Coastal Dune Forests under Scenarios of Groundwater Limitation: from Tropics to Mediterranean (*GWTropiMed*)

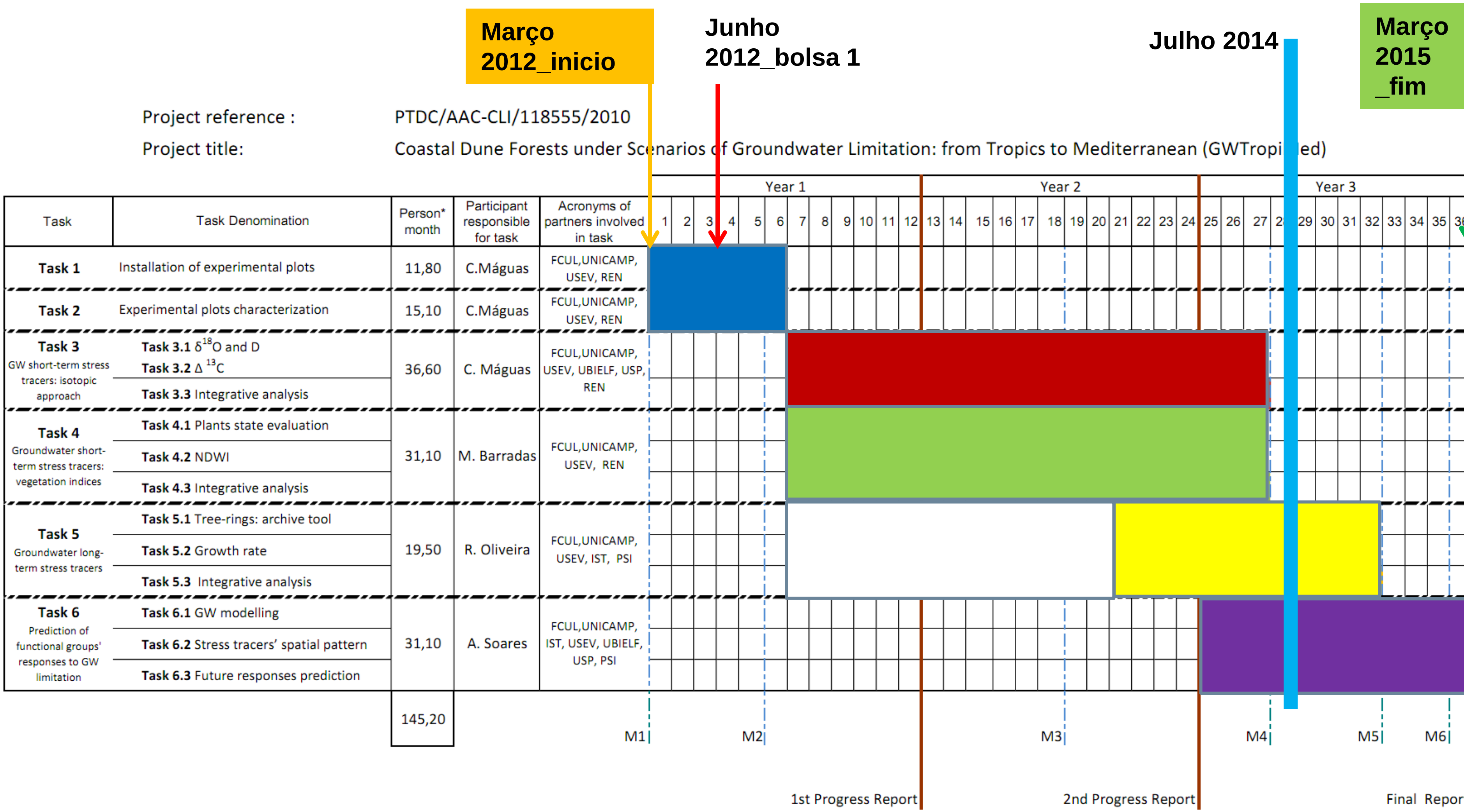
Florestas Costeiras sob Cenários de Limitação da Água Subterrânea: dos Trópicos ao Mediterrâneo

Meeting

10 / 07 / 2014

Objectivos

The core idea of this project is to **evaluate the capacity of different plant communities to adapt to future scenarios of changing GW by an integrative spatial approach of GW stress indicators.**



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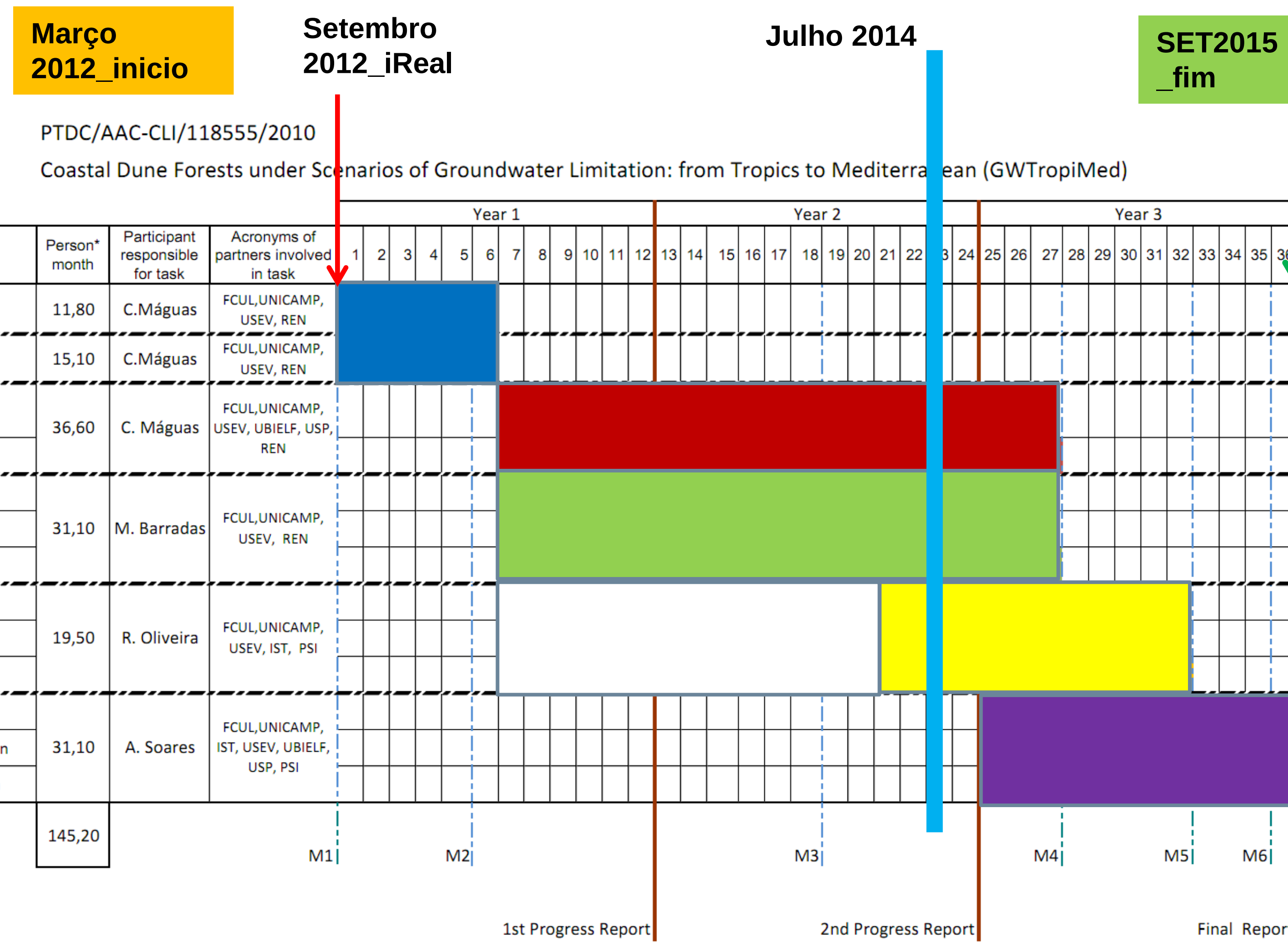
Project reference : PTDC/AAC-CLI/118555/2010

Project title: Coastal Dune Forests under Scenarios of Groundwater Limitation: from Tropics to Mediterranean (GWTropiMed)

Task	Task Denomination	Person* month	Participant responsible for task	Acronyms of partners involved in task
Task 1	Installation of experimental plots	11,80	C.Máguas	FCUL,UNICAMP, USEV, REN
Task 2	Experimental plots characterization	15,10	C.Máguas	FCUL,UNICAMP, USEV, REN
Task 3 GW short-term stress tracers: isotopic approach	**Task 3.1** $\delta^{18}O$ and D **Task 3.2** $\Delta^{13}C$ **Task 3.3** Integrative analysis	36,60	C. Máguas	FCUL,UNICAMP, USEV, UBIELF, USP, REN
Task 4 Groundwater short-term stress tracers: vegetation indices	**Task 4.1** Plants state evaluation **Task 4.2** NDWI **Task 4.3** Integrative analysis	31,10	M. Barradas	FCUL,UNICAMP, USEV, REN
Task 5 Groundwater long-term stress tracers	**Task 5.1** Tree-rings: archive tool **Task 5.2** Growth rate **Task 5.3** Integrative analysis	19,50	R. Oliveira	FCUL,UNICAMP, USEV, IST, PSI
Task 6 Prediction of functional groups' responses to GW limitation	**Task 6.1** GW modelling **Task 6.2** Stress tracers' spatial pattern **Task 6.3** Future responses prediction	31,10	A. Soares	FCUL,UNICAMP, IST, USEV, UBIELF, USP, PSI
		145,20		



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- Installation and characterization of plots; Functional groups definition and forest structure evaluation.

- Understand functional groups water use in a GW limitation situation; and Definition of suitable isotopic short-term stress indicators in GW limitation scenarios.

- Definition of important indices that could function as short-term stress tracers in scenarios of (GW) limitation.

- Evaluate long-term stress sensitivity of the functional groups to temporal/seasonal changes in water availability.
- Estimate important factors that could function as long-term stress tracers in scenarios of groundwater limitation.

- Integrate spatial water resource and short- and long-term groundwater stress indicators among the different climatic conditions and groundwater availability
- Project water use differences under future groundwater change
- Creation of a model to evaluate community water use under future groundwater change scenarios through ecophysiological parameters.

Outputs

1- Interactive webpage ✓

2- National seminars where forest and natural areas managers are encouraged to participate.

3- Press release of the network activities and results to the general public. ✓

PhD Cristina Antunes (orientação:Simone Vieira)_Programa Doutoral Ecologia UNICAMP

Posters – 3

(1) Cost SIBAE Meeting Challenges in the applications of Stable Isotopes across disciplines and scales. 14-17 May Wroclaw, Poland. *Coastal dune forests under scenarios of groundwater limitation: from Tropics to Mediterranean GWTropiMed project.*

(2) CIRCLE-2 Adaptation Frontiers Conference. Special poster session 'Climate and Climate Adaptation research i Portugal' - 10-12 March 2014, **Lisbon** . *Responses of dune forest ecosystems to changing groundwater availability: fro Tropics to Mediterranean*

(3) EGU - 2014. Session BG1.3 'Stable Isotopes in Biogeosciences'– 29 April to 2 May 2014**, Vienna Austria.** Assessing physiological responses of dune forest functional groups to changing water availability: from Topics to Mediterranean.

Apresentações orais – 1

Jornadas de investigación sobre la conservación de Doñana. February 2014, Sevilla, Spain. Florestas de dunas costera sobe senarios de limitación de agua subterránea: de los trópicos a mediterráneo: Proyecto GWTropiMed.

Outras actividades –

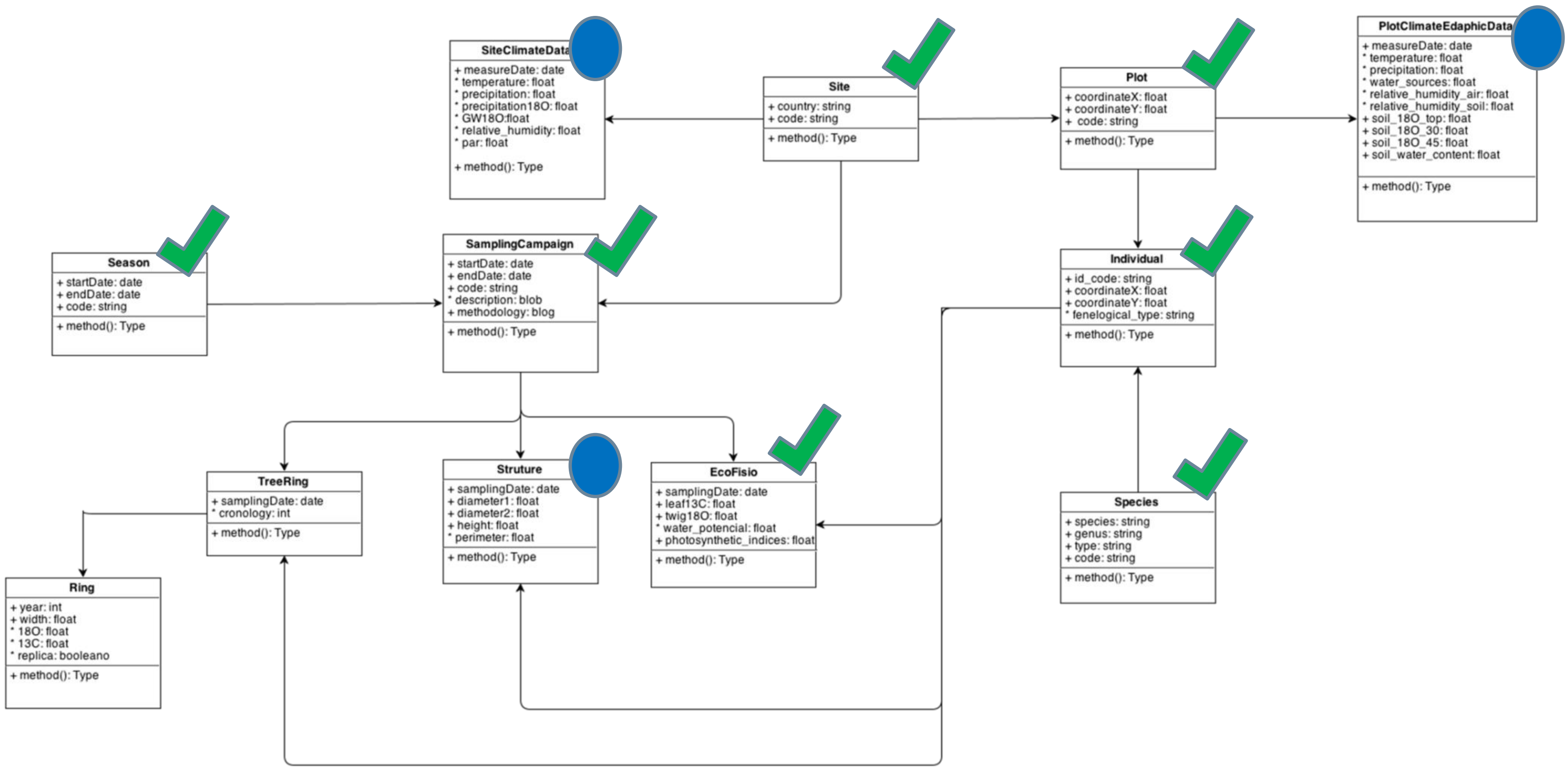
STSM in Paul Scherrer Institute (Switzerland): tree-ring analysis

SPATIAL Stable Isotopes Short Course in University of Utah (USA)

Content management system (CMS) - GWTropiMed project

http://groundwater.cubocreation.net/

(Base de Dados dependente de:
actualização, inserção de dados e criação de novos campos)



