Analysis of the effects of water salinity and coastal erosion on function and growth of pine forests in the Maremma Regional Park

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MEDCORE

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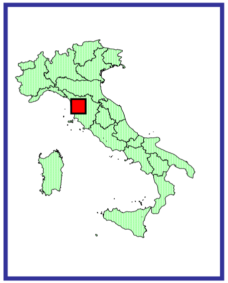
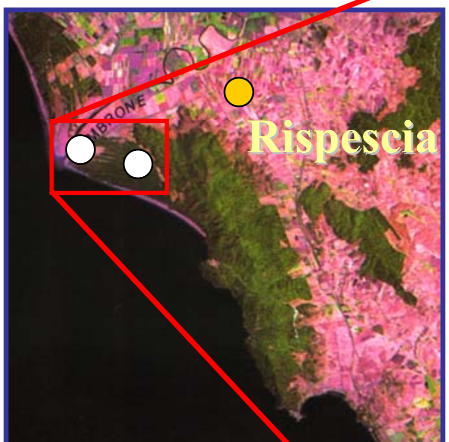
Area of Study

Pinewood of Alberese, Maremma Regional Park

(42° 39 ' 30"N, 11° 04 ' 29''E)



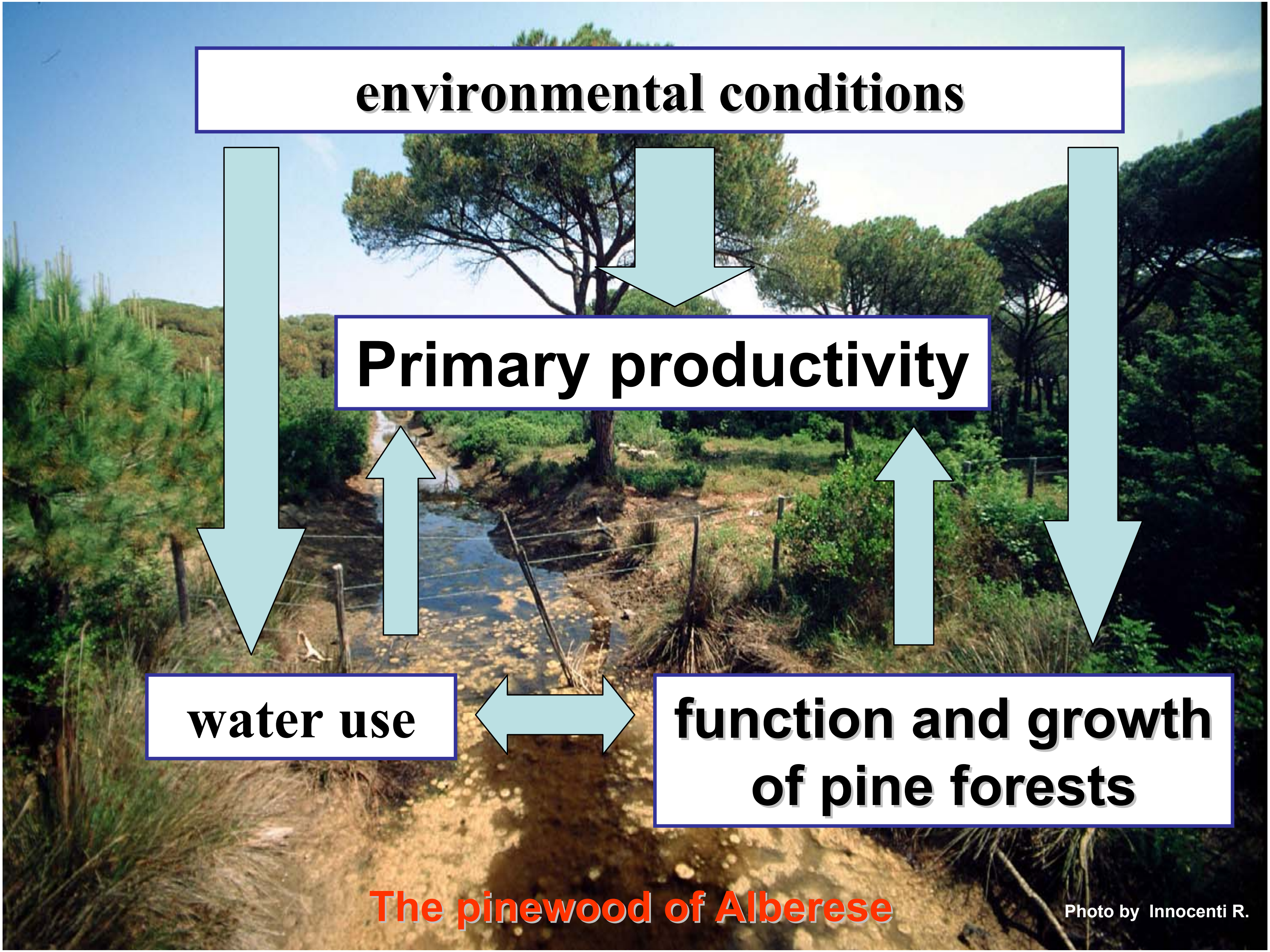


Previous studies reported the presence of a **reduced health status** in the pinewood of Alberese

1. Low timber & seed productivity (Ciancio O. et al. 1986)
2. Coastlines erosion, seawater infiltration and resurfacing of salted water from the deep watertable (Conese C. et al. 1989; Maracchi G. et al. 1996);
3. Absorption of salts by the umbrella pine trees (Barbolani E. et al. 1997; Pekari B., 2000);
4. Reduced pine needle length after years with reduced precipitation (Torta G. and De Capua E., 1993; Piussi P. and Torta G., 1994);

Problem:

As far as we are concerned, the problem is the stability and primary productivity of coastal pine forests.


environmental conditions
Primary productivity
water use
function and growth of pine forests
The pinewood of Alberese
Photo by Innocenti R.

