7 Years of Vegetation Management Research: Lessons Learned

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Herbicide Use in PNW Forestry

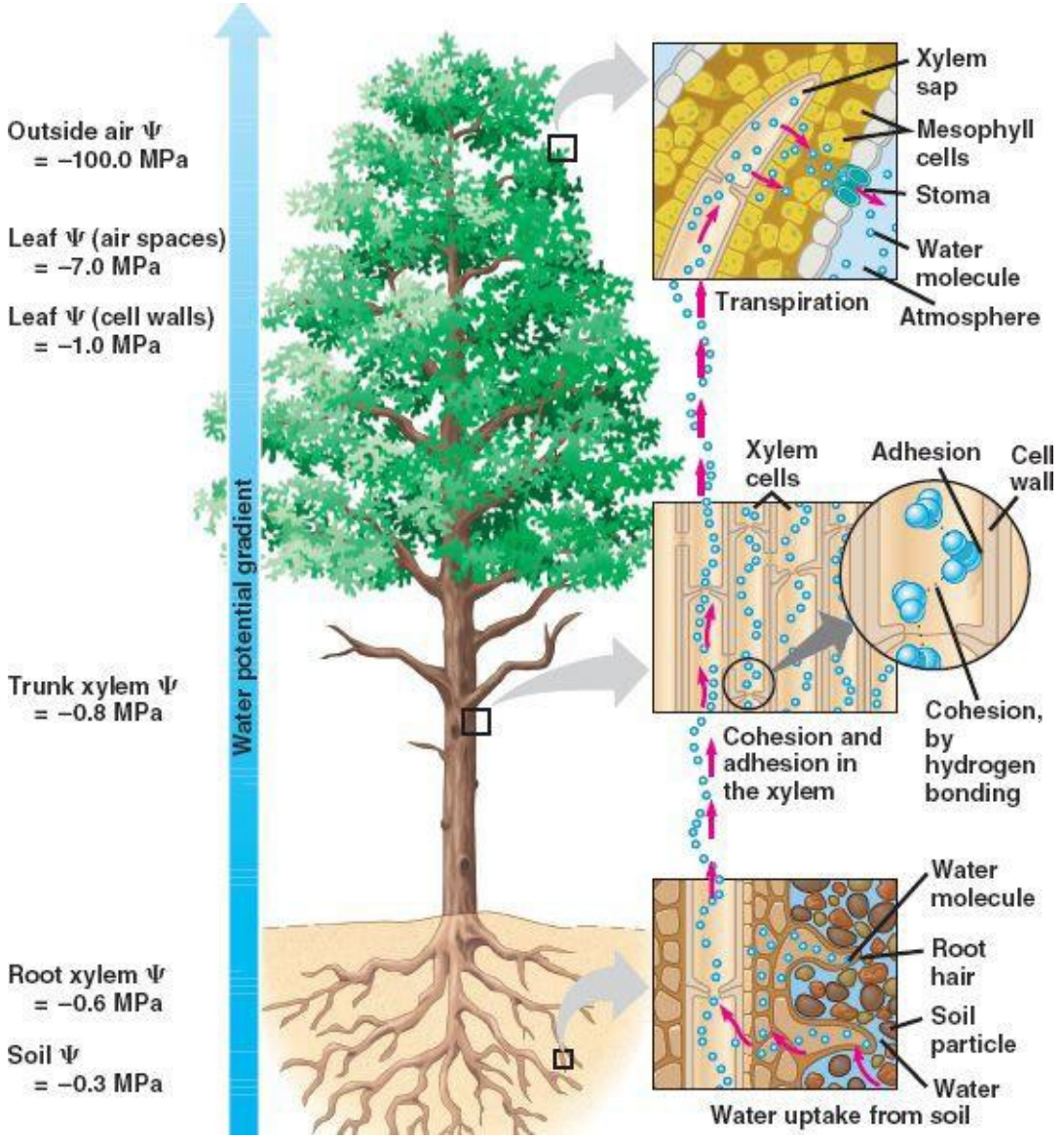
Herbicides are a necessary part of most reforestation projects in the PNW:

- The Mediterranean climate creating intense competition for soil water resources during the dry summer months → seedling mortality or reduced growth
- Competition reduction during stand establishment produces long-term impacts on the productivity of our long rotation crop of trees
  - The presence of long lived and difficult to control woody tree and shrub species
- The lack of an effective and economic alternative to herbicides.

Figure 1. This example is for an area where helicopter service is unavailable, Alaska. Photo credit: Liz Cole.

The Cohesion Tension Theory: The Chain

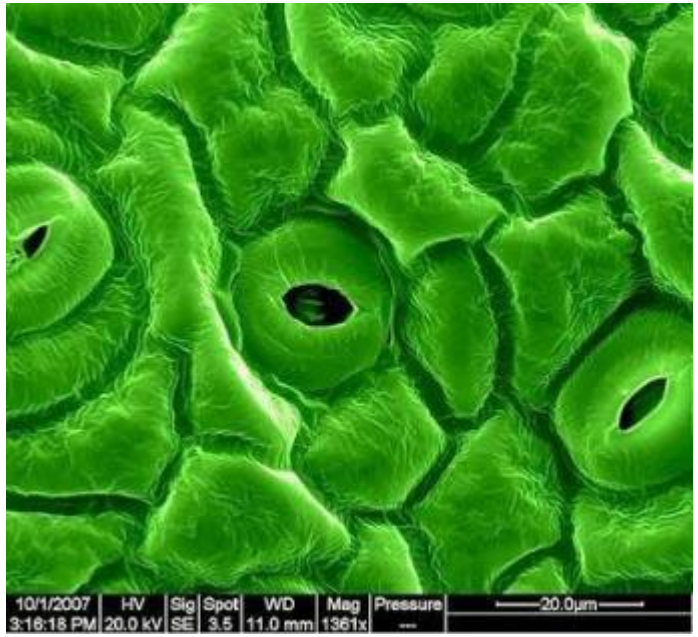
- Hydrogen bonding among water molecules creates an unbroken "chain" from plant roots to plant leaves
- There are many xylem (straws) and "chains"
- As water evaporates from the leaves the "chain" is pulled up moving water through the plant (passive process)
- If the pull becomes too great, the "chain" of water can become broken (cavitation) → reduced hydraulic conductivity → Mortality
- Plants can regulate leaf water potential (the pull) through stomatal regulation
- The rate of water loss (transpiration) depends on the difference between soil and atmospheric water potential (driving force), stomatal conductance, tree hydraulic conductivity and **tree leaf area**



Gas Exchange in Plants

Plants are constantly facing a **trade off** between **carbon gain** and **water loss**:

- Gas exchange between the atmosphere and plant leaves is facilitated through **stomatal regulation**
- When stomata are open CO_2 diffuses into the leaf → photosynthesis → plant growth
- At the same time H_2O diffuses out of the leaf → reduces soil water availability
- The rate at which CO_2 diffuses into the leaf can limit photosynthetic rate → growth



www.quora.com/Are-stomata-cellular-structures-If-yes-then-why-and-if-no-then-also-why

What percentage of water that travels through a plant is used in photosynthesis:

a) 1%
b) 5%
c) 25%
d) 90%

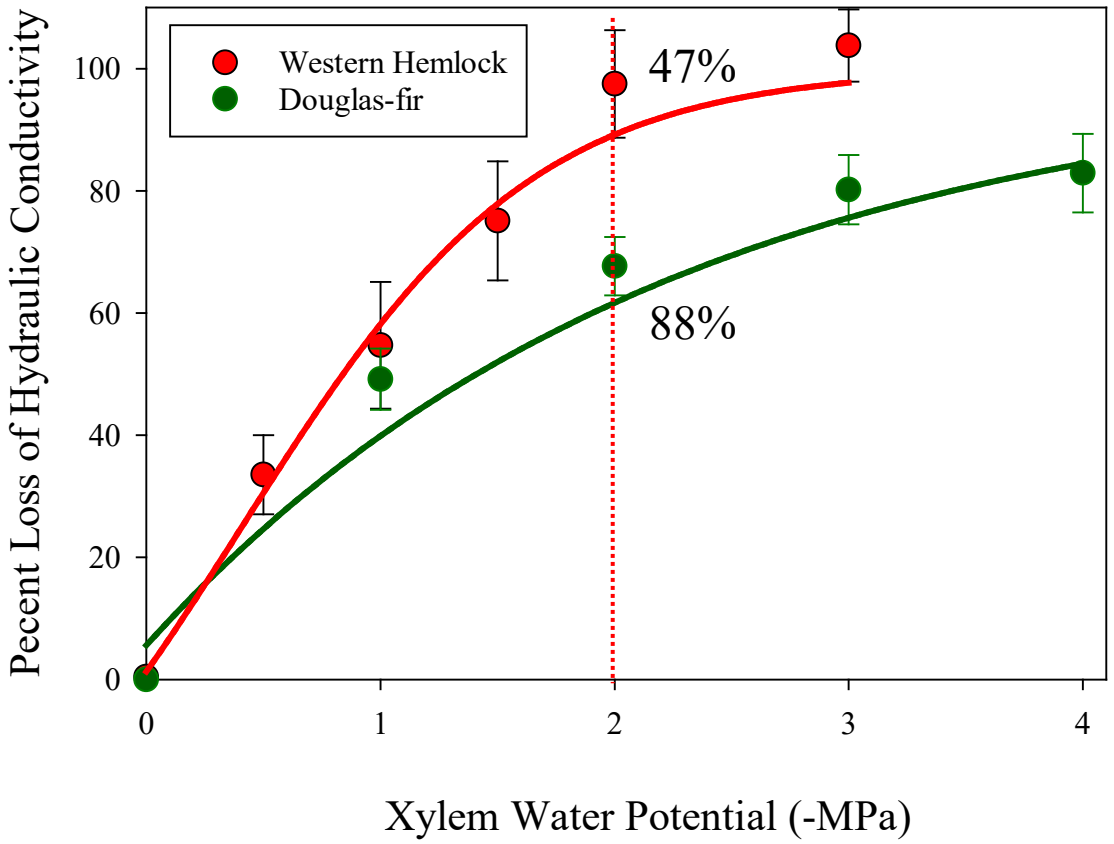
Lesson 1

Not all seedlings are created equal

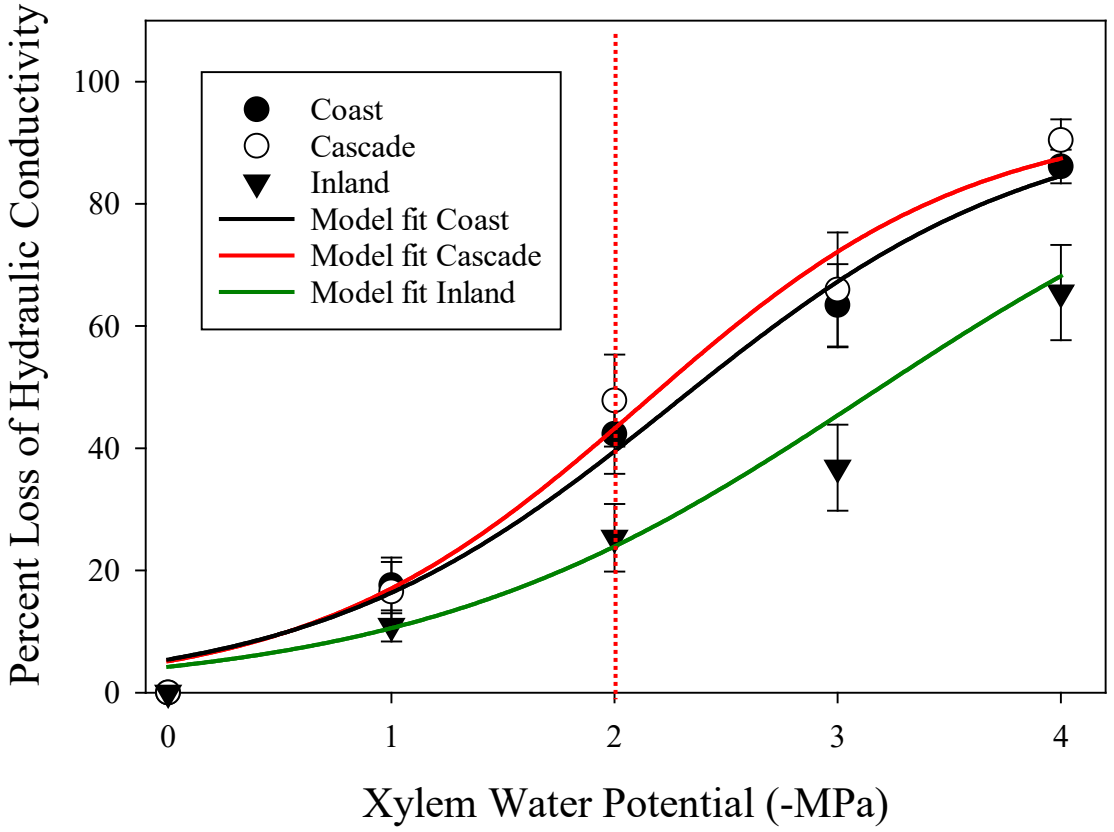
Photo: R. Lefebvre

Vulnerability to Cavitation

VC curves for two crop species in the OR Coast Range
- Field drought stress was about -2 MPa
- Differences in VC created differences in survival
  - DF > WH



High variability of DF VC among seed sources
- Impact drought related mortality



Seedling Size x VM Interactions

Study Objective

Evaluate the interactive effects of vegetation control and Douglas-fir container stock size on stand productivity.

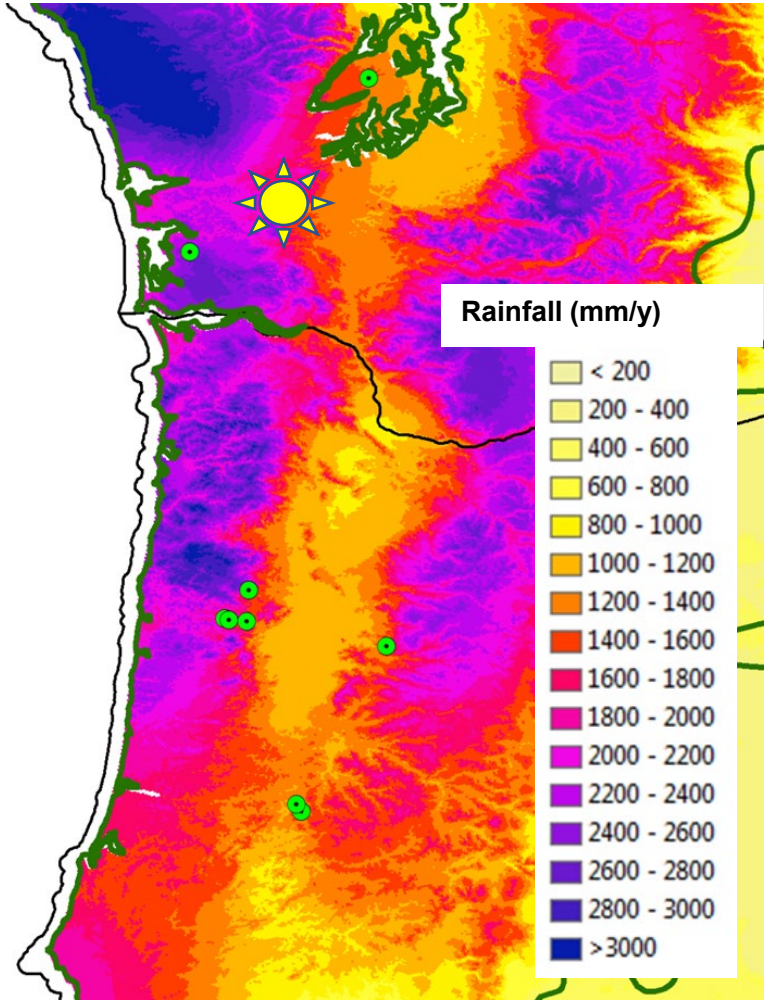
Vegetation Management Treatments:

- OOO: No-action control
- FTO: One year weed free (Fall Site Prep + SR year 1)
- FTT: Two years weed free (Fall Site Prep + SR years 1 and 2)

Stock Type: Container

- Styro-8 (130 ml)
- Styro-15 (250 ml)
- Styro-60 (1,000 ml, repotted from styro-8)

Included Browse Protection (Vexar Tubing)



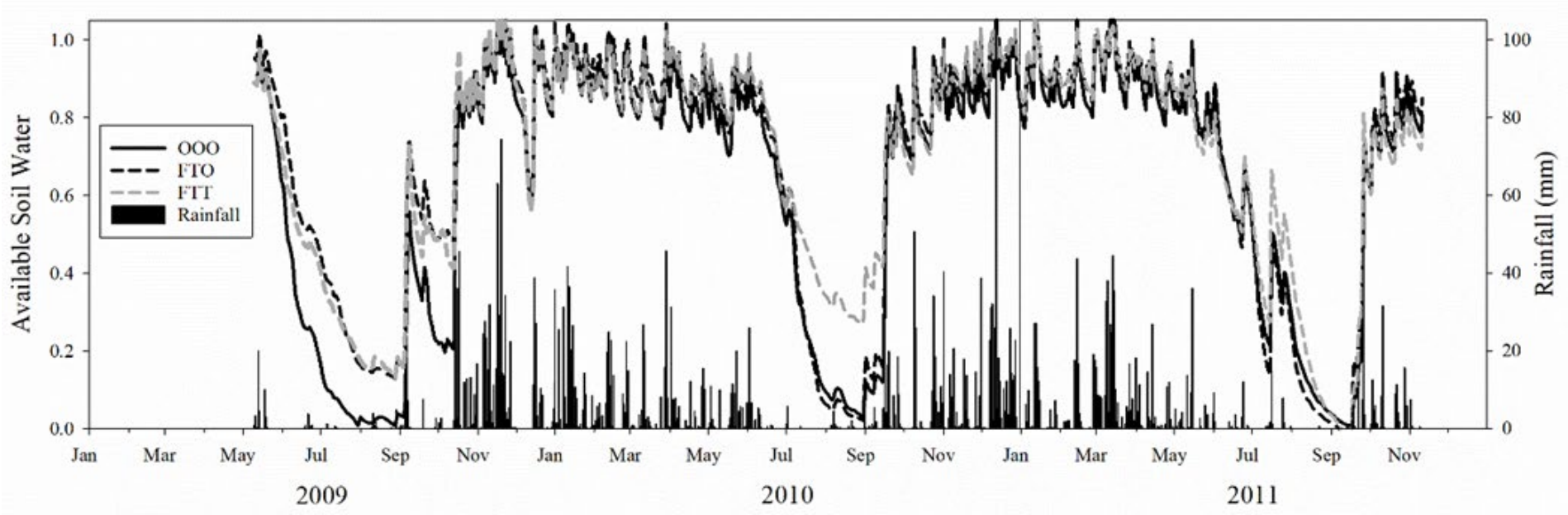
Seedling Size x VM Interactions

Table 2. Initial seedling height (H), root-collar-diameter (RCD), height to root collar diameter ratio (H:D), shoot volume, root volume and shoot to root volume ratio (S:R) of styro-8 (S8), styro-15 (S15), and styro-60 (S60) Douglas-fir seedlings. Values after ± represent standard error. Within a column, variables that share a letter are not significantly different at $\alpha = 0.05$ ($n = 40$).

