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FOREST PRODUCTIVITY COOPERATIVE
North Carolina State University · Virginia Polytechnic Institute and State University · Universidad de Concepción

Combining soil and environmental information to predict growth response to Nitrogen fertilizer in adult stands of radiate pine in Chile.

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Aims for this research

- Can we increase productivity fertilizing with N and P in Chile?
- How long does the response last?
- Develop tools to asses responsive sites
- Determine value treshold for fertilizer under uncertain climatic scenarios.

The state of California goes from 32° to 42° N so does the study area but South

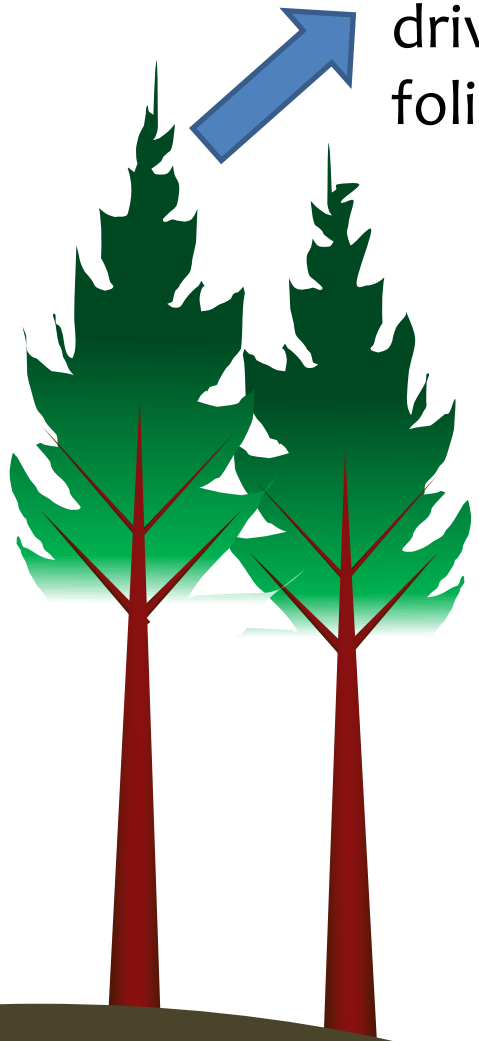
Marine Sediments

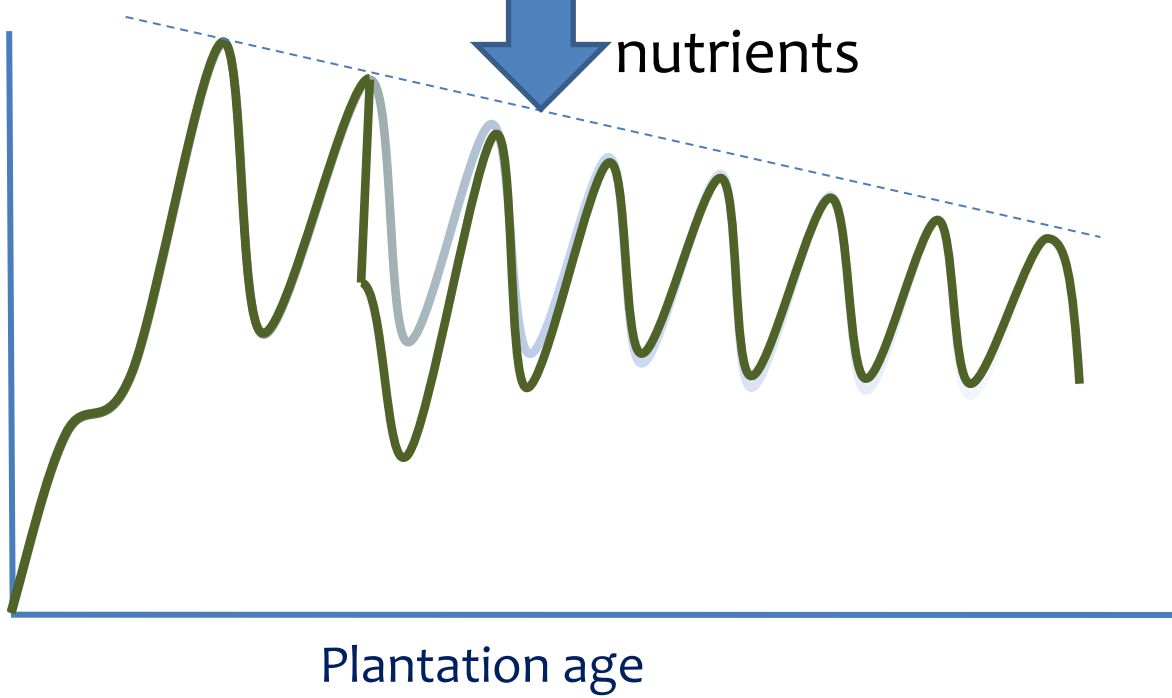
Costal Range

Central Valley

2. Nutrint accuisition
driven by transpiration rate and
foliage amount and %N.

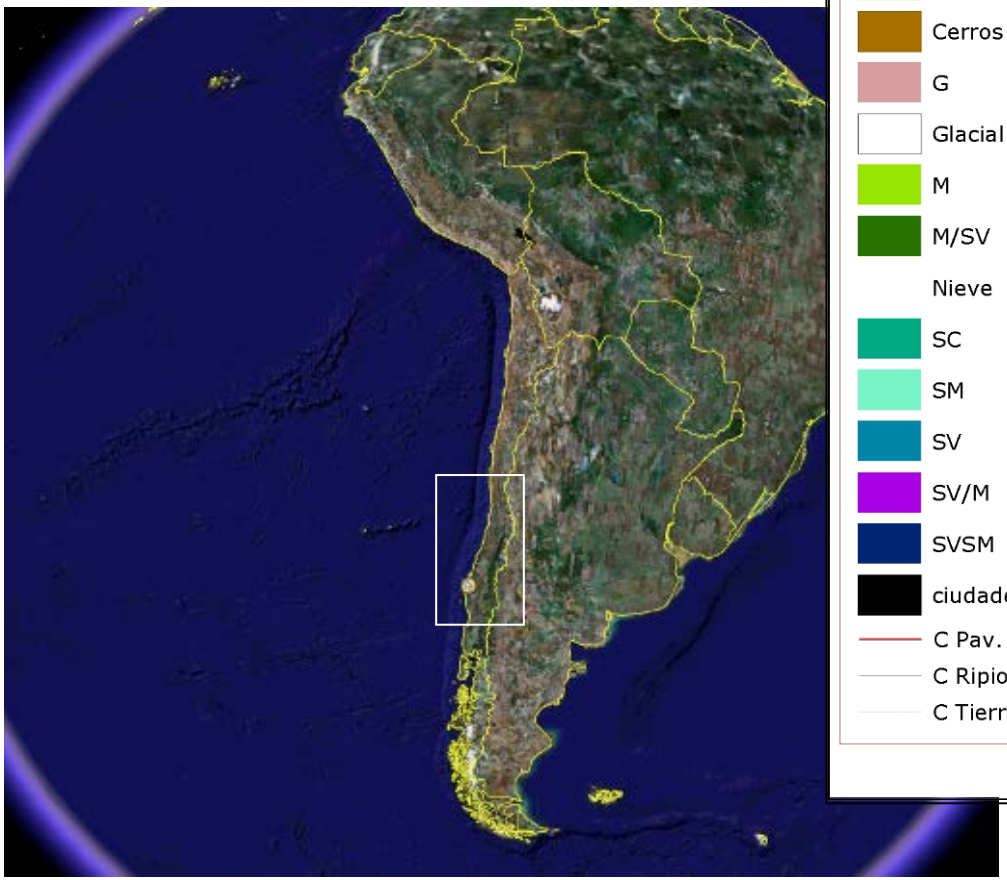
3. LA display
limited by water
in the soil and
nutrients

