MODELIZATION OF PHOTOSYNTHESIS IN RELATION TO LIGHT AND ENVIRONMENTAL VARIABLES OF NATURAL REGENERATION OF TWO MIXED *Pinus pinea-Quercus ilex-Juniperus oxycedrus* STANDS

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1. INTRODUCTION

- The study site is located in the Tietar and Alberche Valleys (Madrid Community and Avila province) where the dominant species is *Pinus pinea*

- High ecological, landscape and productive values of Spanish mixed stone pine-holm oak stands

- Traditional forest management "pine nut-goats-holm oak firewood" is changing. Thus, open stands with scattered adult pines are found

1. INTRODUCTION

Poor regeneration

Transition to drier conditions

Climate change

Necessity to delve into ecophysiological background of seedlings

AIM

Modelization of ecophysiological response of three naturally-regenerated species from a mixed forest stand under a climate change scenario.

2. MATERIAL AND METHODS

- Two plots (0.45 ha) differing in their structural typology

  <u>Residual Basal Area</u>

  Plot 1: 9.05 m^2/ha

  Plot 2: 20.31 m^2/ha

- 3 species

- 48 plants (from 0.2 to 1.3 m) per plot

Plot 1

Plot 2

Juniperus oxycedrus

Pinus pinea

Quercus ilex

2. MATERIAL AND METHODS

Physiological measurements

Net photosynthesis(An) and micro-environmental variables (temperature (T), soil moisture (H) and incident light (I)) were measured

- **2 plots**
- **3 species**
- **12-16 plants per species**
- **10 dates: Sep 2010- Oct 2011**
- **2 measurement/date: morning/midday**

120 inventories

3. MODELING

What we propose?:

The parameterization of the non-rectangular hyperbolic model of photosynthesis that relates gross photosynthesis rate (A)with incident light (I) for a particular moment:

$$A = A_n + R_d = \frac{1}{2\theta}\left\{\alpha I + A_{\max} - \left[\left(\alpha I + A_{\max}\right)^2 - 4\theta\alpha I A_{\max}\right]^{1/2}\right\}$$

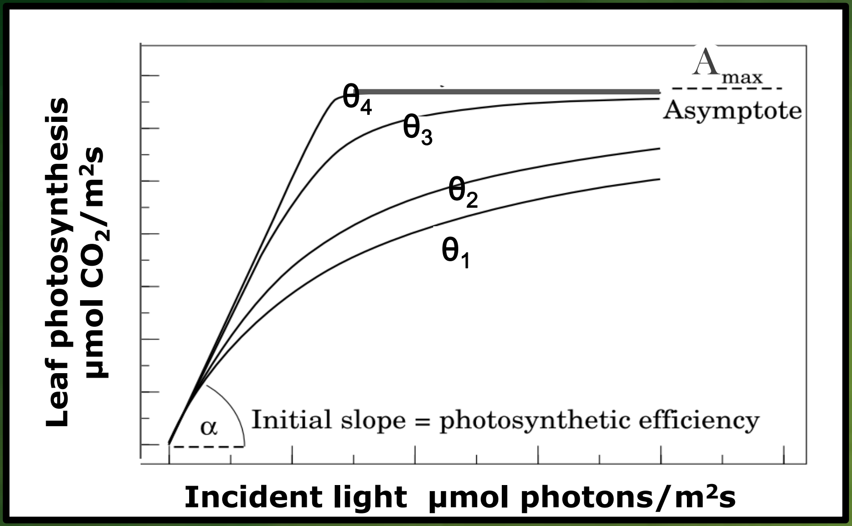
(Thornley & Johnson ,1990)

We have measured An on field

An=A –Rd

Rd= leaf dark respiration

3. MODELING



I= incident light

Amax= asymptote, maximum rate of net photosynthesis

θ= the dimensionless convexity of the light response curve, related to the diffusion resistance and resistance to carbon transport

α = the initial slope of light response curve, it represents photochemical efficiency

3. MODELING

Step 1: Fitting the model for each inventory. A combination of parameters is obtained

Rd=f(T)

