Carbon stocks and fluxes in the Andean treeline of *Polylepis reticulata* in Ecuador:

present balance and projected values for the XXI century.

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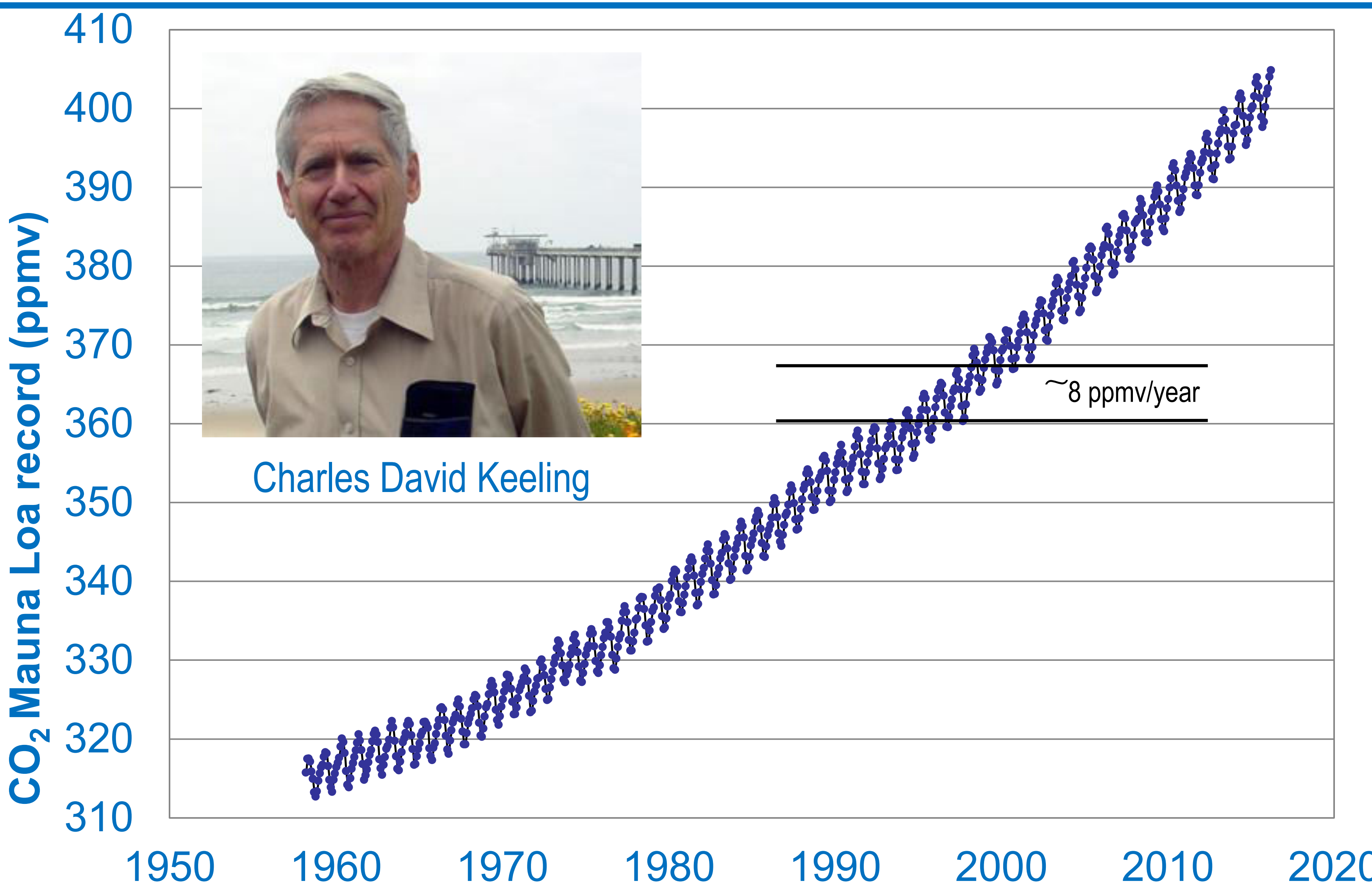
Background:

- Frequent oppinions about afforestation to reduce atmospheric CO_2, often without good empiric data on the table...
- but.....
- **What is the role of forests in this context?**
- **What about side effects i.e. shortage of water in arid and semi-arid areas in the world?**

CO_2 concentration at Mauna Loa



Updated April 2016

Background

- *Polylepis* species are among the trees living at higher altitude in the world.

- The genus is endemic from the Andean *Cordillera.* These are **forests at the limit**.

- *P. reticulata* is one of these species living between 3800 and more than 4500 m a.s.l. in the Ecuadorian Andes.

- The open question is**: How *Polylepis* will cope with the increasing temperature and increasingly dry periods?.**

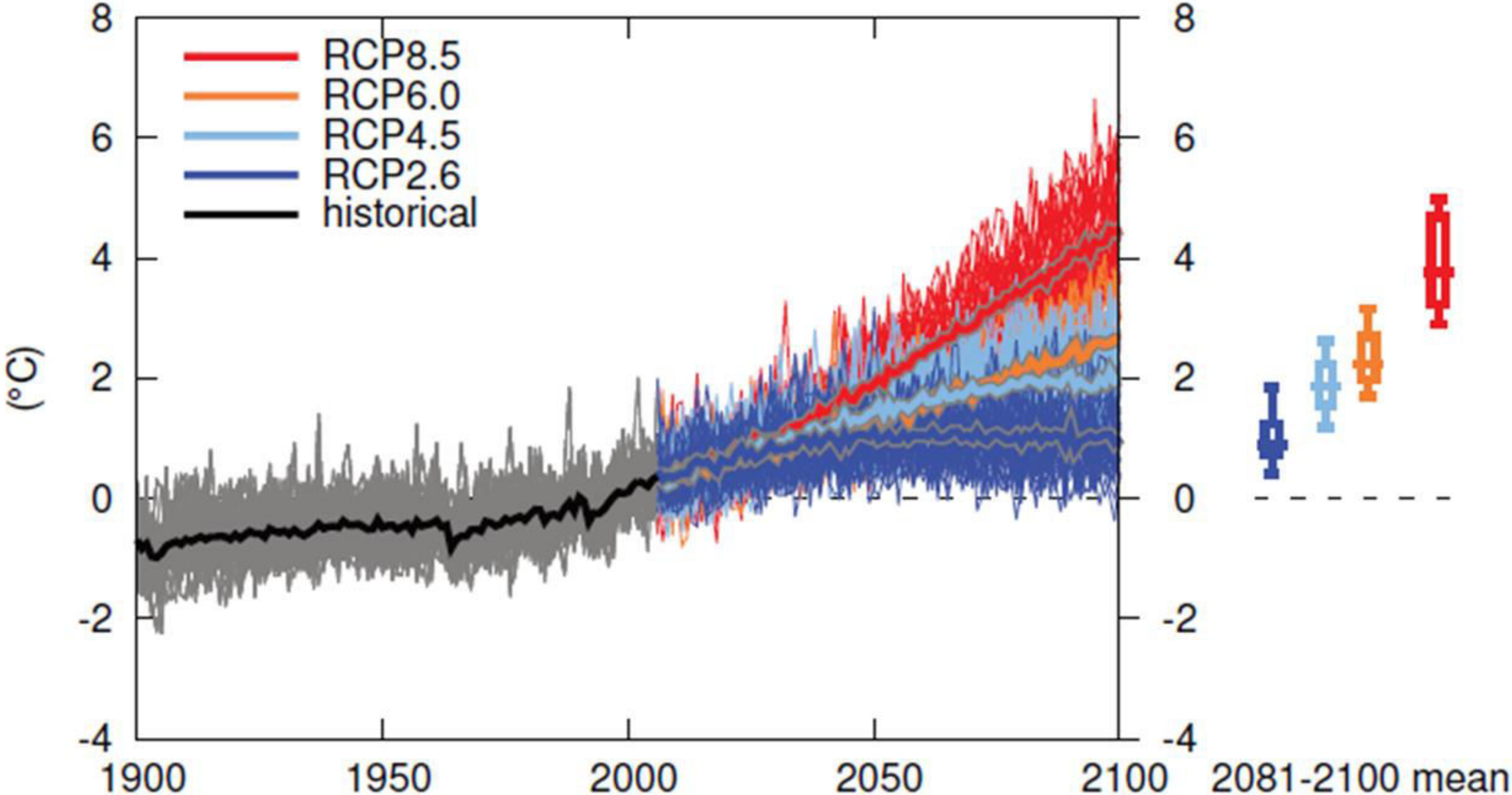
Two main objectives:

- To understand the basic ecophysiology of *Polylepis reticulata* by analyzing the carbon stocks and fluxes.

- To explore the possible responses of *P. reticulata* to Climate Change in the coming decades.

