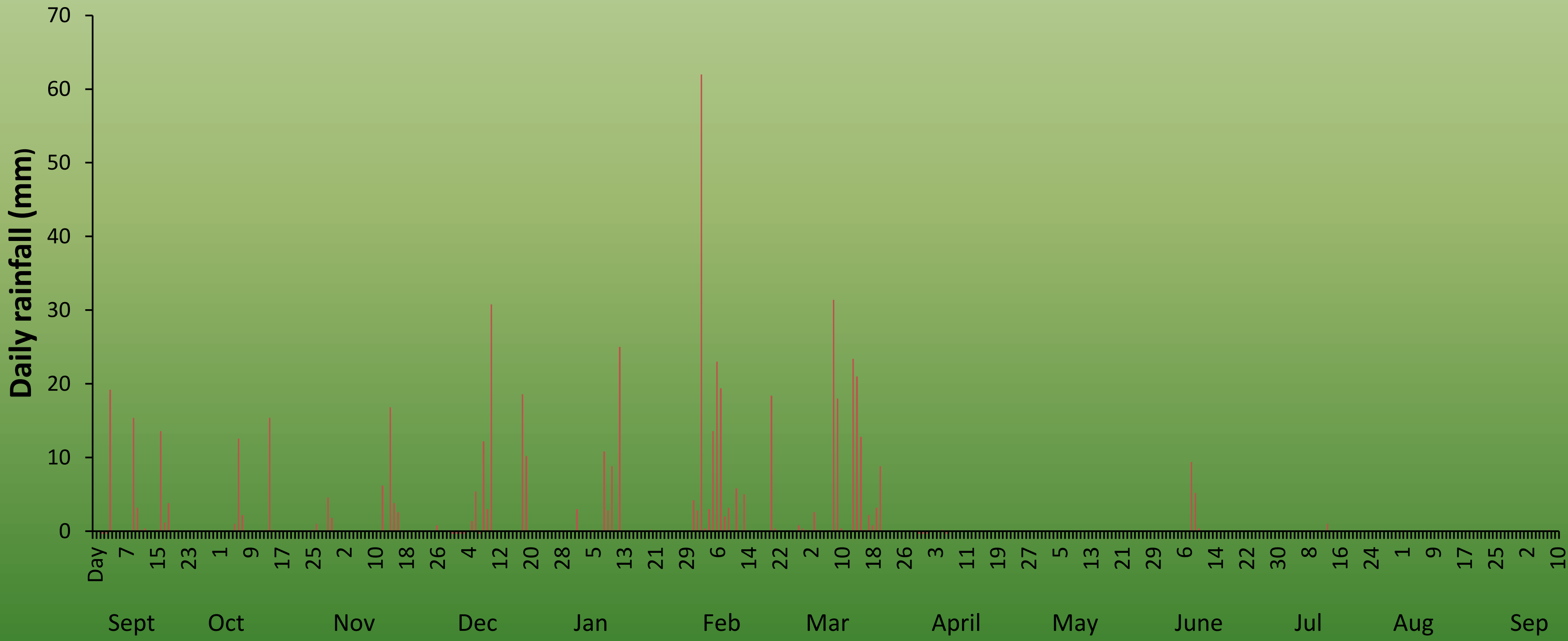
Carbon and water fluxes of an arid zone Mulga: some random observations

Derek Eamus, Nicolas Boulain and James Cleverly

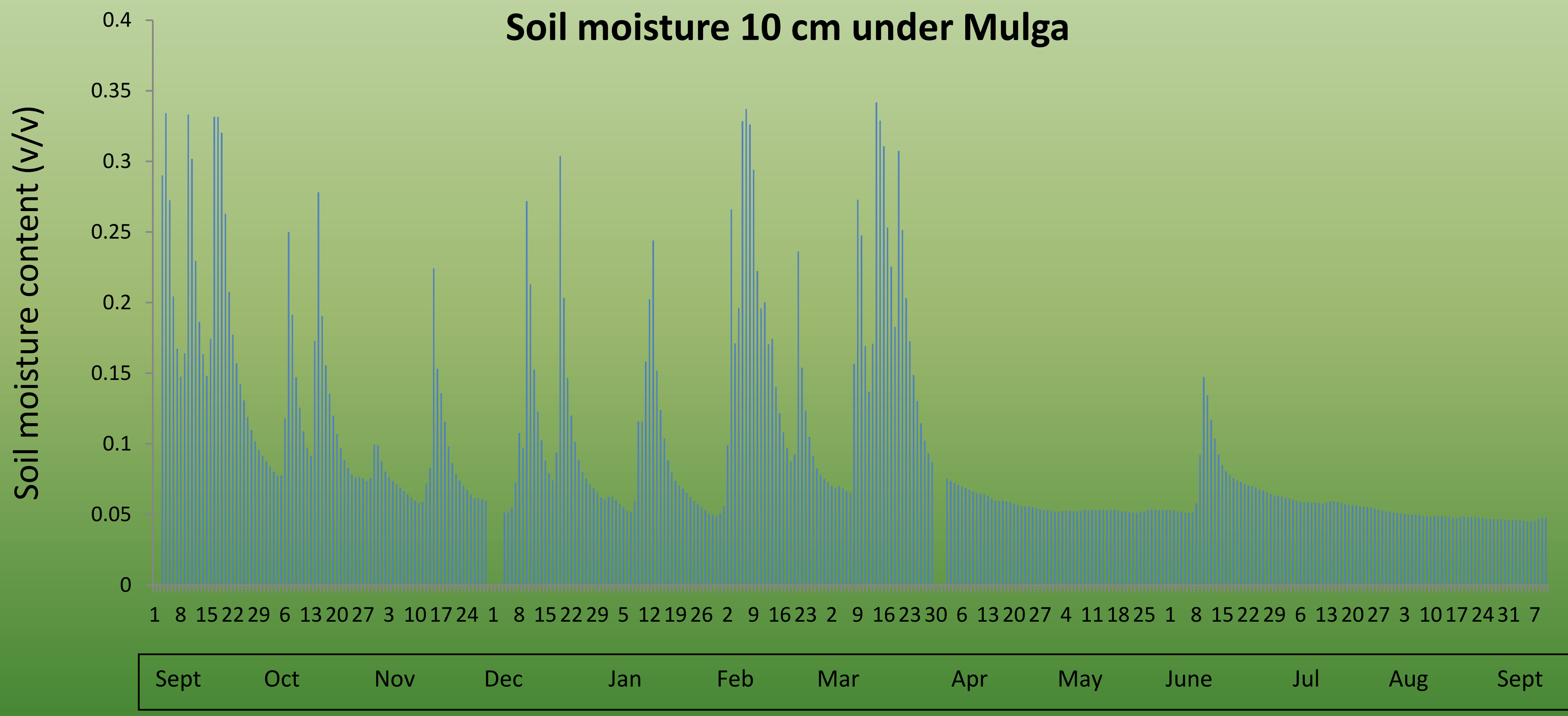




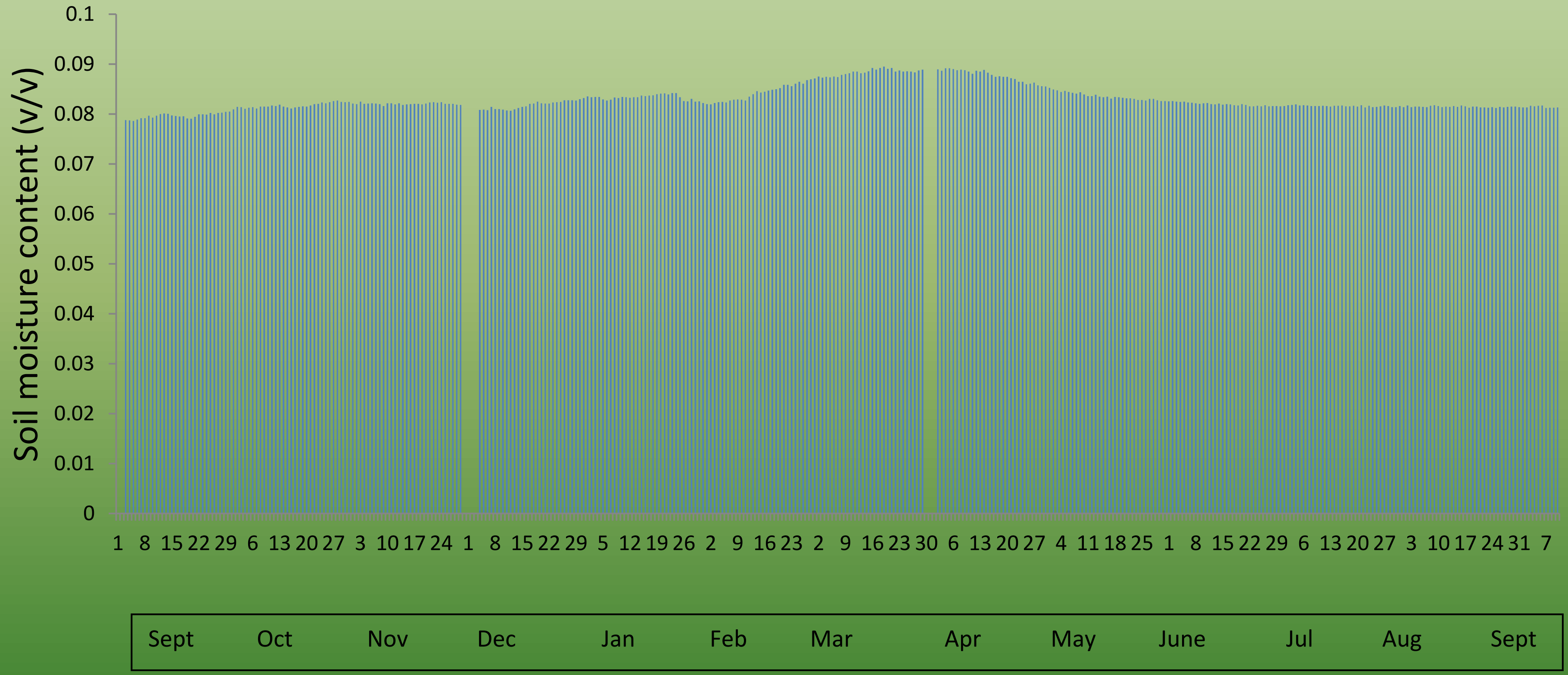

Rainfall was concentrated in the first 7 months of the study period ("wet season")



