WATER USE AND ECOSYSTEM FUNCTIONS OF GRASSLANDS, INDIGENOUS FORESTS AND AGRO-FORESTRY SYSTEMS

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WRC 40 Year Conference

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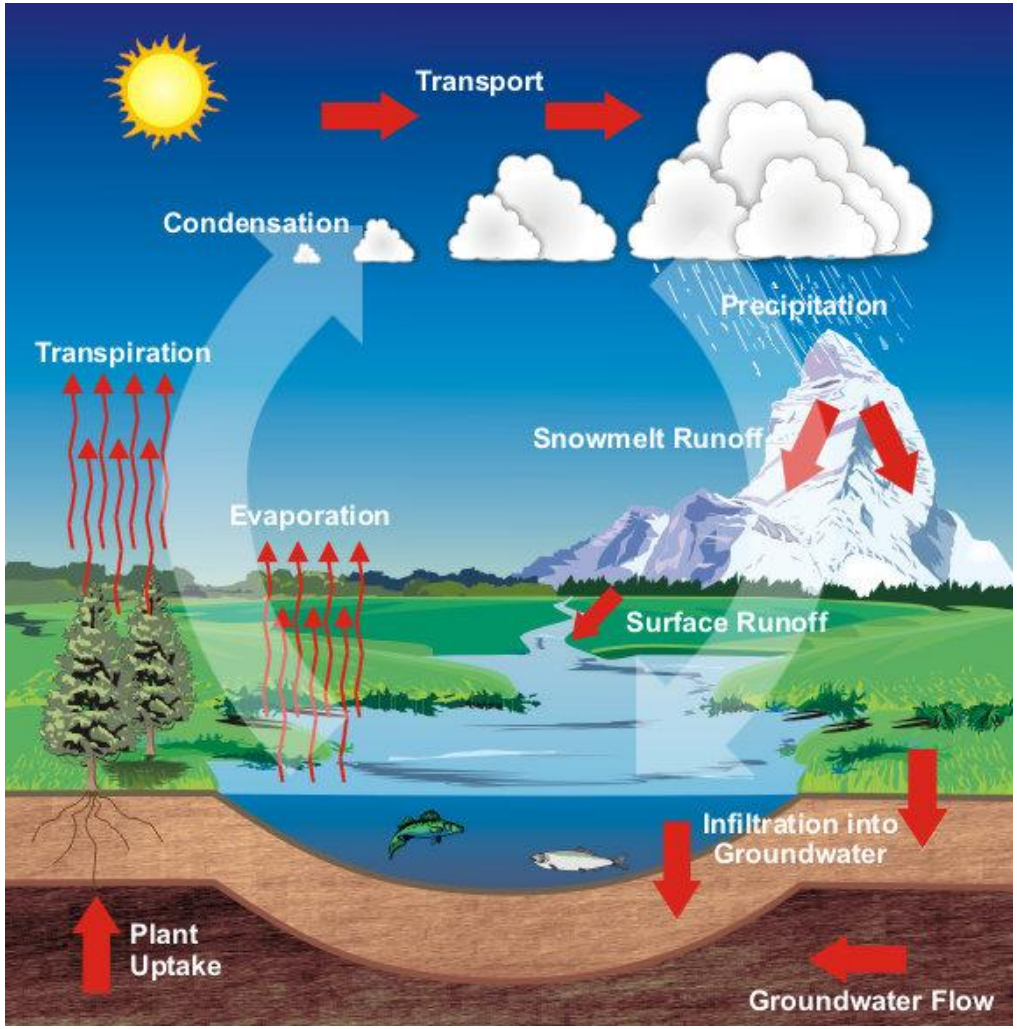
Introduction



- Ecosystems have complex exchanges of energy and water giving ecosystems their distinct identities
- Ecosystems provide functions critical to survival but human activities place increasing demands on ecosystem services.
- The effect of these activities on ecosystem functioning has been the focus of numerous WRC studies

The Montane Grasslands

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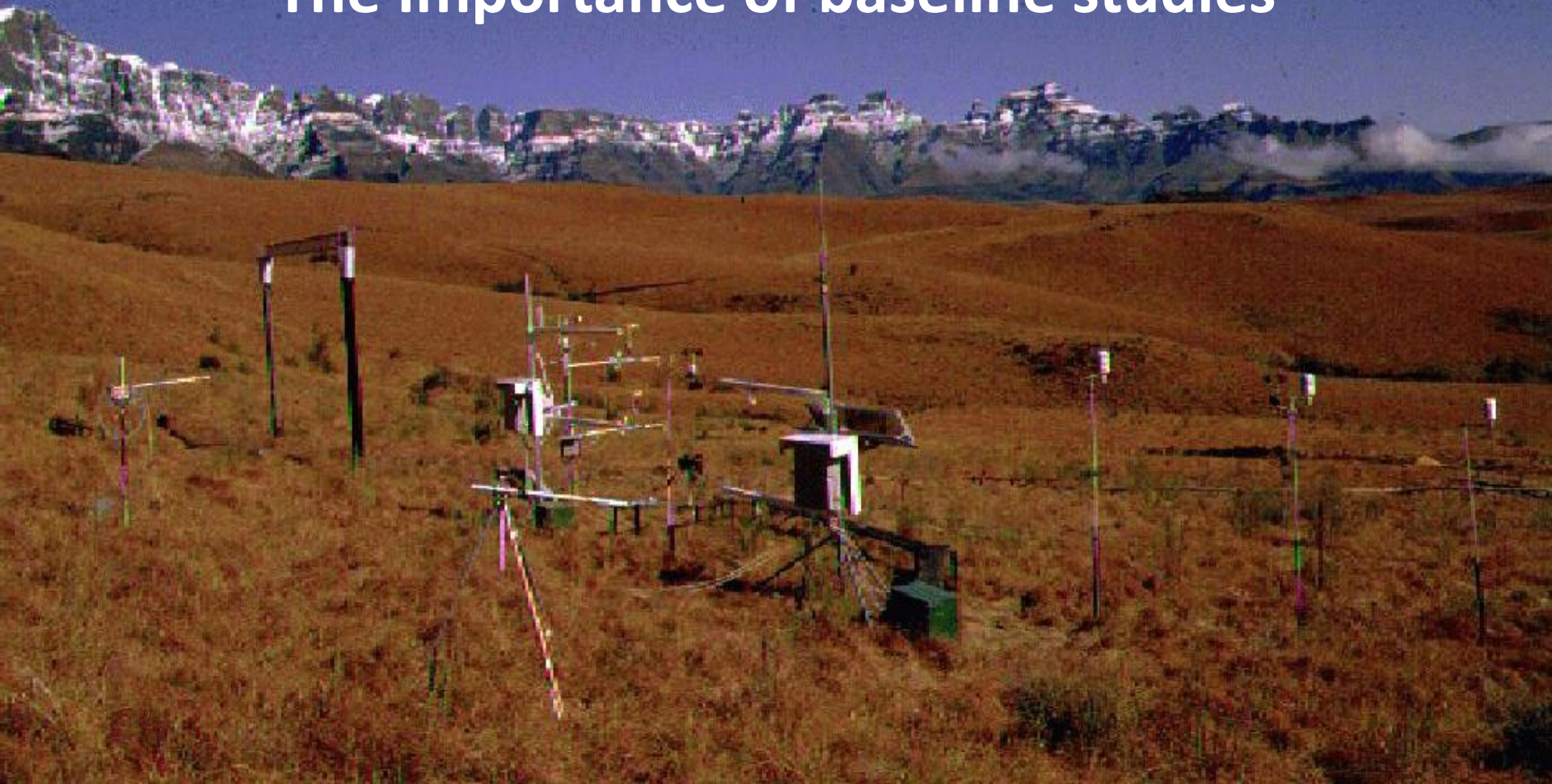
Paired Catchment Research

The objective:

To investigate the influence of different veld management treatments on the vegetation and streamflow.