Temperature change

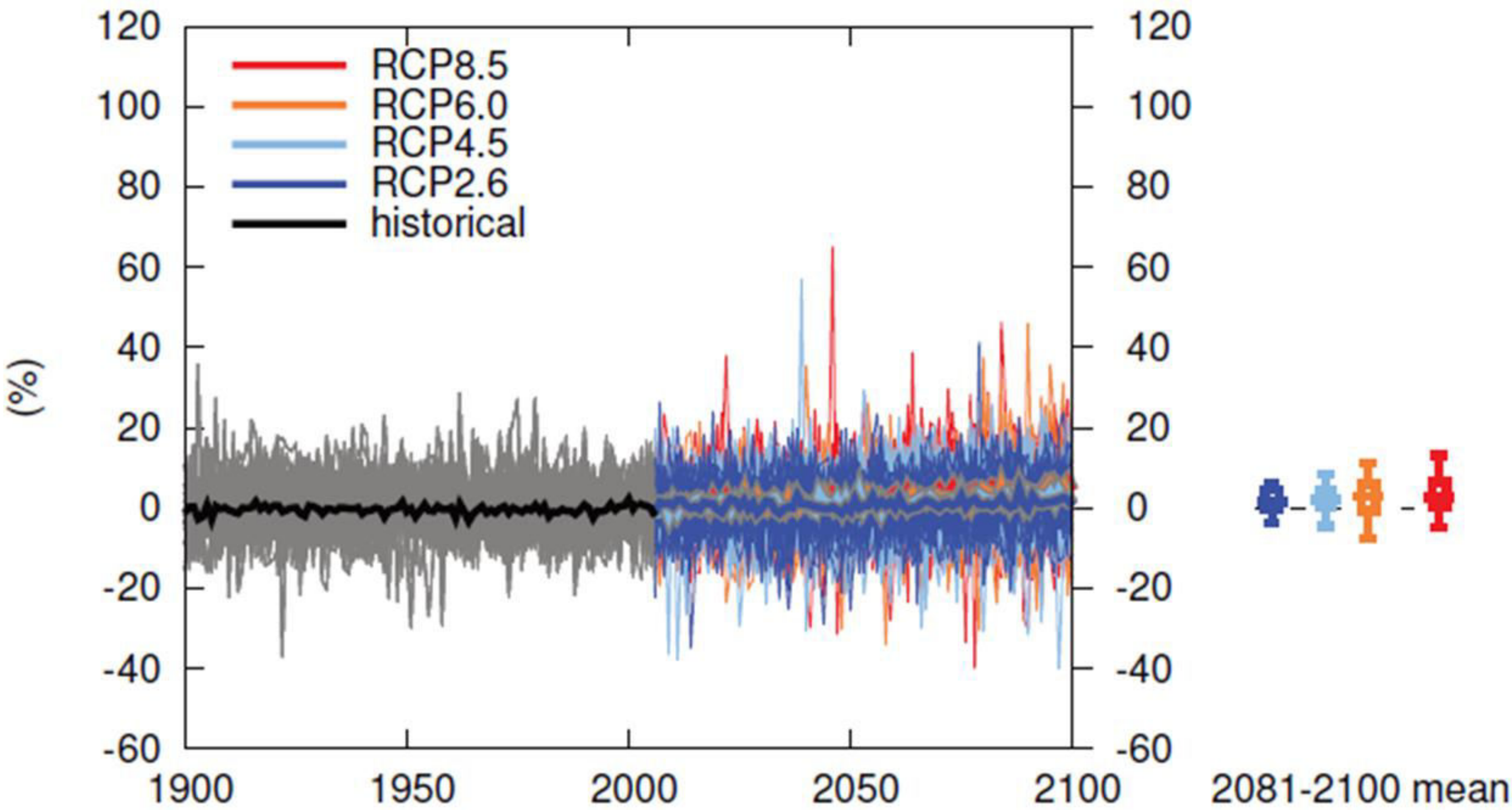
West Coast South America…



Source: IPCC, 5th AR, 2013

Precipitation change

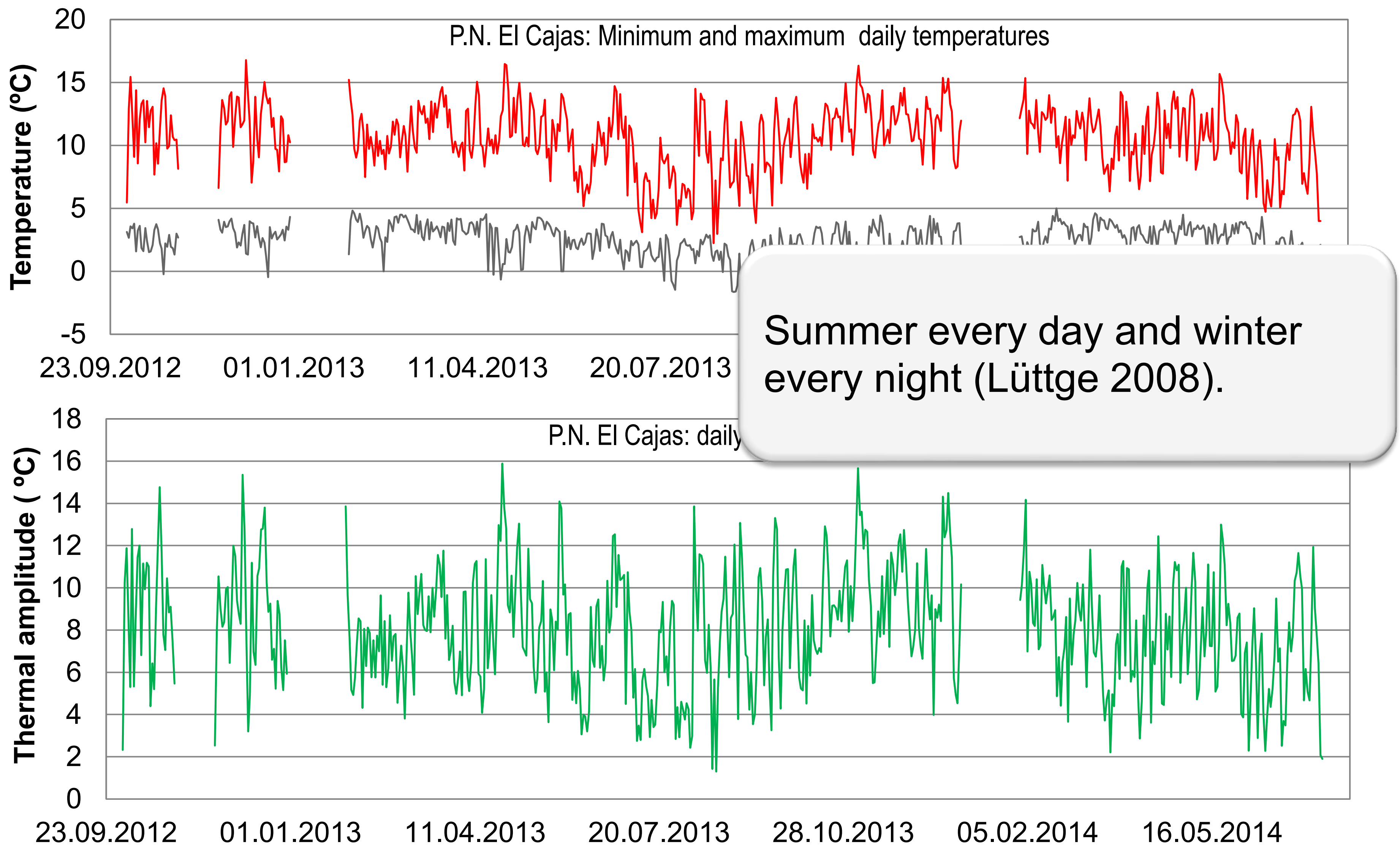
West Coast South America…



Source: IPCC, 5th AR, 2013


Environmental conditions…

Temperature and thermal amplitude...

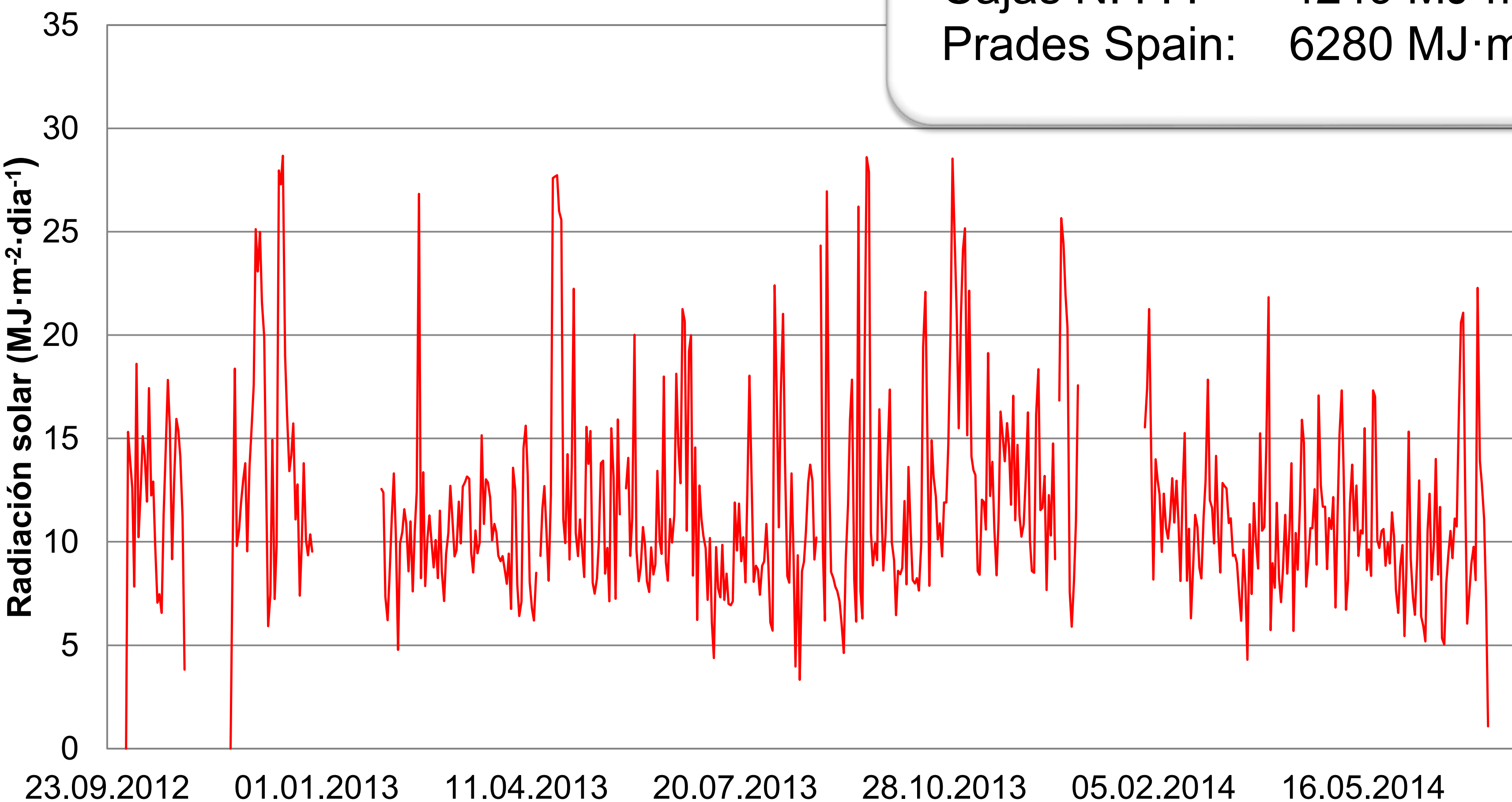


Summer every day and winter every night (Lüttge 2008).

