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Effect of thinning on the growth and carbon uptake of pine cones in northern Tunisia

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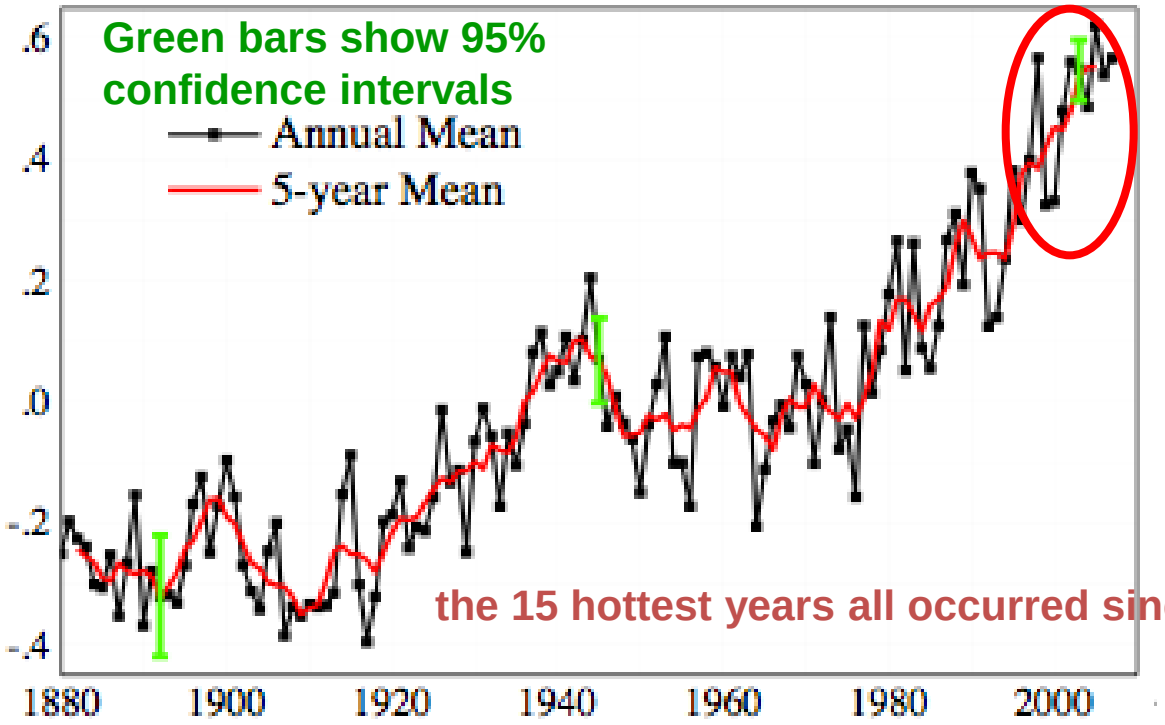
Mediterranean ecosystems are defined and configured by the climate

