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

Kickoff Meeting

25 / 05 / 2012

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.**

O objectivo deste projecto é o de avaliar a capacidade de diferentes comunidades florestais se adaptarem a diferentes condições e/ou futuros cenários de alterações da AS, através de uma abordagem espacial integrada com base em indicadores de stress causados pela AS

- Understand functional groups water use in a GW limitation situation;
- 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.
- Understand the ecophysiological responses of functional groups in a GW gradient.

- 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.

Participantes

The team will be composed by:

(i) Portuguese institutions: **FCUL** and **IST**; (Cristina Máguas e Maria João Pereira)

(ii) Brazilian institution: **UNICAMP**; (Simone Vieira e Rafael Oliveira)

(iii) Spanish institution: **Univ. de Sevilla;** (Mari Cruz Barradas)

(iv) German instituion: **Univ. Bielefeld**; (Christiane Werner)

and <u>two consultants</u>:

- Rolf Siegwolf, from Paul Scherrer Institut (Zurich, Switzerland)
- Luiz Martinelli from USP (S. Paulo, Brazil)

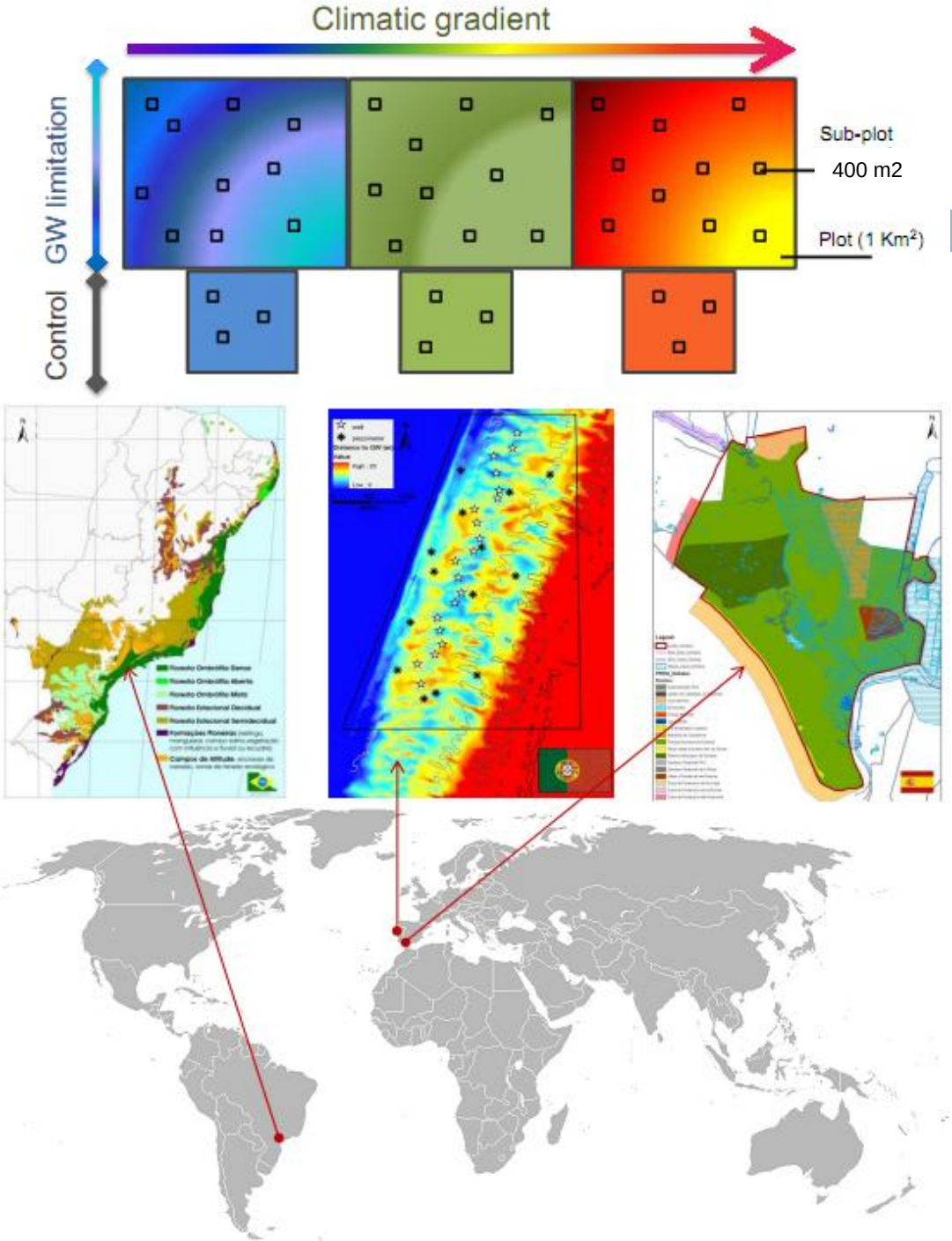
Locais de estudo

Brazil: Mata Atlântica: Tropical

Portugal: Osso da Baleia: Meso-mediterrâneo

Spain: Doñana: Meditarrâneo