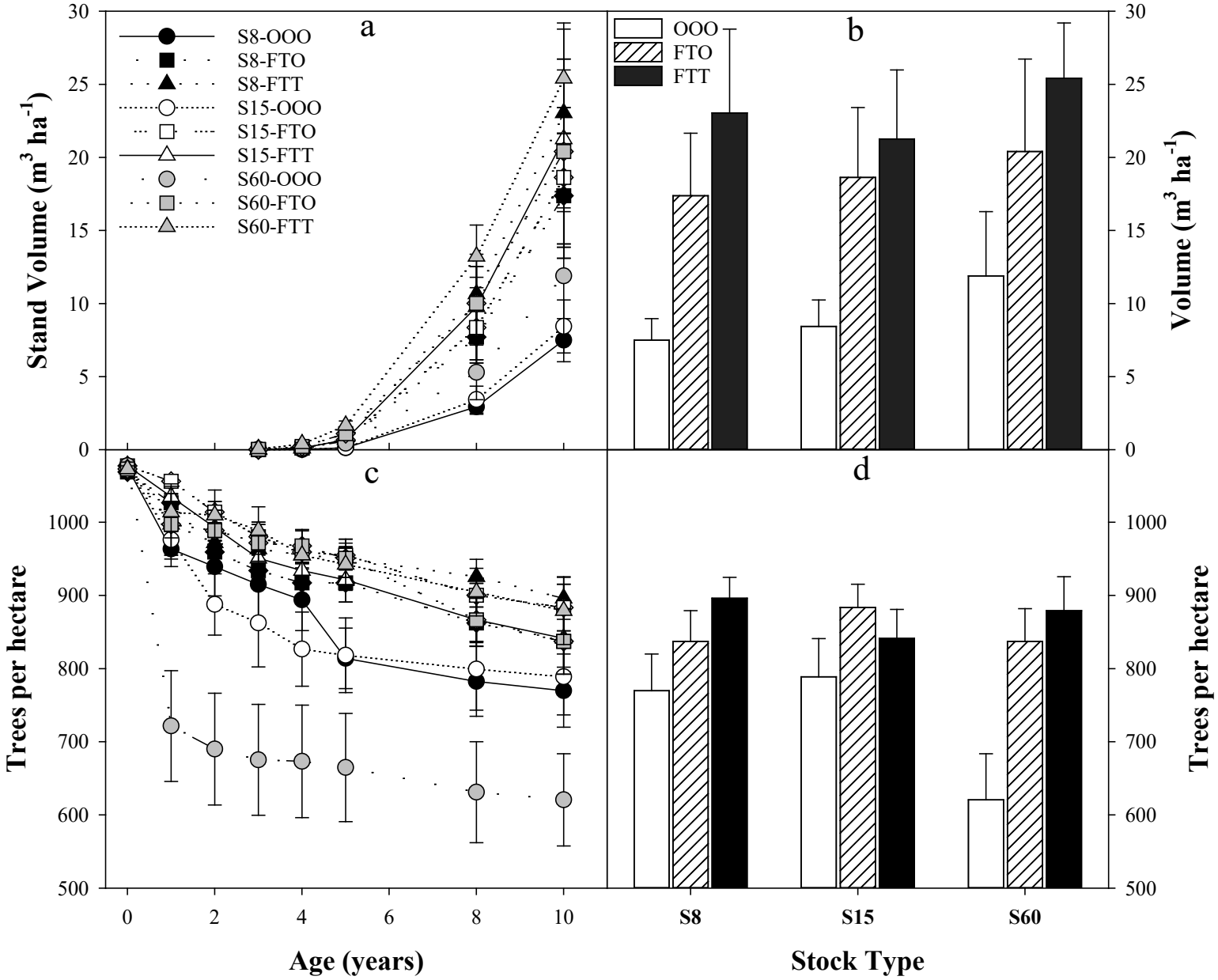
Stock	H (cm)	RCD (mm)	H:D (cm cm^{-1})	Shoot Volume (cm^3)	Root Volume (cm^3)	S:R
S8	24.0 ± 0.5 a	3.3 ± 0.1 a	74.7 ± 2.0 a	6.5 ± 0.3 a	6.1 ± 0.3 a	1.11 ± 0.05 b
S15	29.9 ± 0.6 b	3.7 ± 0.1 b	82.7 ± 2.1 b	12.0 ± 0.6 b	9.6 ± 0.5 a	1.32 ± 0.06 a
S60	68.0 ± 1.2 c	8.9 ± 0.1 c	76.8 ± 1.7 a	56.1 ± 1.8 c	51.5 ± 3.4 b	1.25 ± 0.07 ab
	2.8 x	**2.7 x**		**8.6 x**	**8.4 x**	

Photo: E. Dinger

Seedling Size x VM Interactions



Age 10 Results



FTO & FTT **11.3 m³ ha⁻¹** > OOO
126% increase

<u>Survival at Year-10</u>

- OOO = 68%
- FTO = 79%
- FTT = 81%

ANOVA for TPA at Year-1

Year	Stock Type * FVM
1	0.003

Seedling Leaf Area Affects Drought Stress

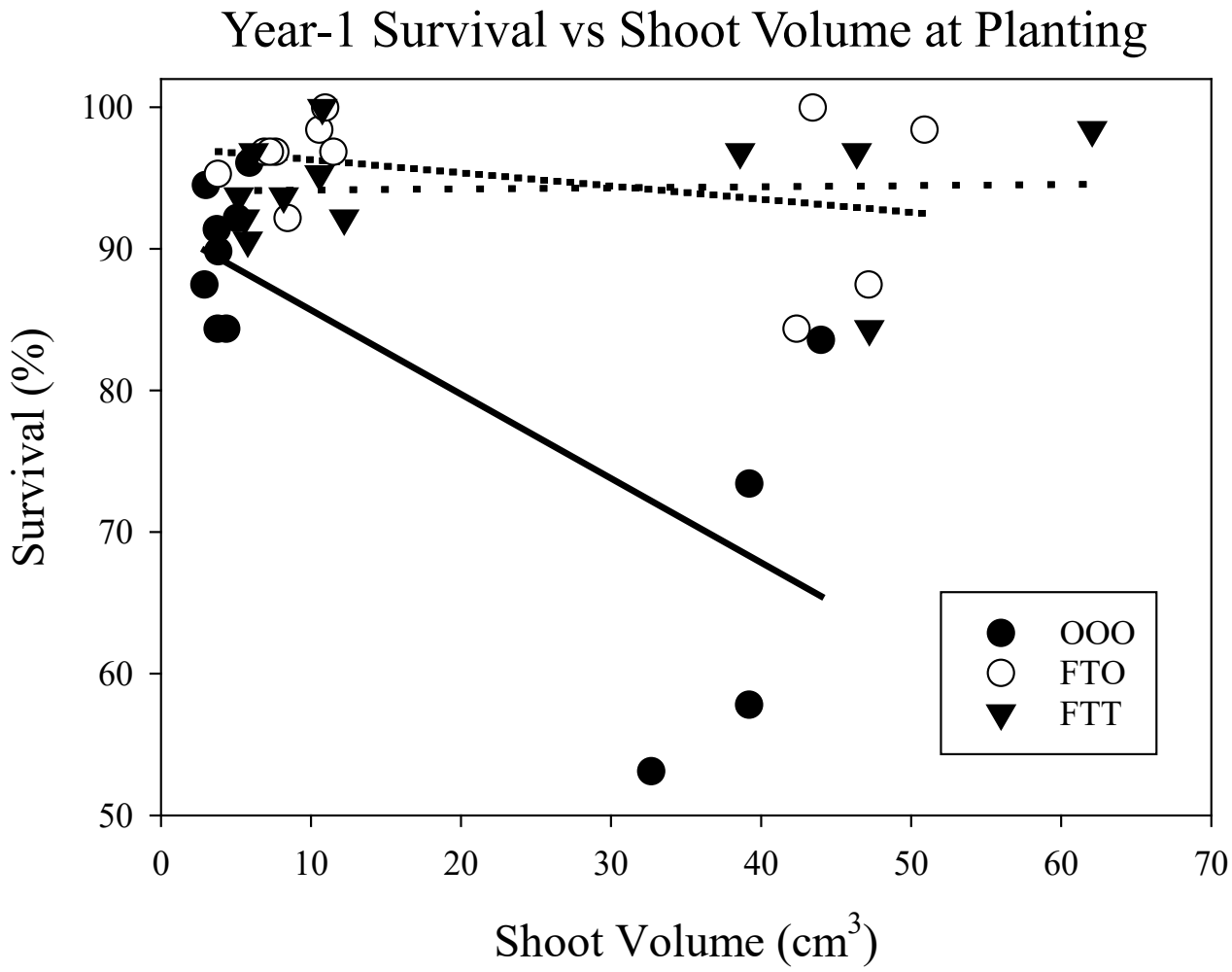


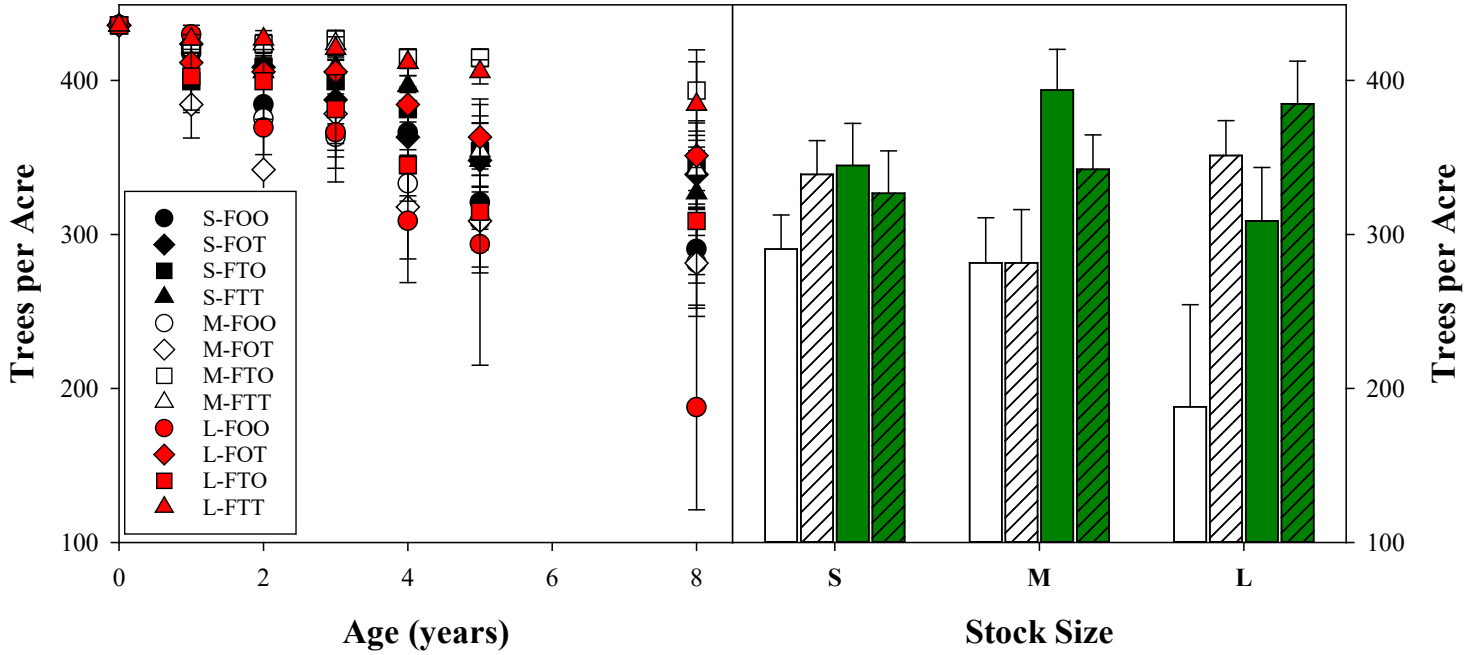
Photo: E. Dinger

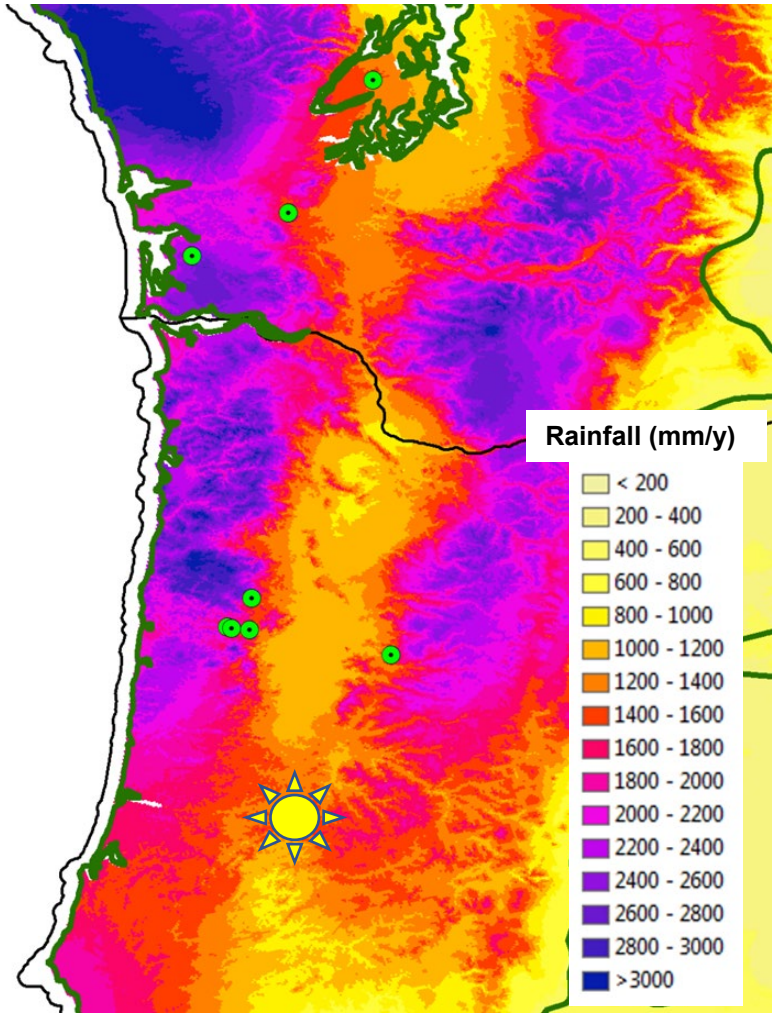
Costs and Logistics

Age 8 Results

Stock Type: Bare Root

- S: 5-7 mm RCD (211A → 28 /LBF)
- M: 8-10 mm RCD (211A → 20 /LBF)
- L: 11-13 mm RCD (410A → 14 /LBF)





Lesson 2

Site preparation can solve one problem, but create another

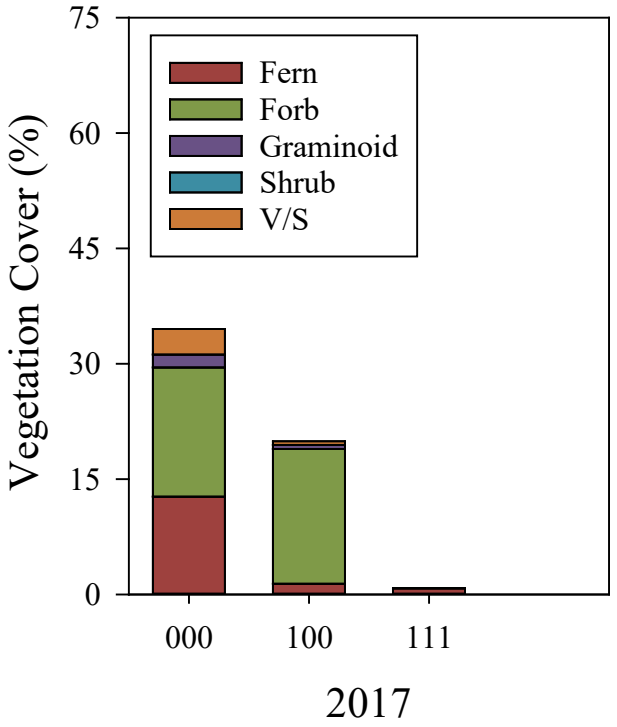
Site Preparation is Still Important!