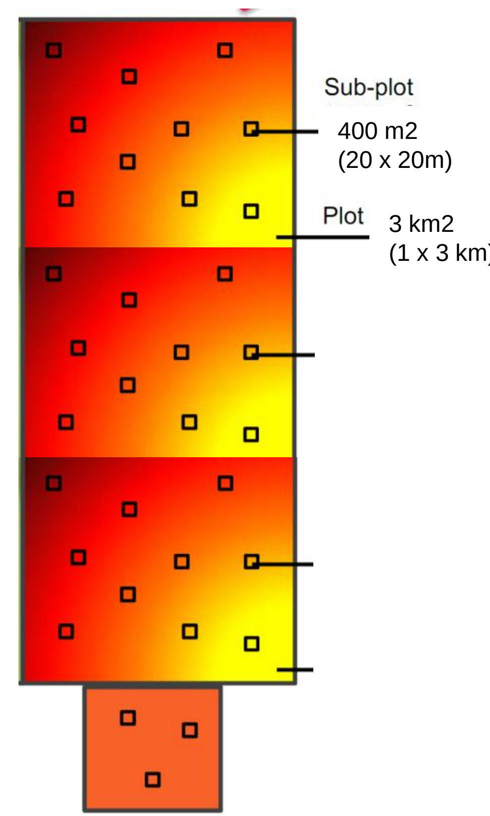
Orçamento

Rubrica	Orçamento	Despesa	Uso	Saldo Final	Uso futuro
R. Humanos	45.009,00 €	43.508,39	***4 bolsas(CA + AP + MLC + ?)***	**1.500,61 €**	?
Missões	16.757,00 €	12.319,56 €	***9 campanhas (3Sites x 3 Seasons)***	**4.437,44 €**	***3 campanhas***
Consultores	3.400,00 €	1.400,00 €	*(troca)*	**2.000,00 €**	***Viagem de Simone + 1 consultor***
AQ ODC	18.427,00 €	18.308,49 €	***SIIAF manutenção + additional field and lab material***	**118,51 €**	***lab material***
Equipamento	67.200,00 €	64.498,27 €	***IRMS***	**2.701,73 €**	Divers**?** + Hobos **?**
Gastos Gerais	30.158,00 €	21.483,34	***FFCUL***	**8.674,66 €**	***FFCUL***
Total:	**180.951,00 €**	**161.518,05 €**		**19.432,95 €**	

Locais de estudo

In each climatic region, it will be install 1 experimental plot of 3 km^2 (1km x 3 km) under GW limitation and 1 plot of 0,25 km^2 (500m x 500m) with no groundwater limitation. ***30*** *sub-plots of 400 m^2 (20 x 20) in each experimental plot (=12 000 m^2) and 3 sub-plots in control plot (=1200 m^2).*

Proposto	Realizado	Observações
Definição de 30 plots	SIM	(plots de Brasil são 10x10)
Instalação de plot controlo	NÃO	Sem necessidade



Locais de estudo

Enquadrament	Brasil	Portugal	Espanha
N espécies	c. *70 (trees)*	*12*	*18*
Exemplos	*Euterpe edulis* (Palmito) *Jacaranda puberula* Myrcia racemosa *Pera glabrata* *Eugenia schuechiana*	*Pinus pinaster* *Myrica faya* *Salix repens* *Corema album*	*Pinus pinea* *Erica scoparia* *Juniperus phoenicea* *Halimium halimifolium* *Corema album*
Estrutura	Restinga - floresta prístinas com elevação de 0-10m (c. 1700 trees em 1 ha; c.40 trees em 20 x 20m, de 1,5 m a 26 m de altura)	Formação florestal de Pinhal bravo (c. 100 ind em 20 x 20m)	Formação de matorral mediterrâneo, floresta sabinar e pinhal manso (c. 100 ind em 20 x 20m, maioria shrubs)
Clima	Precipitação **média** anual: c. 3000 mm (com menor pp em junho: 87mm) T med anual – 22°C	**total** de precipitação anual de c. 900 mm (menor pp em julho-Agosto: 10mm)	**Total** de precipitação anual em ano chuvoso: c.712 mm (ano seco < 354 mm)
Solo	Alto conteúdo de areia, baixo pH, baixa concentração de fósforo e soma de bases e alta saturação de alumínio.	Arenoso	Arenoso e com horizonte argiloso (semi-permeável nas zonas de charcas temporárias

Ubatuba- Brasil

Restinga Parcela A

			94						100
81					86				
			74				78		
	62					67			
		53							60
					46				
31		33					38		
				25					
		13							20
1					6		8		

Ubatuba- Brasil

Euterpe edulis (Palmito)

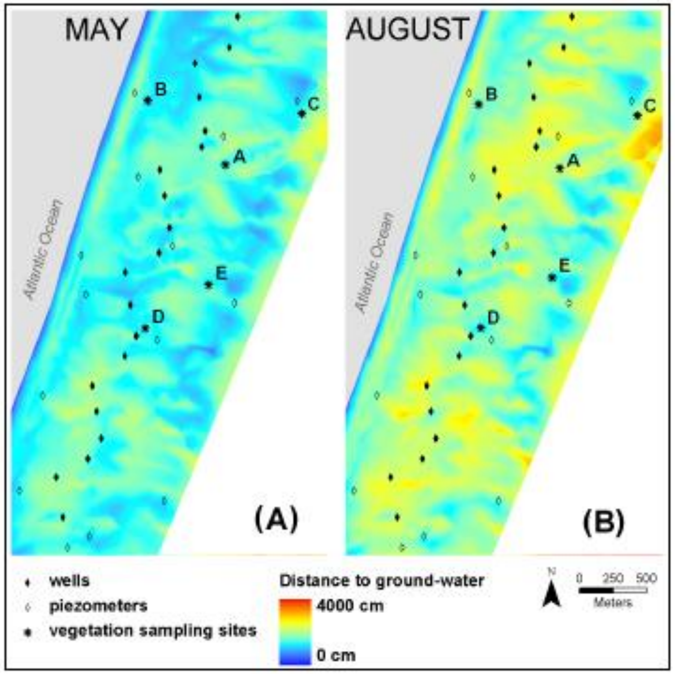
Jacaranda puberula

Myrcia racemosa

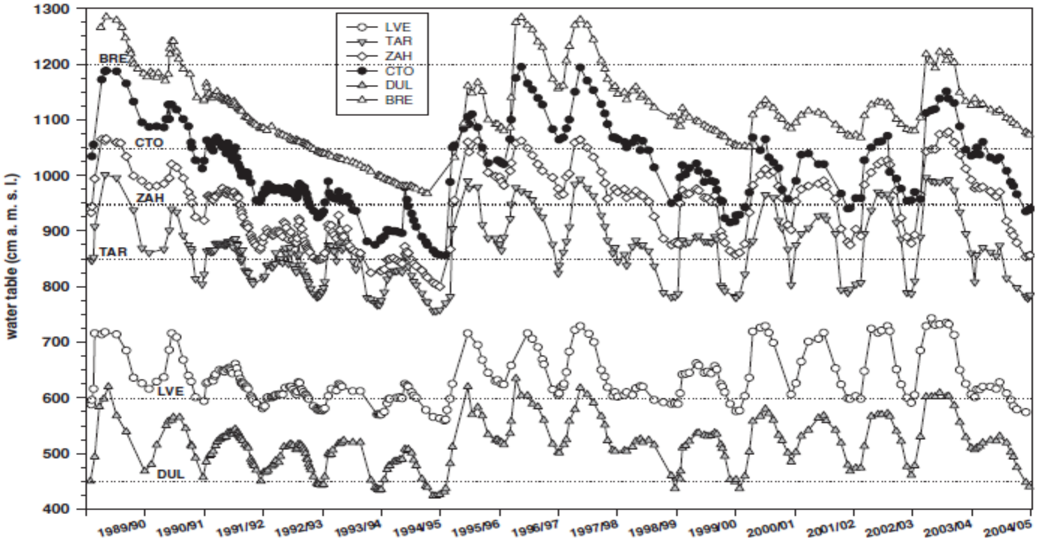
Pera glabrata

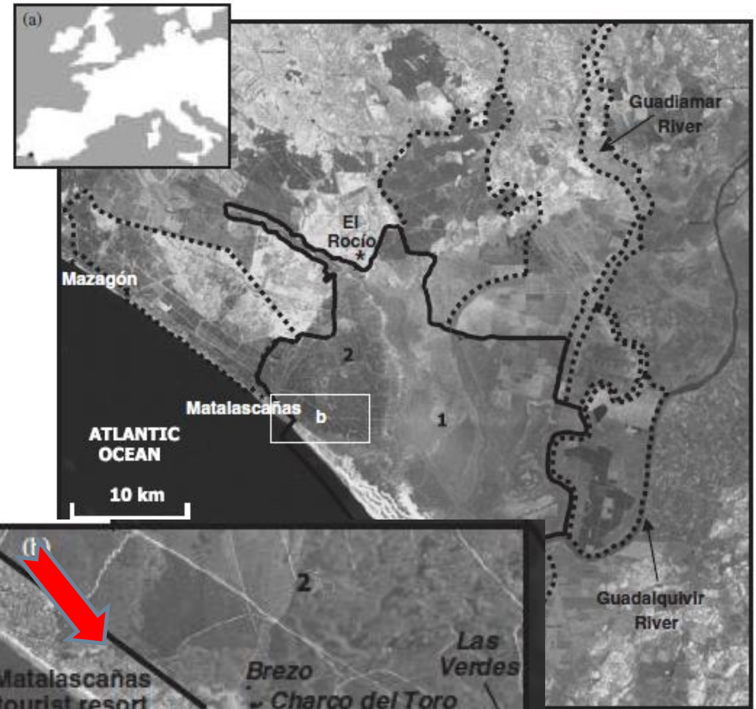
Eugenia schuechiana

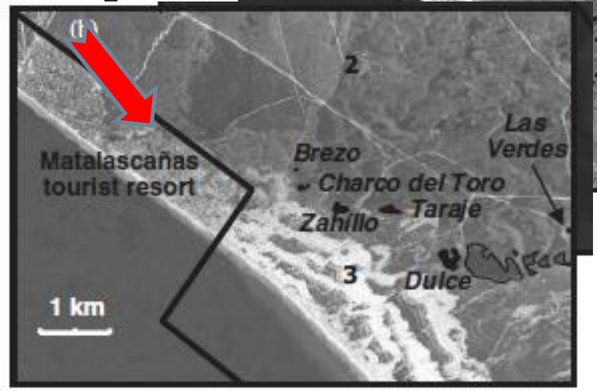
Osso da Baleia - Portugal

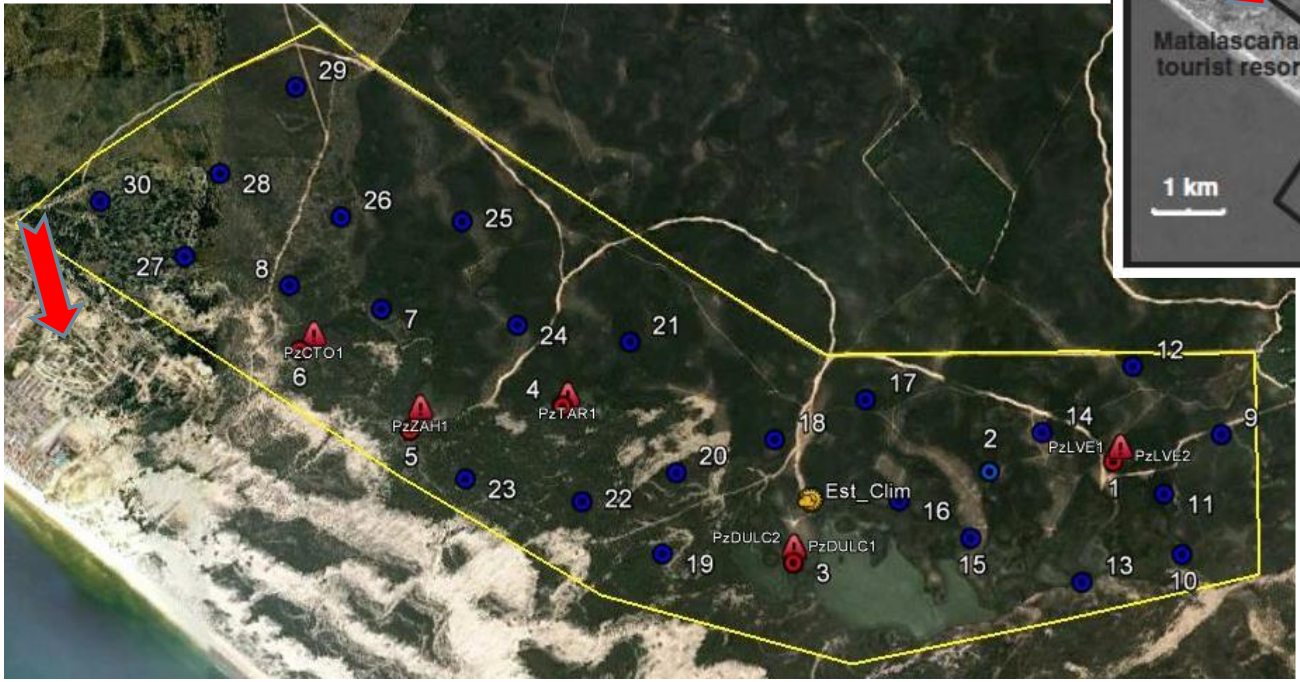


Doñana - Espanha









Estación Biológica Doñana CSIC

Doñana - Espanha

Erica scoparia

Tarefa 1

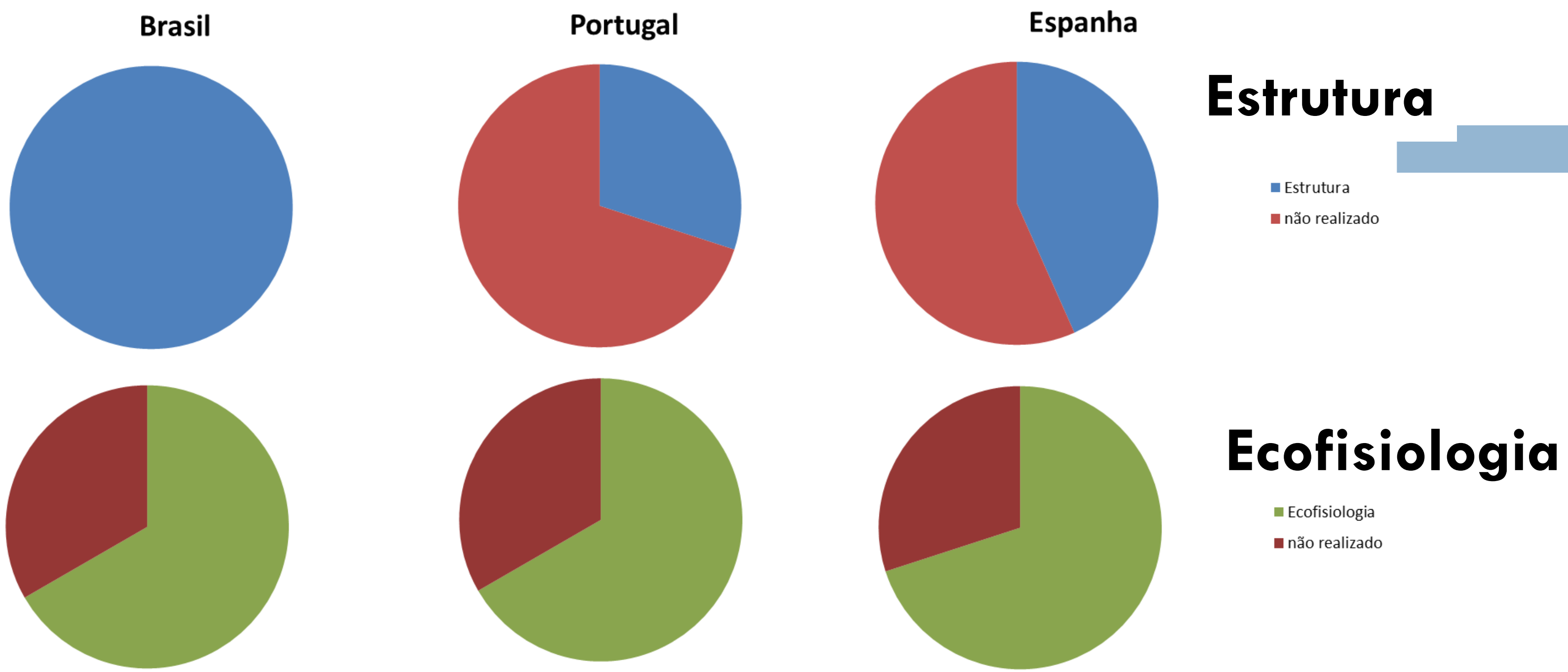
Locais de estudo	Brasil	Portugal	Espanha
Local climate data will be available from a **climate station** already installed **in each site** (3 in total). Variables monitored will be: precipitation, air and soil humidity and temperature, solar radiation and photosynthetic photon flux density.	Sim	Sim Mas falhou de Março2013 a Julho 2013!	Sim
Precipitation will be collected by installing **1 collector at each study plot** (6 in total).	Não (colheita feita na época de campanha)	Sim Mas falhou!	Sim (colheita diária, mas depende de Prof Manuela)
To quantify **fog-water inputs and due, 1 passive collector** - a vertical net with a collection surface- will be placed **in the sea-facing side of each plot** (6 in total).	Não	Não	Não
Groundwater monitoring will be assessed from piezometers (water level recording and sampling): **10 piezometers** will be installed per plot, **one in each sub-plot** (total of 30) - ALTERNATIVA: kriging maps	Não	Sim Informação só agora disponivel (apenas level)	Sim Informação não está ainda disponivel apenas charcas.
Maximum of **climate** (past information); **plant diversity / functional groups information; Aerial photographs;**	Sim; Sim; Não	Sim; +/-; Não	Sim; Sim; Não
Installation of **dendrometric bands** in the 30 points (3 sps per point)	Sim	+/- (apenas instalados, mas não monitorizados)	Não