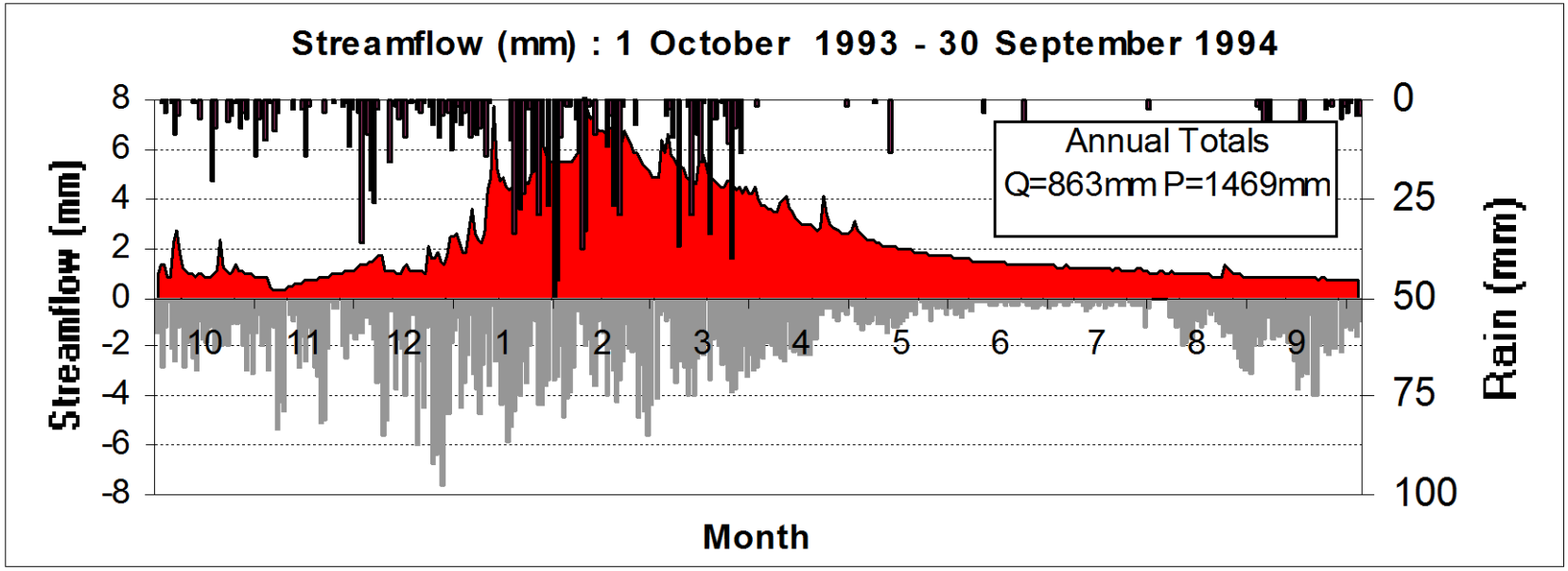
Catchment Water Balance Studies

The Importance of baseline studies



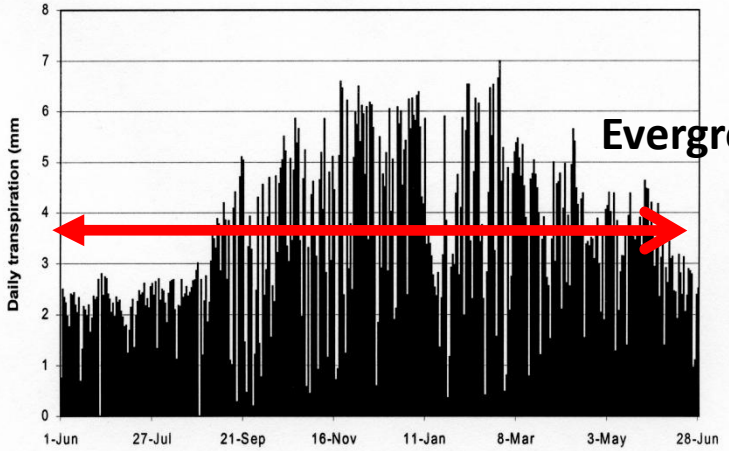
The Grassland Catchment Water Balance

$$\overline{P} - \overline{E_a} = \overline{Q} \quad \text{mm annum}^{-1}$$



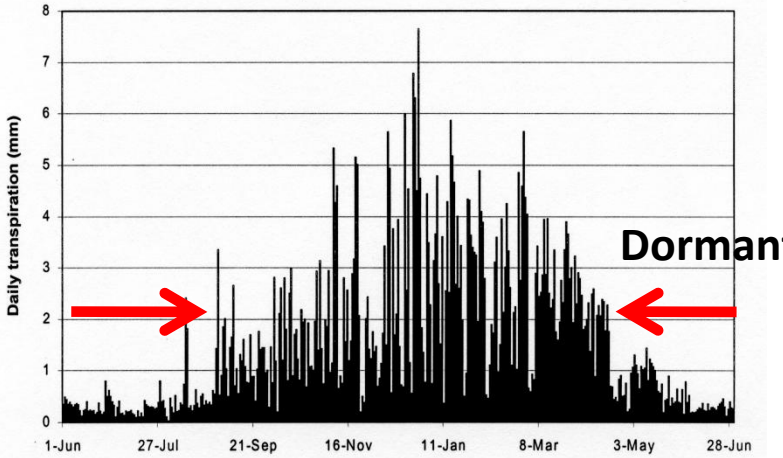
Q
P
E_a

Grasslands vs Eucalyptus trees



Evergreen

Figure 1. The pattern of daily transpiration recorded in a 3-year-old stand of *Eucalyptus grandis* in the Sabie district.



Dormant season

Figure 2. The pattern of daily evapotranspiration recorded above montane grassland in the Cathedral Peak district.




Indigenous Tree Water Use: Background

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- Rainfall higher along eastern seaboard, & in high-lying catchments, favoured for afforestation.
- Limited indigenous timber resources.
- Increasing demands for timber initiated large-scale exotic plantation forestry (replacing grassland & fynbos).
- High water-use necessitated regulation (SFRA) & constrained expansion of forestry.
- **What about indigenous tree species?**
- WRC/WfW project : Water-use and economic value of the biomass of indigenous trees under natural and plantation conditions (2009 – 2015).

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Alternative forestry systems based on indigenous tree species?

Indigenous trees slow growing,

low water use?

Higher WUE?

Economically viable?

- Hardwood value
- Other products (traditional medicine)
- Recreational value

- Ecosystem goods and services

5-yr project (WRC)

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Main objective

Improve knowledge of WU in relation to biomass and compare to commercial forest plantations.

