MODELLING DAILY TRANSPIRATION OF DECIDUOUS AND EVERGREEN FRUIT TREES, USING PECANS AND MACADAMIAS AS AN EXAMPLE

by

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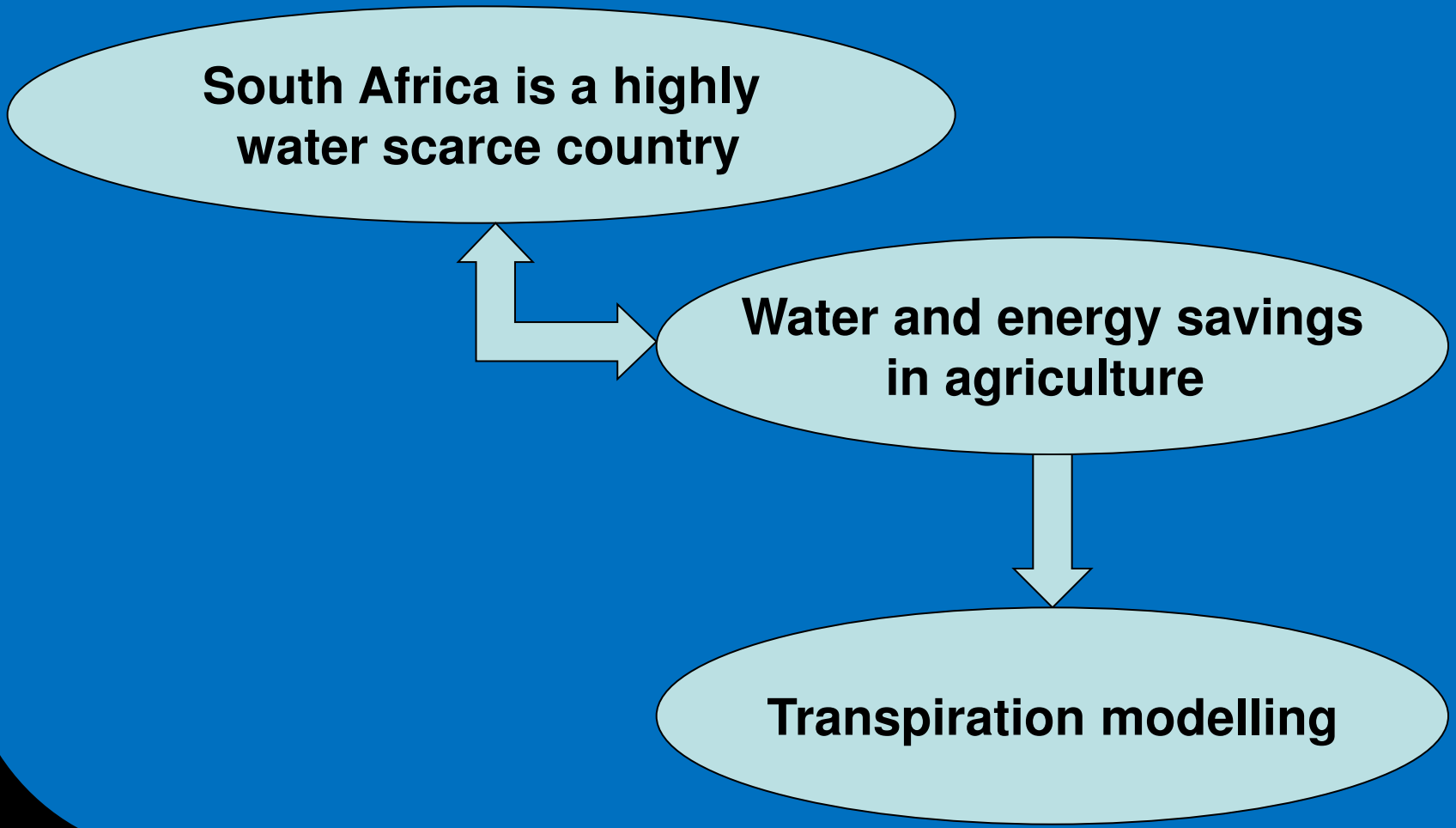
Why model transpiration of fruit trees?



Factors affecting transpiration of orchard crops

Orchard management
- pruning strategies

Environmental conditions




Study hypothesis

Transpiration of deciduous and evergreen fruit tree species can be modelled using a canopy conductance approach.

Aim of the study

To assess the performance of a simple canopy conductance approach, which requires minimum and easily accessible input parameters to model transpiration of deciduous and evergreen fruit tree species, using pecans and macadamias as specific case studies.