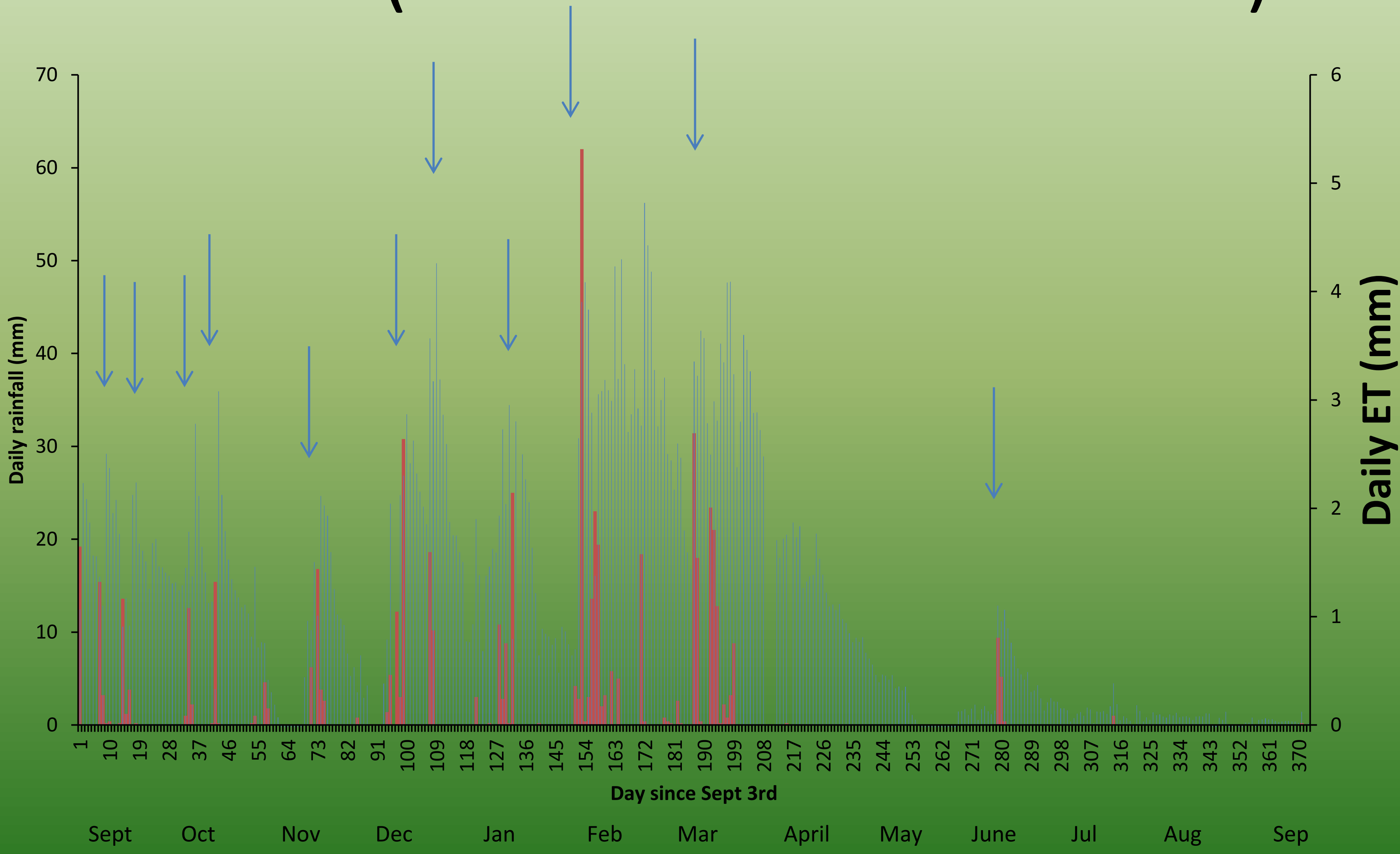
Soil moisture content at 10 cm responds to small rainfall events



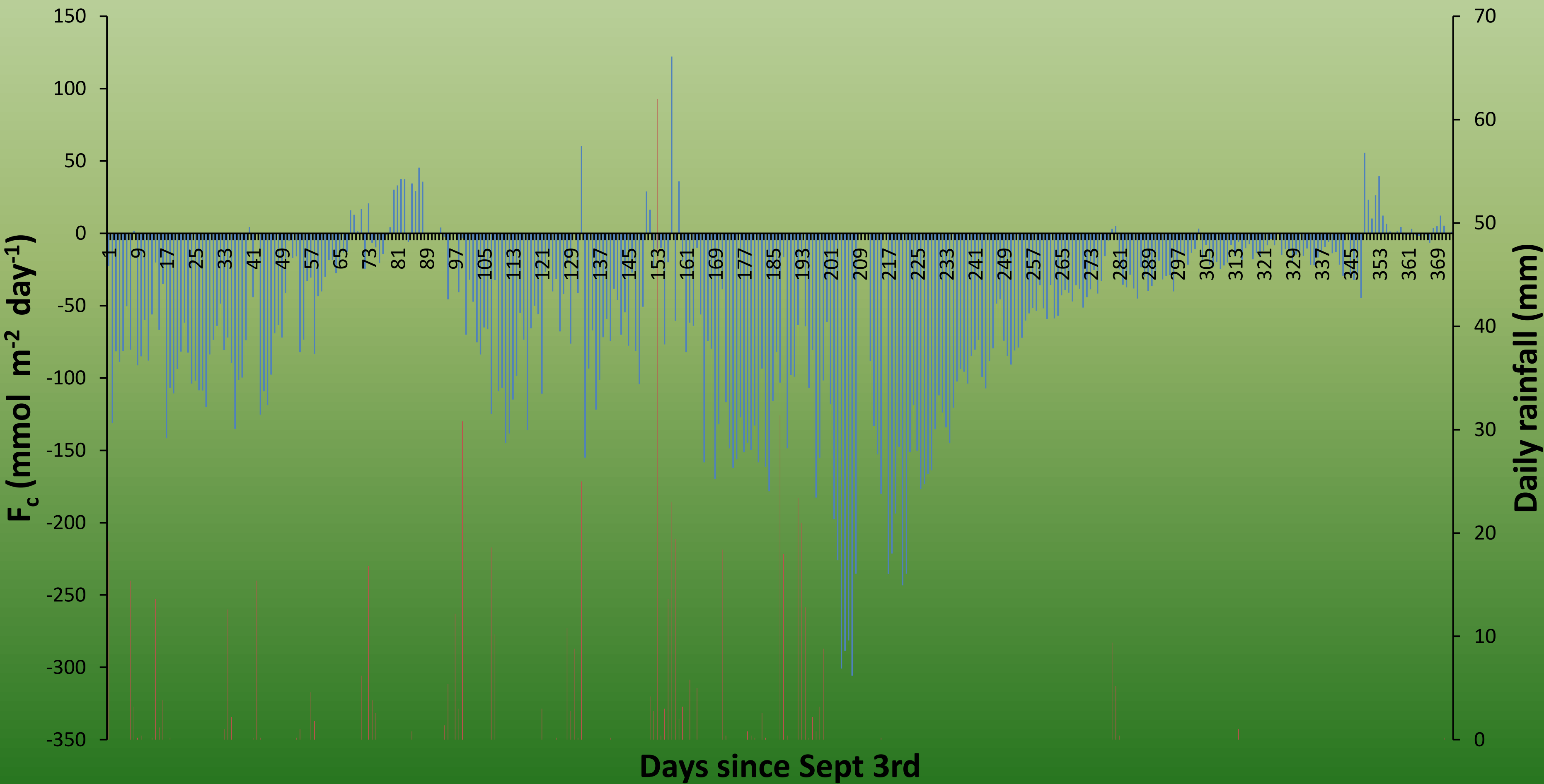
Soil moisture content at 100 cm shows minimal change