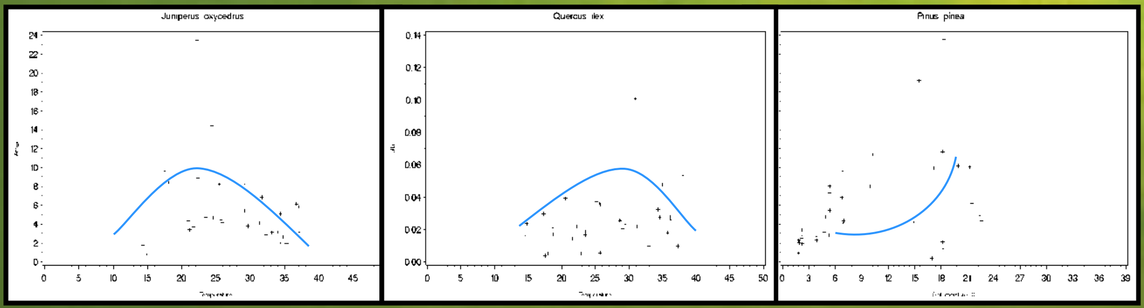
θ=0.8

→ α y Amax

per species and inventory

Step 2: Plotting soil moisture (H) and temperature (T) against Amax and α to study their relationship

Amax vs T α vs T Amax vs H



$Rd = p_5 . T^2$

$Amax = [\ p_0 + p_1\ (T-T_{ref})^2]\ e^{\ p2.H}$ ⟺ For Quercus ilex: $Amax = [\ p_0 + e^{p1(T-Tref)2}]\ e^{\ p2.H}$

$\alpha = p_3 + p_4\ (T-T_{ref})^2$

3. MODELING

Step 3: A six-parameters model is fitted by the expansion of Amax and α .

Assumptions: θ=0.8 and Tref=25ºC

P.pinea and J.oxycedrus:

$$A_n = 1/2\theta \{ (p_3 + p_4 (T-T_{ref})^2) I + [(p_0 + p_1 (T-T_{ref})^2) e^{p2.H}] - [[(p_3 + p_4 (T-T_{ref})^2) I + (p_0 + p_1 (T-T_{ref})^2) e^{p2.H}]^2 - 4\theta(p_3 + p_4 (T-T_{ref})^2) I [(p_0 + p_1 (T-T_{ref})^2) e^{p2.H}]]^{1/2} \} - p_5 T^2$$

Q.ilex:

$$A_n = 1/2\theta \{ (p_3 + p_4 (T-T_{ref})^2) I + [(p_0 + p_1 (T-T_{ref})^2) e^{p2.H}] - [[(p_3 + p_4 (T-T_{ref})^2) I + (p_0 + e^{p1(T-Tref)2}) e^{p2.H}]^2 - 4\theta(p_3 + p_4 (T-T_{ref})^2) I [(p_0 + e^{p1(T-Tref)2}) e^{p2.H}]]^{1/2} \} - p_5 T^2$$

4. RESULTS AND DISCUSSION

- All parameters show coherence with their biological sense
- The parameters are statistically significant with the exception of p_1 and p_5 in the Q. ilex case

	Parm	Estimate	Prob-t
Q.ilex	p0	2.76552	<0.0001
	p1	-0.01589	0.18041
	p2	0.02092	<0.0001
	p3	0.01112	<0.0001
	p4	-0.00003	<0.0001
	p5	-0.00023	0.16646
P.pinea	p0	3.88275	<0.0001
	p1	-0.00884	<0.0001
	p2	0.01866	0.00016
	p3	0.01388	<0.0001
	p4	-0.00003	0.02541
	p5	-0.00076	0.00090
J.oxycedrus	p0	3.31344	<0.0001
	p1	-0.00674	<0.0001
	p2	0.03697	<0.0001
	p3	0.01174	<0.0001
	p4	-0.00003	0.00019
	p5	-0.00059	0.03383

4. RESULTS AND DISCUSSION

Six scenarios with variations of soil moisture (H) and temperature (T)