A simple canopy conductance approach to model daily transpiration (E_{pd}) of fruit trees (Villalobos *et al.* 2013)

$$E_{pd}(mm) = 37.08 \times 10^{-3} \frac{Q R_{sd}}{a + b D} \frac{D}{P_a}$$

where:

- R_{sd} (J m^{-2} d^{-1}) – daily solar radiation
- D (kPa) – vapour pressure deficit
- P_a (kPa) – atmospheric pressure
- a (μEmol^{-1}), b (μEmol^{-1}kPa^{-1}) – coefficients of the linear function $\frac{QR_{sd}}{G_c}$ vs. D
- $G_c(mm\ s^{-1}) = \frac{E_p P_a}{D}$ – canopy conductance
- Q (dimensionless) – fraction of photosynthetically active radiation (PAR) intercepted by the canopy

Modelling the parameter Q

Tree orchard dimensions

- H – tree height
- B – height of lower branches
- W_x, W_y – canopy width and depth

Orchard configurations

- E_x, E_y – spacing rows – trees
- Φ_R – row orientation

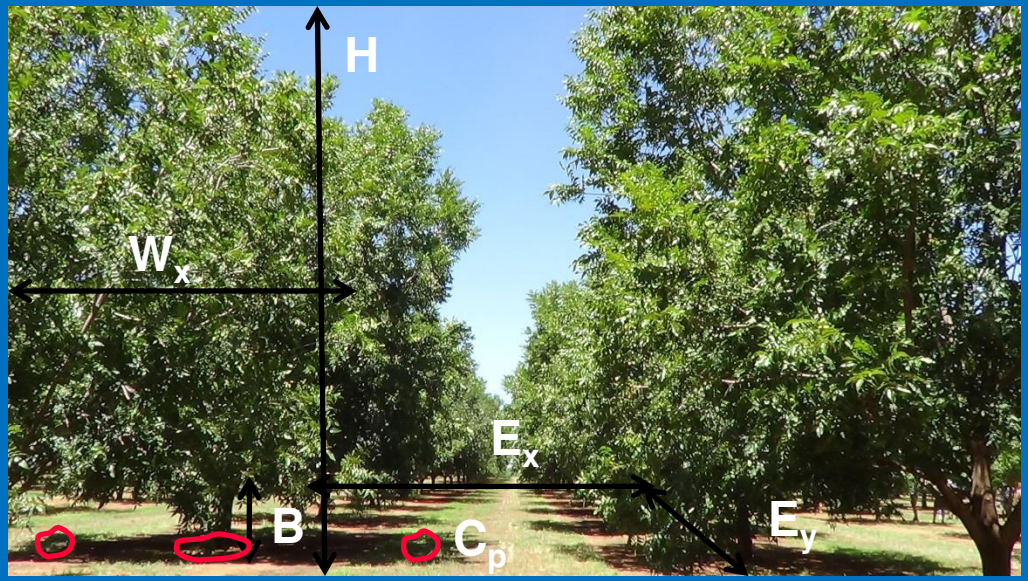
Location data

- Altitude, latitude, longitude, standard meridian, slope (ρ)