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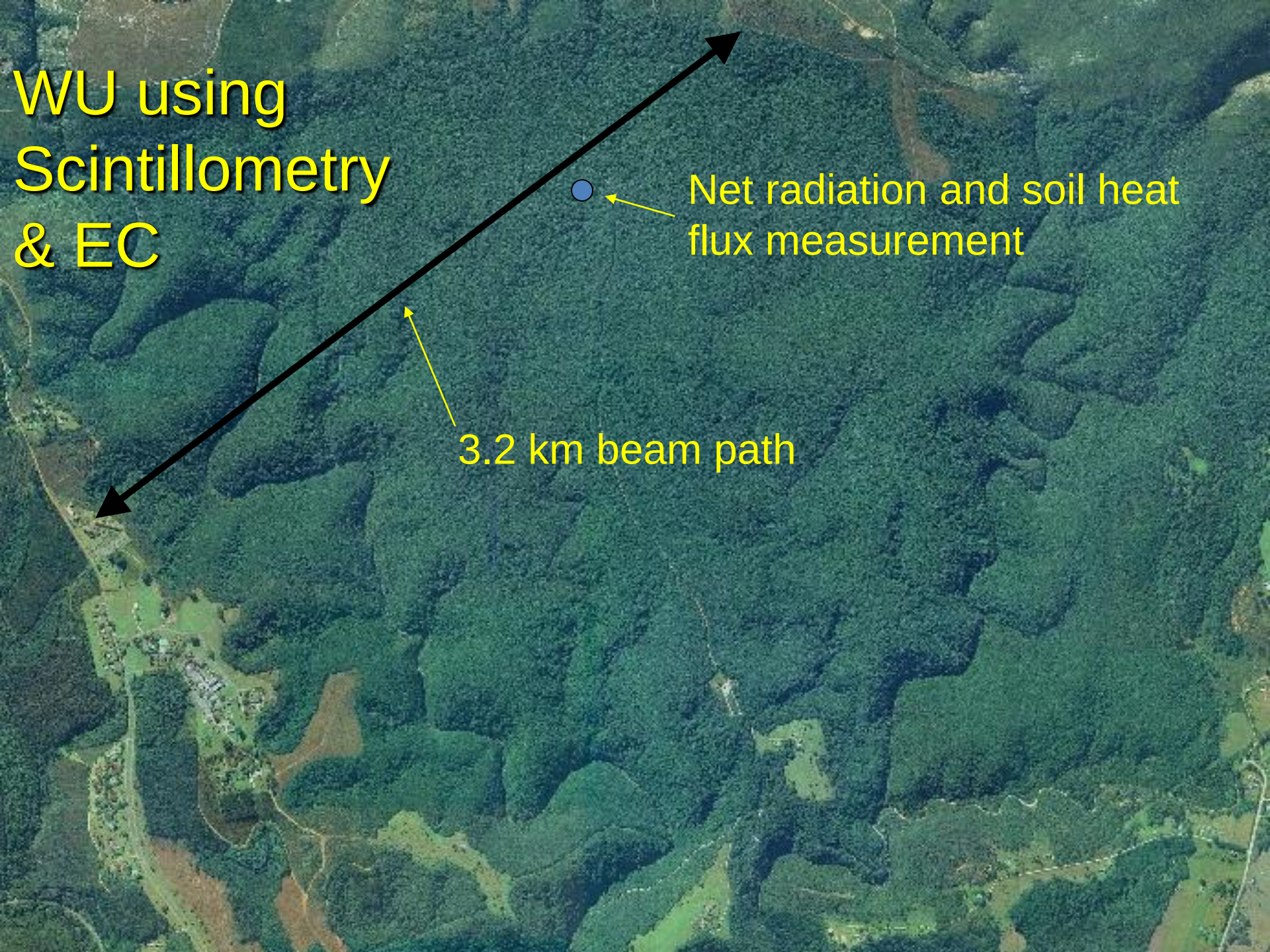
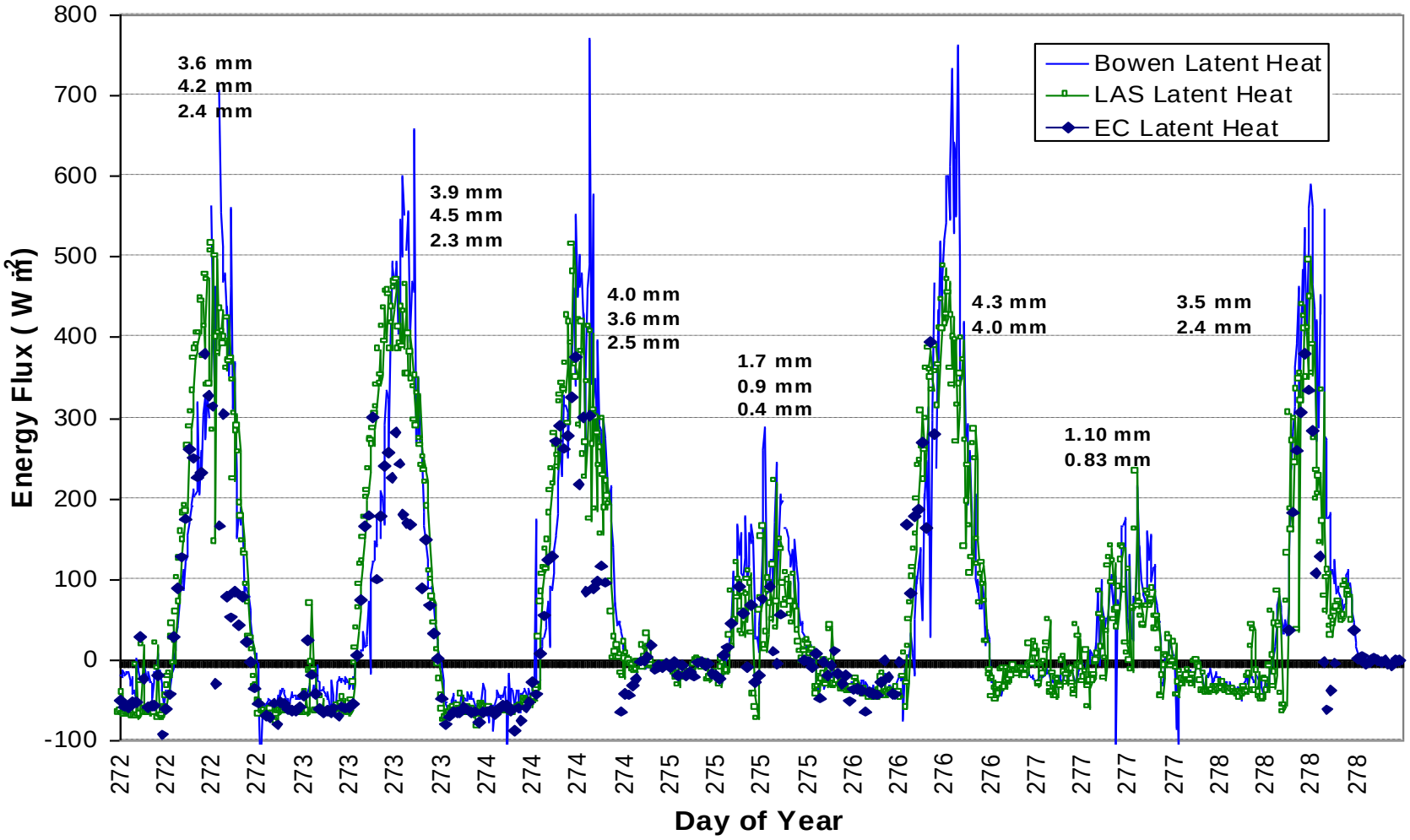
Groenkop forest, southern Cape


