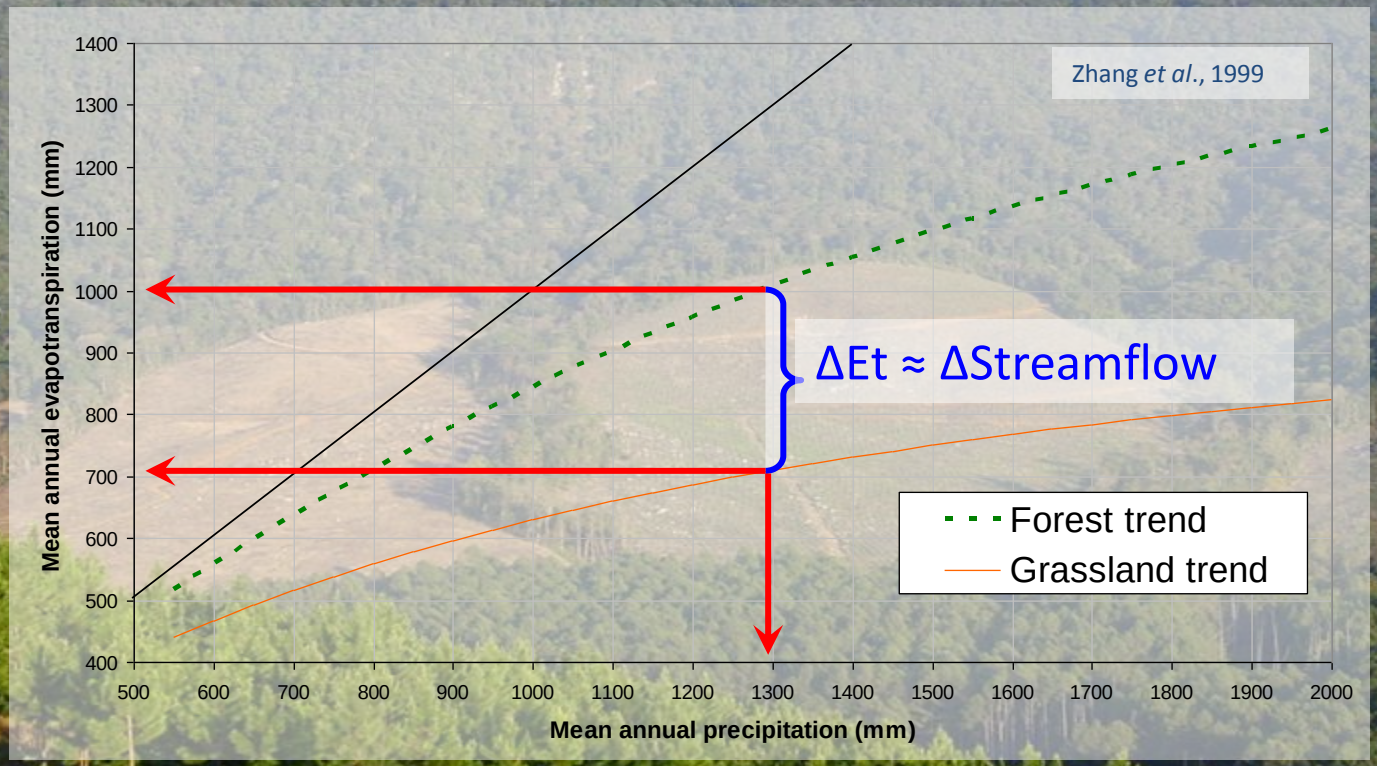

Kc 'Delta' Valencias - Groblersdal
Kcb 'Delta' Valencias - Groblersdal

Results

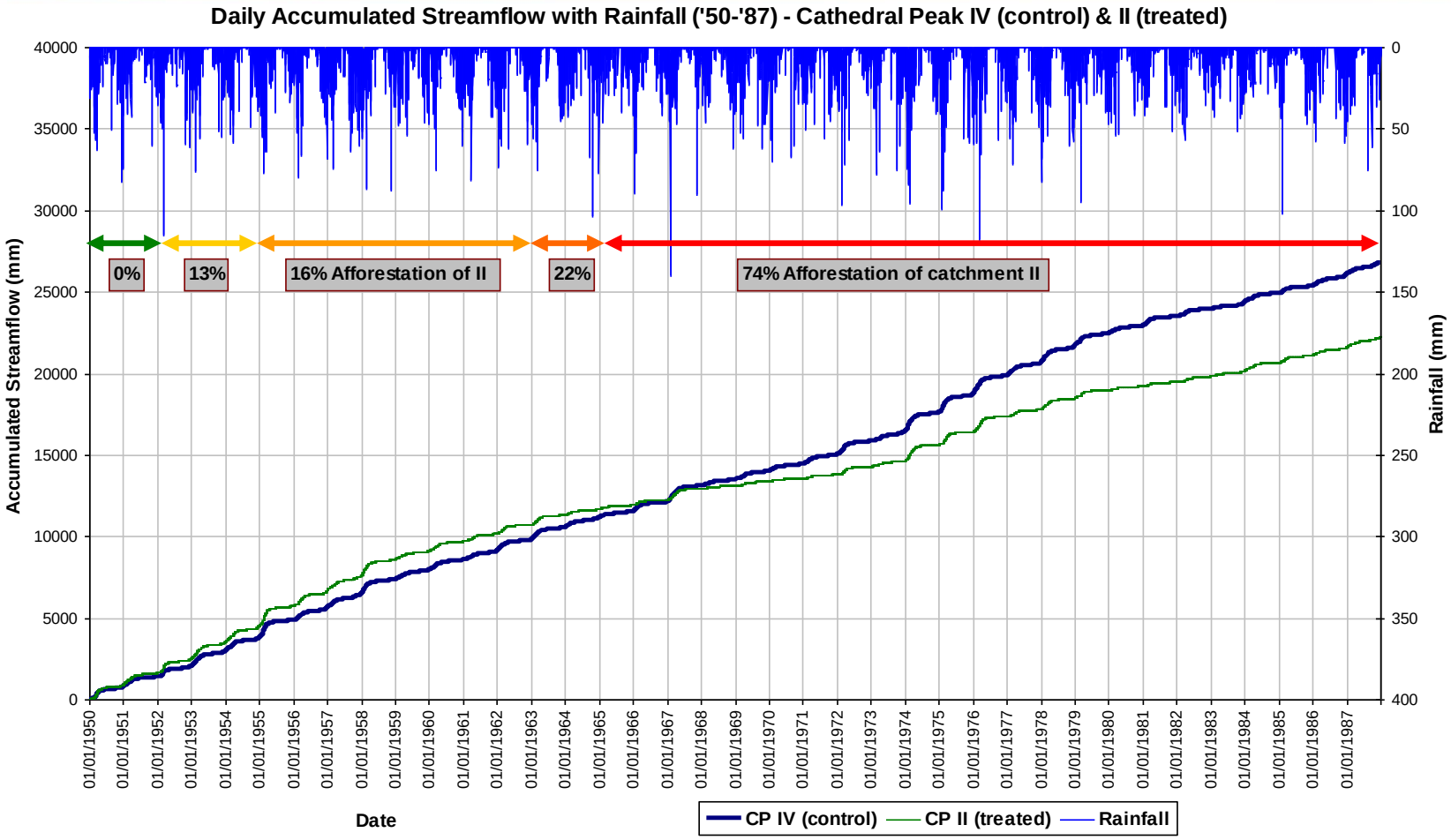
- A 14 yr old ‘Pink Lady’ apple tree transpires:
- ± 20-30 L water/day in summer (max 42 L)
- ± 4000 L water/yr (680 mm / 6800 $m^3.ha^{-1}$)
- ± 27 L water per apple (170 L/kg apples)



