Temporal variability in Alice Springs Mulga:
Influence of extreme precipitation on carbon source–sink strength

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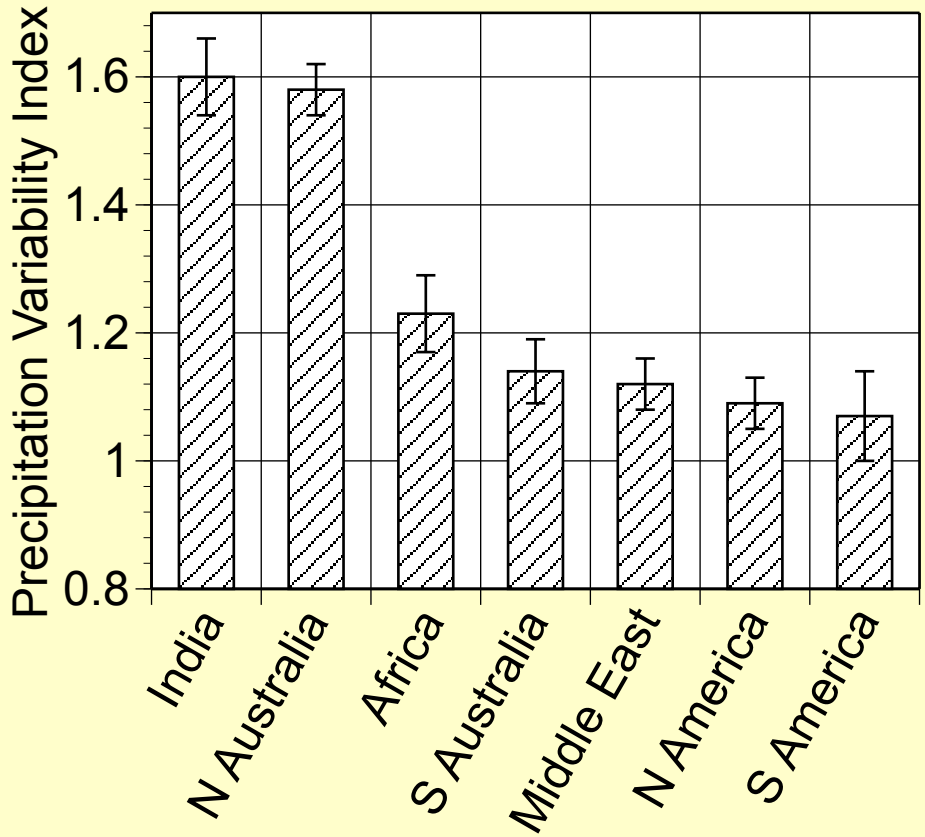
Australian and New Zealand Flux Research and Monitoring Network (OzFlux)
Terrestrial Ecosystem Research Network (TERN)

UTS:
Terrestrial Ecohydrology Research Group (TERG)
Plant Functional Biology and Climate Change Cluster (C3)
School of the Environment (SoE)

Research Questions
Alice Springs Mulga

- ***How does precipitation variability affect ecosystem assimilation and respiration in semi-arid mulga?***
- ***What is the evapotranspiration cost of assimilation?***
- ***How is ecosystem metabolism partitioned between the mulga canopy and grassy understory?***

- ***Funding: Terrestrial Ecosystem Research Network (TERN)***



redrawn from Van Etten 2009

Four Topics

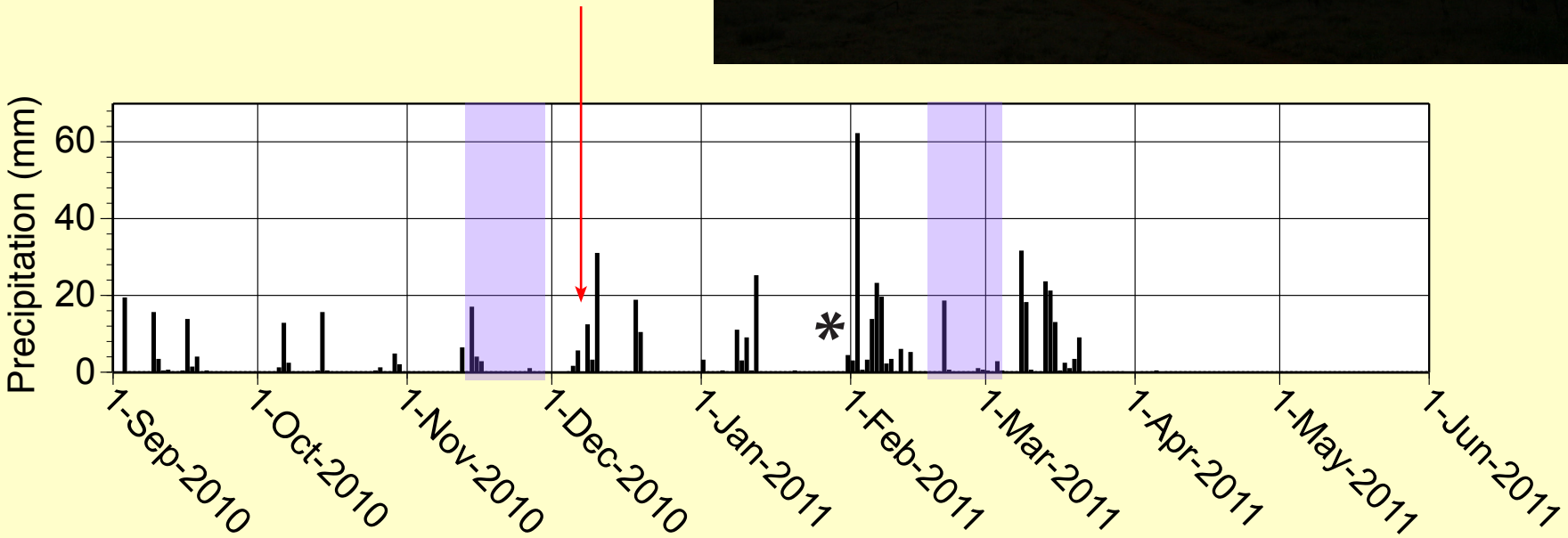
Responses to precipitation pulses

- *Leaf Light Response*
- *Soil moisture*
- *Fluxes — springtime*
- *Fluxes — summertime*