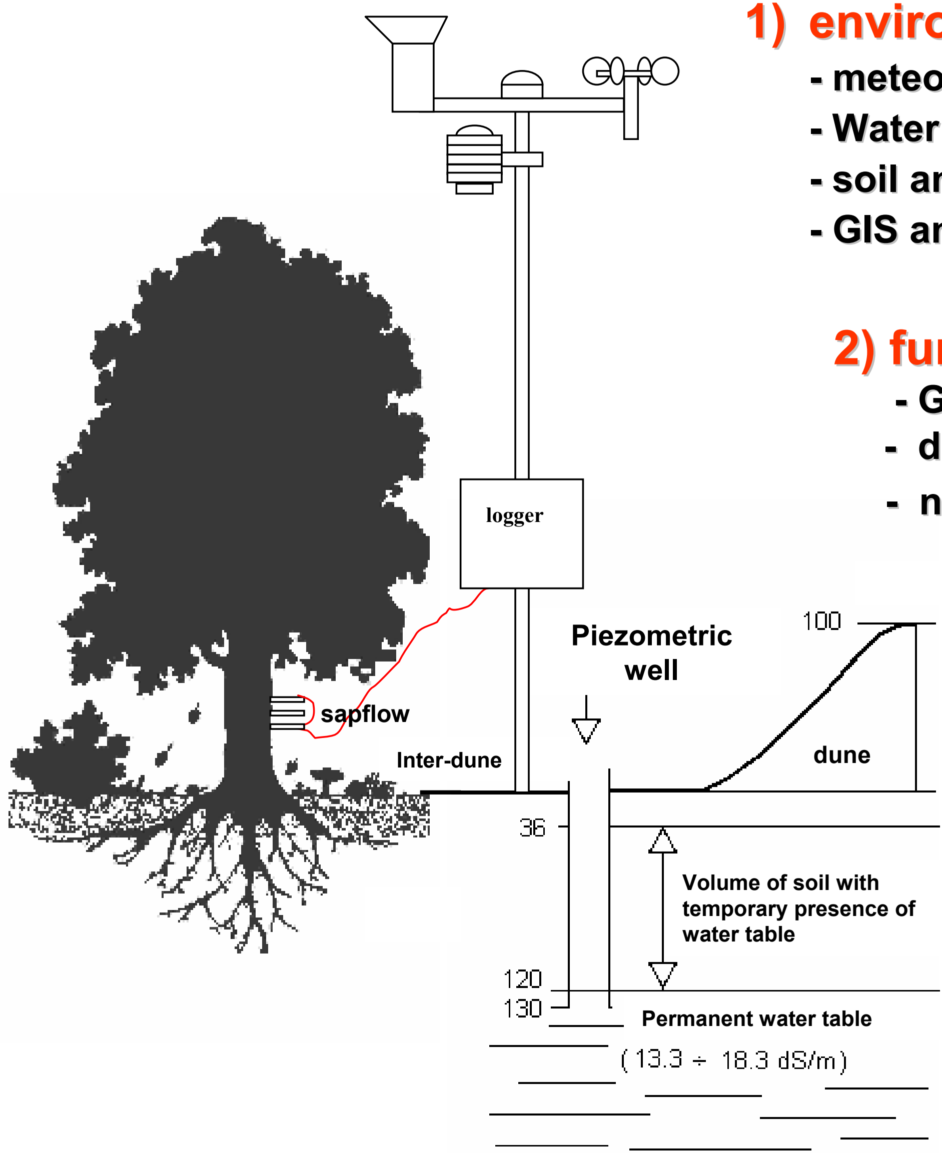
Materials and methods:

1) environmental analysis

- meteorological station
- Water table monitoring (salinity and depth)
- soil analysis (organic matter, salinity, etc.)
- GIS analysis (coastal erosion, DEM)

2) function and growth of pine forests

- GIS analysis (vegetation map, NDVI)
- dendroecological analysis
- needles length analysis



3) water use

- Relative Water Content
- Oxygen Isotopic analysis
- Sap flow measurement
  (Teobaldelli et al. 2004)

Main Questions to be addressed:

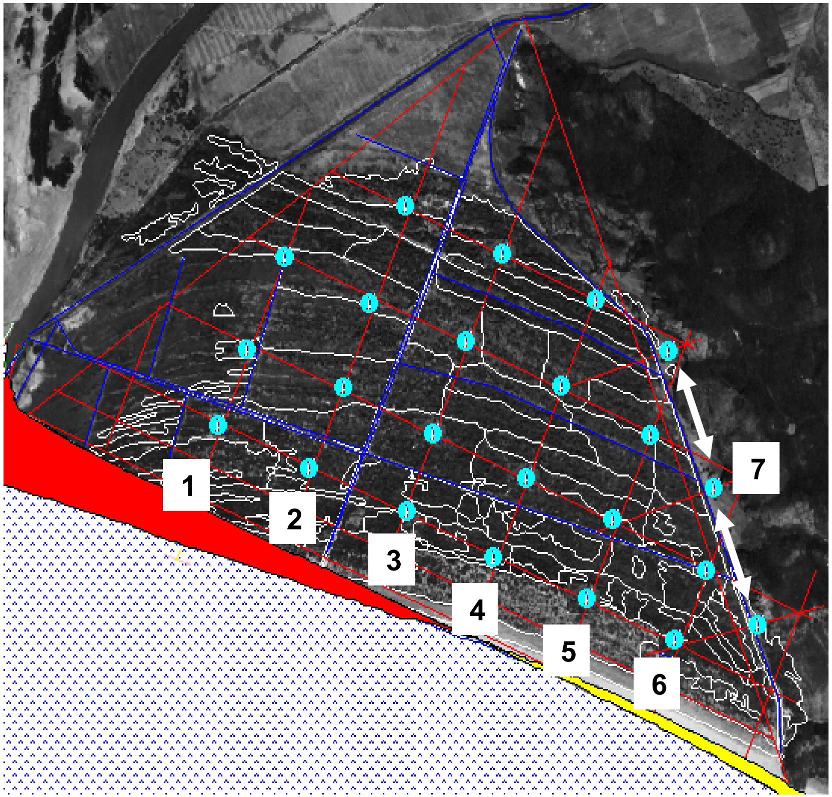
1) <u>What are the environmental parameters which drive such functional responses?</u>

- coastal erosion
- altitude
- water table depth
- water table salinity
- management
- stand age
- What is the impact of human activities on these environmental variables?

<u>2) What is the state of vegetation?</u>

- primary productivity
- LAI and light interception
- leaf structural characteristics

Where and How?



- Seven transect have been positioned using a GPS.

- 23 wells of 2 m depth, have been installed.

-Transects from 1 to 6 are orthogonal to the coast-line

-Transect n. 7 is parallel to the Monti dell'Uccellina

In each transect have been measured:

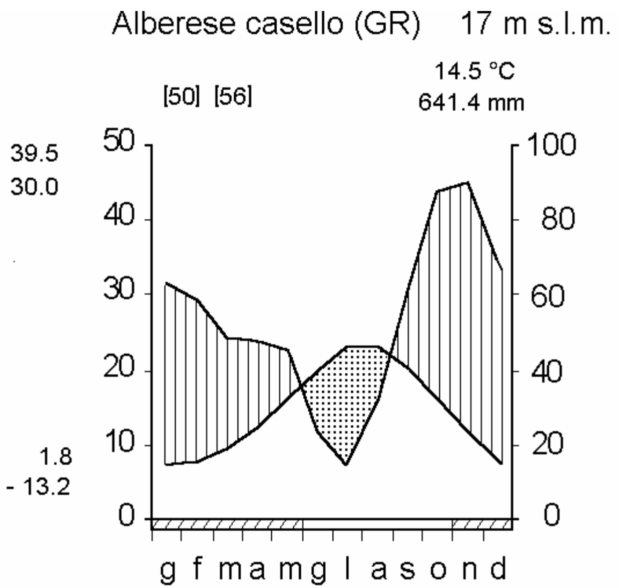
1) length of around 100-200 needles of *Pinus pinea* collected in the ground on July 2003
2) Water- table depth on May '03 and July '03
3) Water Table EC on July 2003
4) % salt in the soil from 0 to 200 cm depth

In transect 1, 2, 4 and 7 have been measured:

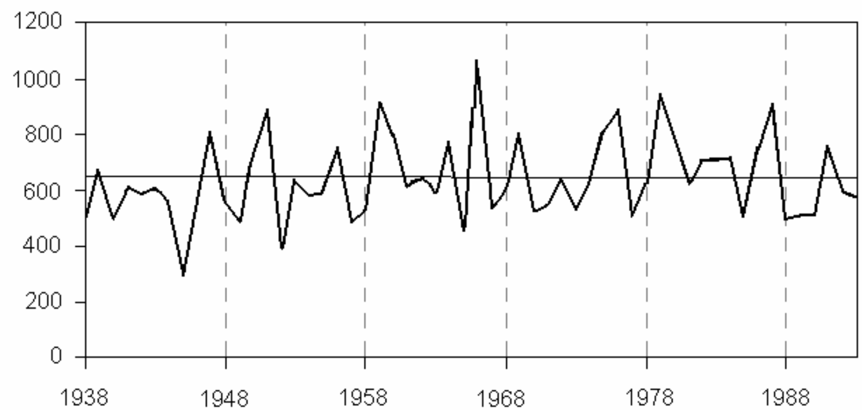
- % Organic Carbon in the soil from 0 to 200 cm depth
- Relative water Content (RWC) of wood core
- Pinus pinea wood-cores yearly increments

environmental analysis

- **Mediterranean climate**
- **Sandy soils**
- **High permanent water table level**
- **High concentrations of sea salts in water table**
- **Maximum EC values reached in summer**



Climatic diagram of Walther and Lieth



Annual yearly rainfall 1938/1993.