Annual Solar Radiation…

Annual Solar Radiation:

Cajas N. P. : 4249 $MJ \cdot m^{-2}$
Prades Spain: 6280 $MJ \cdot m^{-2}$



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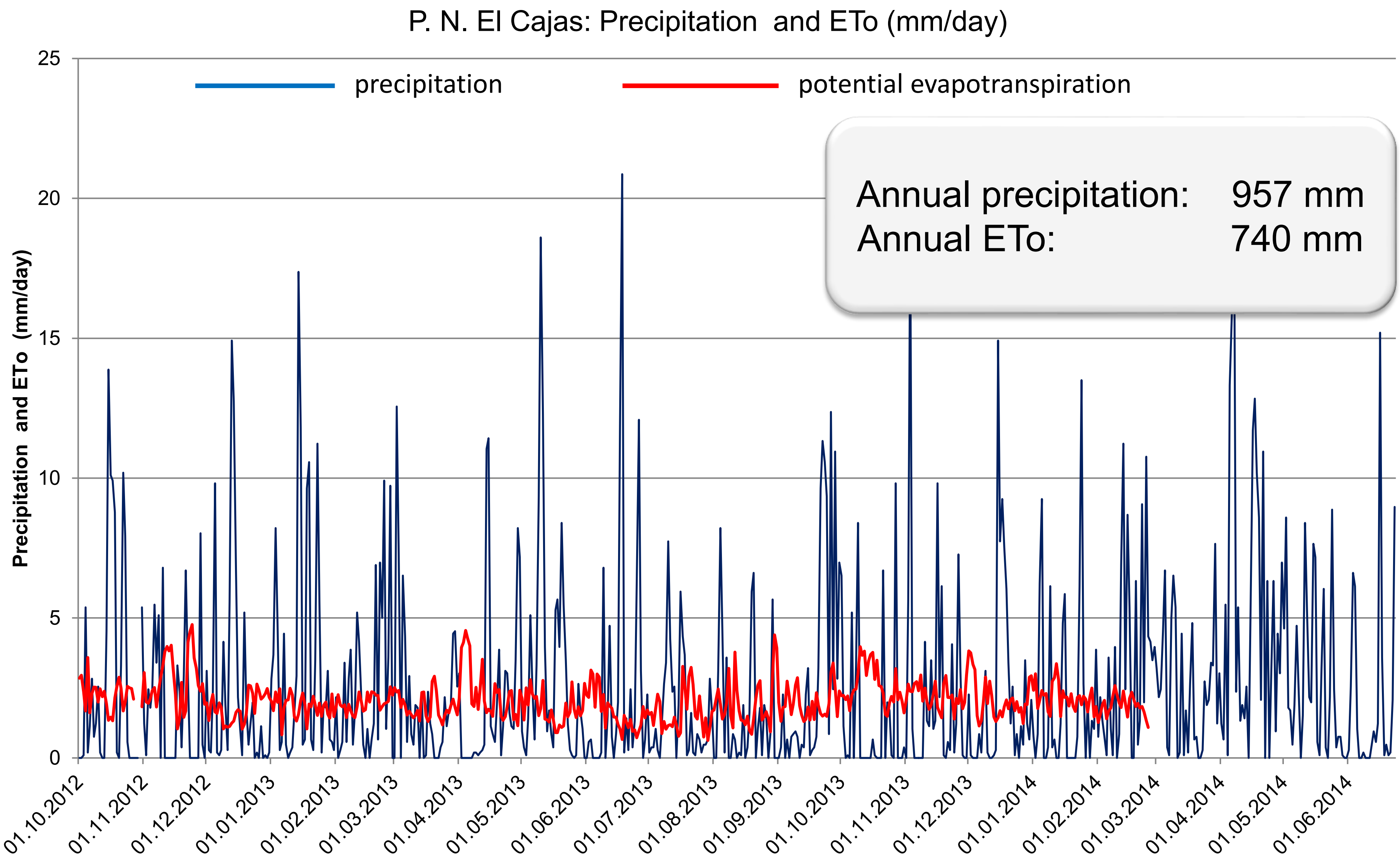
The high UV component of solar radiation induces particular responses of vegetation such as...

...the common white hairy leaves very efficient to reflect incident radiation.

Precipitation vs. ET_0...




Polylepis reticulata

Polylepis reticulata Cajas N.P.

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Polylepis reticulata Burines valley

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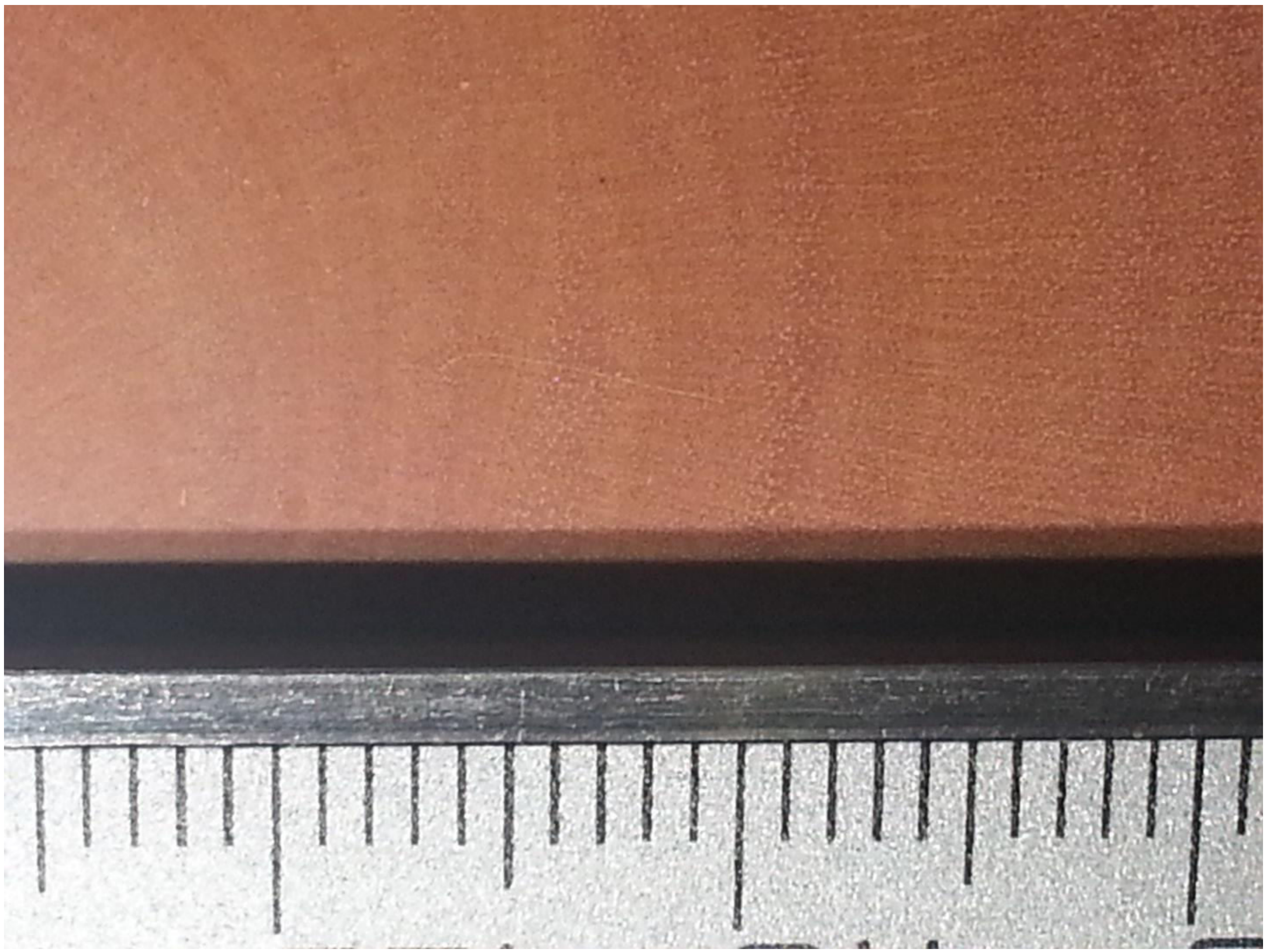
Polylepis reticulata