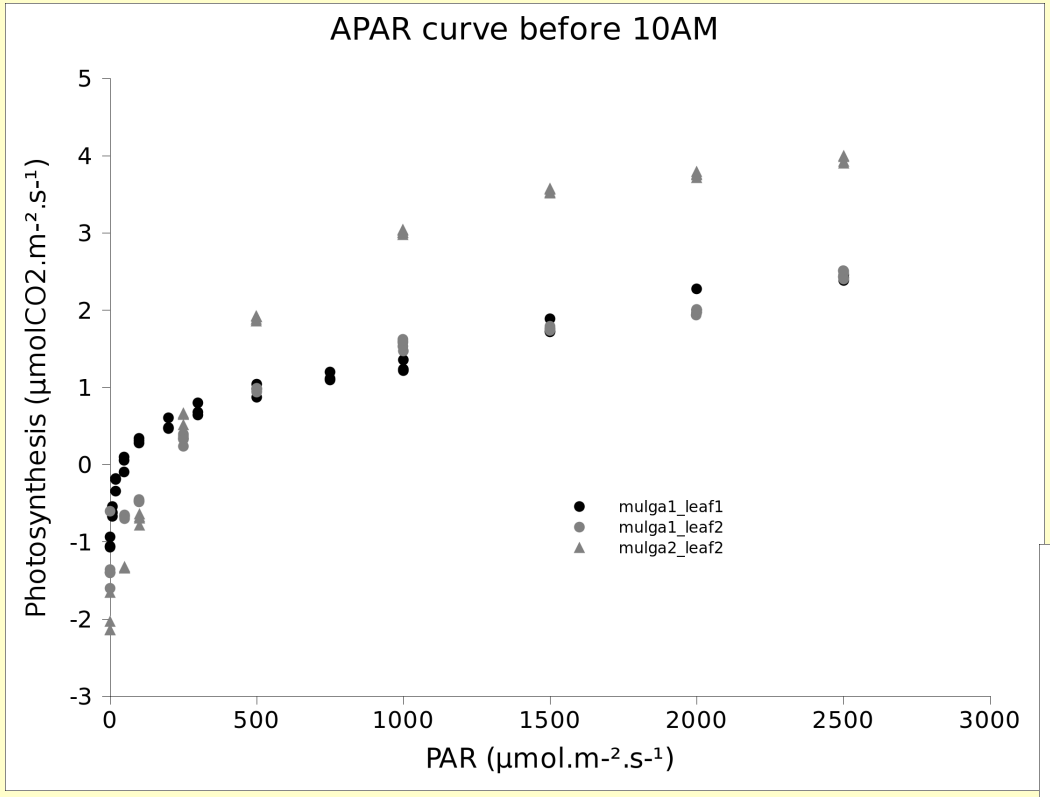
Heavy Rainfall

Sep 2010 — Mar 2011

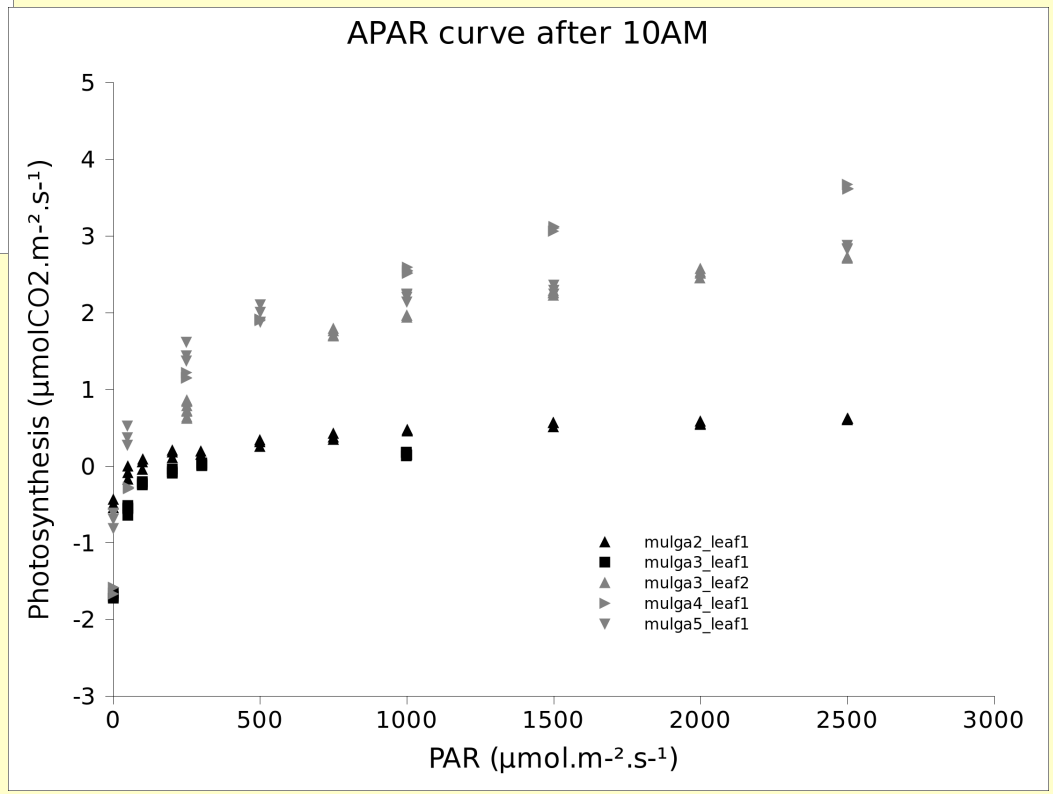
- *549 mm in 203 days (Sep – Mar)*
- *Total: 549.2 mm*
- *Days: 267 (Sep – May)*
- *Max daily total: 62 mm*
- *Max 30-min total: 38.2 mm*
- *Waves of wet & dry periods*