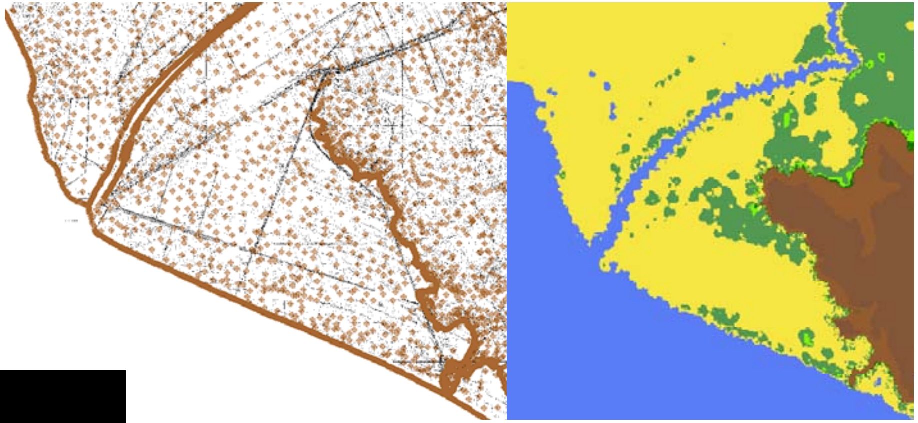
environmental analysis

Coastal erosion

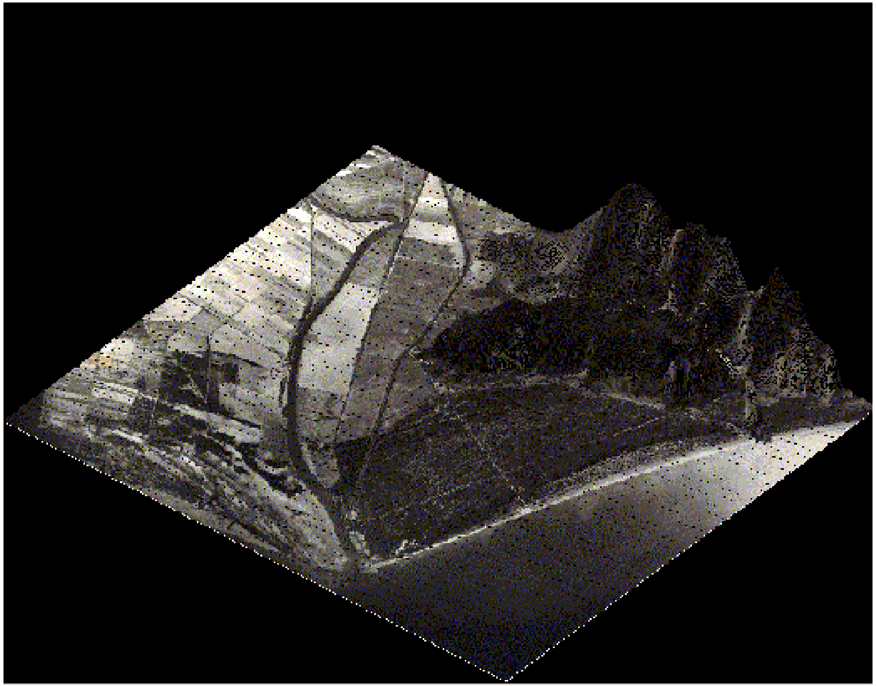
To quantify temporal and spatial effect on vegetation