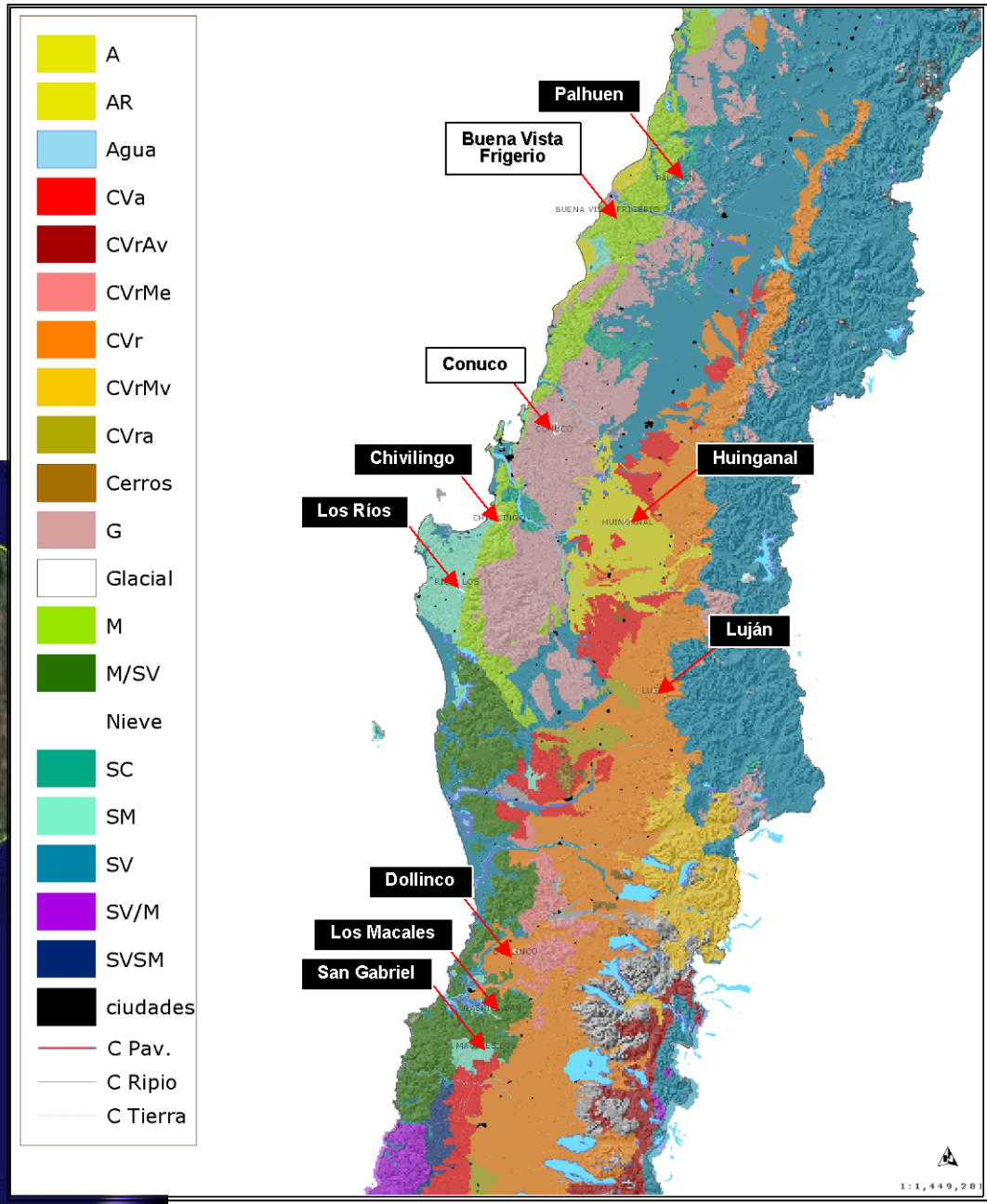




1. N availability
driven by C:N ratios,
Temperatura, Soil Moisture

Trials were established in different parent materials





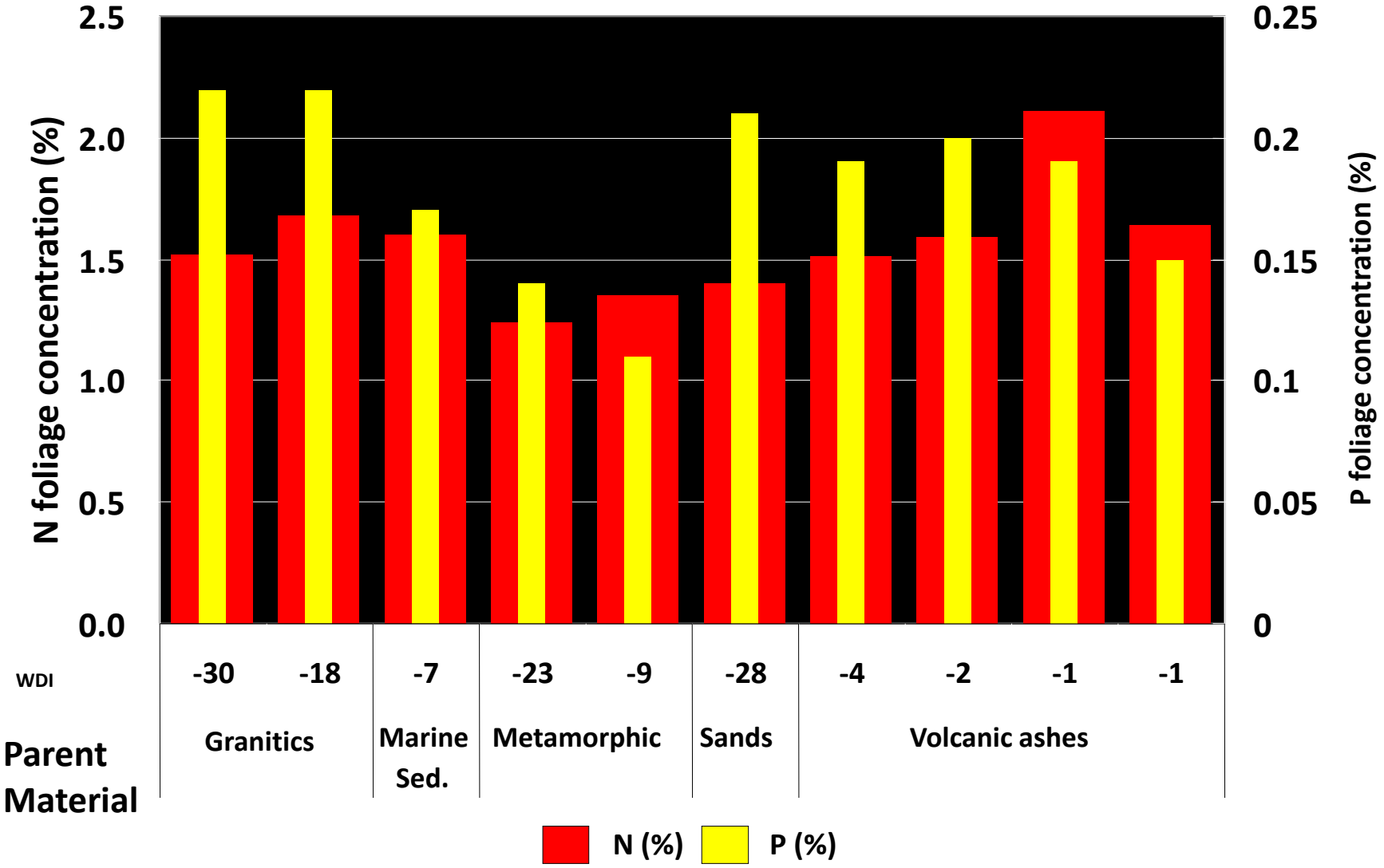
The Trial

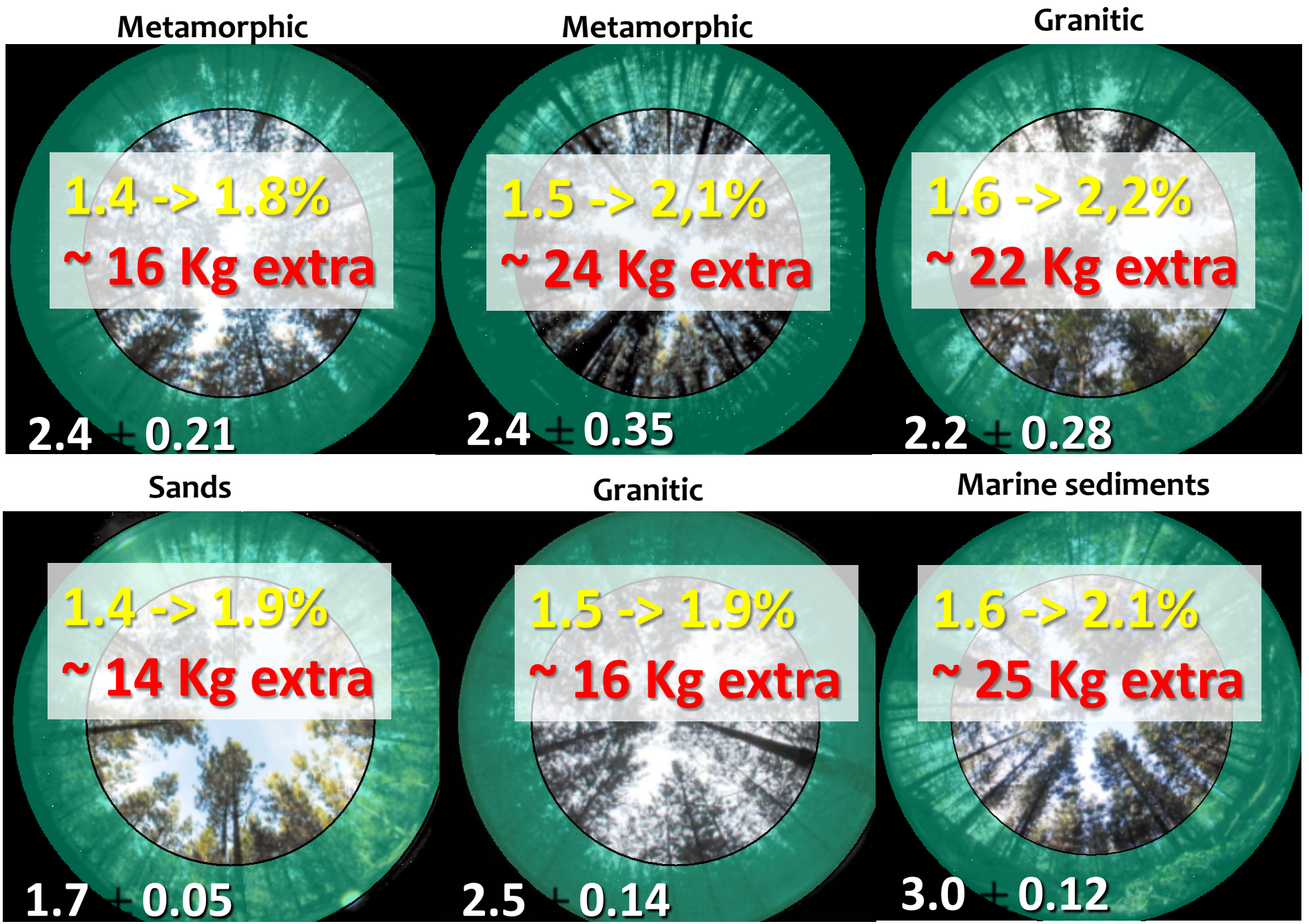
- T009 = Boron Only (8Kg/ha)
- T000 = Nothing
- T100 = 150 N, 0 P, 8 B
- T200 = 300 N, 0 P, 8 B
- T110 = 150 N, 20P, 8B
- T120 = 150 N, 40P, 8B
- T210 = 300 N, 20P, 8B
- T220 = 300 N, 40P, 8B

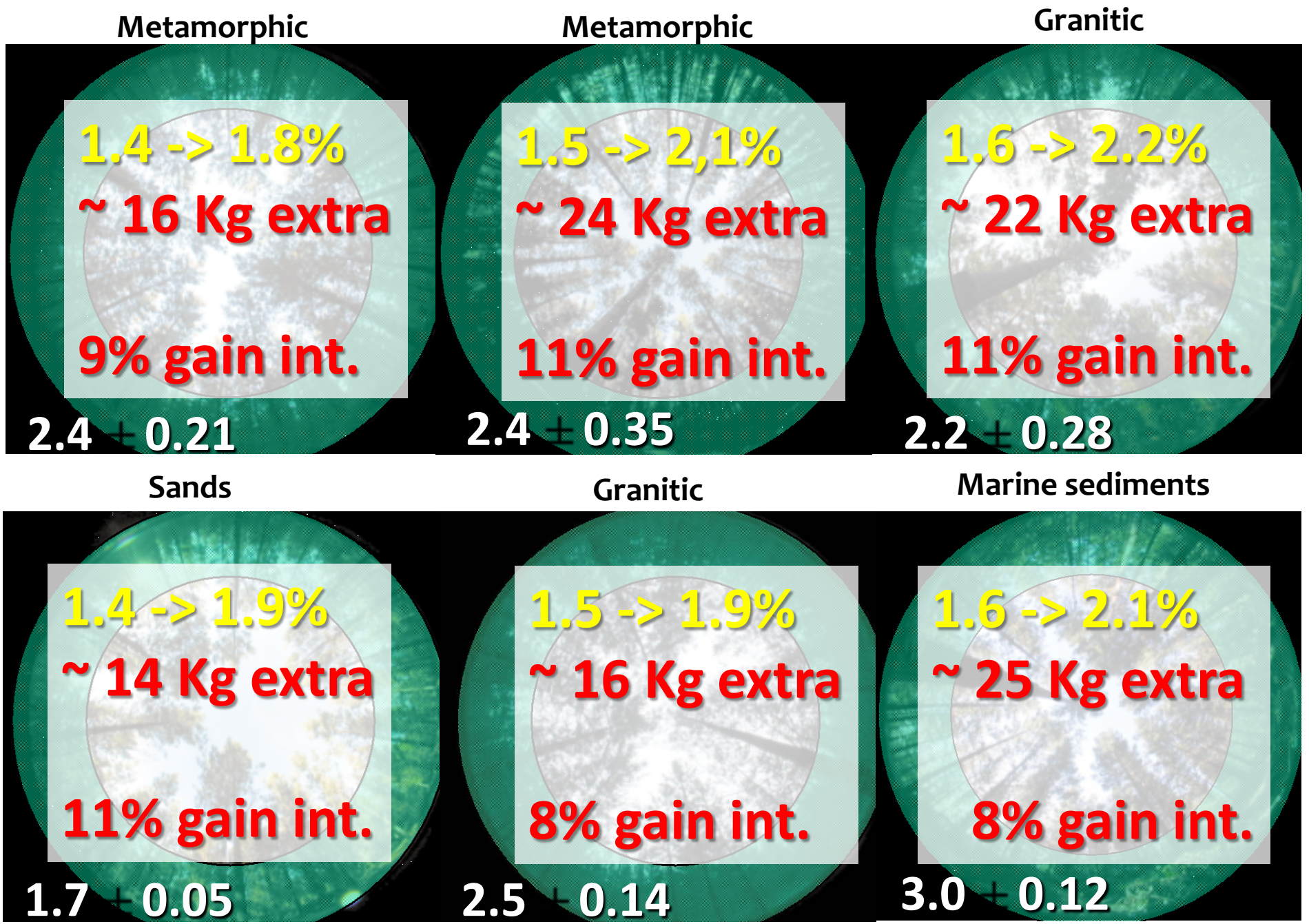
Design/Measurements

- 250 m^2 plots (50*50)
- 900m^2 measurement plots
- 4 replicates
- DBH, Height, $D_{H=5.2}$
- LAI (hemyview)
- Foliage and litterfall
- Lab incubation for NH_4^+
- Soil samples for fertility

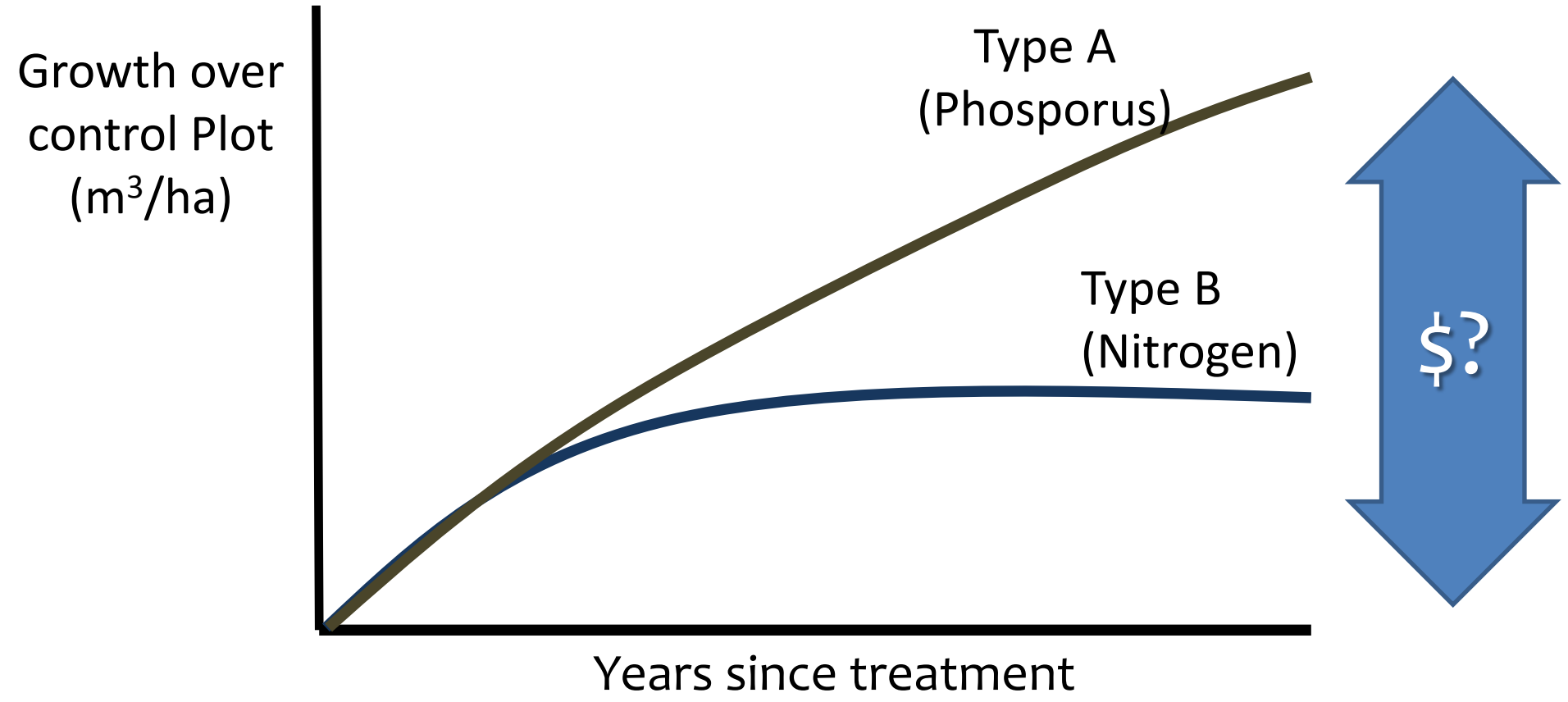
All sites had an adequate foliar nitrogen concentration, one site had a relatively low P concentration