December Precipitation Pulse
Summer Leaf Physiology



- ***Black symbols: preceding 12 mm rainfall, grey symbols following***
- ***Midday xylem Ψ ranged from –5.2 MPa to –7.5 MPa***
- ***Late afternoon xylem Ψ ranged from –3.4 MPa to –5.2 MPa***



- ***Pre-rainfall (dry soil), photosynethtic capacity at full-light was limited, especially at midday***
- ***Midday autotrophic respiration 1.75 pre- and post-rainfall***
- ***Morning R_a higher post- than pre-rainfall***

Carbon partitioning

Nocturnal extrapolation v Diurnal light response curve

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Separation of net ecosystem exchange into assimilation and respiration using a light response curve approach: critical issues and global evaluation

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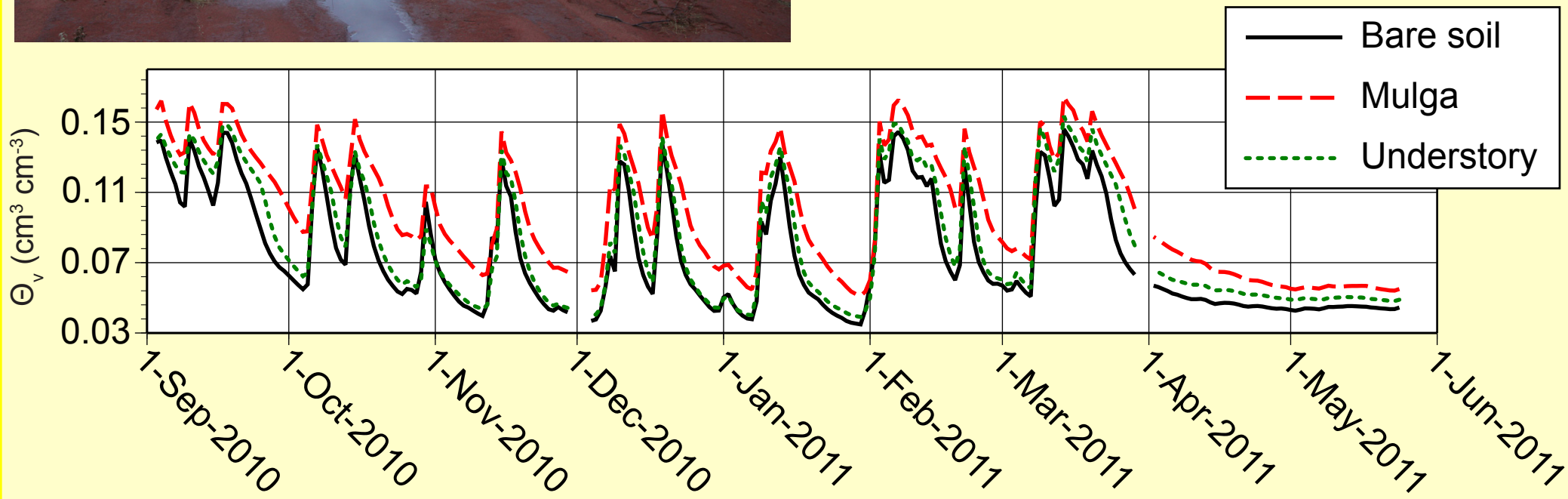
- ***Hyperbolic light response curve (Falge et al. 2001):***

$$\mathrm{NEE} = \frac{\alpha\beta\mathrm{R}_g}{\alpha\mathrm{R}_g + \beta} + \gamma$$

- ***Avoid extrapolation of nocturnal fluxes into diurnal respiration***
- ***Vapour pressure deficit: constrain GPP due to stomatal response to drought***
- ***Temperature: constrain R_e***
- ***R_a = 1.75 µmol (m^{-2} LA) s^{-1} @ LAI = 0.6 = 1.05 µmol (m^{-2} GA) s^{-1}***
- ***$R_{e\text{-}lrc}$ = 0.94 µmol m^{-2} s^{-1}; Δ = 0.11 µmol m^{-2} s^{-1}***
- ***$R_e = R_h + R_a$; Within-canopy recycling?***