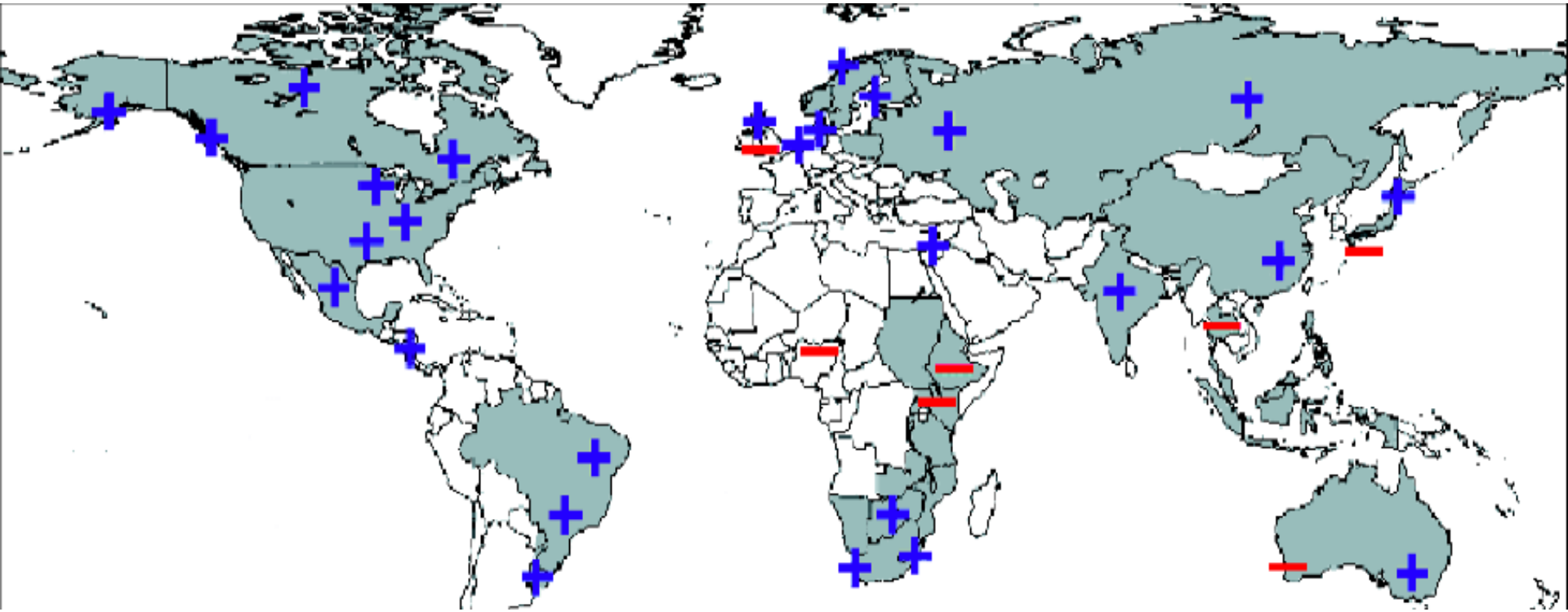
rapidly changing

Climate change in ecosystems like Mediterranean ecosystem encompasses not only increased mean temperature and lower precipitation but also increased variability and a higher frequency of extreme climatic events such as heat waves droughts and orgy rains.

Global Temperatures are increasing



Proportion of extreme precipitation events increasing in most areas



The frequency of heavy precipitation events has increased over most land areas - consistent with warming and increases of atmospheric water vapor while more intense and longer droughts have been observed.

Mediteranean ecosystems are not only exposed to a changing climate

human activities for centuries, and many of these activities are also changing resulting in increased habitat fragmentation, deforestation and land abandonment.

Given current and future global change scenarios, the ability to tolerate and changing environmental conditions is critical for Mediterranean species.

Changes in land use and climate can have significant influences on trees establishment and on forest structure and dynamics in formerly managed landscapes.

Climate change could affect forest growth (***the availability of nutrients, water and sunshine***), factors that may all be influenced by climate change as well.

Ecosystem management that could be defined as the balance between ecosystem functions and human requirements of natural resources can help foresters to cope with climate change challenges.

By understanding **the carbon cycle , soil water balance and trees growth** in forest dynamics under different management regimes, foresters can design suitable forest strategies..

Forest carbon stocks changes can be measured by accounting net sink and sources directly. Moreover, changes in vegetation cover have significant implications on local and regional water balance.

Catchments studies have been widely used to quantify such effects, considering the impact of processes such as afforestation, deforestation, and thinning, with or without regrowth.

Effect of thinning on the growth and carbon uptake of pine cones in northern Tunisia

to evaluate the impact of silvicultural management (thinning) on water balance and carbon stock and flux on Pinus pinea forests and conclude the role of this type of management on greenhouse gases attenuation and climate change effects.

Methods

Study areas

Ecological data of the investigational plots in Nefza area and characteristics.

Ecological data and characteristics	Study area
Location	Nefza
Latitude	9°04'E E
Longitude	37°08' N
Altitude	120 m
Bioclimate	Sub humid
Precipitations (annual average)	1044 mm
Soil	Sandy Clay
Slope	12 – 15%

The **dominant soils** are classified as brown humus soils with high biological activity. **Vegetation** is largely dominated by a dense storey of **Pinus pinea** with a stratum shrubby composed by Erica multiflora, Pistacia lentiscus, lavandula stoechas, Myrtus communis, Halimium halimfolium.

Methods

The Pinus pinea stands are located on two adjacent plots differ by their silvicultural treatments .

Plot 1 without thinning

- Planted in 1989
- No silvicultural management
- Pruning passage
- Density of plantation: 1600 / ha
- Absence of the scrubland

Plot 2 with thinning

- Planted in 1989
- A first thinning (a line on two) in 2005
- A second thinning second (a tree on two) in 2010
- Density of plantation: 400 / ha
- Few scrubland

Methods

Measured parameters

1-Climatic features: Variations in the microclimate in each plot, mainly **the temperature** and **humidity** were recorded through **Hobo recorders logger U23 Pro V2.** The recorders were placed for a period of 25 days (one measurement every two hours)..

Once the data are collected, **the minimum daily temperatures**, **the maximum daily temperatures**, **average daily temperatures and daily relative humidity** were determined

Methods

2-Dendrometric measurements → In this study, we measured per site "the diameter at breast height (DBH) and the height of all living.

3-Carbon stock estimation → Equations are developed and applied to estimate tree carbon content.

