Water energy and carbon exchanges in young coniferous plantations: effect of the presence of gorses

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Energy, water and carbon exchanges in young coniferous stands in South West of France

Effect of the presence of a layer of gorse

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Introduction

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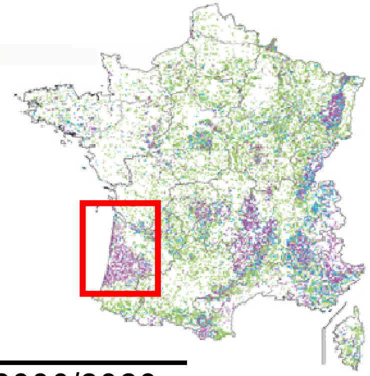

❑ Context

Environmental round table, 2007

Renewable energy production (Mtep)	2006	2020	2006/2020
Heat	**9.7**	**19.7**	**+10.1**
Biomass	8.8	15.0	+6.2
Geothermal energy	0.4	2.3	+1.9
Solar energy	0.00	0.9	+0.9
Waste	0.4	0.9	+0.5
Biogaz	0.00	0.6	+0.5
Electricity	**5.6**	**12.9**	**+7.2**
Hydraulic energy	5.2	5.8	+0.6
Land Wind energy	0.2	3.6	+3.4
Sea Wind energy	0.0	1.4	+1.4
Biomass	0.2	1.4	+1.2
Photovoltaic energy	0.0	0.5	+0.5
Other (geothermal energy, marine energy...)	0.0	0.1	+0.1

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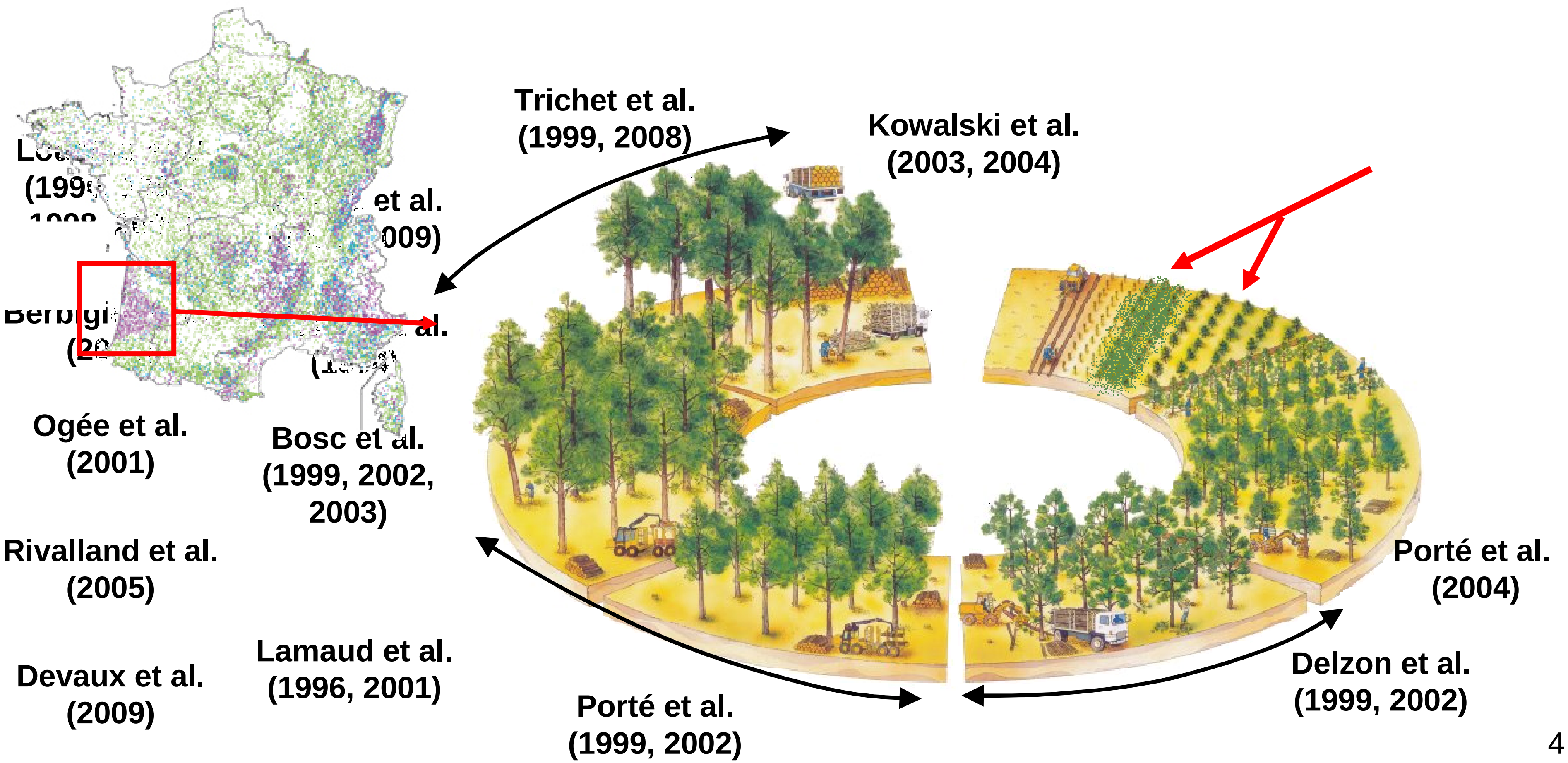
+ 12 Mm^3 in 2012
(ie. 30%)

+ 20 Mm^3 in 2020
(ie. 1 Mm^3/yr)

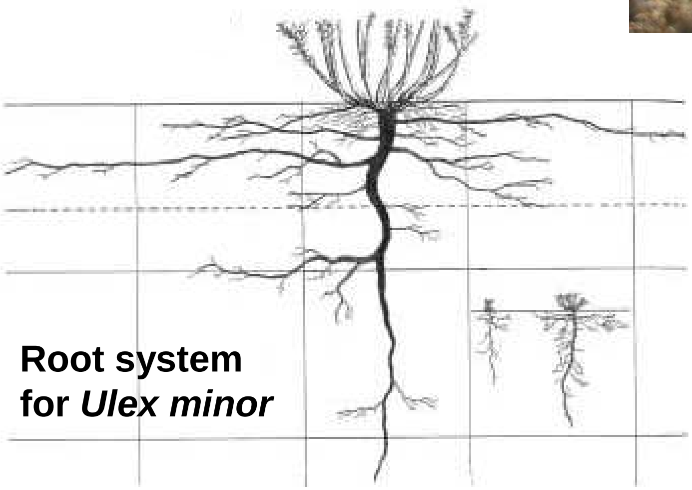
Introduction

➢ Background around the Landes forest (France).

- The process of cultivation and growth follows a production cycle that extends over a period of 45-50 years (*Lesgourgues et al. 1997).*



➢ Nitrogen cycle and legume plants input (Fabaceae)



Root system for *Ulex minor*

Intensification of the forest practices

↓

Sustainibility of the forest ecosystem towards the soil fertility, and water resources ?