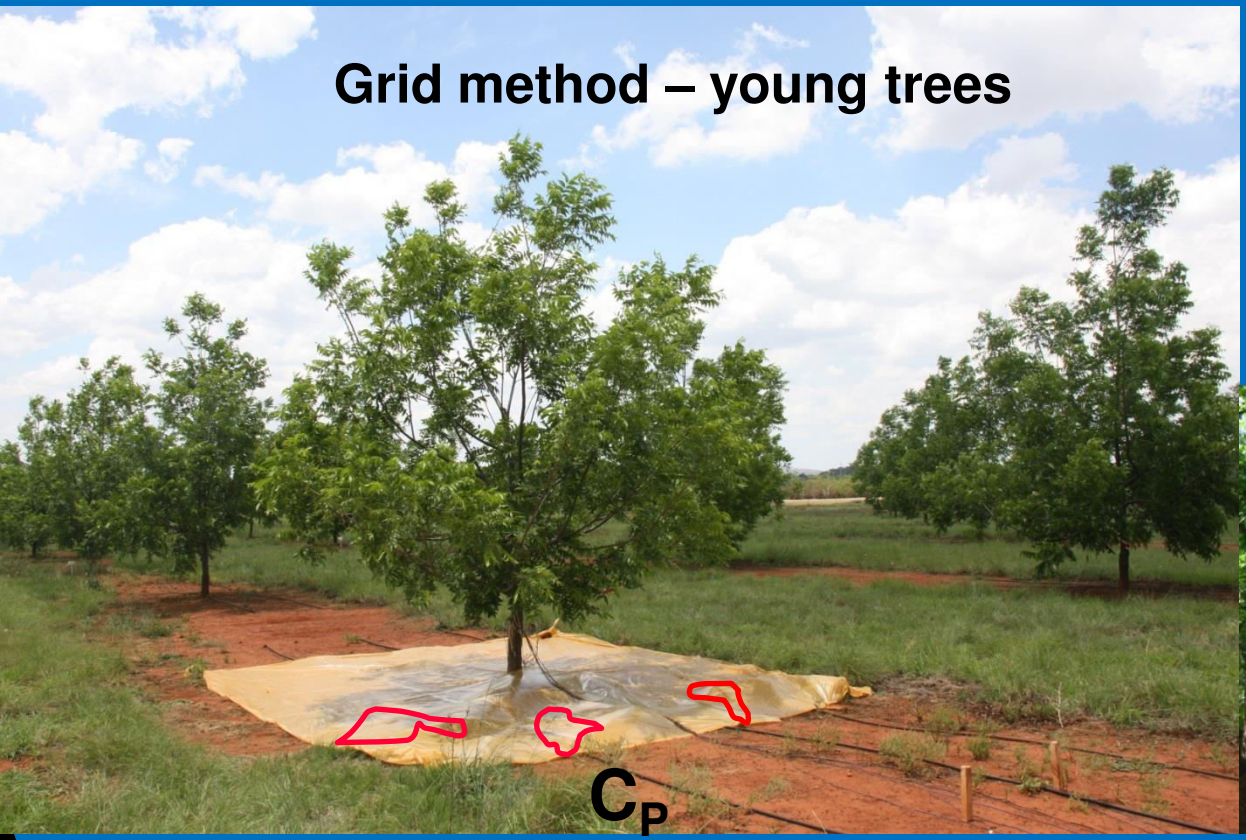
Daily global solar radiation

C_p - Canopy porosity

Oyarzun *et al.* (2007)



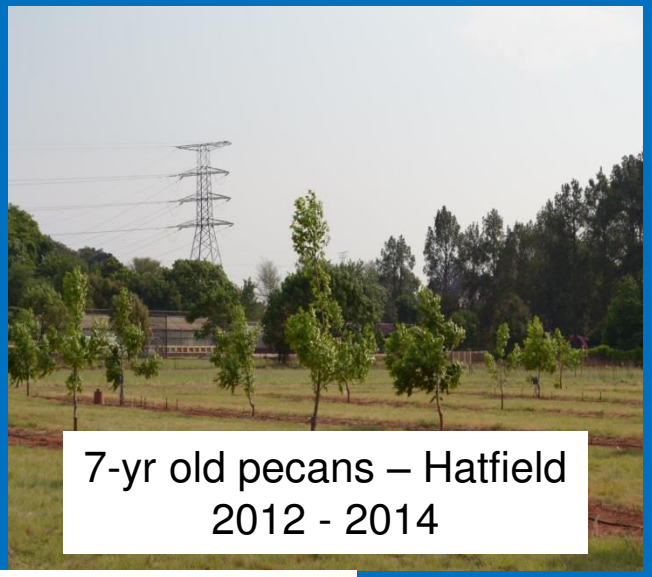
Measurements of canopy porosity (C_p)



Thermal time approach
- mature trees -

Orchards used for field Measurements

37-yr old pecans – Cullinan
2009 - 2012



7-yr old pecans – Hatfield
2012 - 2014

7-yr old macadamias – White River
2010 - 2012

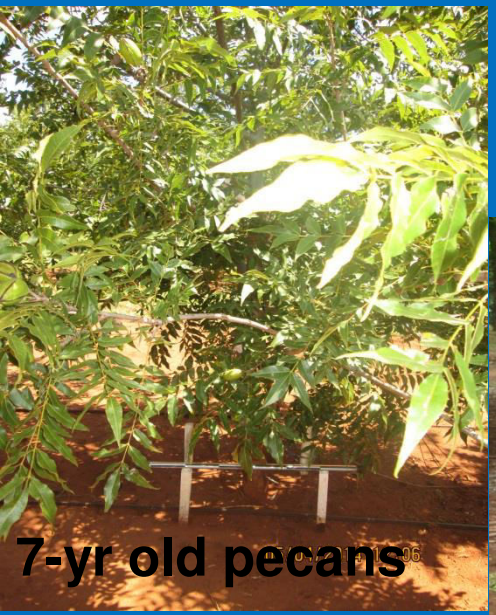
Characteristics of the different orchards

- model parameterization for Q estimation -

					Tree height	Canopy dimensions		Canopy porosity	Row orient.	Slope
Site	**Tree**	**Age**	**Spacing (m)**	**Pruning**	**H (m)**	**W_y, W_x (m)**	**B (m)**	**C_p**	**Φ_R (º)**	**ρ (º)**
Cullinan	Pecan	37	9 x 9 x 9	Varied seasonally	12 - 16	6 - 9	0.6 - 2.0	0.02 - 0.40	20 NNE-SSW	0.2
Hatfield	Pecan	7	10 x 10	Modified central leader	3 to 5	5.2, 5.7	0.8 to 1.4	0.30 to 0.45	10 N-S	0.4
Hatfield	Pecan	7	10 x 5	Modified central leader	3 to 4.5	4.8, 5	1.0 to 1.4	0.35 to 0.50	8 N-S	0.4
White River	Maca damia	7	8 x 4	Modified central leader	5	3 to 4, 4 to 7	0.6 to 1.0	0.10 to 0.20	6 N-S	1.5