Tarefa 2

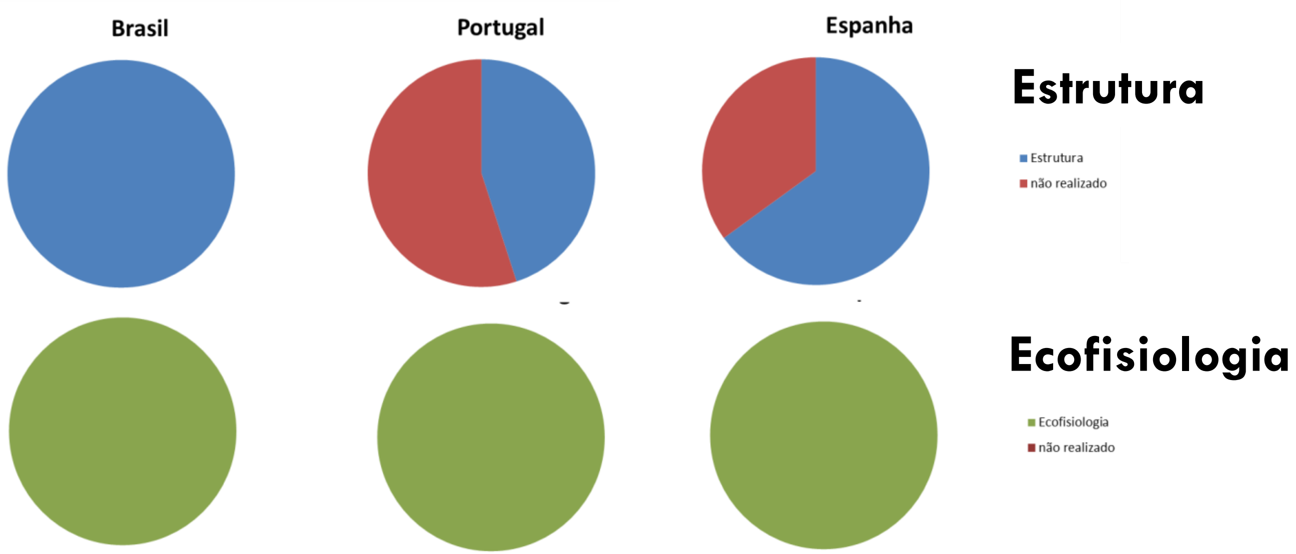
In every sub-plot	Brasil	Portugal	Espanha
Species identification (sampled individuals)	Sim	Sim	Sim
Defining **functional groups** traits (root system; type;...)	Sim (Incompleto)	Sim (Incompleto)	Sim (Incompleto)
Ecophysiological measurements In every sub-plot 15 plants will be marked (5 per functional group), totalling 450 per site - Apenas 20 sub-plots amostrados e max 12 plantas (3 por FG, sendo 4 FG considerados)= max 12*20=240 por site	Sim	Sim	Sim
Forest structure evaluation In each sub-plot, the projected area, spatial distribution and allometric measurements will be registered for each individual	Sim (falta sub-coberto)	Sim (mas não a totalidade)	Sim (mas não a totalidade)
Evaluation of growth rate – <u>3 em 3 meses</u> This will be performed by installation of dendometer bands in: 3 tree from the different functional groups in each sub-plot (=30 x 3 x 3= 270) in each groundwater limitation plot (270 x 3 = 810) and in 27 trees (=3subplots x3ind x 3 functional groups) in the control plots (27 x 3sites = 81), totaling 891marked trees.	Não	Não	Não
Soil profiles In each sub-plot one/ three soil profile will be performed. For that, soil will be sampled in 10, 20, 40, 60/ 10, 30, 50 cm, for 18O water analysis.	Sim	Sim	Sim

Tarefa 2 – Estrutura e Ecofisiologia

30 plots

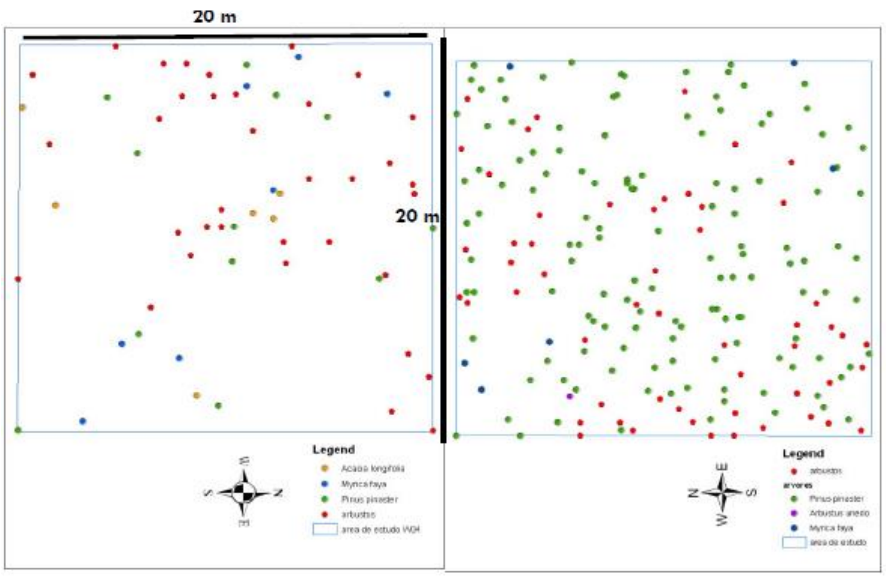


20 plots



Tarefa 2 – Estrutura

Site:	L1					
Date:	3/12/2012					
Observers:	CA+ SG					
Shrubs						
ID	X	Y	Diameter (Max)	Diameter (Perp)	Height (total)	Observation
L 001	36,9853148	6,463481	85	55	45	
Ul 001	53210	34160	120	100	50	
L 002	53145	34071	120	65	75	
Ul 002	53251	34041	190	140	50	
As 001	53349	33889	60	30	65	
L 003	53342	33863	60	20	65	
L 004	53429	33954	140	70	75	
As 002	53502	34083	120	100	60	
Hc 001	53455	34065	40	20	25	
Hh 001	53655	34004	80	70	65	debil
Ul 003	53535	33819	140	100	60	
As 003	53678	33877	25	25	40	



Tarefa 2 – Estrutura

A fazer:

Estrutura em mais pontos (quais?)

Estrutura de sub-coberto em Ubatuba

Cálculo de Indices

(i) Spatially explicit

(ii) No spatial relation

Aggregation patterns

Tab. 1: List of selected structural indices

Name	Formula	Short description	Source
Spatially explicit indices			
Clark Evans Index	$CE = \frac{\frac{1}{n}\sum_{i=1}^{n} r_i}{0{,}5\sqrt{10000/N}}$ with r_i = distance of tree $_i$ to next neighbour; N = number of trees per ha; n = number of sample trees	measure for regular or clustered horizontal distribution	Clark and Evans 1954
Contagion Index	$W_i = \frac{1}{4}\sum_{1}^{4} w_j$ with w_i = 1 if α angle j < 90°; w_i = 0 otherwise	defines the degree of regularity of the distribution of tree positions	Gadow et al. 1998
Mingling Index	$MI_i = \frac{1}{4}\sum_{j=1}^{4} v_{ij}$ with v_{ij} = 0 in case that neighbour $_j$ belongs to same species and v_{ij} = 1 in case that neighbour $_j$ belongs to same species	describes the probability that none of the three nearest trees belongs to the tree species of the centre tree	Gadow and Füldner 1995
Diameter differentiation	$T = \frac{1}{n}\sum_{i=1}^{n}(1 - r_i)$ with r_i = (thinner dbh)/(thicker dbh) of tree pair $_i$; n = number of measured tree pairs	Quantifies the degree of diameter differentiation	Gadow and Füldner 1995
Indices without spatial relation			
Shannon Index of diversity	$H' = -\sum_{i}^{N} \log p_i \cdot p_i$ with p_i = relative abundance of the *i*th species; N = number of species (log = natural logarithm (base = e))	ecological standard measure for diversity	Shannon 1948
Evenness	$E = \frac{H'}{H'_{Max.}}$ with H' = Shannon-Index; $H'_{Max.}$ = Potential maximum value (= log N [species number])	ecological standard measure for diversity	Pielou (1975)
Simpson index of diversity	$SI = \sum_{i}^{N}(1 - p_i) \cdot p_i$ with p_i = relative abundance of the *i*th species; N = number of species	ecological standard measure for diversity	Simpson 1949
Species profile index	$A = -\sum_{i=1}^{S}\sum_{j=1}^{B}\log(p_{ij}) \cdot p_{ij}$ with p_{ij} = proportion of species i in height band j; S = number of different tree species; B = number of height bands; band 1: 100 - 80 % of maximal tree height (h_{max}); band 2: 80 - 50 % of h_{max}; band 3: 50 - 0 % of h_{max}	Shannon index calculation for the proportion of tree species in different stand layers	Pretzsch 1996

Tarefa 2 – Ecofisiologia (Isotopes)

Espanha

N= 16

Species		Ind(n)
Cistus	libanotis	4
Cistus	salviifolius	6
Corema	album	12
Erica	scoparia	43
Halimium	calycinum	21
Halimium	halimifolium	59
Juniperus	phoenicea	32
Lavandula	stoechas	7
Phillyrea	angustifolia	7
Pinus	pinea	32
Quercus	suber	5
Rosmarinus	officinalis	11
Salix	atrocinerea	3
Stauracanthus	genistoides	3
Tamarix	africana	3
Ulex	australis	4

Portugal

N= 10

Species		ind (n)
Acacia	longifolia	45
Acacia	melanocylon	4
Cistus	salviifolius	10
Corema	album	33
Halimium	calycinum	3
Helycrisum	italicum	9
Juniperus	phoenicea	5
Myrica	faya	56
Pinus	pinaster	43
Salix	repens	27

Brasil

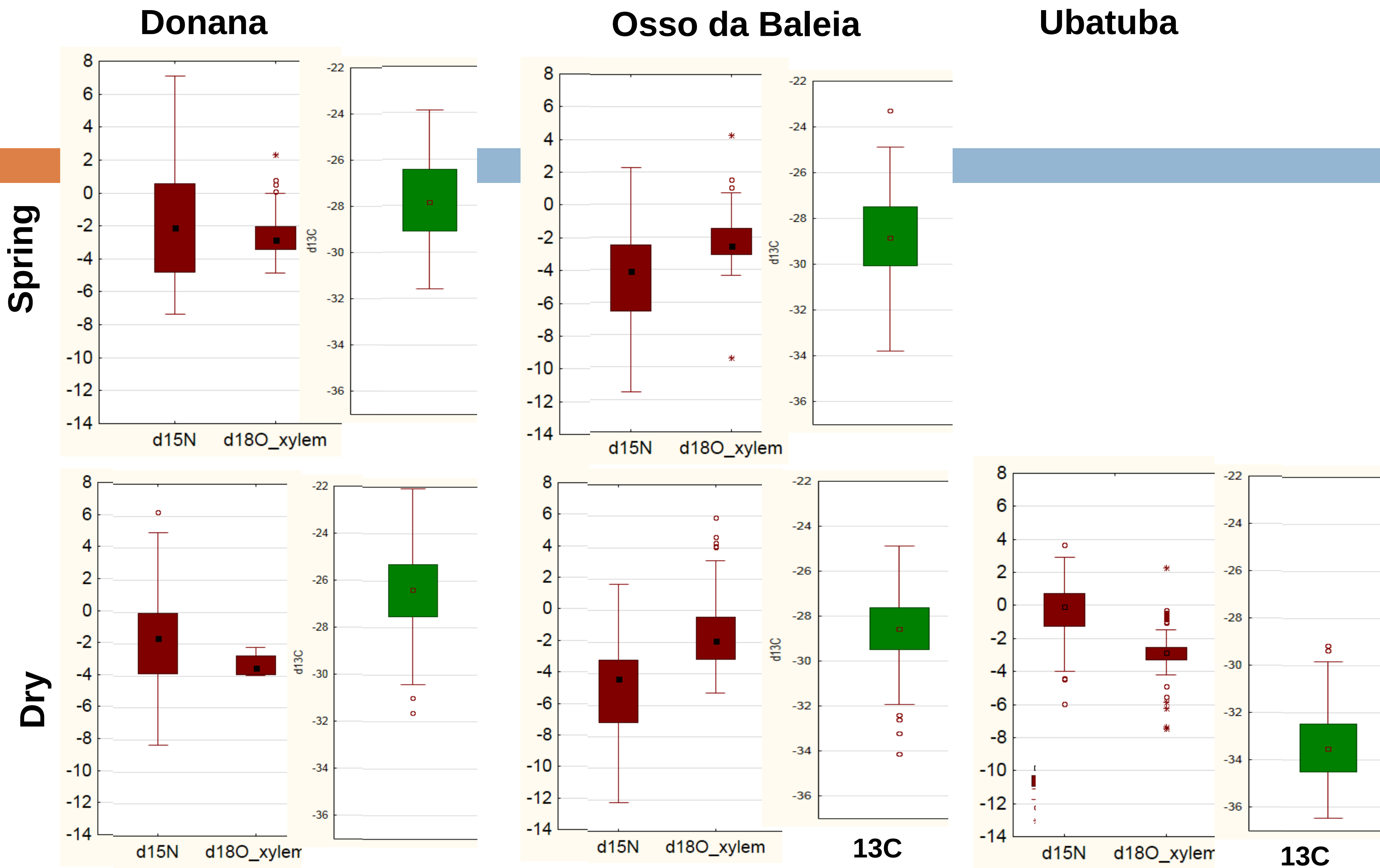
N= 35

Species		Ind (n)
Alchornea	triplinervia	2
Andira	fraxinifolia	2
Byrsonima	ligustrifolia	1
Calyptranthes	concinna?	1
Couepia	venosa	1
Endlicheria	paniculata	2
Eugenia	schuechiana	4
Eugenia	umbelliflora	2
Euterpe	edulis	7
Faramea	pachyantha	4
Garcinia	gardneriana	2
Guapira	opposita	4
Guarea	macrophylla su	7
Guatteria	sp. 4	9
Jacaranda	puberula	5
Kielmeyera	petiolaris	1
Lacistema	pubescens	1
Margaritaria	nobilis	1

Marlierea	tomentosa	5
Maytenus	littoralis	11
Myrcia	brasiliensis	5
Myrcia	multiflora	5
Myrcia	racemosa	15
Myrcia	splendens	1
Nectandra	oppositifolia	2
Ormosia	arborea	1
Pera	glabrata	6
Rapanea	ferruginea	1
Sloanea	guianensis	1
Tapirira	guianensis	1
ND	ND	35
Psychotria	sp1	50
Psychotria	sp2	11
Tibouchina	sp1	1
Inga	sp	1

Tarefa 2 - Ecofisiologia

		Brasil	Portugal	Espanha
Campanha 1	Xylem d18O	Sim	Sim	Sim
(Março e Junho 2013)	Leaf d13C,d15N, C, N, C:N	Sim	Sim	Sim
(primavera) + ("dry")	Reflectance indices (Unispec)	Sim	Sim	Sim
	Soil profile (d18O)	Sim	Sim	Sim
	Soil moisture	Não	Sim	Sim
Campanha 2	Xylem d18O	Sim	Sim	Sim
(Ago, Set, Nov 2013)	Leaf d13C,d15N, C, N, C:N	Sim	Sim	Sim
(verão) + ("rainy")	Reflectance indices (Unispec)	Sim	Sim	Sim
	Soil profile (d18O)	Sim	Sim	Sim
	Soil moisture	Não	Sim	Não
Campanha 3	Xylem d18O	Sim	Sim	Sim
(Fev e Maio 2014)	Leaf d13C,d15N, C, N, C:N	Sim	Sim	Sim
(primavera) + ("dry")	Reflectance indices (Unispec)	Não	Sim	Sim
	Soil profile (d18O)	Sim	Sim	Sim
	Soil moisture	Não	Não	Não



Donana
Osso da Baleia
Ubatuba
Spring
Dry
d15N
d18O_xylem
d13C
13C

Tarefa 3

MEMBERS: FCUL, Campinas, U. Sevilla, Bielfeld, Consultor Luis Martinelli, REN
Responsável: FCUL

TASK 3. Groundwater short-term stress tracers: isotopic approach

Objectives

(i) Definition of important isotopic parameters that could function as short-term stress tracers under groundwater (GW) limitation.