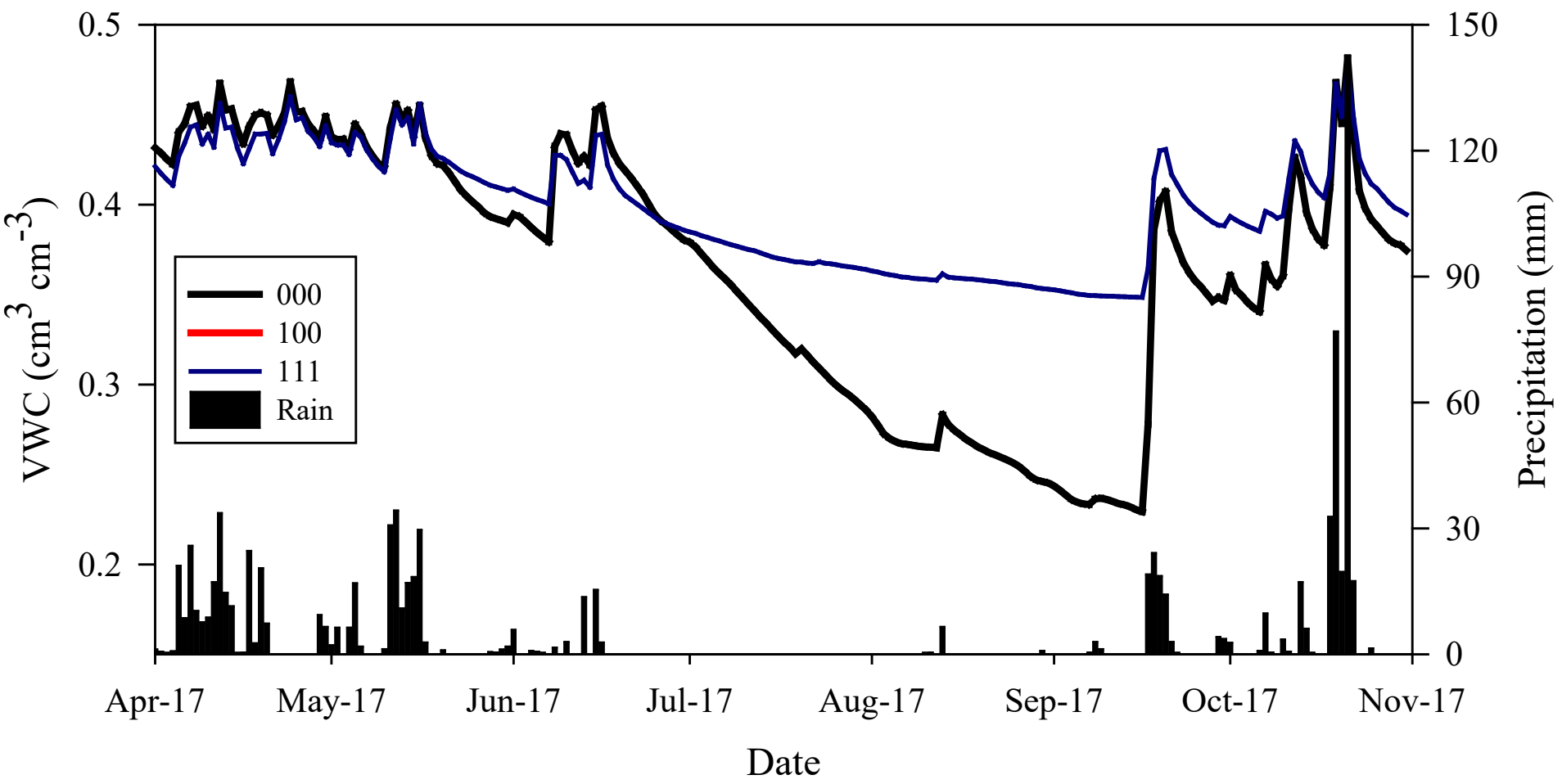
Applying herbicides prior to tree planting:

- Allows the utilization of a wider variety of herbicides (more options)
  - Once trees are planted many tools are no longer available (crop damage)
- Is the most effective way to control difficult species:
  - Hardwoods
  - Brush
  - *Rubus spp.*
  - Scotch Broom

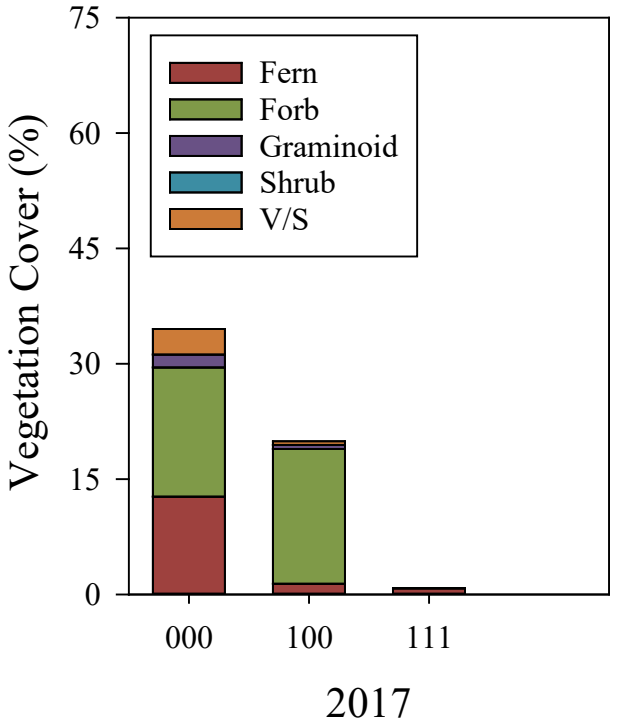
Site Preparation is Still Important!

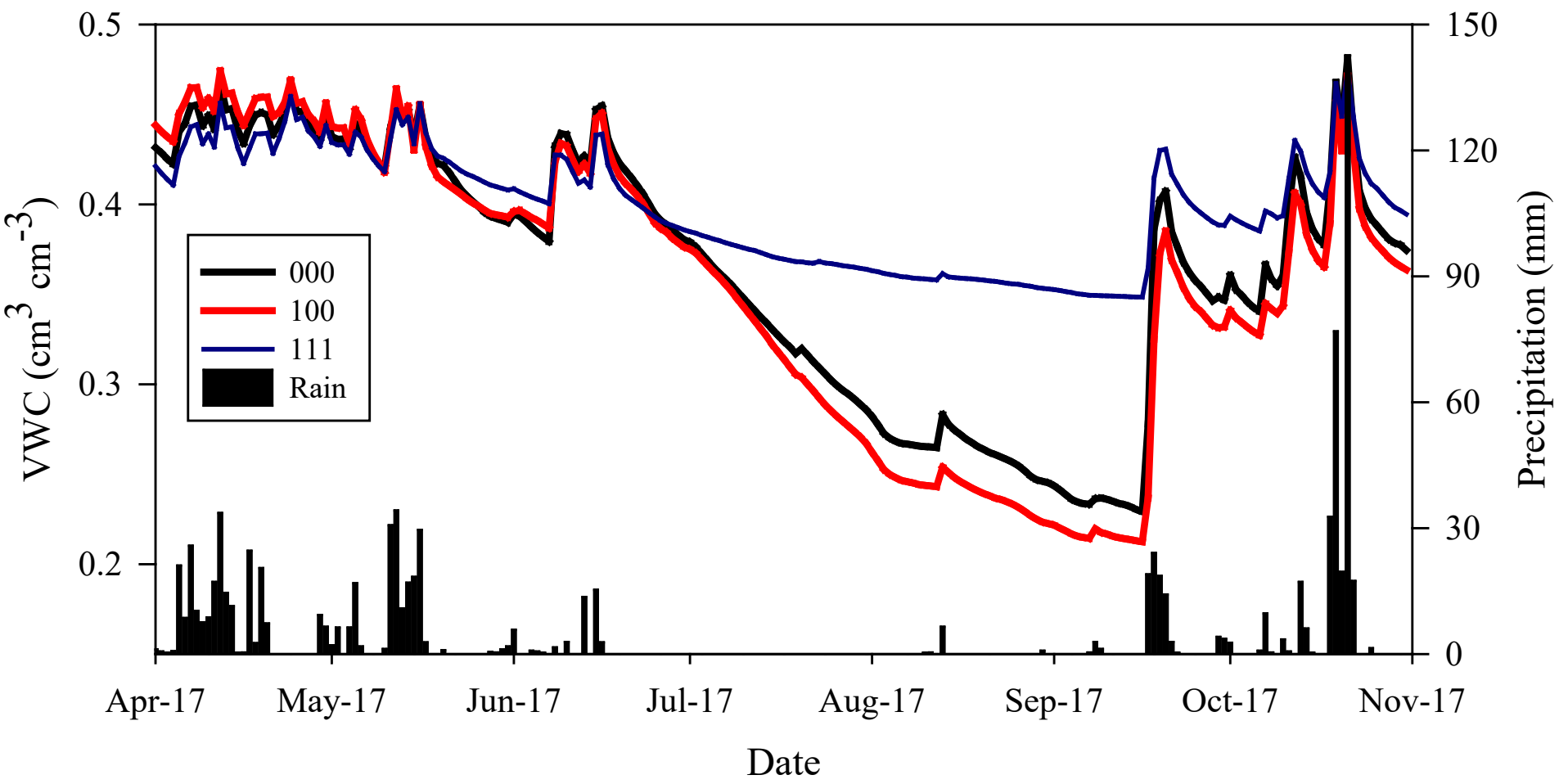
VM Regime Effects on Soil Moisture



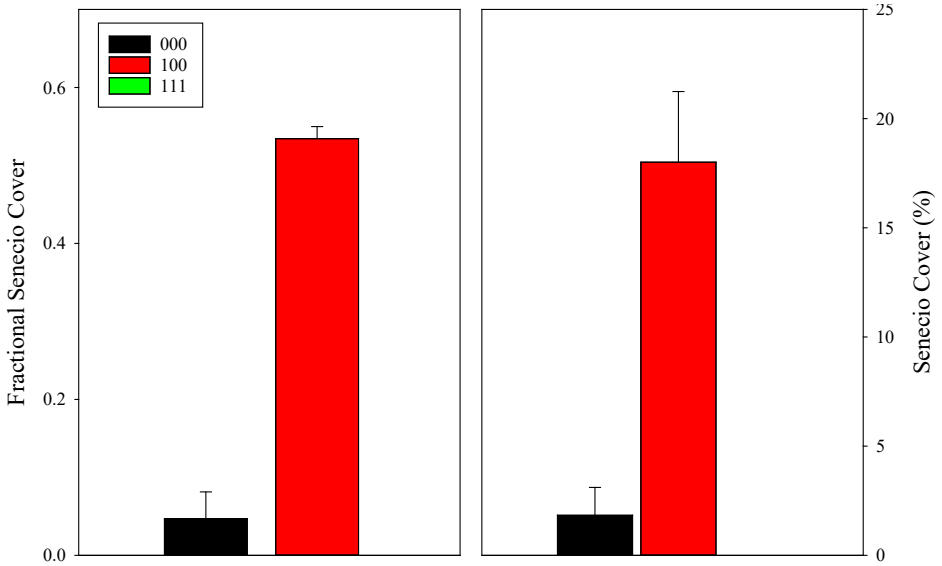


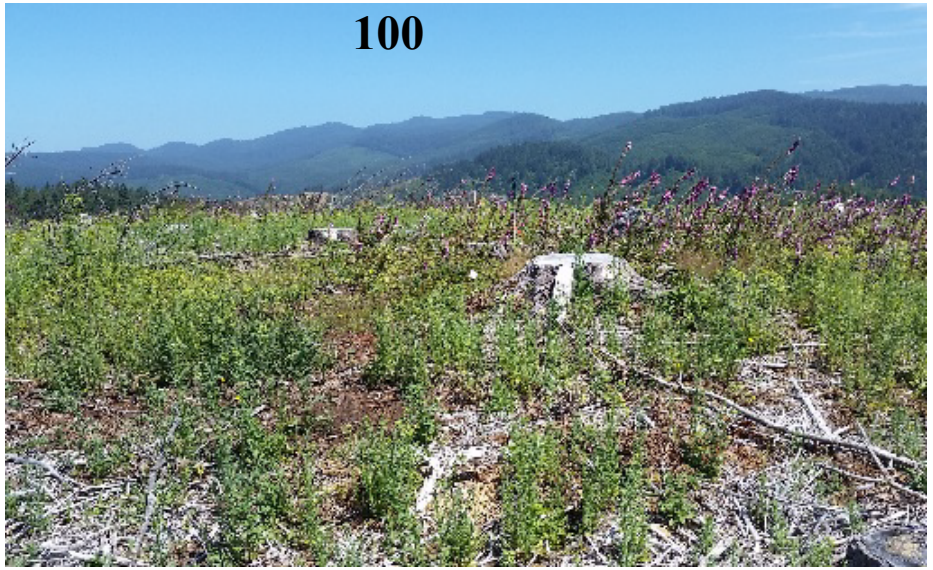
VM Regime Effects on Soil Moisture

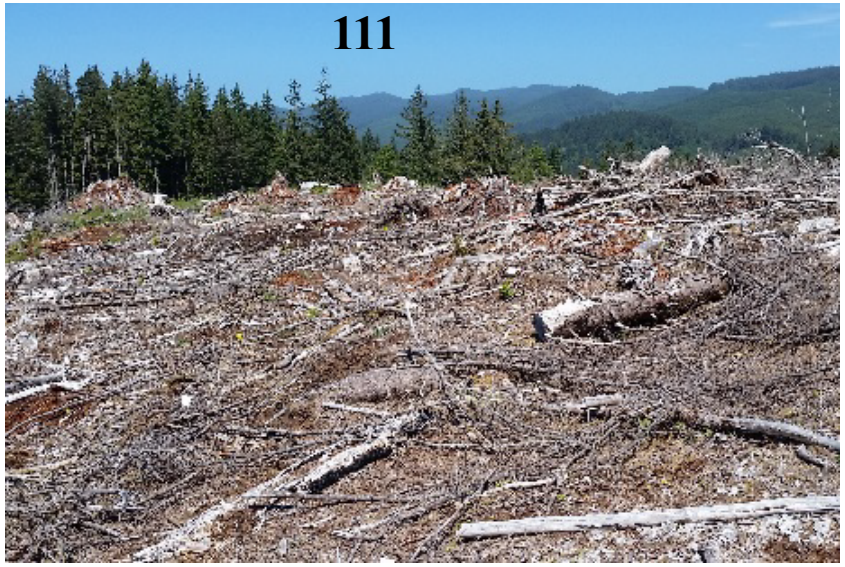




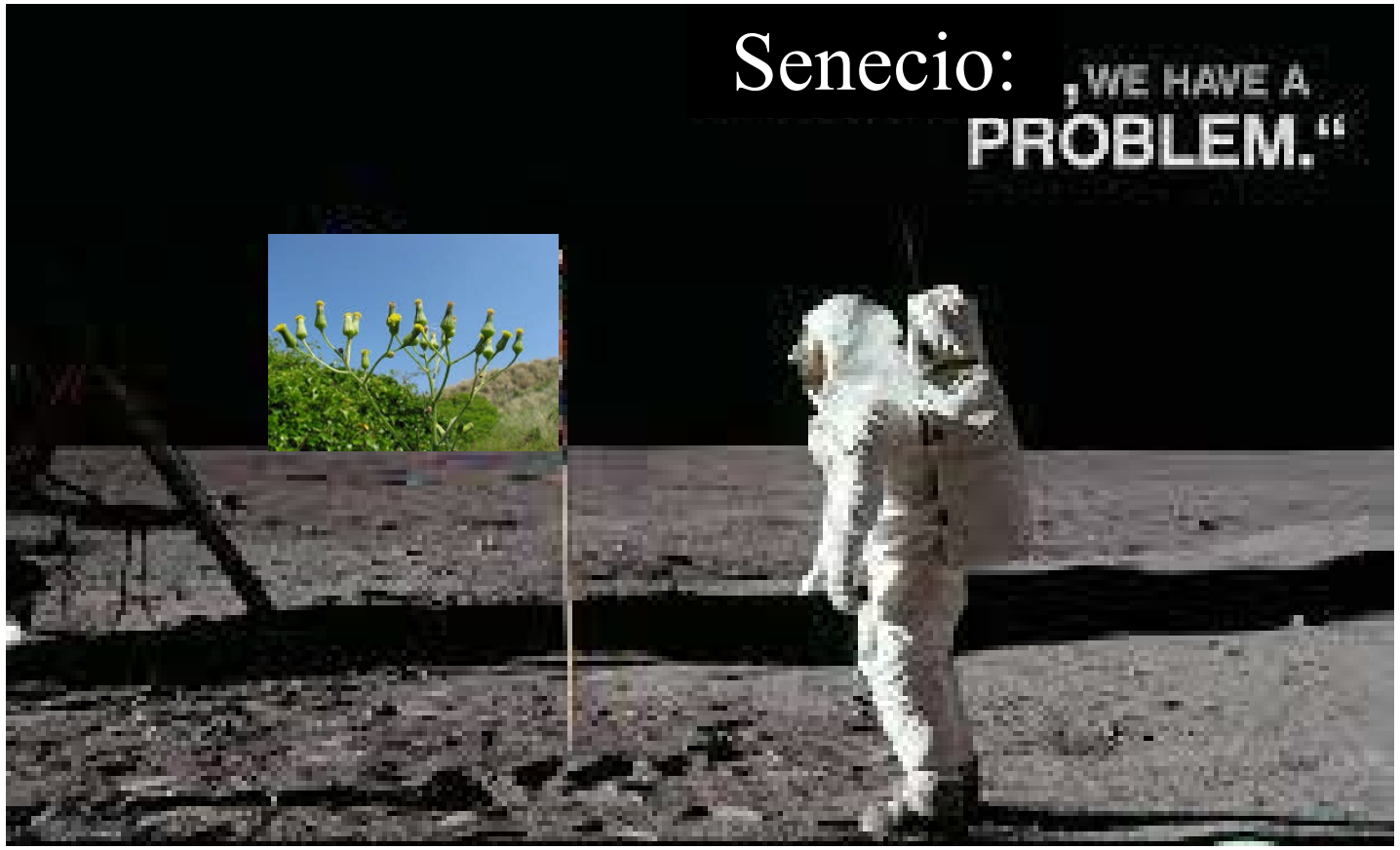
How can This Be???????







Invasion by Annual Forbs



- Not effectively controlled by pre-emergent herbicides
- Small wind dispersed seeds
- Prolific seed producers (thousands per plant)

Rapid Growth

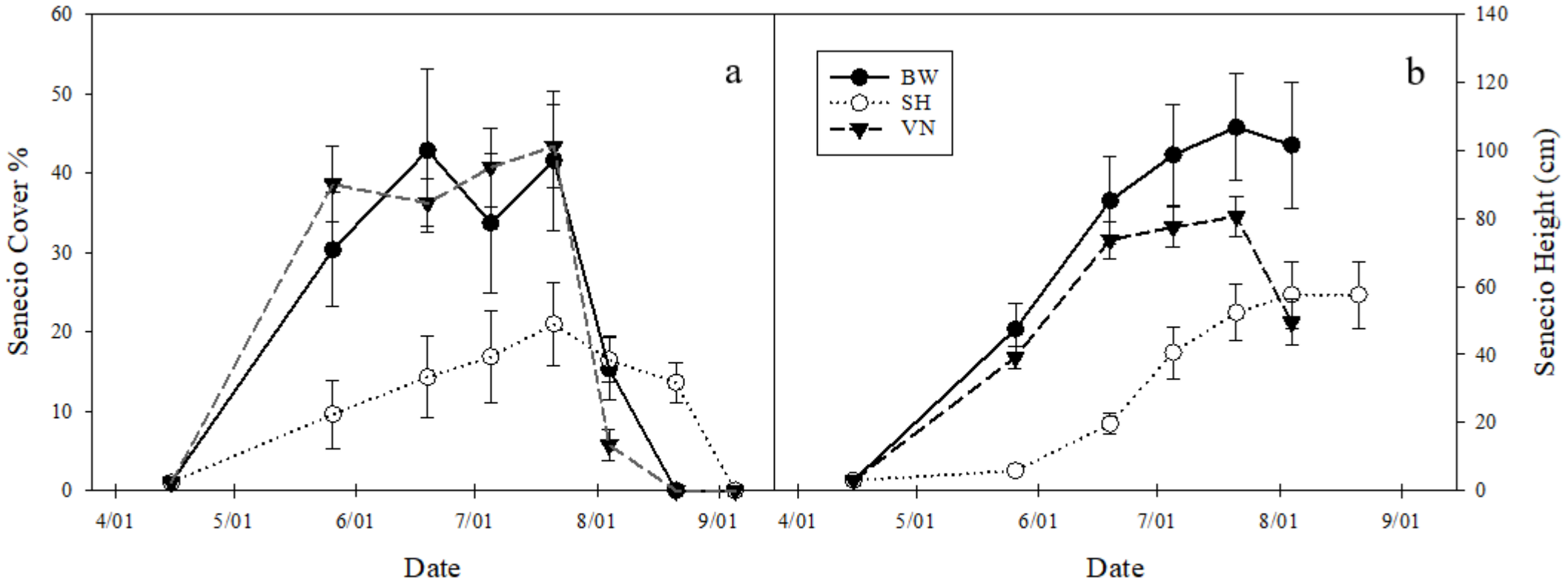


Fig. 3 Seasonal dynamics of: a) cover (%) and b) height (cm) for Senecio growing at the BW (filled circle), SH (open circle) and VN (filled triangle) sites. Error bars represent standard error. Measurements were centered on soil moisture probes (n=8)