Measurements of hourly transmitted solar irradiance

- model validation for Q estimation -



Delta-T tube solarimeters

$$\tau_{Q_h} = \tau_{S_{g,h}}^{\frac{1}{0.7}}$$

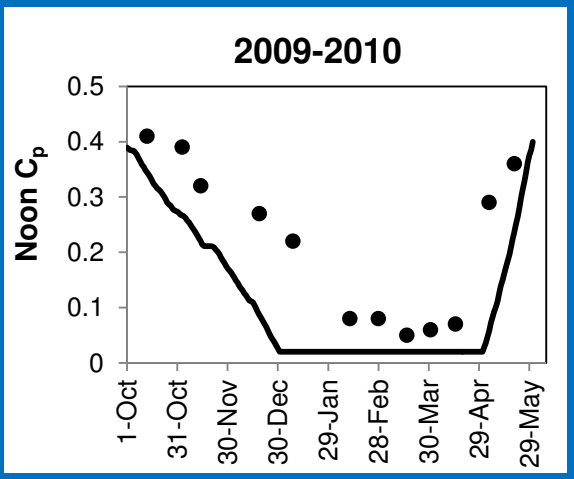
Oyarzun et al. (2010)

Measurements of sap flow

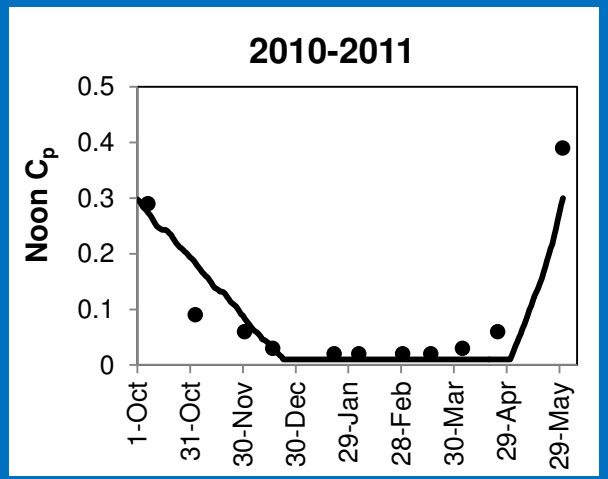
(parameterization and validation of the T model)

Measured vs. modelled noon canopy porosity (C_p)

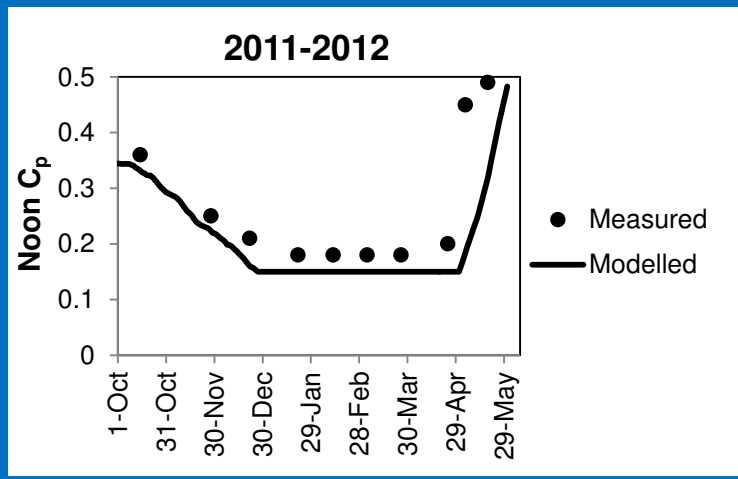
37-yr old pecan orchard



Light mechanized hedge pruning



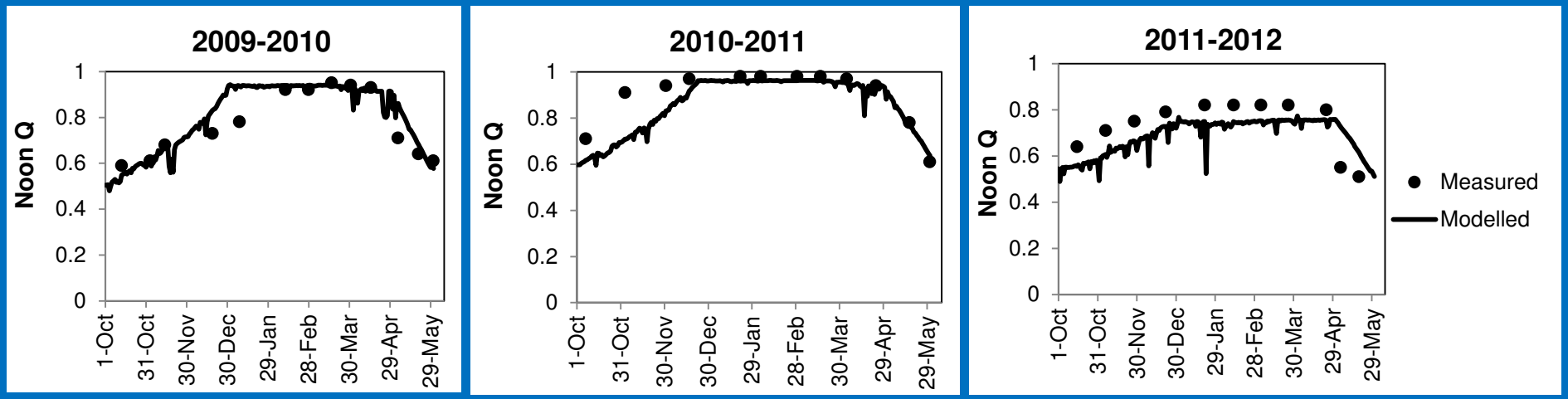
Manual selective limb pruning



Light mechanized hedge and top pruning

Measured vs. modelled noon fractional intercepted PAR (Q)