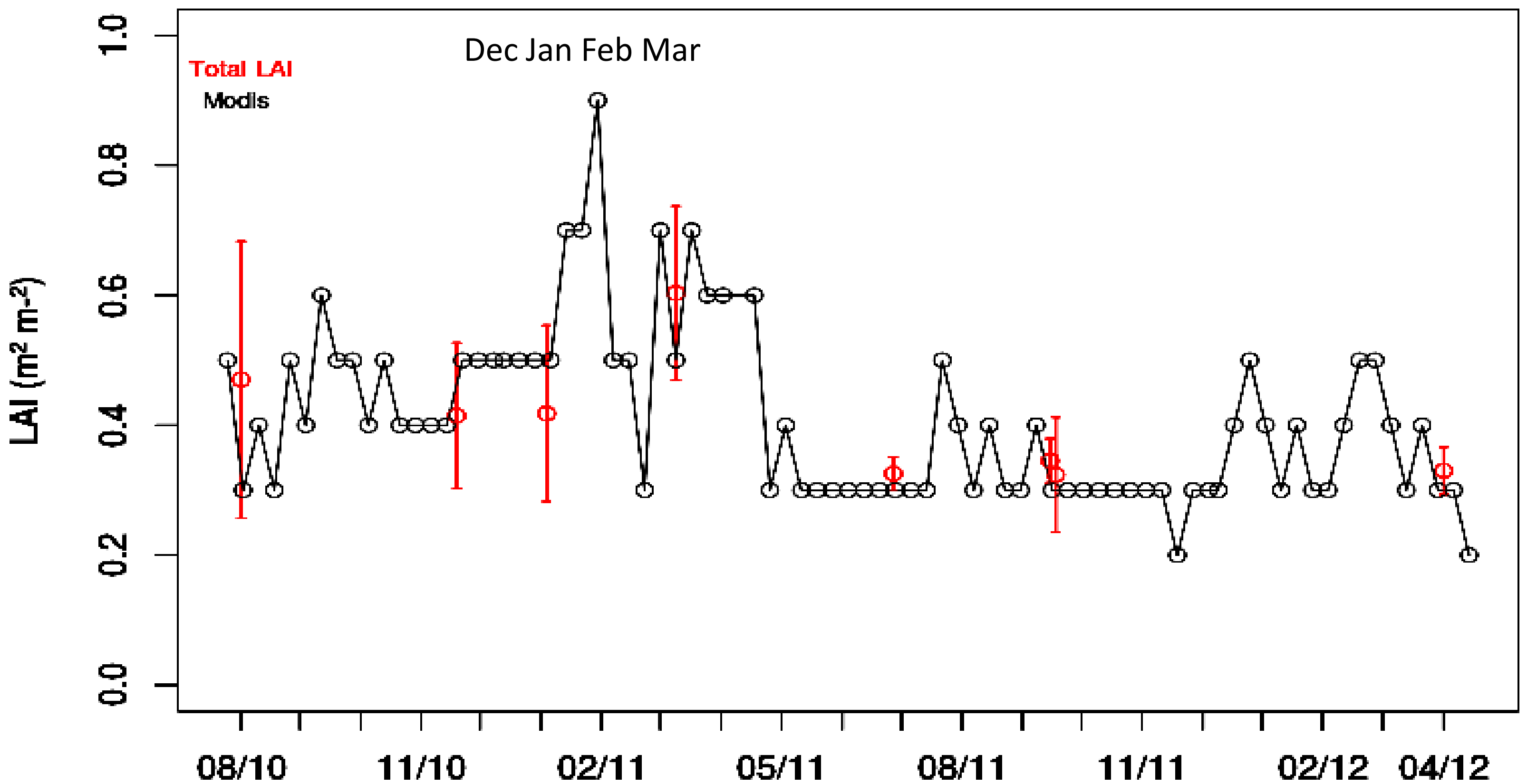
Daily ET rises and falls according to rainfall (ie soil moisture content)



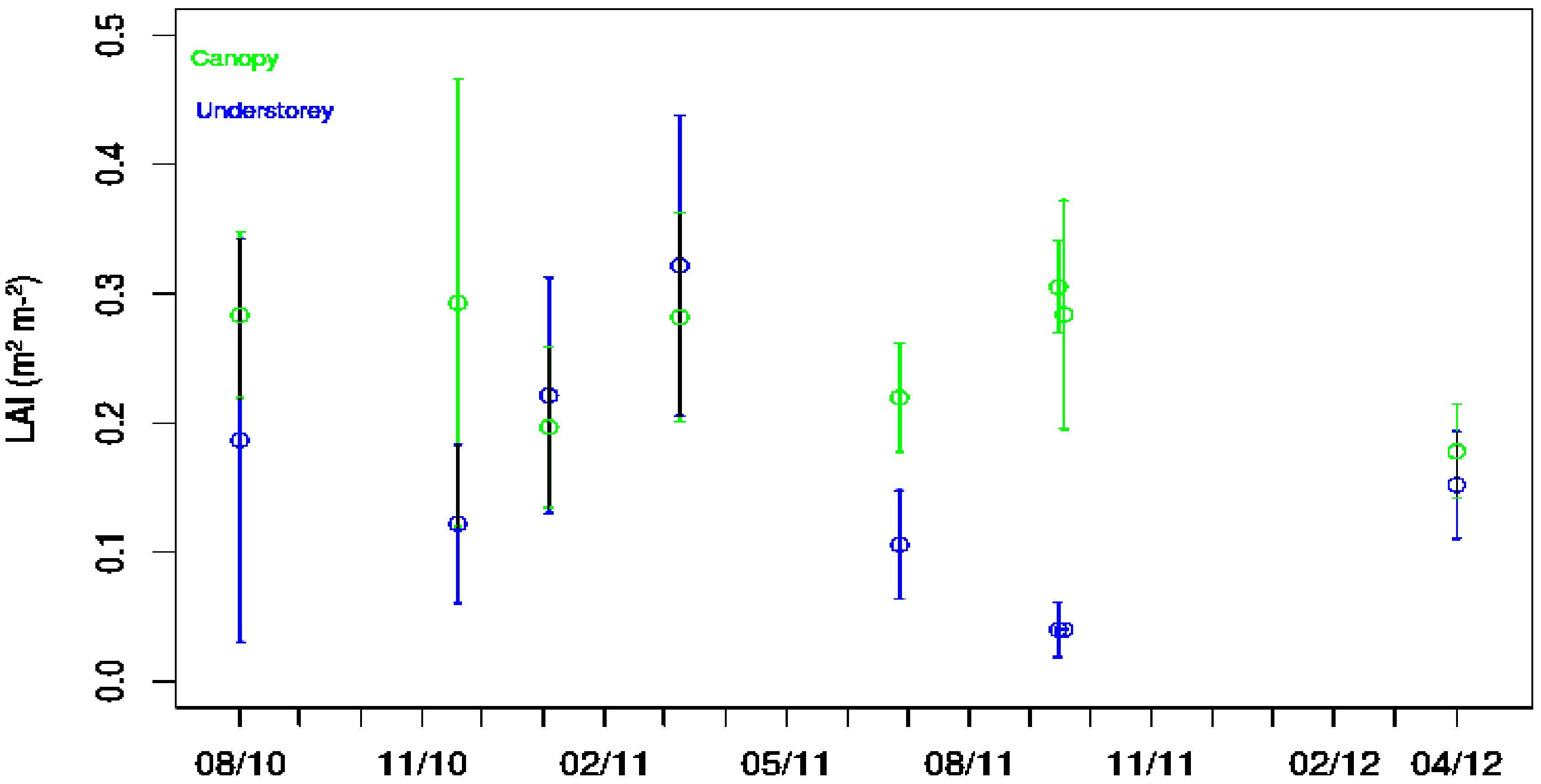
F_c peaks in Dec – Mar when soil moisture consistently high and solar radiation and temperatures are high – but these aren't the only drivers