The large-climatic-scale study, covering **Brazil**, **Portugal** and **Spain**, will provide an excellent and innovative experimental condition to study the GW dynamics and community functioning (functional groups) in natural intact ecosystems of high ecological value.



Locais de estudo

Requisitos

i) all sites are coastal sand dune forests,
ii) the different climatic regions sites have two contrasting situations: with groundwater limitation and without this stress
iii) the sites with groundwater limitation have spatial heterogeneity (gradient)

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).

(a) 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.

(b) Precipitation will be collected by installing **1 collector at each study plot** (6 in total).

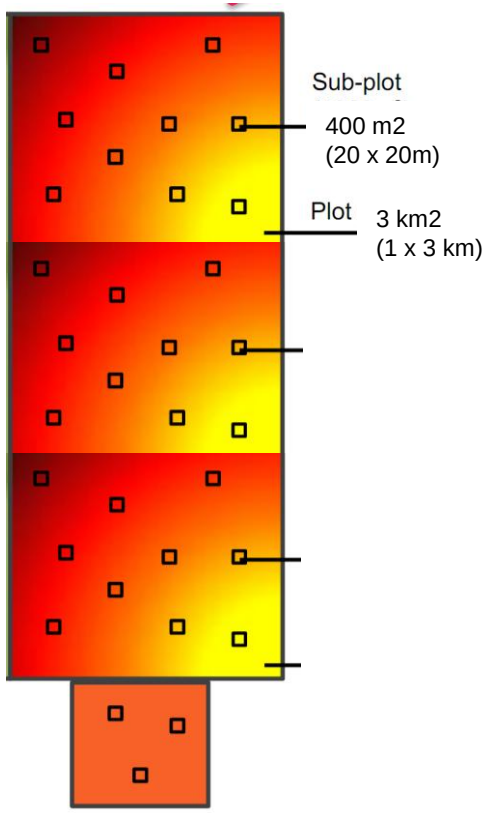
(c) To quantify **fog-water inputs and due, 1 passive collector** - a vertical net with a collection surface- will be placed **in the sea-facing side of each plot** (6 in total).

(d) 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). Note: Osso da Baleia already has this piezometers installed.

(e) Maximum of **climate** (past information); **plant diversity / functional groups information; Aerial photographs;**

(f) Possibility of installation of **dendrometric bands** in the 30 points (3 sps per point)