37-yr old pecan orchard

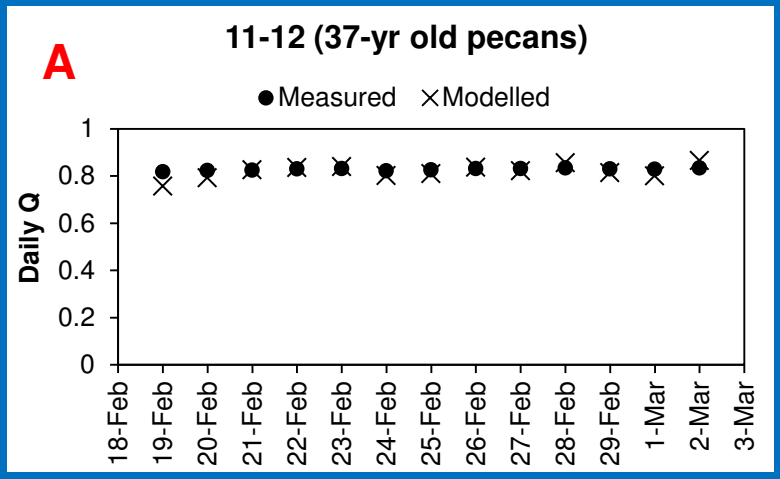


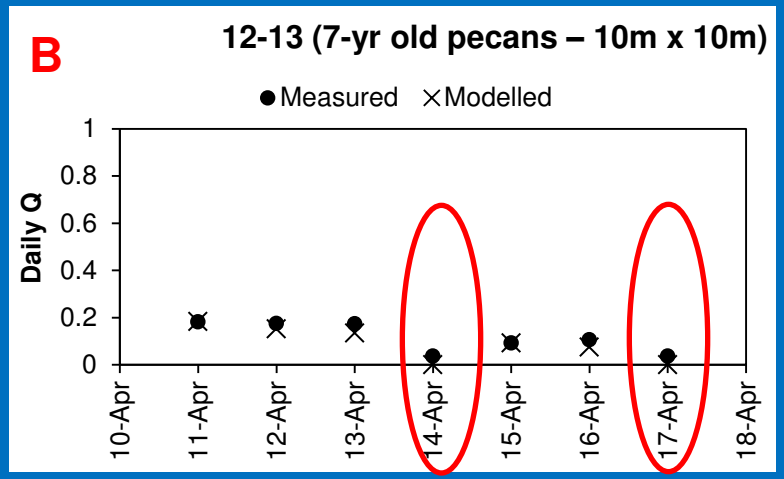
Light mechanized hedge pruning

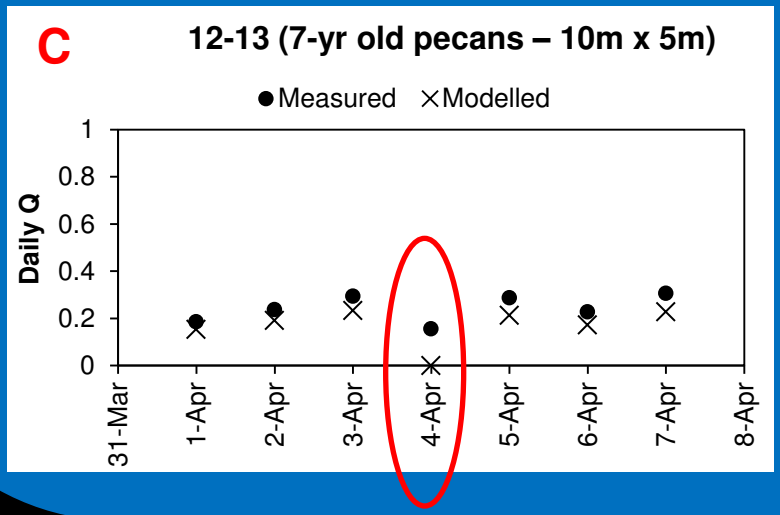
Manual selective limb pruning

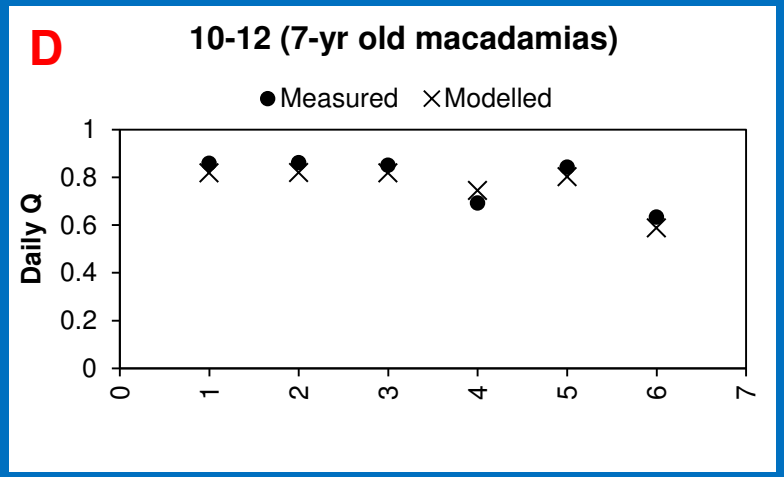
Light mechanized hedge and top pruning

Measured vs. modelled daily fractional intercepted PAR