MODIS LAI checked with 8 field measurement – with reasonable agreement

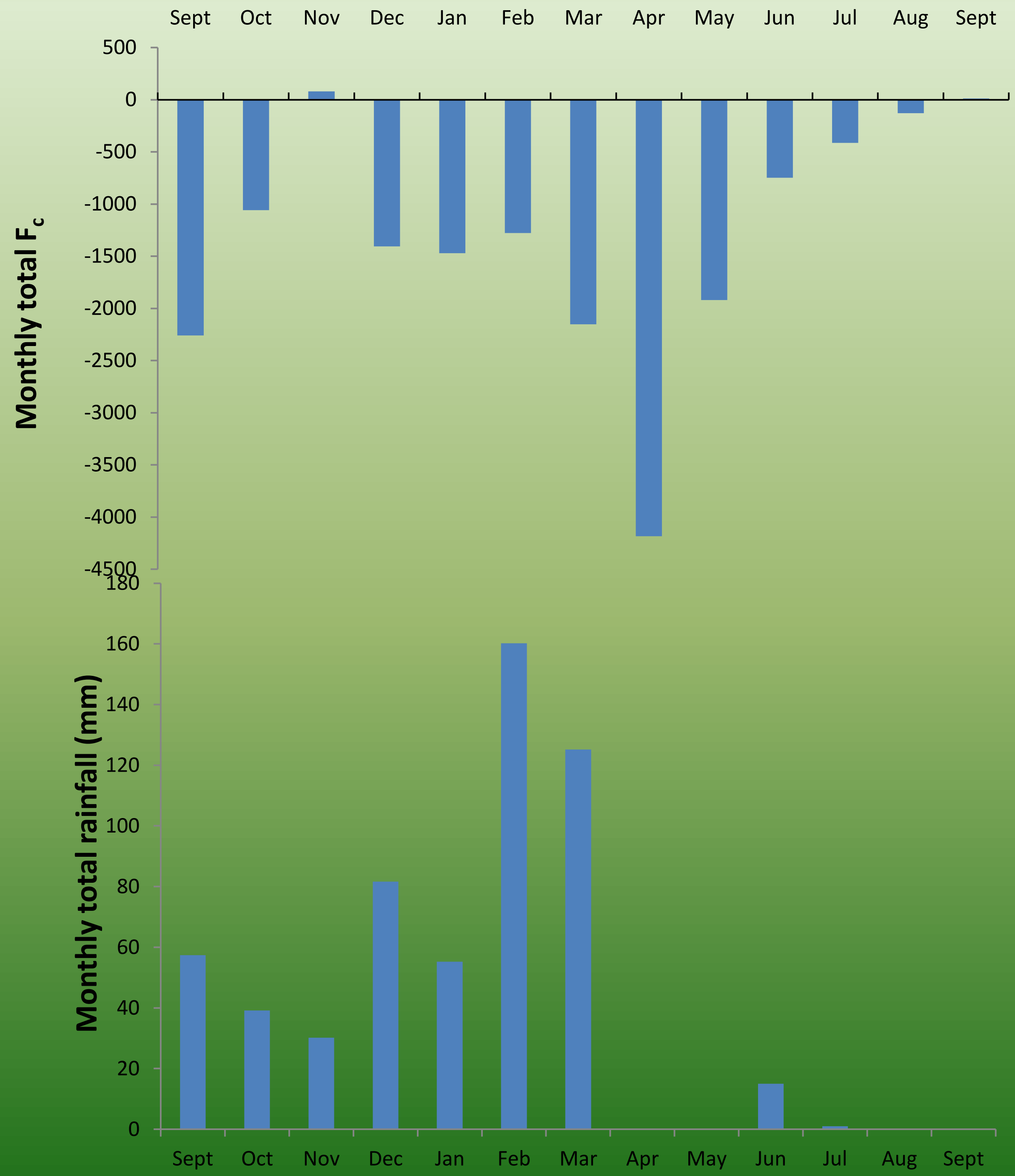


Field measurements partition overstorey and understorey LAI – largest change occurs in the understorey

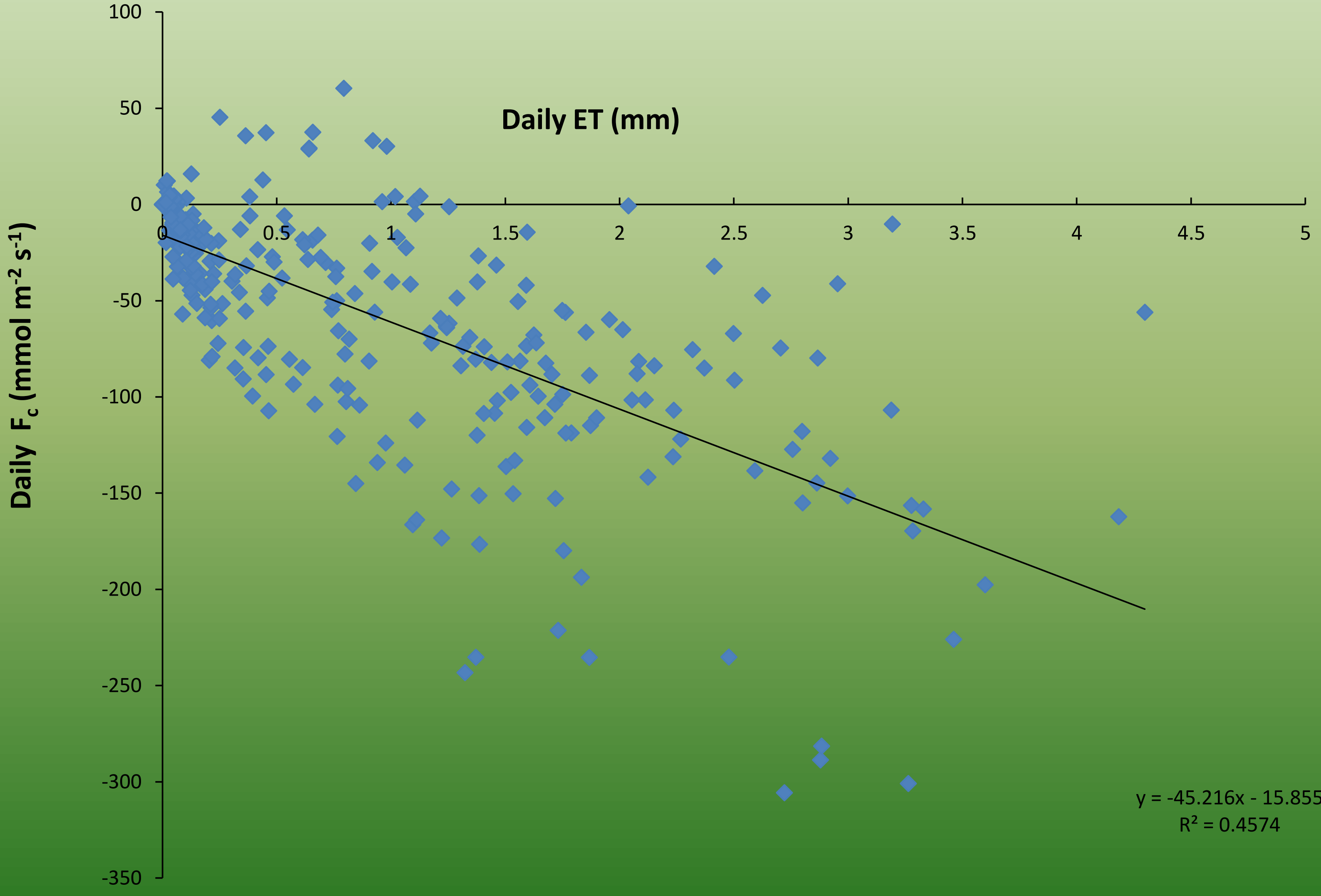


Conclusion:
Changes in LAI account for large part of seasonal changes in F_c and most of the change occurs in the understory – same as NT savannas –but soil crusts might be important too!