Polylepis reticulata Quinoas plot

Growth pattern... **no annual tree rings**

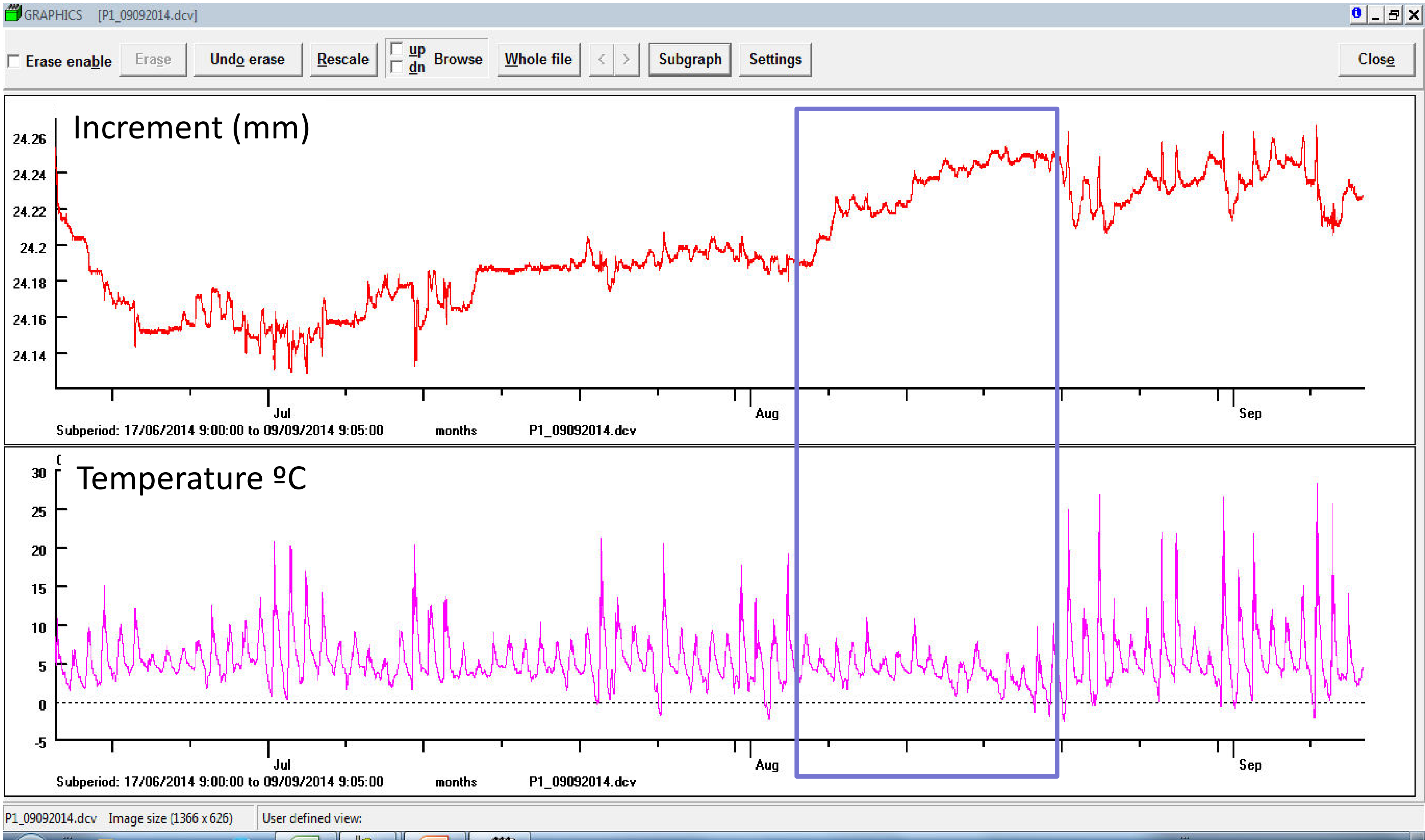


- To estimate the annual growth rate, tree ring analysis is required.
- Tree rings not easy to identify and most of the visible rings are not annuals.

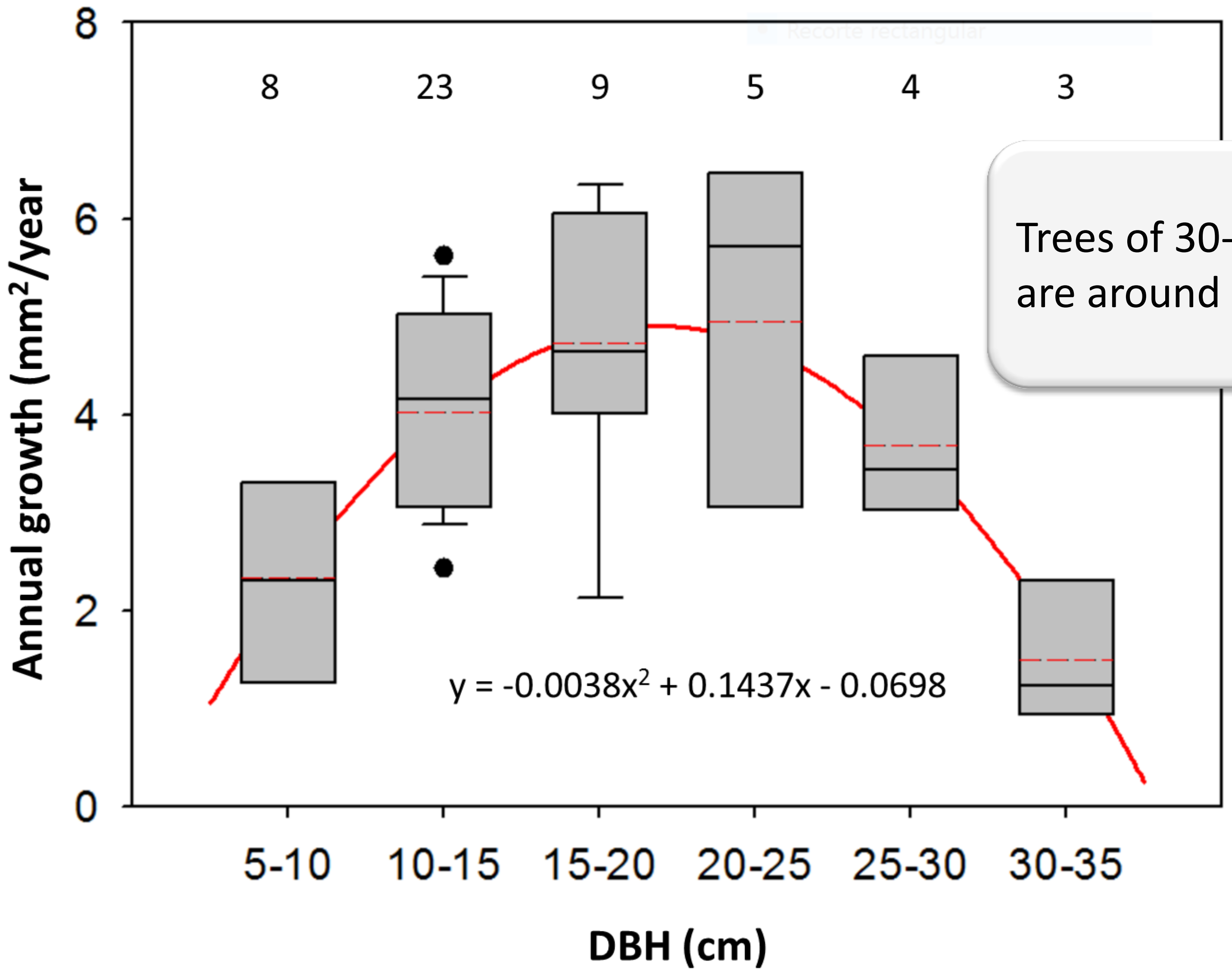
Polylepis growth rates…..

The growth rate has been estimated using continuous recording with dendrometers

Dendrometric continuous recording



Annual growth as a function of tree size



Trees of 30-35 cm DBH are around 400 years old.

Light response of photosynthesis

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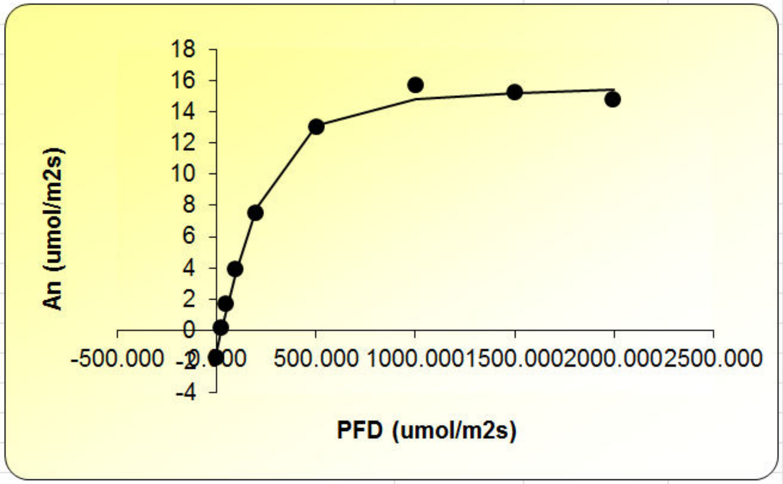
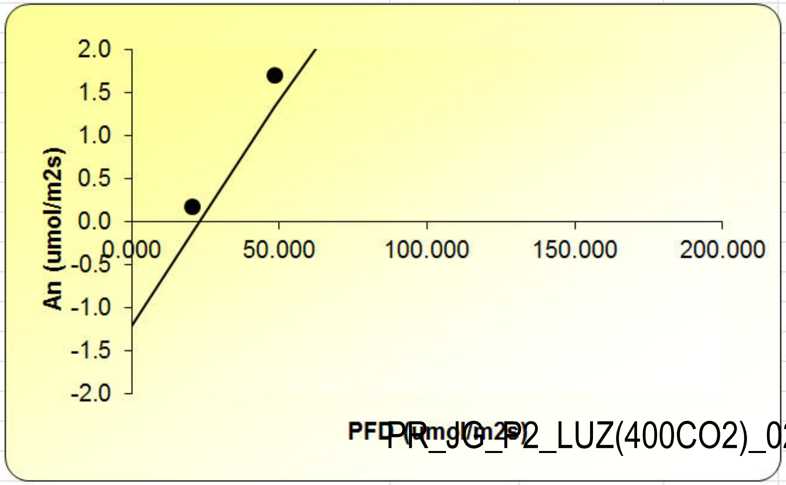
µmol m^{-2} s^{-1}	mol/mol	µmol m^{-2} s^{-1}	µmol m^{-2} s^{-1}	---	µmol m^{-2} s^{-1}	---
Dark respiration	Apparent Quantum Yield	Light Compensation Point	Maximum Net Assimilation Rate	Curvature		
R_{dark}	ϕ	LCP	Amax	θ	SSD	r^2
1.21	0.054	22.74	17.14	0.83	1.82	0.995