WU using Scintillometry & EC
Net radiation and soil heat flux measurement
3.2 km beam path

Water Use Measurements



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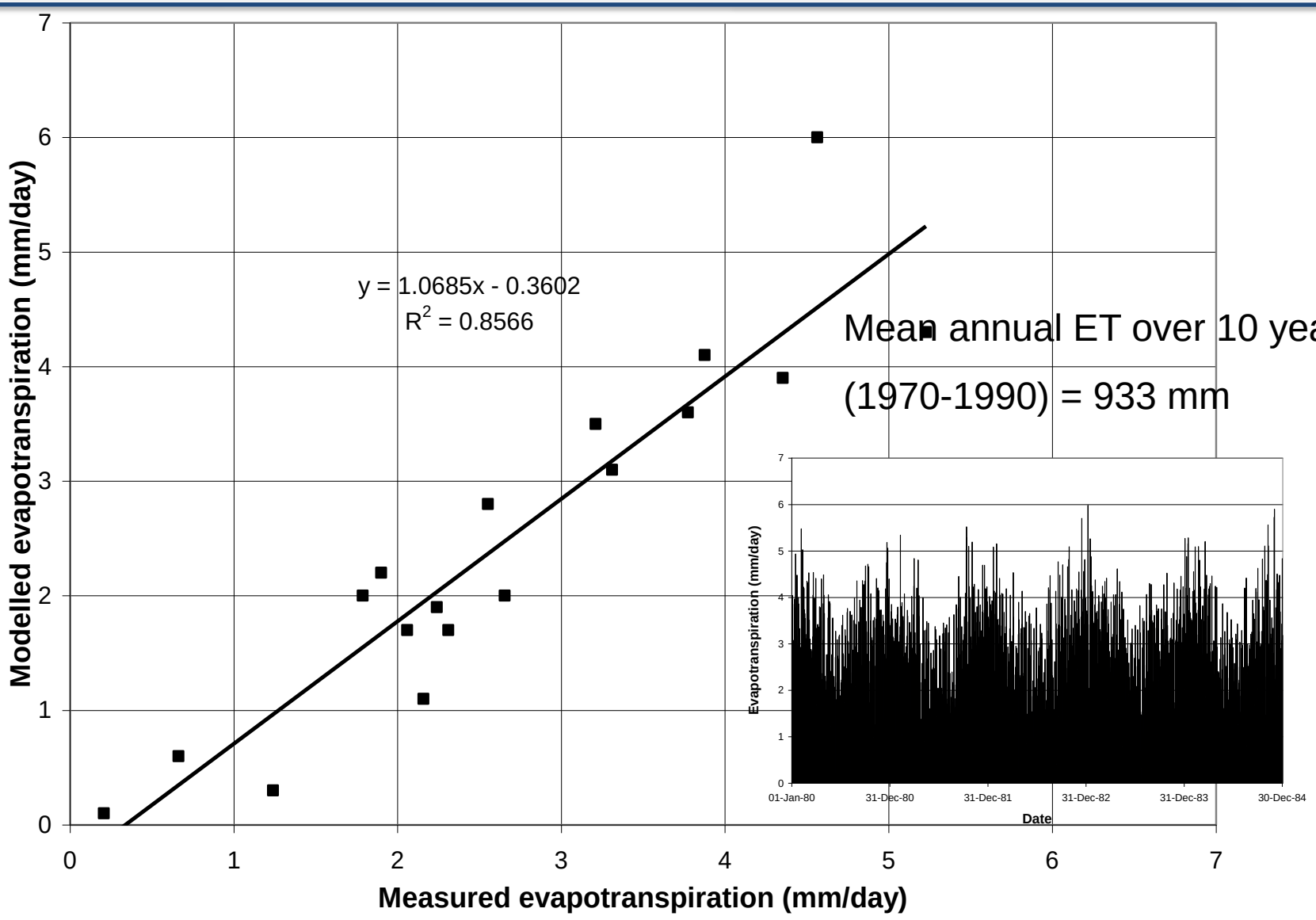
ET modelling



Mean annual ET over 10 years (1970-1990) = 933 mm

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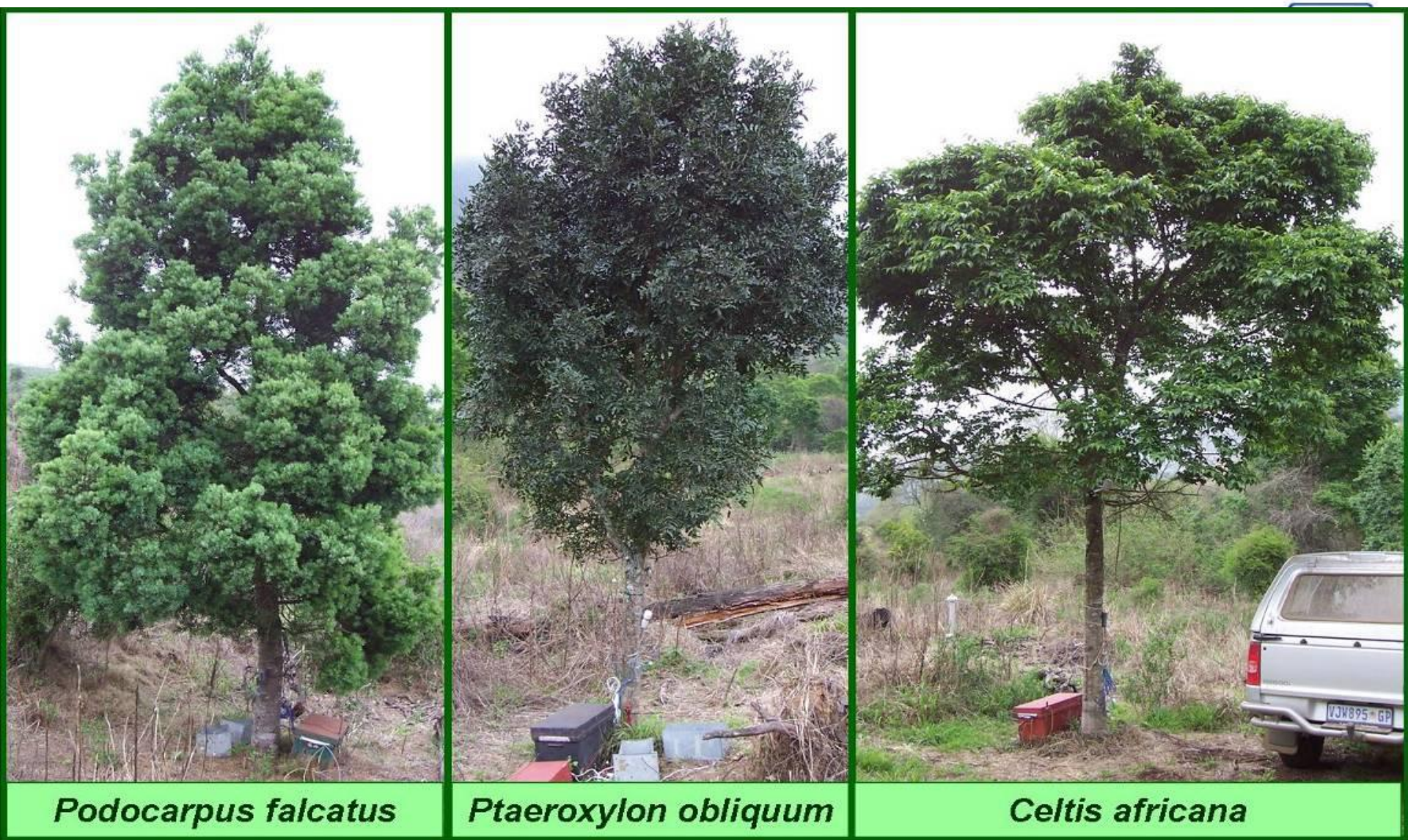
WUE of indigenous species potentially suitable for plantations