High Biomass Allocation Plasticity

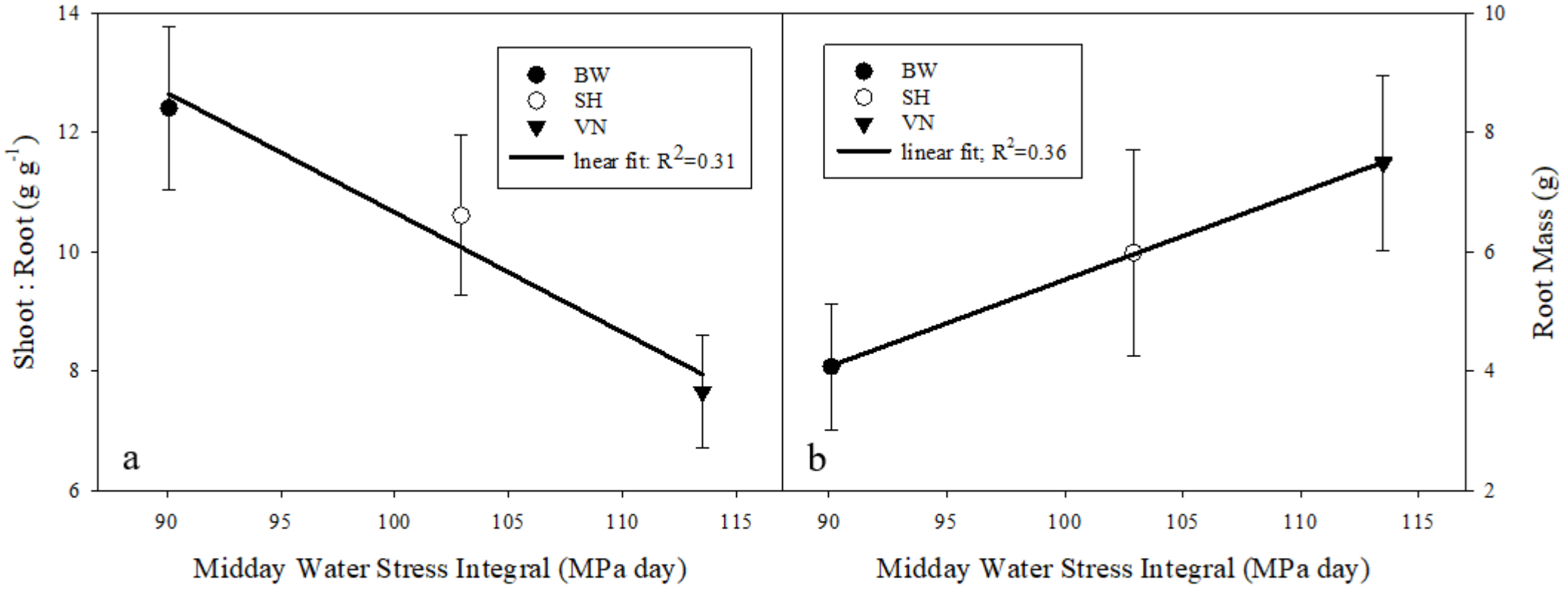


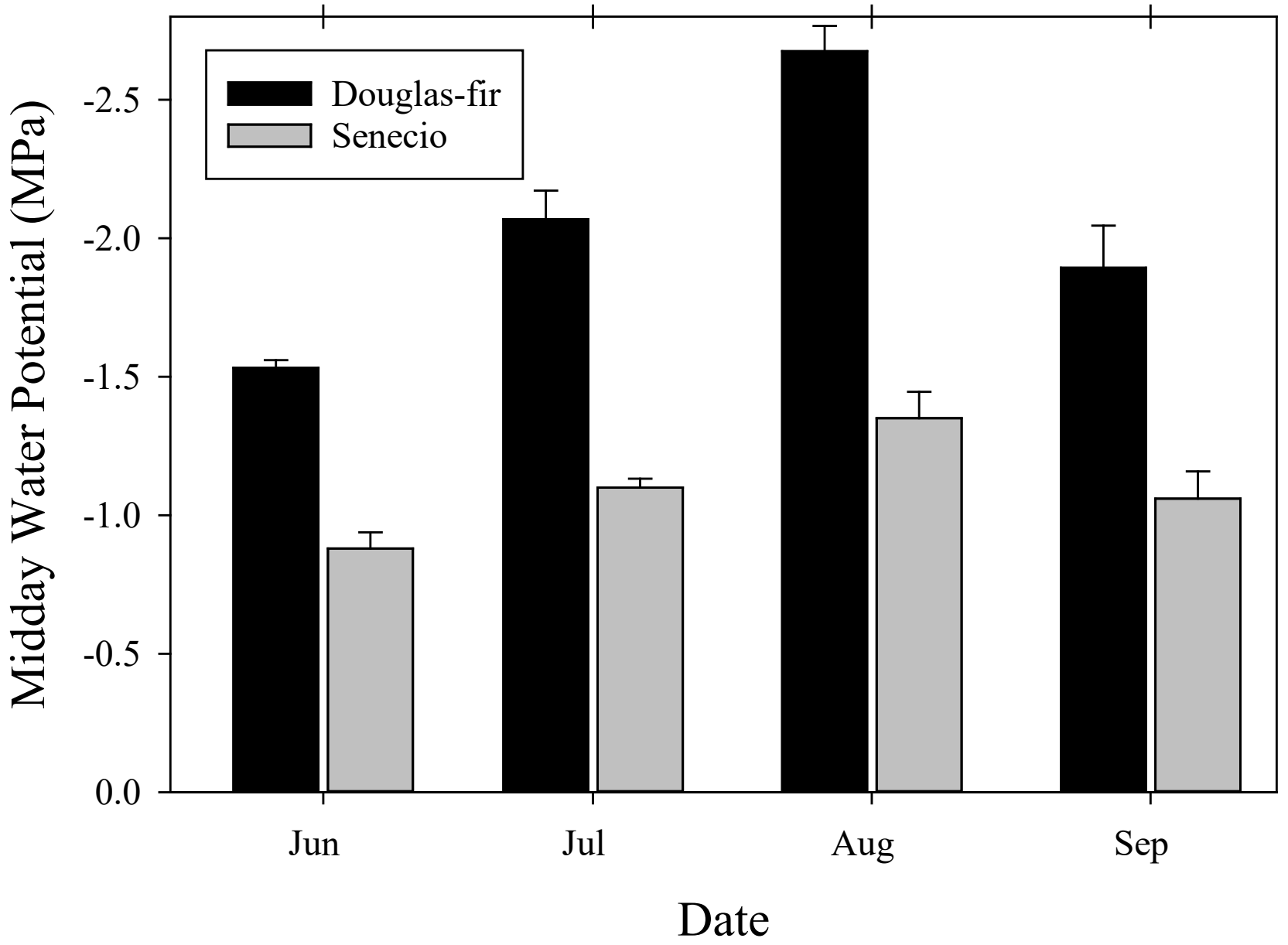
Fig. 10 Relationship between midday water stress integral (WSI_{MD}, MPa day) a) and shoot to root ratio (g g^{-1}) and b) root mass (g) at the end of the growing season for Senecio plants growing at the BW (filled circle), SH (open circle) and VN (filled triangle) sites

Senecio Roots

End of Year 1

Douglas-fir Roots

Rapid Growth + Plasticity = Water Hunter



There's a Solution!!!!!

How to deal with Senecio during the first growing season:

- Clopyralid (Transline) during late May/ early June
    - Want to apply before plants go to seed

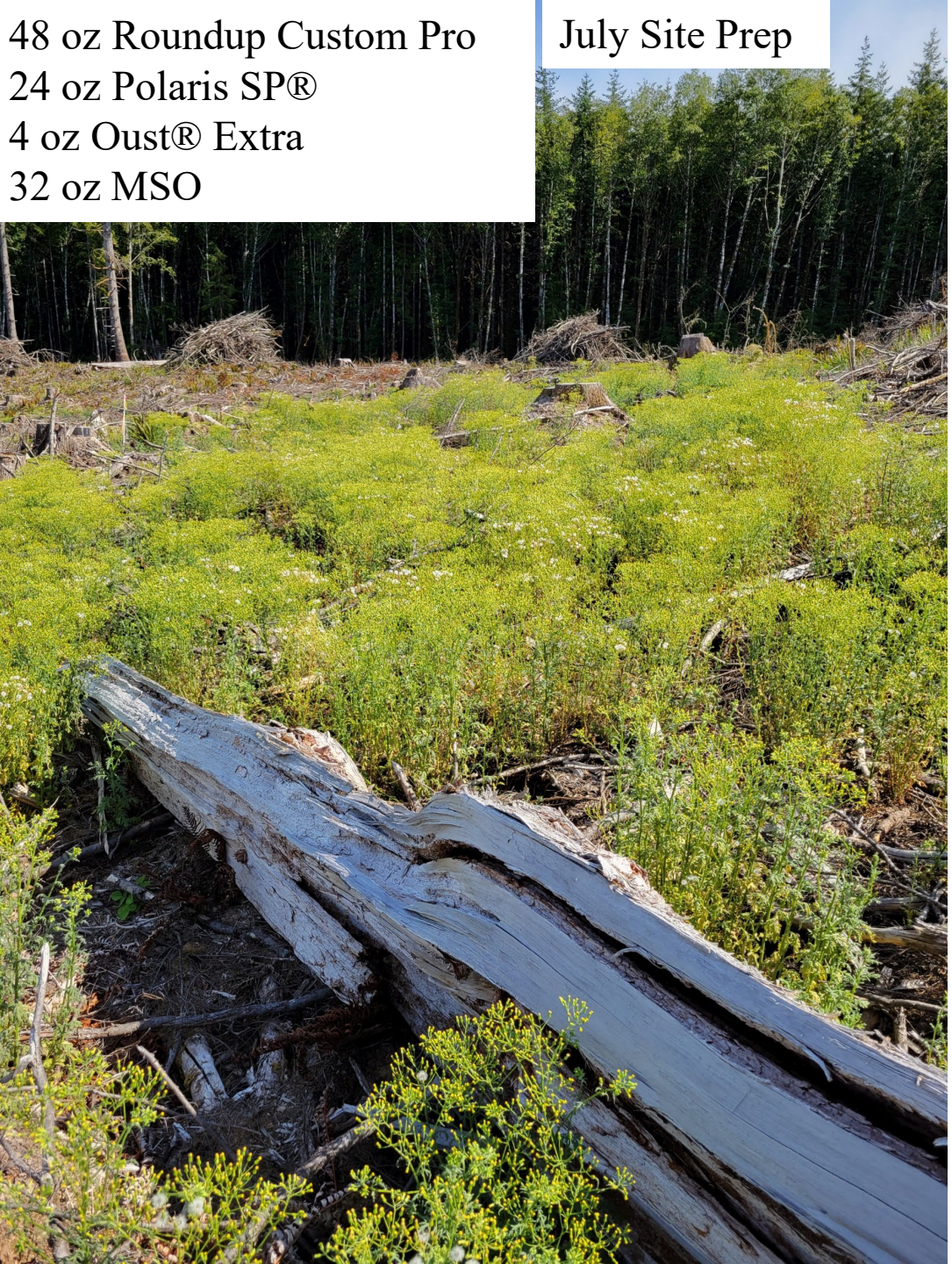
- Combination of hexazinone (Velpar DF or Velossa) and clopyralid prior to bud break

- Esplanade included in the site prep mix: Fall application
    - Works best on clean sites
    - Requires rainfall to activate

- Cleantraxx included in the site prep mix: Fall application
    - Efficacy can be reduced when a scalp is used during planting
    - Requires rainfall to activate

48 oz Roundup Custom Pro
24 oz Polaris SP®
4 oz Oust® Extra
32 oz MSO

July Site Prep



<- no release

-> release

Same + 16 oz Transline in early June

There’s a Solution!!!!!

Fall (9/14)
2 qts/acre Roundup Custom
24 oz/acre Polaris SP
1 oz/acre MSM 60
1 qt/acre MSO

Fall (9/14)
2 qts/acre Roundup Custom
24 oz/acre Polaris SP
1 oz/acre MSM 60
1 qt/acre MSO

Spring (4/27)
2lbs Velpar DF
10 oz Transline

4 oz Oust Extra, 1.5 qts glyphosate, 8 oz imazapyr

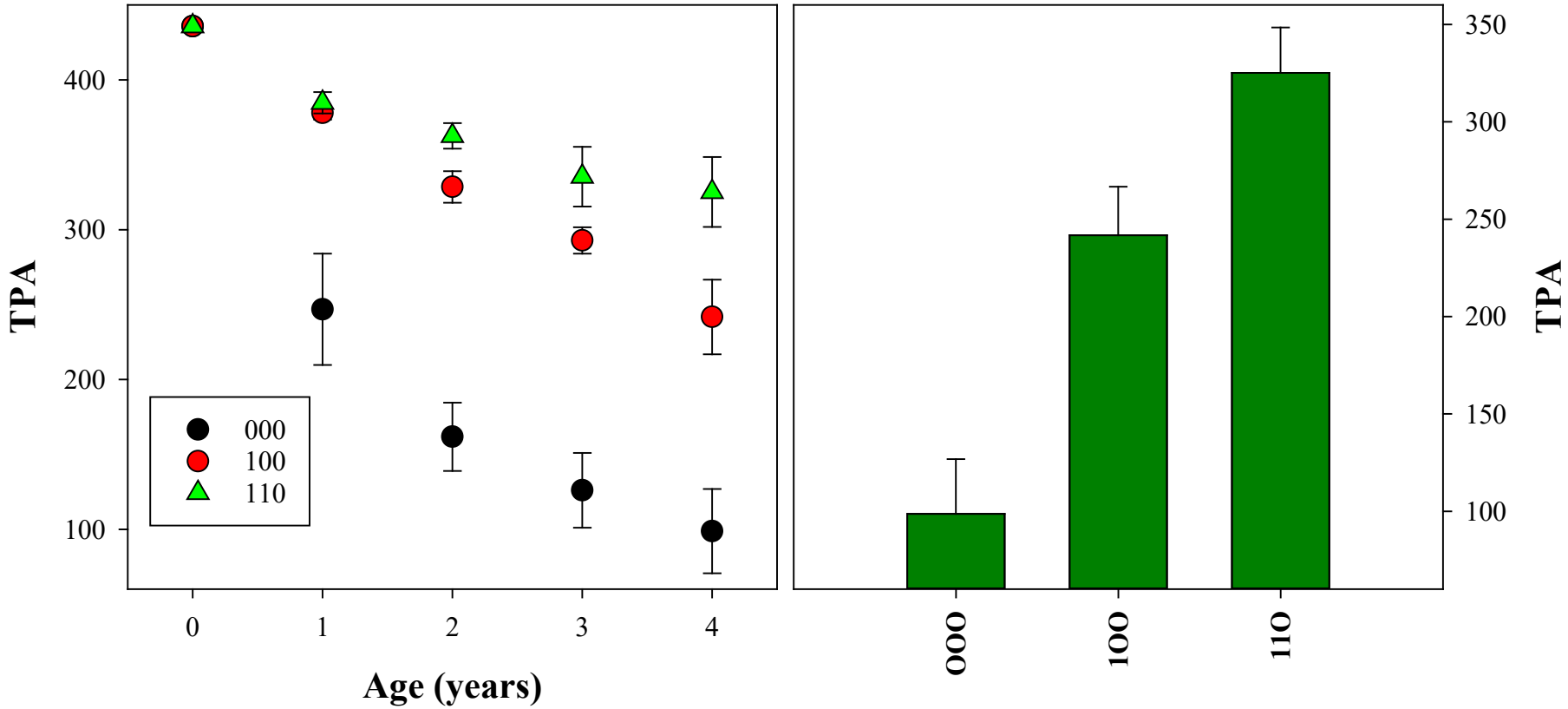
4 oz Oust Extra, 1.5 Qts glyphosate, 7 oz Esplanade