↓

Early stage: presence of species as natural N-fixing shrubs

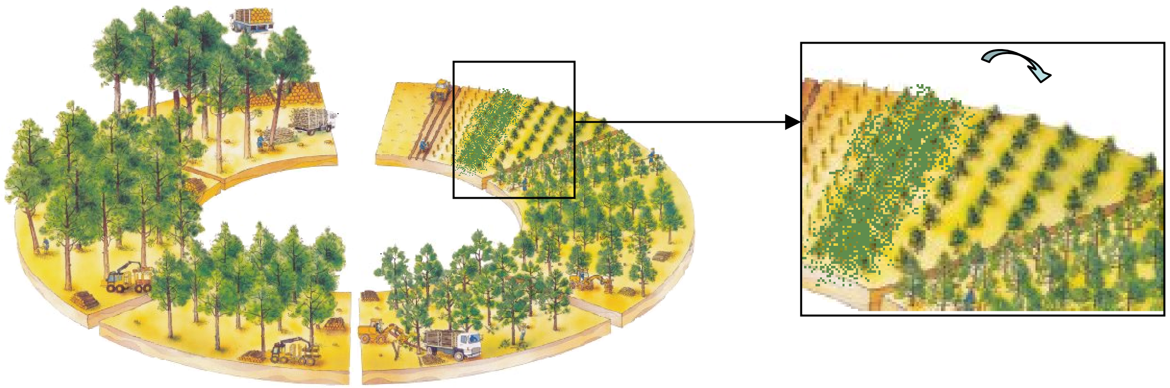
In the Landes forest: gorses and brooms

Ulex Europeaus, *Ulex Minor* and *Cytisus scoparius*

Heath and Luckwill, 1938, Gloaeguen 1986, Stokes 2002, Augusto et al. 2005, 2010

Introduction

❑ Main objective



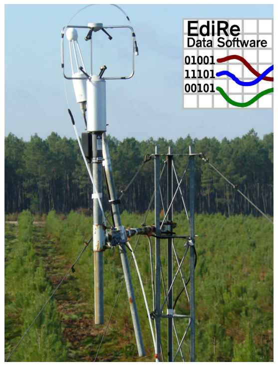
➢ analyse the effects of a the first sylvicultural pratice on the energy, water and carbon **fluxes** from two **young** maritime pine stands: JUNE 2009 – MAY 2010


Material & Method

Material & method

❑ Paired measurements in the two sites

DATA :	CONTROL (C)	WEEDED (W)
Tree species	*Pinus pinaster*, Ait	*Pinus pinaster*, Ait
Age (July 2009)	4 years	5 years
Forest practices	None	1st weeded and depressing in November 2008 2nd weeded in November 2009
Stocking (tree.ha^{-1})	14400	1803
Mean LAI (m^2.m^{-2})	2.62	0.79



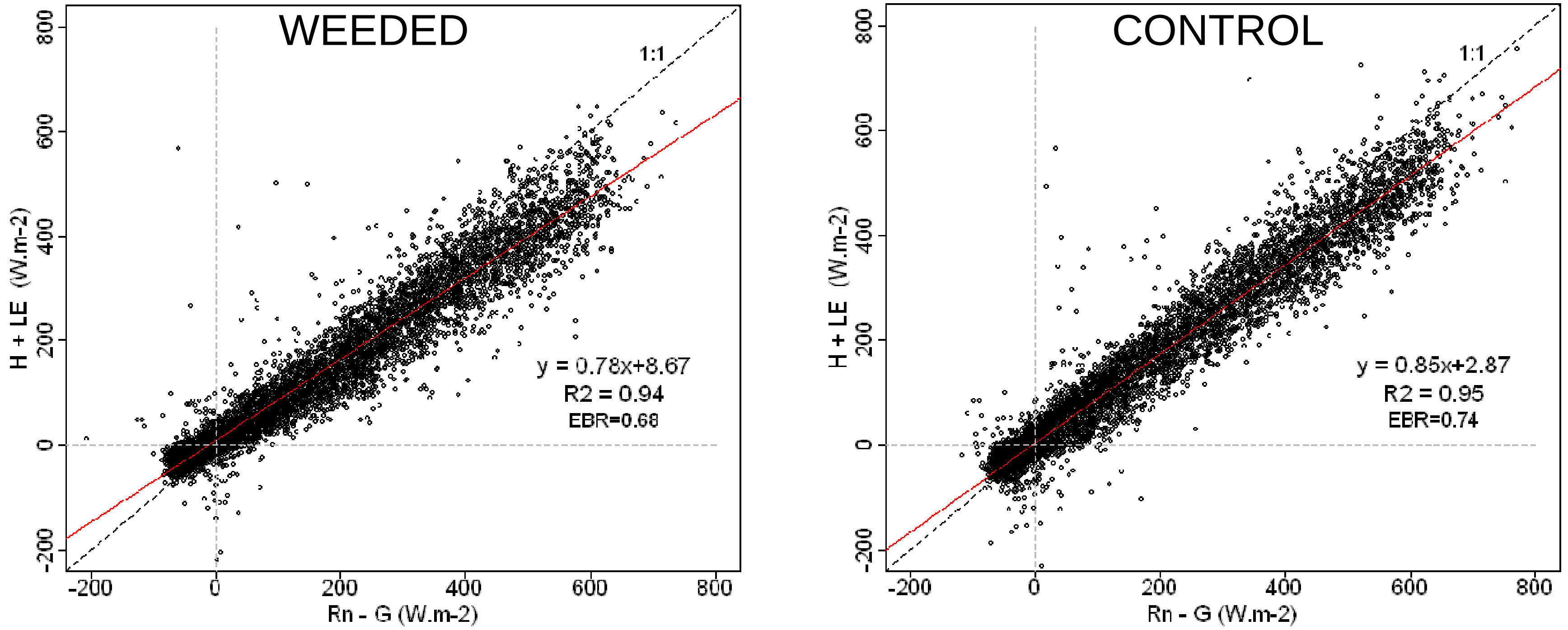
JUNE 2009 – MAY 2010

Results

Energy balance
Water exchanges
Carbon exchanges

Results

❑ Energy balance closure (EBC)



➢ EBC is better closed on the CONTROL with a slope of 0.78 compared to a slope of 0.85 on WEEDED.