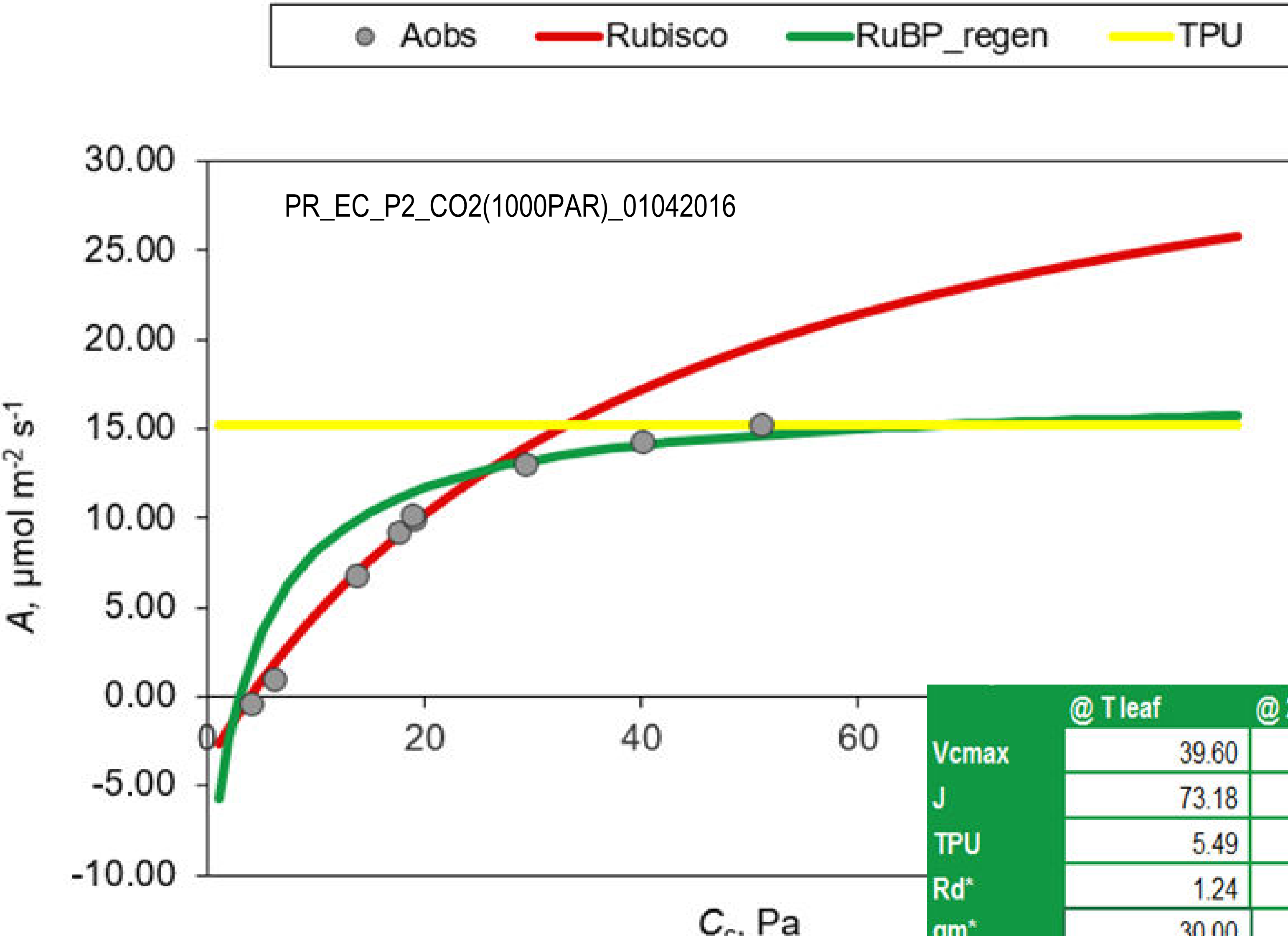
Observations		Predictions
PFD	An	Pred An
-0.066	-1.7	-1.2
20.789	0.2	-0.1
48.566	1.7	1.3
98.431	3.9	3.8
199.000	7.5	7.8
502.439	13.0	13.2
1002.367	15.7	14.8
1500.981	15.2	15.2
1997.661	14.8	15.4