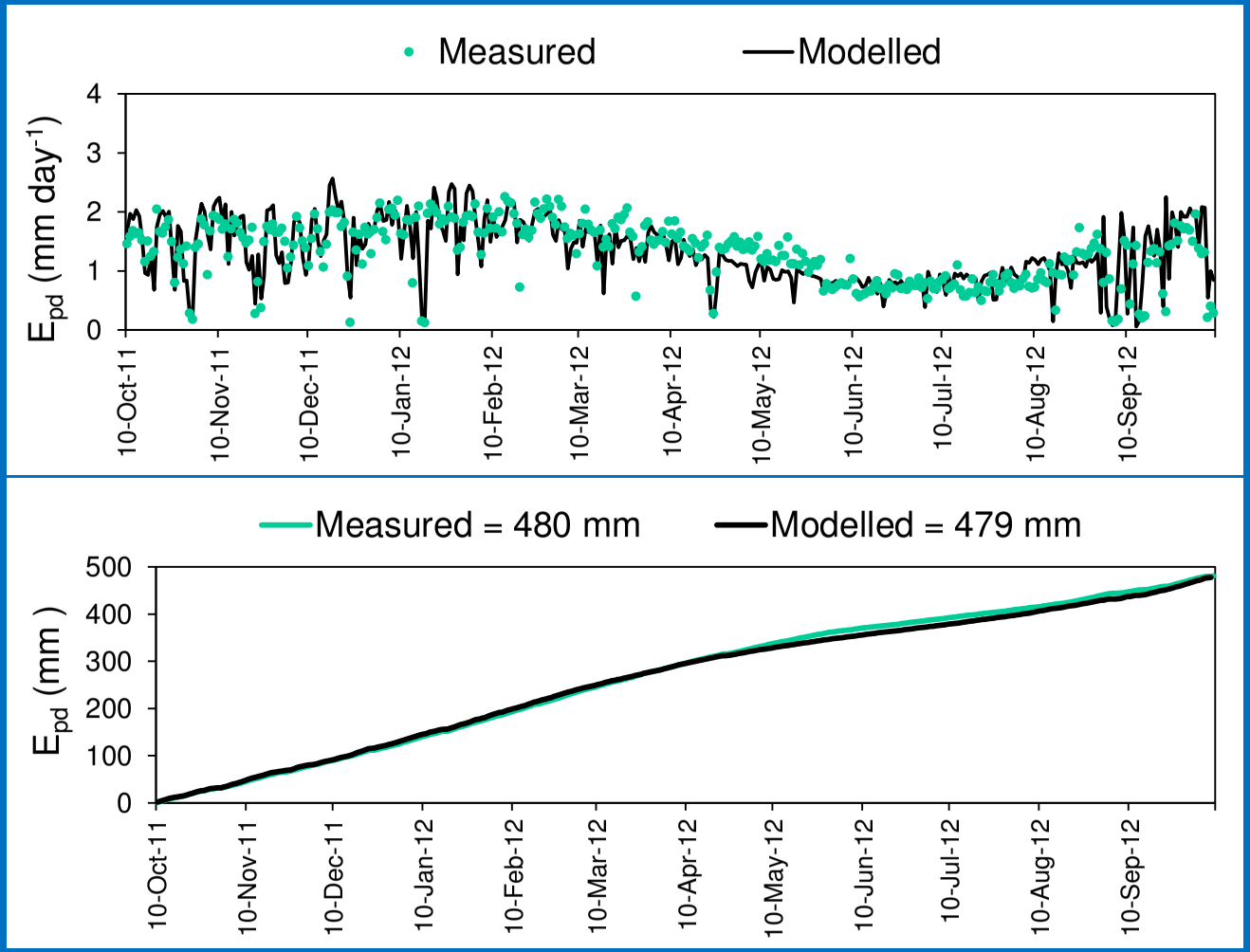




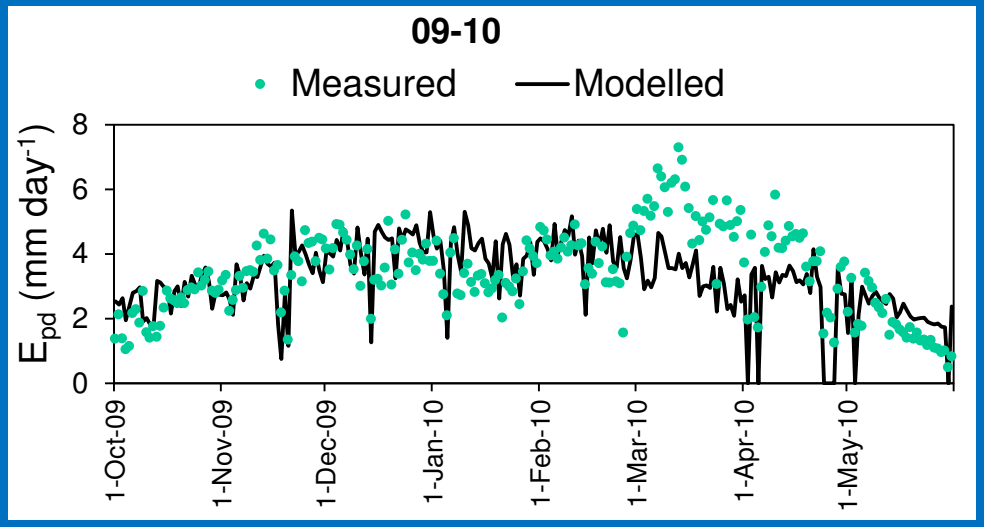
Ratio of intercepted radiation and canopy conductance vs. vapour pressure deficit

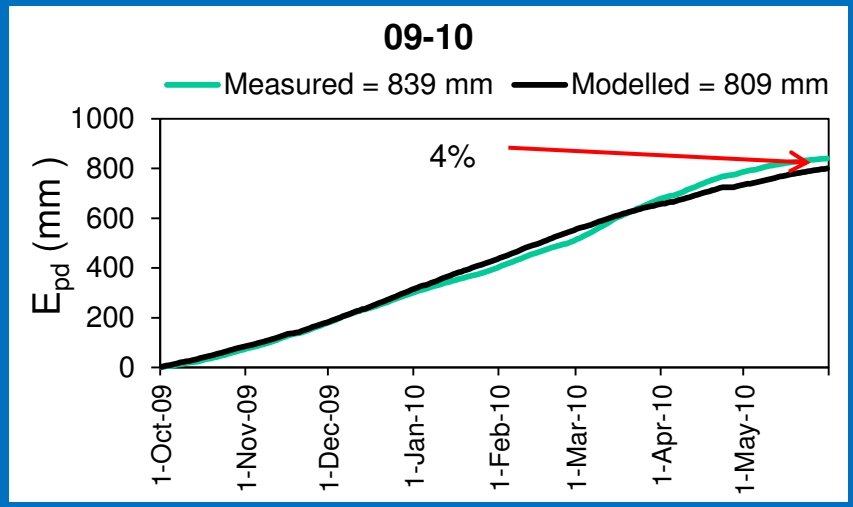
Season	Tree	Planting year	R^2	a $\mu Emol^{-1}$	b $\mu Emol^{-1}\ kPa^{-1}$
10-11	Macadamia	2005	0.87	705	4372