- **Literature:**

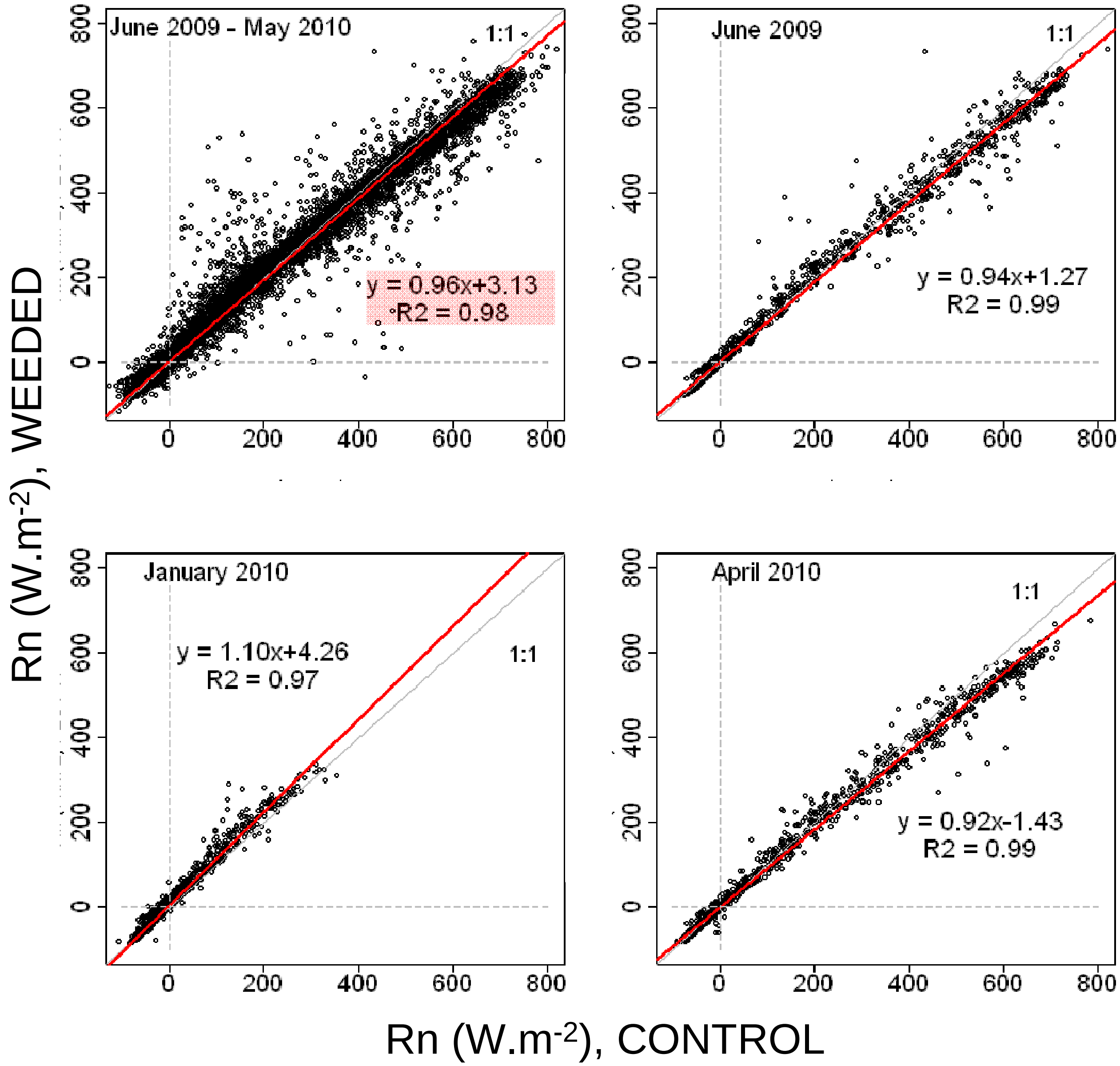
Wilson et al 2002 : slope: 0.79 ± 0.01, intercept: 3.7 ± 2.0
Berbigier et al 2001 : slope: 0.86, intercept: 0.007

Results

❑ Energy balance

W

C



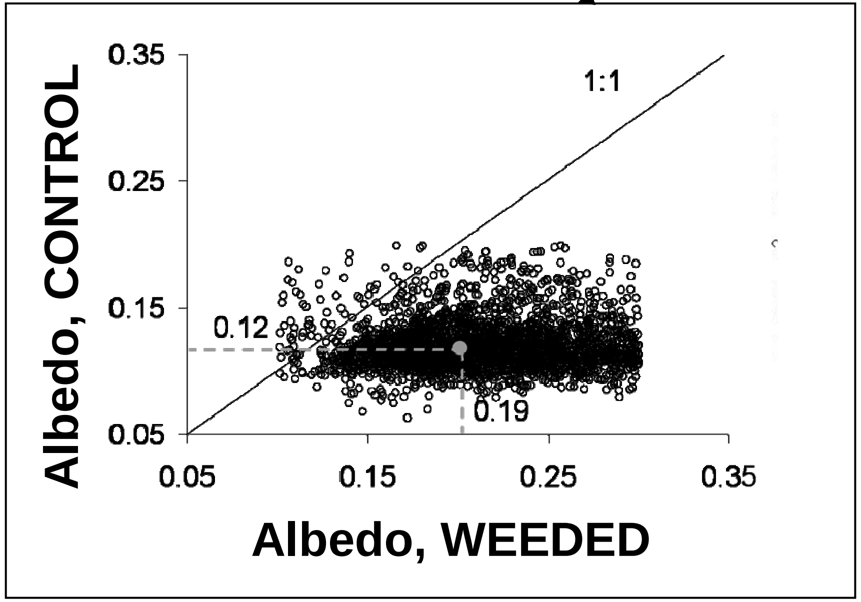
- **Annually**
  - Rn (W) < Rn (C)
  - Difference of ~4%
- **Seasonally**
  - High differences from April to July
  - Reversed in winter