(ii) Understand the water source and use of functional groups in a GW gradient.

All measurements of the following Task will be conducted in **2 seasons** in all sites: **dry and wet season**. The 15 samples (4 per functional group) per sub-plot will be sampled in the marked individual (Task 2.1).

3.1. Identification of water sources and their differential utilization by plants

Natural $^{18}O/^{16}O$ ($\delta^{18}O$) ratios will be used to quantify different water sources (precipitation, GW and atmospheric water)

Potential water sources will be collected in the 2 seasons in each study plot. Xylem water samples will be collected seasonally in each marked individual (Task 2.1).

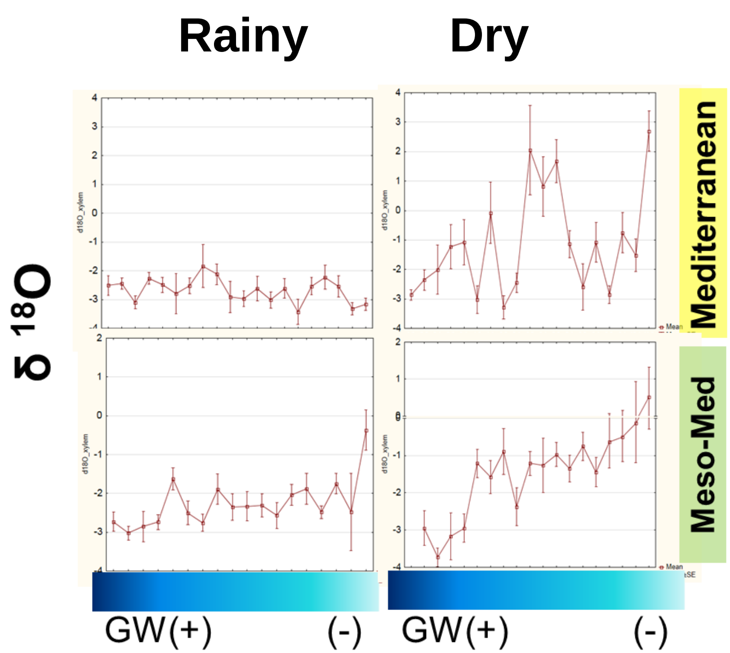
3.2. Plant water use efficiency

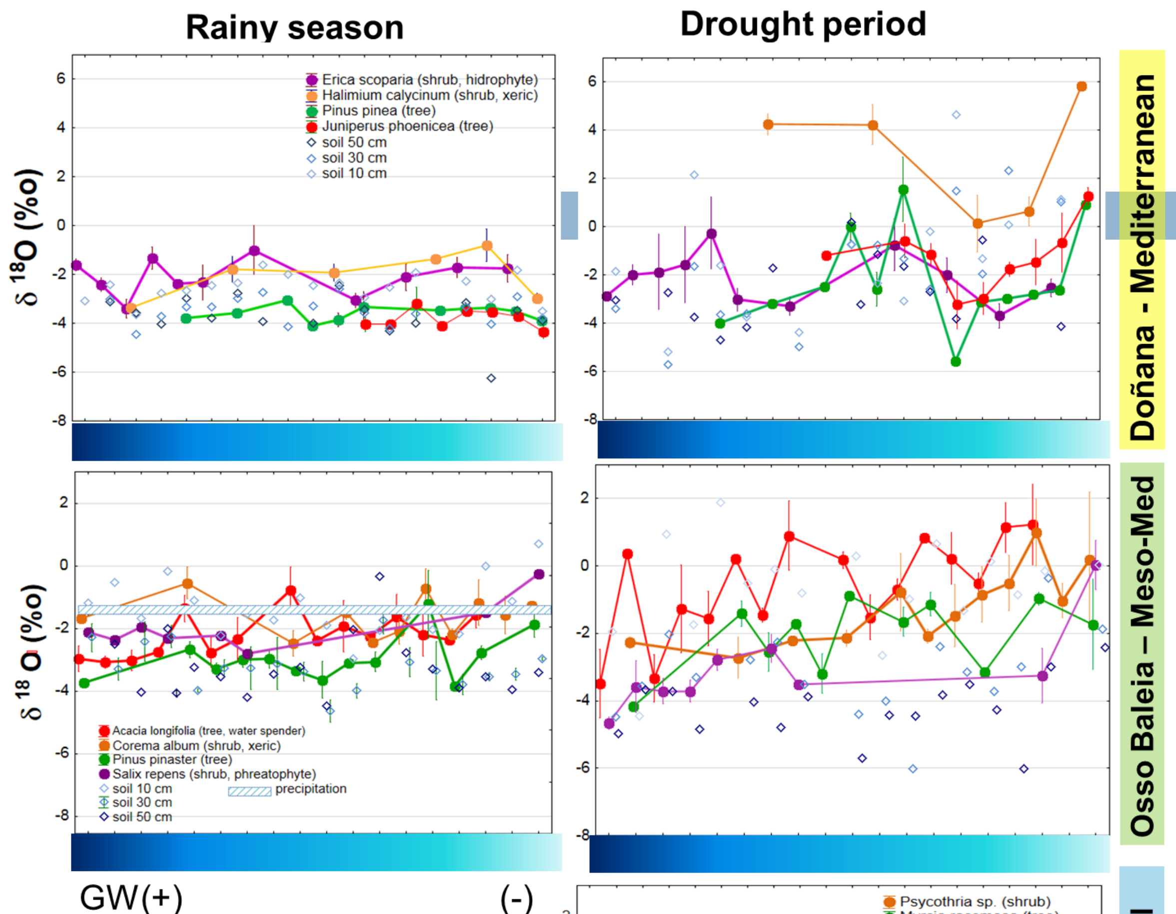
Carbon isotope discrimination of leaves ($\Delta^{13}C$) integrates plant physiological and structural attributes. Leaf samples will be collected seasonally in each marked individual (Task 1).

3.3 Integrative analysis of isotopic factors in function of GW availability

For answering the question: "which isotopic factors can be used as short-term GW stress tracers?" we will use the data collected to perform correlations between them and the distances to GW (task 1.3). All functional groups will be considered and compared with control plots.

Expected achievements: i) Understand functional groups water use in a GW limitation situation; ii) Definition of suitable isotopic short-term stress indicators in GW limitation scenarios.





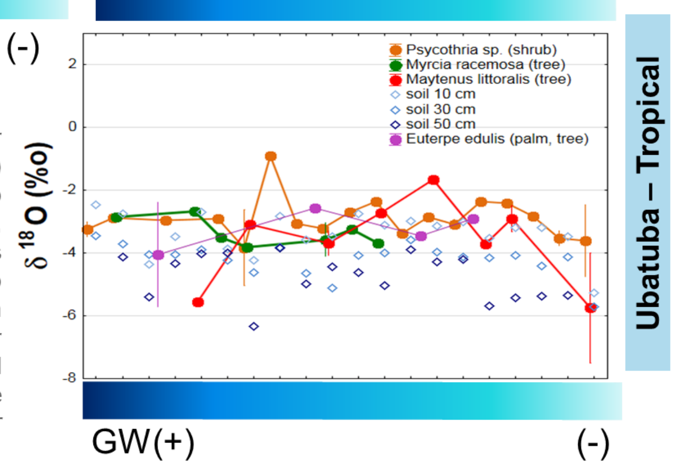


Fig. 2: Mean and SE of xylem water oxygen isotopic composition ($\delta^{18}O$ ‰) of 4 plant functional groups, in two seasons (rainy and drought) and 3 sites, in a groundwater gradient: (+) = less distant; (-) = higher distance to groundwater (GW)). n= 3 per species in each local. Data from rainy season for Tropical site is not shown (still analysing). Note: For Tropical site the drought period correspond to a lower availability of rain (not a drought condition).

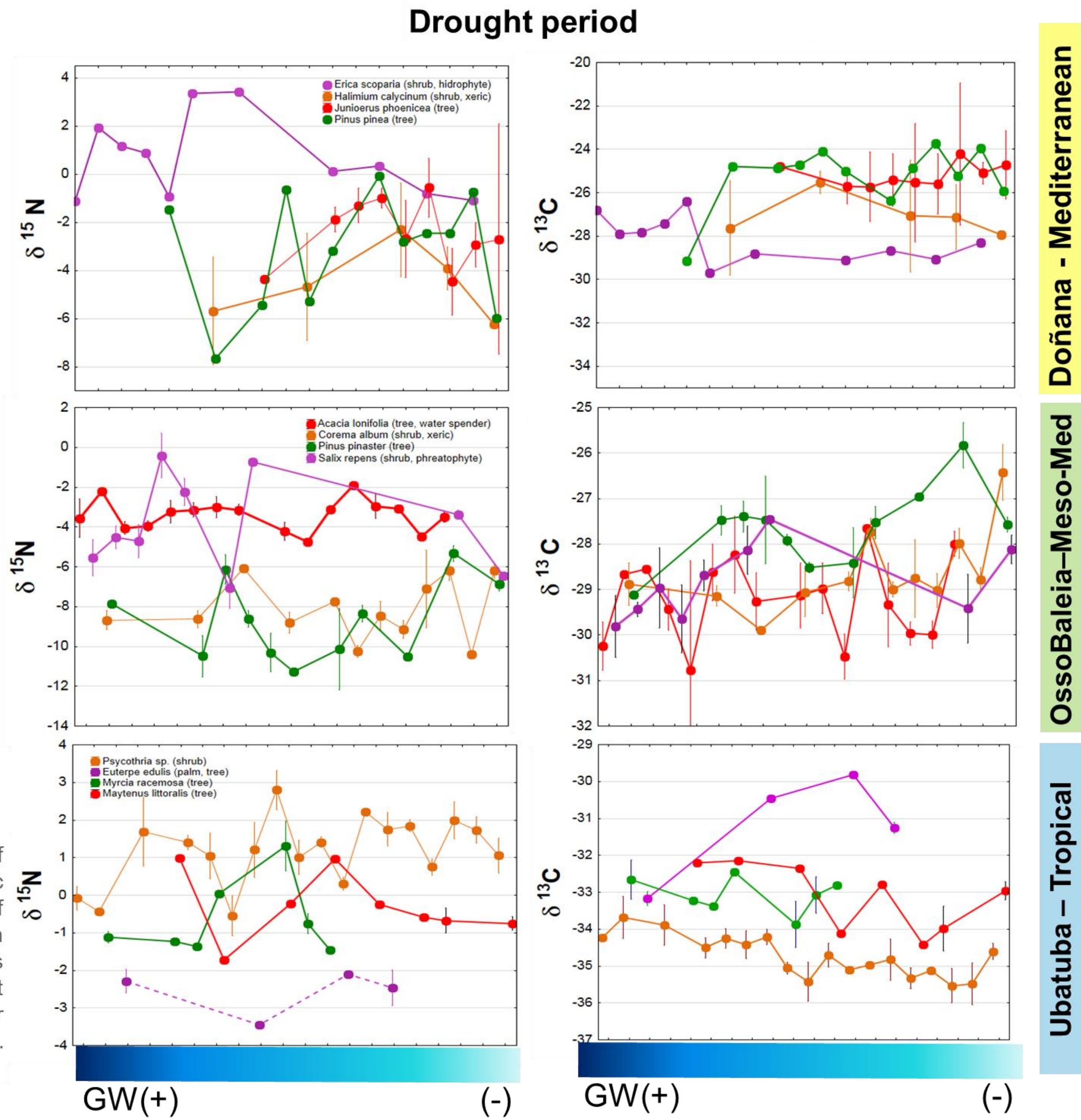
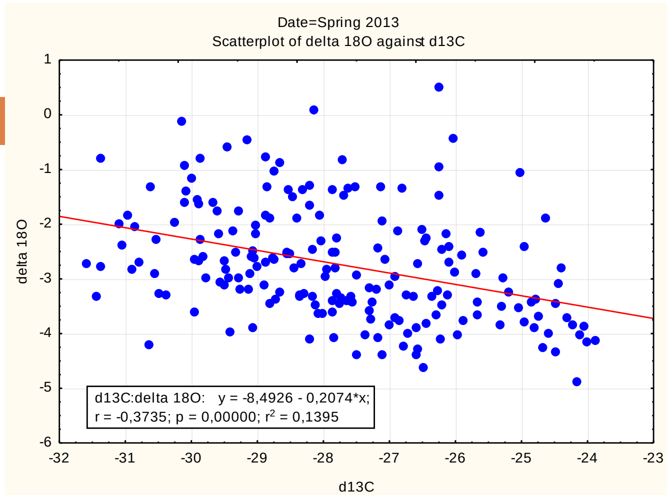
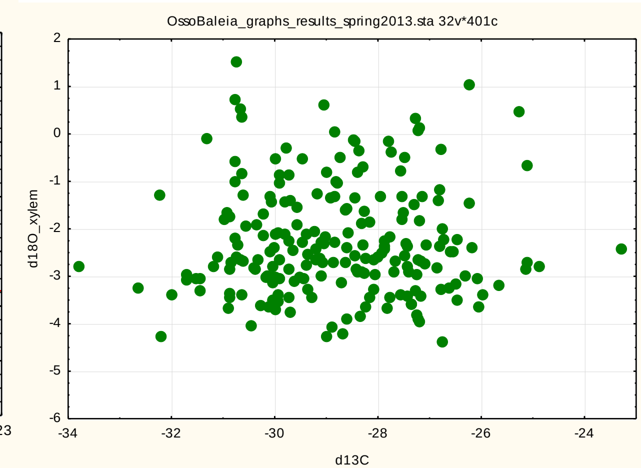


Fig. 3: Mean and SE of leaf nitrogen and carbon isotopic composition ($\delta^{13}C$, $\delta^{15}N$, %o) of 4 plant functional groups, in drought season, in the 3 sites and in a groundwater gradient (+)=less distant; (-) = higher distance to groundwater (GW)). n= 3 per species in each local.