Net C uptake except for Nov 2010 and Sept 2011

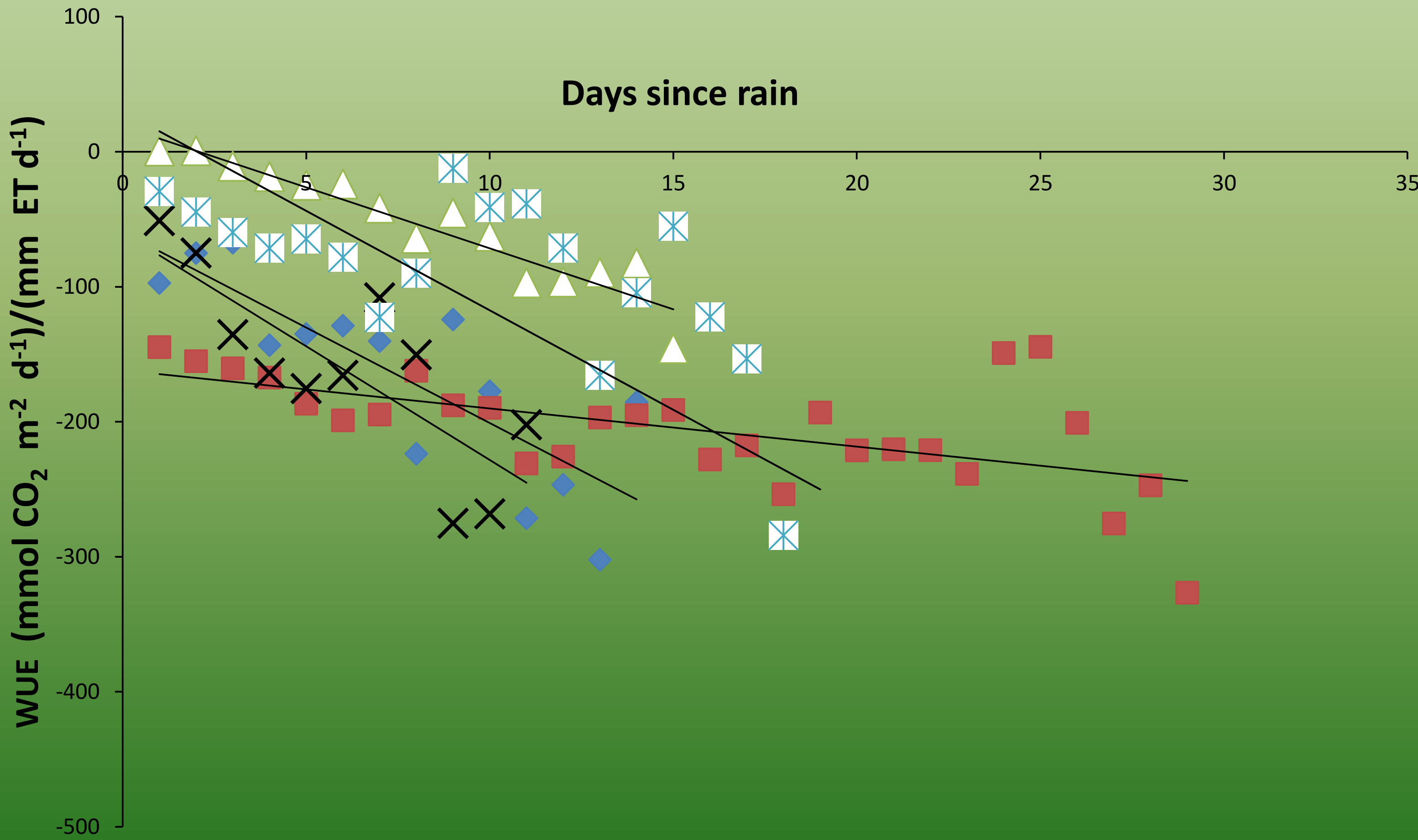


F_c increases with increasing ET

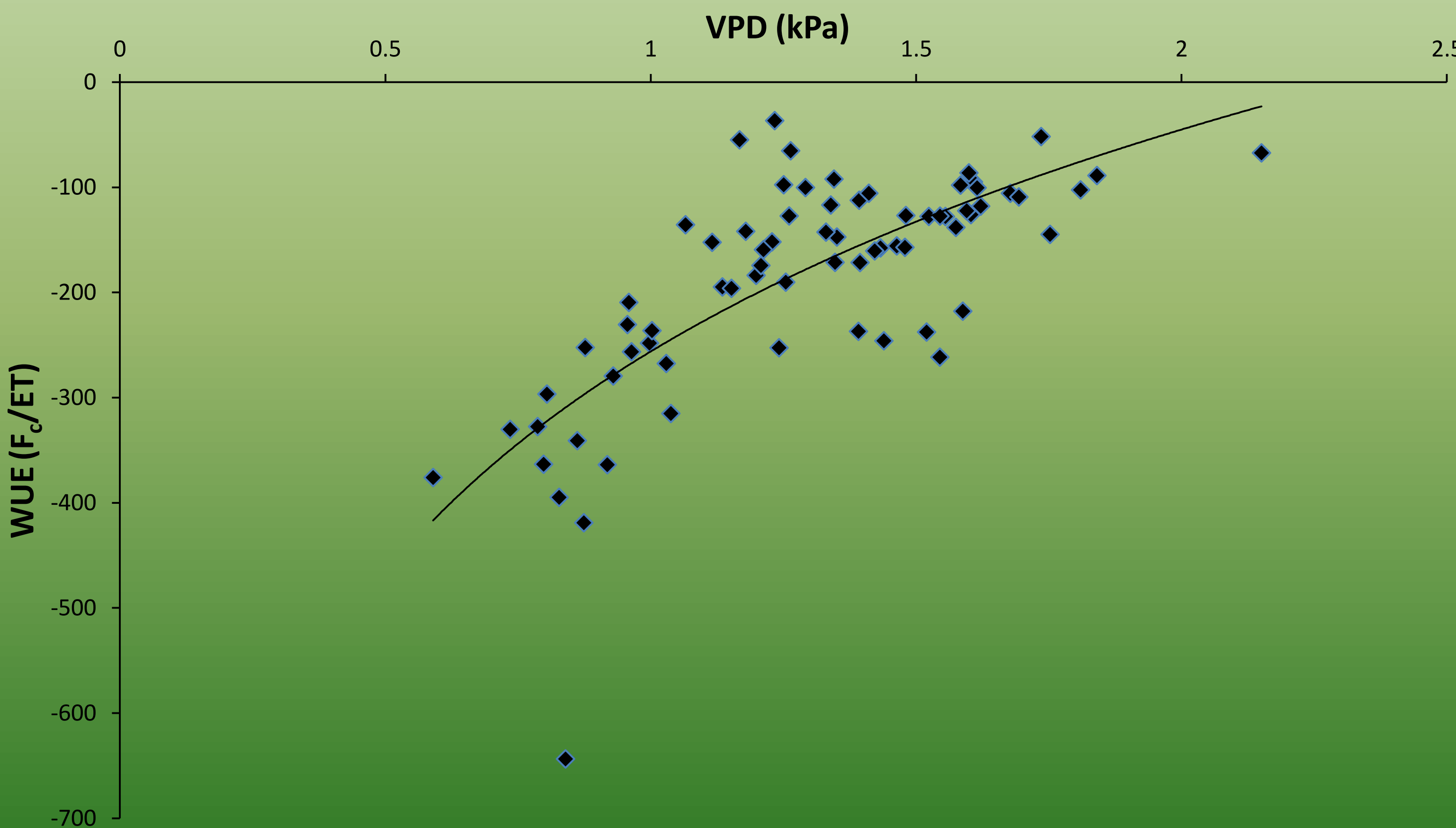


WUE (F_c/ET) increases as time since last rain increases. What drives this?

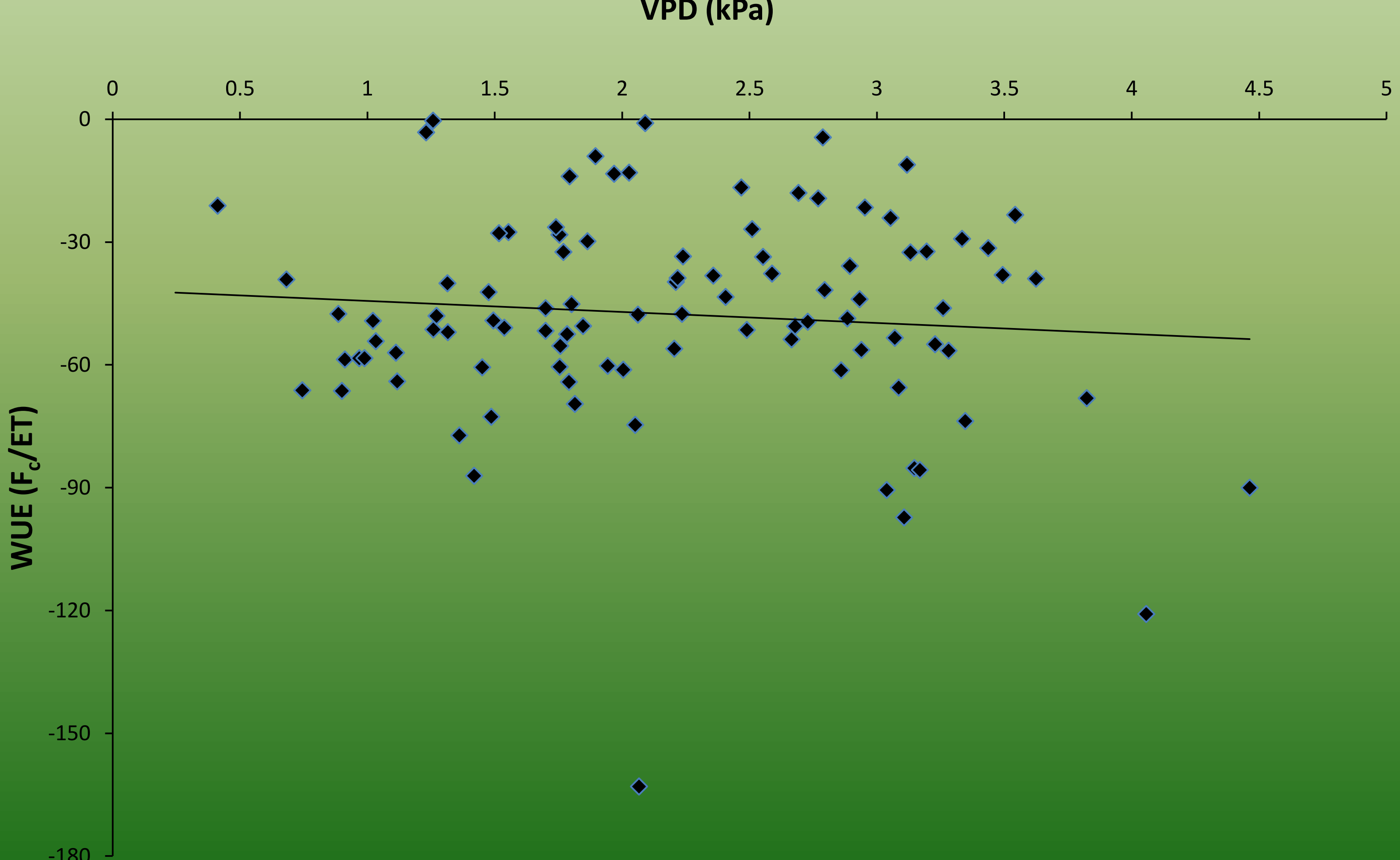
(each line is a single rain event)