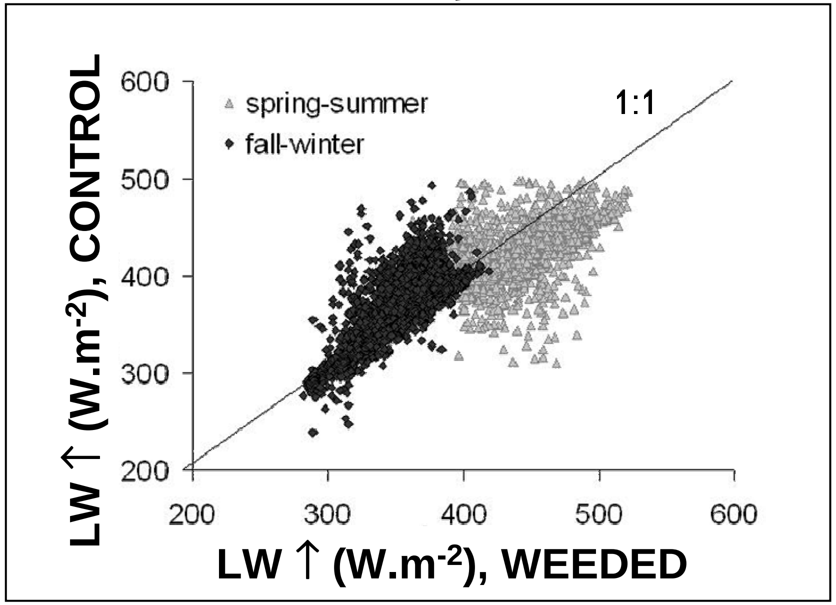
Results

W

C

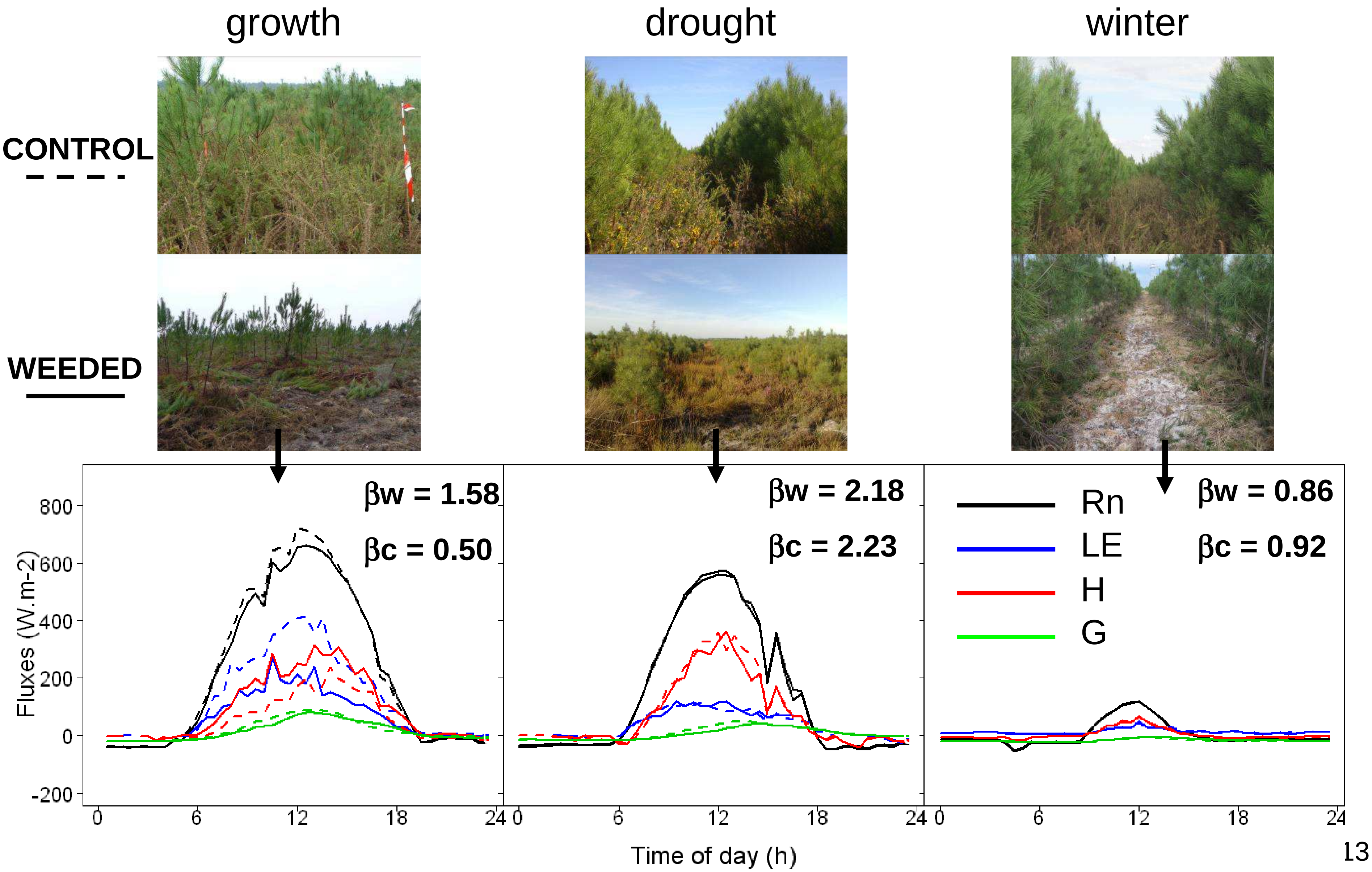
$$Rn = Rg - aRg + LW\downarrow - LW\uparrow$$





Effect of albedo is compensated by the effect of LW ↑

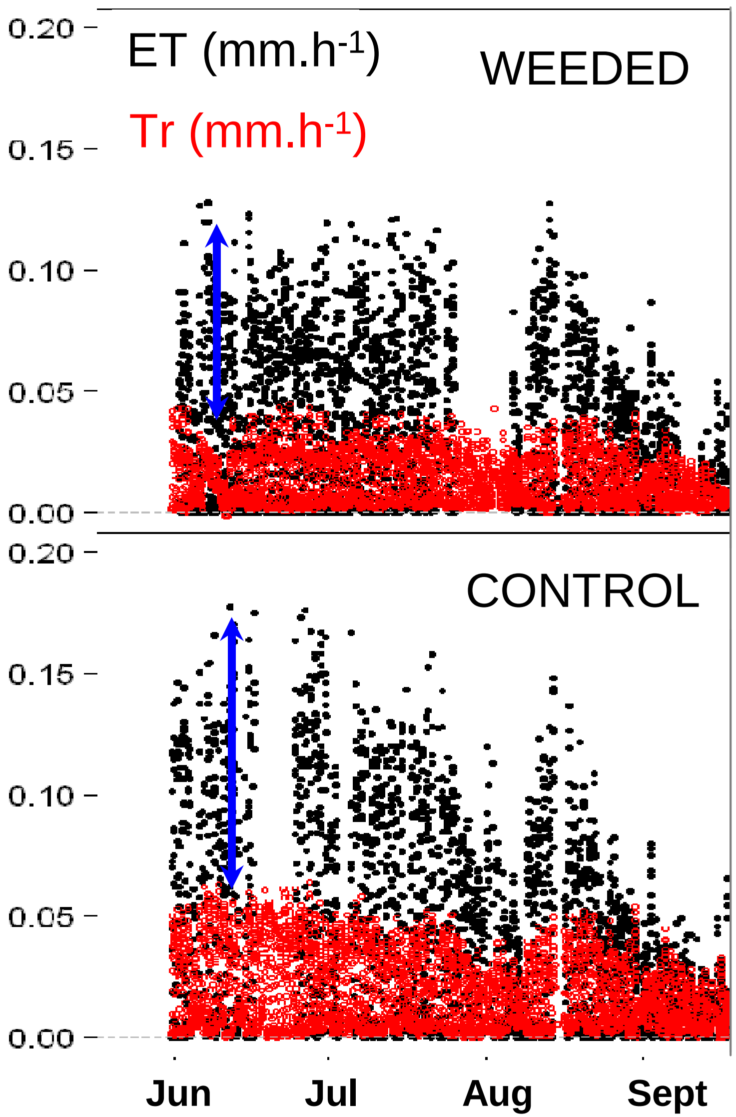
❑ Partionning of the energy fluxes



Results

Water balance

- Partitionning between evapotranspiration (ET) and transpiration (Tr)



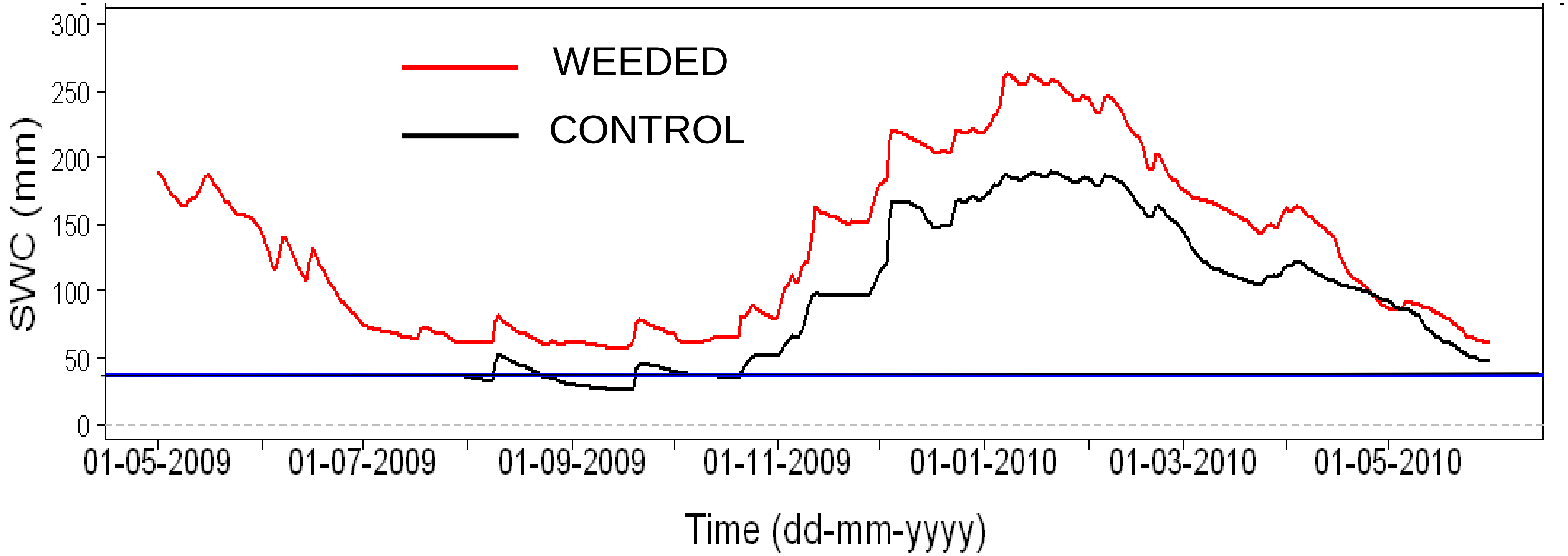
- **Total ET** comparison:
  Growing season: ET (C) = **1.5** ET (W)
  Drought: ET (C) = ET (W)