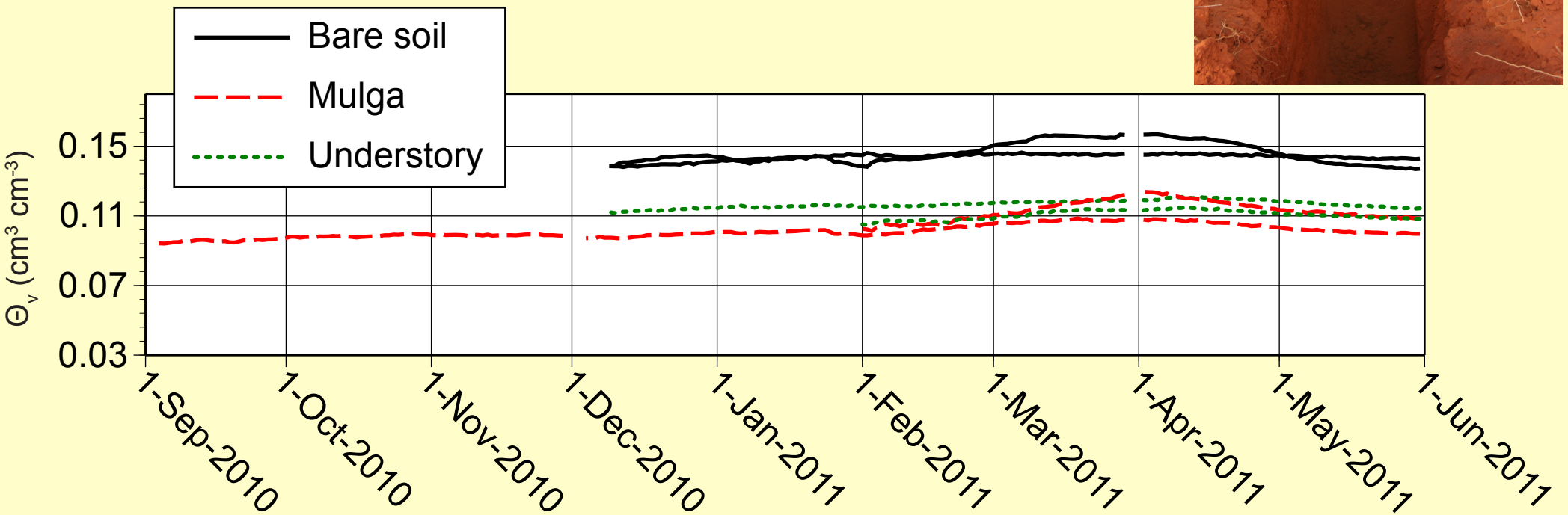
Soil Water Content
Surface

- *Rapid wetting and drying responses*
- *Soil wettest under mulga*
- *Driest in bare soil during inter-rain periods*

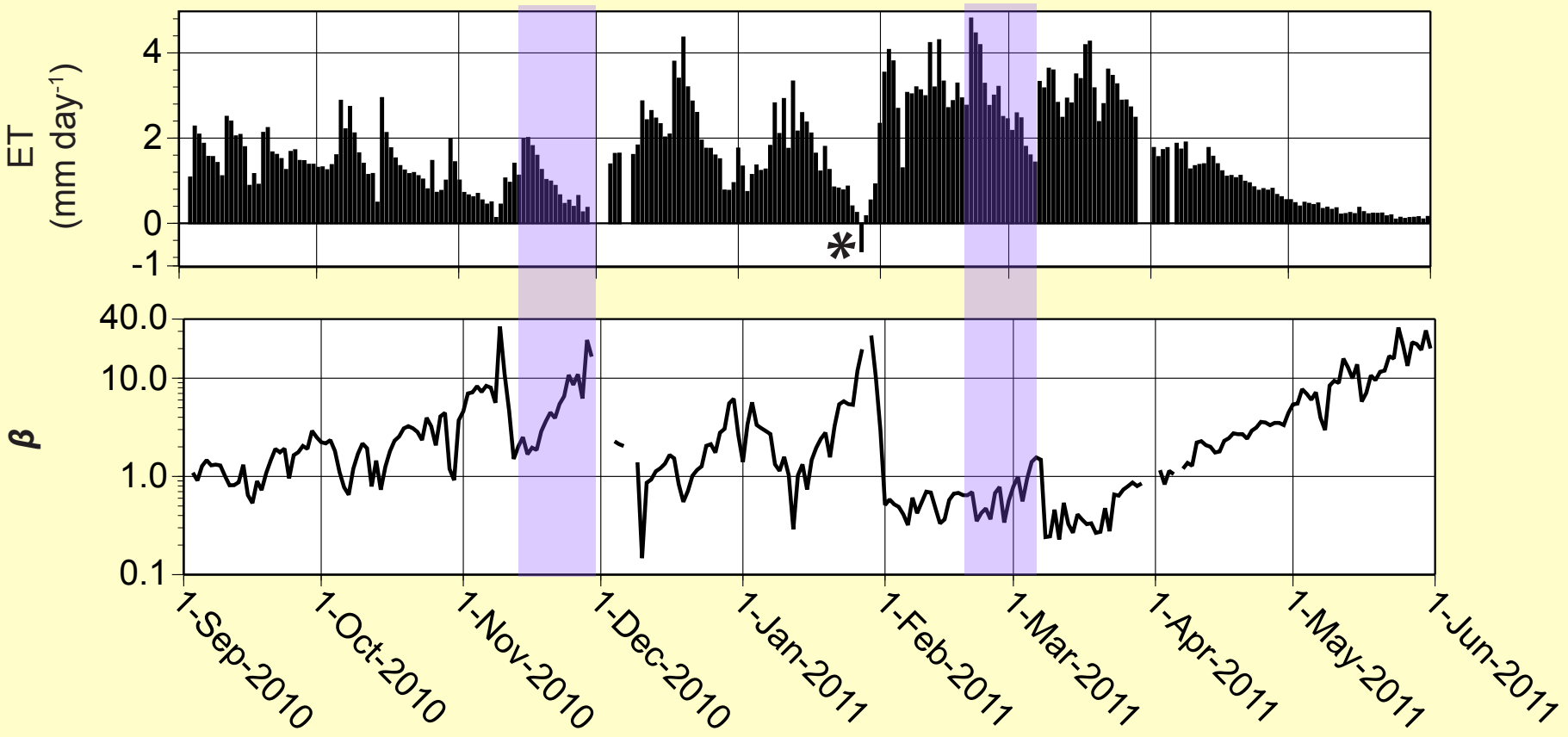


Soil Water Content
100-120 cm

- ***Minimal wetting and drying responses***
- ***Wettest in bare soil***
- ***Driest under mulga, increasing only following extreme precipitation***