WUE of indigenous trees: Results

Compare against data from exotic tree species

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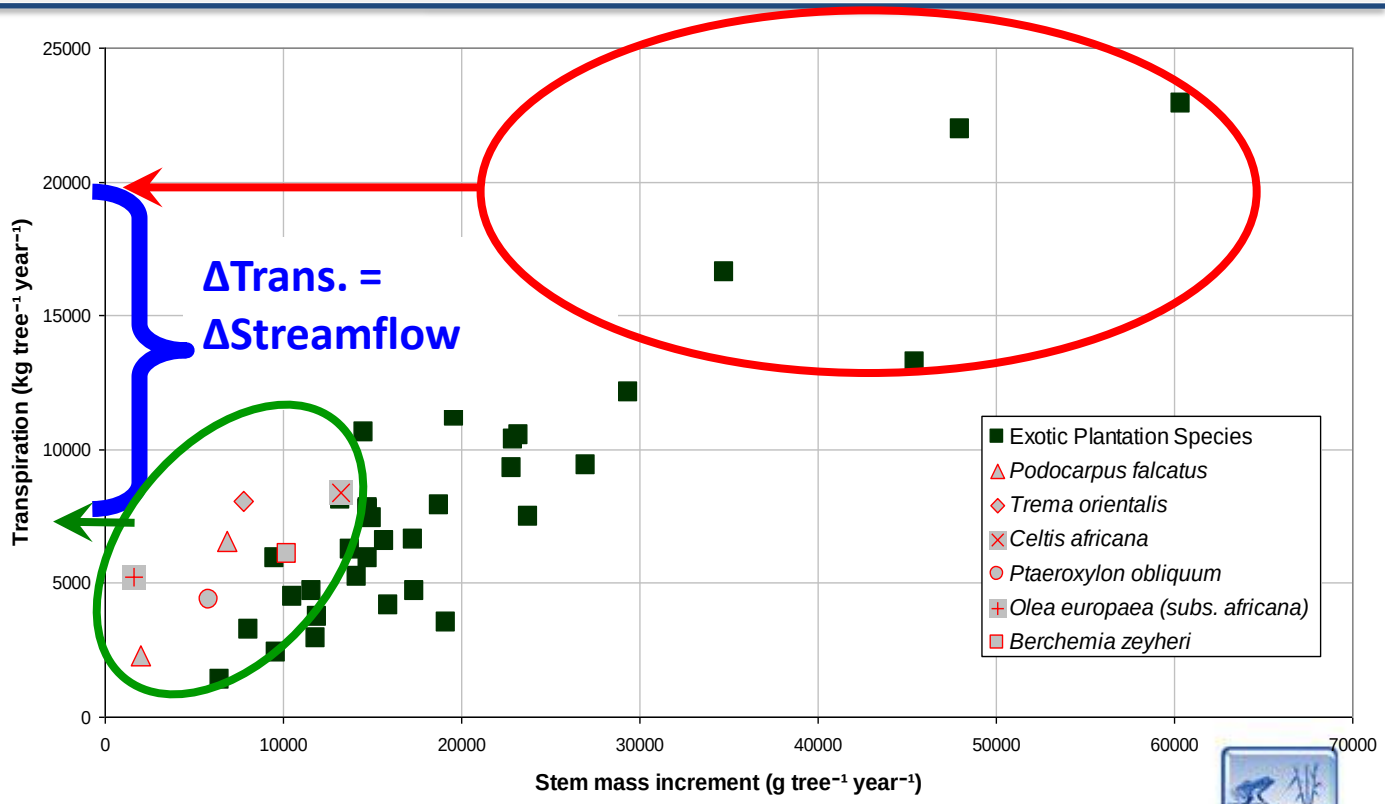

Relative differences in water-use - optimal conditions

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WUE of Indigenous Forests: Conclusions

Low WUE in indigenous forests

- Low ET
- Low growth rate, dominance of mature trees

High profit per unit of water

- High value of wood
- Low management costs

Viable land use option

- only wood considered in this analysis
- non-wood products would increase profitability

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Agroforestry

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Problems: Shortage of Fodder

Shortage of Fuel Wood

Shortage of Land

Shortage of water

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Possible solution – Agroforestry

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Effect of agroforestry species on traditional cropping systems in rural areas.

Phase I and II

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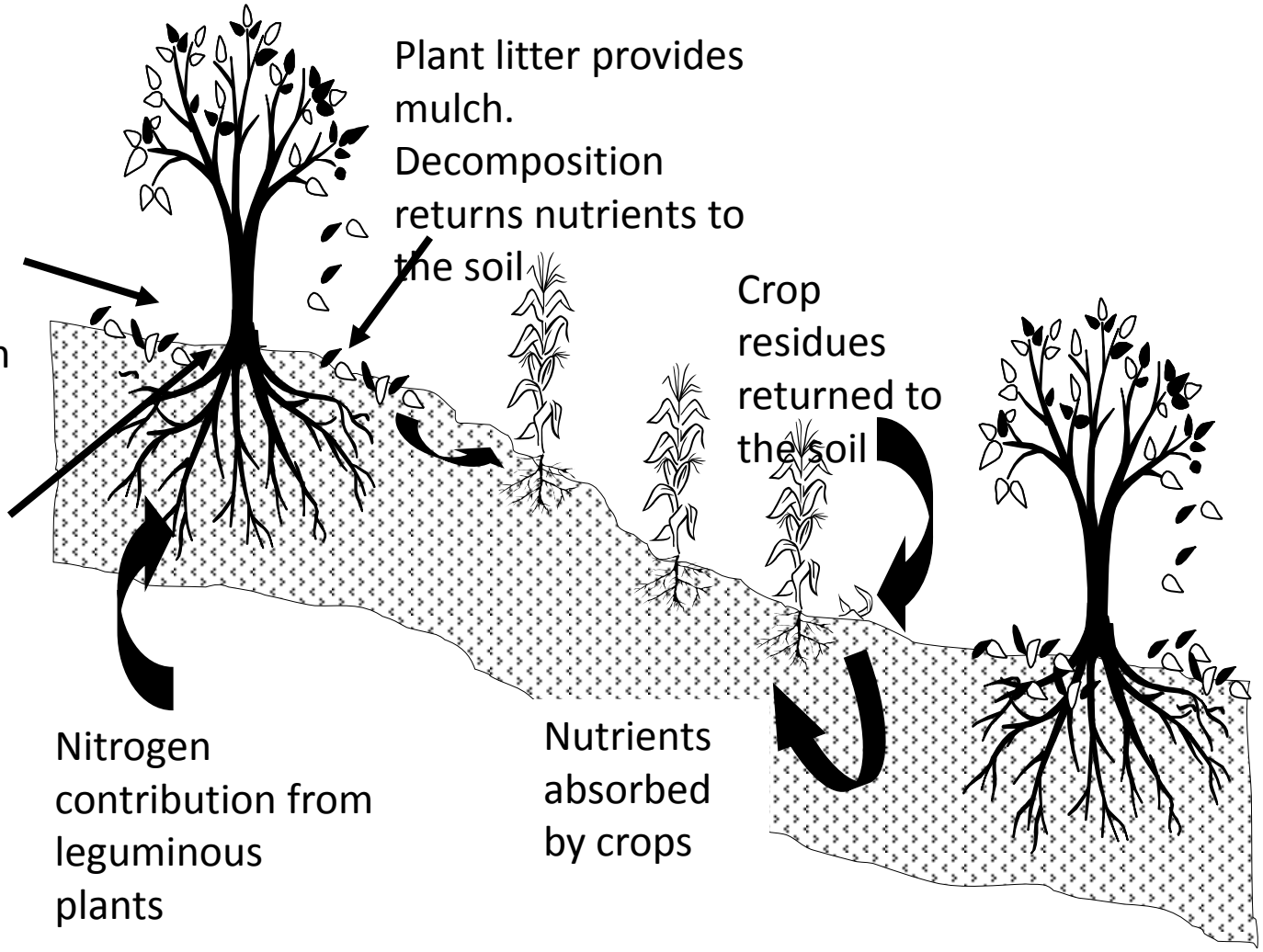
Multiple benefits