1. Spring:
Fixed H= 15%   T range= 15-35º

2.Spring:
Fixed T= 20º   H range= 10-30%

3.Summer:
Fixed H= 2.5%   T range= 25-47º

4.Summer:
Fixed T = 35º   H range= 0.8-6%

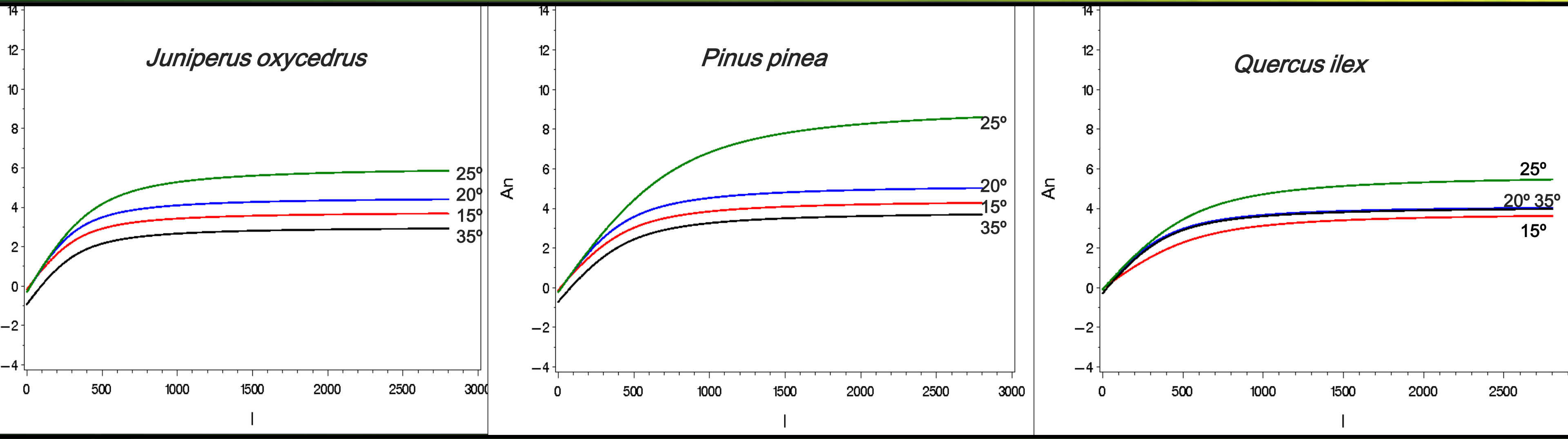
5.Spring:
Dry T= 25º H= 8%
Wet T= 20º H= 15%

6.Summer
Dry and hot T= 40º H= 0.8%
Soft T= 28º H= 4%

4. RESULTS AND DISCUSSION

Scenario 1: Spring, non-limiting environmental conditions

Soil moisture= 15%

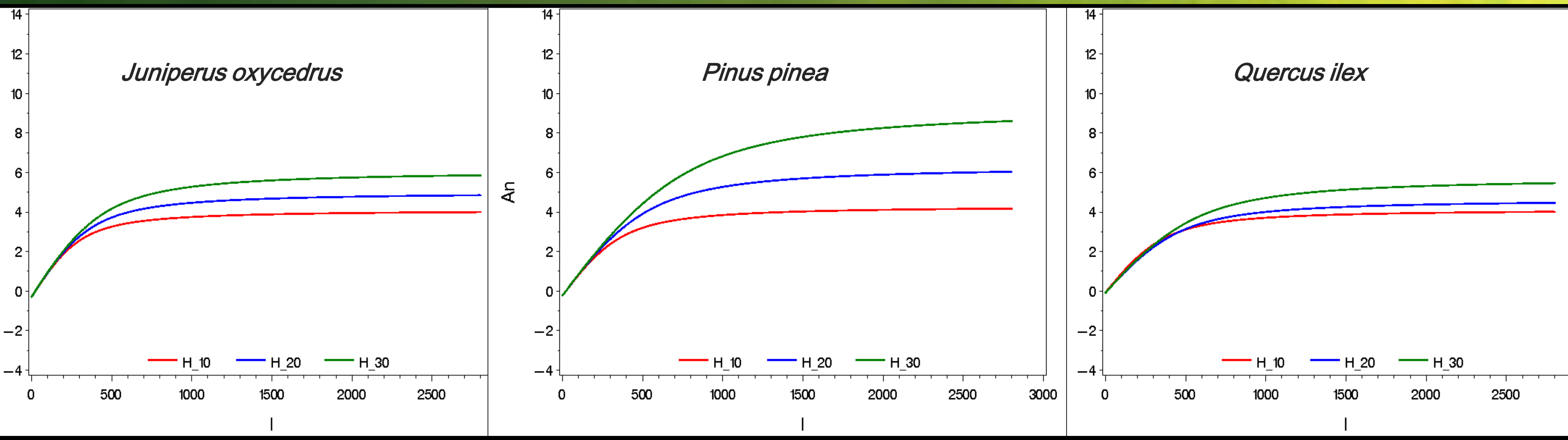


Pinus pinea shows higher An rate in response to changes in temperature than Juniperus oxycedrus and Quercus ilex.