- **Pine Tr** comparison:
  Growing season: Tr (C) = **1.5** Tr (W)
  Drought: Tr (C) = **1.5** Tr (W)

- **(ET – Tr)** comparison:
  Growing season: Higher on the control plot
  Drought: Similar

Vegetation layer is more sensitive to drought

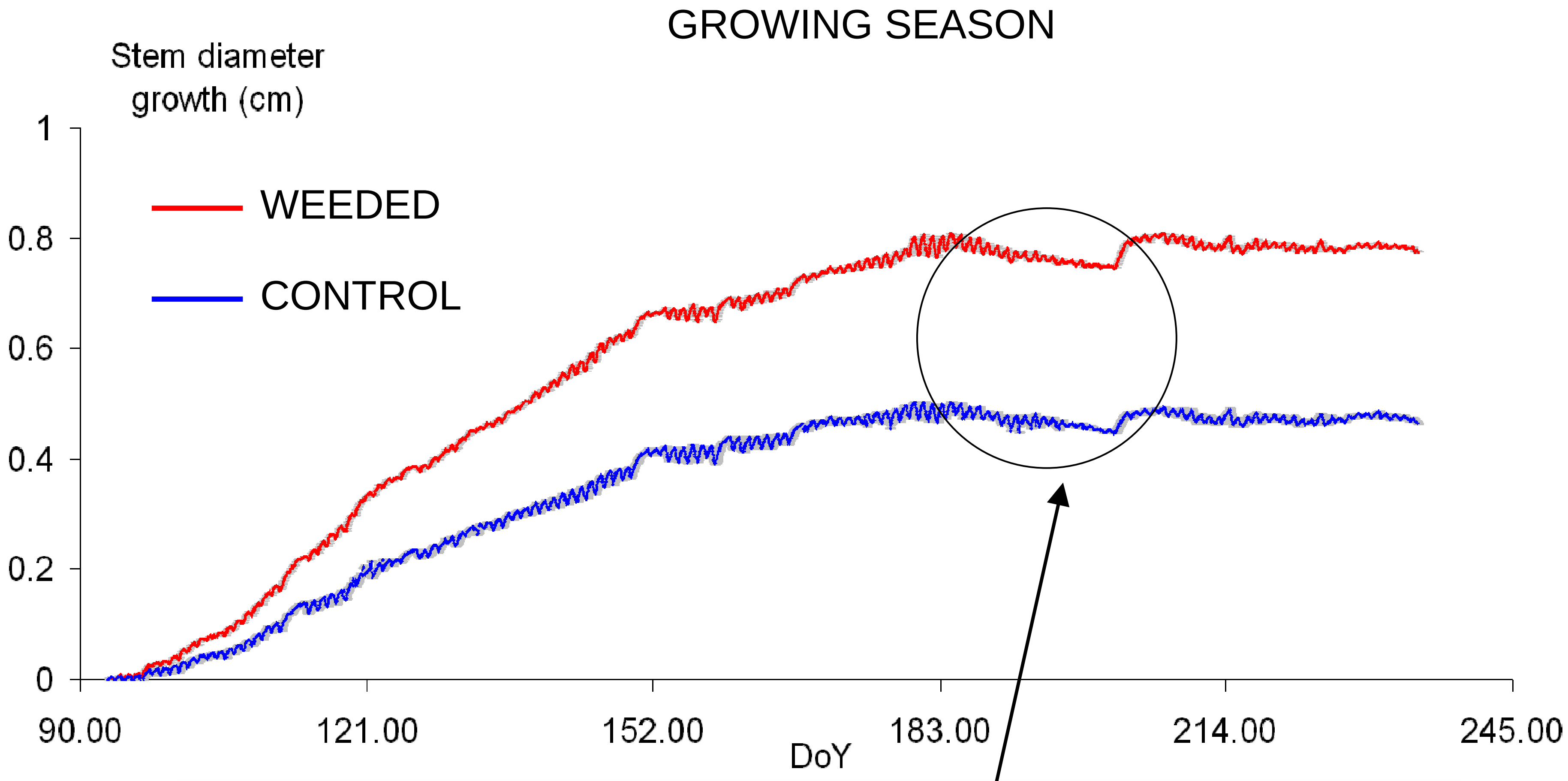
➢ Soil water content (0-80cm)



SWC higher in the weeded plot due to:

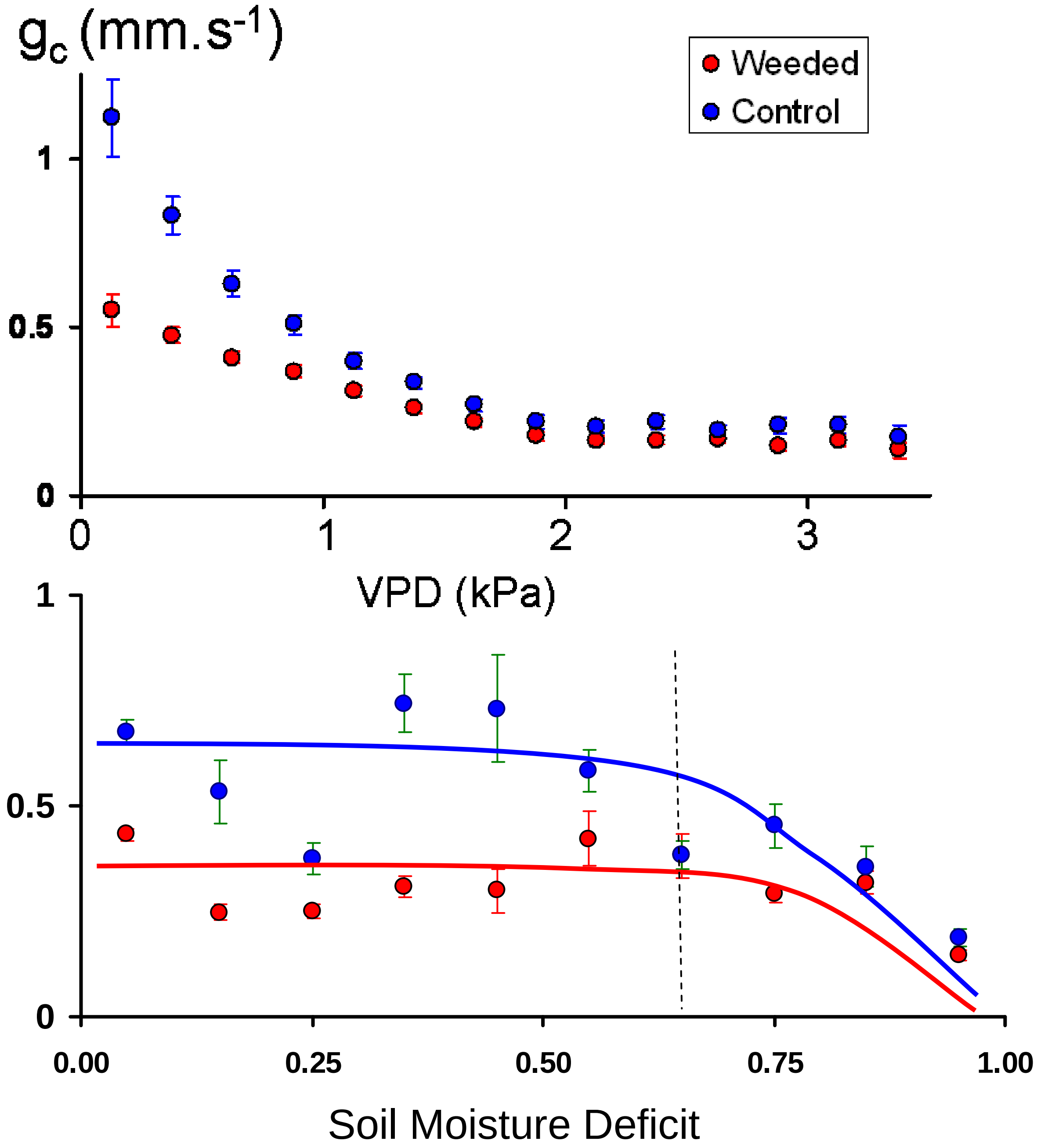
- lesser ET
  - weaker rainfall interception
  - lesser transpiration