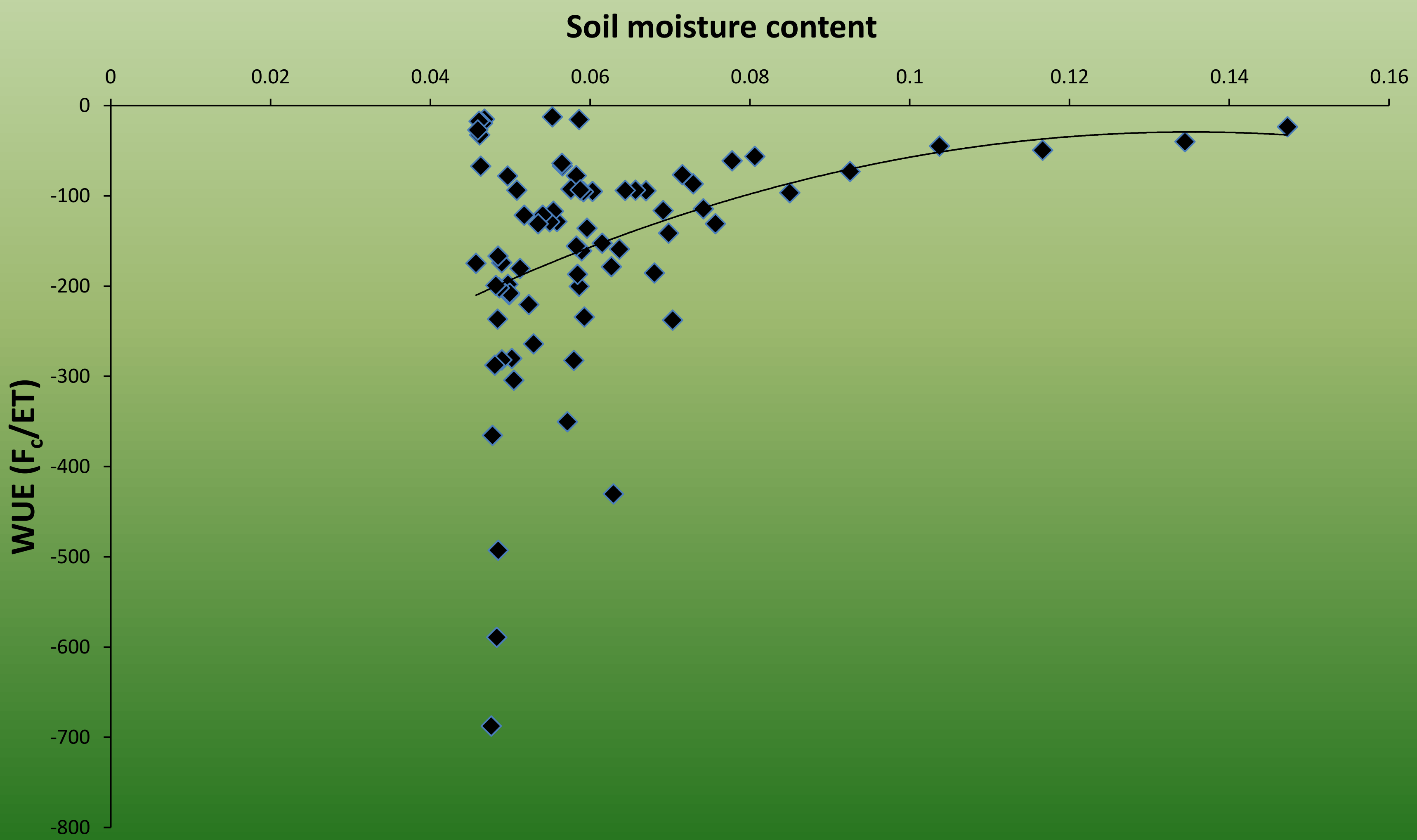
WUE (F_c/ET) in the "dry season": WUE decreases with increased D



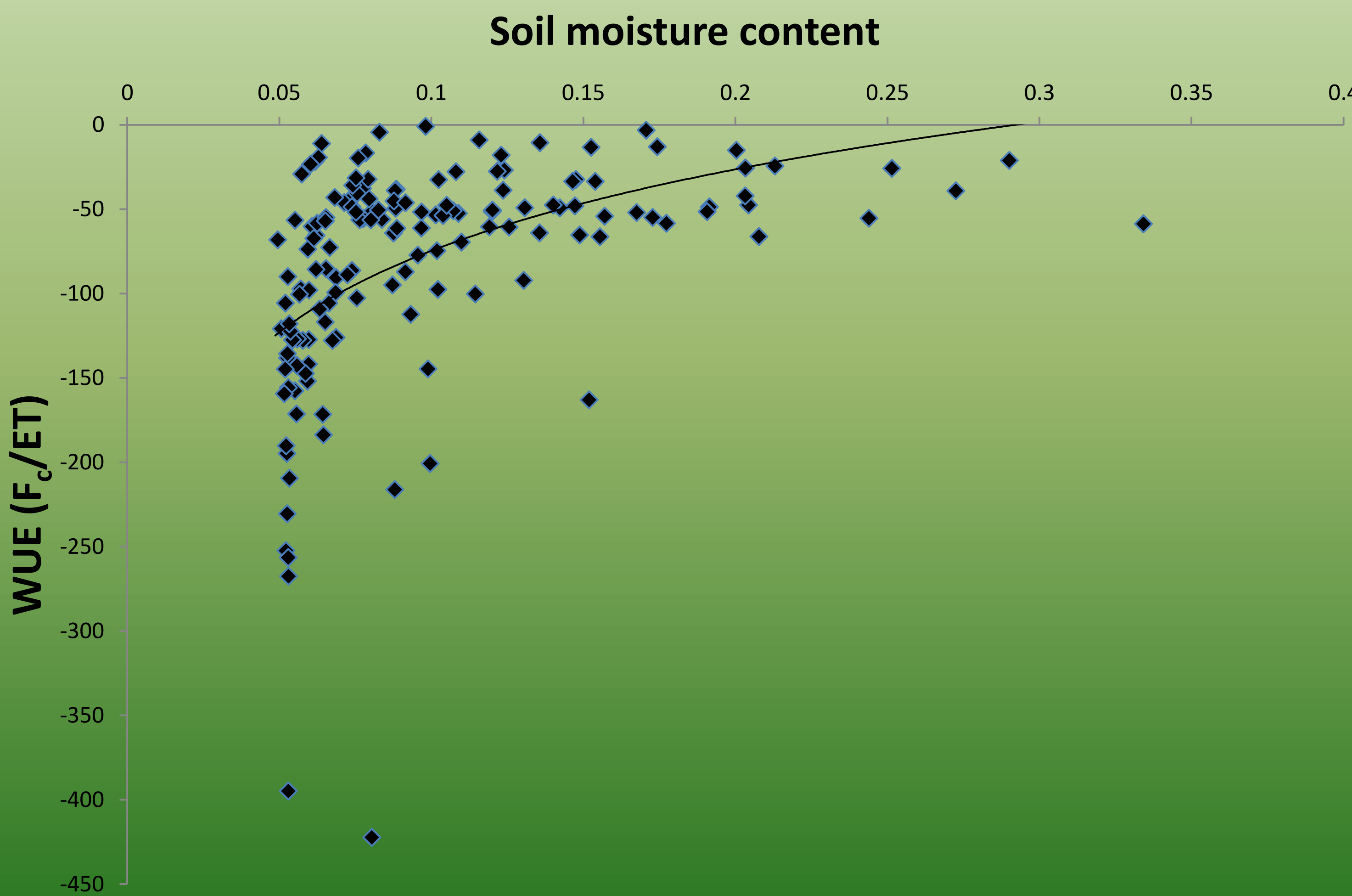
WUE (F_c/ET) for the "wet " season: no response to D. D does not drive increased WUE in the wet season (as soil moisture declines D increases)



WUE (F_c/ET) in the dry season: WUE increases with decreasing soil moisture content