environmental analysis

Altitude



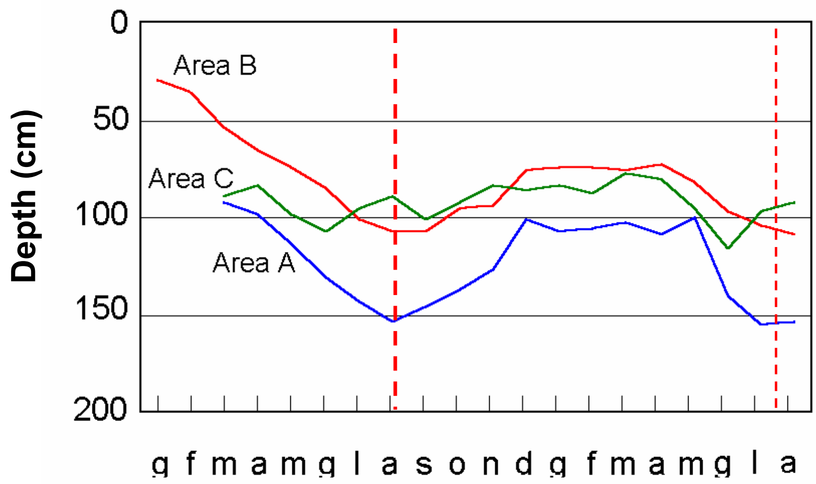
Digital Elevation model



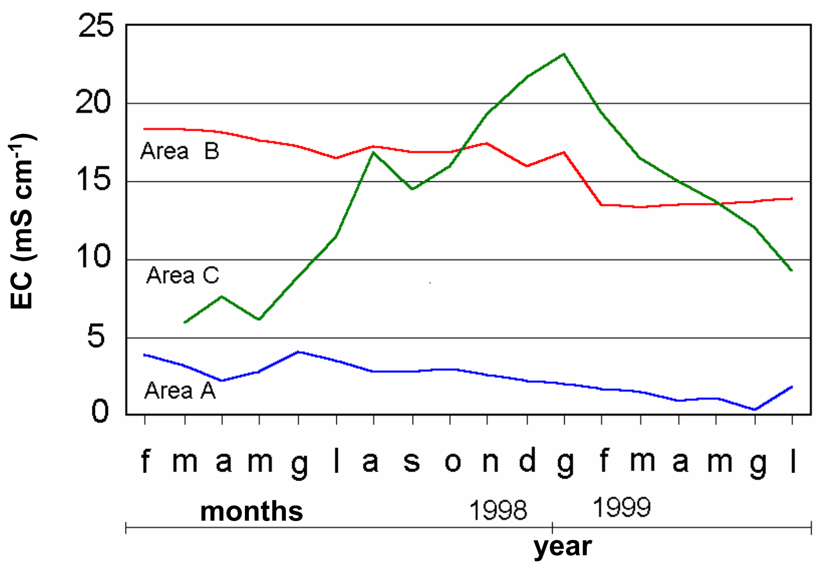
3-D image of Pinewood af Alberese

Water table

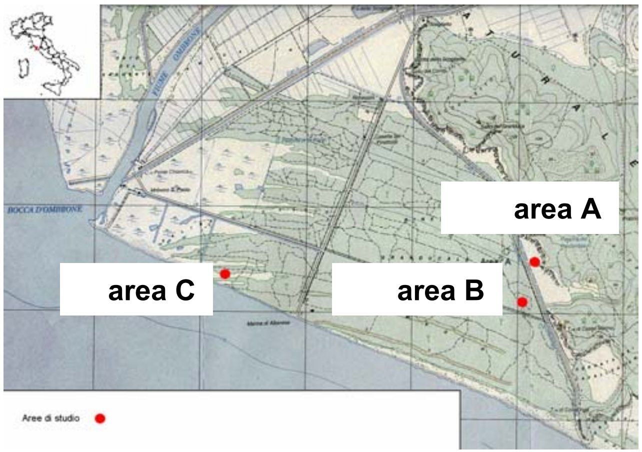
environmental analysis



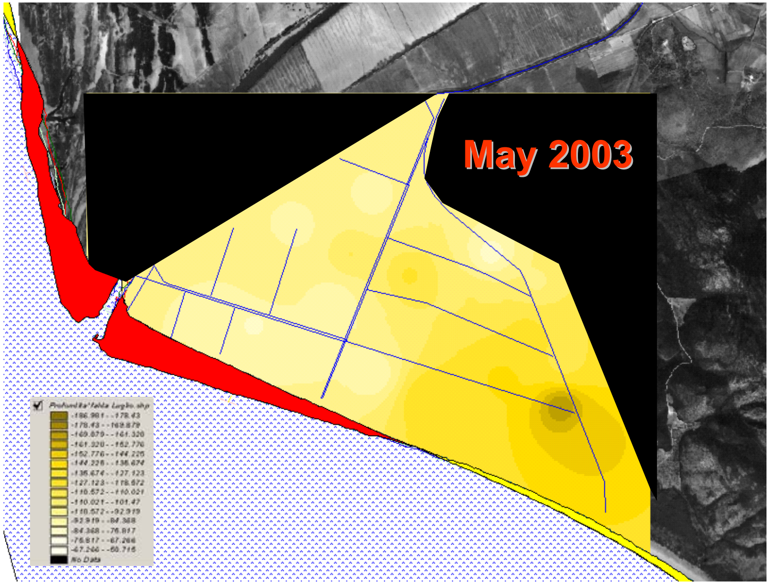
Water table depth

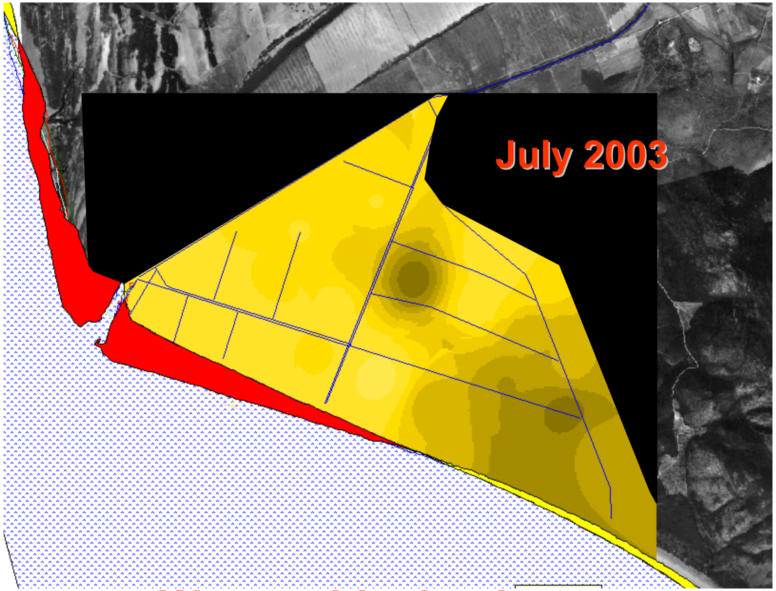


Water table electrical conductibility

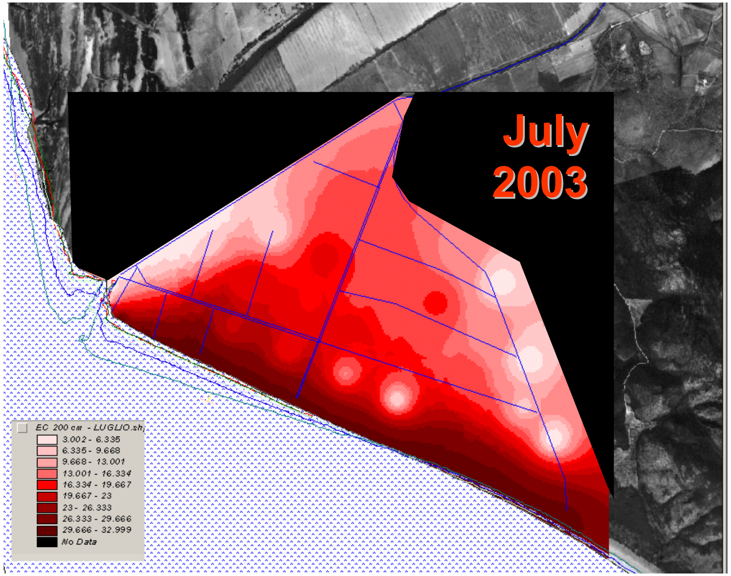


environmental conditions





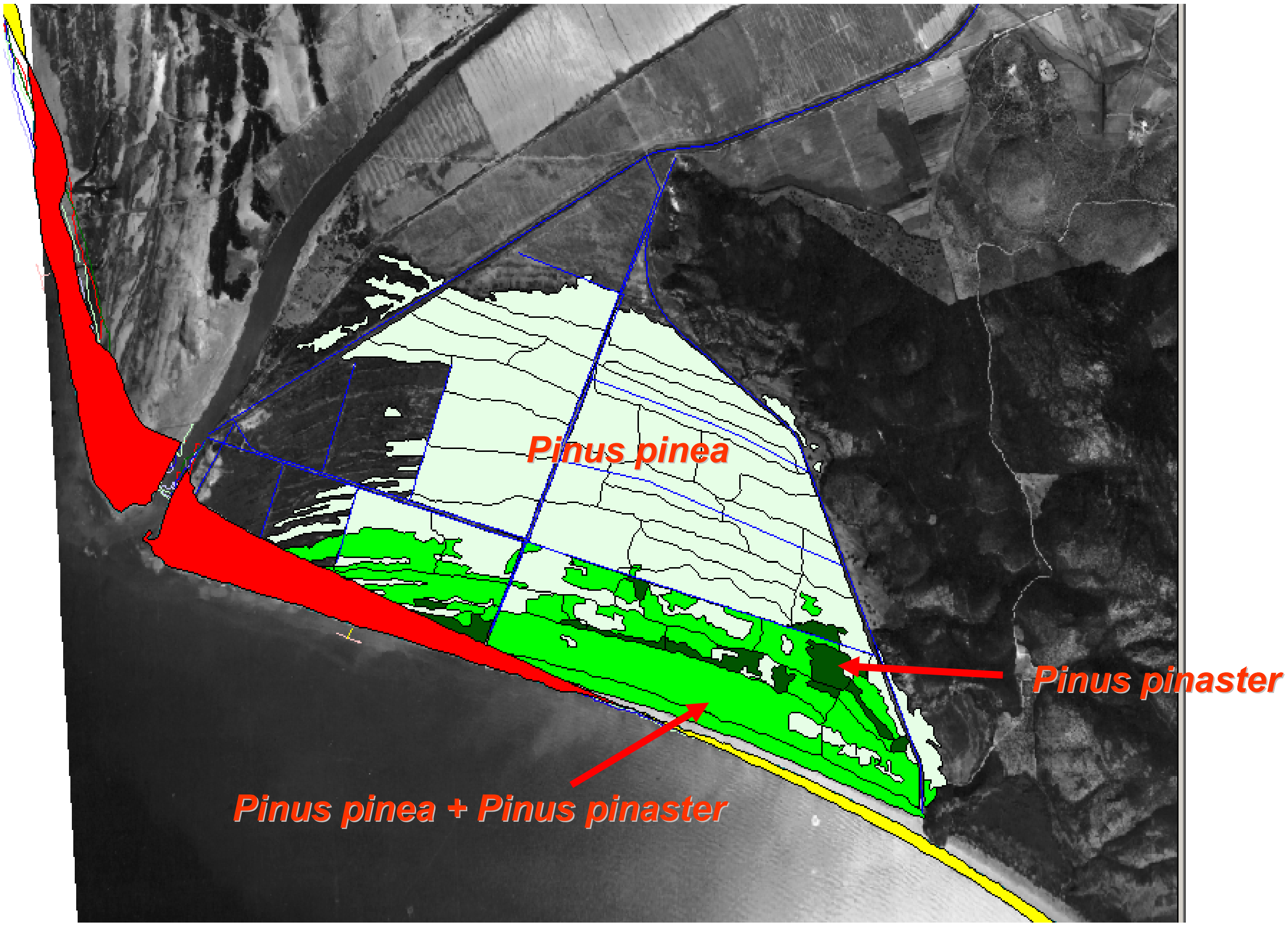
Water table depth