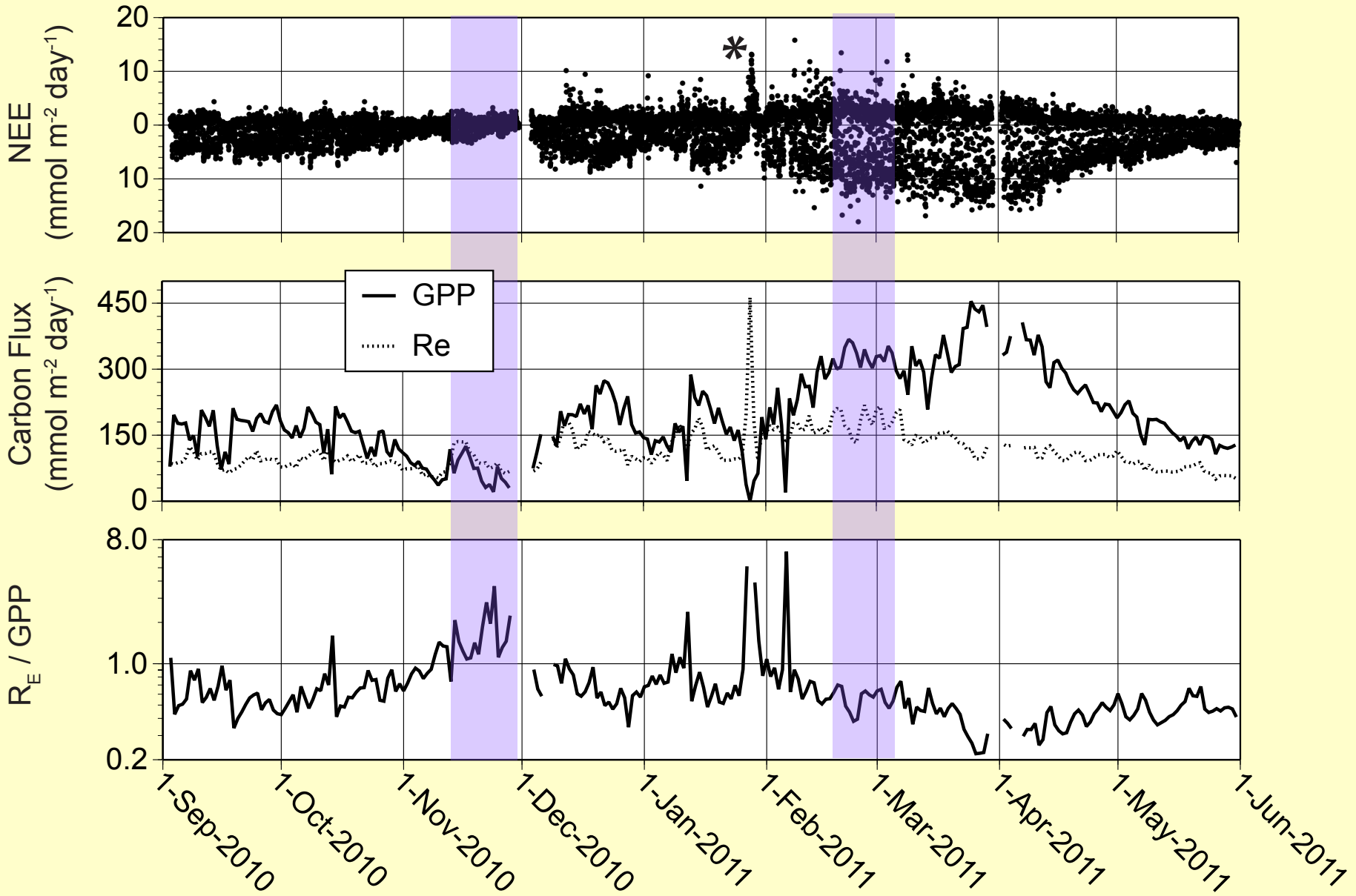
Water Fluxes
β & ET



- ***Evaluate carbon and water responses to precipitation pulses in November and February–March, constrasting:***
  - ***ET***
  - ***β***
  - ***R_E & GPP***
  - ***R_E / GPP***