11-12	Macadamia		0.58	318	3744
09-10	Pecan	1975	0.65	900	2930
10-11	Pecan		0.85	1019	2832
11-12	Pecan		0.58	35	2142
12-13 (10m x 10m)	Pecan	2006	0.65	3467	4569
12-13 (10 m x 5m)	Pecan		0.60	5546	5926

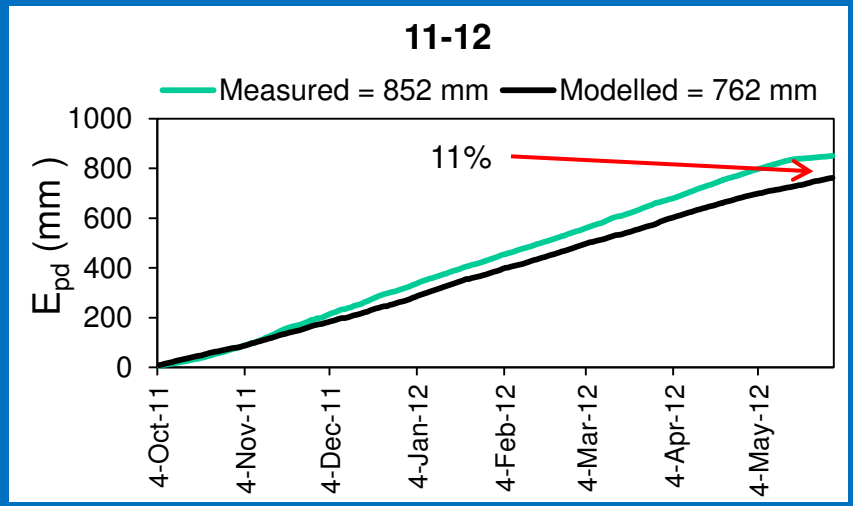
Measured vs. modelled daily transpiration (E_{pd}) of macadamia trees