Water table electrical conductibility (EC)

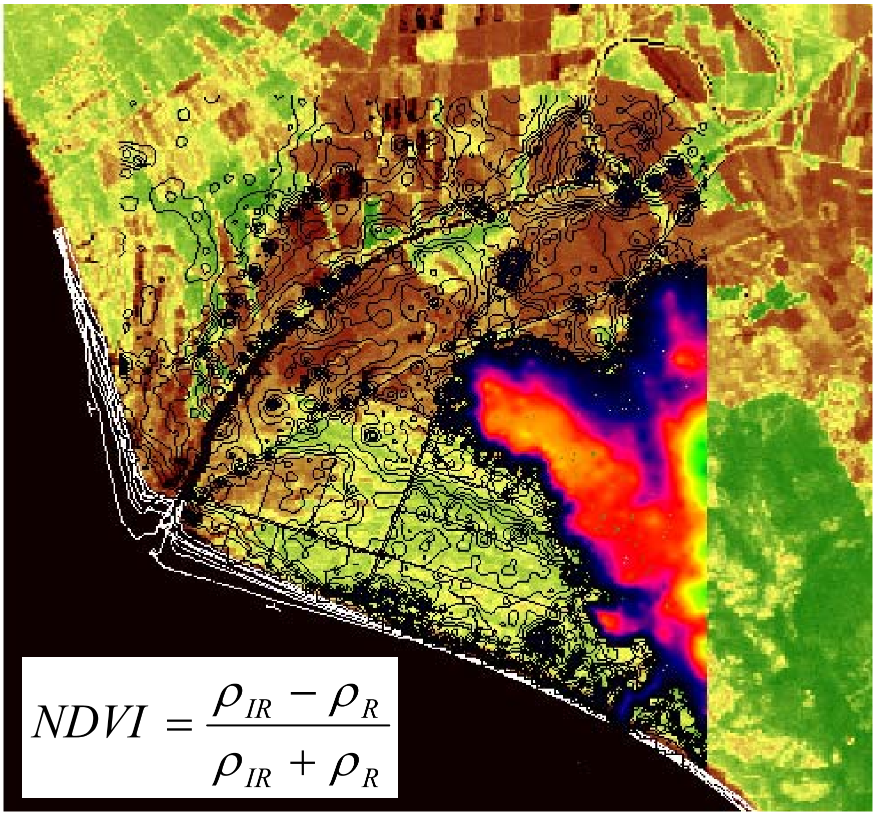
Vegetation map

The vector layer of trees species had been created using the data of RDM (1992).



Functions and growth

Normalized difference vegetation Index (NDVI) analysis by use of SPOT satellite image



$$NDVI = \frac{\rho_{IR} - \rho_R}{\rho_{IR} + \rho_R}$$

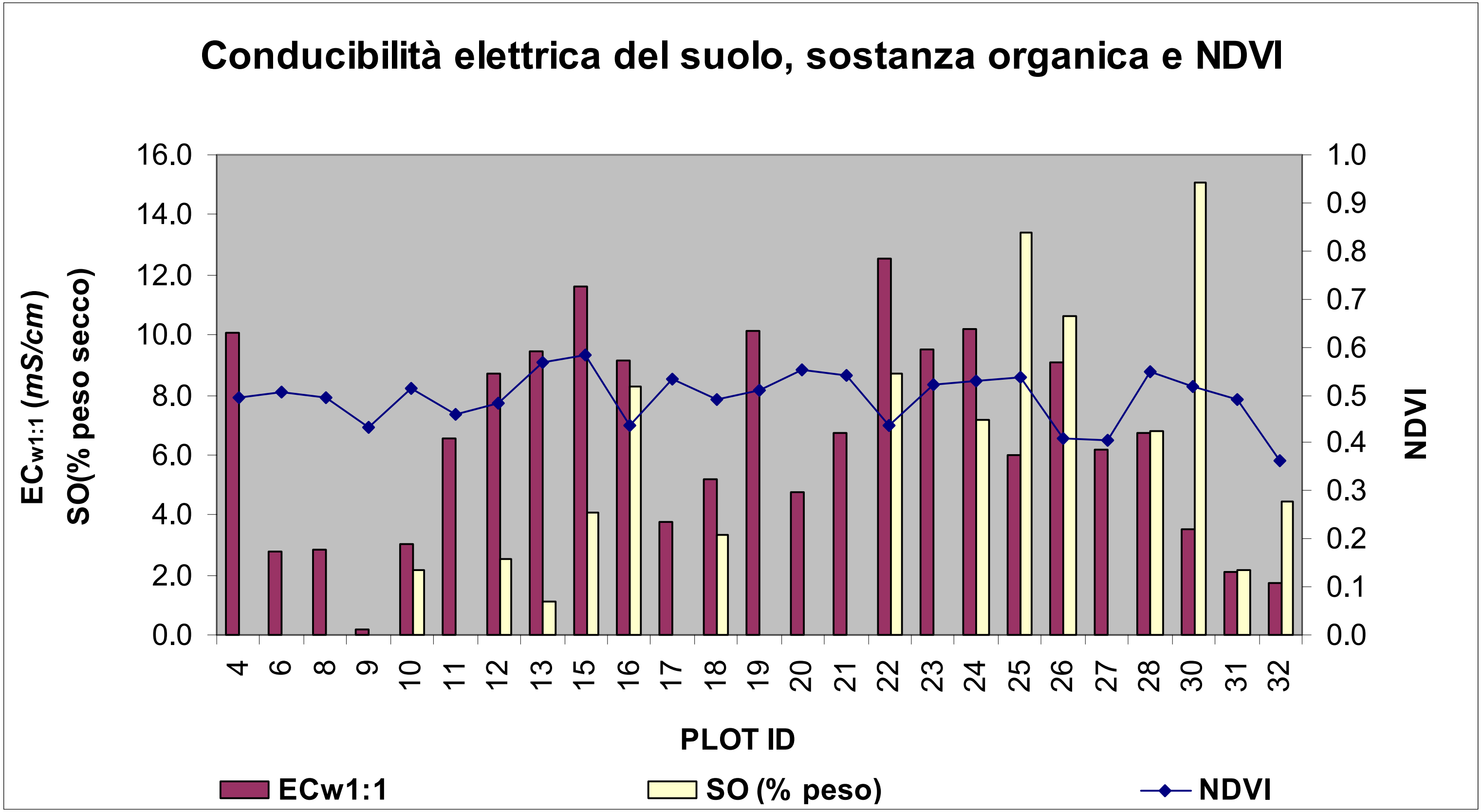
	Pixel Plot	

Matrix 3*3 used for NDVI estimation

where
ρIR = near IR band (0.76 – 0.90 μm)
ρR = red band (0.63 0.69 μm)