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A field assessment of the agronomic performance and water use of *Jatropha curcas* in South Africa

Aim: To measure changes in water-use, growth & yield of a *Jatropha curcas* / kikuyu agro-forestry (silvopastural) system

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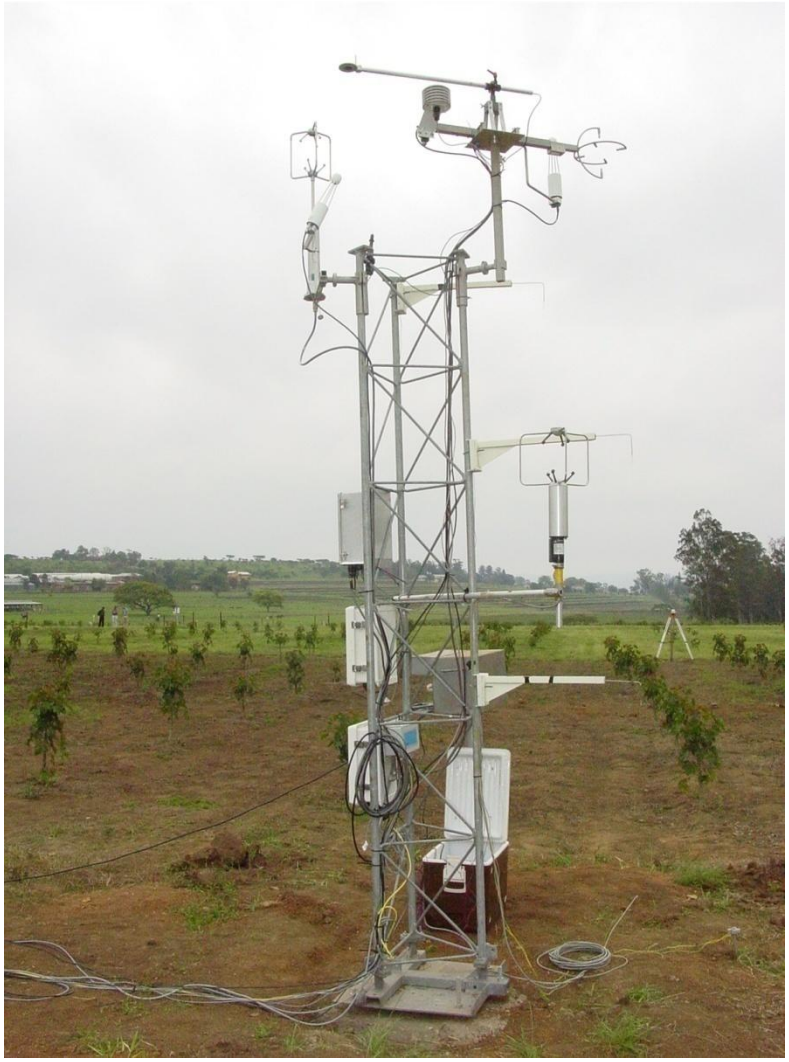
Jatropha grown in a silvopastoral (Kikuyu) agro-forestry system



Ukulinga Research Farm Pmb.

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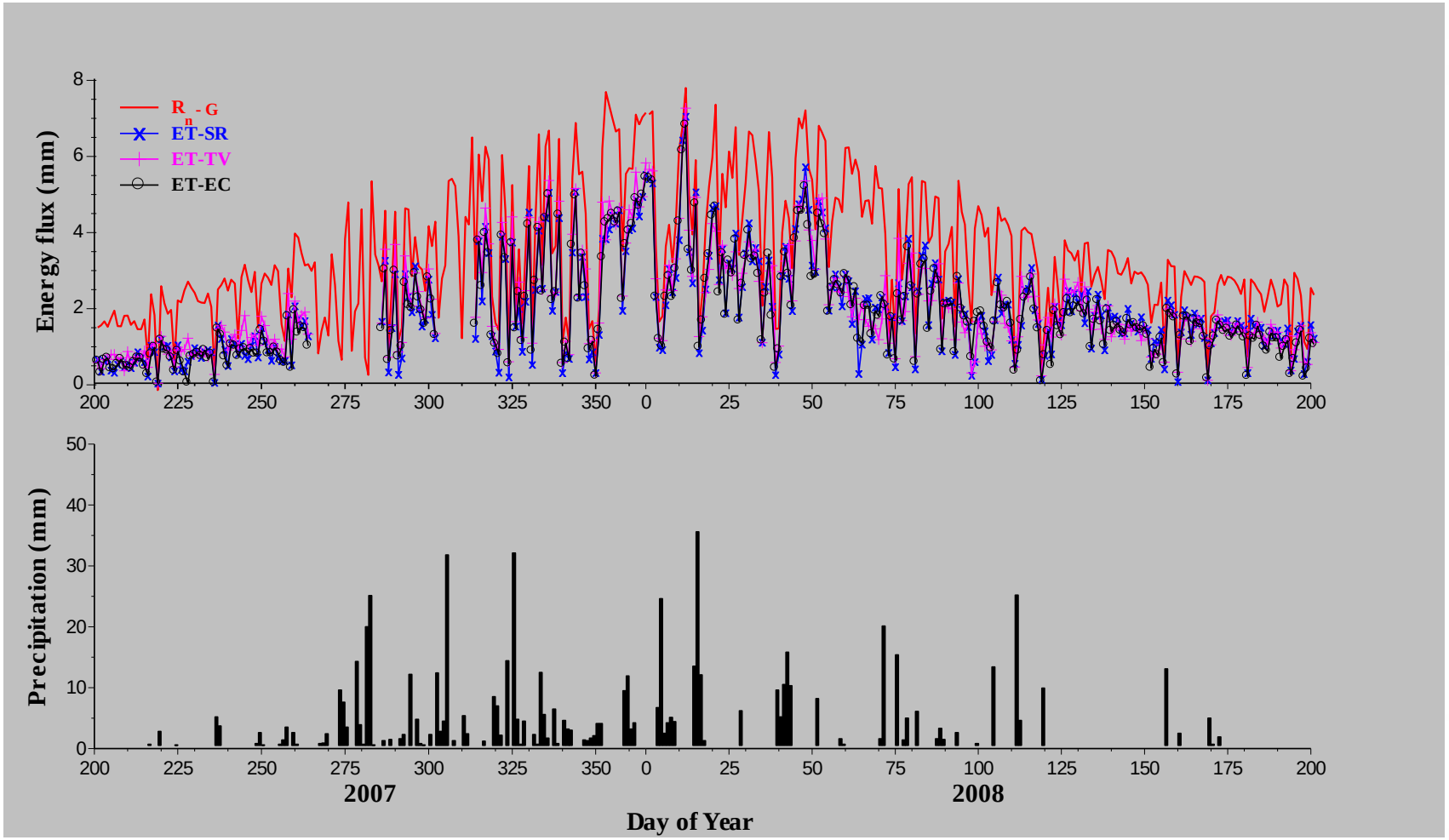
Total evaporation of *Jatropha* curcas in a silvopastoral system