4. RESULTS AND DISCUSSION

Scenario 2: **Spring, non-limiting environmental conditions**

Temperature = 20ºC

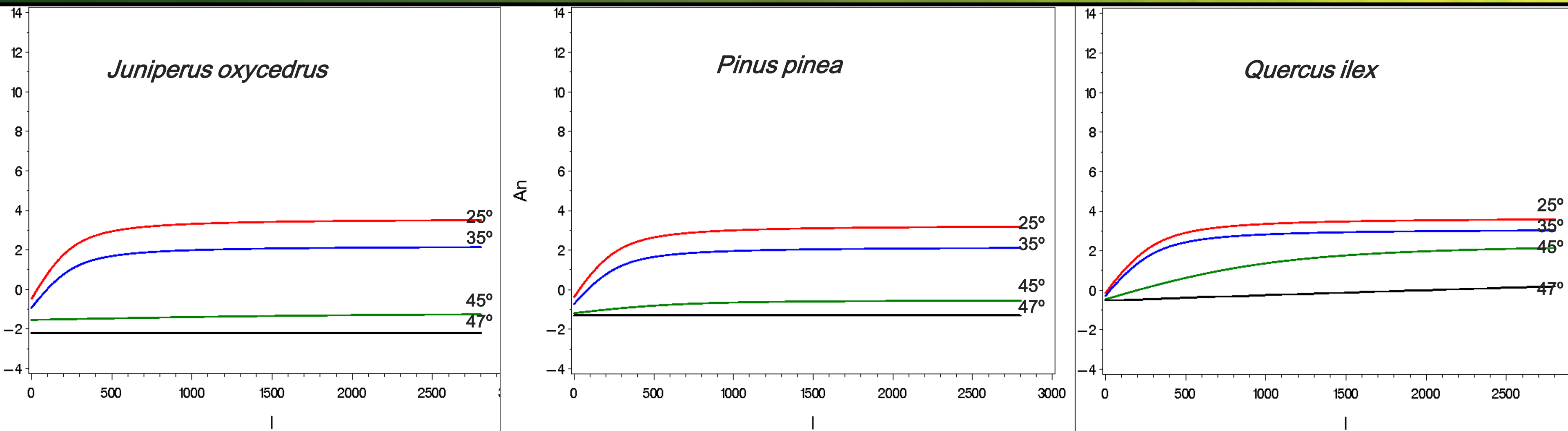


Pinus pinea shows higher An rate in response to changes in soil moisture than Juniperus oxycedrus and Quercus ilex.