PR_JG_P2_LUZ(400CO2)_02062016

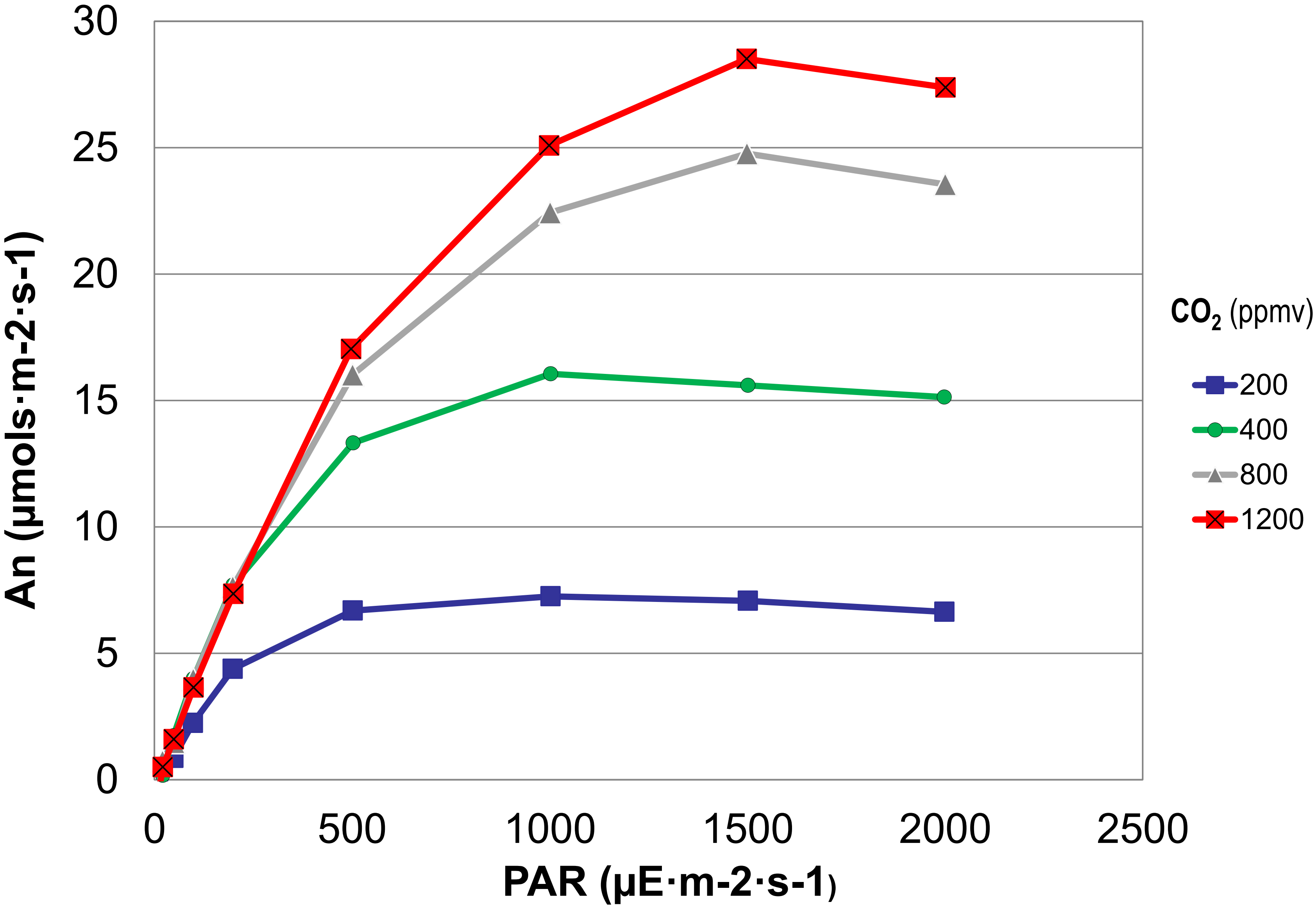
response of photosynthesis to CO_2



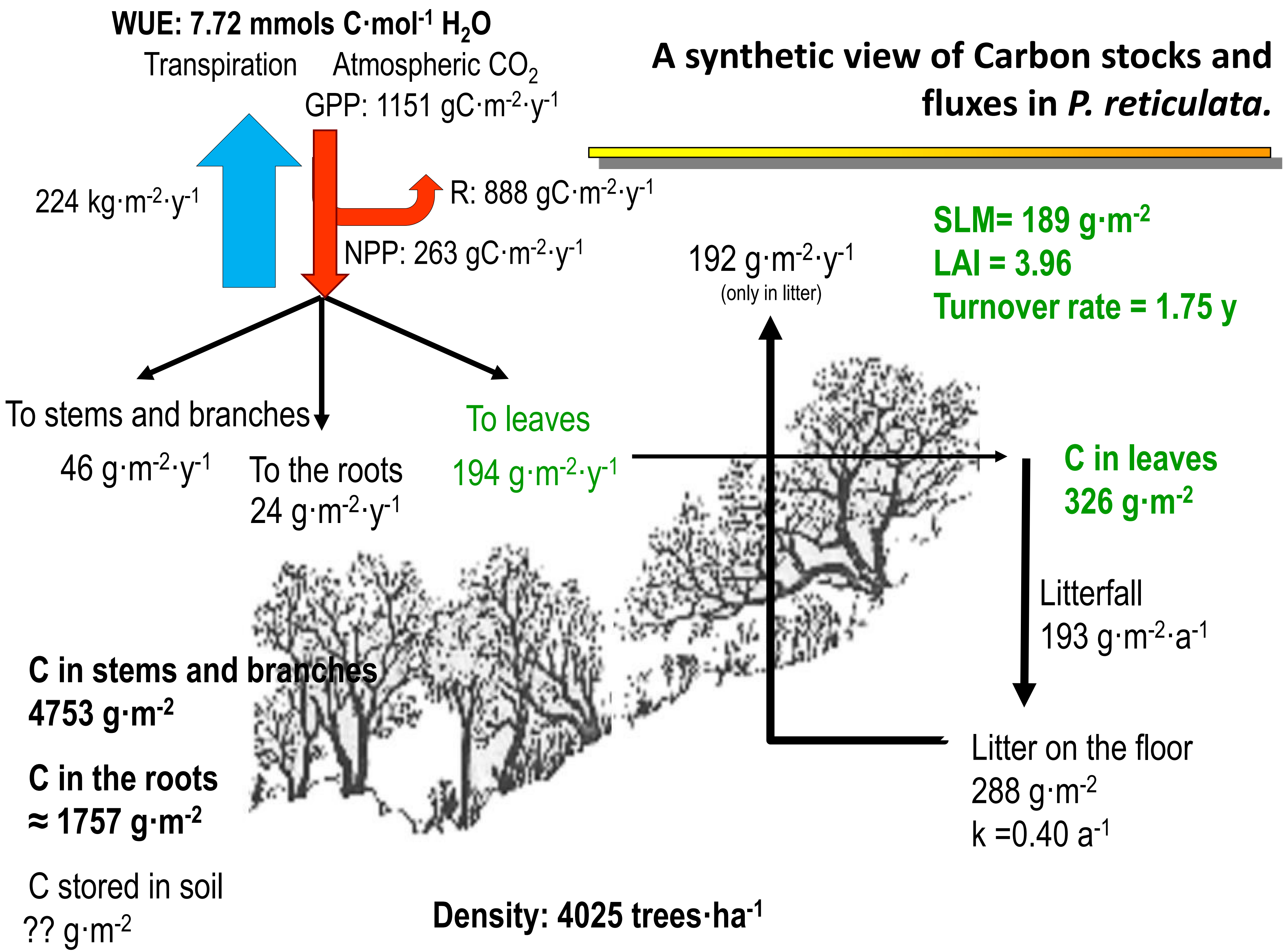
	@ T leaf	@ 25°C	
Vcmax	39.60	49.67	$\mu mol\ m^{-2}\ s^{-1}$
J	73.18	85.21	$\mu mol\ m^{-2}\ s^{-1}$
TPU	5.49	6.47	$\mu mol\ m^{-2}\ s^{-1}$
Rd*	1.24	1.46	$\mu mol\ m^{-2}\ s^{-1}$
gm*	30.00	35.61	$\mu mol\ m^{-2}\ s^{-1}\ Pa^{-1}$