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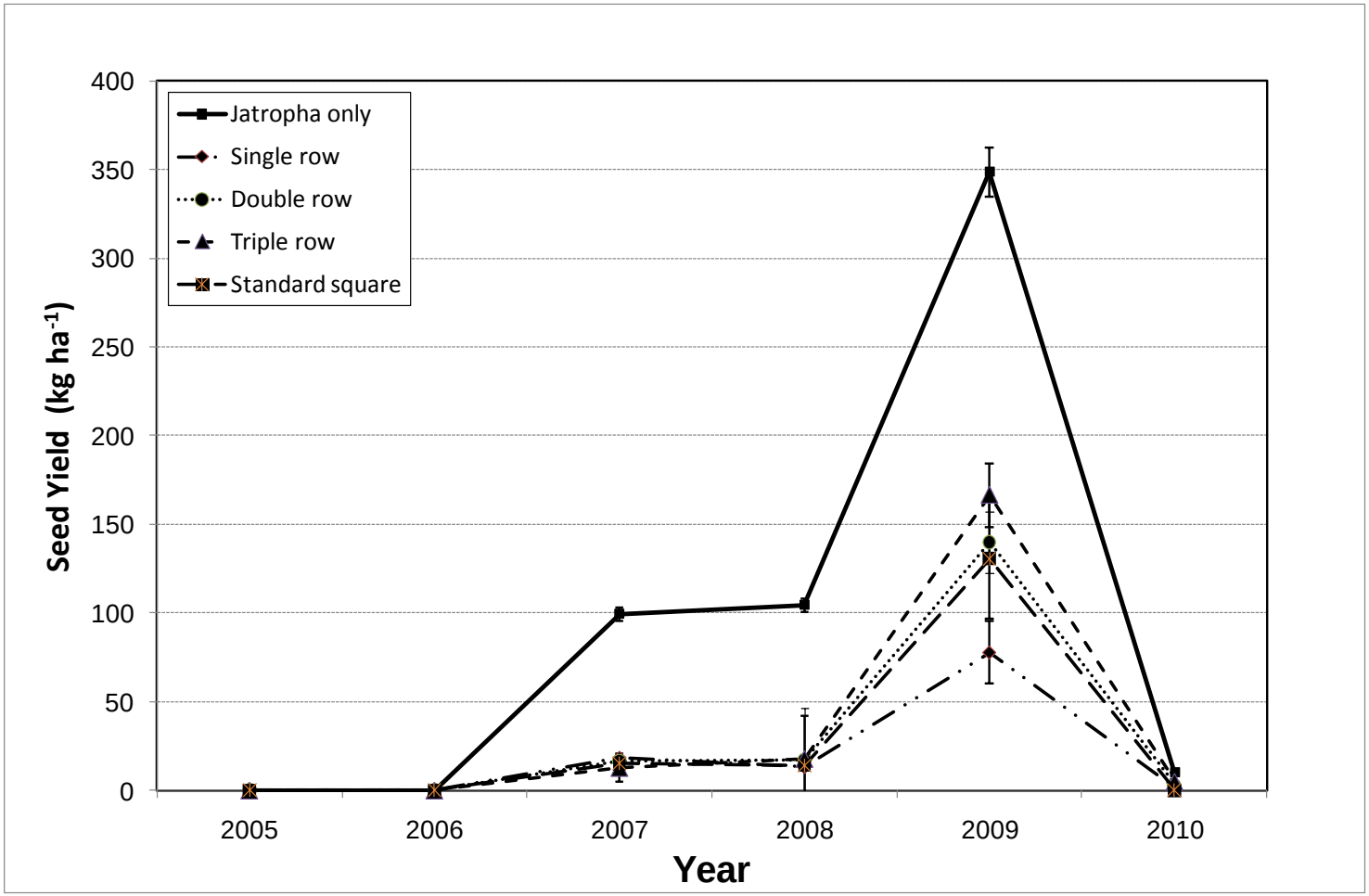
Seed Yield



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Modelling - Spatial Extrapolation

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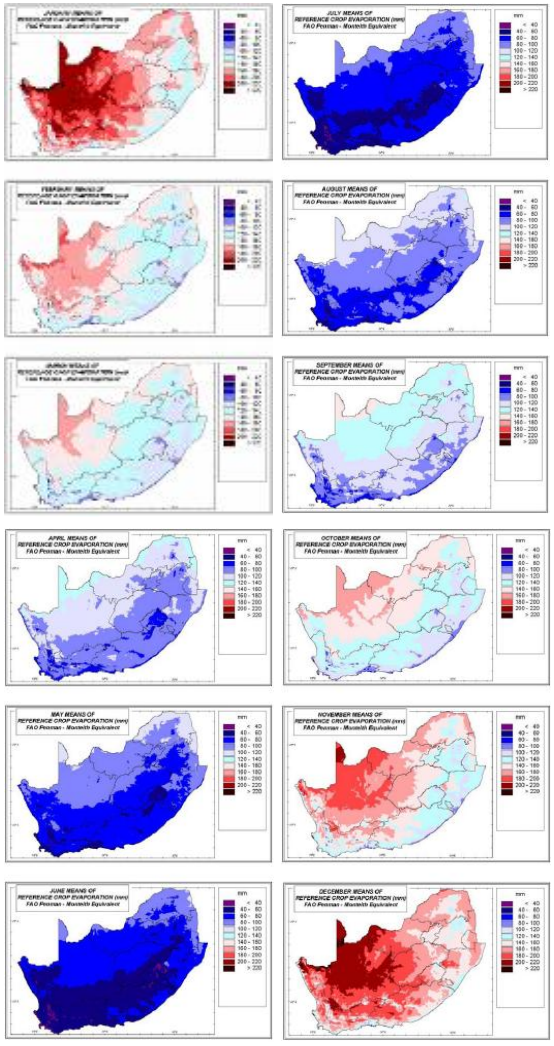
Monthly P-M ET_o