4. RESULTS AND DISCUSSION

Scenario 3: Summer, limiting environmental conditions

Soil moisture = 2.5%

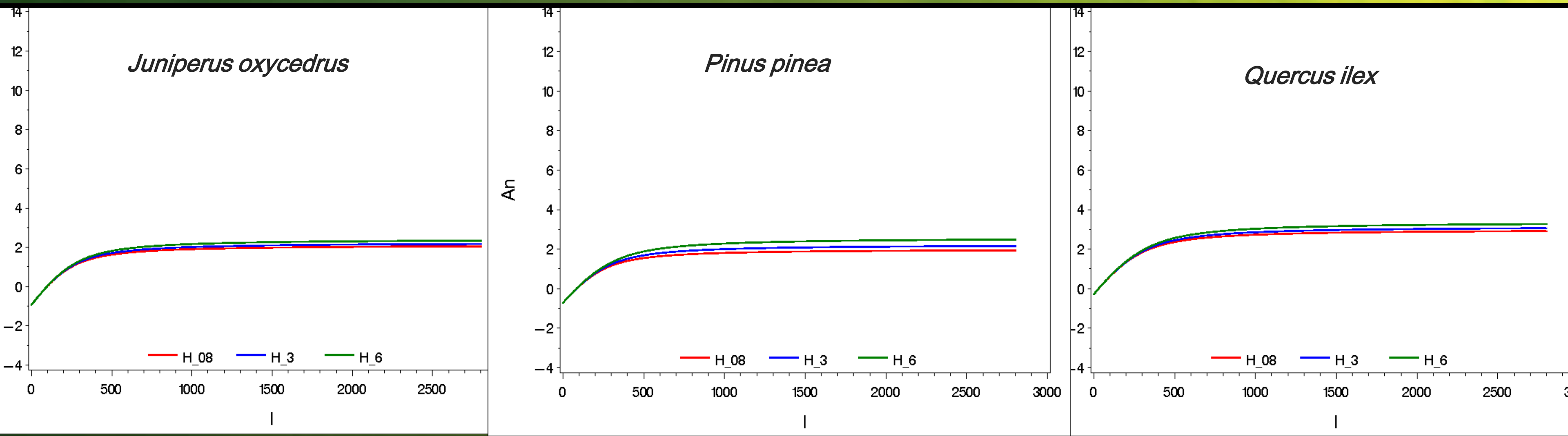


In a low soil moisture scenario, higher temperatures implies no CO_2 assimilation.

4. RESULTS AND DISCUSSION

Scenario 4: **Summer, limiting environmental conditions**

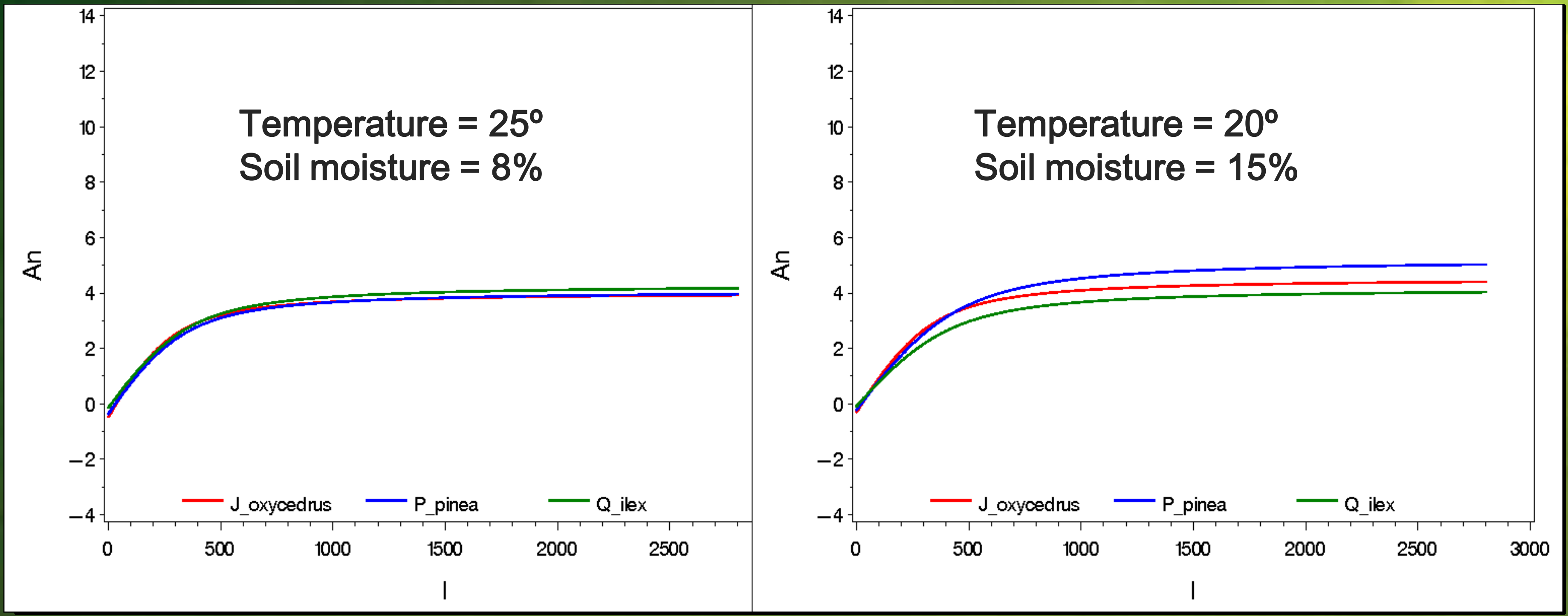
Temperature = 35ºC



In a high-temperature scenario, all species show very low CO_2 assimilation irrespective of changes in soil moisture.