SERVICES

4 OZ OUST EXTRA + 3 QTS ACC XRT II + 4.5 PTS CLEANTRAXX

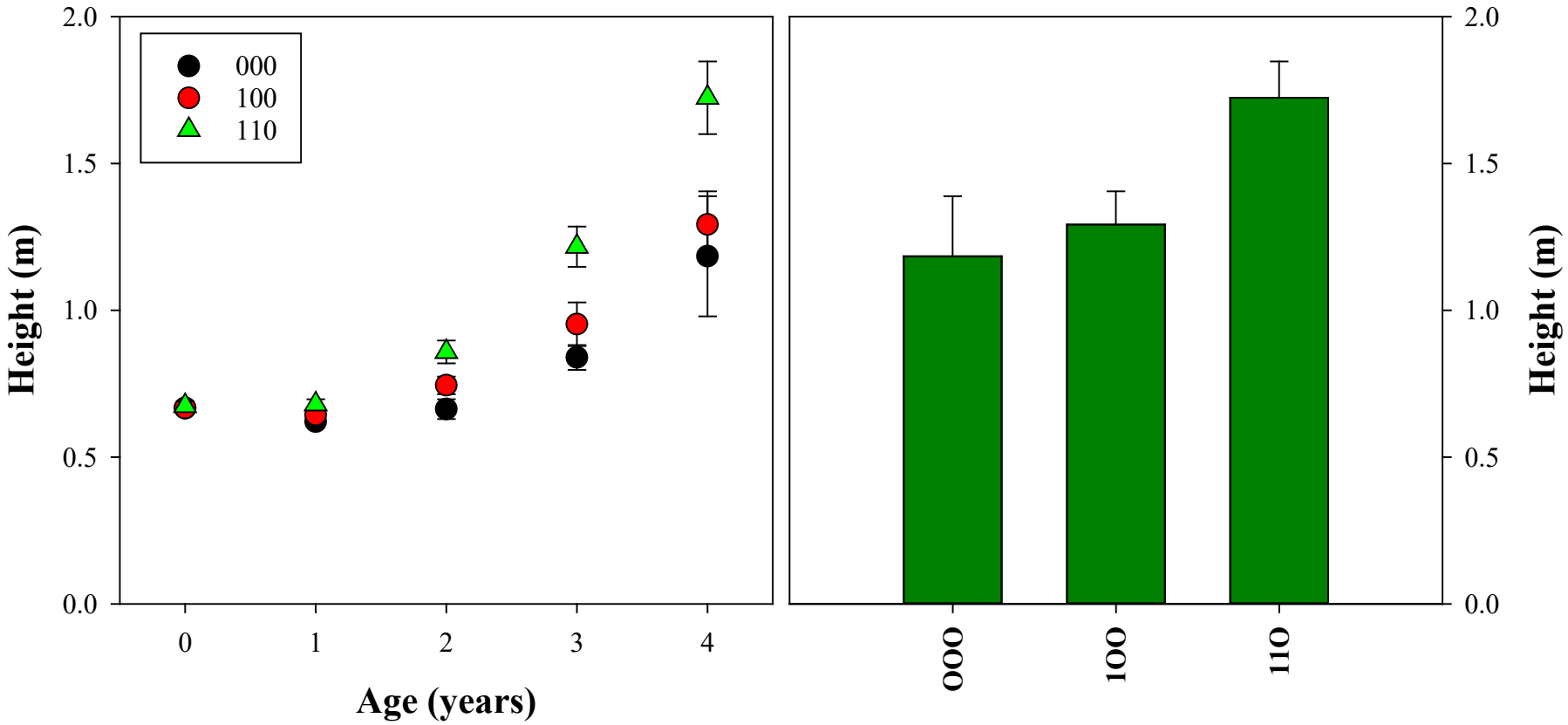
Tree Effects: Survival

Douglas-fir on a dry site near Yoncalla, OR



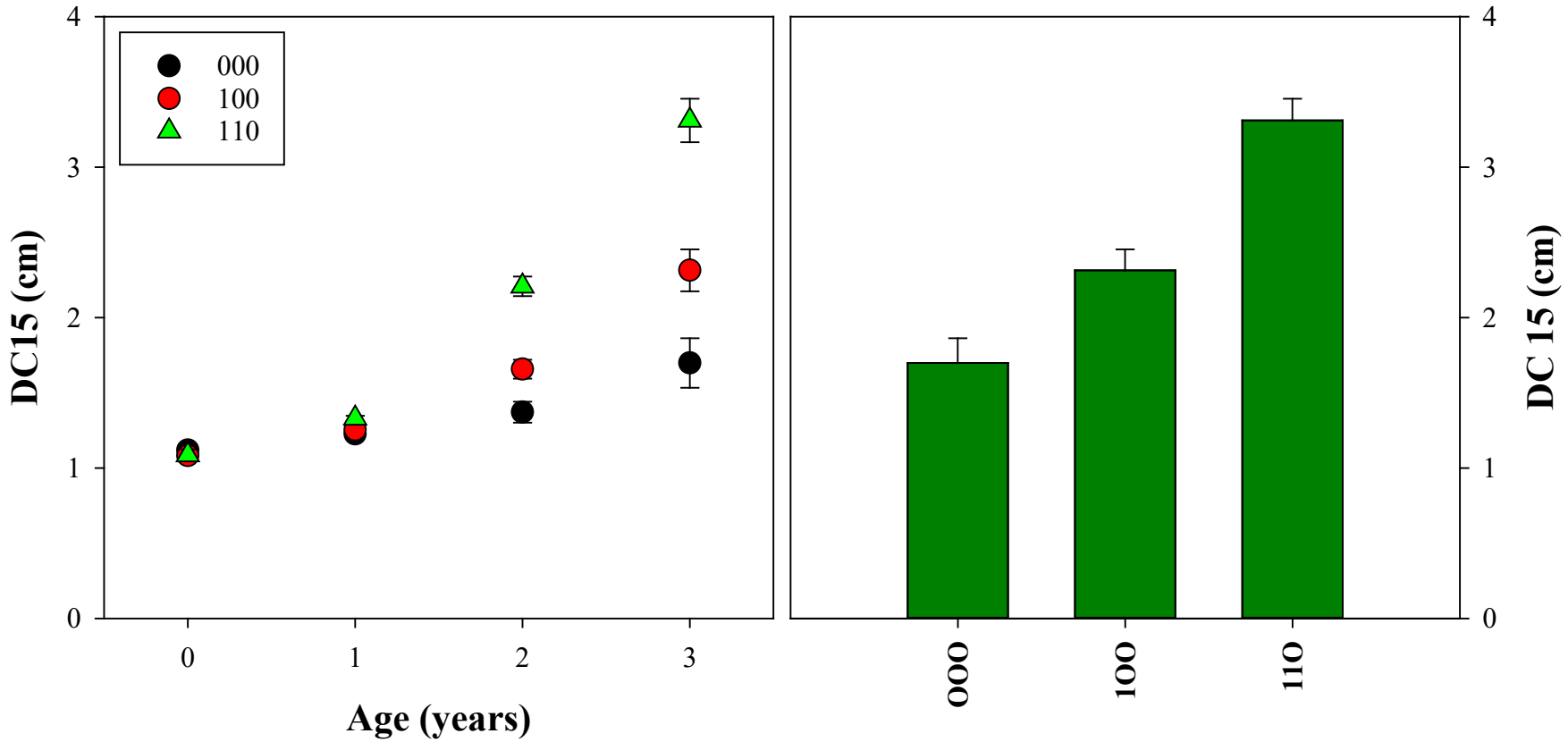
Tree Effects: Height

Douglas-fir on a dry site near Yoncalla, OR

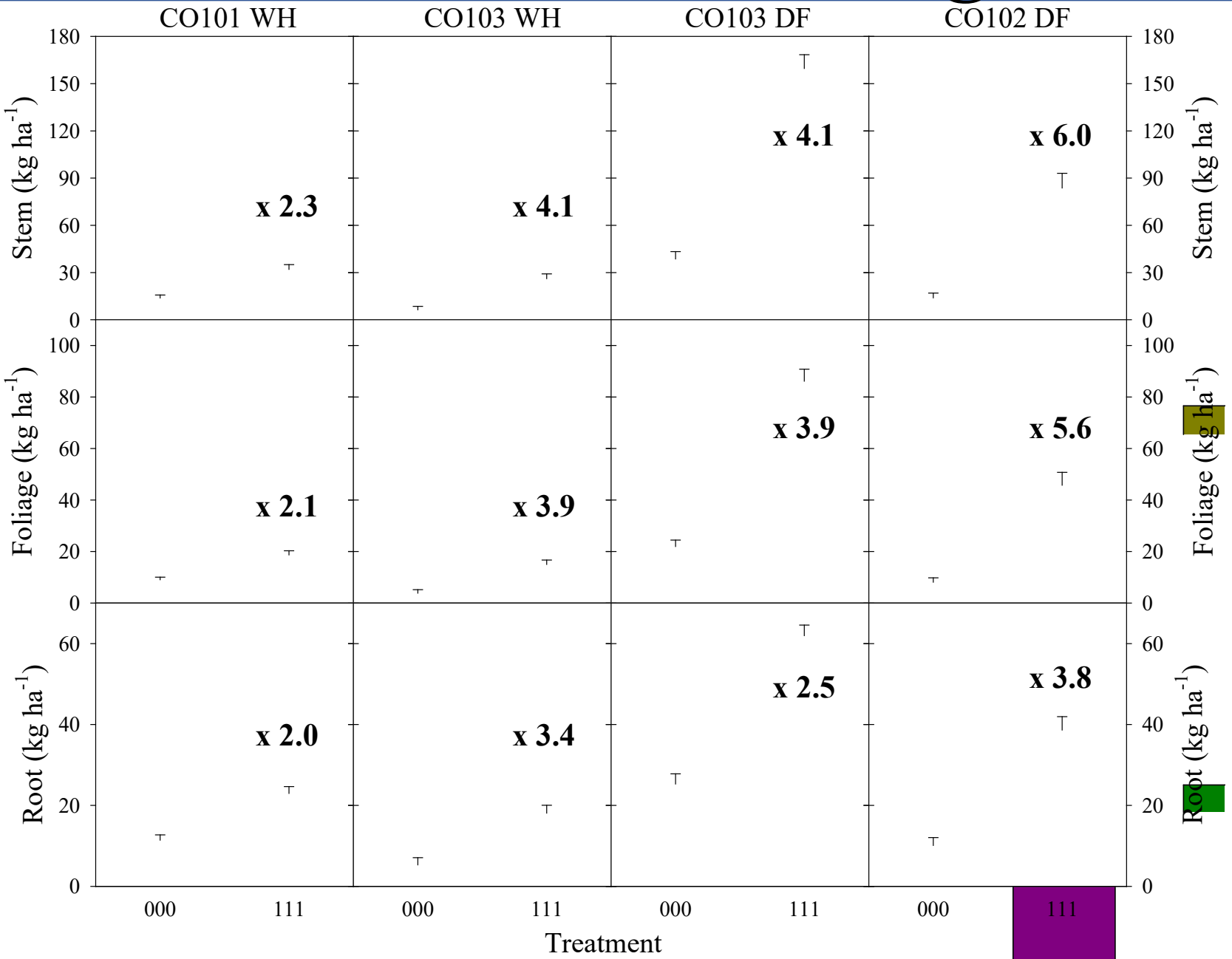


Tree Effects: Diameter

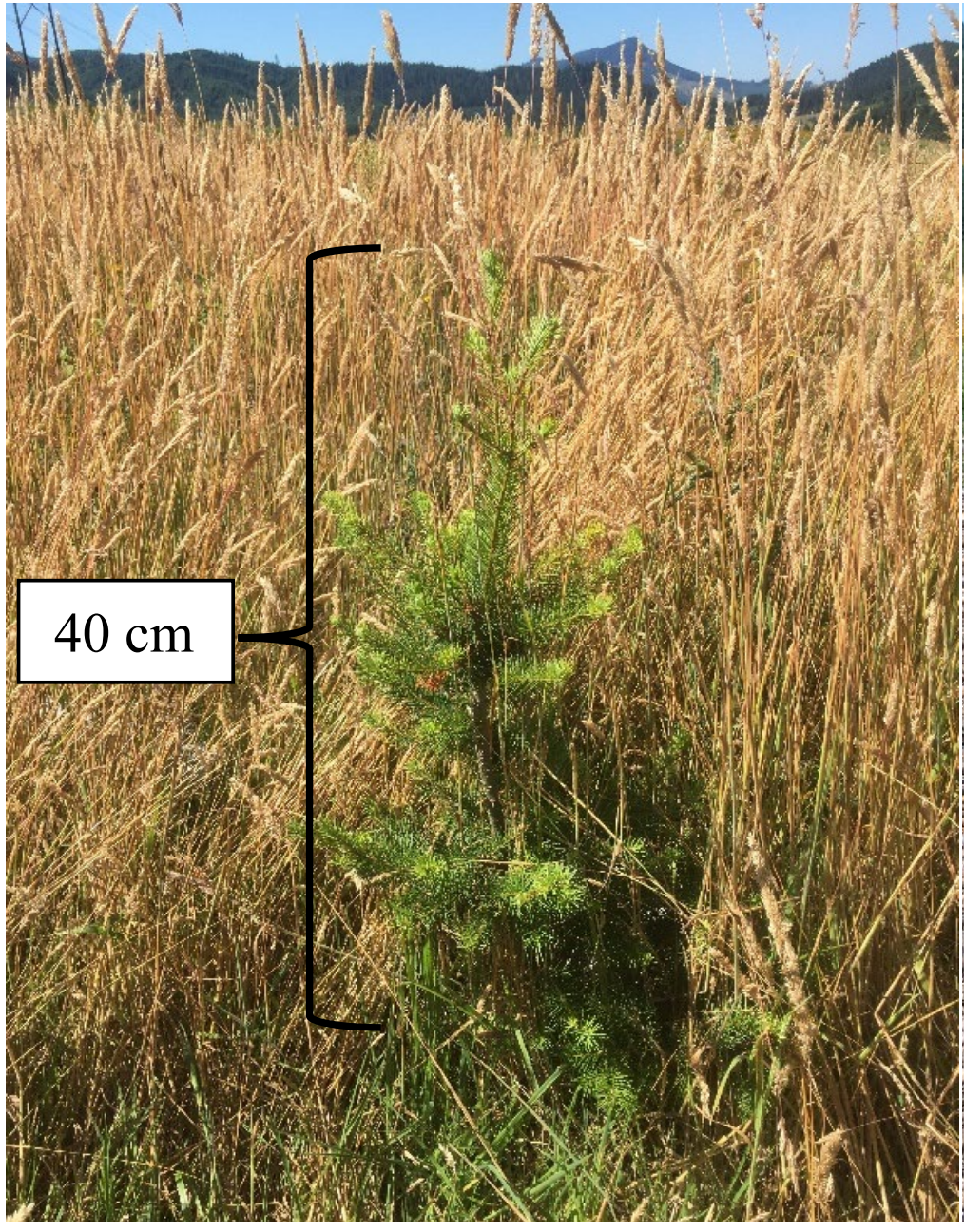
Douglas-fir on a dry site near Yoncalla, OR