PR_JG_P2_LUZ(400CO2)_02062016

response of photosynthesis to light and CO_2

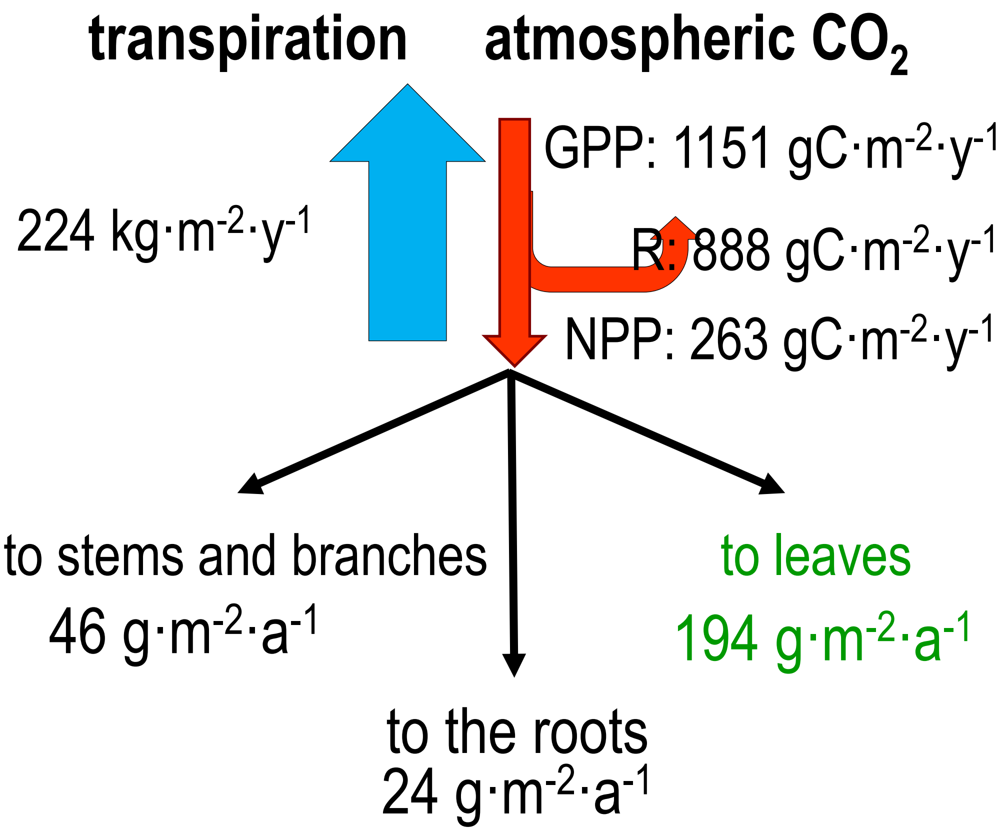


A synthetic view of Carbon stocks and fluxes in *P. reticulata.*



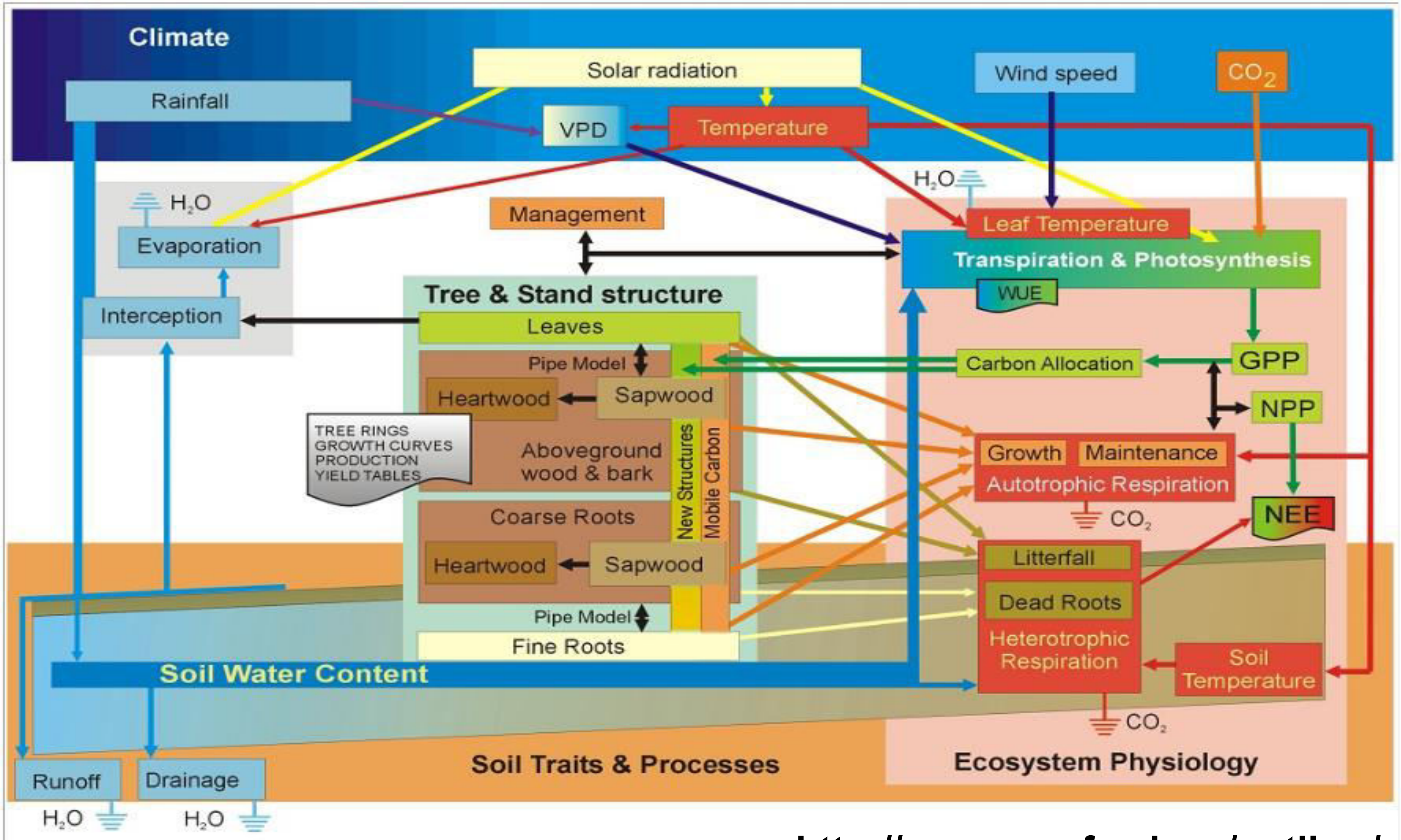
Polylepis at present

WUE: 7.72 mmols C·mol^{-1} H_2O

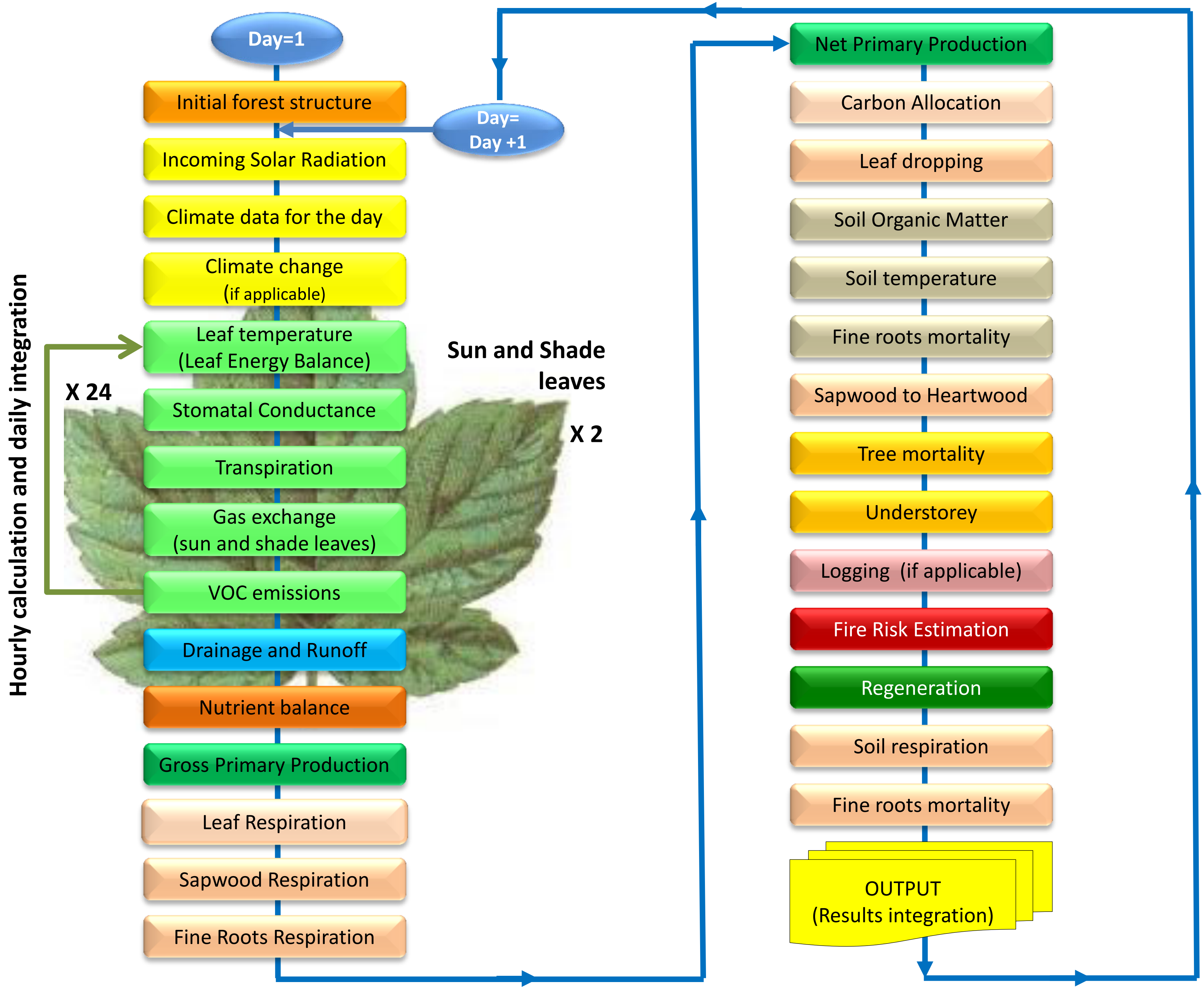


GOTILWA+ model

Gracia *et al.* 1998-2016



http://www.creaf.uab.es/gotilwa/


Day=1
Initial forest structure
Day=
Day +1
Incoming Solar Radiation
Climate data for the day
Climate change
(if applicable)
Leaf temperature
(Leaf Energy Balance)
Stomatal Conductance
Transpiration
Gas exchange
(sun and shade leaves)
VOC emissions
Drainage and Runoff
Nutrient balance
Gross Primary Production
Leaf Respiration
Sapwood Respiration
Fine Roots Respiration
Hourly calculation and daily integration
X 24
Sun and Shade
leaves
X 2
Net Primary Production
Carbon Allocation
Leaf dropping
Soil Organic Matter
Soil temperature
Fine roots mortality
Sapwood to Heartwood
Tree mortality
Understorey
Logging (if applicable)
Fire Risk Estimation
Regeneration
Soil respiration
Fine roots mortality
OUTPUT
(Results integration)

Leaf Energy Balance vs. Gas Exchange

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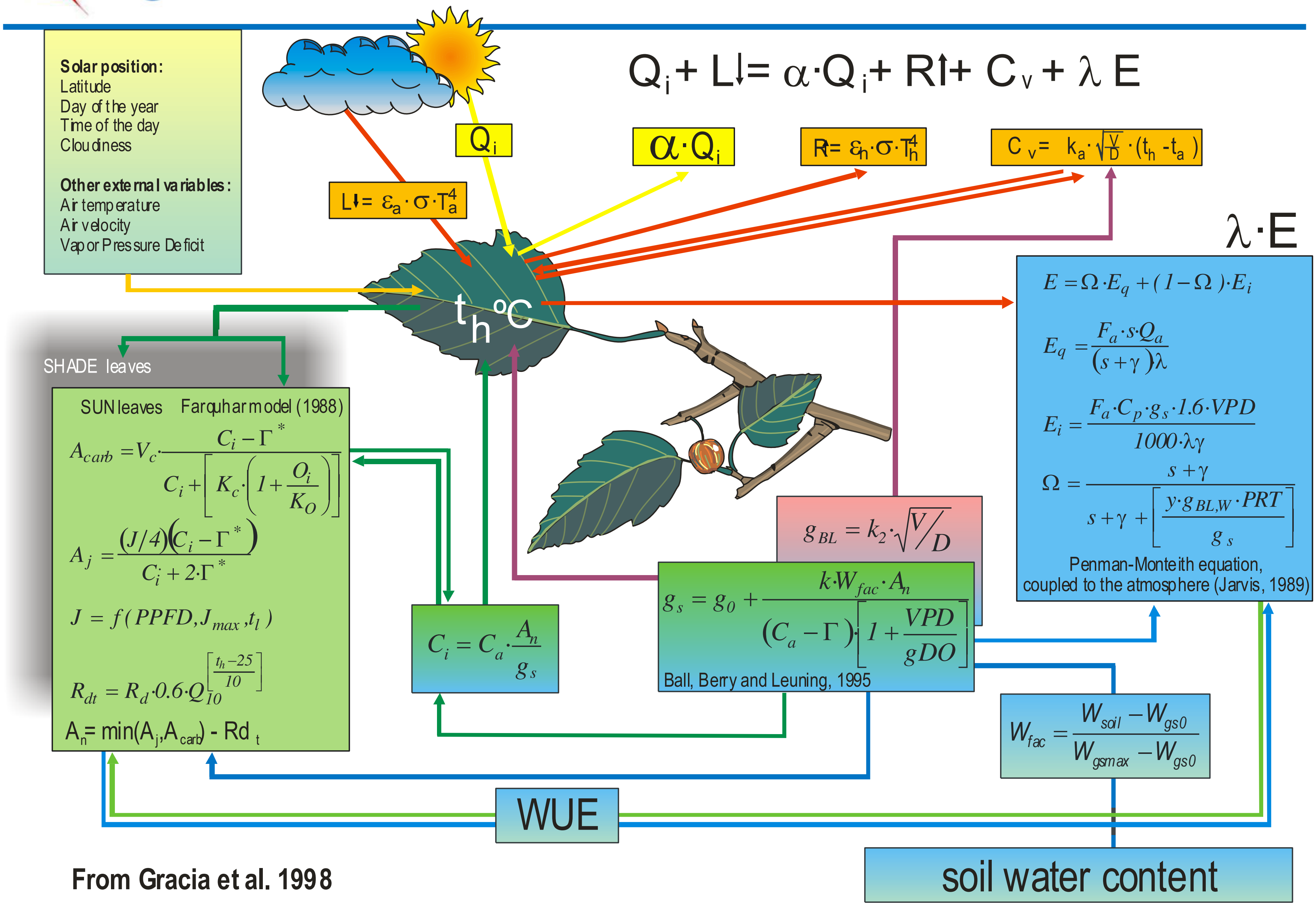
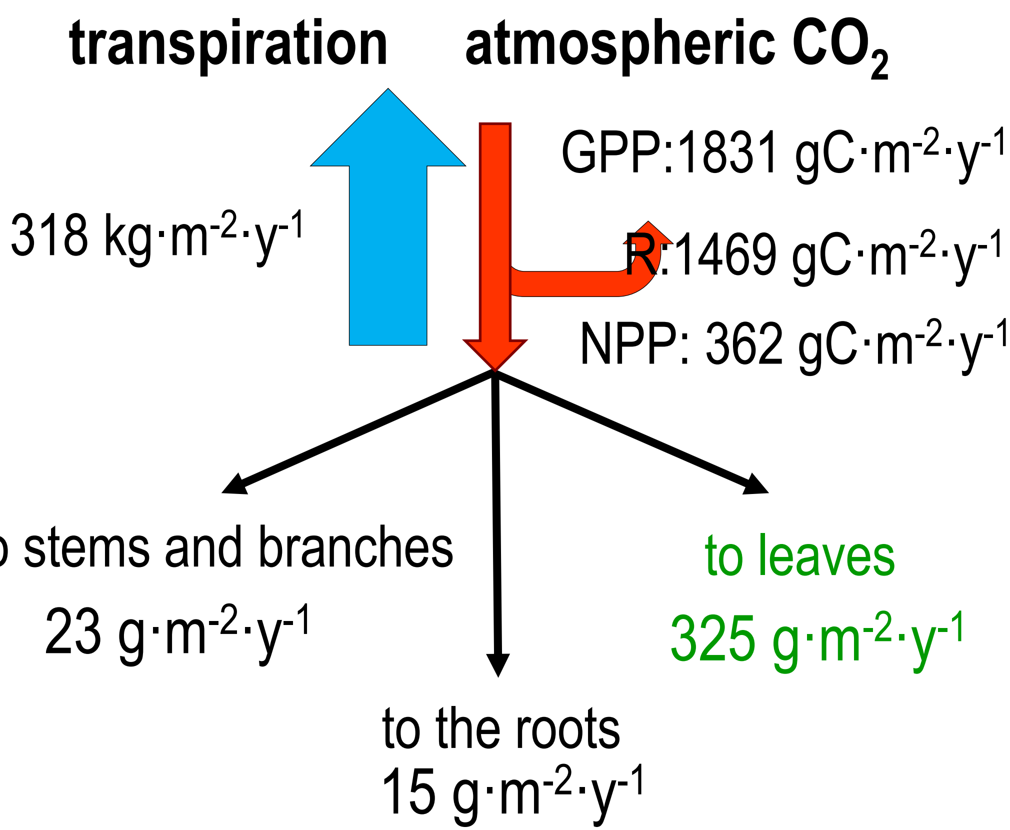