❑ Simultaneous water stress



Parallel dynamic of secondary growth

Identical effect of drought



Higher gc on the control plot at low VPD

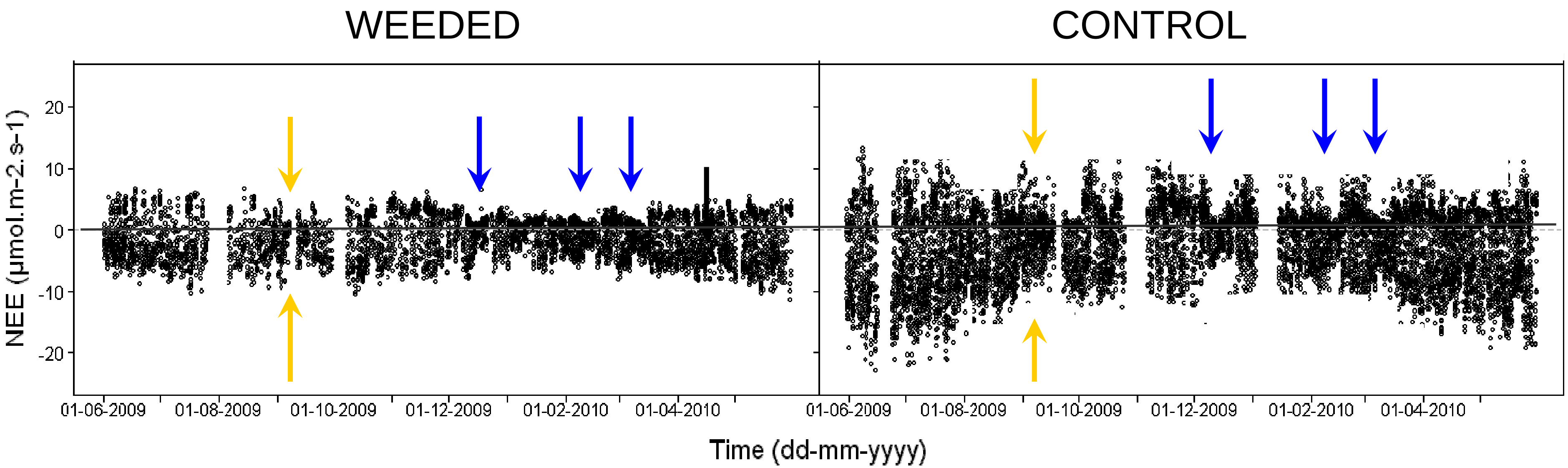
Abrupt response of gc to an increase of VPD

(mm)	C	W
Field capacity	135	135
Wilting point	25	55
Holding capacity	110	80

Results

❑ Carbon fluxes

➢ Temporal evolution of NEE (filtered data)



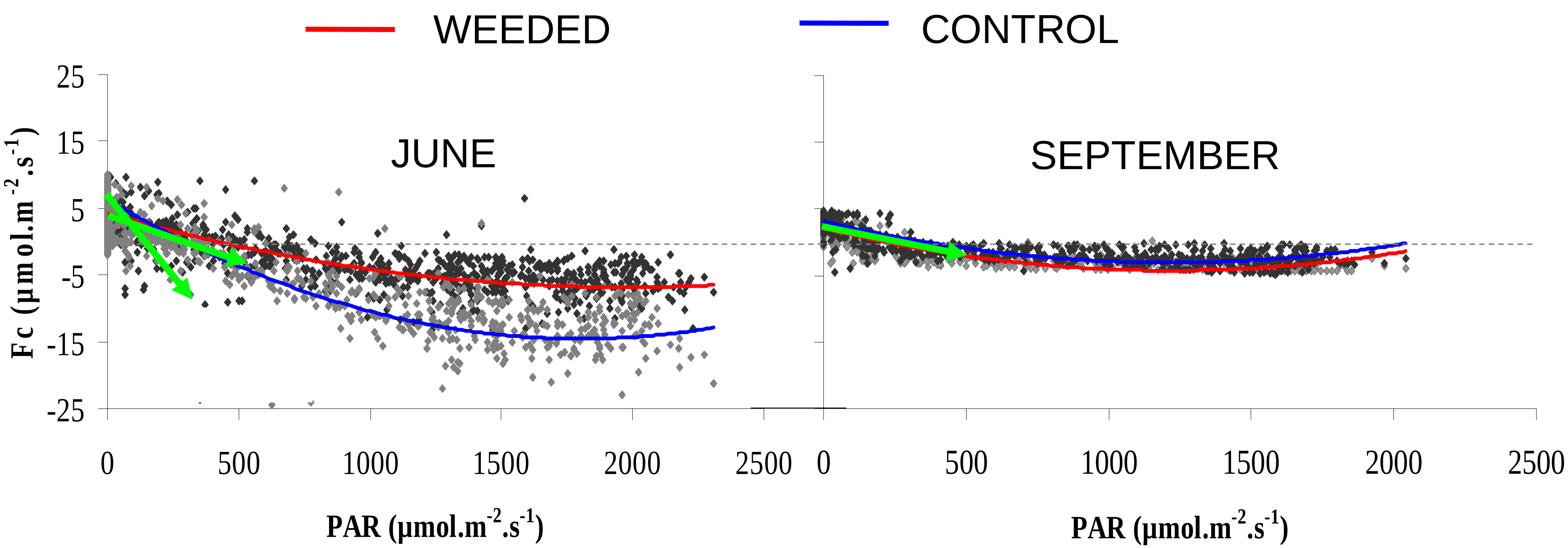
Dynamic of the fluxes more pronounced on the control plot, with higher values