(g) Possibility of installation of the **30 sub-plots** for experiments



Locais de estudo

Osso da Baleia

Forest structure – Osso da Baleia

Árvores_perimetro + altura + localização

Arbutos_ diametro copa + altura + localização

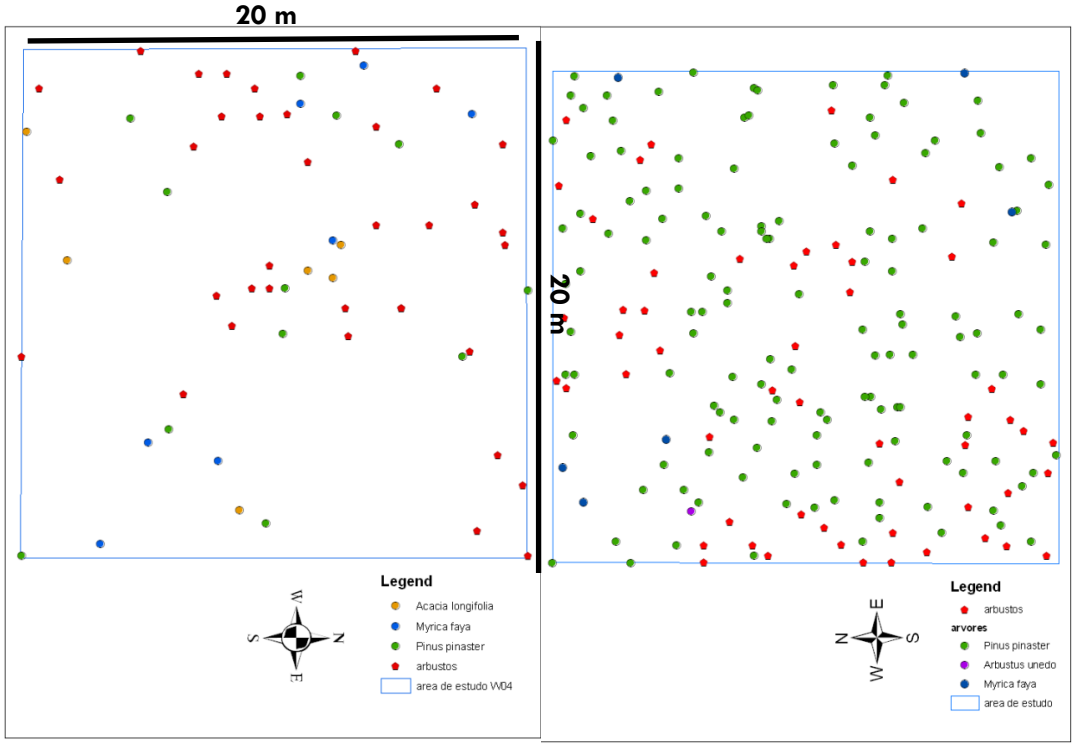


Figura A – Exemplo de dados obtidos da estrutura florestal em Osso da Baleia

Figura B – Green trees: sampling points (dendometric bands already installed); Red circules: water wells; Blue circules: piezometers. Red circles: sampling sites= sub-plot

Experimental plots

In every sub-plot (20 x 20m – depending on field conditions)

- Functional groups identification

In every sub-plot the species identification, composition and distribution will be performed and grouped in the following functional groups:

- shallow root species
- deep root species
- mixed root species

- Ecophysiological measurements (isotopes, UniSpec…) – <u>two seasons</u>

In every sub-plot 15 plants will be marked (5 per functional group), totalling 450 individuals in groundwater limitation plots and 45 in the control plots per site (total=495*3=1485).

- Forest structure evaluation

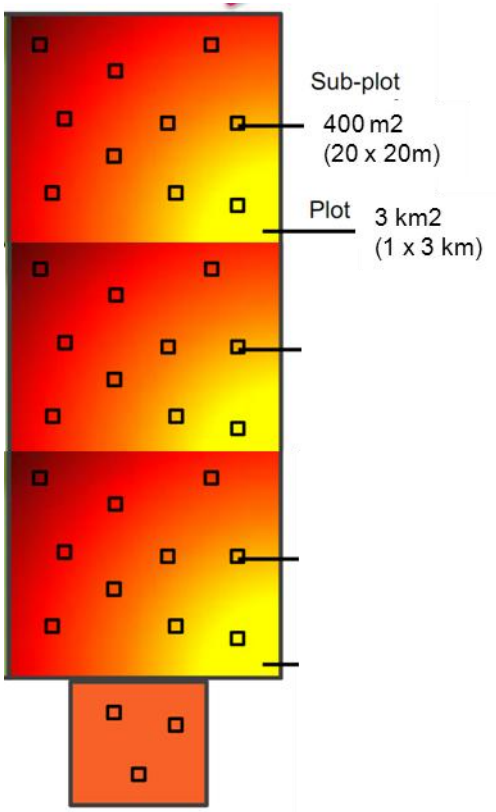
In each sub-plot, the projected area, spatial distribution and allometric measurements will be registered for each individual (within functional group defined in 1.4).