From Gracia et al. 1998

Polylepis 2095-2100

Scenario IPCC RCP 2.6

WUE: 8.64 mmols C·mol^{-1} H_2O



Polylepis 2095-2100

Sce… …3.5

WUE: 13.4 mmols C… …$^{-1}$ H_2O

transpiration **a… …eric CO_2**

332 kg·m^{-2}·y^{-1}

GPP:2971 gC·m^{-2}·y^{-1}

R: 2388 gC·m^{-2}·y^{-1}

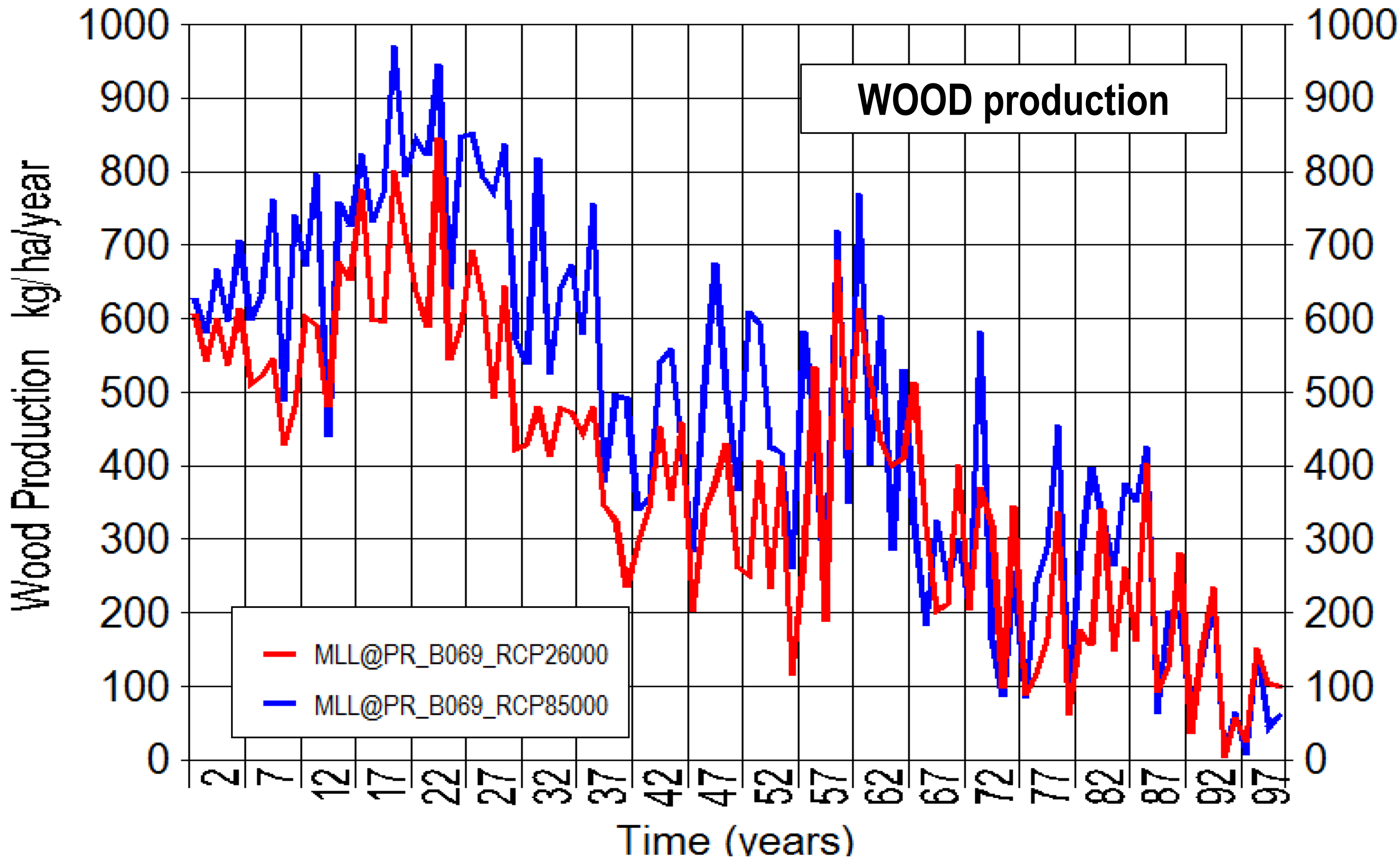
NPP: 584 gC·m^{-2}·y^{-1}

to stems a…

28 g·r…

Acclimation ?

Down regulation of photosynthesis?



La producción de tejidos leñosos experimenta un moderado incremento durante los próximos 20 a 40 años debido a que el aumento de la temperatura se traduce en efectos positivos sobre la fotosíntesis, pero pasado este periodo, las diferencias se van reduciendo drásticamente. A finales de siglo la producción, que hoy es de 500 kg/ha/año, se reduce hasta 60 kg/ha/año

Conclusions...

- 77 per cent of Carbon uptake (1151 $gC \cdot m^{-2} \cdot y^{-1}$) is returned to the atmosphere by respiration (888 $gC \cdot m^{-2} \cdot y^{-1}$).
- 74 per cent of NPP is allocated to leaves.
- In the coming decades increasing temperature and dry periods will increase the respiration rate.
- At present 5 m^3 of water are invested to produce 1 kg of woody tissues
- The amount of water is projected to increase up to 14 m^3 by the end of the century (scenario RCP2.6)

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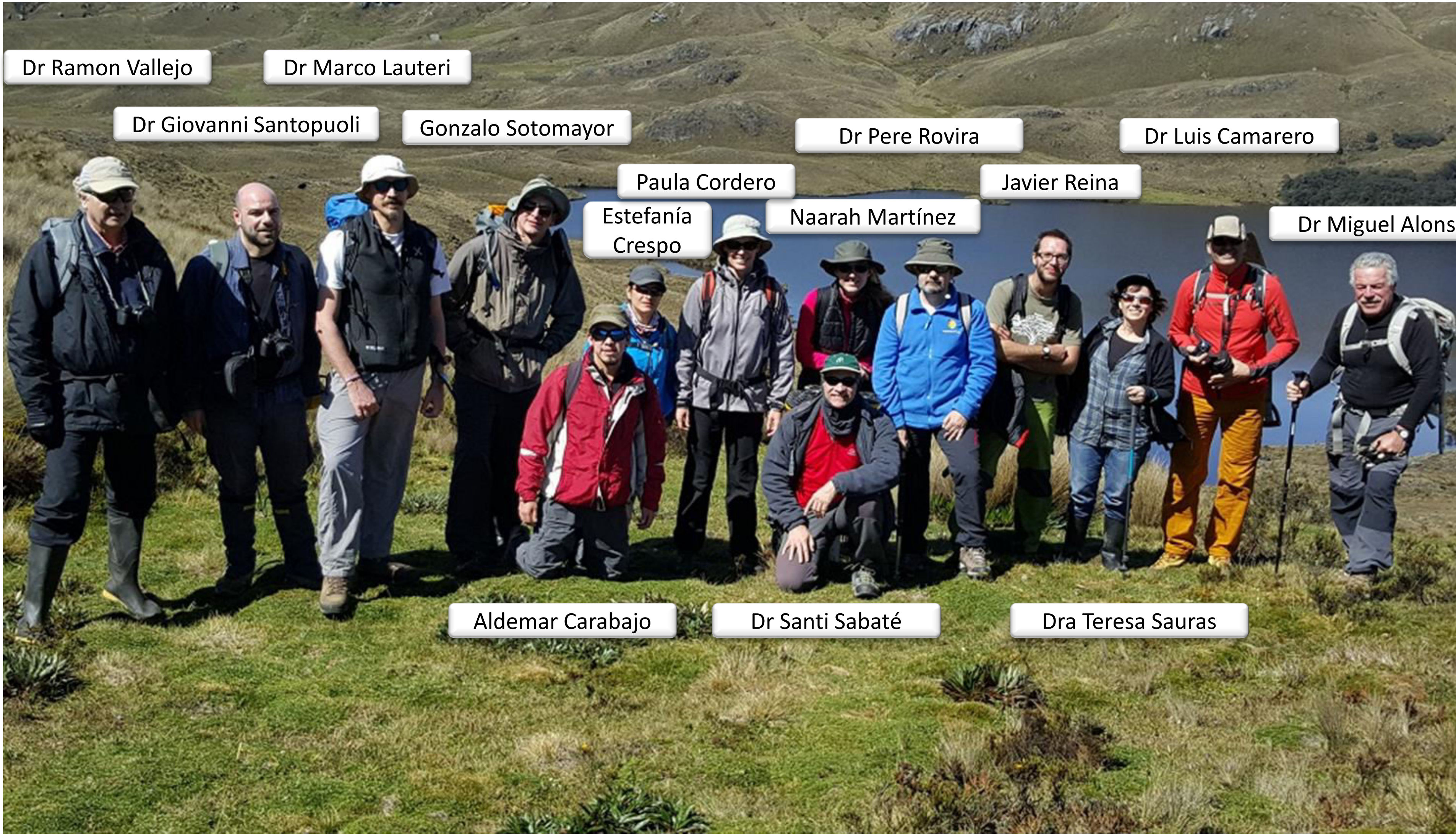
The ECUAFLUX team



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Thank you very much!

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Polylepis reticulata Estrellascocha