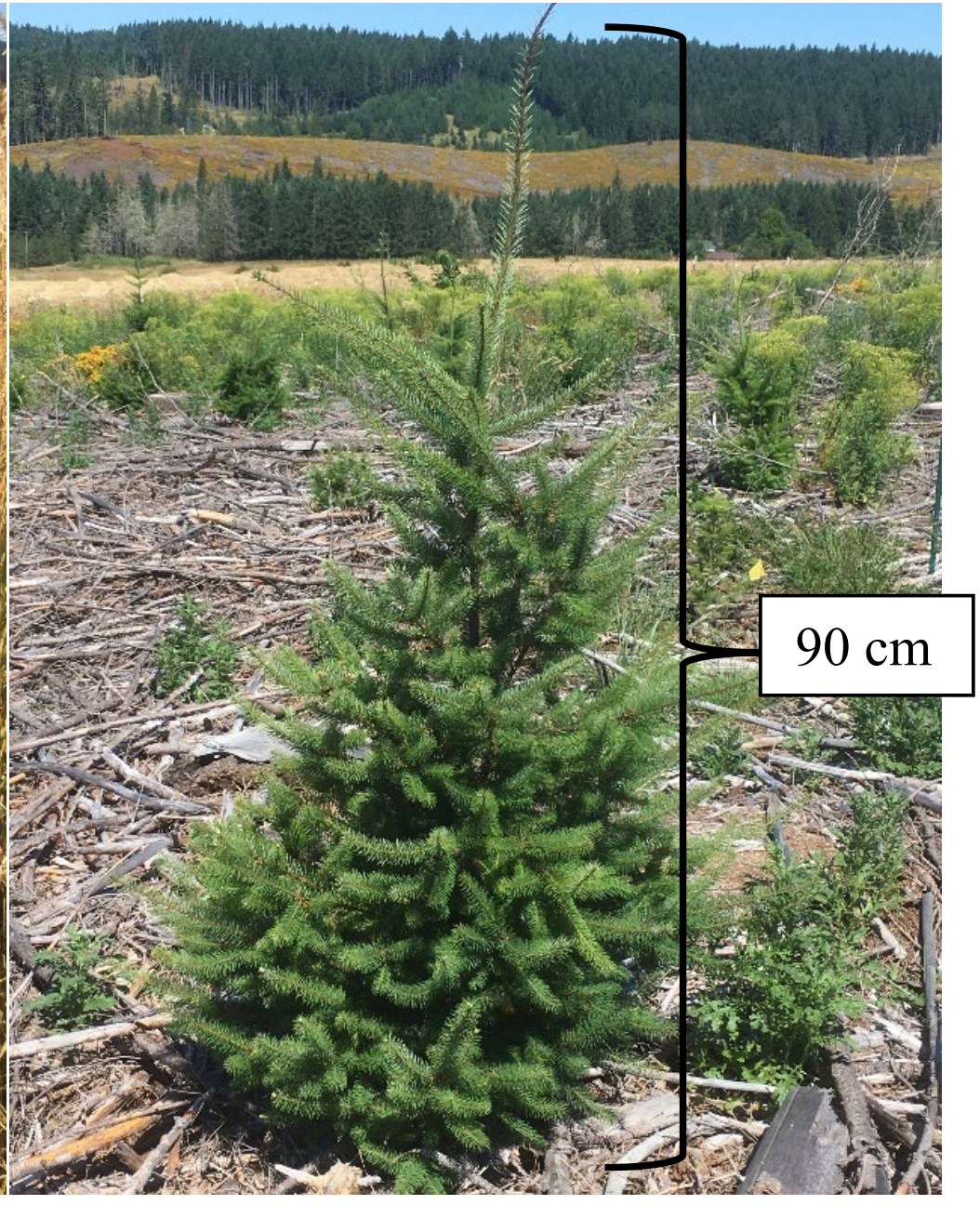


Biomass Effects: Growing Season 2



Tree Effects

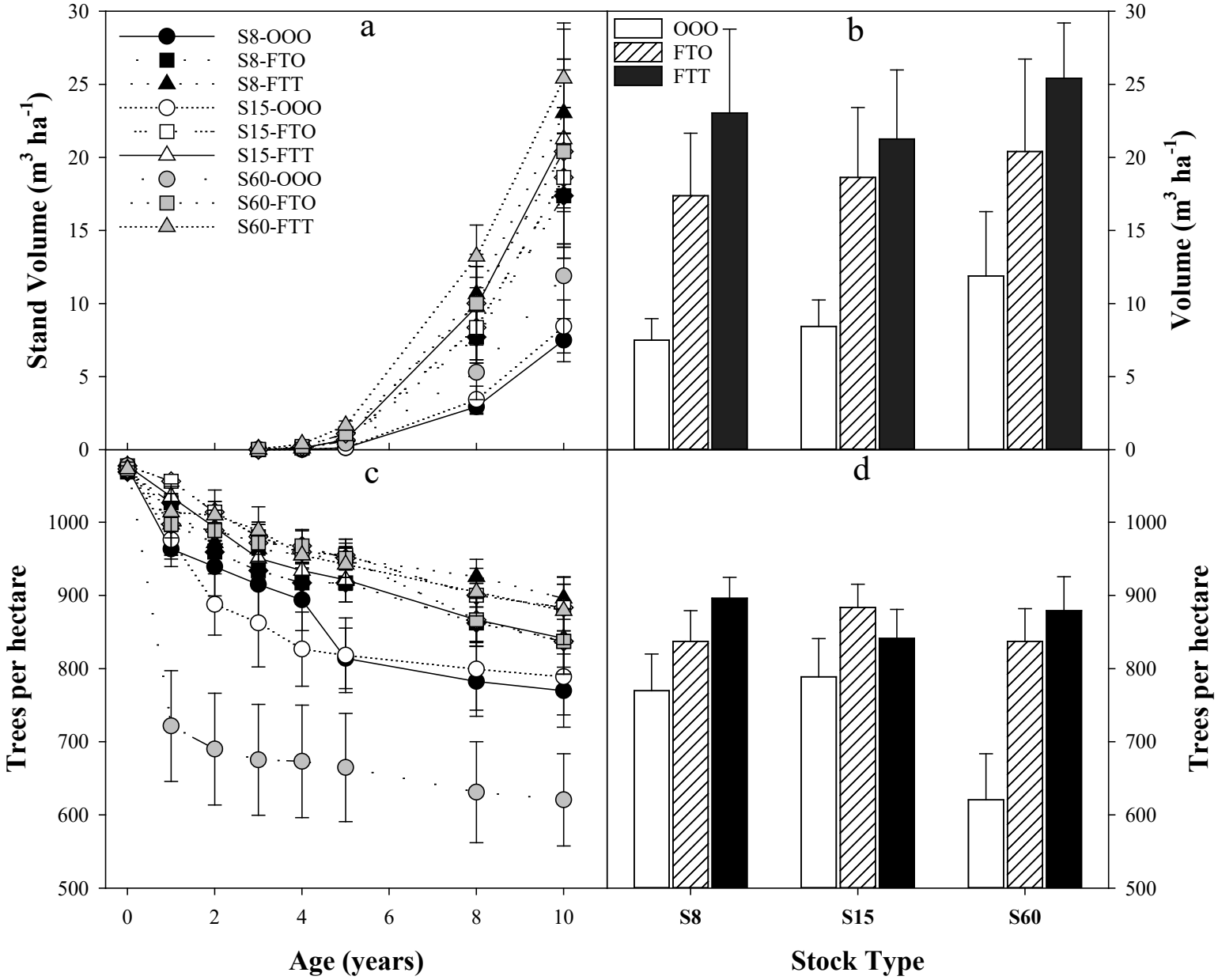




Lesson 3

A Seedling Never Forgets

Age 10 Results



FTO & FTT **11.3 m³ ha⁻¹** > OOO
126% increase

<u>Survival at Year-10</u>

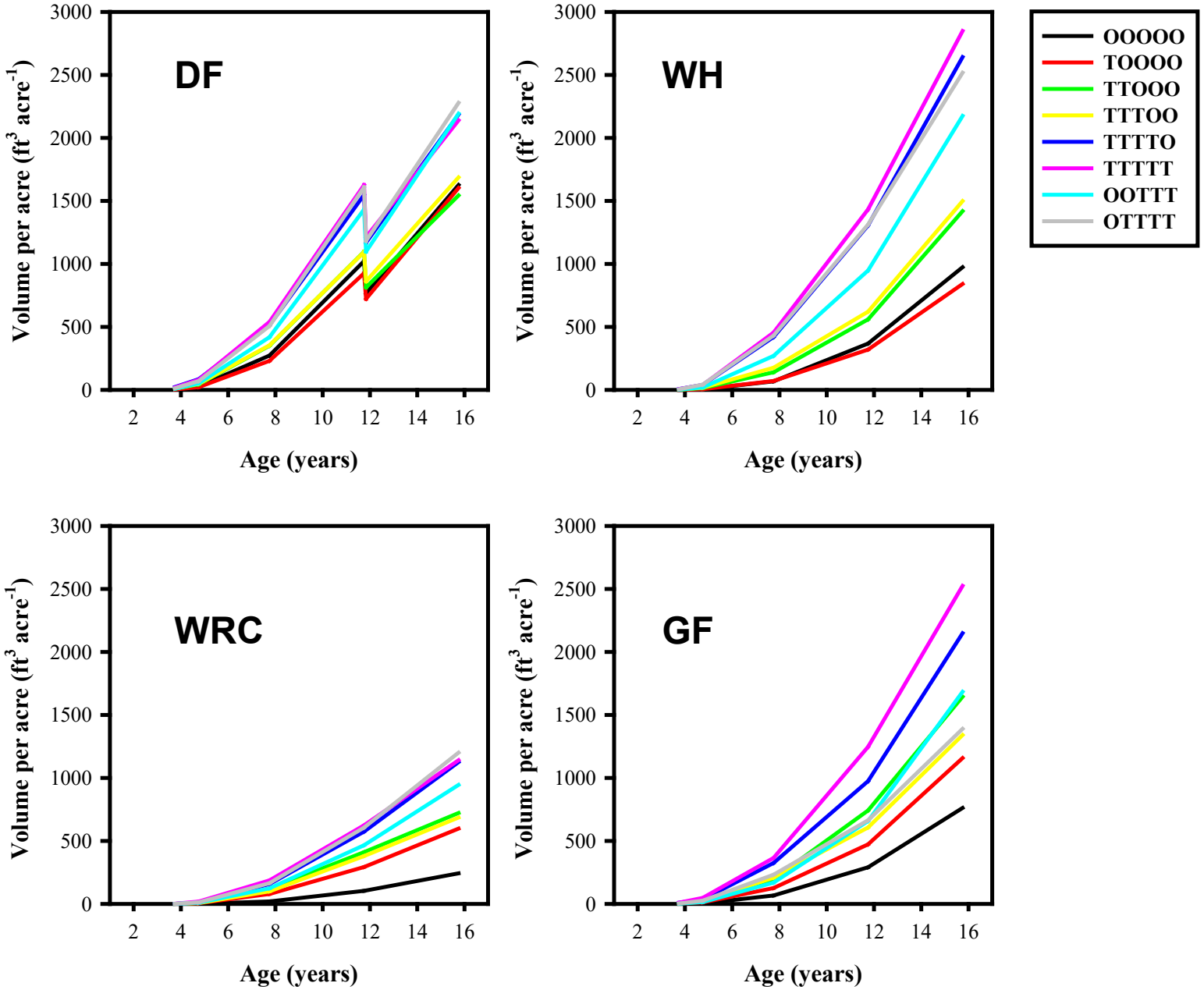
- OOO = 68%
- FTO = 79%
- FTT = 81%

ANOVA for TPA at Year-1

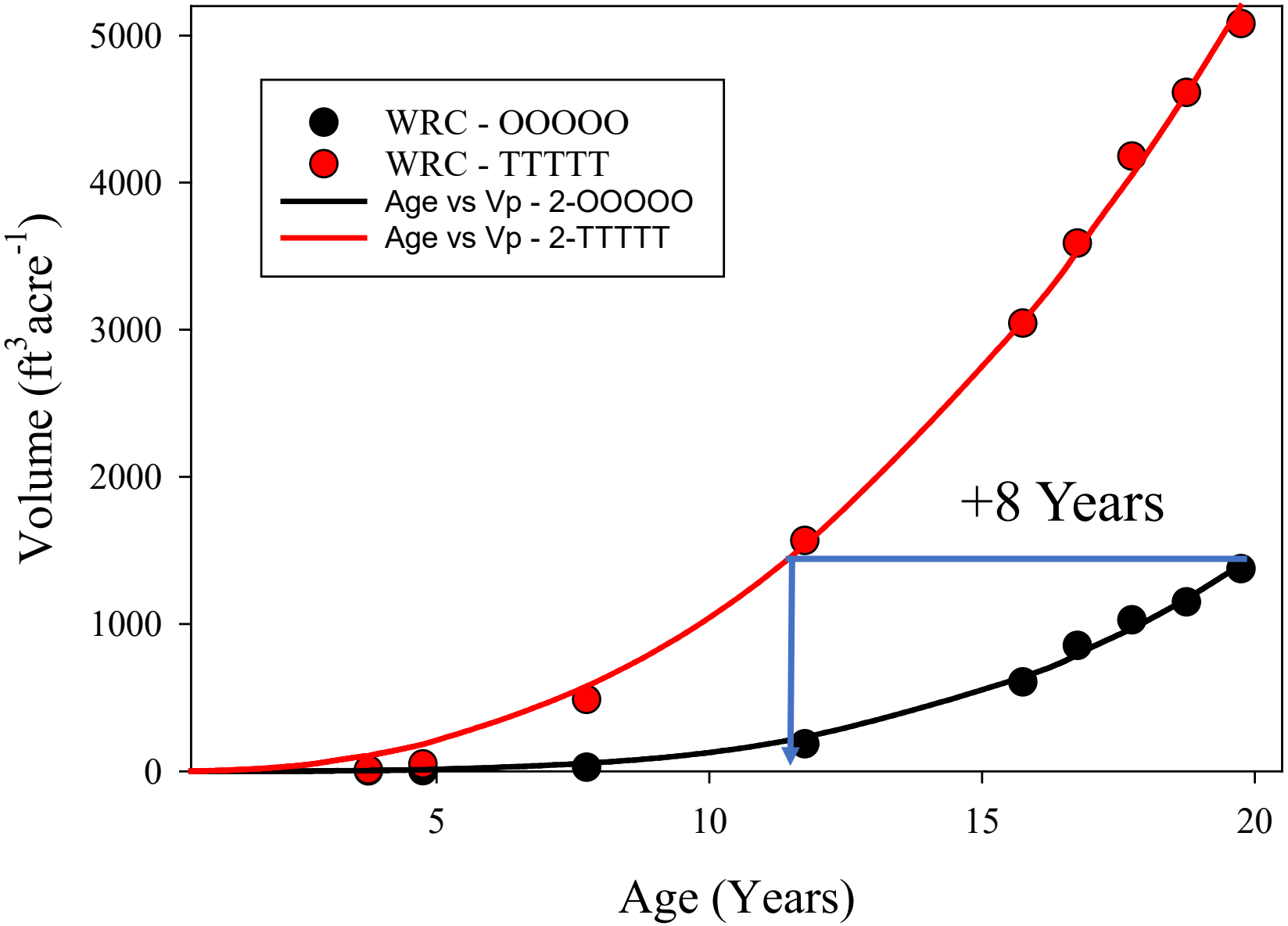
Year	Stock Type * FVM
1	0.003

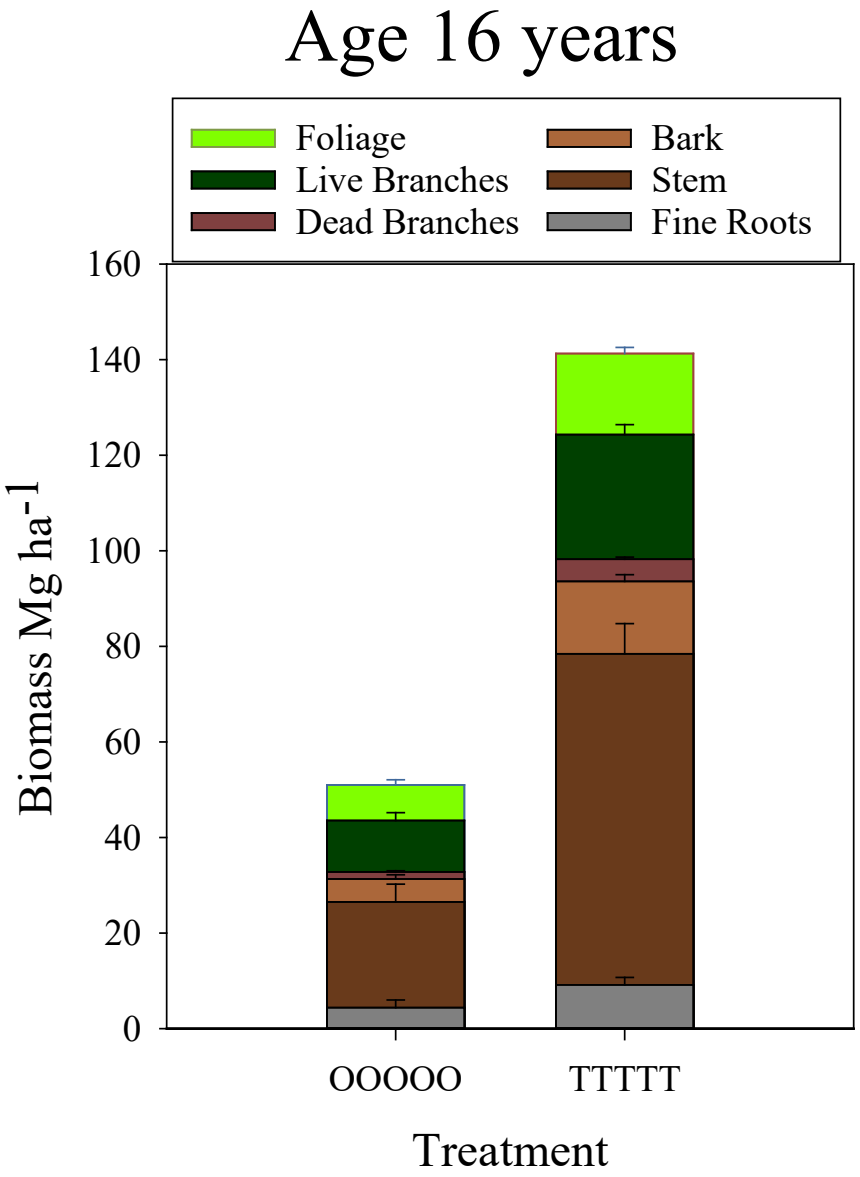
Time Series Response Volume (ft^3/acre)

Df: Thinned at age=12 years



Age Shift


WRC - OOOOO
WRC - TTTTT
Age vs Vp - 2-OOOOO
Age vs Vp - 2-TTTTT
+8 Years
Volume (ft3 acre-1)
Age (Years)
0
1000
2000
3000
4000
5000
5
10
15
20


Age 16 years
Foliage
Live Branches
Dead Branches
Bark
Stem
Fine Roots
Biomass Mg ha-1
0
20
40
60
80
100
120
140
160
OOOOO
TTTTT
Treatment