- 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.

- Soil profiles – <u>two seasons</u>

In each sub-plot one soil profile will be performed (totaling 39 soil profiles x 3 sites). For that, soil will be sampled in 10, 20, 40, 60 cm, for water analysis.



Orçamento

Orçamento Global
Global budget

Descrição Description	2011	2012	2013	2014	2015	Total
Recursos Humanos Human resources	0	18,420	13,250	20,066	0	**51,736**
Missões Missions	0	8,522	5,566	8,169	0	**22,257**
Consultores Consultants	0	0	1,350	2,050	0	**3,400**
Aquisição de bens e serviços Service procurement and acquisitions	0	15,760	3,000	3,000	0	**21,760**
Registo de patentes Patent registration	0	0	0	0	0	**0**
Adaptação de edifícios e instalações Adaptation of buildings and facilities	0	0	0	0	0	**0**
Gastos gerais Overheads	0	10,980	15,633	6,657	0	**33,271**
Equipamento Equipment	0	12,200	55,000	0	0	**67,200**
Total	**0**	**65,882**	**93,799**	**39,942**	**0**	**199,624**

Bolsa Mestre (3 Anos)
Bolsa Licenciado (6 + 6 meses IST)

Field trips (Portugal + Spain + Brazil)

Rolf Siegwolf (2º ano)
Luiz Martinelli (3º ano)

SIAF (IRMS) manutenção/ gás/ consumíveis
Additional field and lab material

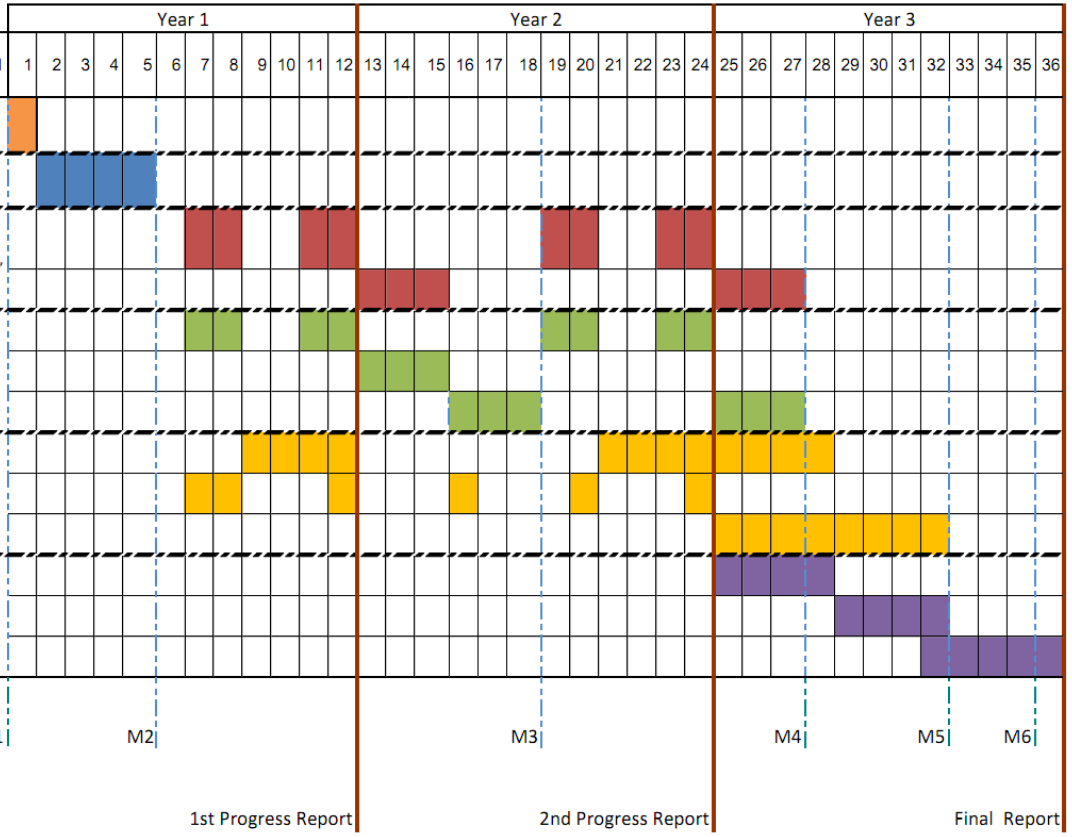
20 piezometros Mini-Diver (10 for Spain site + 10 for Brazil Site)
1 Laser AO212 Picarro
1 IRMS Upgrade MT3 Electronics
+ (additional field material)