Trunks biomass was estimated by using a cubing rate established for Tunisian Pinus pinea. It is a tool that expresses the relation between the tree volume and its dendrometric characteristics according to the following equation:

$$V = -0.251 + 0.005\ C1.30 + 0.008\ H$$

V= trunk volume (m^3)
C1.30 = Circumference (cm)
H = trunk height

Branch samples of each site are sampled, dried and weighed. Their biomass was calculated using the equation:

Dry biomass = dry weight of the sample x fresh weight of the branch / fresh weight of the sample

Methods

wood biomass crown is calculated later using the following equation:

B wood = B average x number of branches

the total mass of the foliar carbon is determined after sampling needles, branches, their treatment in the laboratory and using the following formula:

Mcf = Mci x Nb

Mcf = total mass of foliar carbon per tree

Mci = carbon weight per sample

Nb = number of branches

4-Water balance : → temporal variations in soil water content and assess drought stress for plants in a forest stand

TDR 30 (Time domaine reflectometry)

Methods

To each site

six pedological pits of 1m were dug

The volumetric soil water content is measured at **4** different depths (**20 cm, 40 cm, 60 cm and 1 meter).**

For every depth **4** measures are taken

3 repetitions per site for all depths during wet and dry seasons were realized, between April and June.

Methods

5-Gas exchange measurements

a Li-Cor Li-6400XT Portable Photosynthesis System (Li-Cor, Lincoln, NE, USA) based on the IRGA principle (Infra RedGas Analysis). The leaf stomatal conductance (g, in mol H2O $m^{-2}s^{-1}$), net carbon assimilation (A, in µmol CO2 m^{-2} s^{-1}), and transpiration (T, in mmol H2O $m^{-2}s^{-1}$), were measured on the Pinus pinea needles of both sites.

More than 10 branches were taken from each site. They were cut and transported to the laboratory; their bases under water in tubes. The experiments were carried at a leaf temperature of 25°C and humidity of 50-60%.

Methods

6-Carbon assimilation : The carbon assimilation of the various light conditions was measured on pine needles of both sites using a Li-6400 (Li-Cor, Lincoln, NE, USA).

The needles of each branch are acclimatized thereafter in an incident light of 1200 µmol $m^{-2}s^{-1}$ PAR for 30-60 minutes to induce photosynthesis and reach a stationary state.

A program is then developed to make vary the incident light intensity, for a period of 5 to 7 minutes. For each applied incident light intensity, the net carbon assimilation, stomatal conductance and transpiration are measured.

These measurements were used in the calculation of intrinsic water-use efficiency (WUE, in mmol CO2 $mol^{-1}H2O$) according to:

WUE = A / g.

7- A-Ci curves : internal CO2 concentration (A-Ci curves) using a Li-6400 (Li-Cor, Lincoln, NE, USA).

Results: 1-Tree growth, biomass and carbon stock

Morphological features of all trees located inside plot with thinning (site 2) showed that trees were significantly larger and taller than the plot without thinning

Mean (±SE) stand-level estimates of diameters at breast height (dbh) and height of *Pinus pinea* sites.

Sites	Parameters	Mean (± SE)	Coef. of variance
Site 1	DBH (cm) Height (m)	24.35 ± 0.95 14.94 ± 0.26	0.18 0.027
Site 2	DBH (cm) Height (m)	30.10 ± 0.92 16.24 ± 0.37	0.13 0.021

Results: 1-Tree growth, biomass and carbon stock

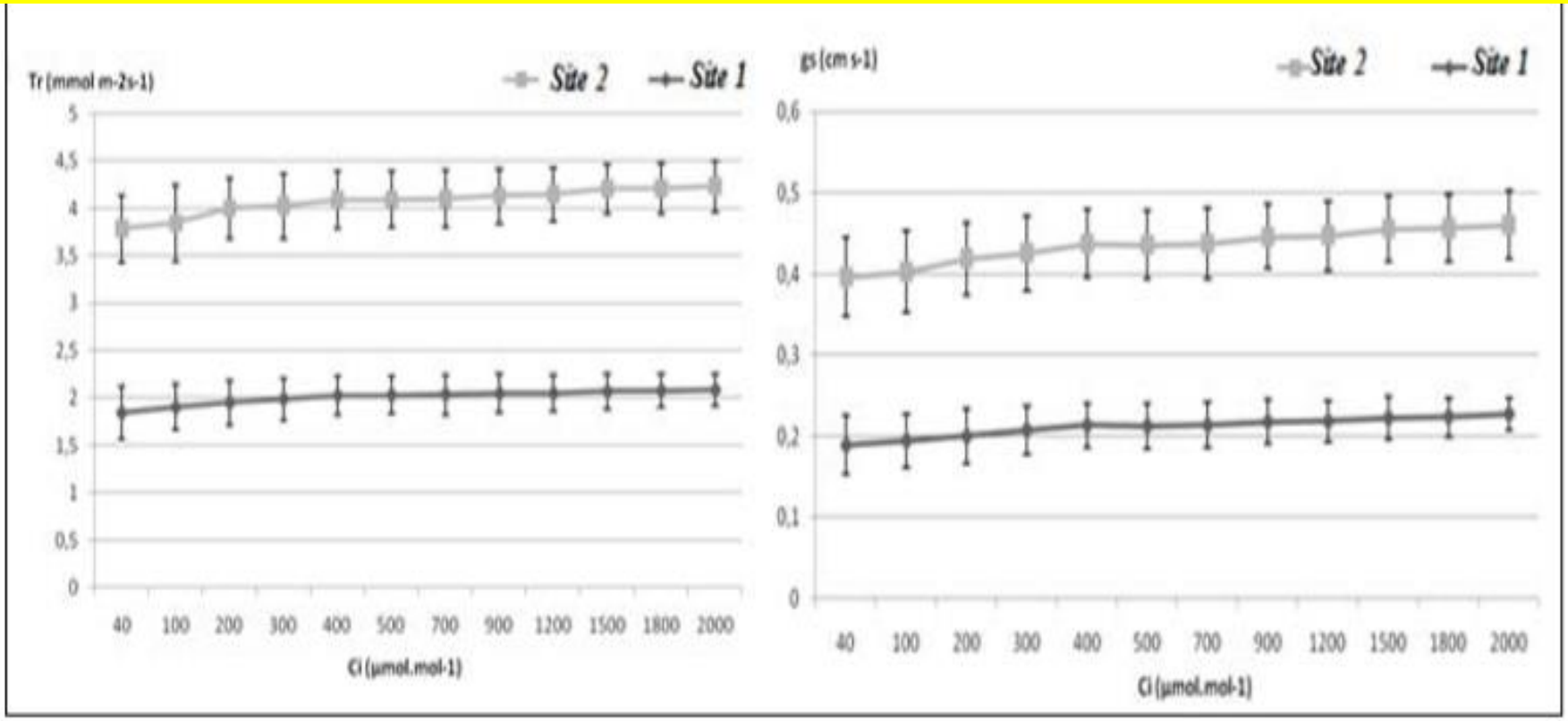
Carbon stock estimation of trunks and branches