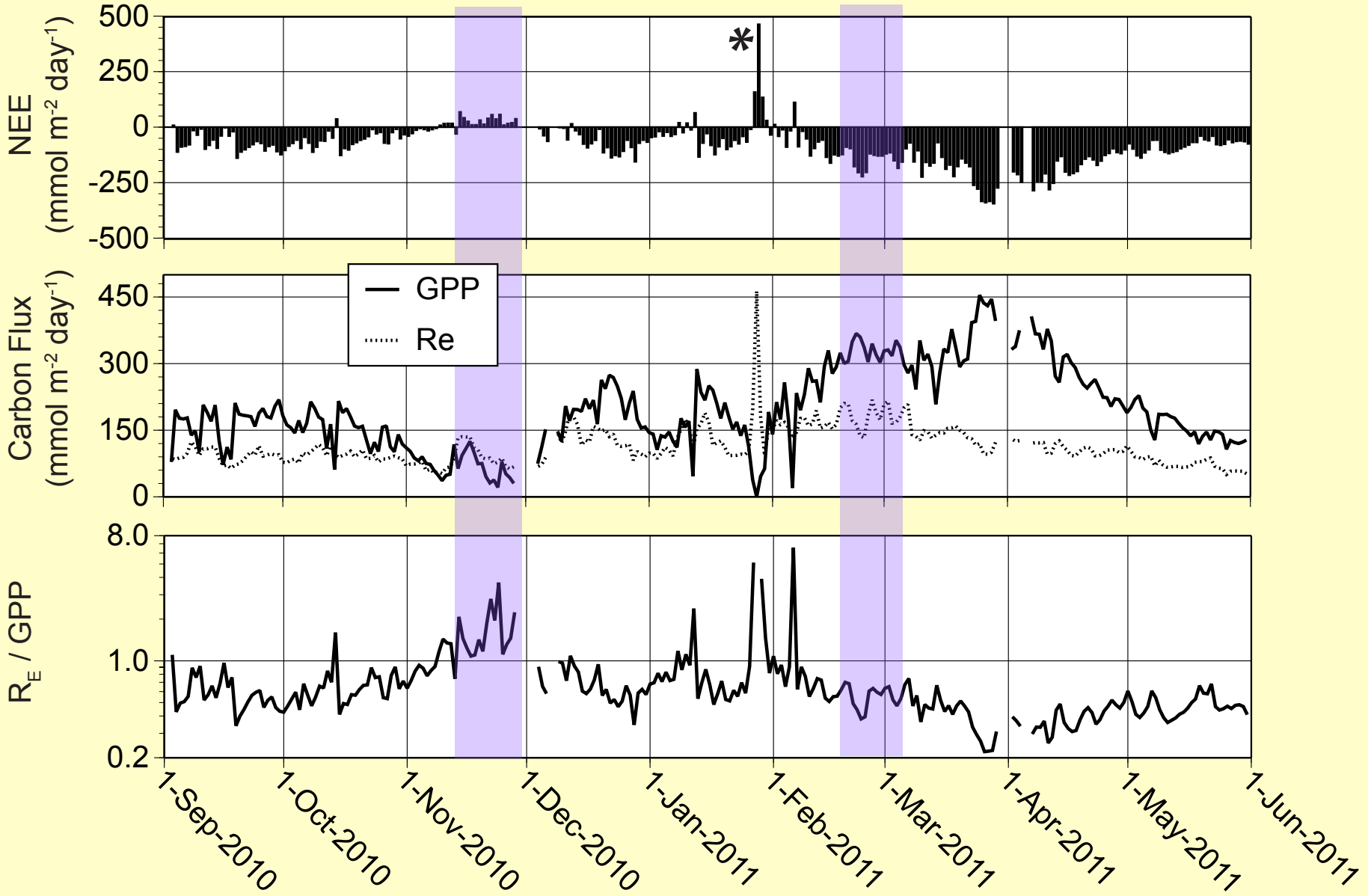
Carbon Fluxes

F_c, R_e & GPP



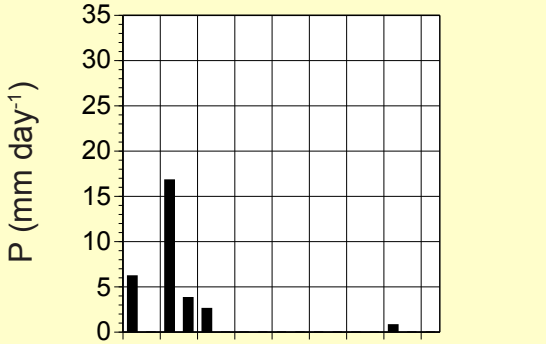
Carbon Fluxes

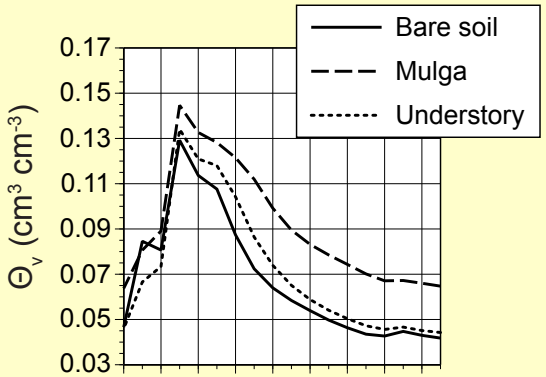
NEE, R_e & GPP

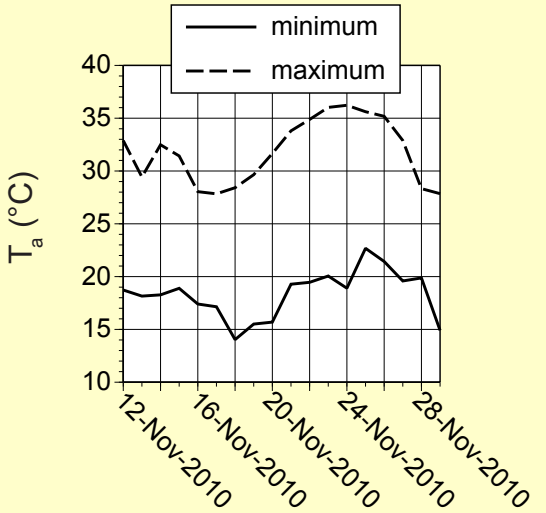


November Precipitation Pulse

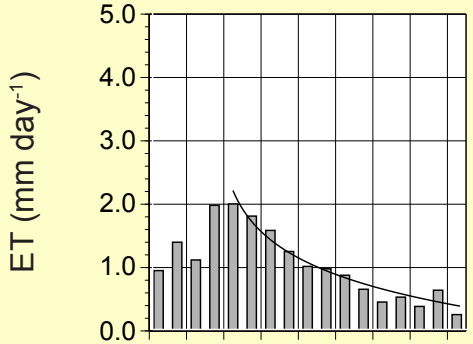
Low ET, GPP & R_E — High β & R_E / GPP

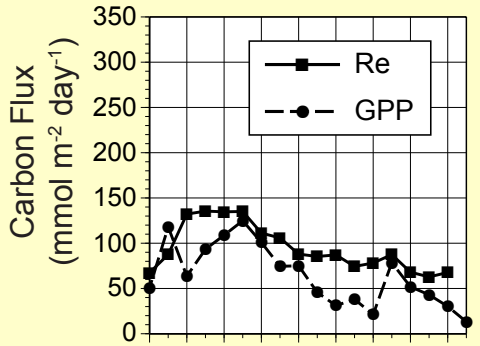


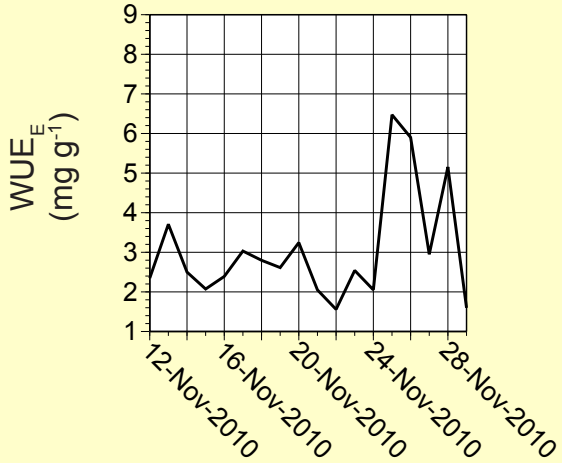




- $ET = -0.71 \ln(t) + 2.2$
- $ET_{½} = 1.00$ mm; $t_{½} = 4.36$ days
- $\Theta_{v½} = 0.068$; $t_{½} = 7.53$ days
- Plateau R_E during rainfall, declining linearly thereafter
- Peak GPP 1-2 days following rainfall, declining linearly afterward
- Maximised WUE_E on 9th day following peak ET, coinciding with maximal temperature