Timeline

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		



Tarefa 1

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

TASK 1- Installation of experimental plots

Objective
Installation of experimental plots to evaluate the dynamics between plant functional groups under groundwater stress scenarios.

1.1. Establishment of experimental plots
Tropical site: we will use a permanent plot established by BIOTA/FAPESP – Gradiente Functional project at "Parque Estadual da Serra do Mar - Núcleo Picinguaba", Brazil (23°31' to 23°34' S and 45° 02' to 45° 05' W);
Meso-mediterranen site: we will use a plot established in Osso da Baleia, Portugal (40° 0' 3.47" N; 08° 54' 14.73" W);
Mediterranean site: we will install a permanent plot in Doñana, Spain (36°53'24.41"N; 06° 23' 11.19" W).

In each plot with groundwater limitation will be created **30 sub-plots** (20x20 m), totaling 12 000 m2 per plot. In each **control plot 3 sub-plots** of 400 m2 each (20x20m) will be defined

1.2. Monitoring climatic conditions
Local climate data will be available from a climate station

1.3. Ground water assessment
Groundwater monitoring will be assessed from piezometers (water level recording and sampling):
•At Tropical Site: 10 piezometers will be installed within the sub-plots; + 20 ?
•At Meso-mediterranean site: 14 piezometers already installed, provided by REN-Armazenagem. This field site has already been well characterized in terms of species composition and distribution, holography, and both subterranean water flow and spatial and temporal changes in depth of the ground water table;
•At Mediterranean Site: 10 piezometers will be installed within the sub-plots. + 20 ?

Expected achievements: i) Set up of field sites to evaluate the dynamics between plant functional groups under groundwater limitation in a climatic gradient; ii) Set up of an innovative comparison of groundwater patterns under contrasting environmental conditions: fluctuating groundwater versus relatively stable groundwater.

Tarefa 2

MEMBERS: FCUL, Campinas, U. Sevilla, REN
Responsavel: FCUL

TASK 2- Experimental plots characterization across climatic and groundwater availability gradients

Objective
The aim of this task is the manipulation and characterization of forest structure, functional groups and soil in a climatic and groundwater availability gradient.

2.1 Functional groups identification
In every sub-plot the species identification, composition and distribution will be performed and grouped in the following functional groups: shallow root species/deep root species/mixed root species

Additionally, in every sub-plot 15 plants will be marked (5 per functional group) for **ecophysiological measurements**, totalling 450 in groundwater limitation plots and 45 in the control plots. (total in the 3 sites =495*3=1485).

2.2 Forest structure evaluation (3 em 3 meses)
In each sub-plot, the projected area, spatial distribution and allometric measurements will be registered for each individual (within functional group defined in 1.4).

Additionally, the **evaluation of growth rate** 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.

2.3 Soil profiles (two seasons)
In each sub-plot one soil profile will be performed (totaling 39 soil profiles). For that, soil will be sampled in 10, 20, 40, 60 cm.

Expected achievements: The characterization of the experimental plots in terms of functional groups traits (i.e. root system), forest structure and soil profiles.

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.

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.

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 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.

Divulgação

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.