Sites	Trunck (kg/arbre)	Branches (kg/arbre)	Total
Site 1	58.47 ± 7.33	14.41 ± 7.46	72.88
Site 2	87,35± 4.39	12.26 ± 6.89	99.61

the standing volume and biomass were significantly affected by thinning in site 2. We noticed that thinning realized induced an increase of 33% of the carbon stock in trunks and have a total of carbon stock equivalent to 99.1 kg/tree against 72.88 kg/tree for the site 1.

Results: 2- Influence of elevated CO2 on stomatal conductance and transpiration

these parameters were significantly higher at the thinned site (Site 2) than control site (Site 1) and these differences increased with CO2 concentrations (Fig. 3).

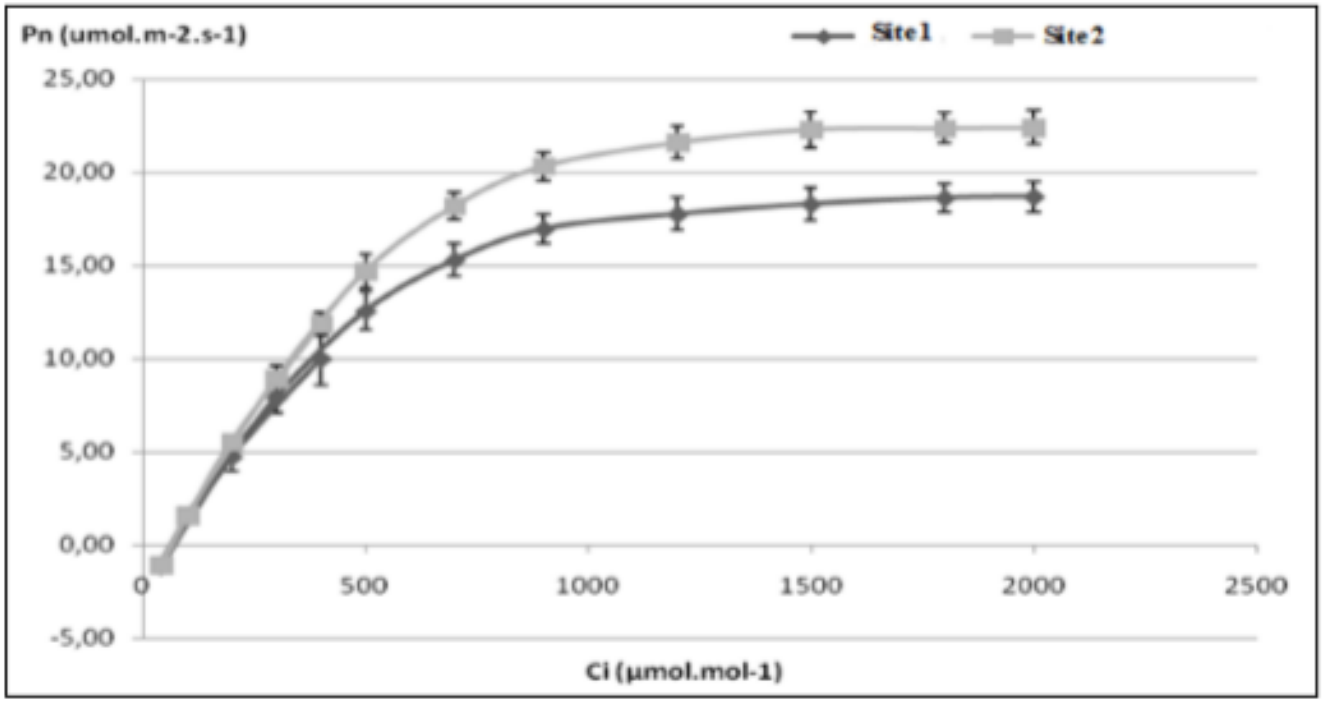


Variation curves of leaf transpiration and stomatal conductance according to the CO2 concentrations of both sites (from 11/05/2015 to 13/10/2015).

Results: 3- Light and A-Ci response curves

light and A-Ci response curves indicated there were significant differences between the two sites

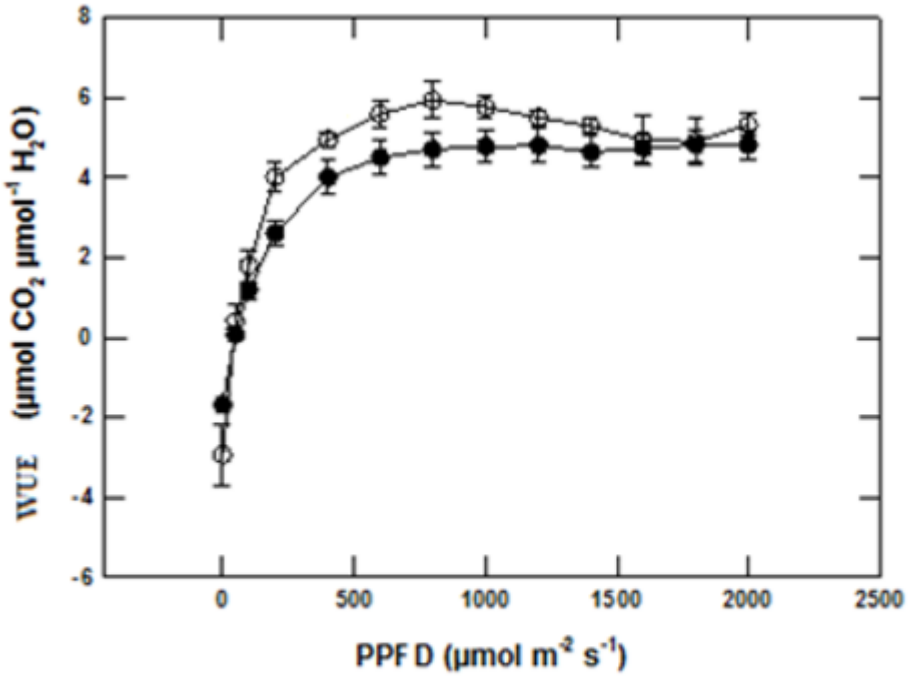
Pn for the thinned site was 18.5 µmol. $m^{-2}s^{-1}$ while it was only 16.8 µmol. $m^{-2}s^{-1}$ for the control site.
For a CO2 concentration of 1800 µmol. m^{-1}, the assimilation capacity of thinned trees was more important and reached 22.5 µmol. $m^{-2}s^{-1}$.



Net photosynthesis Pn according to the CO2 intracellular concentrations of both sites (from 11/05/2015 to 13/10/2015).

Results: 4- Water-use efficiency

The water use efficiency use for to estimating the biomass produced per unit of water consumed.