Dry and warm events: high reduction of the fluxes on the control plot

Dry and cold events : high reduction of the fluxes, for both realesed and fixed carbon

➢ Partitionning between GPP and Re

$$NEE = \frac{a_1 PAR}{a_2 + PAR} + R_{ref} . Q_{10}^{(\frac{T_{SURF} - 15}{10})}$$



Higher respiration

Higher carbon assimilation

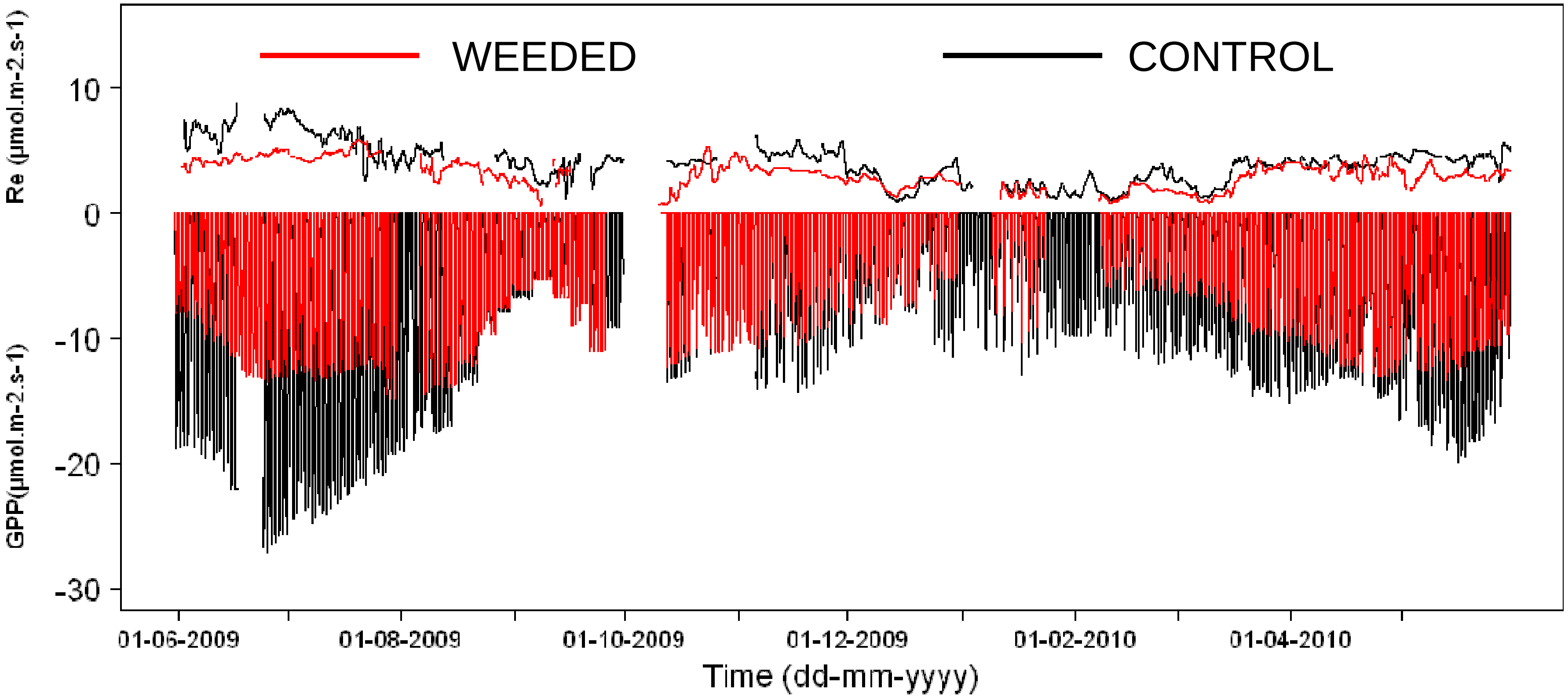
Higher LUE

Same respiration

Same carbon assimilation

Same LUE

➢ Partitionning between GPP and Re



GPP and Re higher in the control plot, with a earlier decreasing in GPP

Is this earlier decrease in GPP during the drought linked to the layer vegetation?


Conclusion and prospects

Effects of weeding and thinning

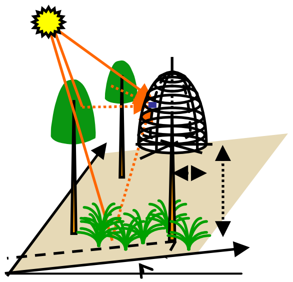
❑ on radiative balance:

- Slight decreasing of the available energy (4%)
- Reducing of latent heat flux but few change in sensible heat

❑ on hydrological processes and carbon fluxes:

- No attenuation of the summer drought since effects on transpiration on tree growth look **identical**.
- Dynamic of the ET and GPP on the control plot is more important and react **faster** to dry conditions: attributed to **the dynamic a the gorse layer**

❑ Next step: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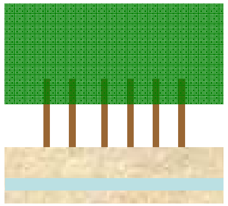


- **Modelling**: using a 3D- model

(Maestra, Wang, 1989, Medlyn, 1997):

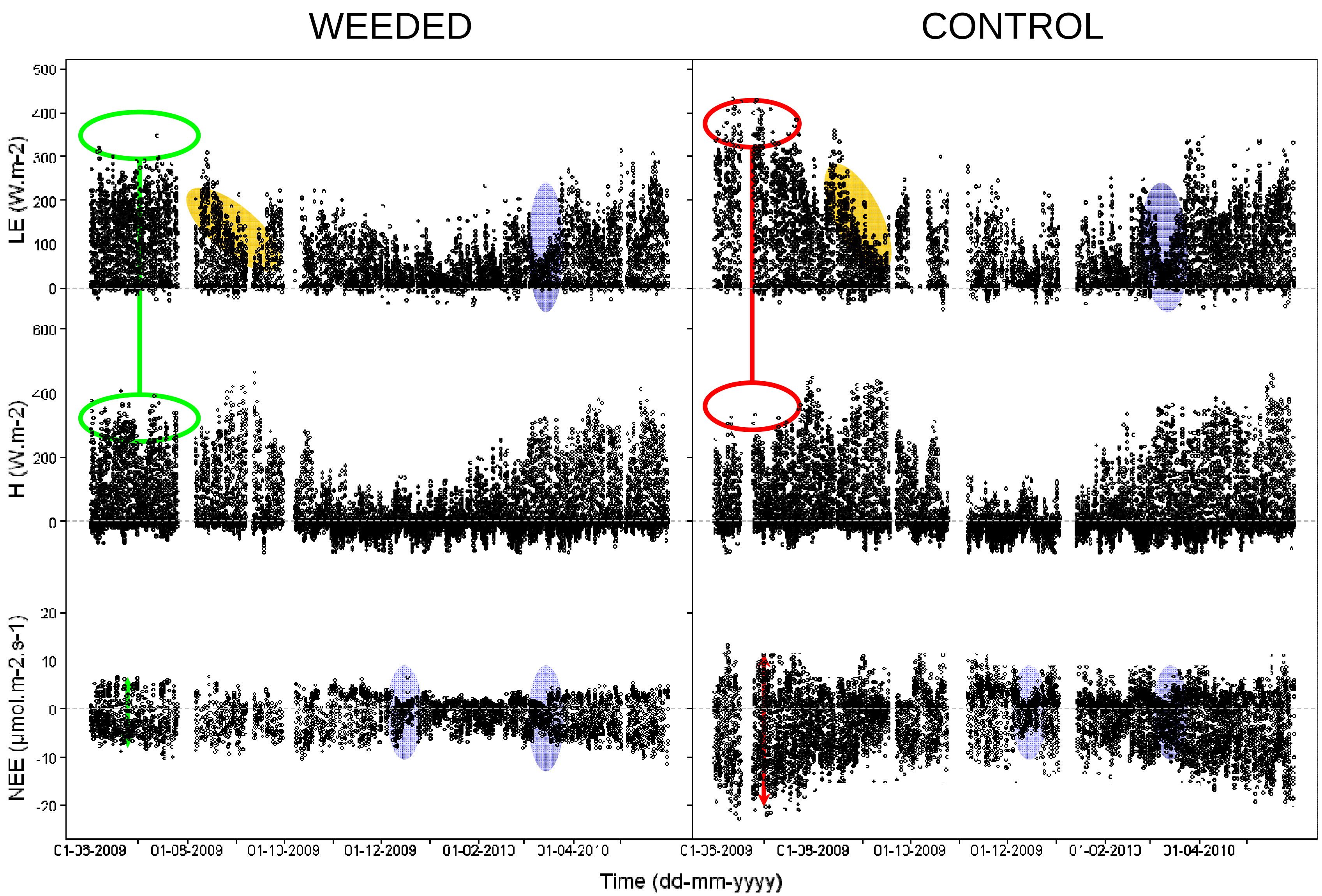
better representation of the understorey layer in young stand.