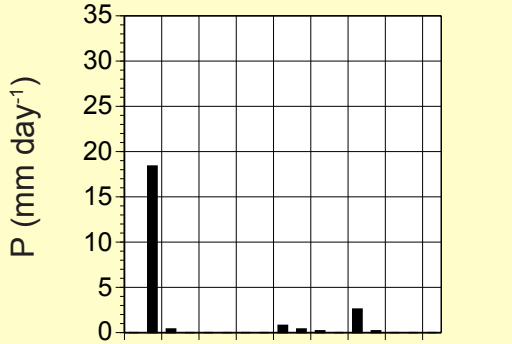


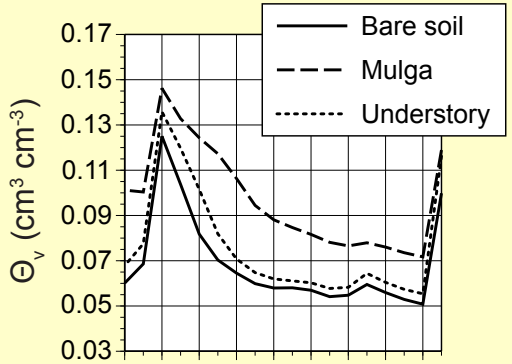


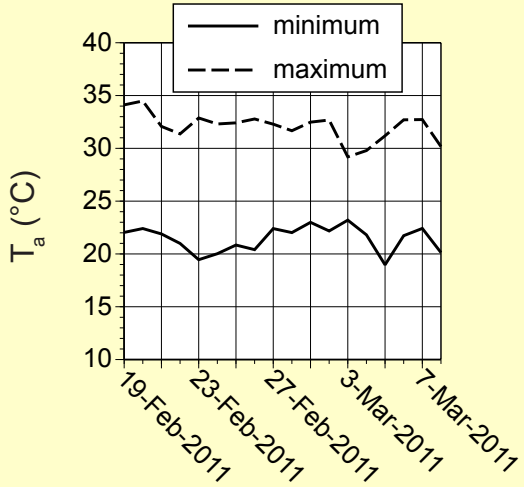


February Precipitation Pulse

High ET, GPP & R_E — Low β & R_E / GPP

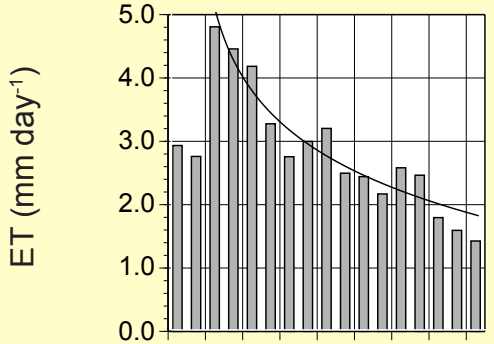


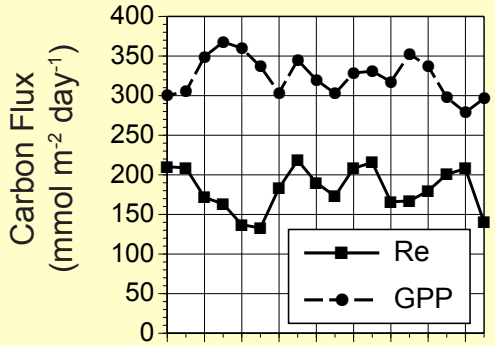


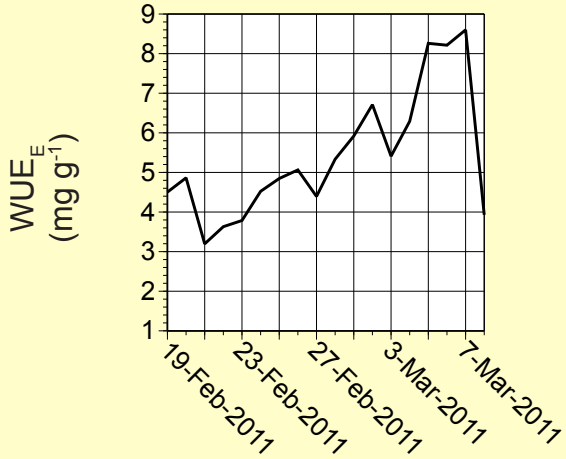


- $ET = -1.23\ ln(t) + 5.13$
- $ET_{½} = 2.40$ mm; $t_{½} = 8.19$ days
- $\Theta_{v½} = 0.068$; $t_{½} = 8.64$ days
- Cyclic fluctuations in carbon fluxes, R_E and GPP a-phasic
- WUE_E increases exponentially following rainfall untill peaking above 8 mg g^{-1} on the 12th day