WUE (F_c/ET) wet season increases with declining soil moisture content



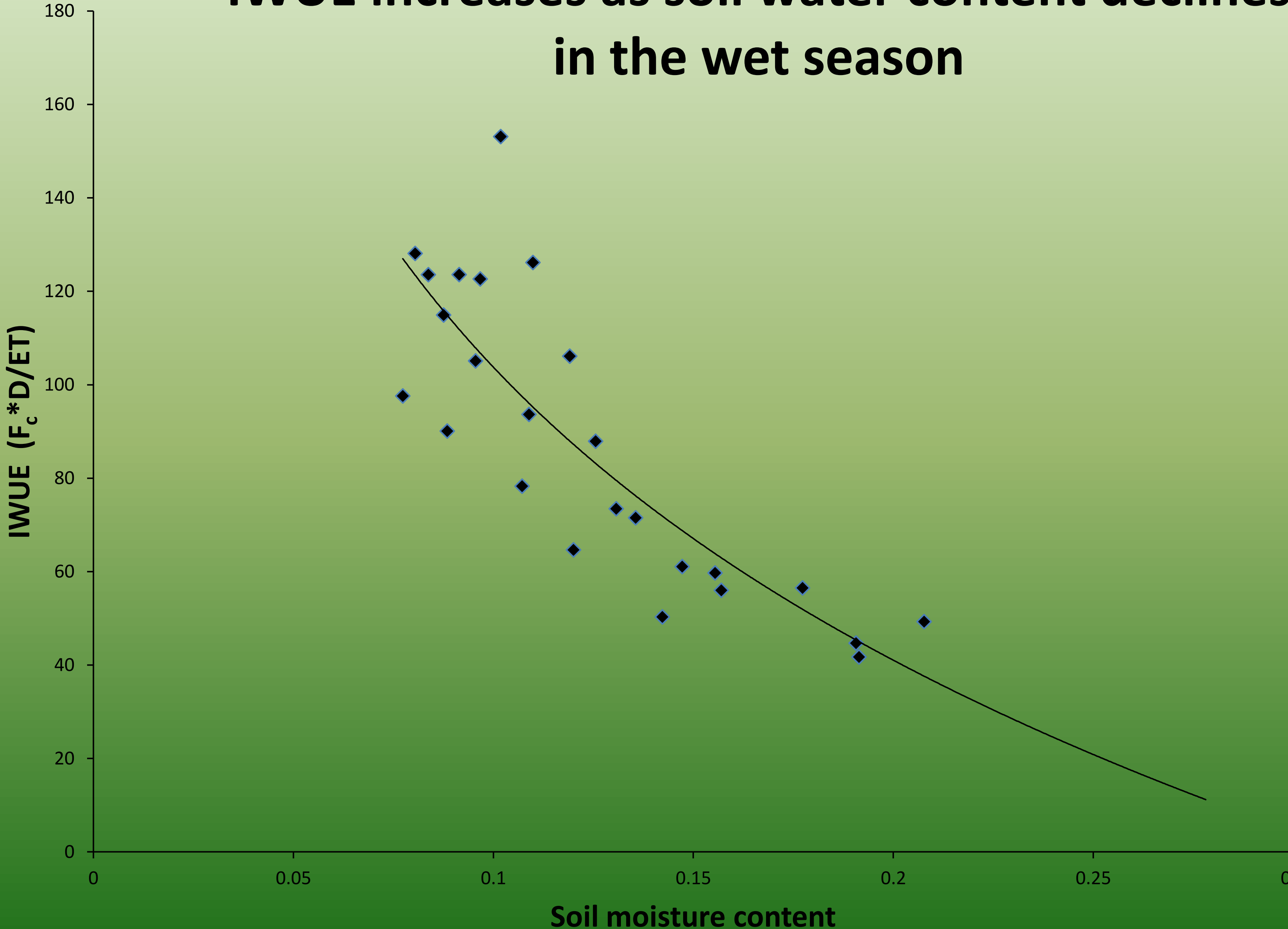
Conclusions about WUE

- In the dry season, changes in WUE driven by D
- In the wet season, changes in WUE driven by soil moisture content

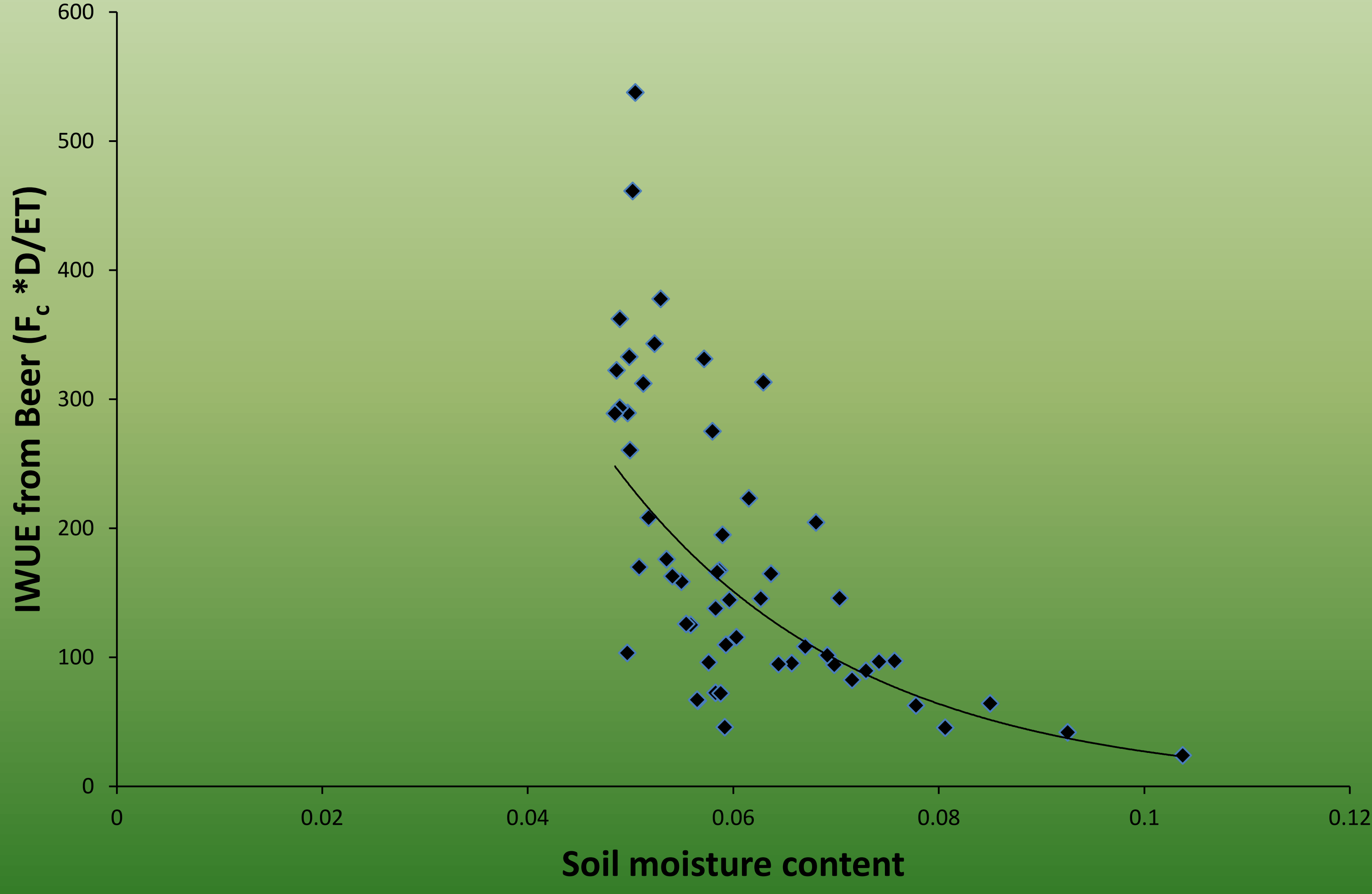
What about Inherent WUE?

- Inherent WUE = A/g_s
- Since $g_s = E/D$ then $A/g_s = A/(E/D) = A*D/E = WUE*D = F_c*D/ET$
- This is a measure of WUE independent of differential effects of D on ET and F_c
- Essentially IWUE is a measure of efficiency of fixing C per unit g_s

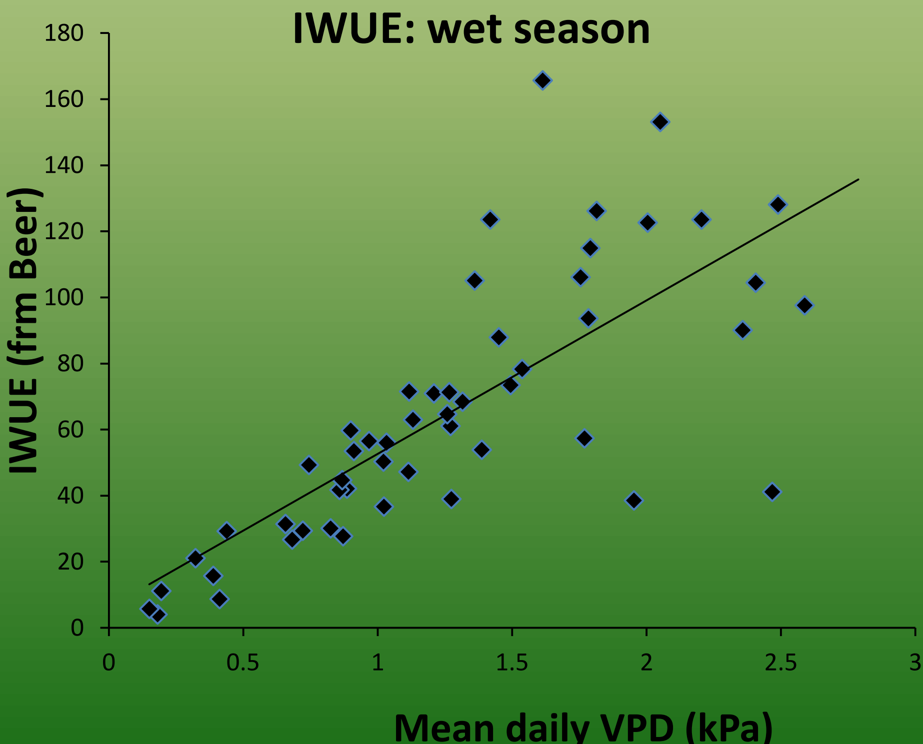
IWUE increases as soil water content declines in the wet season