Forests & plantations



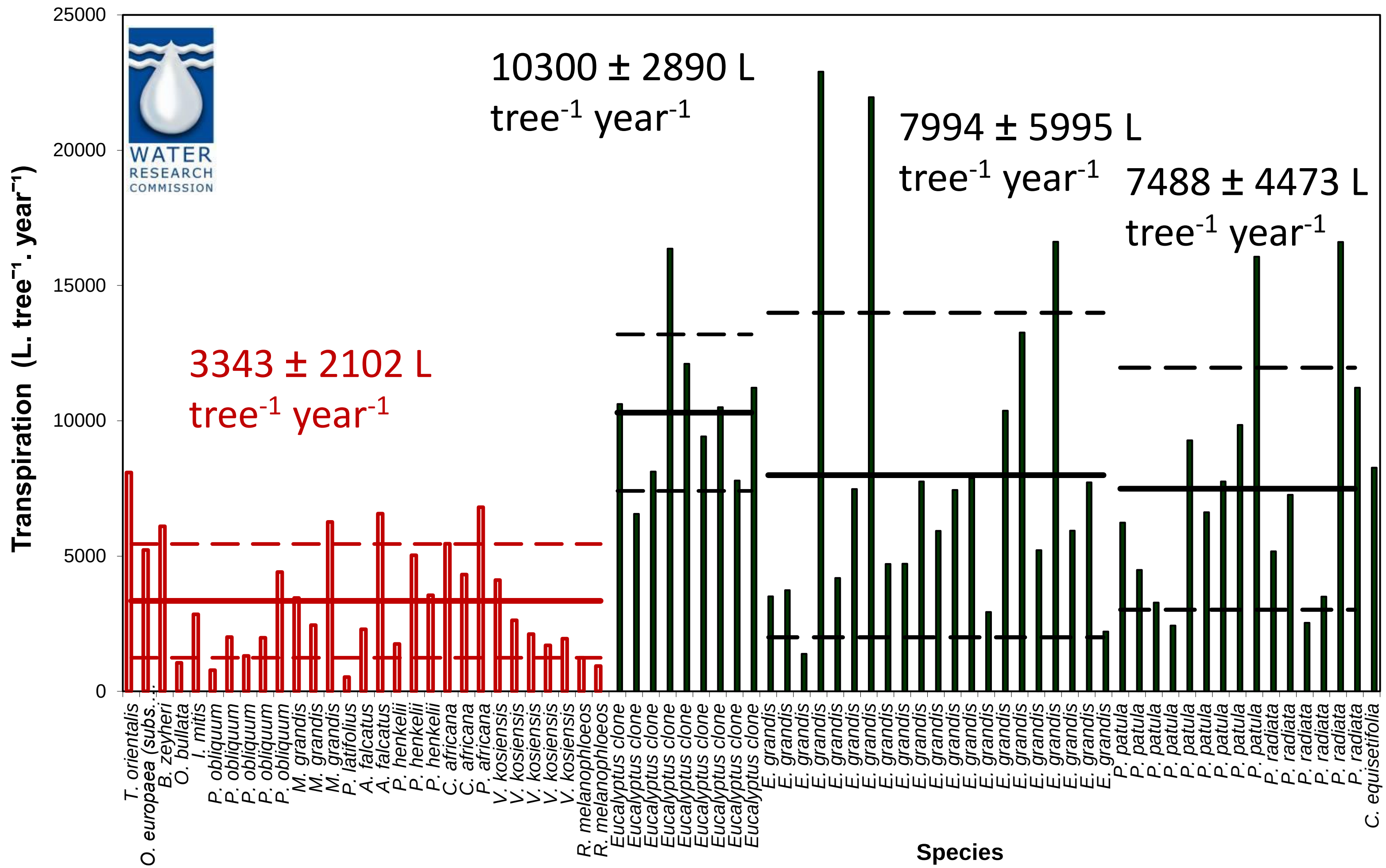
Streamflow reductions



- Cathedral Peak (1950 – 1987): Afforested (treatment) vs. grassland (control).

*Gush, M.B. 2010. Policy-orientated research for forests and water in South Africa. In: German, L.A., Karsenty, A. and Tiani, A., (Eds). Governing Africa's Forests in a Globalized World. Earthscan, UK. Pp 208-211.