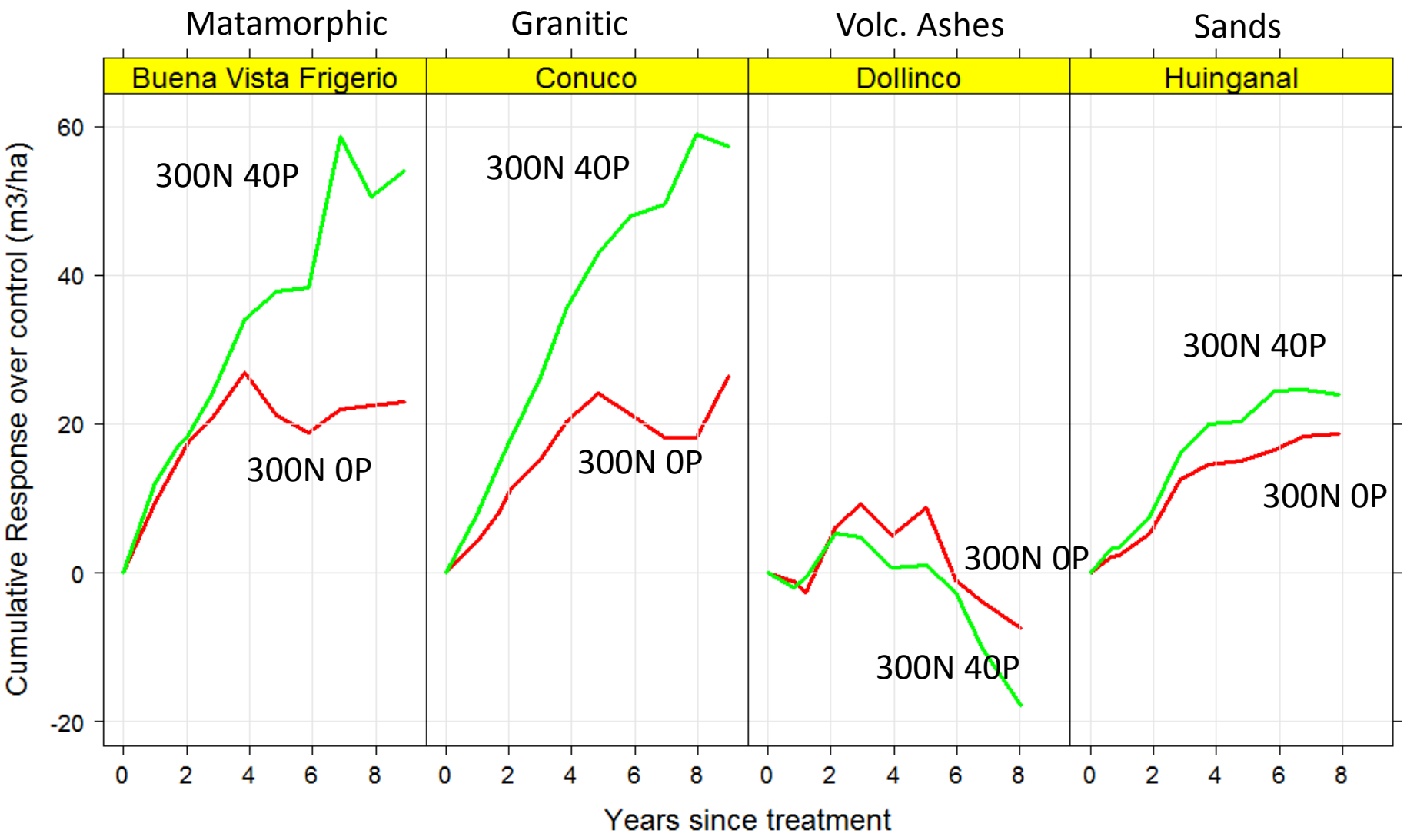

Metamorphic
1.4 -> 1.8%
~ 16 Kg extra
2.4 ± 0.21
Metamorphic
1.5 -> 2,1%
~ 24 Kg extra
2.4 ± 0.35
Granitic
1.6 -> 2,2%
~ 22 Kg extra
2.2 ± 0.28
Sands
1.4 -> 1.9%
~ 14 Kg extra
1.7 ± 0.05
Granitic
1.5 -> 1.9%
~ 16 Kg extra
2.5 ± 0.14
Marine sediments
1.6 -> 2.1%
~ 25 Kg extra
3.0 ± 0.12


Metamorphic
1.4 -> 1.8%
~ 16 Kg extra
9% gain int.
2.4 + 0.21
Metamorphic
1.5 -> 2,1%
~ 24 Kg extra
11% gain int.
2.4 + 0.35
Granitic
1.6 -> 2.2%
~ 22 Kg extra
11% gain int.
2.2 + 0.28
Sands
1.4 -> 1.9%
~ 14 Kg extra
11% gain int.
1.7 + 0.05
Granitic
1.5 -> 1.9%
~ 16 Kg extra
8% gain int.
2.5 + 0.14
Marine sediments
1.6 -> 2.1%
~ 25 Kg extra
8% gain int.
3.0 + 0.12

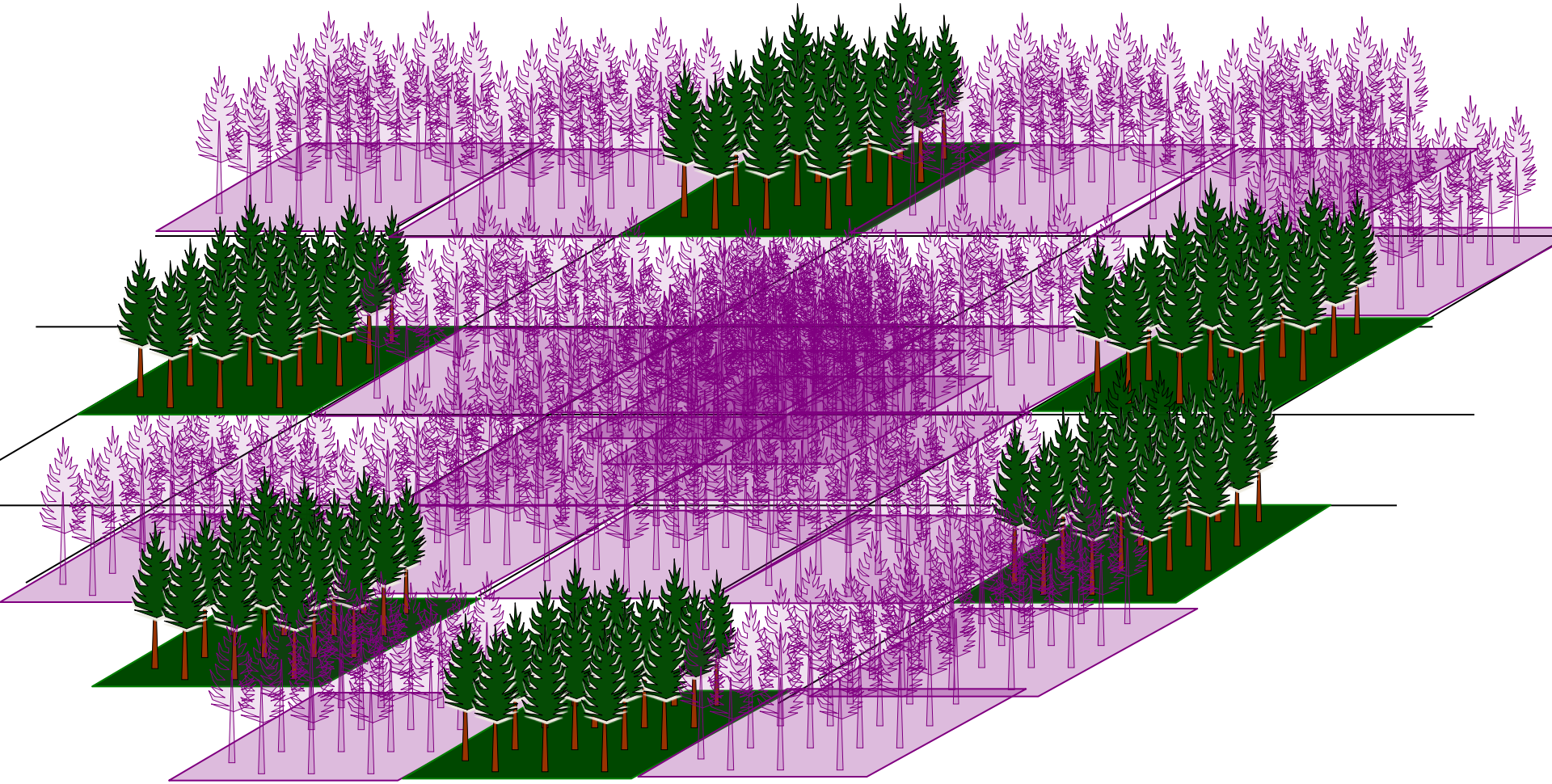
Expected response

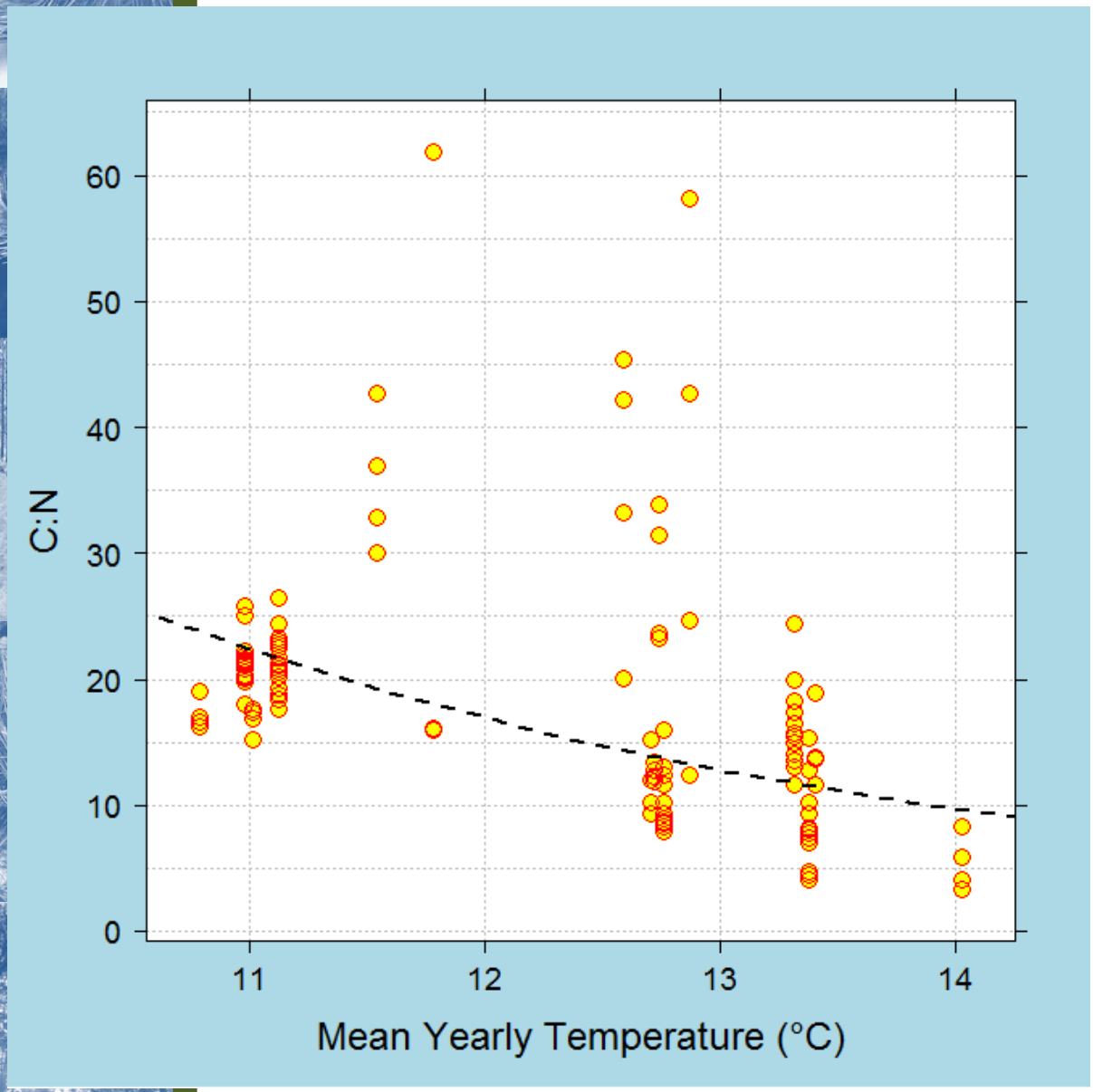


N + P provided a better response, depending on the type of soil we where.