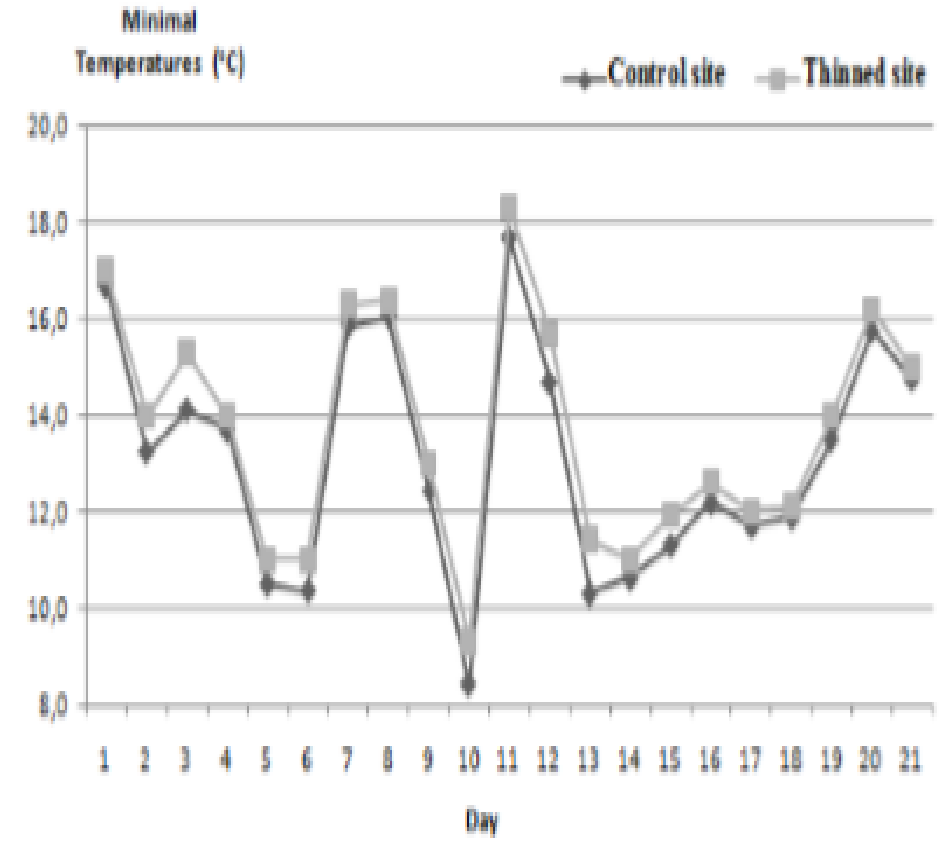
the WUE values were higher at the thinned site than the control site

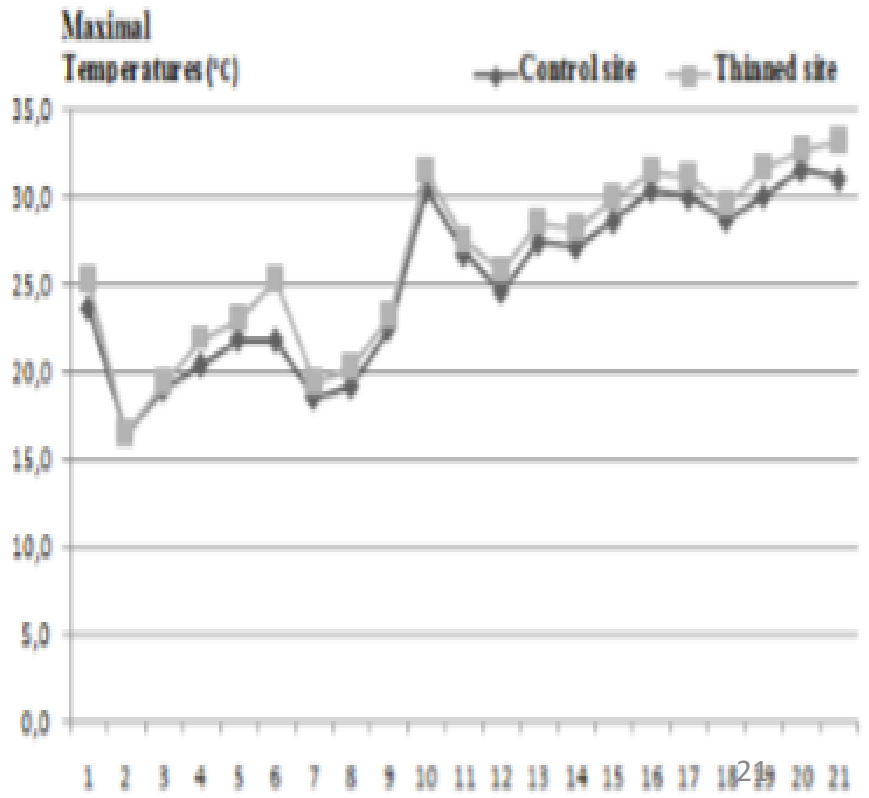
Curves of stomatal conductance induction (gs) of *Pinus pinea* trees under different silvicultural systems (● without thinning; ○ with thinning).

Results: 5- Microclimate and water balance

Statistical analyses of the collected data from both recorders shows that the temperatures degrees registered at the thinned site are significantly higher than those at the control site.