- WUE_E higher during summer than during springtime
- ET declined more slowly during the summer than spring

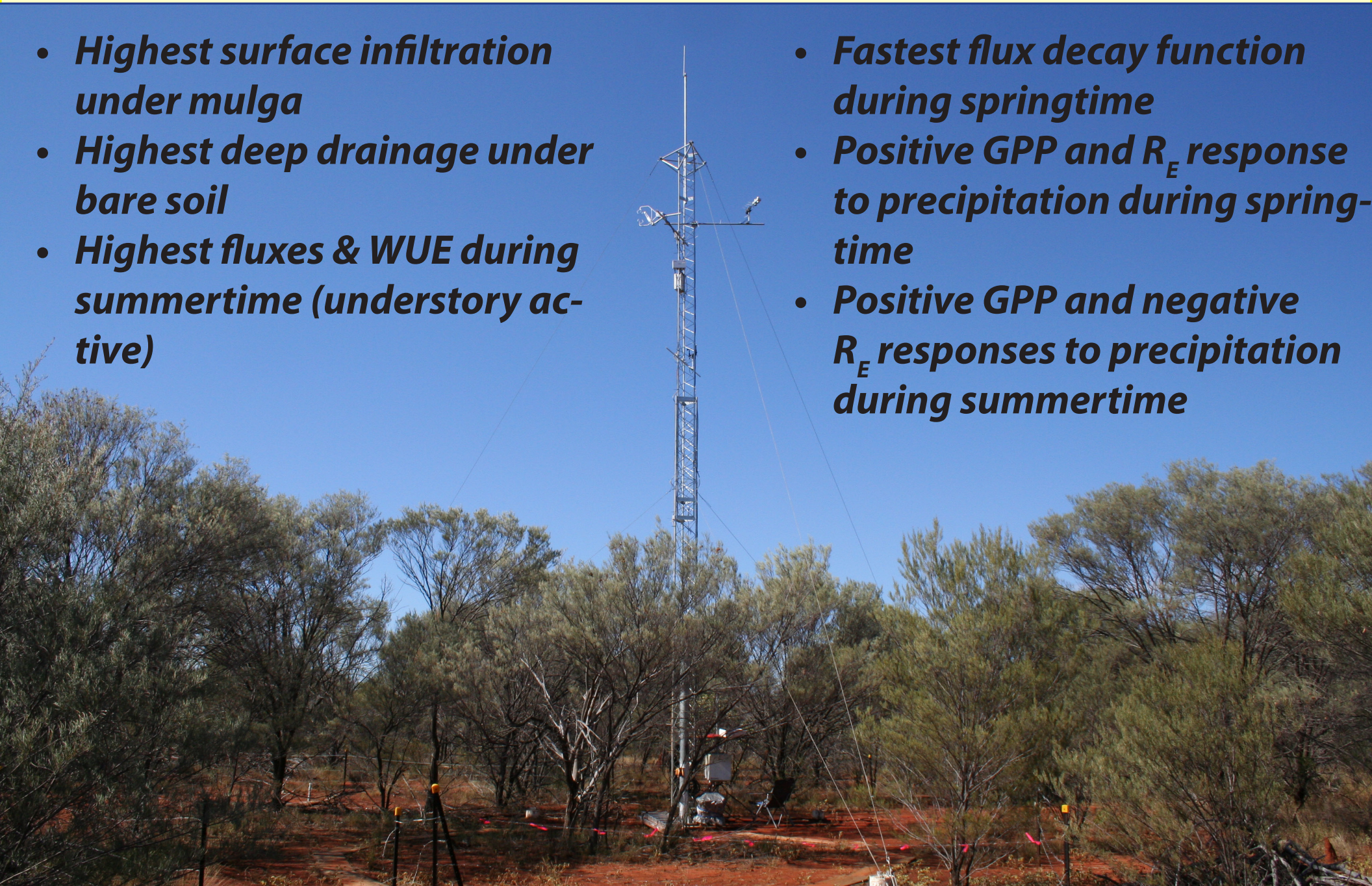






Conclusions

- *Highest surface infiltration under mulga*
- *Highest deep drainage under bare soil*
- *Highest fluxes & WUE during summertime (understory active)*
- *Fastest flux decay function during springtime*
- *Positive GPP and R_E response to precipitation during springtime*
- *Positive GPP and negative R_E responses to precipitation during summertime*



Thank you

Questions?