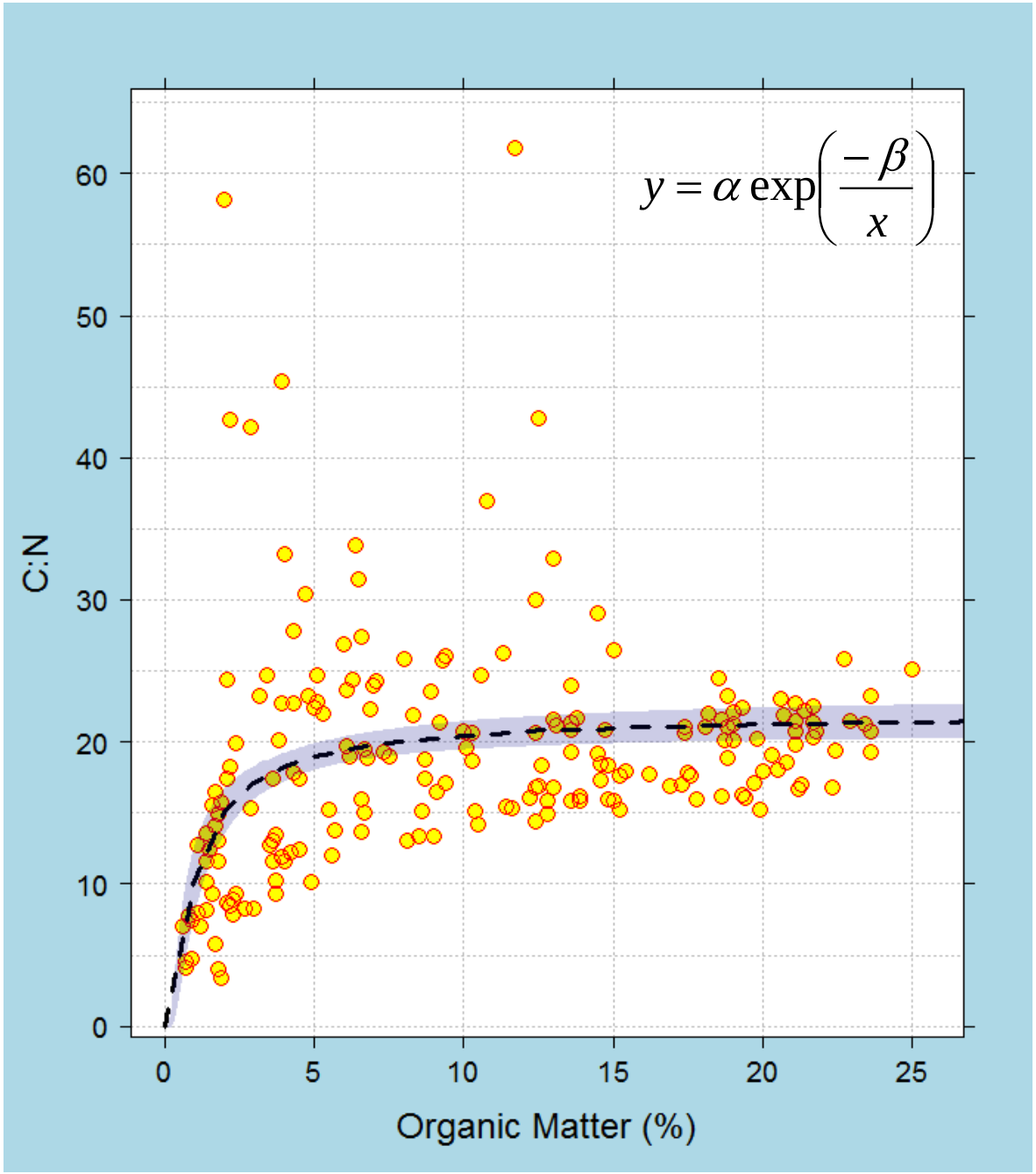


Can we predict response size in different sites?



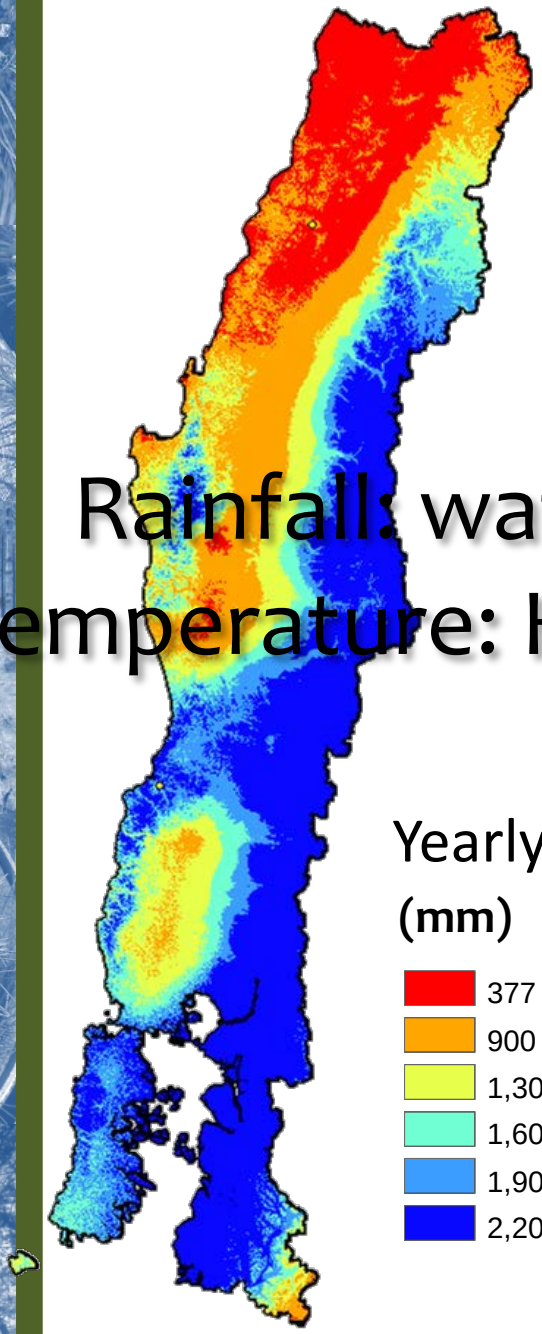


For each degree increase
We get 25% decrease in C:N ratio.



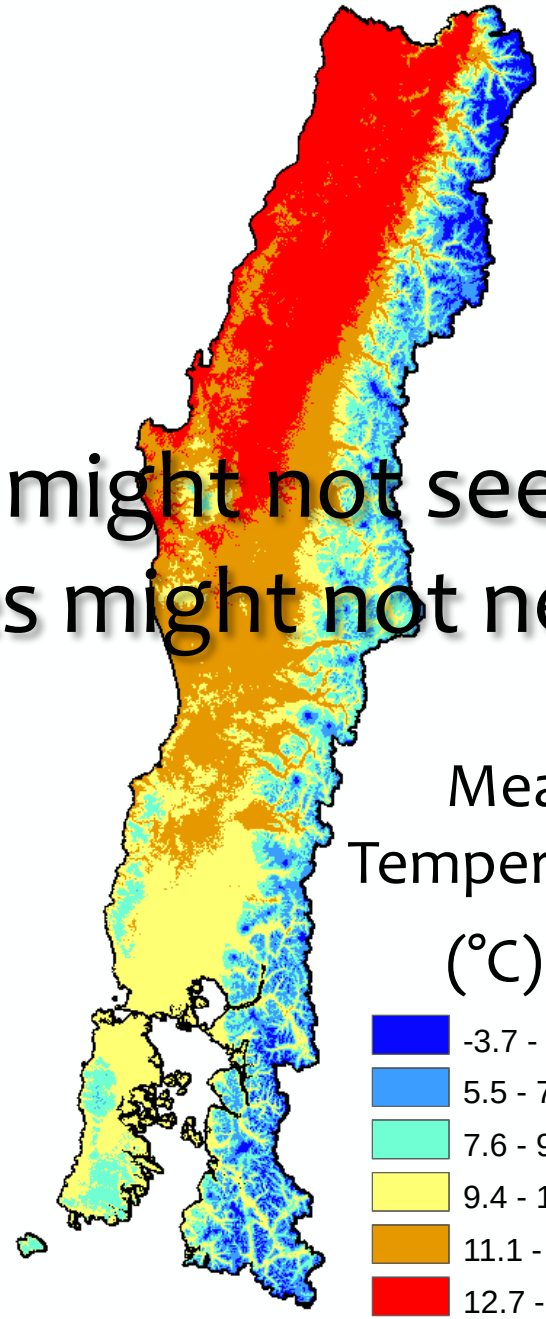
Above 5% C:N ratio doesn't increase suggesting a Nitrogen dynamics limited by other factors.
(e.g. Temperature?)

Rainfall: water trees might not see
Temperature: Heat trees might not need



Yearly Rainfall
(mm)

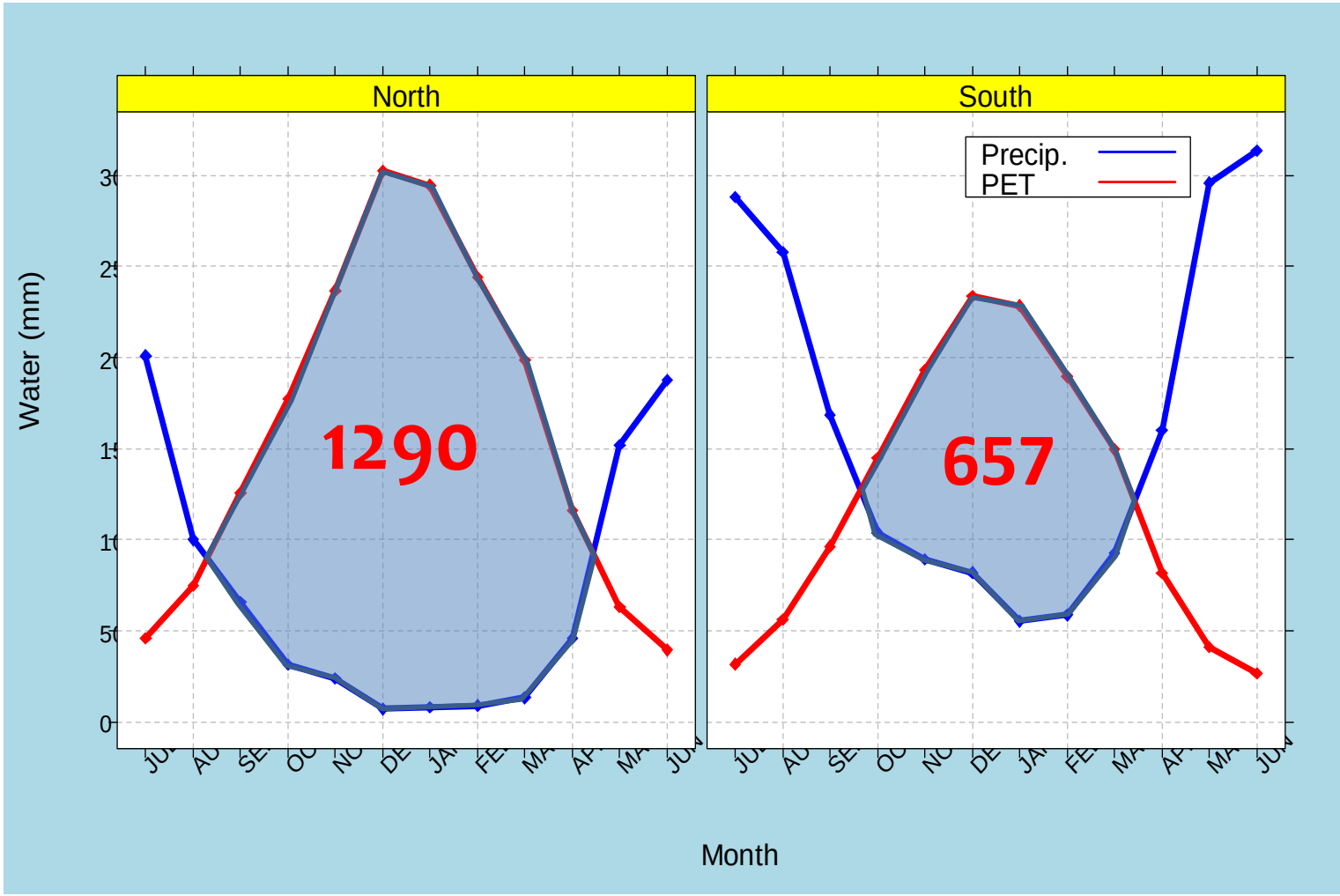
- 377 - 900
- 900 - 1,300
- 1,300 - 1,600
- 1,600 - 1,900
- 1,900 - 2,200
- 2,200 - 3,827