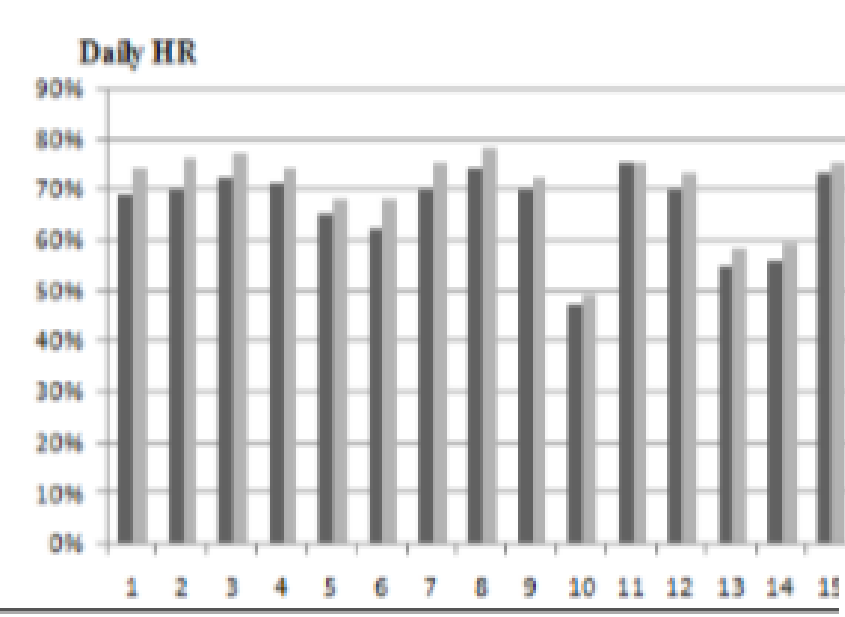
The temperature difference between the two sites achieves until 2.4°C; what presents a very remarkable difference