Results


WATER
RESEARCH
COMMISSION
25000
20000
15000
10000
5000
0
Transpiration (L. tree^{-1}. year^{-1})
3343 ± 2102 L tree^{-1} year^{-1}
10300 ± 2890 L tree^{-1} year^{-1}
7994 ± 5995 L tree^{-1} year^{-1}
7488 ± 4473 L tree^{-1} year^{-1}
T. orientalis
O. europaea (subs...
B. zeyheri
O. bullata
I. mitis
P. obliquum
M. grandis
P. latifolius
A. falcatus
P. henkelii
C. africana
P. africana
V. kosiensis
R. melanophloeos
Eucalyptus clone
E. grandis
P. patula
P. radiata
C. equisetifolia
Species

Invasive alien plants

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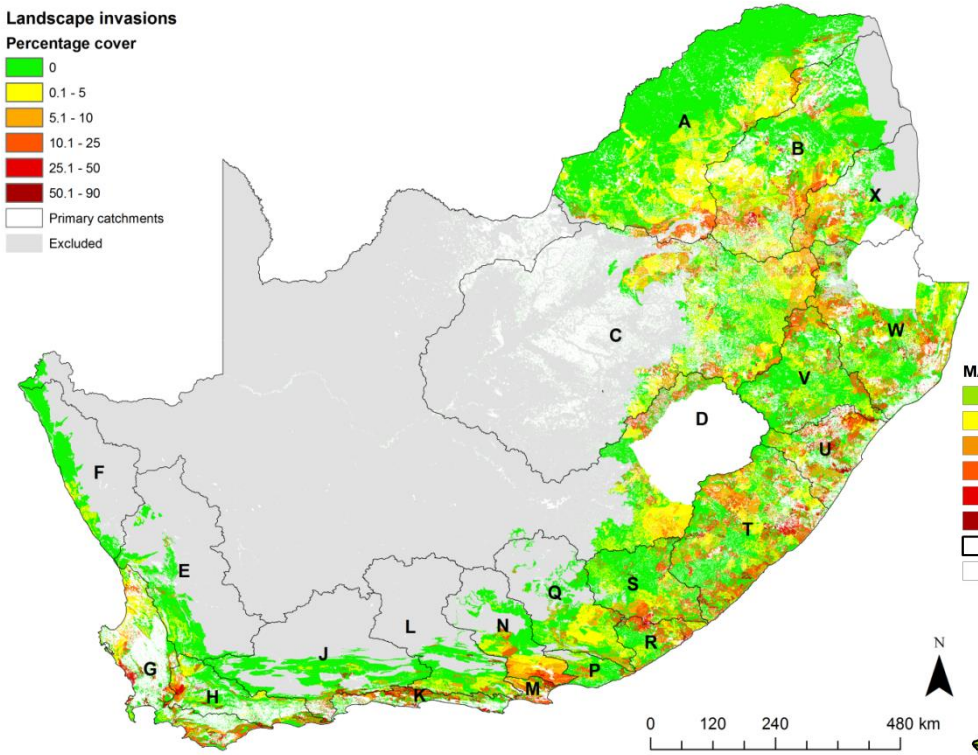
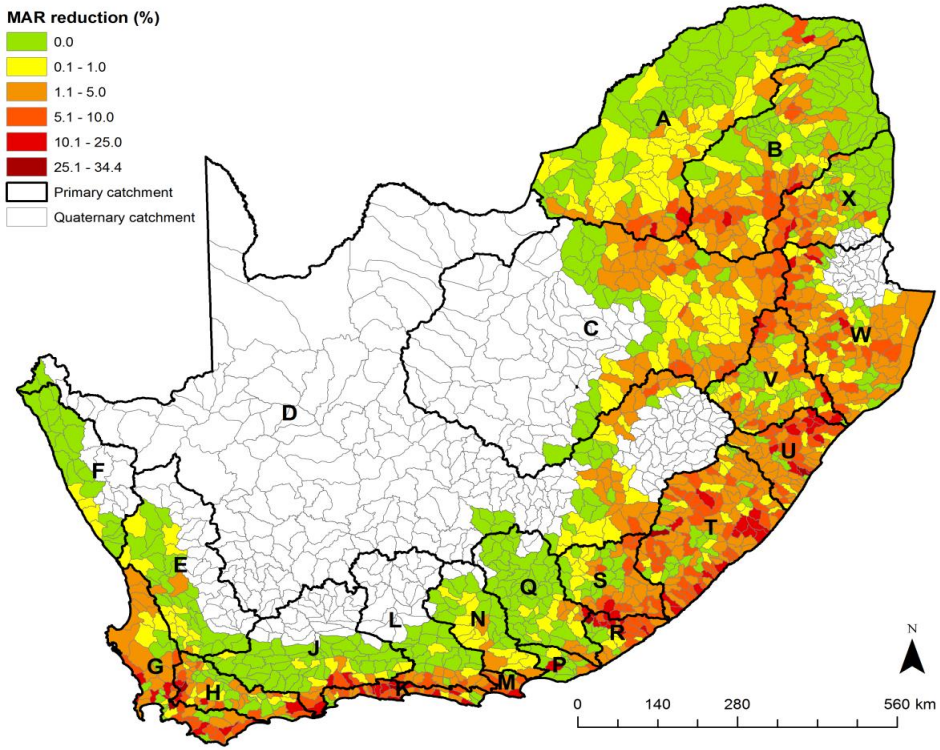
Results