Thanks for your attention

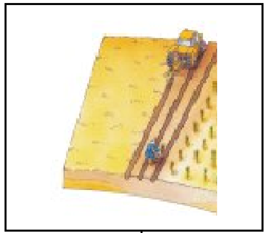
Acknowledgment: Denis Loustau and Eric Lamaud

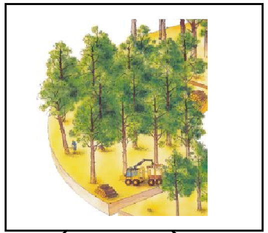
Michel Sartore, Didier Garrigou, Pierre Trichet, Fréderic Bernier, Jean-Luc Denou, Jean Michel Beau, Salles commune

❑ Temporal evolution of the fluxes (filtered data)



➢ Annual ecosystem fluxes

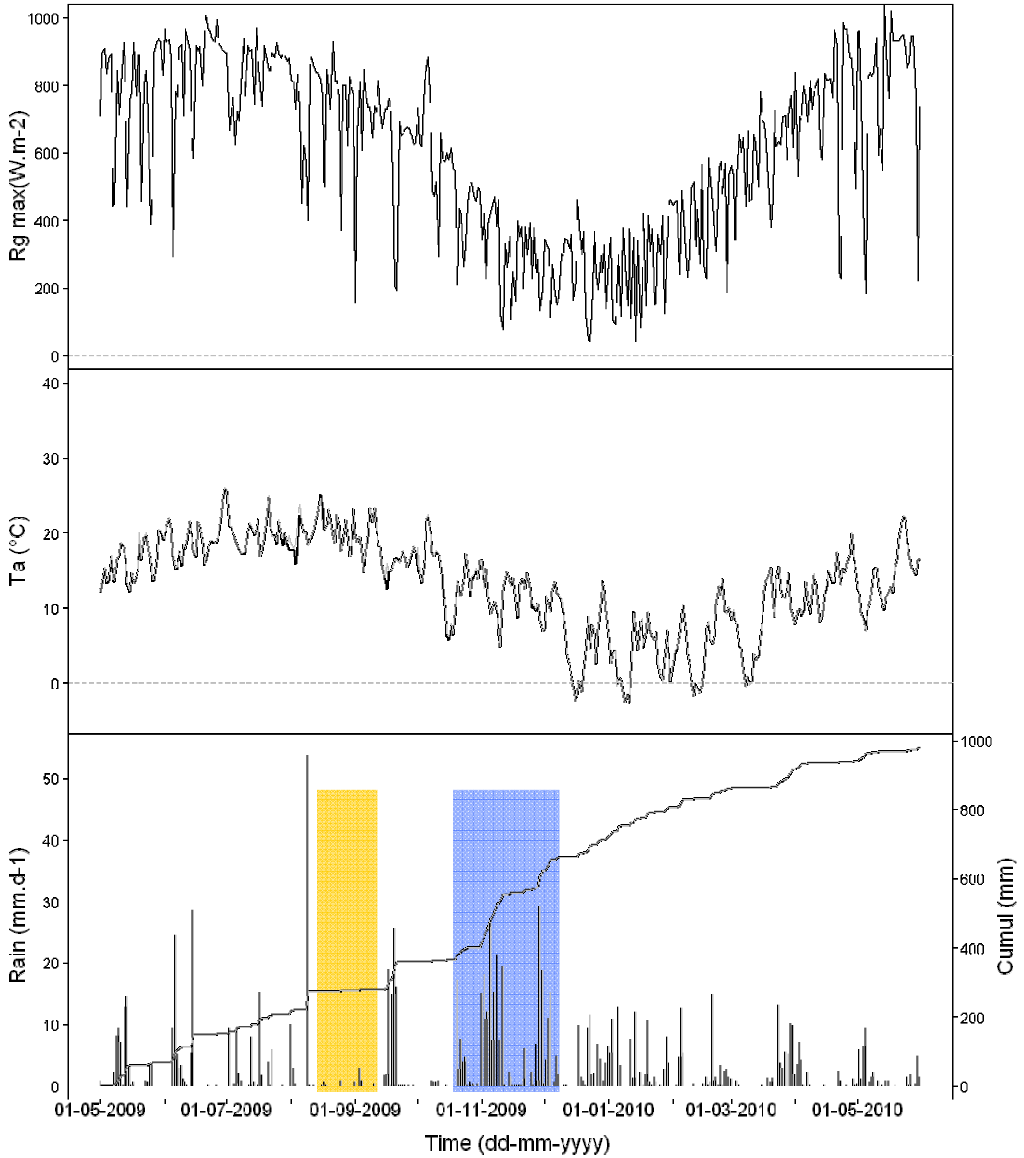




Annual exchange	Bilos (age = 0)	Bray (age = 28)	Bray (age = 31)
NEE carbon ($gC\,m^{-2}$)	290	−575	−498
GPP ($gC\,m^{-2}$)	727	2255	2025
TER ($gC\,m^{-2}$)	996	1680*	1527
PPFD ($mol\,m^{-2}$)	9227	9296	9308
R_n ($MJ\,m^{-2}$)	1956	3006	2746
T_{air} (°C)	13.2	15.0*	13.4
H ($MJ\,m^{-2}$)	928	620	515
LE ($MJ\,m^{-2}$)	895	1592	1491
Evaporation (mm)	358	666	624
Precipitation (mm)	875	930	515†

Kowalski et al. 2003

Meteorological characteristics: June 2009 - May 2010



- Annually:
  - Mean annual T= 12.4 ℃
    13℃ (1950-2000 average)
  - Annual P= 936 mm
    977 mm (1950-2000 average)

- Particular events:
  - **Drought**
    - P = 7mm (10/08 - 16/09)
    - SWC < 50 mm (**0-80cm**)
  - **Storms**
    - P = **222 mm** (November)