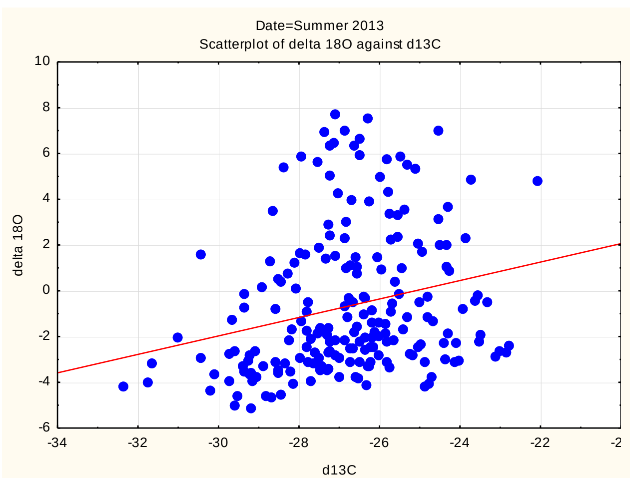
Donana | Osso da Baleia | Ubatuba

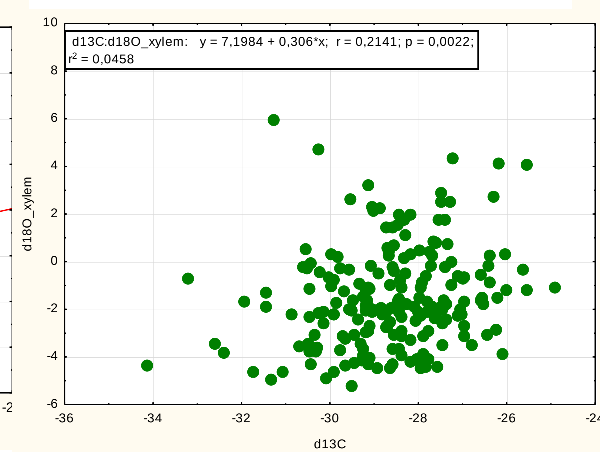
Spring

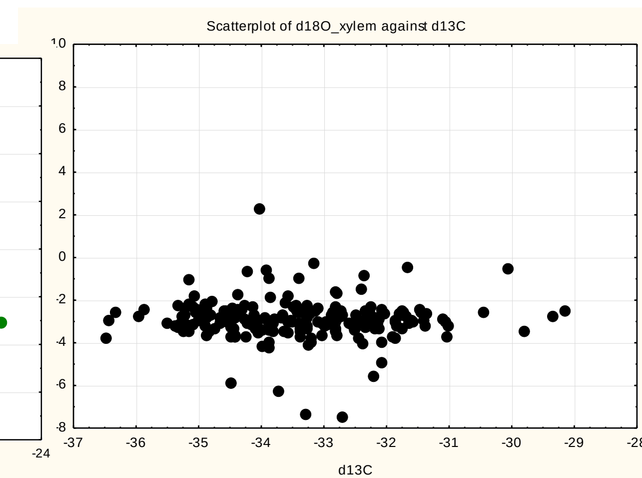




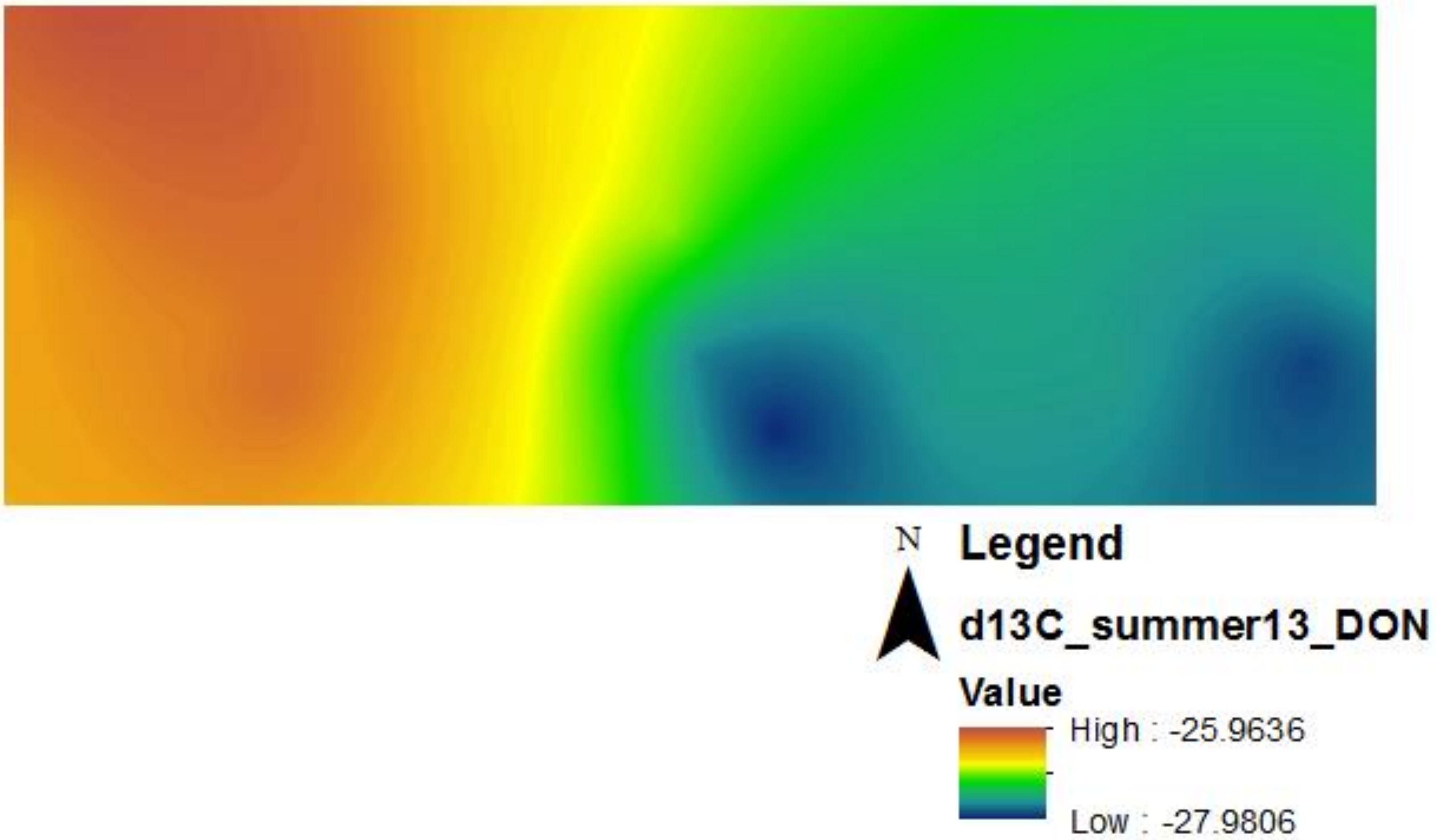
Dry







Isoscape (for all species)



Tarefa 3. Groundwater short-term stress tracers: isotopic approach

Próximos passos:

1) Evaluation of isotopic signals in all Functional groups

2) Evaluation of Isotopic signals in GW gradient (GW level regressions)

2) Isoscapes considering 13C, 18O and 15N for all Functional groups /Species

3) Mixed sources: mixing models (soil, precipitation , GW)

In general, with n isotope signatures, contributions for n+1 sources

$$\begin{aligned} \delta_m^1 &= f_a\delta_a^1 + f_b\delta_b^1 + f_c\delta_c^1, \\ \delta_m^2 &= f_a\delta_a^2 + f_b\delta_b^2 + f_c\delta_c^2, \\ 1 &= f_a + f_b + f_c. \end{aligned}$$

4)

Tarefa 4

MEMBERS: FCUL, Campinas, U. Sevilla, REN
Responsável: Univ.Sevilla

TASK 4. Groundwater short-term stress tracers: vegetation indices approach

Objective

(i) Definition of important indices that could function as short-term stress tracers in scenarios of groundwater (GW) limitation.
(ii) Understand the ecophysiological responses of functional groups in a GW gradient.

4.1 Plants state evaluation (two seasons)

We intend to evaluate plants performance abilities, related with water stress and photosynthetic capacities under the prevalent conditions. Thus, the vitality indices related with physiological traits will be estimate. The Photochemical Reflectance Index (PRI), the Water Index (WI) and Brown pigment index (BPI) will be evaluated with a Spectral Analysis System (UniSpec-SC-PP). Foliar reflectance will be measured in parallel with fluorescence chlorophyll measurements to assess the maximal photosynthetic capacity as Fv/Fm and the effective quantum yield in natural conditions. Additionally, leaf water potential measurements, with a water pressure chamber (Manofrígido, Portugal) will be performed. The measurements will be conducted in the marked individuals (Task 2.1) simultaneously with Task 3. In each marked species, it will be performed 3 measurements.

4.2 Plant water state through NDWI

The canopy water content can be calculated using **remote sensed data**. This results from the different reflectance between water and photosynthetic pigments: water and dry matter in the leaves influence mostly the reflectance on the near-infrared (NIR) and shortwave-infrared (SWIR) bands while photosynthetic pigments absorb mostly in the visible and red spectral band. Therefore, by measuring NIR-SWIR we can calculate a pigment-independent estimation of vegetation water content. Using this information we propose to calculate the Normalized Difference Water Index (NDWI), calculated as (NIR-SWIR)/(NIR+SWIR) to compare the water status of canopy. This will be performed for all the 3 plots area. Because NDWI can be influenced by leaf and canopy structure, this index will only be used to compare plots located on the same climatic region (unless the leaf and canopy structure shows to be similar between sites).

4.3 Integrative analysis of all indices in function of GW availability

For answering the question: "which vegetation indices can be used as short-term ground water stress tracers?" we will use the data collected (task 4.1 and 4.2), to perform correlations between them and the distances to GW (task 1.3).

Expected achievements: i) Understand how functional groups' water state change in GW limitation; ii) Definition of suitable vegetation indices as short-term stress tracers in scenarios of GW limitation.

Reflectance indices

***WI – Reflectance water index*:** The simplest WI is a ratio between reflectance at a reference wavelength where water does not absorb and a wavelength where water does absorb (Sims and Gamon, 2003). It is highly related with **plant water content**, so it can be used as a proxy of water content in the plant (Penuelas, et al., 1997).

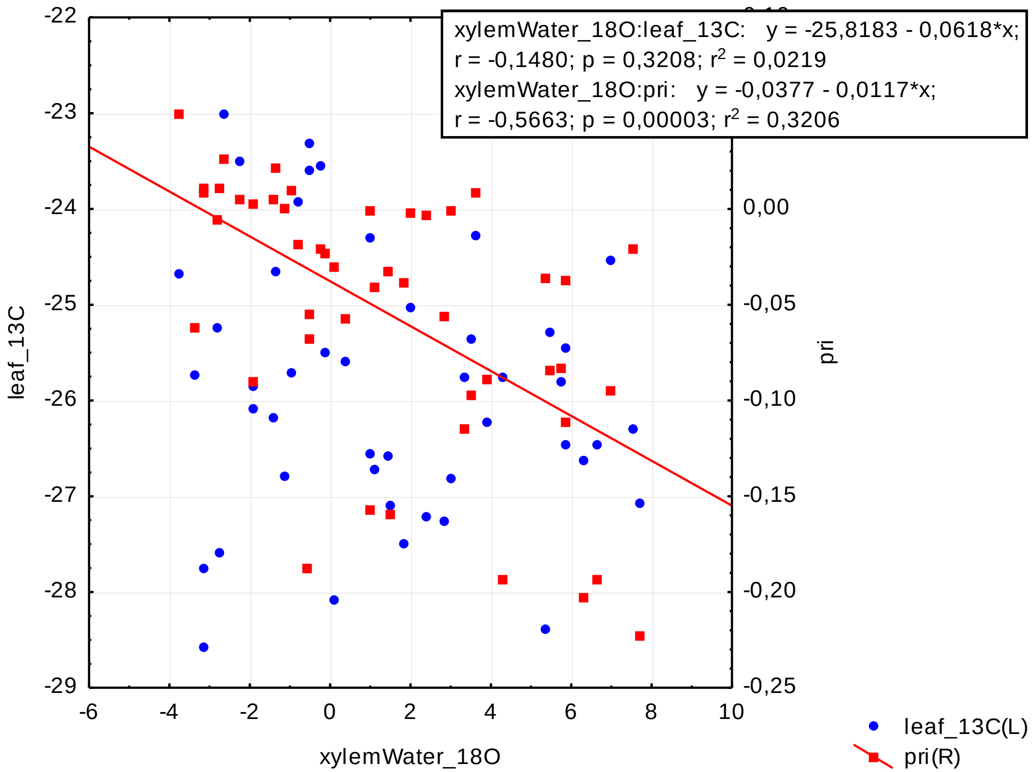
PRI – Photochemical reflectance index. There is an emerging consistency in the relationship between photochemical reflectance index (PRI) and **light use efficiency** (LUE) (Penuelas et al. 2011), It also behaves as an **index of the chlorophyll / carotenoid ratios** and therefore of the **photosynthetic activities** associated with their changes with leaf development, aging or stress at longer term (Penuelas et al., 1997; Sims & Gamon, 2002; Filella et al., 2009). It works well in leaf, canopy and ecosystems LUE assessment (Penuelas et al. 2011).

CHL – Chlorophyll content indices**:* Significant correlations between **total foliar extractable chlorophyll** and chlorophyll content index values (**CHL** or CCI) obtained with portable chlorophyll meters have been reported for a number of agricultural species and several tree species (Schaper and Chacko, 1991; Shaahan et al., 1999; Richardson et al., 2002). Chang and Robison (2003) observed strong relationships between CCI and **foliar nitrogen** in four hardwood species (van den Berg and Perkins 2004). In estimates of **leaf Chl content** the reflectance indices that performed best was ***Chl NDI = (R750 - R705)/ (R750 + R705), although not commonly used in the literature (Richardson et al. 2002).

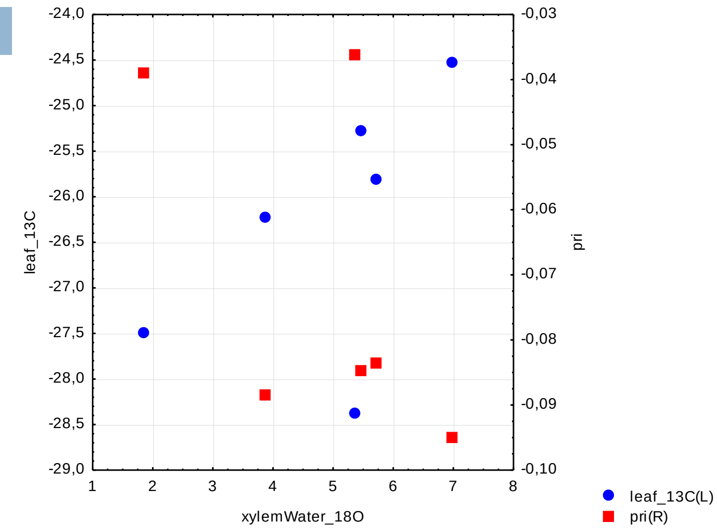
***NDVI – Normalized difference vegetation index**:* this index was found to be less sensitive to water content than other water band indices. NDVI allow the assessment of the **green plant biomass** and **green leaf area** of the ecosystems, and therefore the **absorbed light** and **plant photosynthetic capacity** (Gamon et al., 1995). However, directly detecting how much of this capacity is actually realized at daily and seasonal scales is a much more challenging goal, especially when NDVI-like indices do not scale with CO2 uptake, a quite common situation in many ecosystems. Now, this challenge appears to be solvable by using the PRI (see PRI - *Photochemical reflectance index)*

PRI

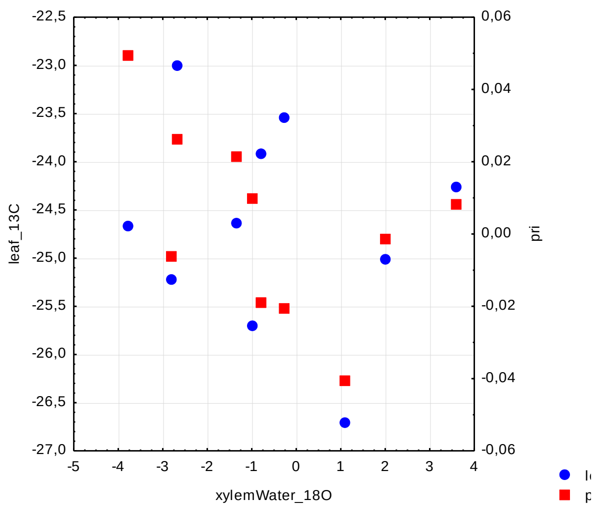
DONANA Summer (not all)