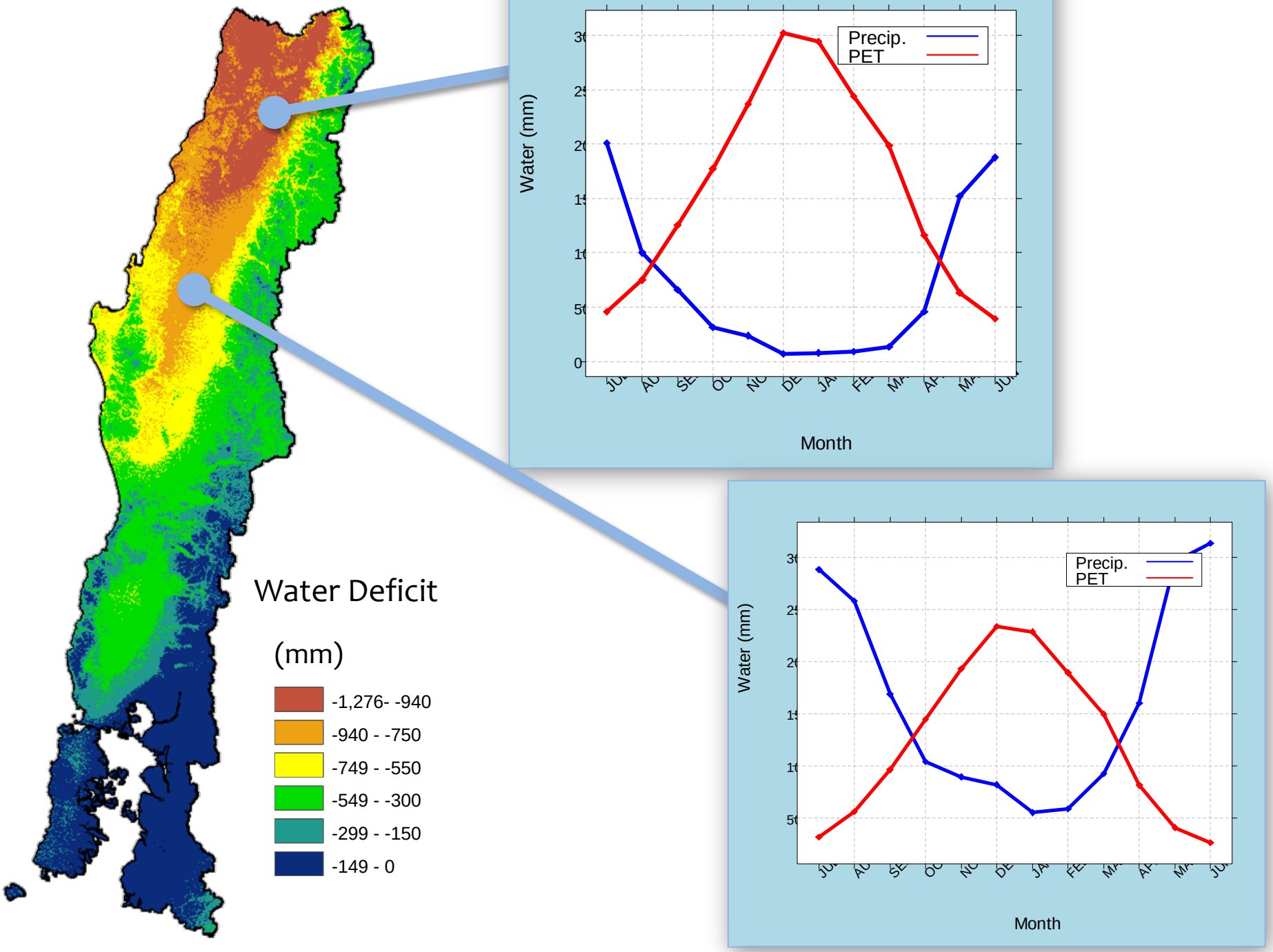


Mean
Temperature
(°C)

- -3.7 - 5.5
- 5.5 - 7.6
- 7.6 - 9.4
- 9.4 - 11.1
- 11.1 - 12.7
- 12.7 - 15.5

In Chile, growth is driven by water availability




Water Deficit
(mm)
-1,276- -940
-940 - -750
-749 - -550
-549 - -300
-299 - -150
-149 - 0
Precip.
PET
Water (mm)
Month
Precip.
PET
Water (mm)
Month