X

K_{cb}	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
OSCA	0.18	0.18	0.26	0.21	0.14	0.06	0.00	0.00	0.00	0.04	0.14	0.15
Makh.	0.55	0.76	0.56	0.47	0.46	0.15	0.00	0.00	0.00	0.00	0.50	0.50

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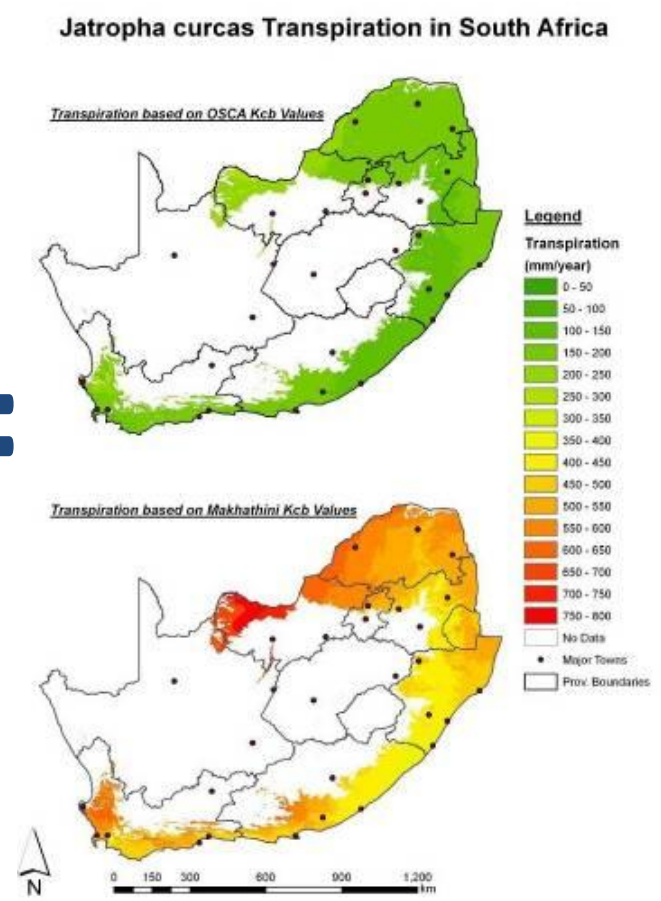

Hallowes, J. 2007. Water use mapping of *Jatropha curcas*.

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General Conclusions

- Dry-land water-use of *Jatropha curcas* is low, **BUT**

- High input costs + low seed production

The wonder of *Jatropha* is a fiction.

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Looking Back

Hydrological **process** studies (field-scale disaggregating)

Paired catchment studies (large scale integrating)

1935: Start of hydrological research in SA
Establishment of long-term paired catchment studies
Assess afforestation (later also agriculture) on streamflow

1970-1997: Tools to estimate impact of afforestation on streamflow
Nänni curves (Nänni, 1970)
Van der Zel curves (Van der Zel, 1990)

1990: Evaporative losses using micrometeorological techniques

CSIR curves (Scott and Smith, 1997)
Gush tables (Gush et al., 2002) informed by evaporation research

Mid 1990's: Process studies assessing full hydrological water balance,
Focus: Evaporation

Early 2000: Introduction of scintillometry
~2004: Remote sensing based techniques

1932: Discontinuing afforestation within 20m of riparian zone
1969: Soil Conservation act
1972: Afforestation Permit System (APS) under Forestry Act of 1968

Green water concept (Falkenmark, 1995)

1998: National Water Act of South Africa
1999: Streamflow reduction activities licensing

Integrated Land and Water Resources Management

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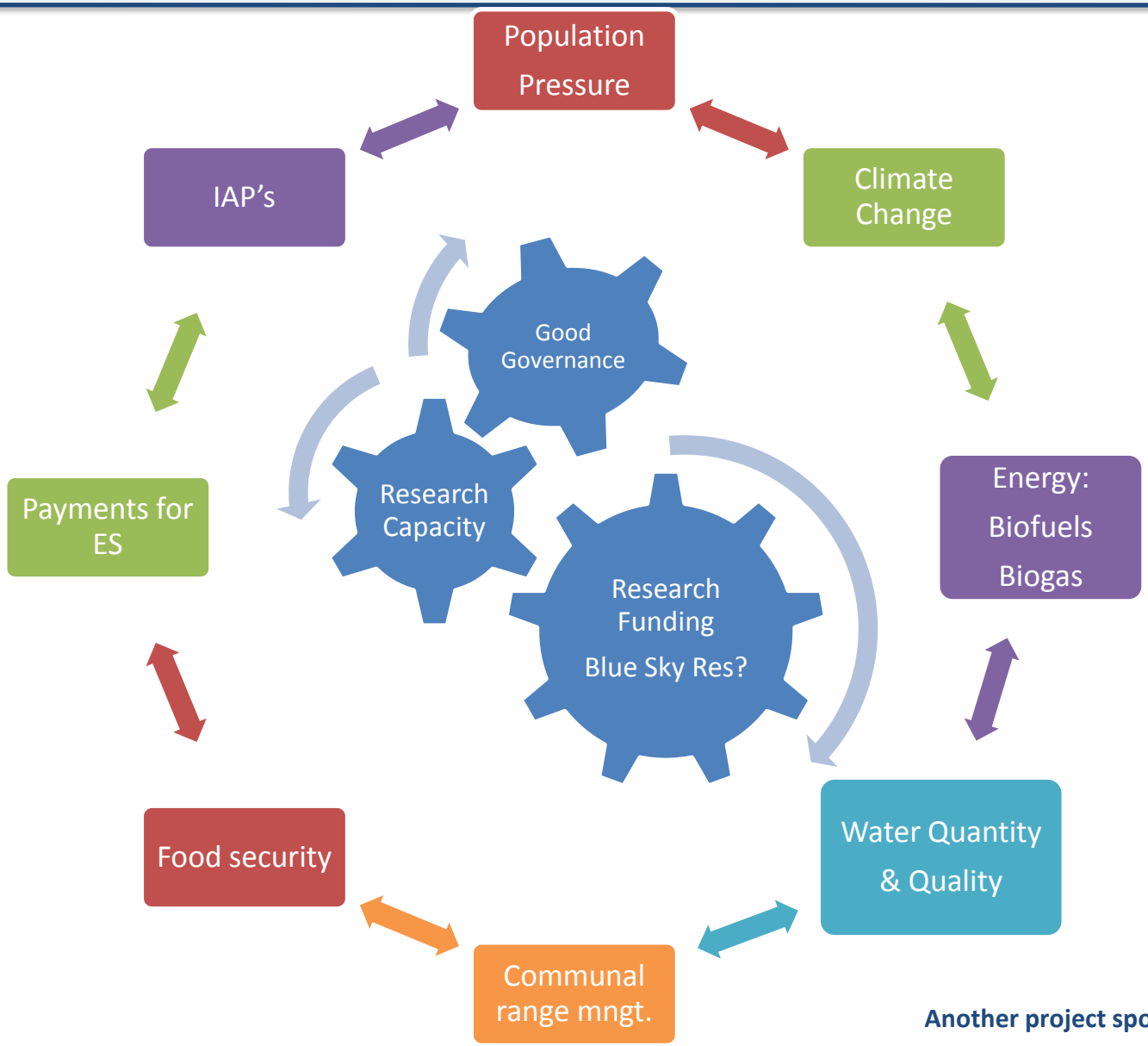
Challenges for the next 40 years



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