at the climate scale

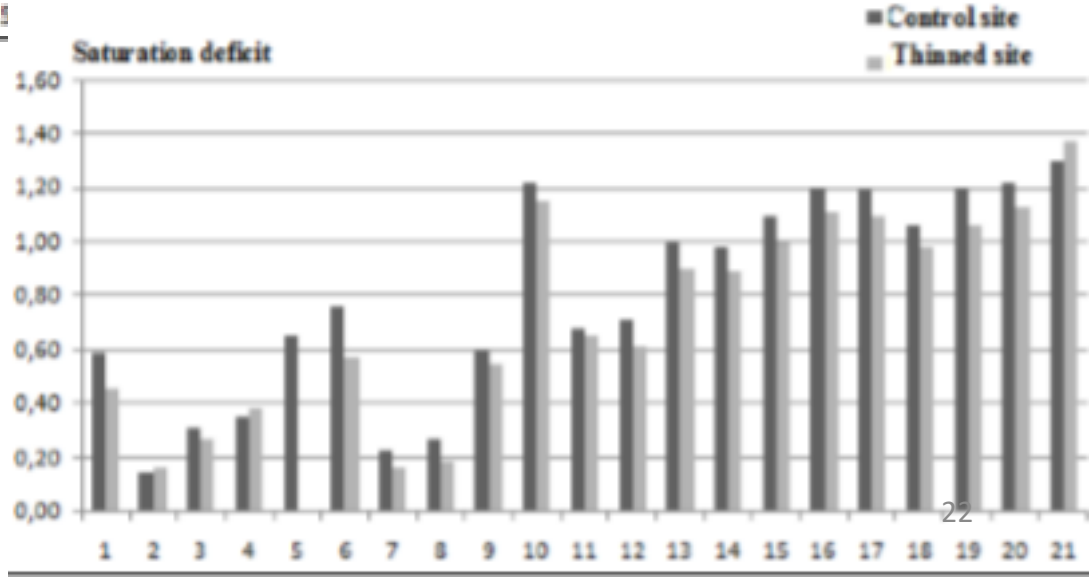




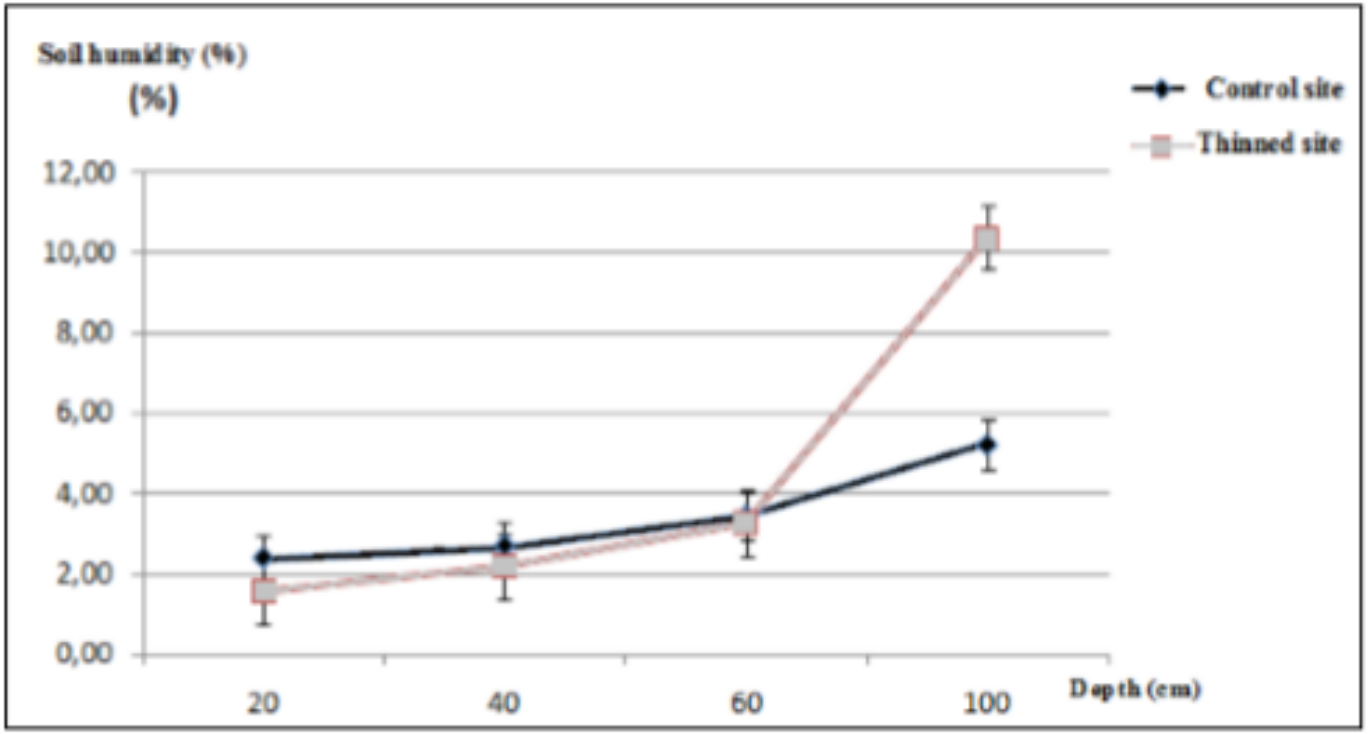
Results: 5- Microclimate and water balance