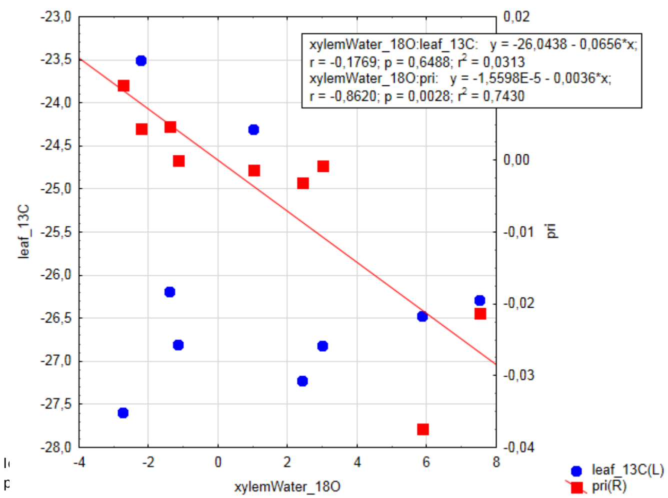
Corema album



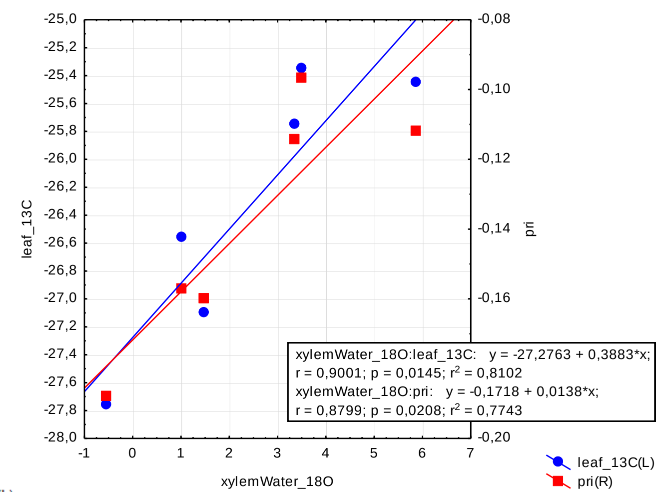
Pinus pinea



Halimium halimifolium

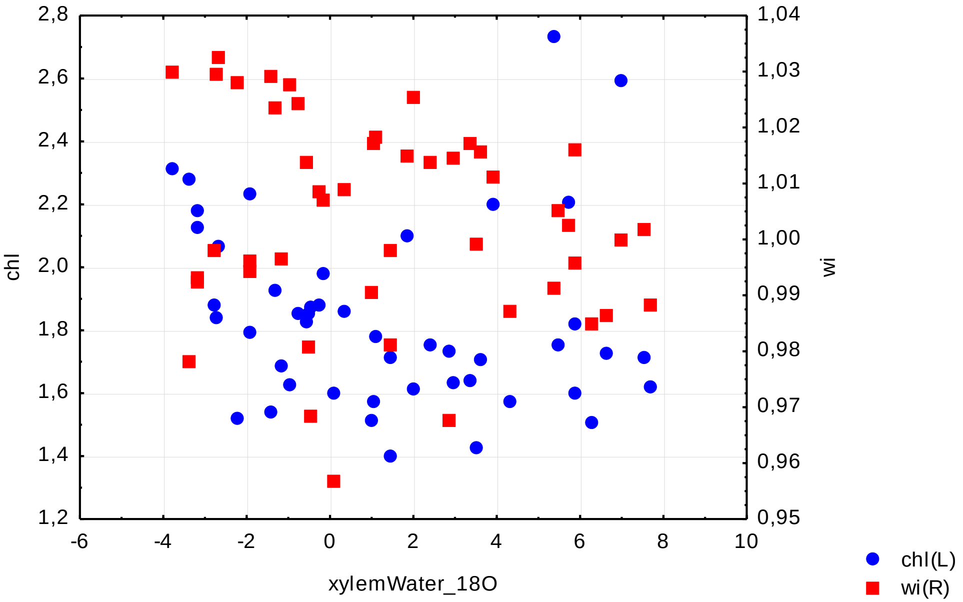


Halimium calycinum



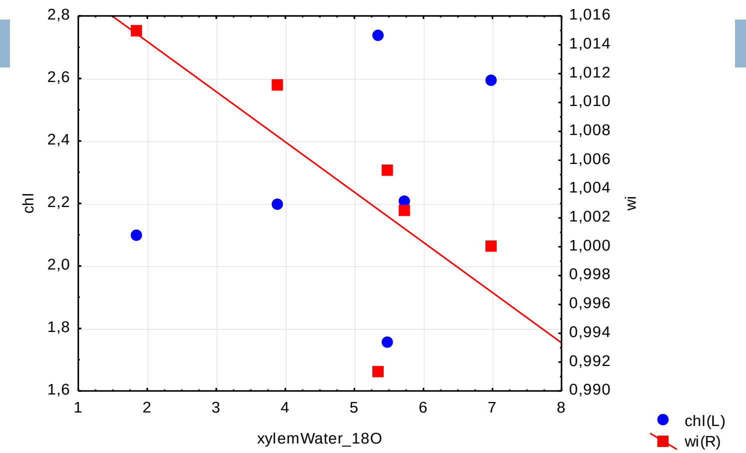
CHL e WI

DONANA Summer (not all)



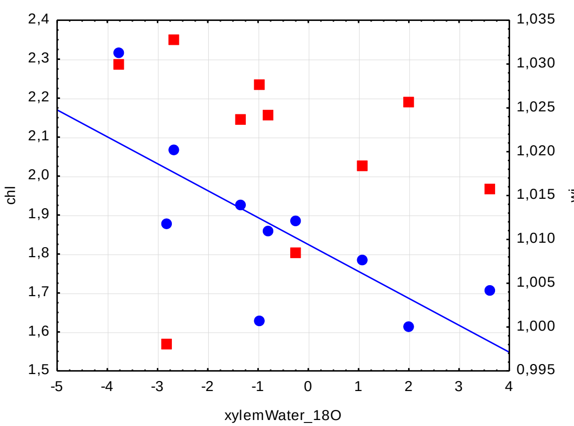
xylemWater_18O:chl: y = 1,8525 - 0,0107*x;
r = -0,1223; p = 0,4130; r^2 = 0,0149
xylemWater_18O:wi: y = 1,0049 - 0,0011*x;
r = -0,1999; p = 0,1778; r^2 = 0,0400

Corema album



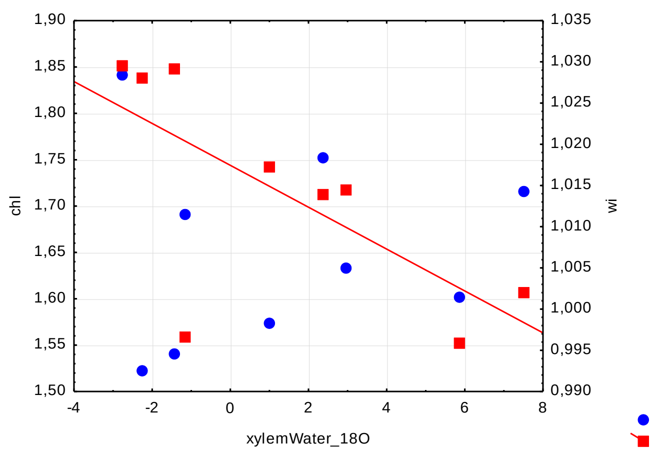
xylemWater_18O:chl: y = 1,9172 + 0,071*x; r = 0,3571; p = 0,4872;
r^2 = 0,1275
xylemWater_18O:wi: y = 1,0212 - 0,0035*x;
r = -0,7399; p = 0,0927; r^2 = 0,5474

Pinus pinea



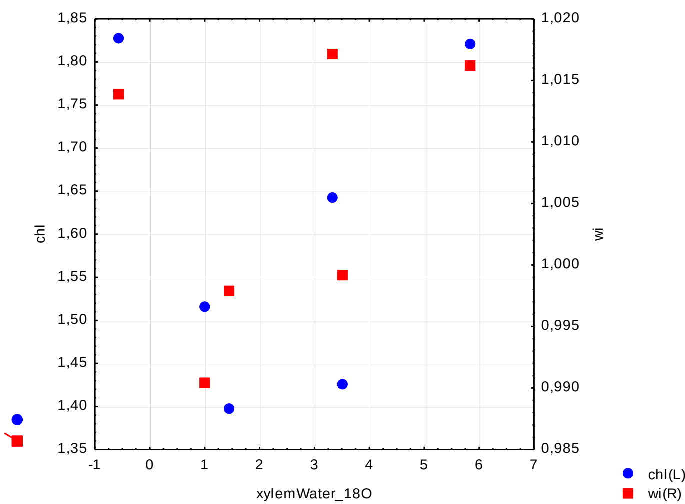
xylemWater_18O:chl: y = 1,8243 - 0,0691*x;
r = -0,7554; p = 0,0115; r^2 = 0,5706
xylemWater_18O:wi: y = 1,0201 - 0,0005*x;
r = -0,1186; p = 0,7442; r^2 = 0,0141

Halimium halimifolium



xylemWater_18O:chl: y = 1,6496 + 0,0015*x; r = 0,0518; p = 0,8948;
r^2 = 0,0027
xylemWater_18O:wi: y = 1,0174 - 0,0025*x;
r = -0,6859; p = 0,0414; r^2 = 0,4704

Halimium calycinum



Tarefa 4. Groundwater short-term stress tracers: reflectance indices approach

Próximos passos:

1) Evaluation of reflectance indices in (i) different seasons; (ii) GW gradient (GW level regressions); (iii) relation to isotopic signals and C/N

2) Reflectance indices spatial approach for all and for Functional groups /Species

3) Understand patterns and functional meanings

4)

Tarefa 5

MEMBERS: FCUL, Campinas, U. Sevilla, Consultor Rolf Siegwolf
Responsável: Univ. Campinas

TASK 5. Groundwater long-term stress tracers

Objective

- Evaluate long-term stress sensitivity of the different functional groups to temporal/seasonal changes in water availability.
- Estimate important factors that could function as long-term stress tracers in scenarios of groundwater limitation.

5.1. Chronological water use and stress: Tree-rings as an archive tool

With increasing frequency, tree-ring width records are being supplemented with tree-ring stable-isotope measurements that are useful for inferring and reconstructing past climate, isotope hydrology, plant ecophysiology, and pollution. Fewer trees seem to be necessary to capture the isotopic signal with some recent instances of isotopic results reported from single trees. Analysis of tree-rings (^{13}C and ^{18}O) will be performed in trees in the groundwater limitation plots per functional group (max of 30 samples per site= 90) and 3 trees in the control plots per functional group (27 samples), with a total of 81 trees considered. This task will be assured by the adviser and consultant Dr. Rolf Siegwolf.

5.2. Growth rate

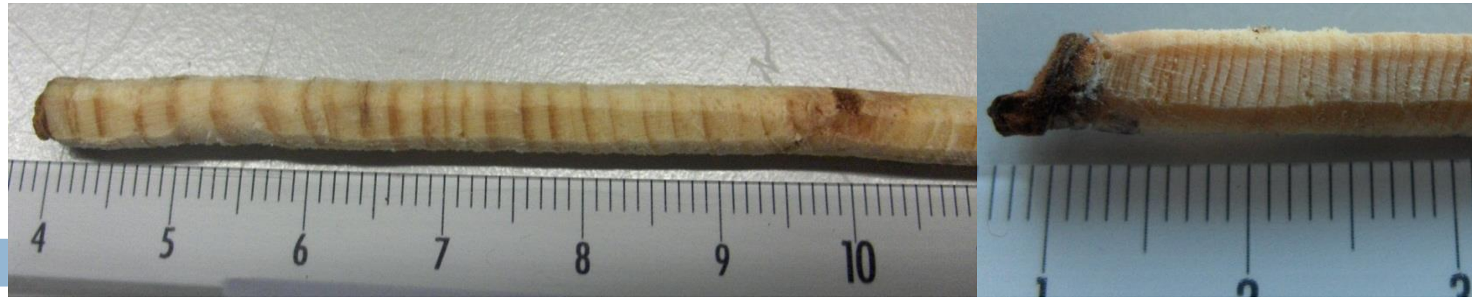
A better understanding of variations in the dynamics and structure of forests is necessary for predicting the potential for these ecosystems to adapt, and for understanding how they recover from disturbances such as groundwater changes. Annual growth increment and seasonal patterns of growth will be assessed in all the trees fitted with dendrometer bands (Task 1) by quarterly measures.

5.3 Integration of studied factors according to groundwater availability

Using the data collected in this task, we will perform correlations between long-term factors and the distances to groundwater (task 1.3) in a temporal scale.

Expected results: i) Analysis of differential utilisation of water and capacity of regulation of water use efficiency in a large temporal scale (from past to present); ii) Determination of functional groups stress sensitivity to changing ground water levels; iii) Determination of changes in relative growth rates patterns according to environmental conditions and groundwater limitation.

Tarefa 5

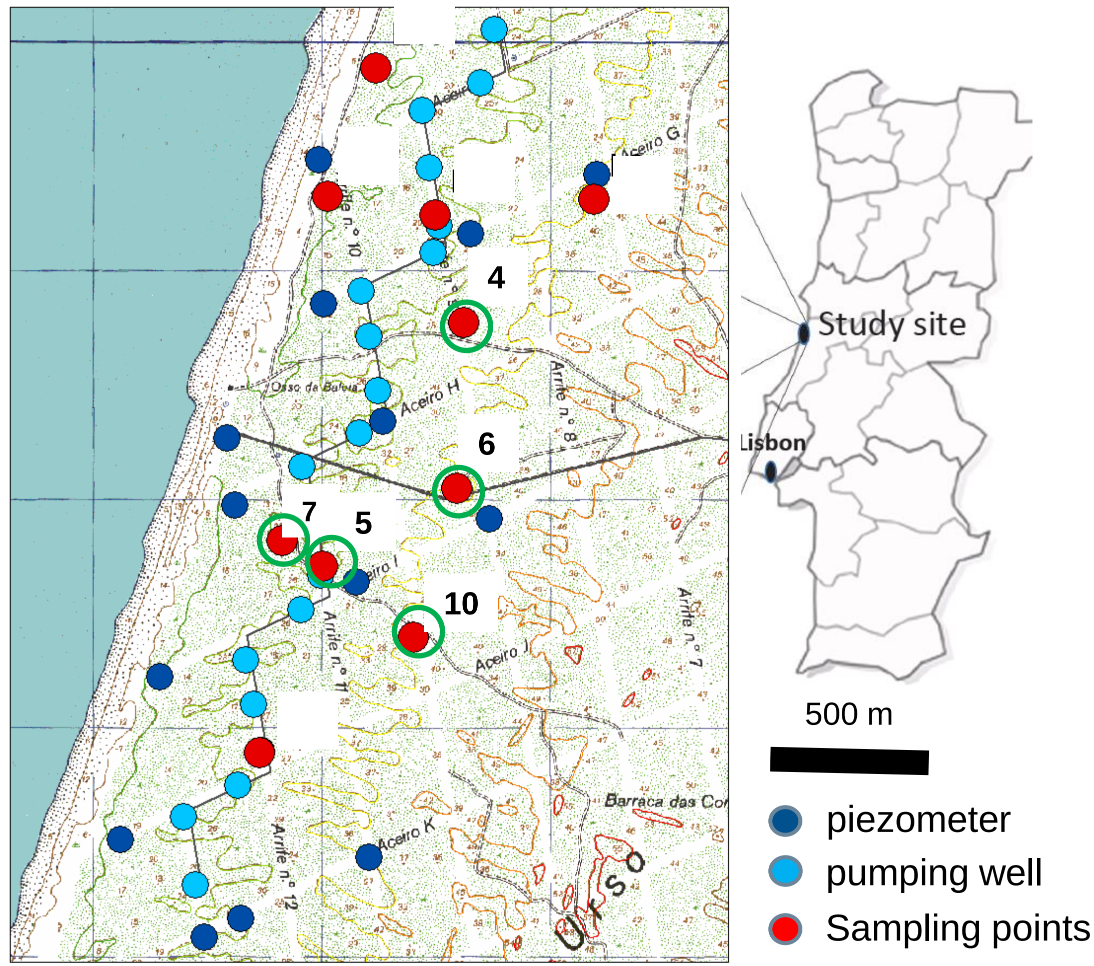


- 1 species: ***Pinus pinaster***
- **5 Sites**
  - *3 with 2 ind*
  - *2 with 1 ind*