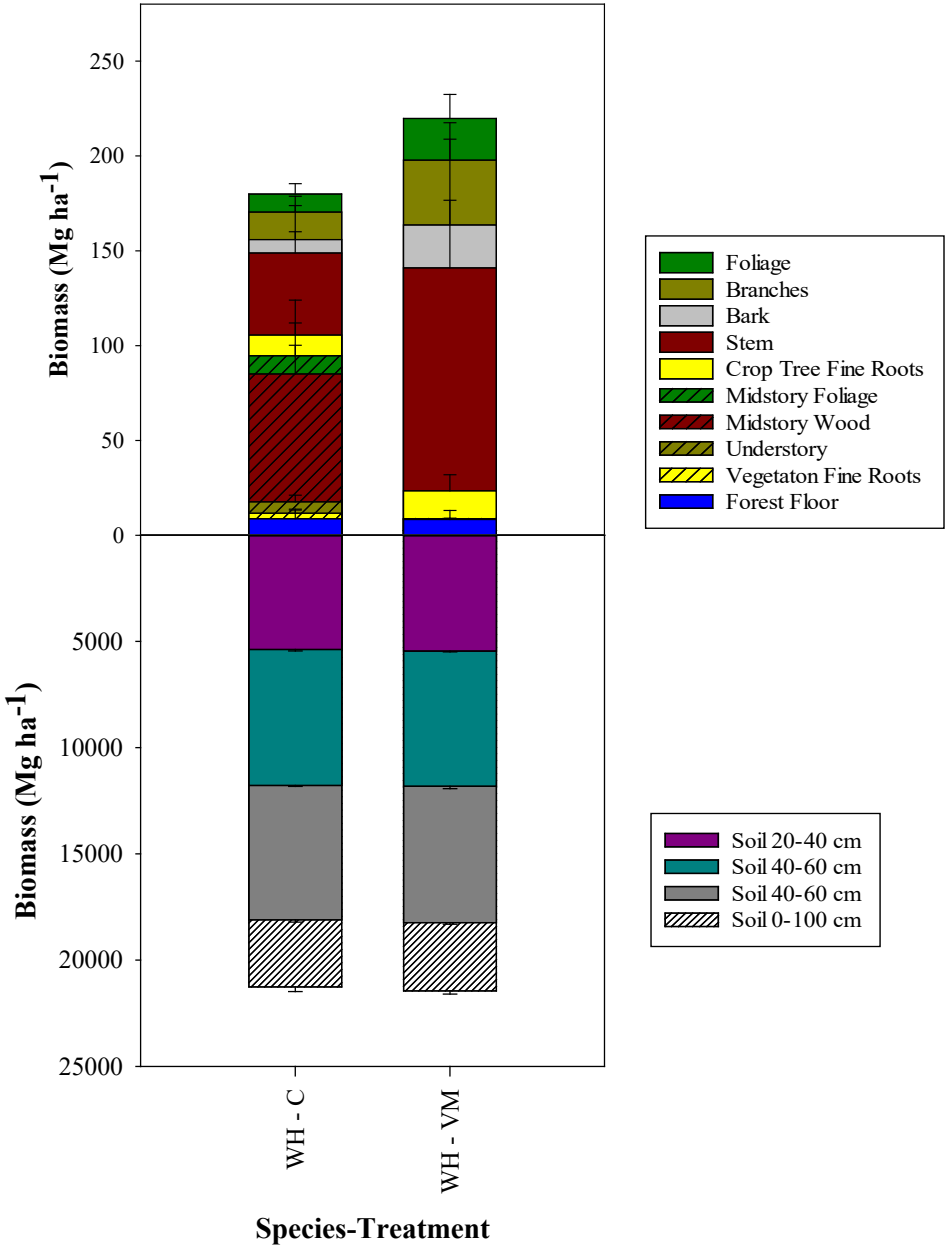
Contrasting Ecosystems

Western hemlock at age 18 years

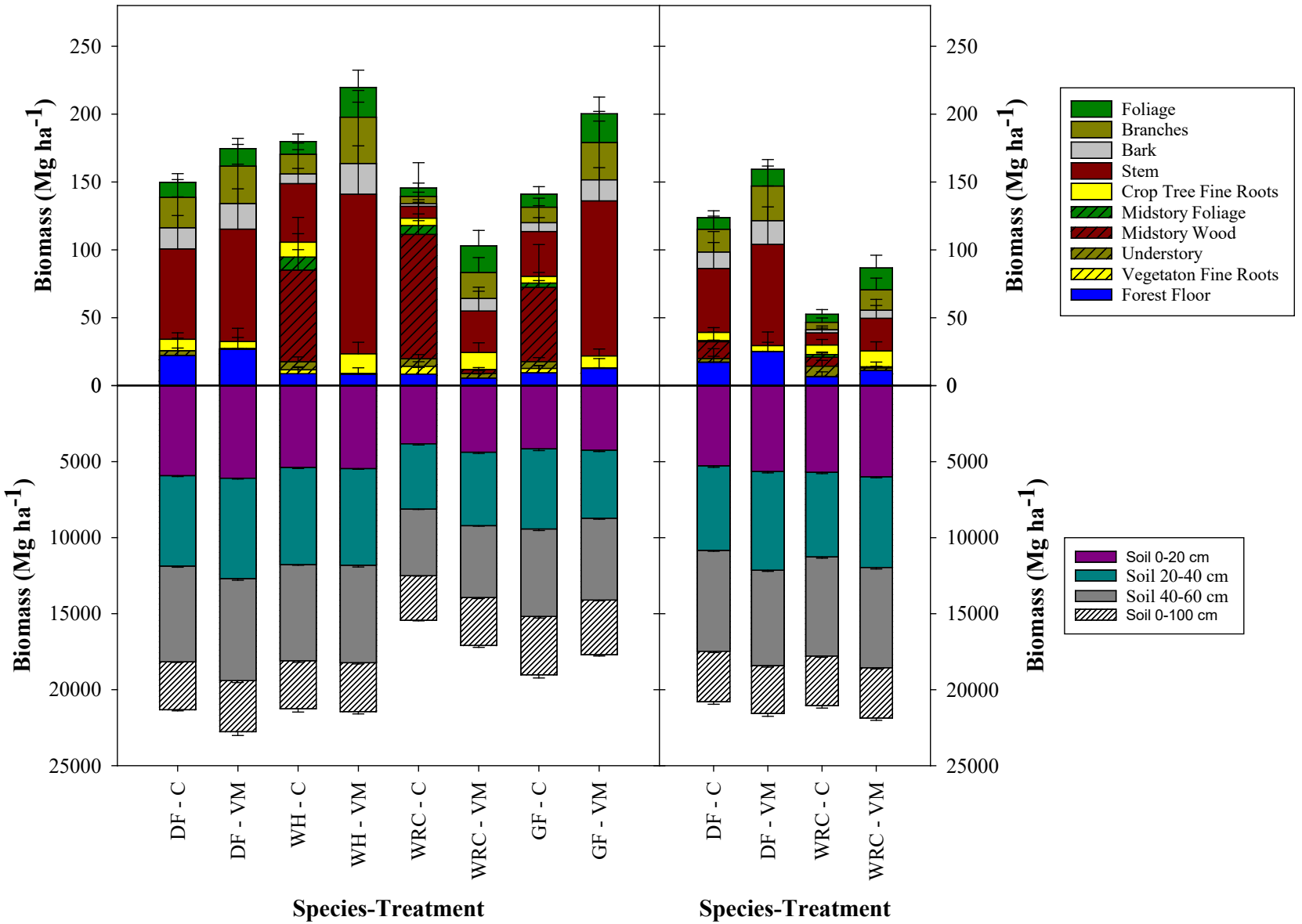
Sustained VM

Site Prep Only

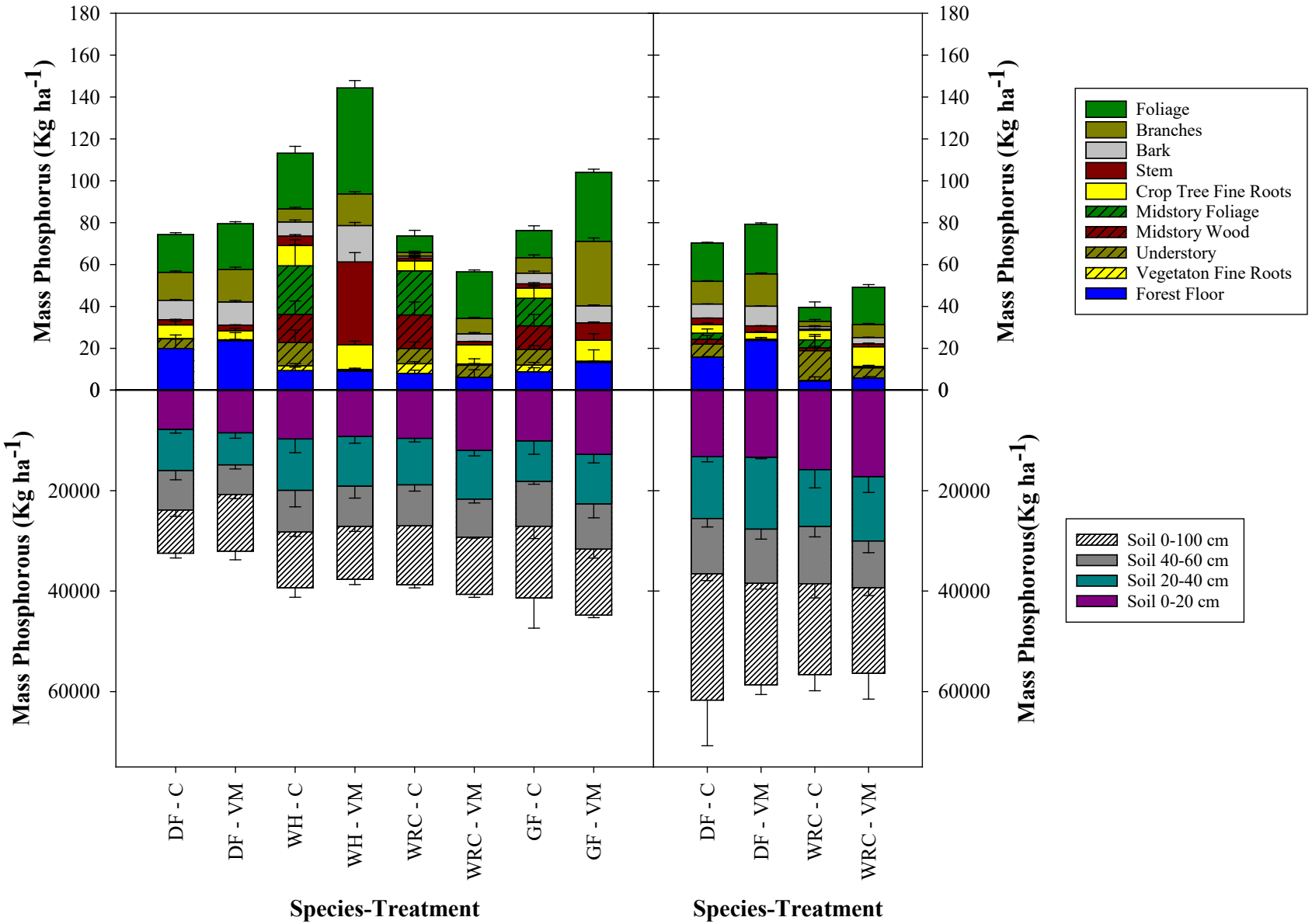
Results: Ecosystem Biomass (Mg ha^{-1})



Results: Ecosystem Biomass (Mg ha^{-1})



Results: Ecosystem Nutrient Content (Mg ha^{-1})



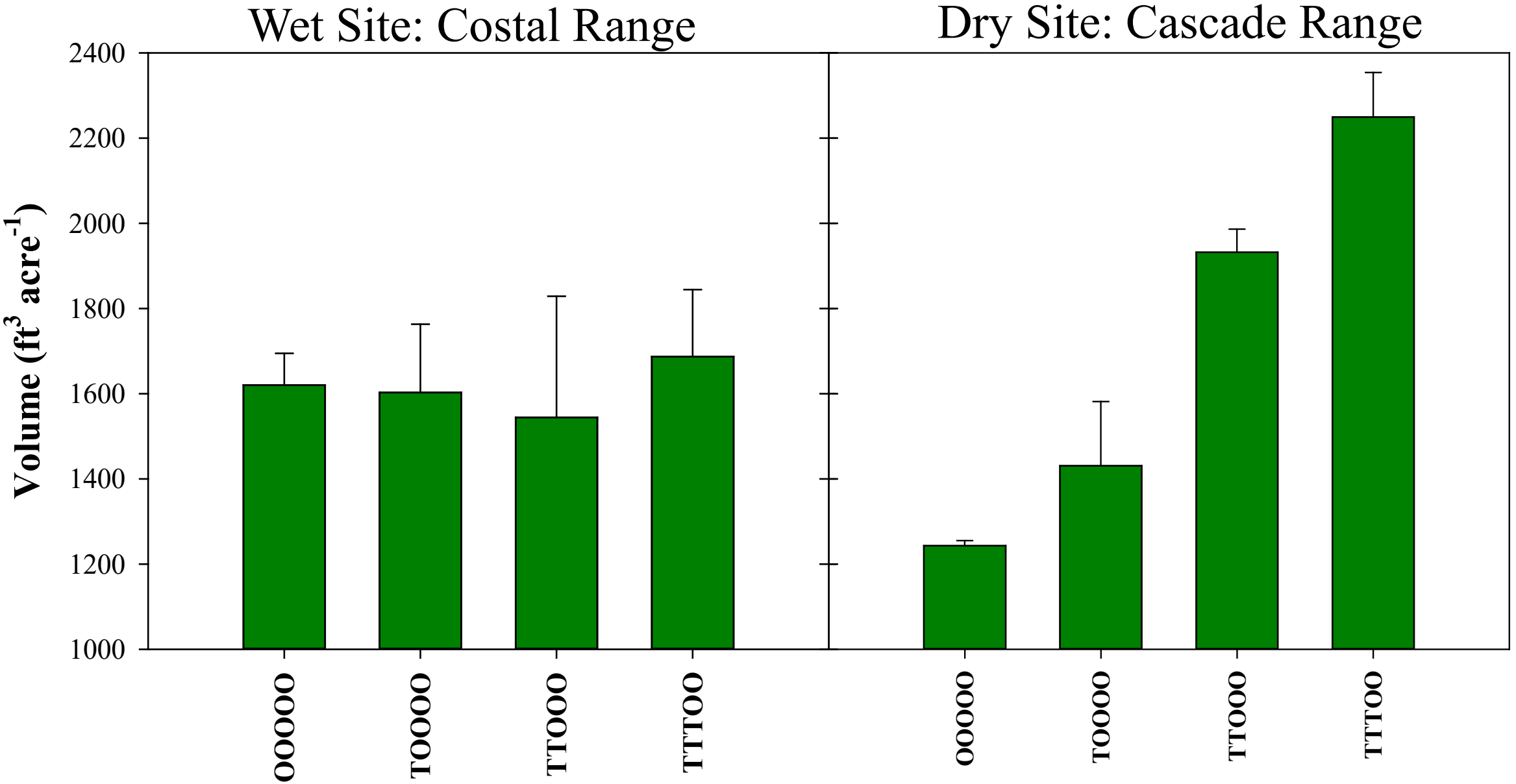
Lesson 4

Its Site Specific…

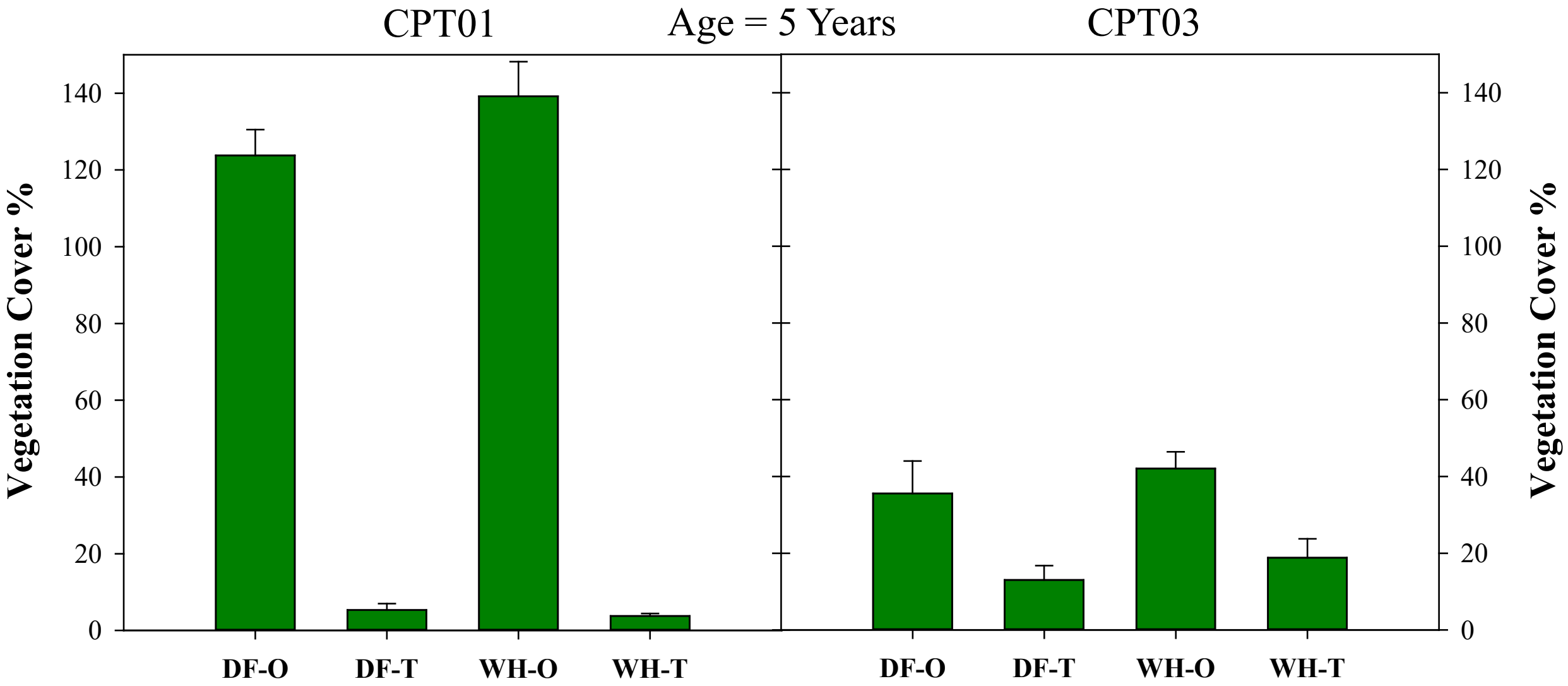
… and Season Specific

… and Species Specific

DF Response to Release: Age 16



Comparison: CPT01 vs CPT03



O > T

CPT01 higher vegetation cover

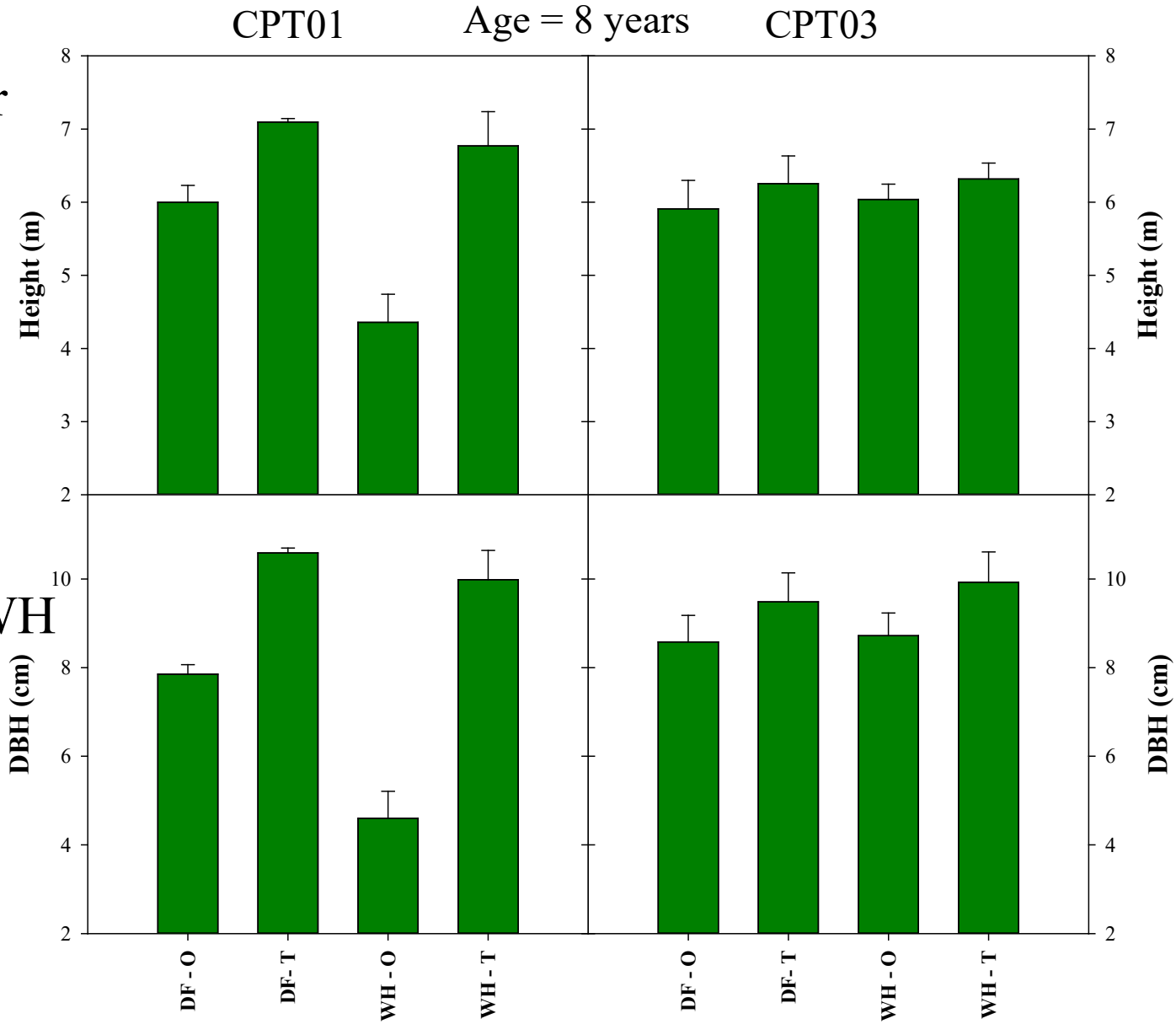
Comparison: CPT01 vs CPT03

Height:

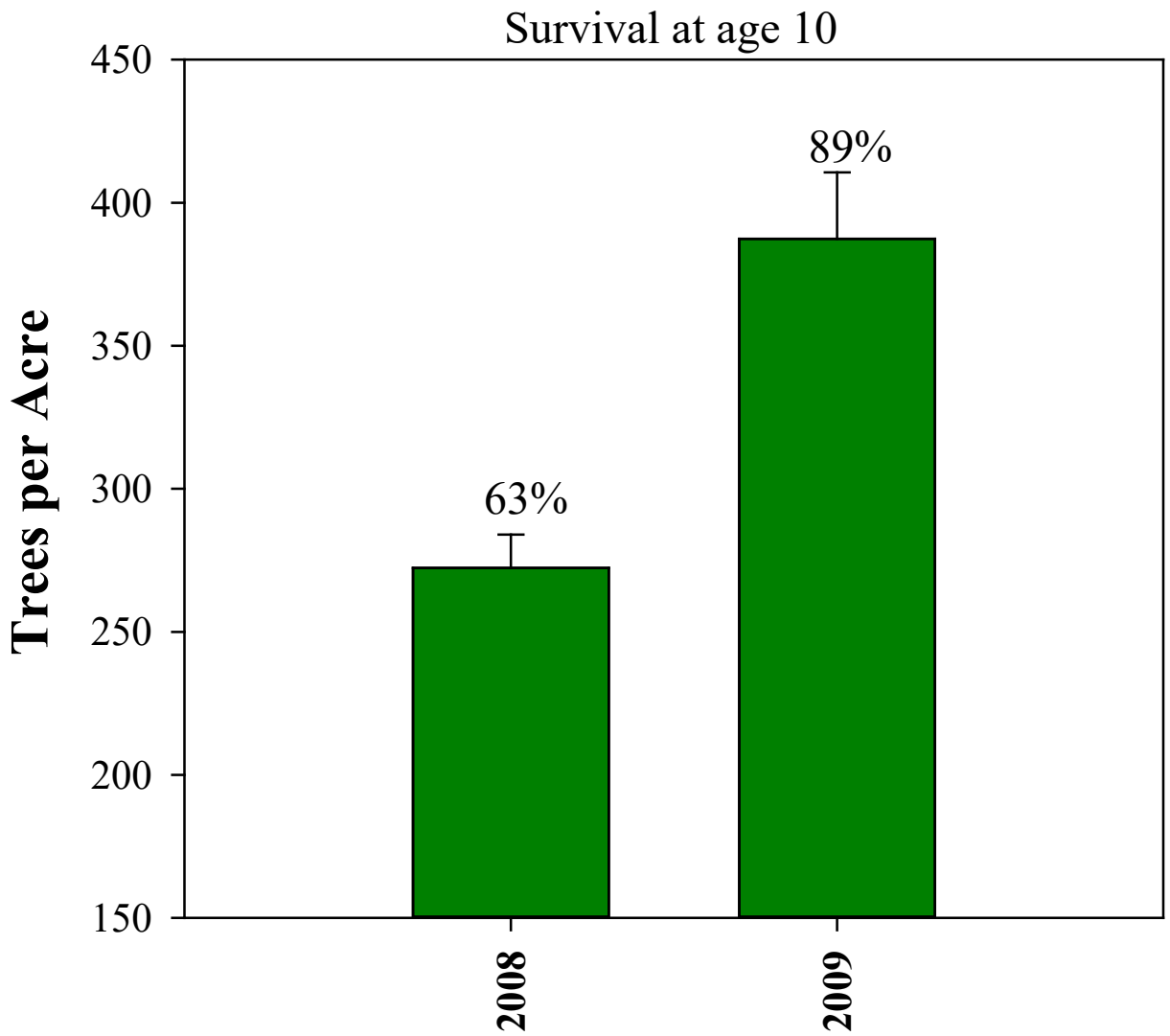
- CPT 01: O < T, larger difference for WH
- CPT 03: O=T DF=WH