Functions and growth

Normalized difference vegetation Index (NDVI) analysis by use of SPOT satellite image



Comparaison of soil electrical conductibility $EC_{w1:1}$ (sample -200 cm; May '03), Organic carbon SO (litter, May '03) and NDVI (SPOT July '03)

Functions and growth

Dendroecological analysis

(Schweingruber *et al.*, 1989)

A dendroecological analysis has been developed to determine the relationships between climate (temperature and precipitation) and radial growth, separately for earlywood and latewood.

-128 wood cores from 64 trees

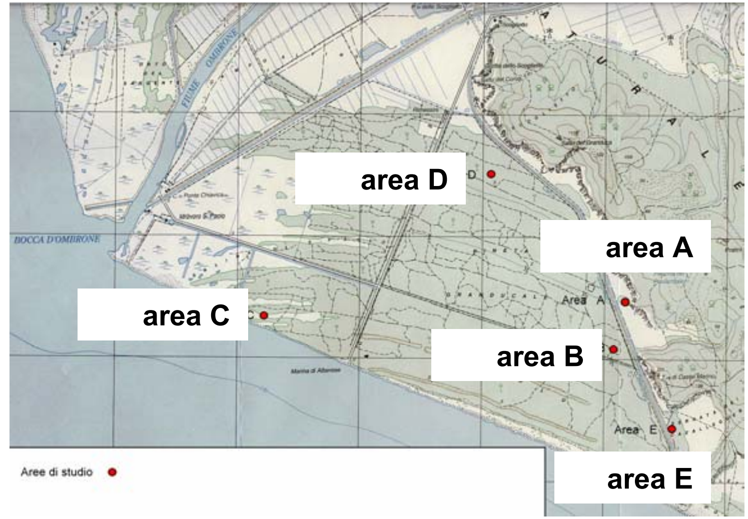
-Three series identified:1) TOT= total annual increment
2) EAR= earlywood
3) LAT= latewood

- **Dendrocronological analysis** **(Fritts, 1976; Fritts e Swetnam, 1986):** [*Controlled Computer Tree Ring Measuring Device*; Aniol, 1987 + software CATRAS]

- **Dendroclimatological analysis:** **(Fritts 1971, Blasing *et al.*, 1984; Guiot *et al.*, 1982; Guiot, 1989a).** *[Arma techniques, Response Functions and Bootstrap methods]*

Dendroecological analysis

(Schweingruber *et al.*, 1989)



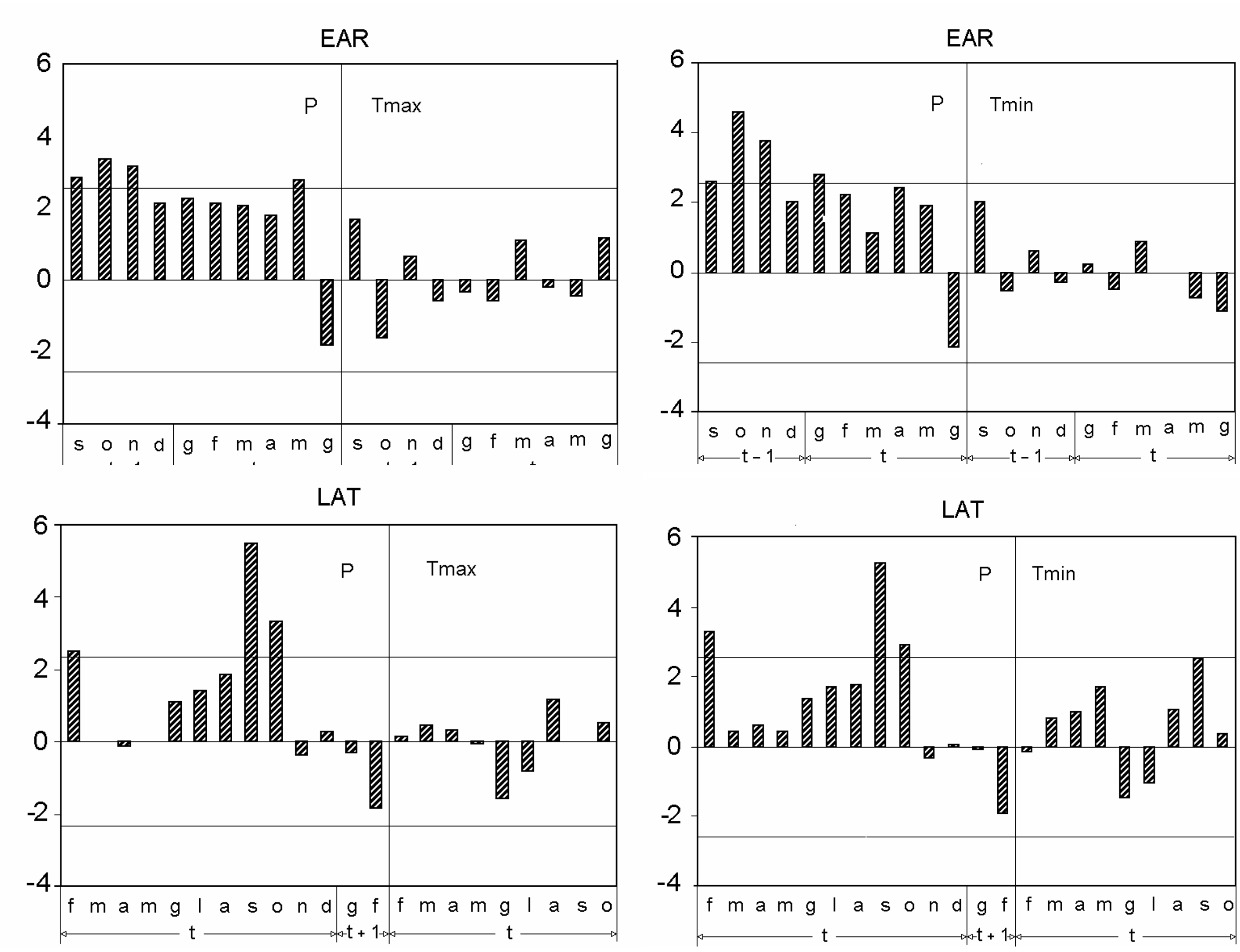
EAR	Pineta		Area A		Area B		Area C		Area D		Area E	
	V %	signif.	V %	signif.	V %	signif.	V %	signif.	V %	signif.	V %	signif.
Prec. feb.(t)-feb.(t+1) Tmax. feb.(t)-ott.(t)	80.8	>99.9%	57.5	<90%	83.2	>99.9%	68.6	>90%	74.3	>95%	70.1	>95%
Prec. feb.(t)-feb.(t+1) Tmin. feb.(t)-ott.(t)	82.3	>99.9%	58.5	<90%	87.4	>99.9%	68.1	<90%	75.2	>99%	71.2	>95%