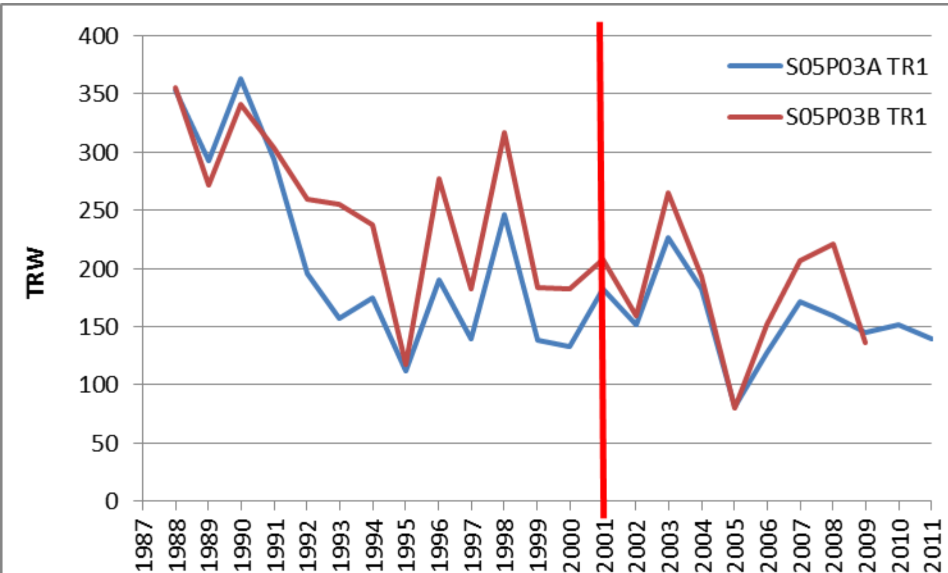
  } **8** individuals
- **Datting** and **TRW**
- From **1991 to 2010**
  - ***10** years **before** GW extraction*
  - ***10** years **after** GW extraction*

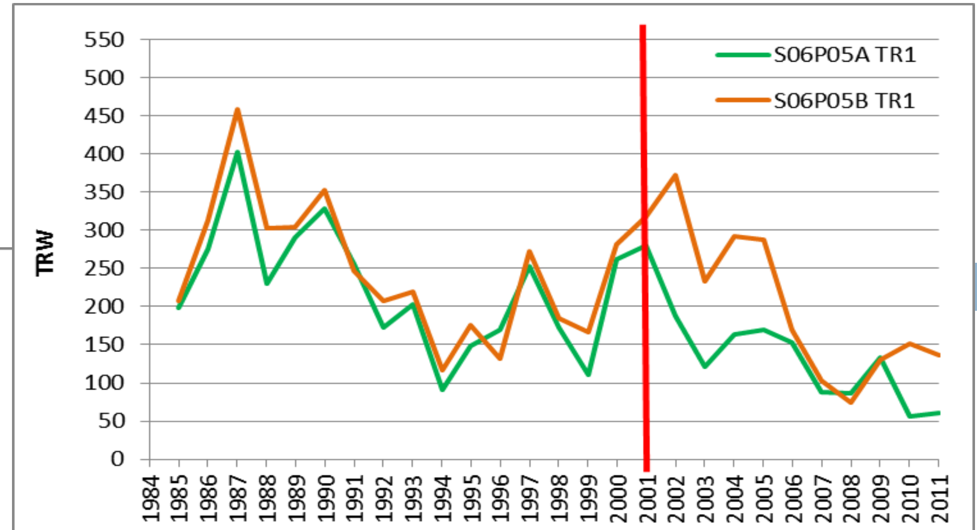
  → **160 samples**
- Analysis of **bulk wood**

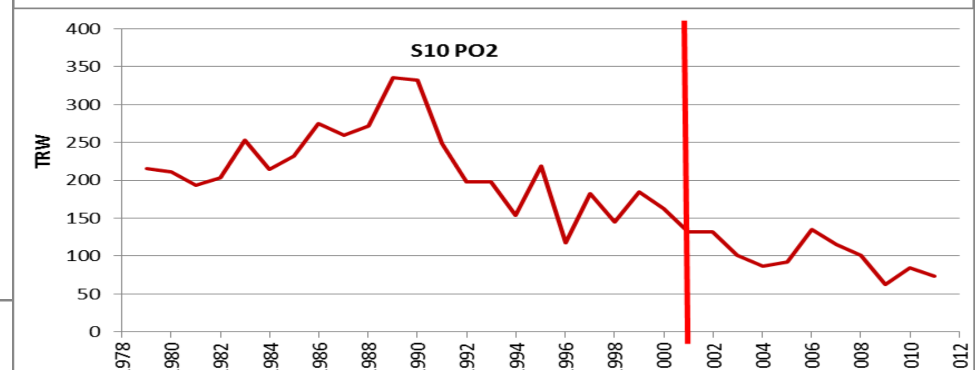
  $\delta^{18}O$ and $\delta^{13}C$
- **Cellulose extraction** in **36** samples (3 sites)