Water holding capacity

Volcanic Ashes

WHC : 200 – 350 mm

Marine sediments

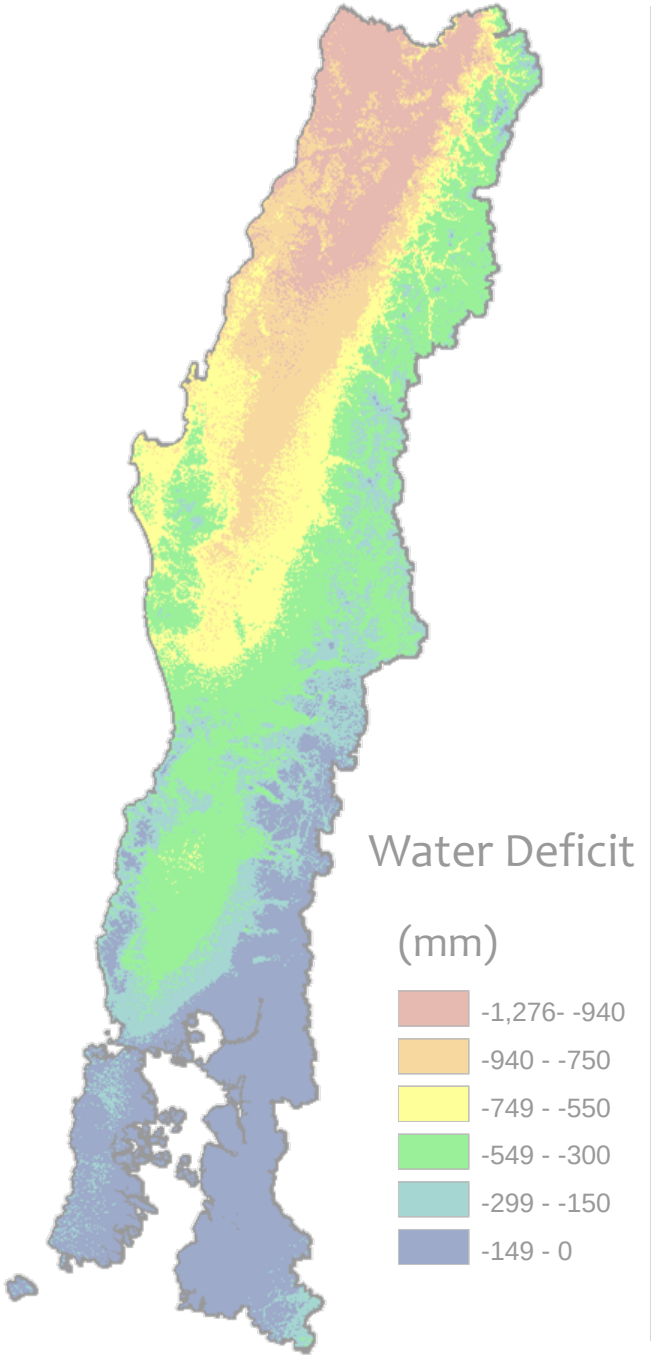
WHC: 180 – 200 mm

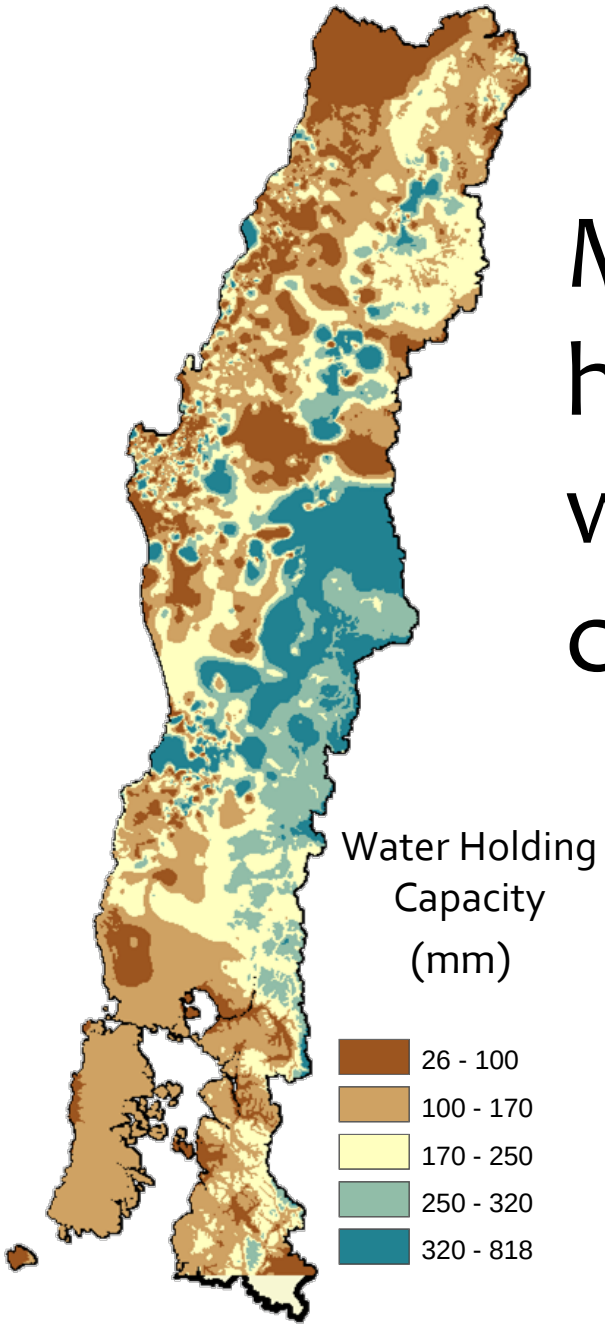
Metamorphic

WHC : 70 – 100 mm

Sandy soils

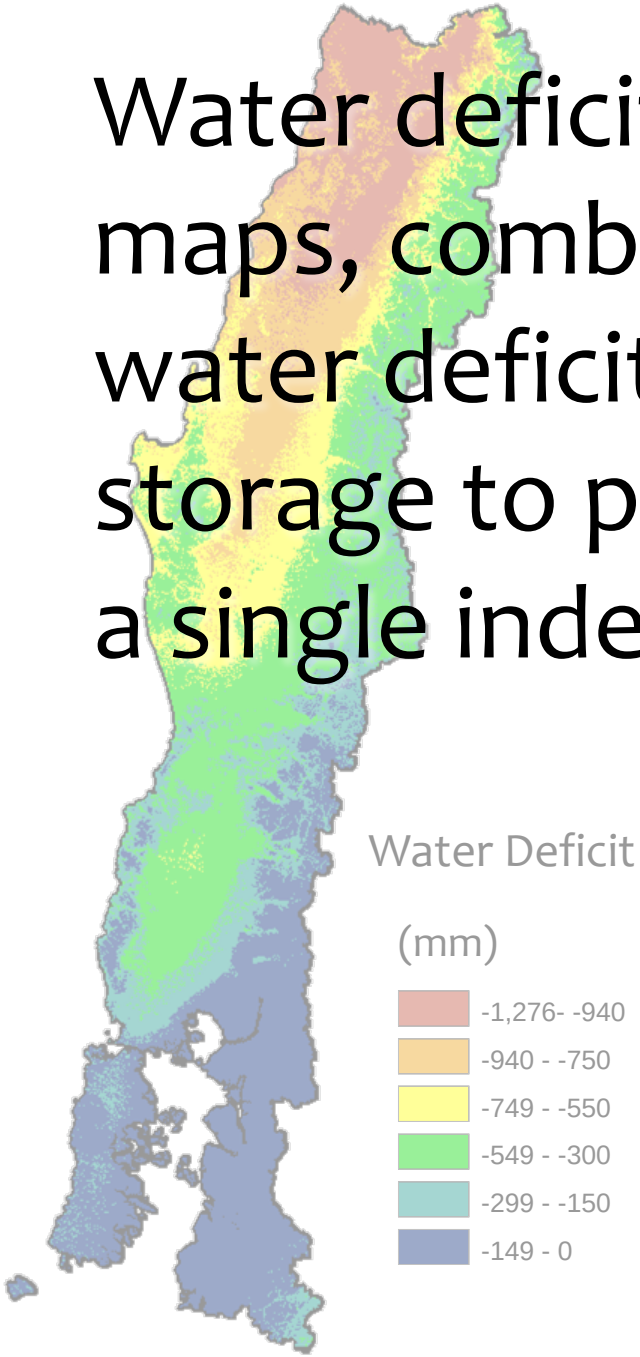
WHC : 50 mm

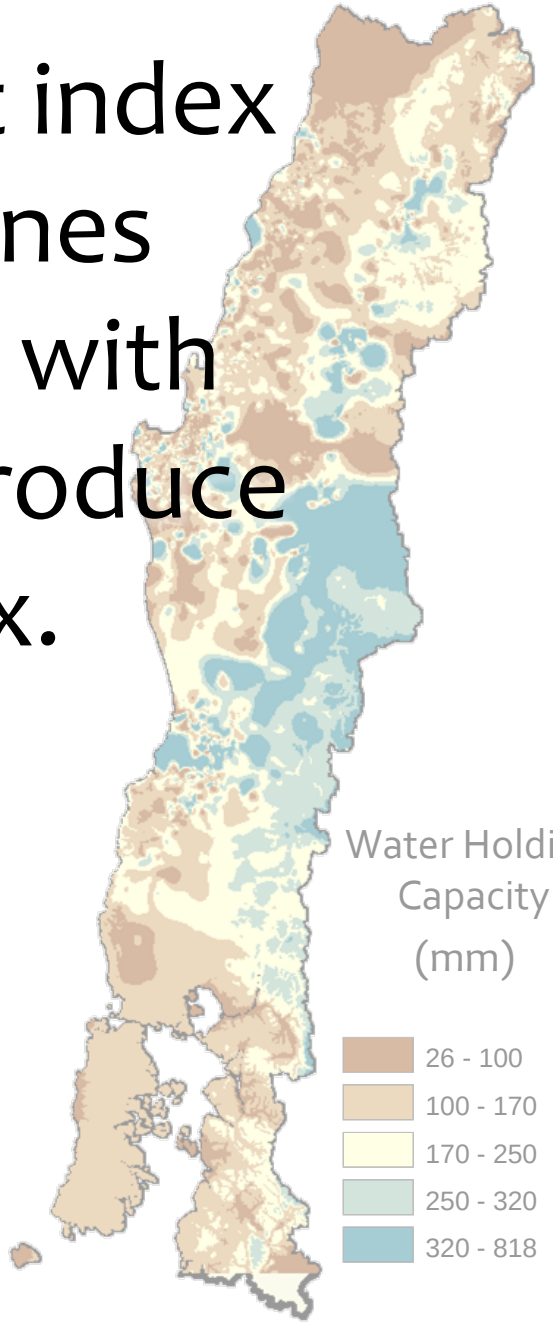


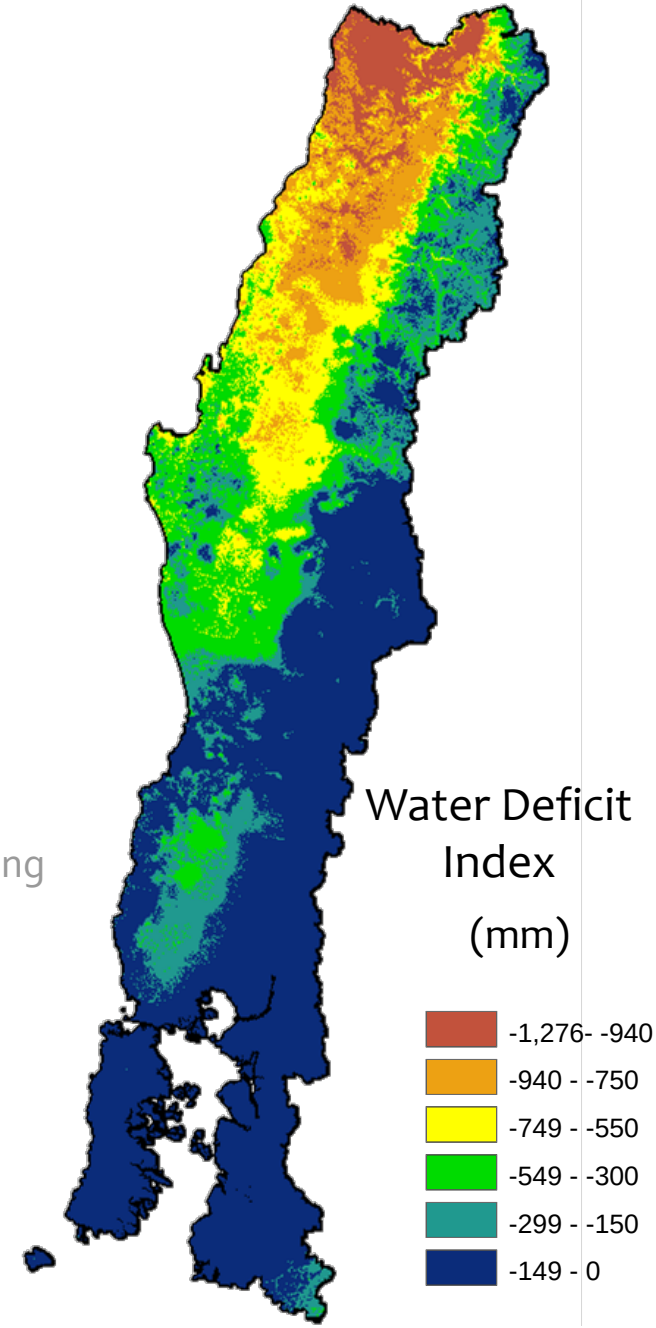


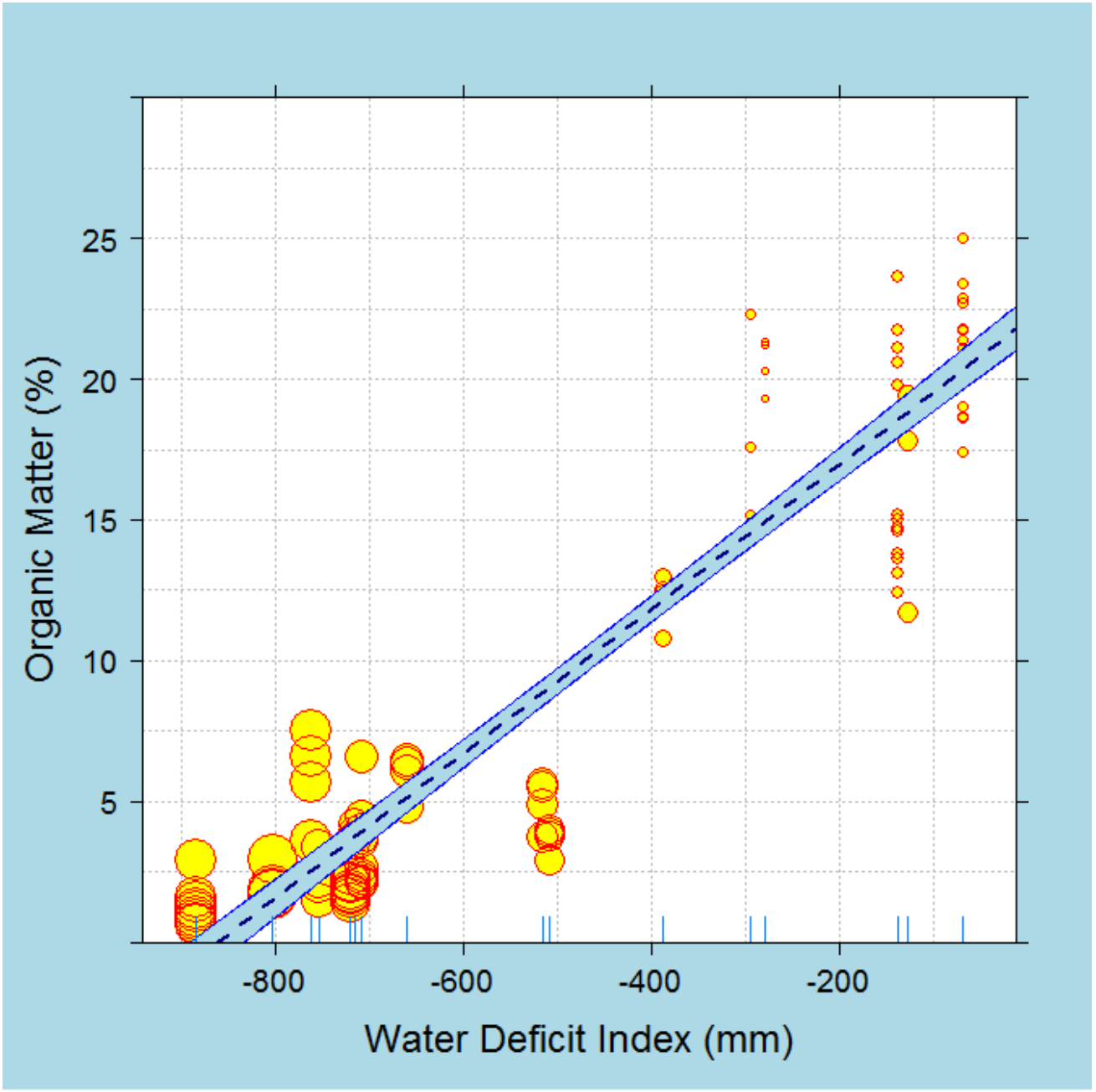
Many soils have large water storage capacity

Water deficit index maps, combines water deficit with storage to produce a single index.