4. RESULTS AND DISCUSSION

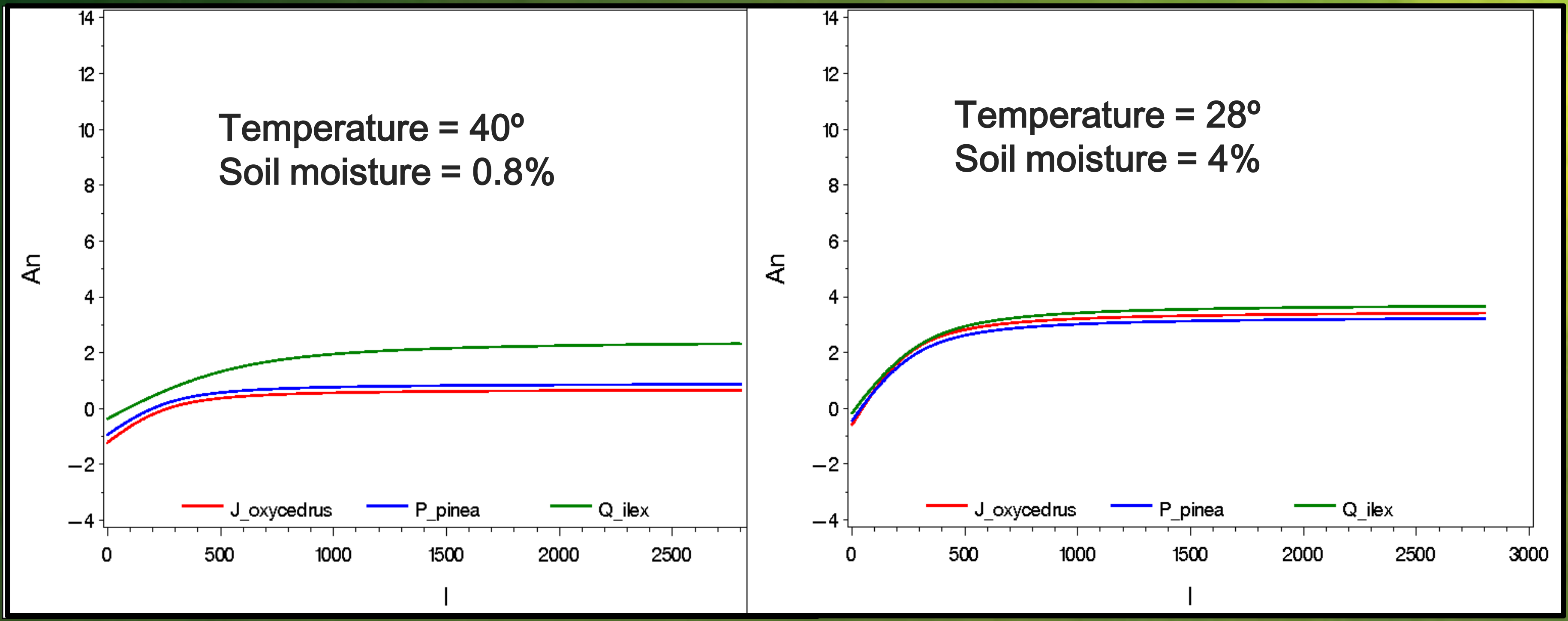
Scenario 5: Spring, non-limiting environmental conditions



Quercus ilex is more sensitive to decreasing temperatures than the other species, even when soil moisture is appropriate

4. RESULTS AND DISCUSSION

Scenario 6: Summer, limiting environmental conditions



Quercus ilex shows the highest assimilation during summer conditions while Pinus pinea and Juniperus oxycedrus have stopped assimilation.

5. CONCLUSSIONS

- *Quercus ilex* is the best adapted to withstand higher temperatures under a climate change scenario of the three species.

- When environmental conditions are non-limiting *Pinus pinea* shows the highest CO_2 assimilation rate.

- Juniperus oxycedrus exhibits behavior intermediate between those of the other species under non-limiting conditions.

Thank you for your attention

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