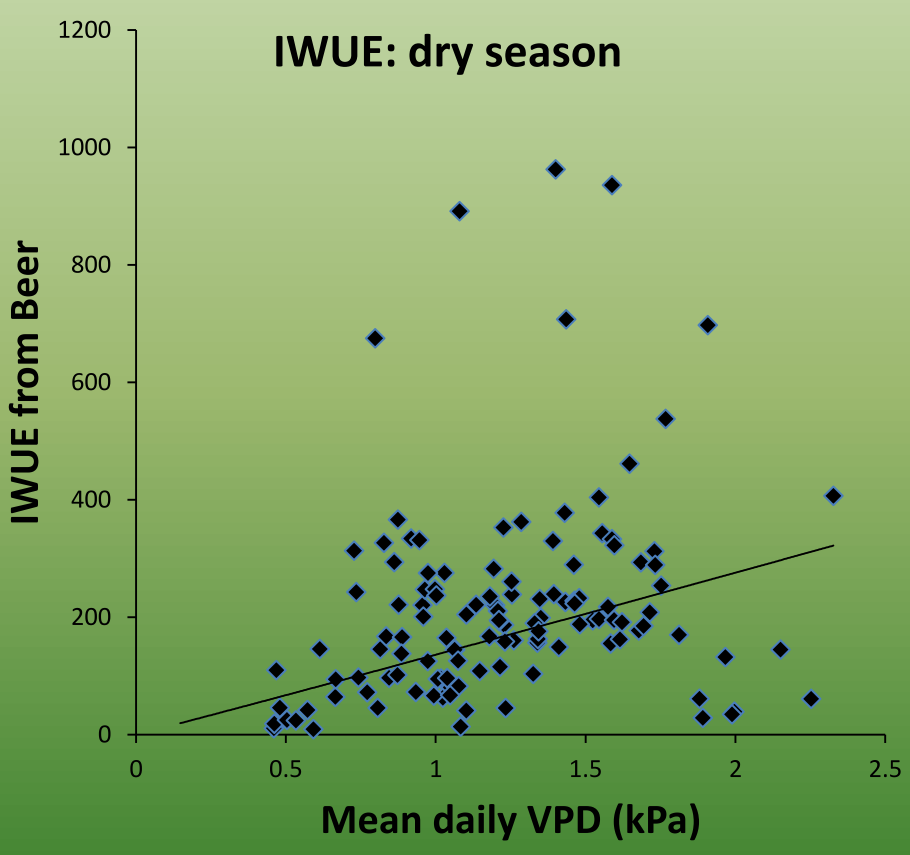


IWUE increases in the dry season as soil moisture content declines

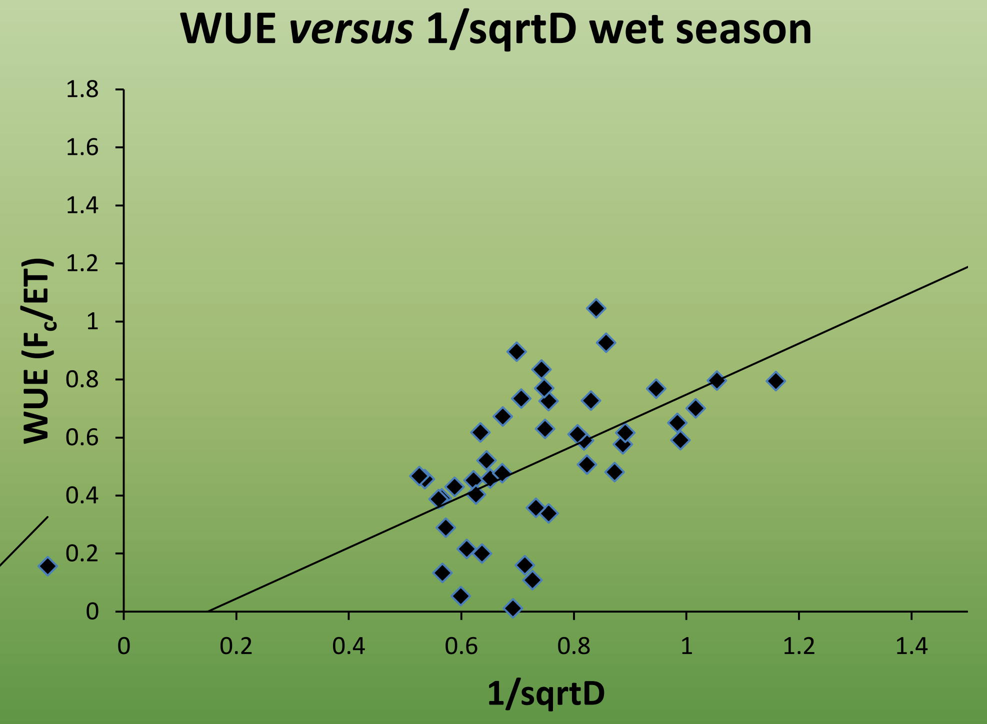


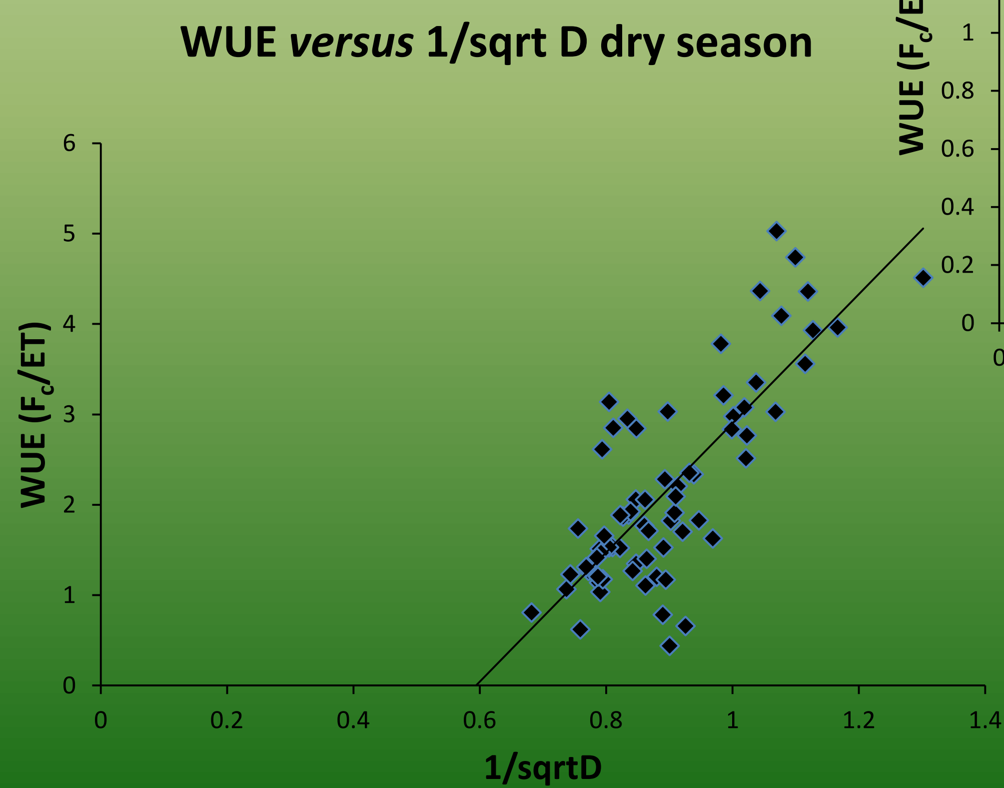
IWUE increases with increasing D in both wet and dry seasons





Slope of WUE vs 1/sqrt D is proportional to the marginal carbon cost of water – which increases in the dry season





Conclusions

- Mulga is highly responsive to rainfall: even 5 mm is sufficient to trigger a response in F_c and ET
- WUE is driven by D in the dry season but soil moisture content in the wet season
- IWUE increases with decreasing D in both seasons
- A positive C balance was seen in 10/12 months
- The marginal C cost of water increases in the dry season
- Changes in LAI of the understory are the main causes of seasonal changes in LAI and F_c
- Very little drainage past 100 cm depth occurs, even when monthly rainfall was > 120 mm (Feb 2011)

Why is marginal carbon cost of water proportional to 1/sqrtD?

$g_s = g_o + (1+g_1/\mathrm{sqrt}D)(A/C_a)$

Where D = VPD and g_1 is a constant that reflects the marginal water cost of carbon and g_o is cuticular conductance (assumed to be negligible)

If canopy coupling is high, $E = g_sD$

Then $A/E = WUE = C_a/(g_1(\mathrm{sqrt}D)+D)$

- So plot of WUE *versus* sqrtD has a slope proportional to the inverse of g_1 so the slope is proportional to the marginal carbon cost of water

Put another way:

g_1 is proportional to sqrt(Γ^* λ) (Medlyn et al 2012)

where Γ^* is the compensation point, and λ is the marginal water cost of carbon

and

- WUE = $C_a/(g_1$ (sqrtD)+D)
- So WUE *versus* sqrtD has a slope proportional to 1/ λ ie, marginal carbon cost of water

Daily ET declines as the number of days since the last rain increases