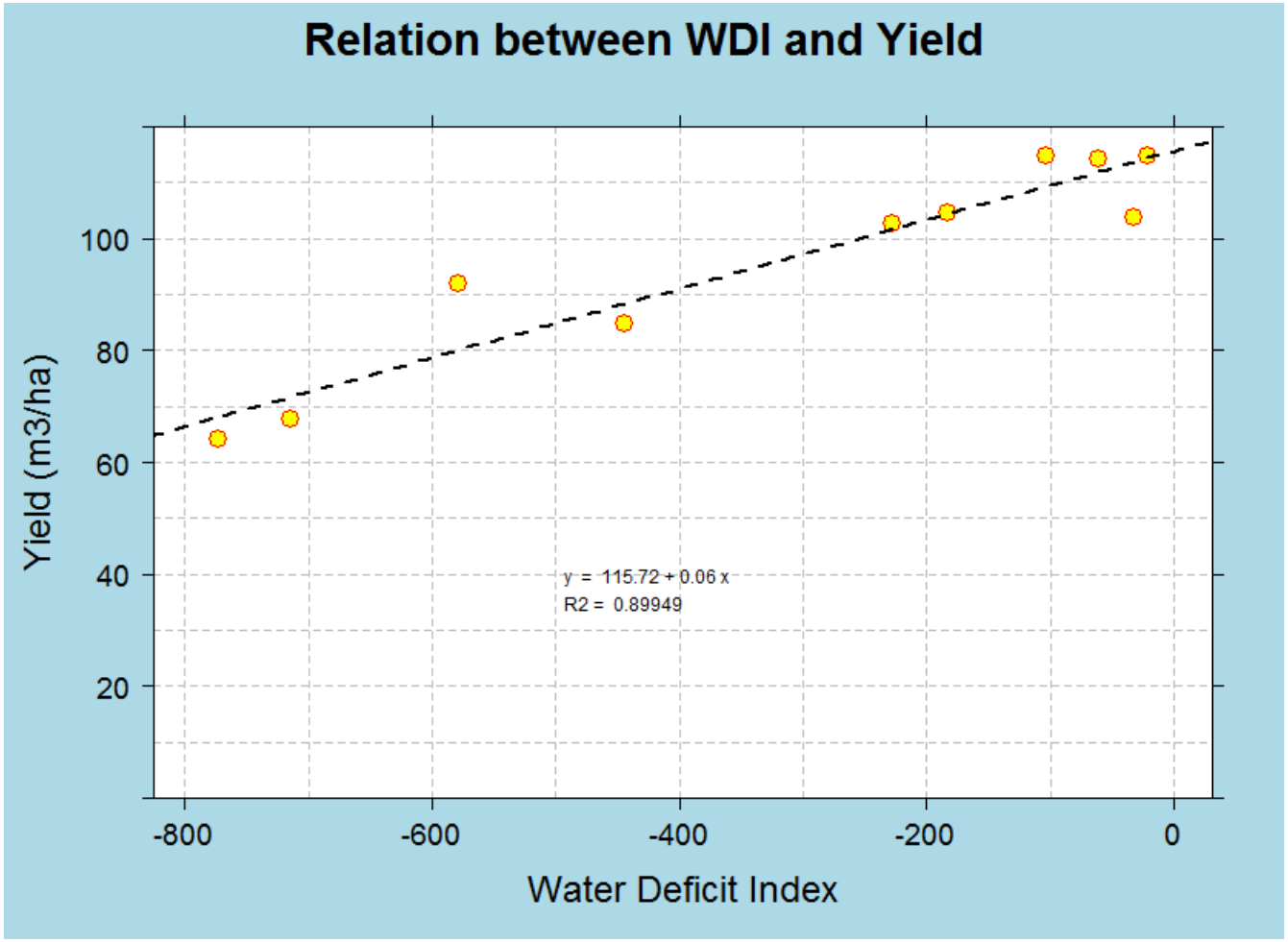




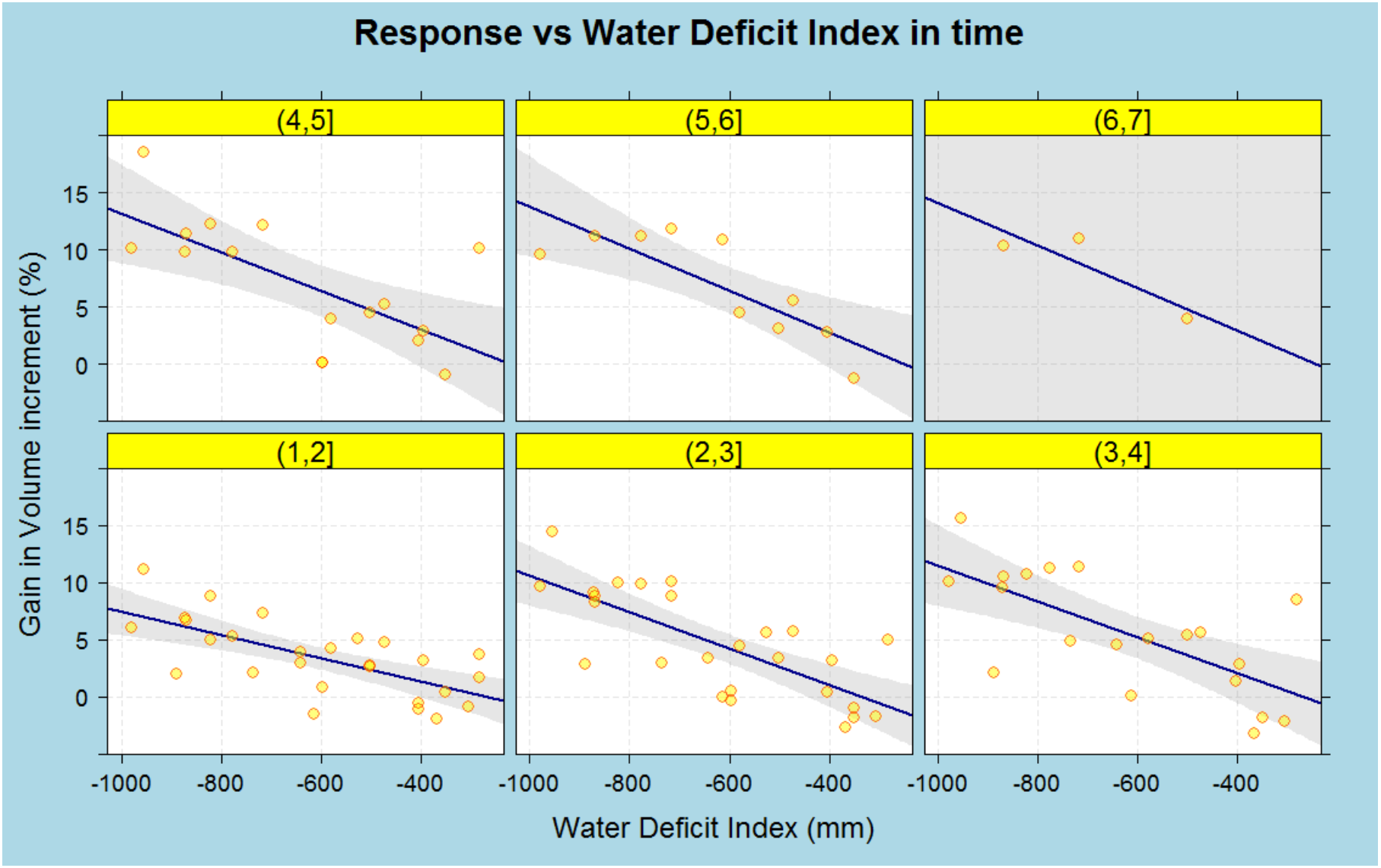
WDI is well correlated to SOM also

Low T°

High T°



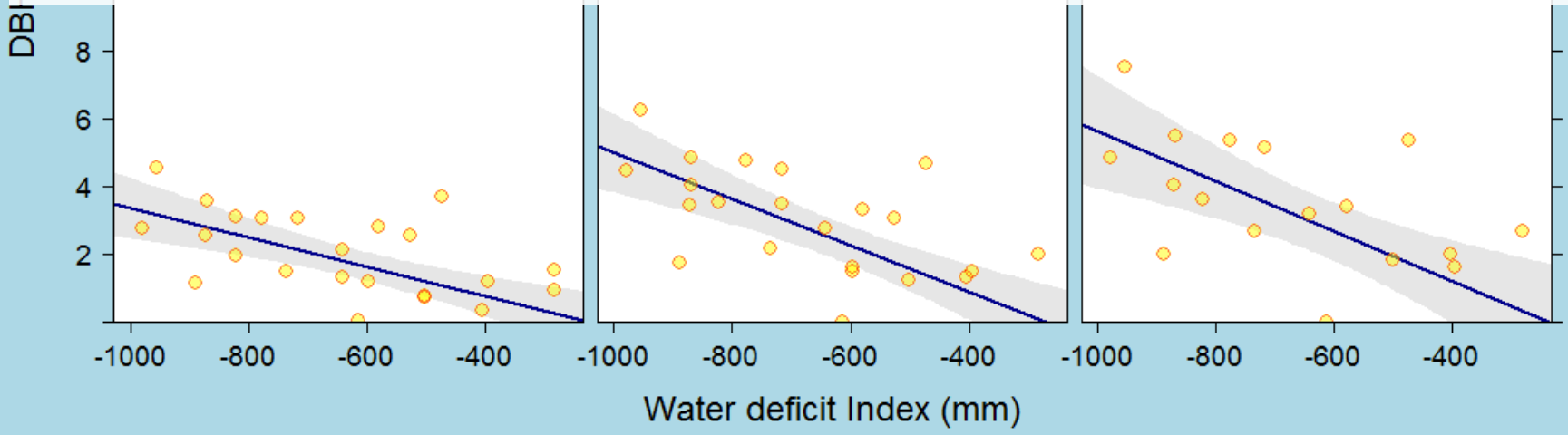
Good agreement between WDI and yield in Chile

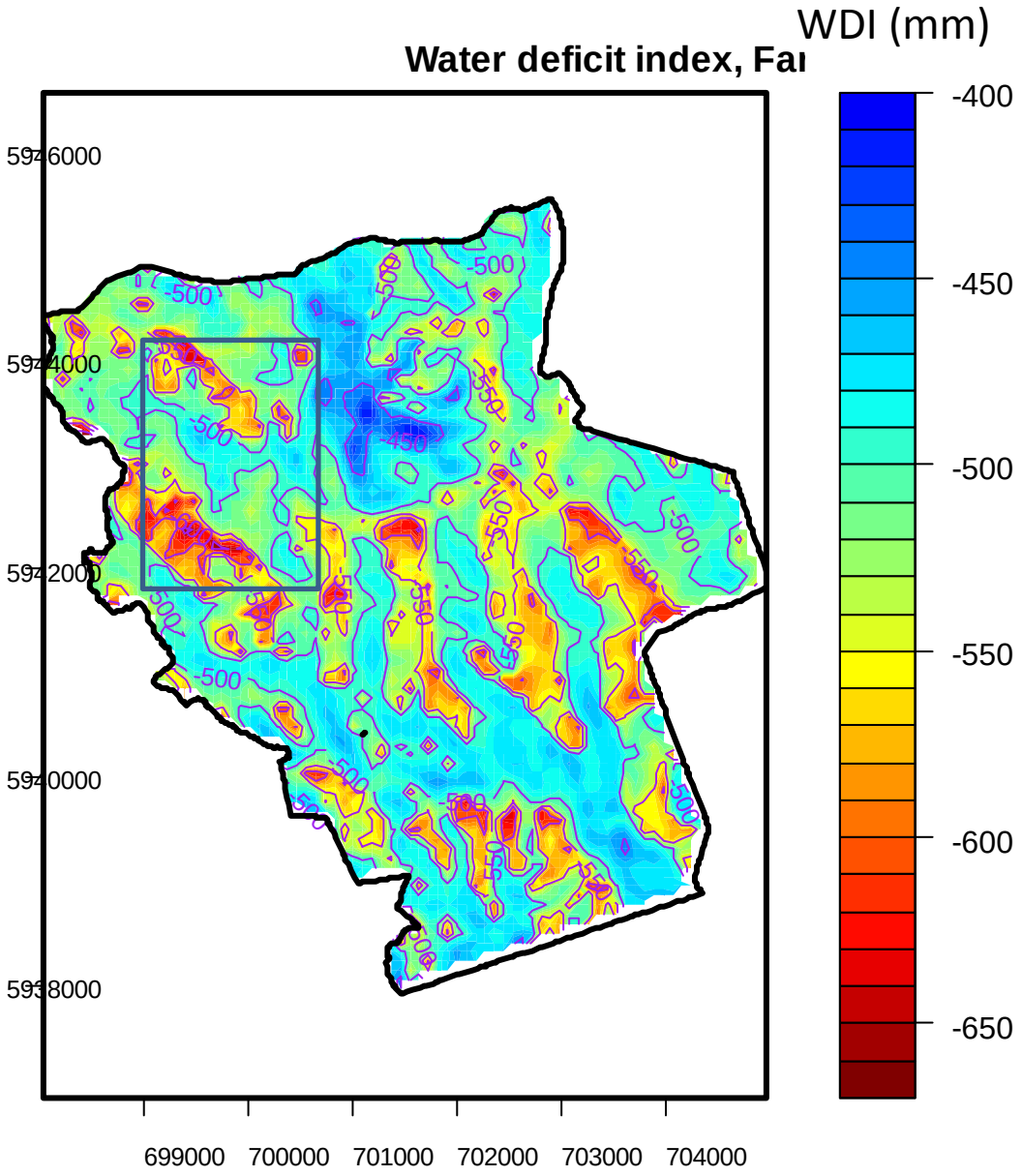

Response vs Water Deficit Index in time
(4,5]
(5,6]
(6,7]
(1,2]
(2,3]
(3,4]
Gain in Volume increment (%)
15
10
5
0
-1000
-800
-600
-400
Water Deficit Index (mm)