LAT	Pineta		Area A		Area B		Area C		Area D		Area E	
	V %	signif.	V %	signif.	V %	signif.	V %	signif.	V %	signif.	V %	signif.
Prec. feb.(t)-feb.(t+1) Tmax. feb.(t)-ott.(t)	80.8	>99.9%	57.5	<90%	83.2	>99.9%	68.6	>90%	74.3	>95%	70.1	>95%
Prec. feb.(t)-feb.(t+1) Tmin. feb.(t)-ott.(t)	82.3	>99.9%	58.5	<90%	87.4	>99.9%	68.1	<90%	75.2	>99%	71.2	>95%

Dendroecological analysis

Functions and growth

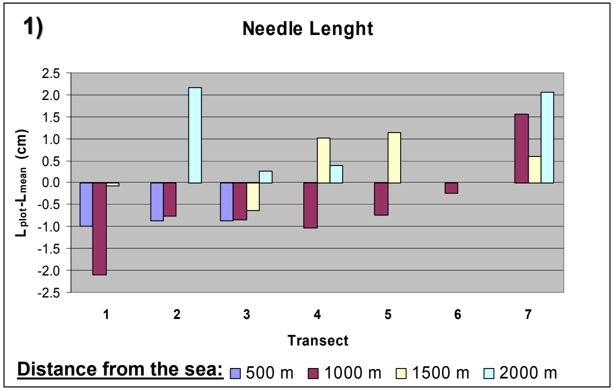
(Schweingruber *et al.*, 1989)

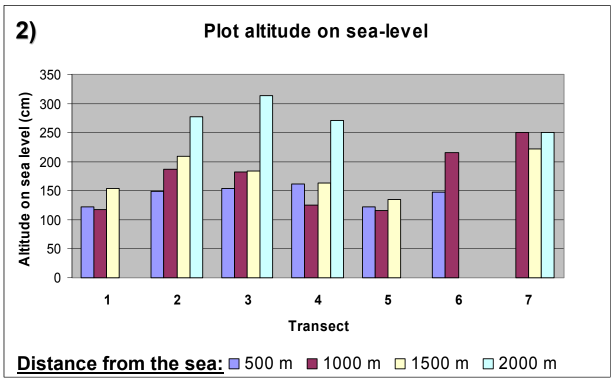


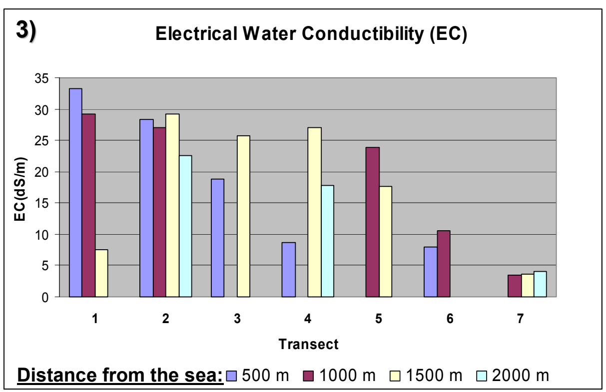
Average response functions for earlywood and latewood

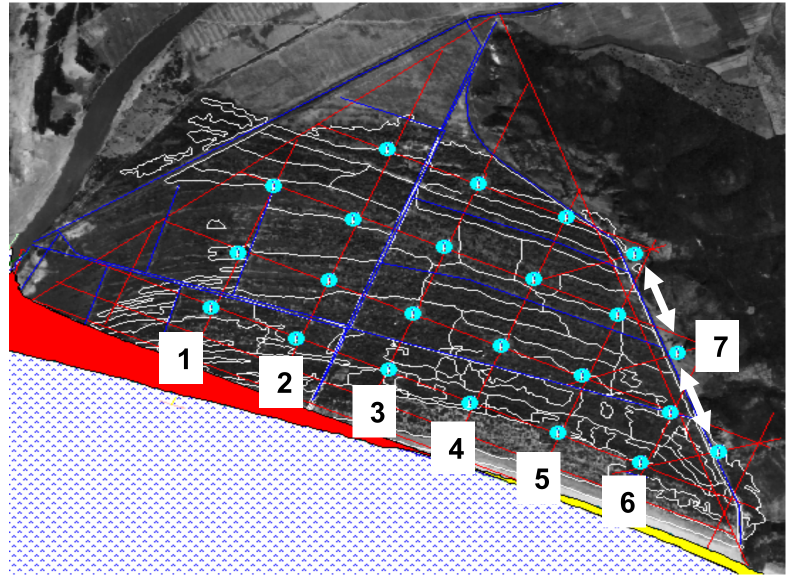
Needle length analysis

Functions and growth









- Maximum EC values (33 dS/m) had been measured on transect n.1 near the Ombrone mouth.

- Some inland plots showed high value of EC. This is due presumably to the dune and inter-dune morfology and/or to the lower altitude on the sea level.

- The transect 6 and 7 showed lower value of EC due to lateral rainfall drainage from the hills.

- Generally needles length increase moving from the mouth of Ombrone river (high value EC) to the inland. There is a good correlation with the altitude on sea-level of the plot rather than with the EC value

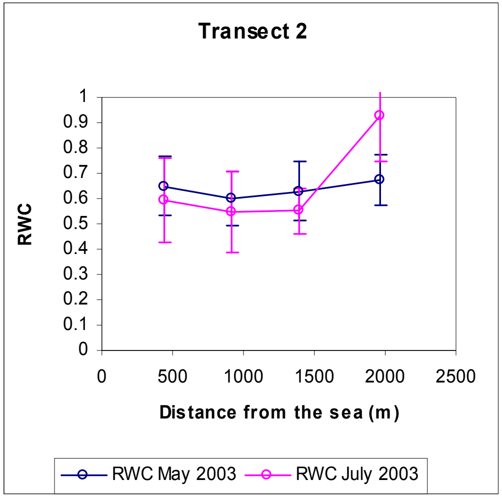
Relative water content (RWC)

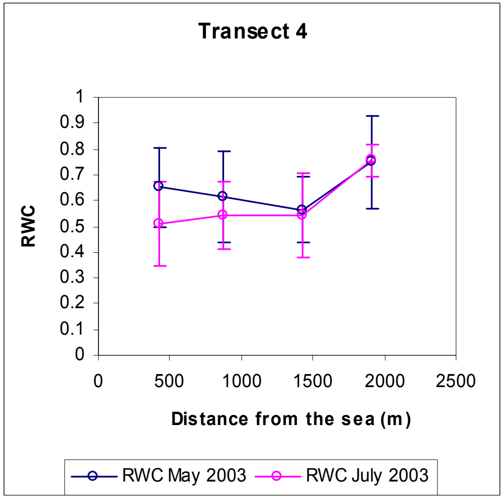
Water use

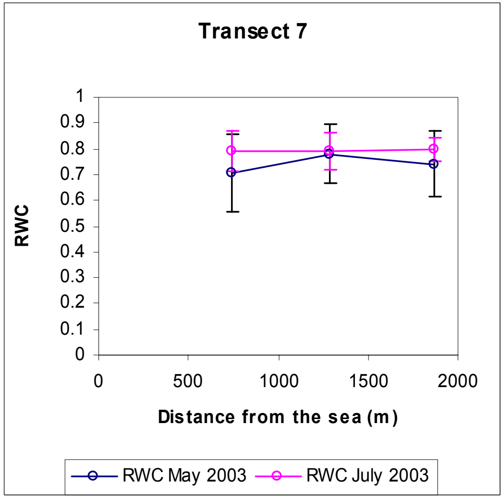
-The analysis of RWC made during May and July 2003 on Plot n. 2, n. 4 and n. 7 didn't showed statistical differences in relation with the distance to the sea or to the "Monti dell'Uccellina".