Landscape invasions
Percentage cover
0
0.1 - 5
5.1 - 10
10.1 - 25
25.1 - 50
50.1 - 90
Primary catchments
Excluded
A
B
X
C
W
V
D
U
F
T
E
Q
S
L
N
R
J
P
G
M
H
K
N
0
120
240
480 km

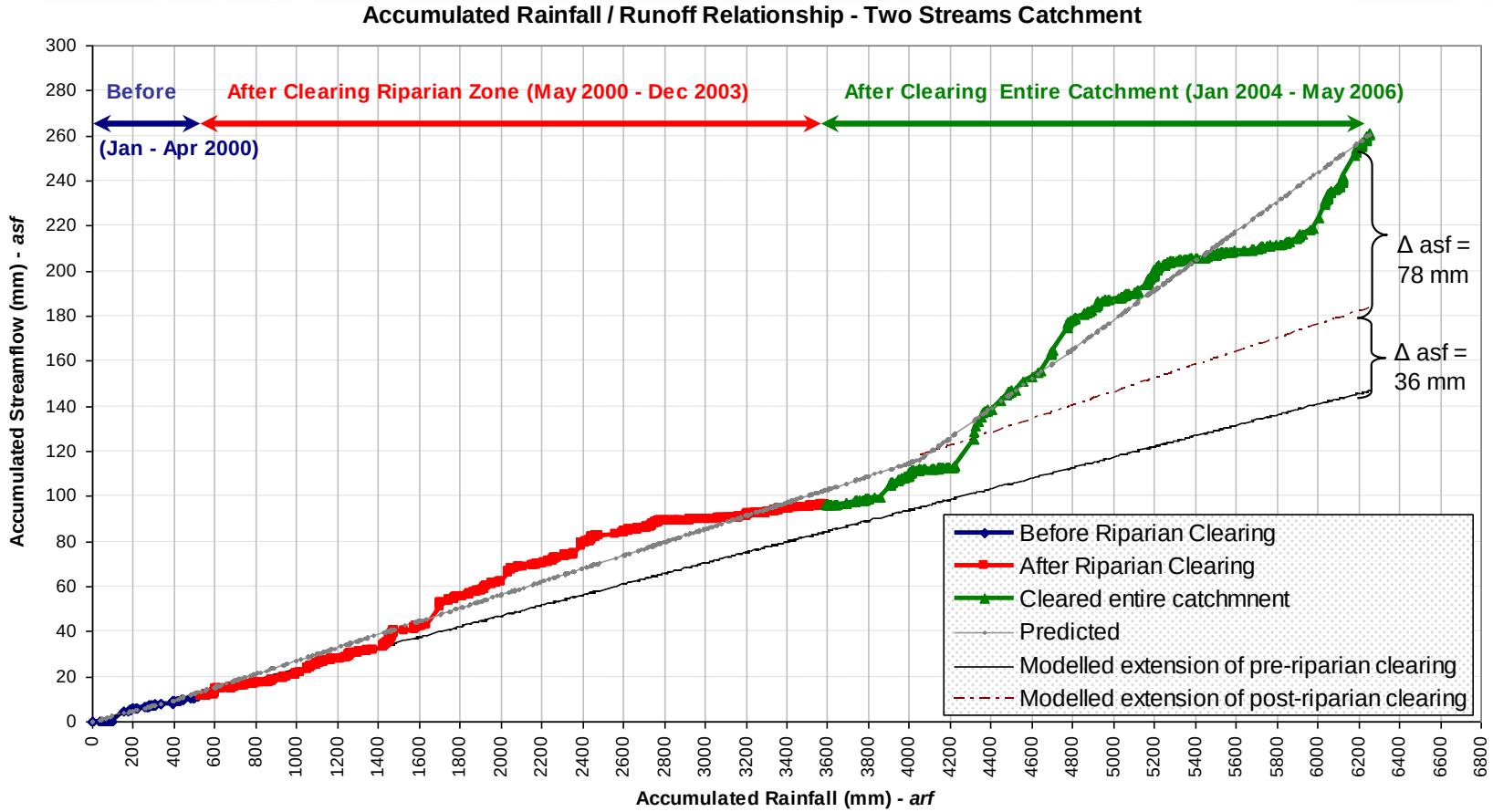

MAR reduction (%)
0.0
0.1 - 1.0
1.1 - 5.0
5.1 - 10.0
10.1 - 25.0
25.1 - 34.4
Primary catchment
Quaternary catchment
A
B
X
C
W
V
D
U
F
T
E
Q
S
L
N
R
J
P
G
M
H
K
N
0
140
280
560 km

IAPs Summary

- Total condensed area 1.50 (1.3-1.7) million ha
- Total MAR reduction 1 444 (1 304-1 598) mill m³/yr (2.88% of MAR) - Equivalent to 97 mm/yr
- Most invasions in E Cape, KZN, Mpumalanga
- Most affected Biome:
  - Forest – issues of data resolution
  - Grasslands – greatest volume
  - Indian Ocean Coastal Belt – highest %

Clearing of IAPs

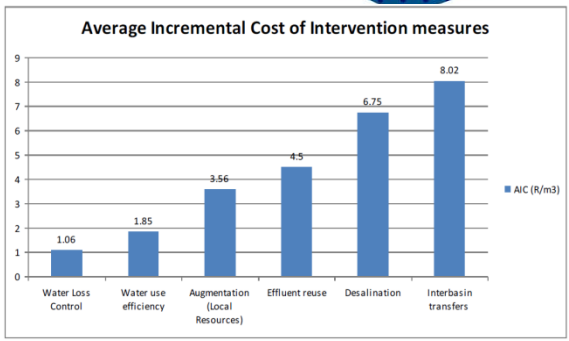
Streamflow gains



- 6-yr increase in streamflow = 114mm / 46.5%
- 1ha riparian zone cleared = 3.5 ha non-RZ cleared

Where to from here?

- On-going field measurements and modelling
- Use results in water allocation & irrigation scheduling
- Improved efficiencies & productivity (“crop per drop”)
- Enhanced monitoring (water meters), reduced transmission losses / leaks, more use of waste-water (grey water, rainwater harvesting etc.)
- Increased use of groundwater for irrigation
- Ongoing removal of IAPs to augment water supplies
- Application of new technologies for precise monitoring of water use e.g. remote sensing (UAVs / satellites), online / real-time irrigation scheduling.



Conclusions

- Agriculture can & must become more efficient in its use of water
- Agricultural water allocation processes need to be enhanced
- Requires accurate crop and tree water use data (how much water is required, when, and where)
- Requires accurate data on crop areas (crop type mapping)
- Requires improved modelling, validated with accurate field data collected for a wide variety of trees and crops, growing in a range of conditions.
- Recognise full value-added benefit of agriculture to SA

"Crop-per-drop"; "Jobs-per-drop", "Frogs*-per-drop"
*Environmental indicators

Acknowledgements

- Funding:
  - Water Research Commission
  - Dept. Agric. Forestry & Fisheries
  - Dept. Environmental Affairs
- Project Teams (CSIR & external)
- Students
- Land Owners and Managers

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Thank you

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