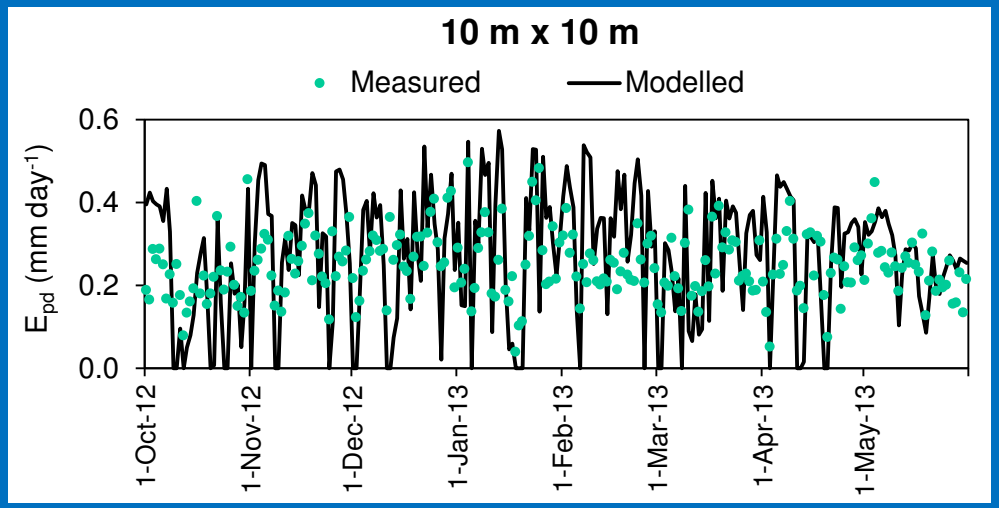
Measured vs. modelled daily transpiration (E_{pd}) of mature pecan trees

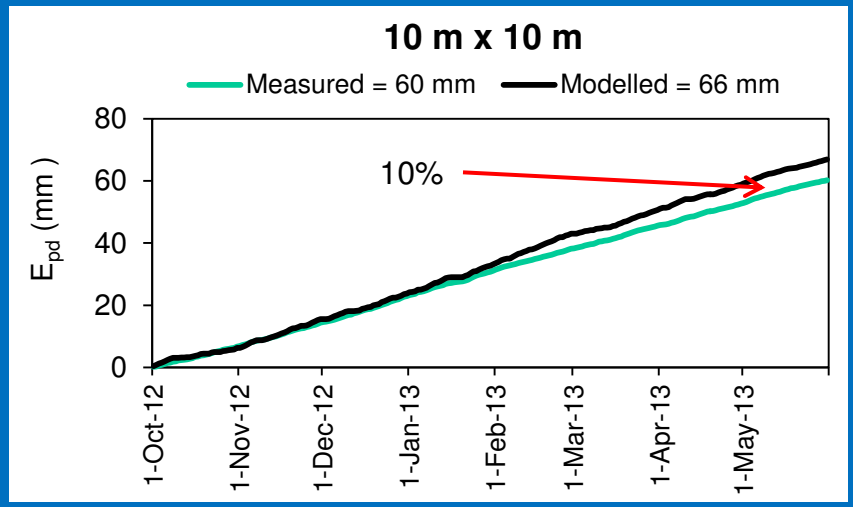


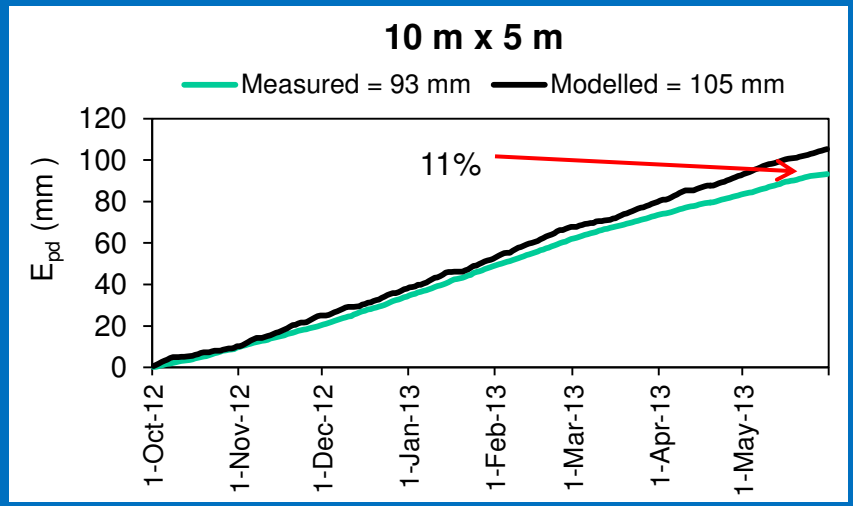




Measured vs. modelled daily transpiration (E_{pd}) of young pecan trees







Conclusions

- A simple modelling approach has been successfully parameterized and validated to estimate transpiration of pecans and macadamias.

- This approach shows promising performance to estimate transpiration of other deciduous and evergreen fruit trees.

- The crop specific parameters used in this simple canopy conductance approach to model E_{pd} seem to be more conservative for evergreen than for deciduous species, resulting in more accurate predictions of E_{pd} in the former.

Acknowledgements

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