Up to 7 years, DBH relative gain is still incrasing

Response vs Water Deficit Index over time

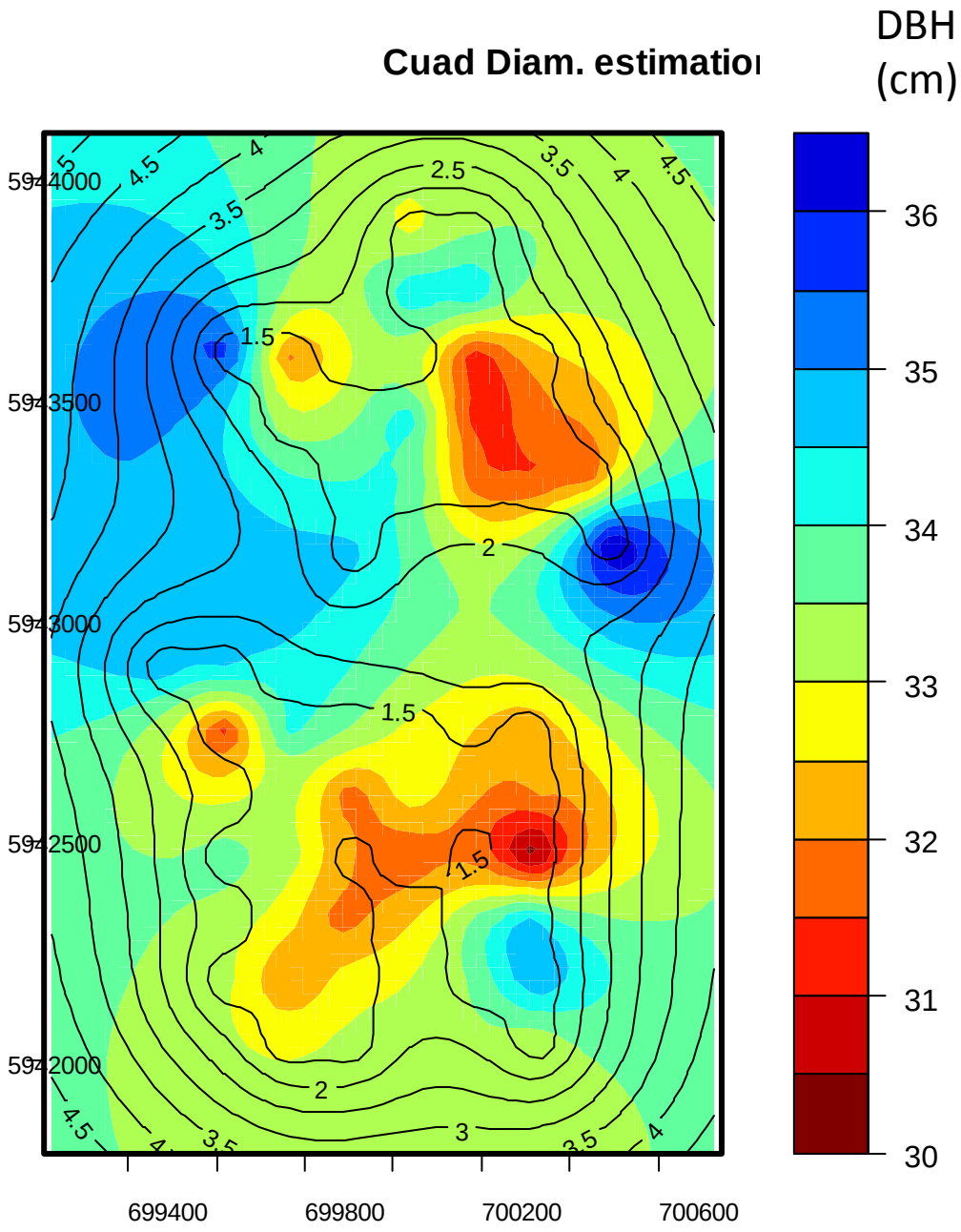
```
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -2.342e-02  3.839e-03  -6.101 9.11e-09 ***
WDI         -4.541e-05  5.369e-06  -8.457 2.70e-14 ***
YST          6.217e-03  6.296e-04   9.875  < 2e-16 ***
---

Residual standard error: 0.01413 on 145 degrees of freedom
Multiple R-squared: 0.5457,     Adjusted R-squared: 0.5394
F-statistic: 87.09 on 2 and 145 DF,  p-value: < 2.2e-16
```



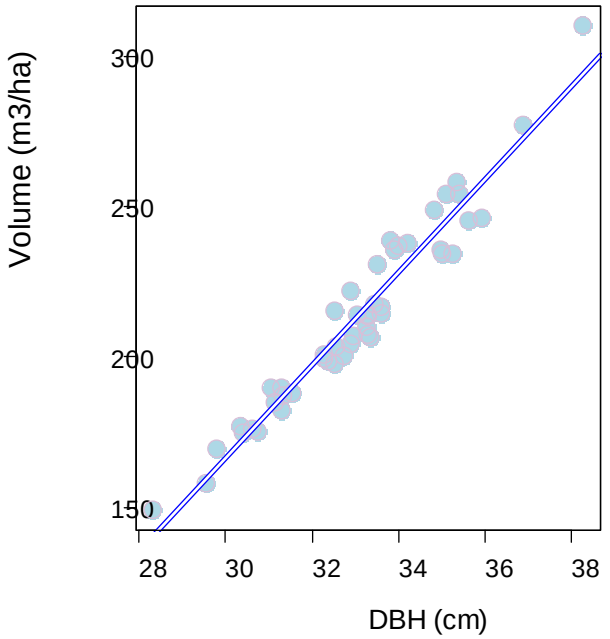


Farms are selected Using WDI as criteria

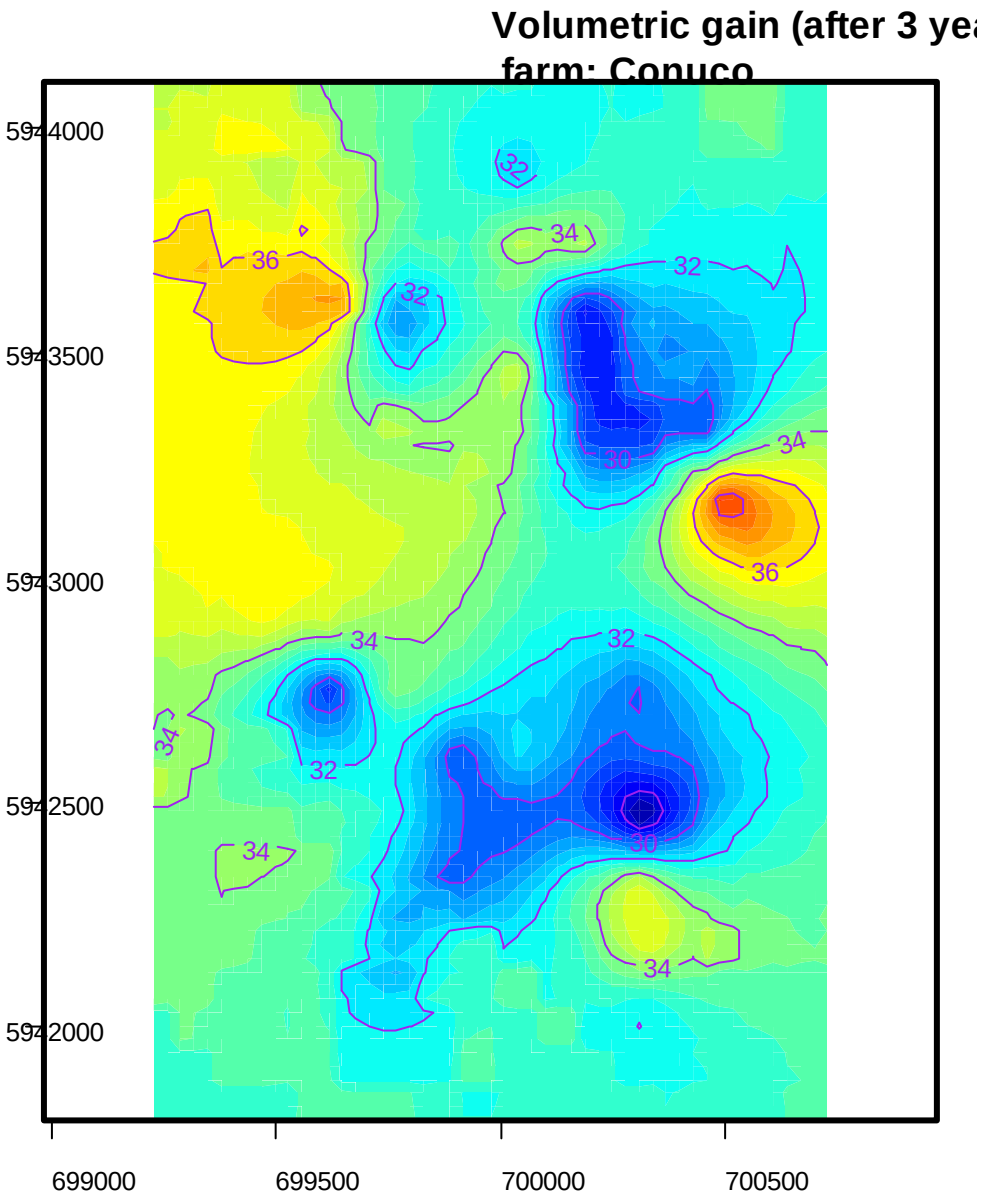
Inventory plots at 7 years projected at 13 years



Using inventory plots/Satellite info, we have a map for expected yield at response age



* black contours correspon to confidence intervals for the mean

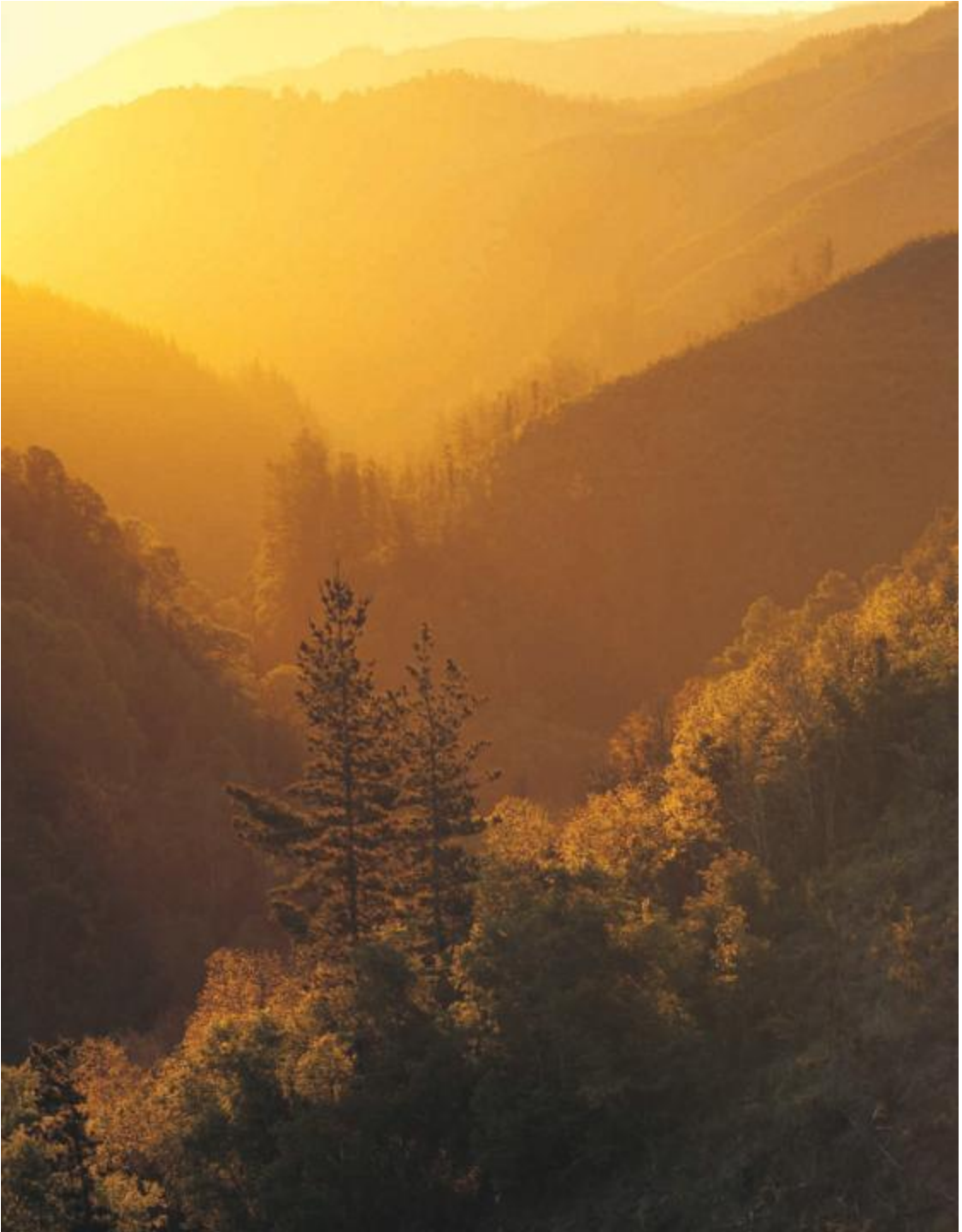


Put your money where there is any value!

Break even Volume gain

Summary

- **Water deficit index** combines plant demand for water with environment supply capability.
- Sites with **high leaf area** might **not be very responsive**
- Organic mater content, **C:N ratio predicted** by Water Deficit Index.
- **Nitrogen relative reponse** explained by water deficit and years since treatment.
- **A model** was able to **predict responsive sites** and is used operationaly.



Thanks, questions?

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