- This is due presumably to variable water availability related to different root-system and soil condition.

- However higher RWC value has been measured along the transect 7 located near the "Monti dell'Uccellina" were pine trees receive lateral rainfall drainage from the hills .







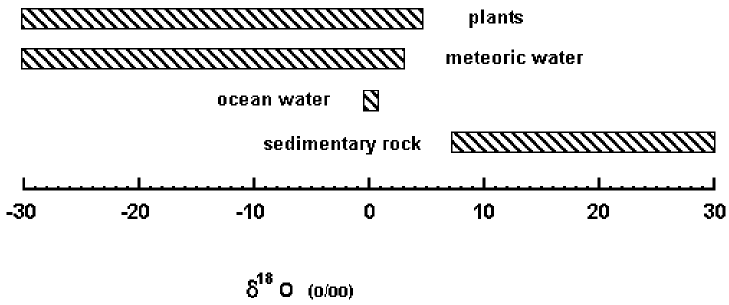
Pinus pinea L. trees: 2 cores/tree; 4 trees/plot extracted with a Pressler borer

Oxygen Isotopic Analysis: $^{18}O/^{16}O$

Water use

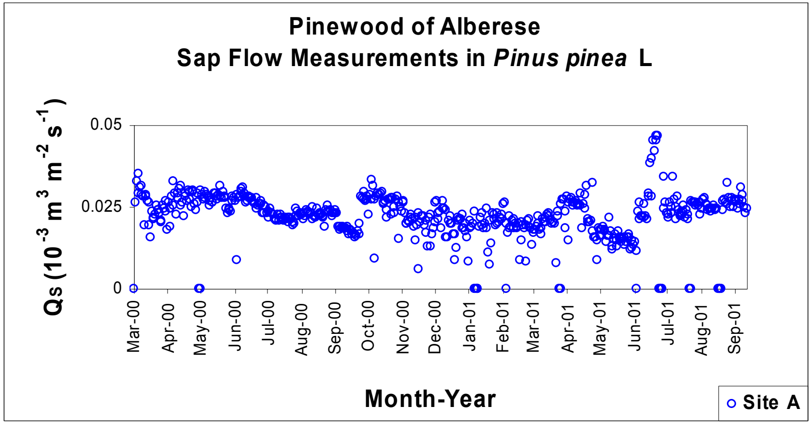
Isotopic discrimination:

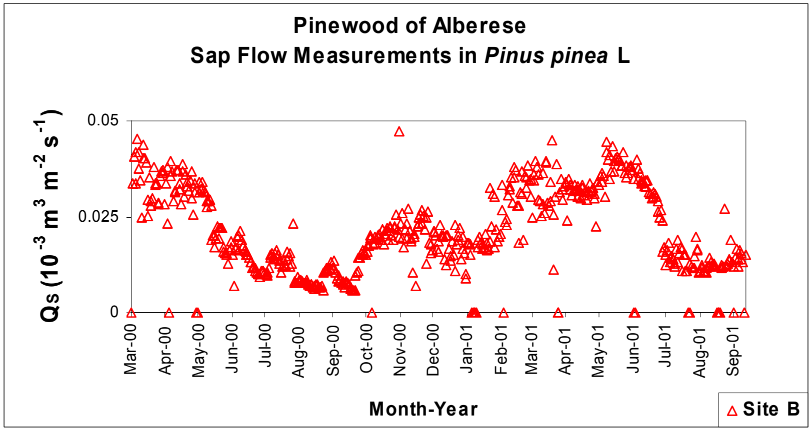
$$\delta = (R_{sample}/R_{std} - 1) \times 1000$$

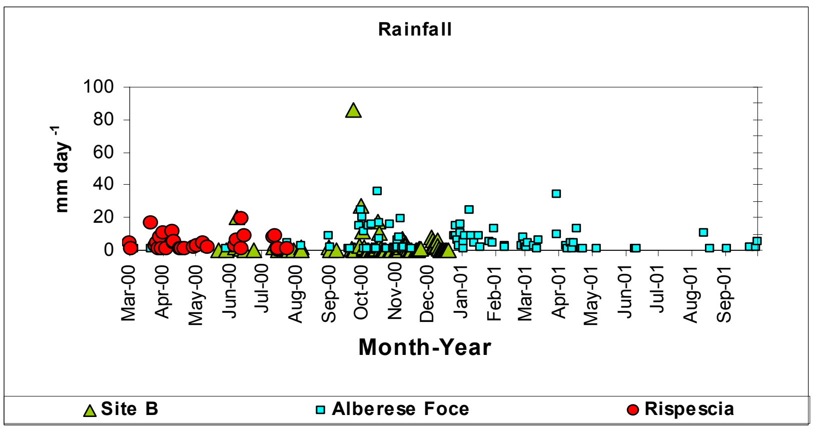


Stable oxygen isotopes have been used to detect soil water origin and the depth at which plants roots extract this water. In this study the stable isotopes in oxygen are used as natural indicators of the water present in the ecosystem (foliage, soil moisture, xylematic water) and of the water that penetrates, or could penetrate, the ecosystem (precipitation, sea, river).

Water use







Maximum daily values of sap flow, related to sapwood area, measured in site A and B

CONCLUSION

1) **This research has been carried on in the pine wood of Alberese (Grosseto), a coastal ecosystem where stone pine (*Pinus pinea* L.) suffered periodically because of drought.**

2) **The present study is aimed at analysing the influence of changes of the coast line, the salinity of the water table and the irregular rainfall regime on the growth conditions of the pine wood in three study sites located at different distances from the sea.**

3) **The research has shown that in the innermost area (AREA A) of the pinewood the groundwater table contains fresh water which represents a supply capable of satisfying the plant communities' needs even during the dry season. In this site pine's radial growth is not affected by precipitation, and only slightly affected by temperature.**

4) **In the area closest to the beach (AREA C) the layer of rainwater which floats on the salty groundwater table does not dry up during the summer. The bad vegetative conditions of this stand are not, therefore, due to water stress, but to direct exposure to marine aerosols. The dendroecological analysis shows a weak response of radial growth to climatic agents which is typical of suffering trees.**

CONCLUSION

4) In the intermediate area (AREA B) during the dry season the insaturated parts of the soil undergo an increasing salinisation caused by the ebbing of the rain water in the soil and the capillary rising of the permanently salty ground water table. The vegetation doesn’t use salt water and therefore absorbs primarily fresh water from the thin layer of soil above the capillary fringe.

The dendroecological analysis highlights the positive influence of the late summer and autumn rains on the production of latewood during the same vegetative season, and during the following season for the production of earlywood.

5) It has been observed that both earlywood and latewood are influenced by climate; the latewood, however, is affected by the climate during the formation period, whereas earlywood is affected primarily by the precipitation taking place during the months preceding the start of the vegetative season.

CONCLUSION

6) Pine transpiration greatly declined in the summer in ccorrespondence with increases in surface salinity of the water table

7) Pines mainly used the fresh water stored at the top of the water table during the previous winter. When fresh water supplies were depleted, the pines drew from the underlying salty water with clear seasonal differences;

8) Re-establishing of water availability, after a summer rainfall, allows the pines in both sites to show greater sap flow fluxes;

Ringraziamenti

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Foto: A. Pastor-López