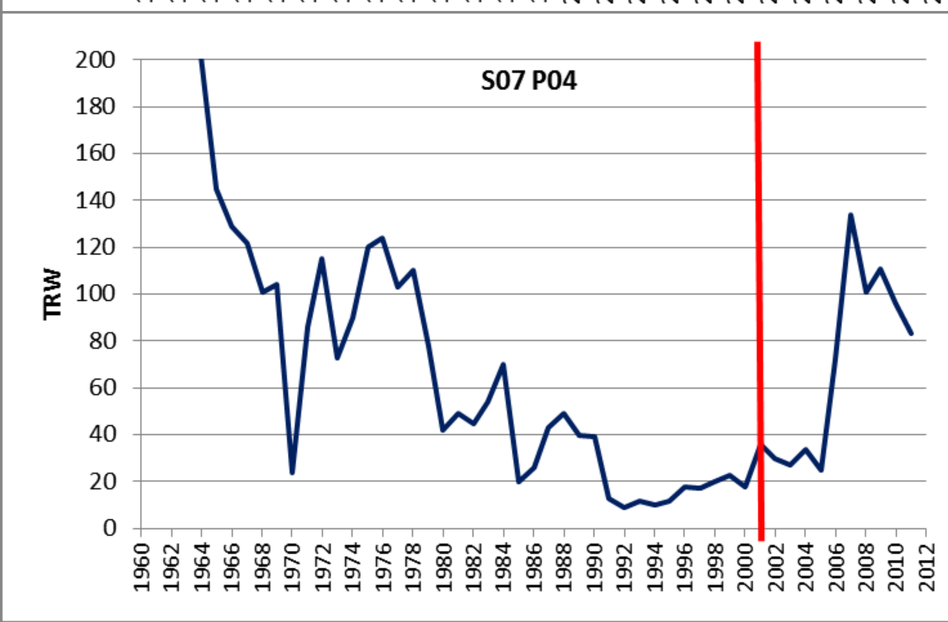


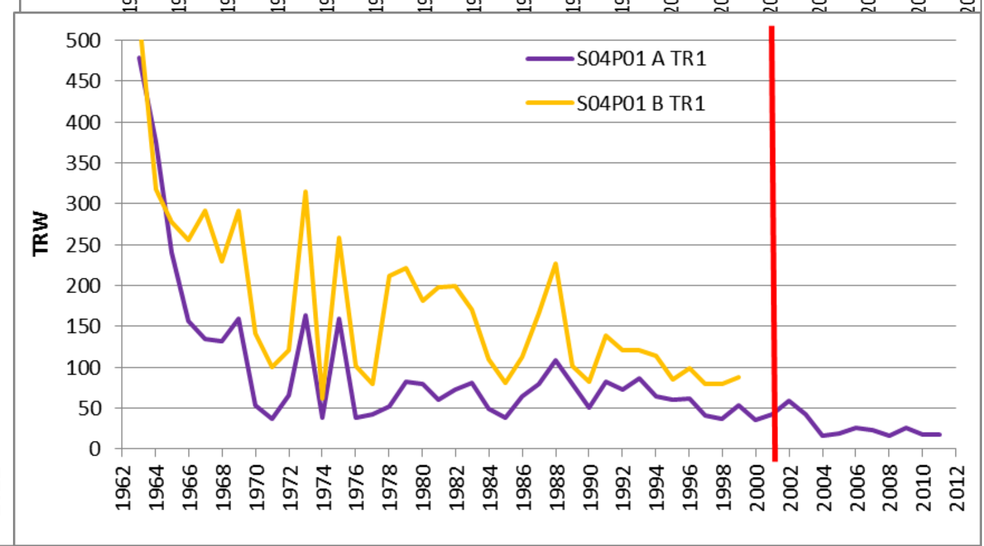
TRWidth


S05P03A TR1
S05P03B TR1
TRW

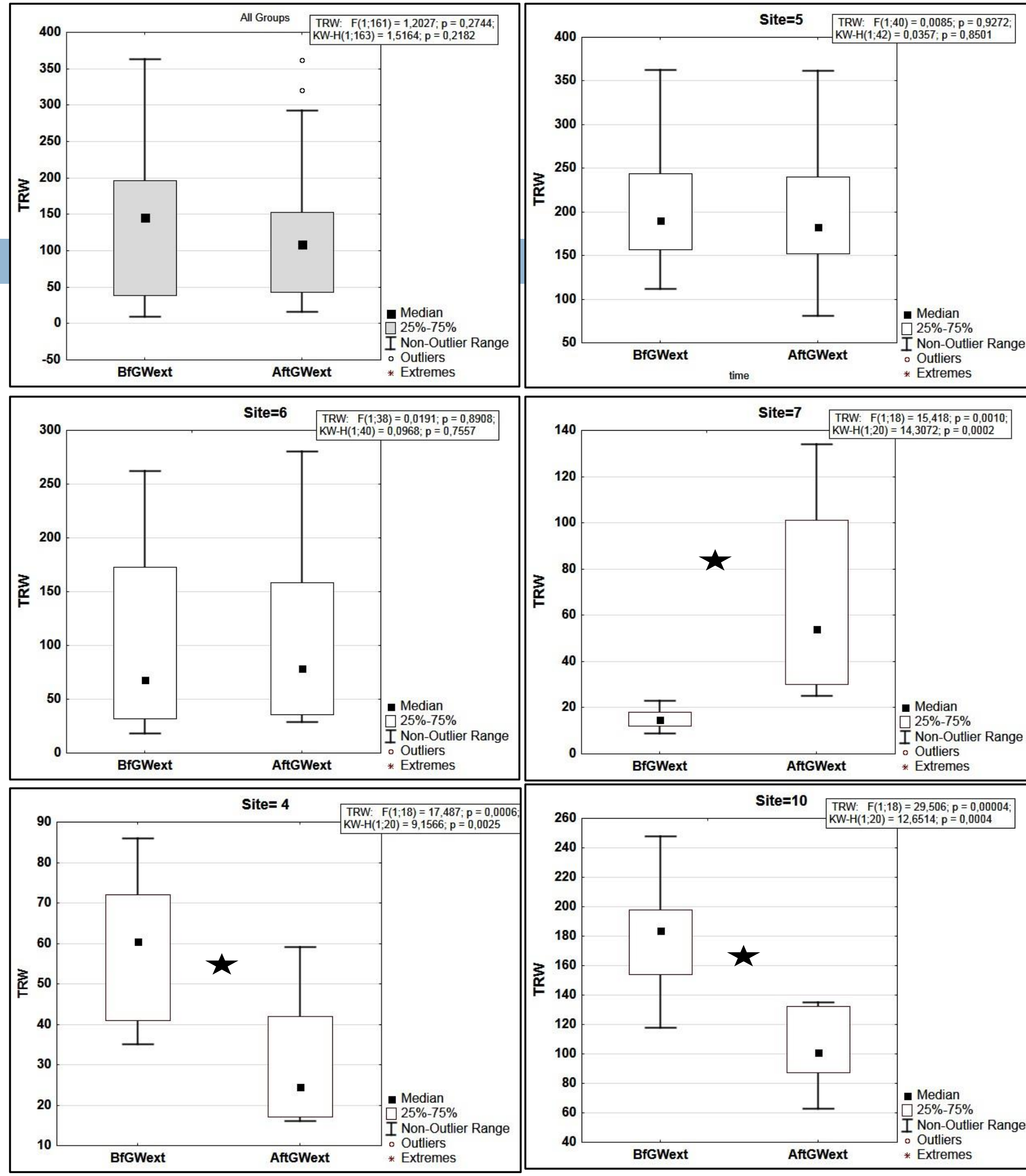

S06P05A TR1
S06P05B TR1
TRW


S10 PO2
TRW


S07 P04
TRW

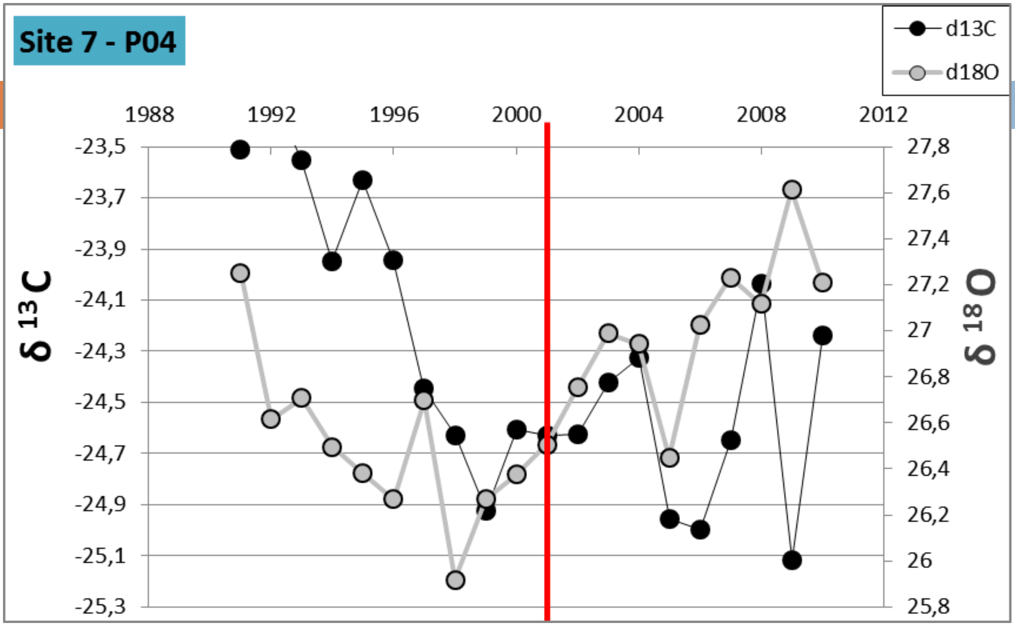

S04P01 A TR1
S04P01 B TR1
TRW

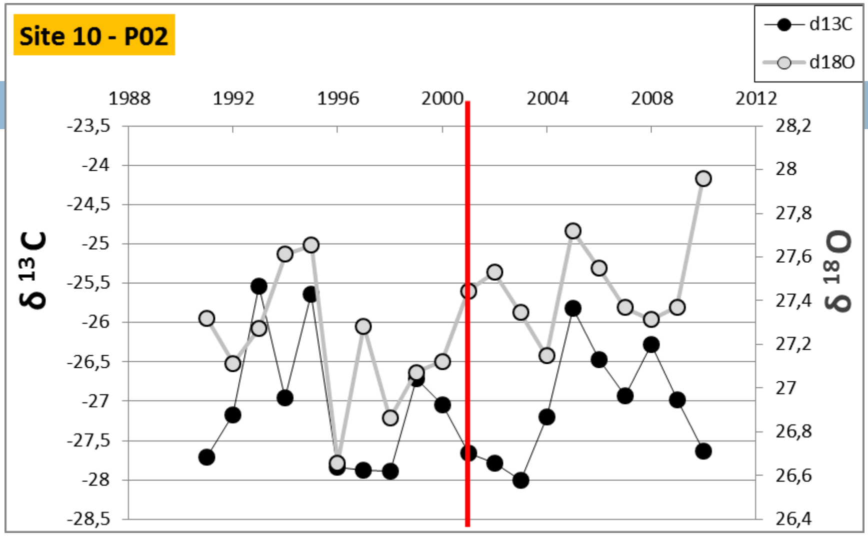
TRWidth

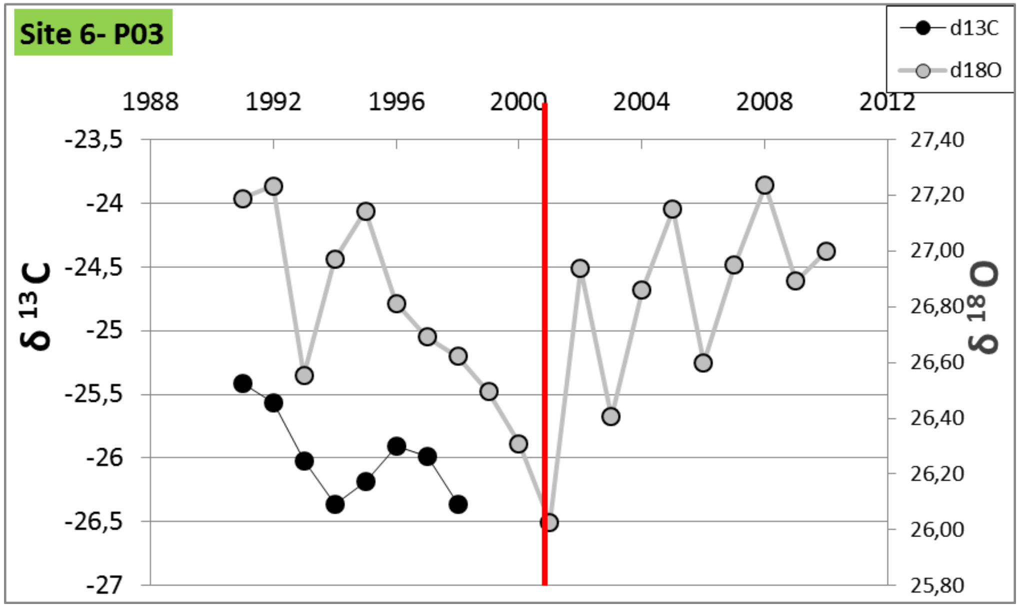


ox-plots (median, 25-75 percentiles, non-outlier range and outliers) of tree-ring width (TRW) from individuals of sites
7, S04 and S10. Data considered: 1991 -2000 = before groundwater extraction (Bf GW ext); 2001 -2010 = after groun
on (Aft GW ext). Black star indicates significant differences between TRW before and after GW extraction.

TR Isotopes







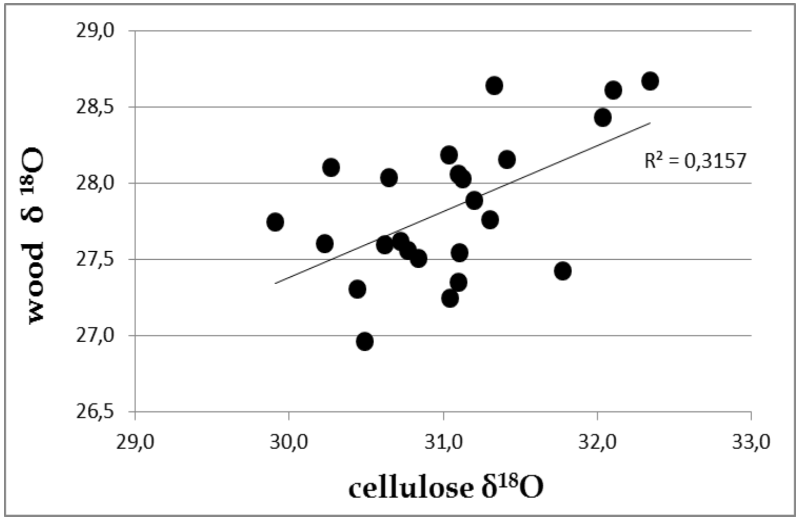


Fig. Bulk wood vs cellulose $\delta^{18}O$ (a) for all samples

TR Isotopes

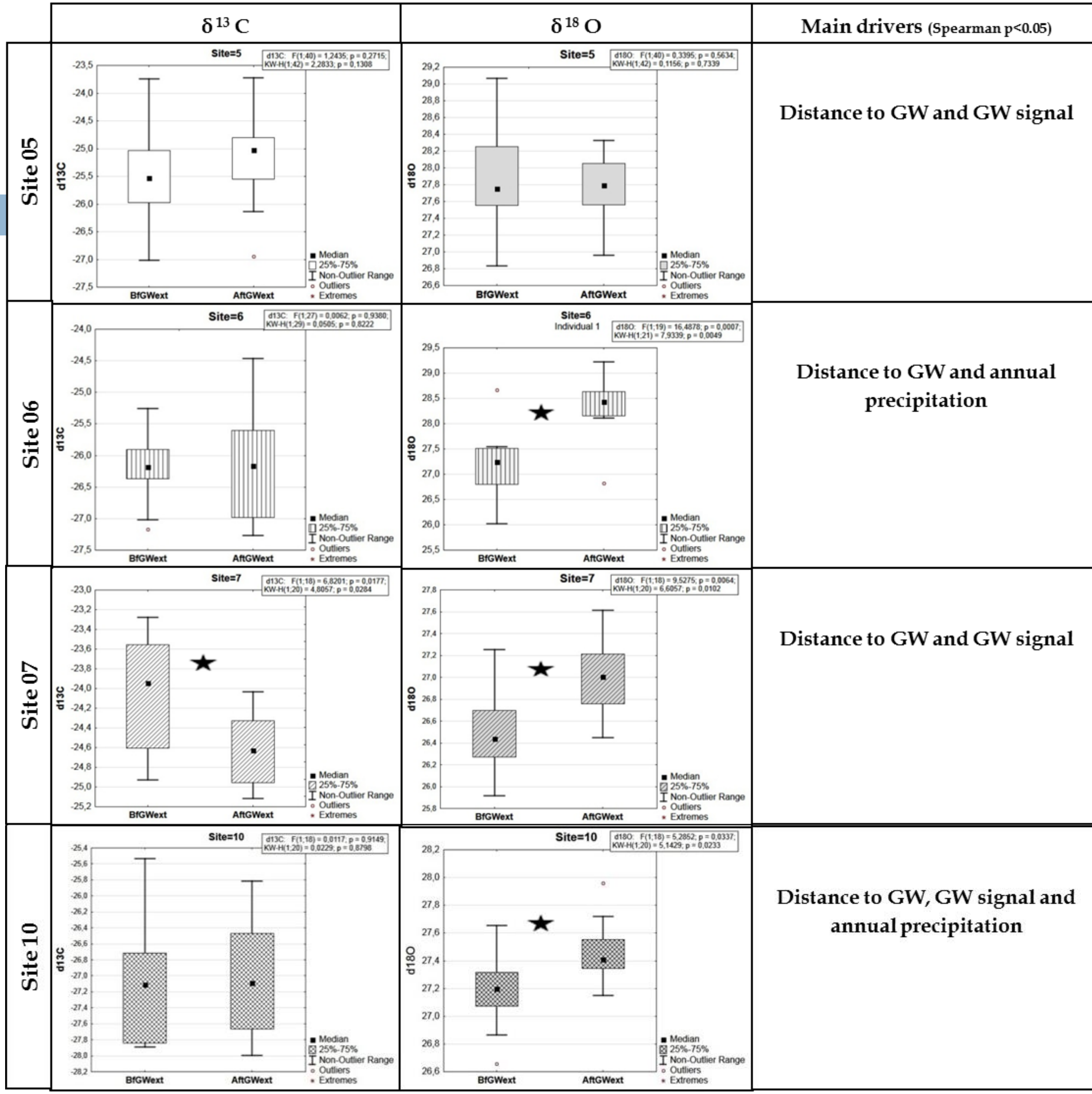
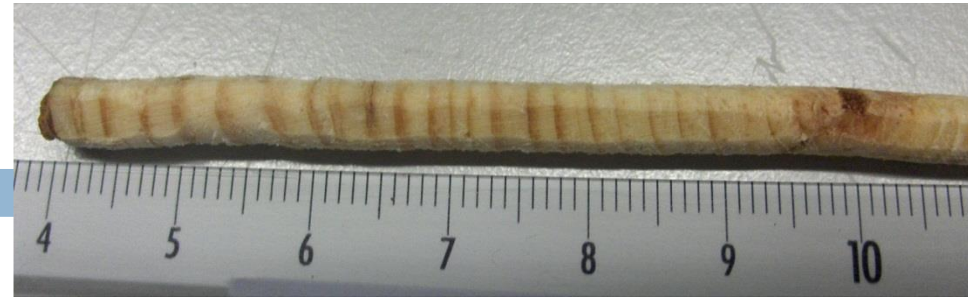


Fig. Box-plots (median, 25-75 percentiles, non-outlier range and outliers) of $\delta^{13}C$ and $\delta^{18}O$(‰) from individuals of all sites and main factors influencing (main drivers). Data considered: 1991 -2000 = before groundwater extraction (Bf GW ext); 2001 -2010 = after groundwater extraction (Aft GW ext). Black star indicates significant differences (p<0.05) between *before* and *after* GW extraction.

Tarefa 5



Próximos passos:

Amostragem Agosto e Novembro –

o que amostrar?

o que analisar?

Aplicar Brooks model

Tarefa 6

MEMBERS: FCUL, Campinas, U. Sevilla, Bielfeld, Consultor Luis Martinelli e Rolf Siegwolf
Responsavel: IST

TASK 6. Prediction of functional groups responses to groundwater limitation

Objective

•Integrate spatial water resource and short- and long-term groundwater stress indicators among the different climatic conditions and groundwater availability

•Project water use differences under future groundwater change

6.1. Groundwater modelling

Monthly groundwater altitude (height relative to sea level), calculated from each well and piezometer, will be interpolated (choosing the best approach possible) within the study area by ordinary kriging, using GeoMS (Cerena, 2000). From this we will obtain a smooth surface representing the water table altitude for all the study area. Afterwards a map showing the distance to ground water for all the area will be calculated as the difference between the water table altitude map and the ground altitude, calculated from the digital terrain model.

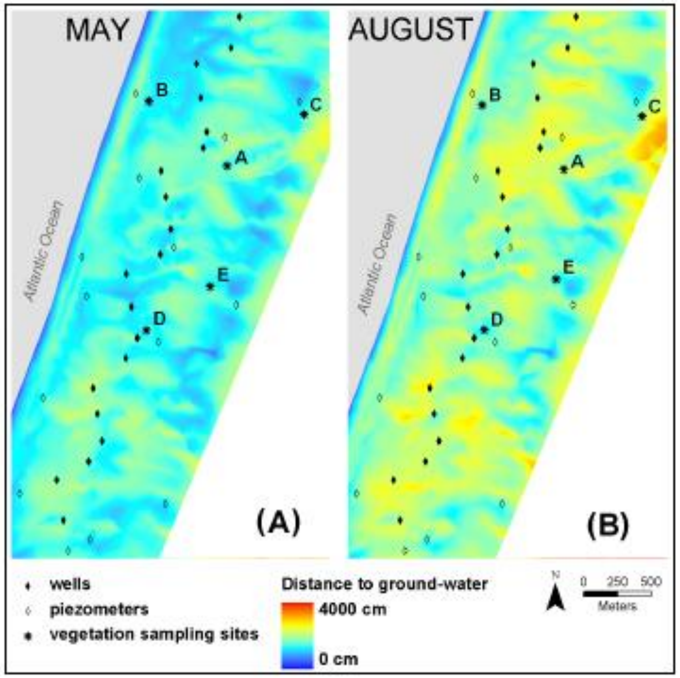
6.2. Stress tracers' spatial pattern

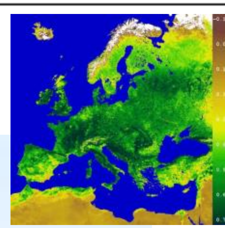
Stress tracers will be scaled up to facilitate comparison between sites and manipulative treatments and also for correlate with the groundwater spatial pattern. For the two season of measurements, we will interpolated (choosing the proper methodology) within the study area by ordinary kriging, using GeoMS (Cerena, 2000) the groundwater stress tracers found suitable in the task 3 and 4. From this we will obtain a smooth surface representing the expected short and long term community responses to groundwater changes for all the study area.

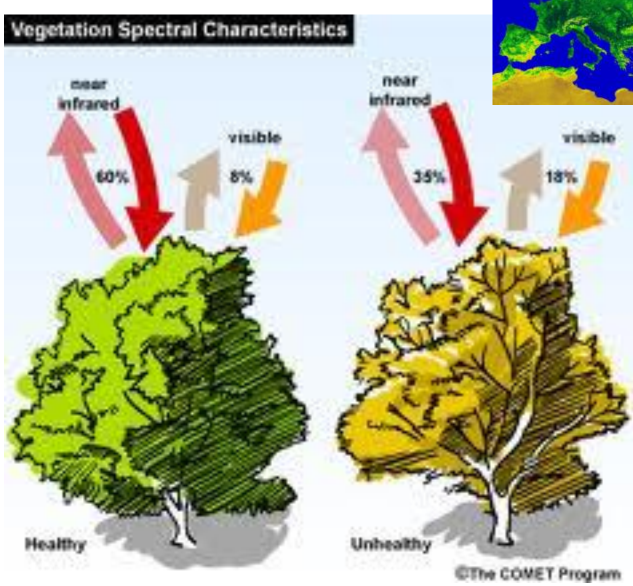
6.3. Integration of groundwater stress tracers and groundwater patterns: prediction of future responses

The extension of the local information in space and time will be accomplished in this task. We are very much convinced that such an approach must be data driven in order to have confidence in future climate change projections. So the model will be aligned with the results of Tasks 2-3 for proper temporal patterns of plant water usage. Accordingly it will be produced for the first time, an integrative spatial approach of groundwater stress indicators. A spatially and temporally well-validated model of ecosystem functioning under future climate change, i.e different groundwater availability and usages, will be developed.

Expected achievements: i) spatially explicit model that includes groundwater dynamics and detailed ecosystem physiology; ii) creation of a model to evaluate community water use under future groundwater change scenarios through ecophysiological parameters.







(1) Desenvolvimento de um DEM (Digital elevation model) de resolução fina para os locais de estudo (Osso da Baleia, Doñana e Ubatuba)

(2) Modelação do GW: GW level modelling (Spatial and temporal maps) para os locais de estudo.
Nota: Seria interessantes tentar modelar mensalmente, tendo como prioridade os meses de amostragem e o anterior à amostragem. Este modelo terá de ter em conta o DEM das áreas. Pode ainda ter em conta efeitos de run-off e precipitação (temporal), teriam de explorar metodos que possam ser adequados.

(3) Modelação de dados de reflectância (ao nível da folha) nos locais de estudo em diferentes épocas do ano.
Nota: Utilização dos valores de indices de reflecatncia para construção de mapas à escala local.

(4) Explorar padrões de NDWI (Remote Sensing Data) nos locais de estudo e em diferentes ápocas do ano.
Nota:Explorar padrões de NDWI para compararmos com os nossos (possiveis) padroes isotopicos e de reflectance ao nivel do individuo..

(5) Utilização de imagens de alta resolução para avalição da estrutura da vegetação (em Doñana e Osso da Baleia).
Nota: Utilização de *drones* para obter imagens e posterior tratamento para obtenção de coberturas e distribuição dos individuos de plantas existentes. Podemos "calibrar" em locais que já temos a esturtura avaliada. (PLots de 20m x 20m).

Obrigado!