the daily relative humidity and saturation deficit of the air in the thinned site were significantly higher than in the control site





Results: 5- Microclimate and water balance



Soil water content at both experimental sites

they were significantly important at the control site until a depth of 60 cm
To a depth of (90-100) cm, they reached a maximum of 12 % at the thinned site while in the control site they reached only 5%.

DISCUSSION

According to the results of **carbon stocks**, the thinned site presents higher carbon stock compared to the control site

The results of this methodology provide useful information and open up the possibility of estimating some of the basic practical forestry parameters related to carbon sequestration and to different parameters.

Thinning and other management measures to increase forest productivity could capture a significant part of CO2 emissions. Factors such as **soil characteristics**, **site productivity**, **landscape and species composition**, **stage of stand development** or **age** are important drivers of spatial variation in biomass accumulation and changes

DISCUSSION

the applied thinning treatments significantly affect **photosynthesis**, **transpiration**, **water use efficiency** and **stomatal conductance** parameters within the thinned site

The highest values were observed at the control site without thinning

strong thinning allowed a better resistance of trees to water stress even if, during years of strong drought, these intensive treatments were not enough to prevent a sensitive reduction in radial growth.

These results suggest that the forest management can significantly increase the carbon assimilation. The thinning of forest is a practice that leads to maintain and improve carbon sequestration

DISCUSSION

Concerning **soil humidity** and **water content**, in the thinned site, the conditions of radiation and exposure support strong soil evaporation.

The superficial layer 0-20 cm is subject to a direct soil evaporation and /or evapotranspiration of vegetation associated with pine forest.

Therefore, the thinned site evaporates more than the control site by exposure effect to direct radiation, while at a depth of 100 cm, the thinned site has more water and thus less taking roots at this level

litter surface at the thinned site is more exposed to solar radiation. The covered surface at the control site is high; all radiation is anticipated by leaves, which makes the control site more shaded than the thinned site. These conditions explain the difference in temperatures recorded on both sites.

CONCLUSION

-Thinning treatments constitute essential operations for forestry. Traditionally, they are defined only on the basis of dendrometric criteria (trees number per hectare and trees height).

-Available data allow considering another definition of thinning on ***ecophysiological bases*** including ***hydric bases***.

-Thinning leads to micro-climatic changes which result modifications in the ecophysiological functioning of trees, at the level of photosynthesis, transpiration, growth, shape of crowns. Thinning can provide a remarkable improvement of soil water availability, and consequently a decrease in the duration of hydric stress.

-This sylvicultural technique could also be an effective may of optimisation of carbon sequestration and water management on our forest ecosystems which are characterized by a water deficit and can also provide more resilience to the current global changes.

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Rapport de Stage
En vue de l'obtention de la

MASTERE PROFESSIONNEL : PROMOTION TOURISTIQUE DU PATRIMOINE NATUREL

Aménagement sylvicole et impact sur la gestion de l'eau et sur la conductivité hydraulique d'une forêt de "*Pin Pignon* " en Kroumirie

Présenté par : **Jihen Mejri**

Soutenu le ....

Devant le Jury composé de :
M. ..... Président
Mme Asma BEN GHNAYA ..... Encadreur
Mme Amel ENNAJAH ..... Encadreur

Année universitaire : 2018/2019

this study was taken over for both sites this year **2019** in addition to the study of the ***hydraulic conductivity and the embolism*** of the pine tree under thinning. the results are being processed.

Thanks