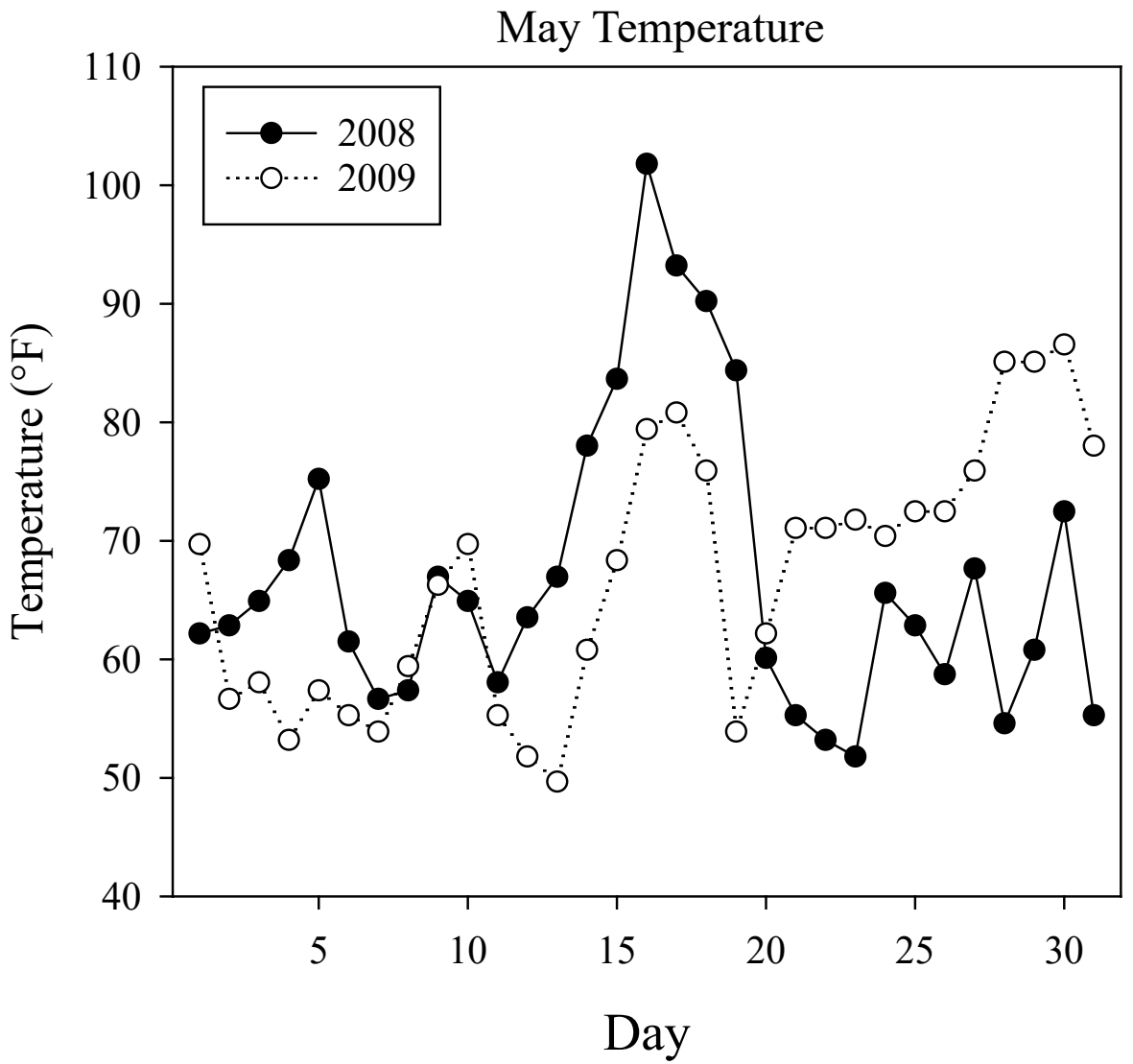
DBH:

- CPT01 O<T, larger difference for WH
- CPT 03: O=T DF=WH



Treatment Responses Vary with Weather

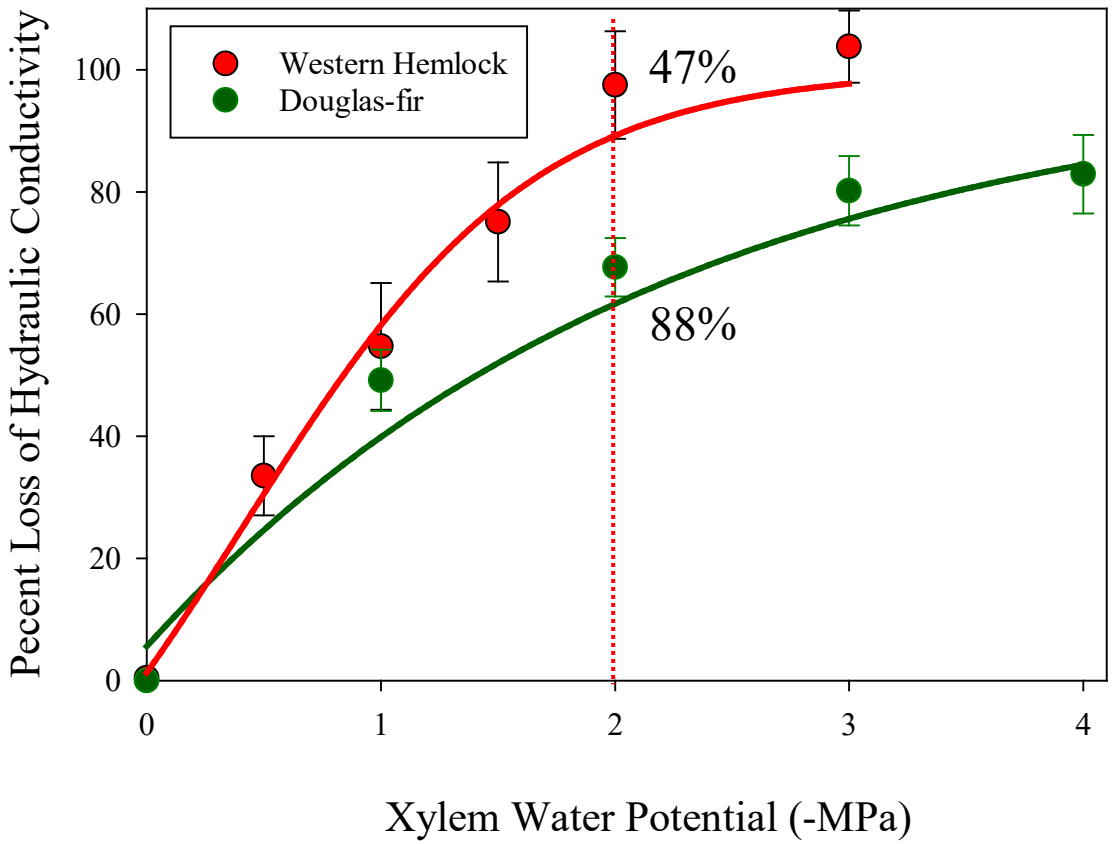




So, What Do We Do????

Understand the mechanism driving treatment responses:

- Select a species and seed sources that matches site conditions



So, What Do We Do????

Understand the mechanism driving treatment responses:

- Select a species and seed sources that matches site conditions
- Select a stock type that matches site conditions and planned VM treatments

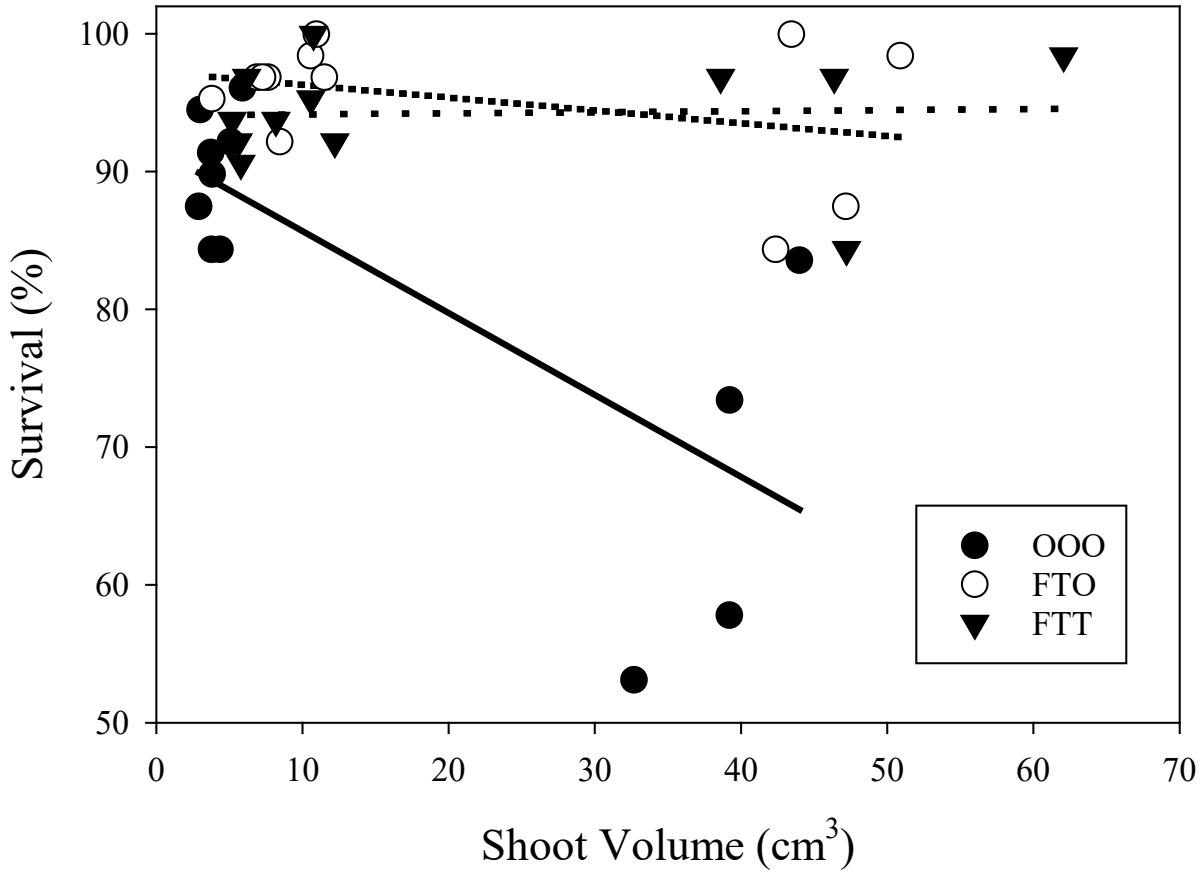
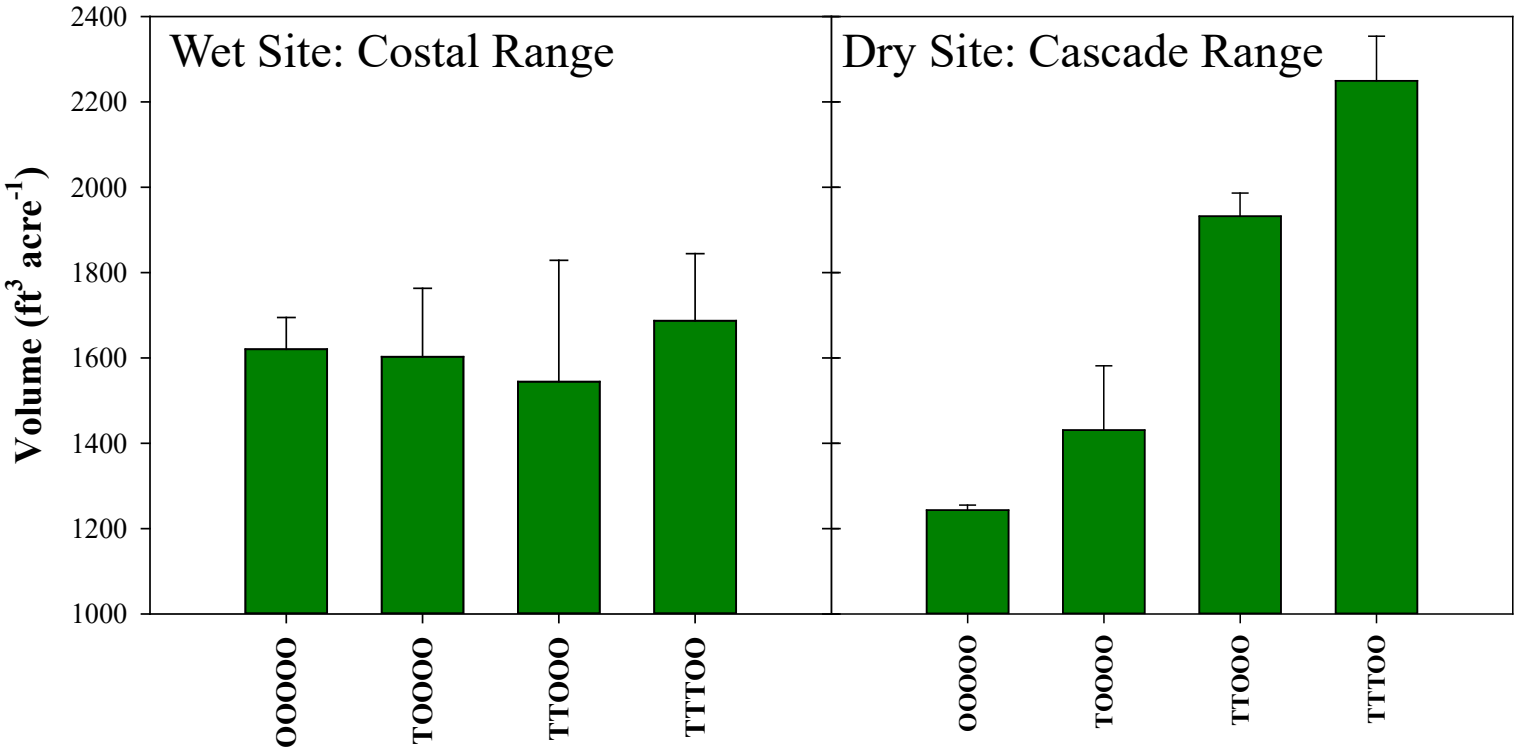


Photo: E. Dinger

So, What Do We Do????

Understand the mechanism driving treatment responses:

- Select a species and seed sources that matches site conditions
- Select a stock type that matches site conditions and planned FVM treatments
- Prioritize release treatments on harsher sites



Lesson 5

Stay Curious

Conclusion

Lesson 1: Not all seedlings are created equal

Lesson 2: Site preparation can solve one problem, but create another

Lesson 3: A seedling never forgets

Lesson 4: Its site, species, and season specific

Lesson 5: Stay Curious

Acknowledgements





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14 Timber Management Companies
2 State Agencies
2 Herbicide Manufacturers

Cascade Timber Consulting
*Corteva AgroSciences
Giustina Land and Timber
Green Diamond Resource
Greenwood Resources
*Helena Agri-Enterprises
Lone Rock Timber
Manulife
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Port Blakely
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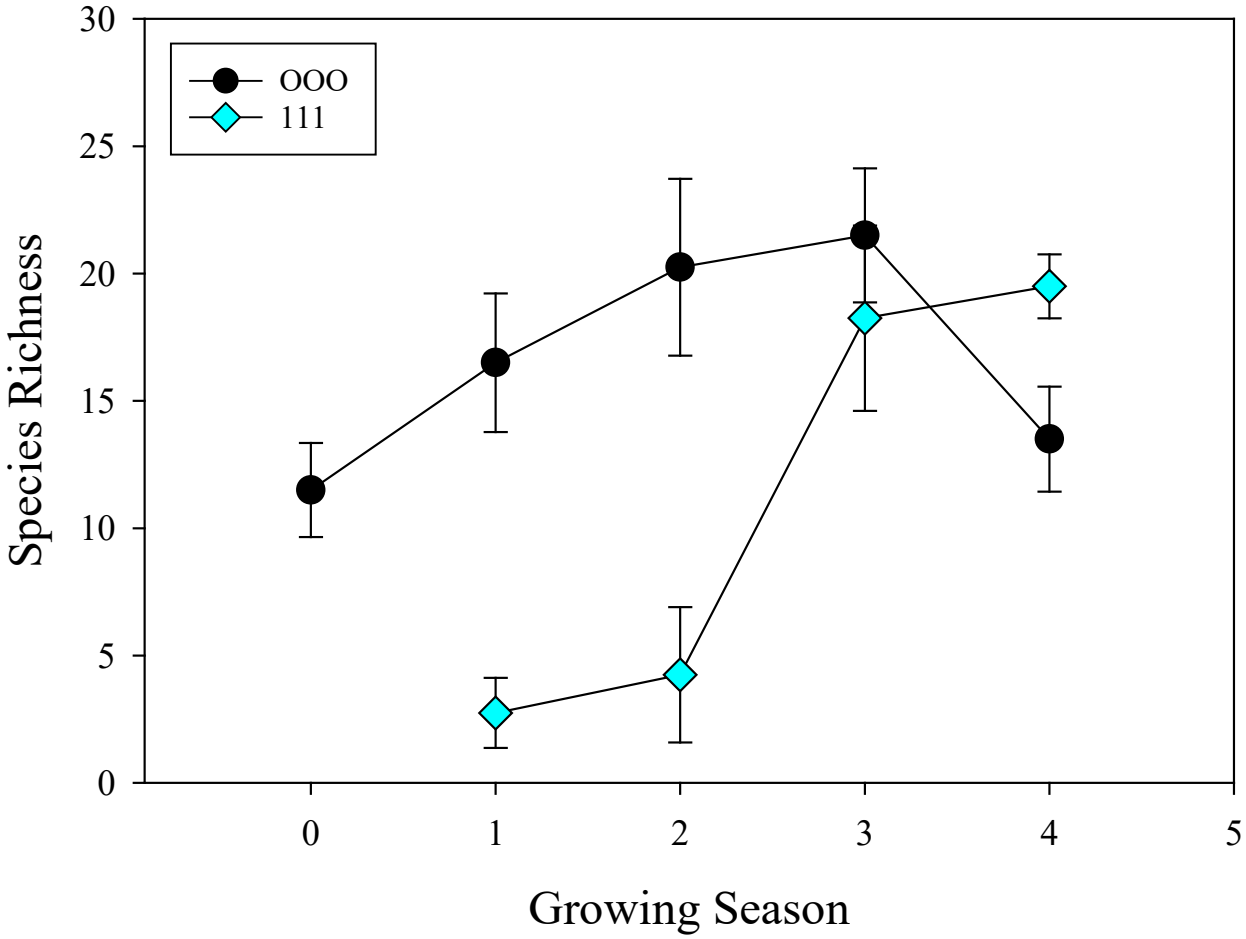
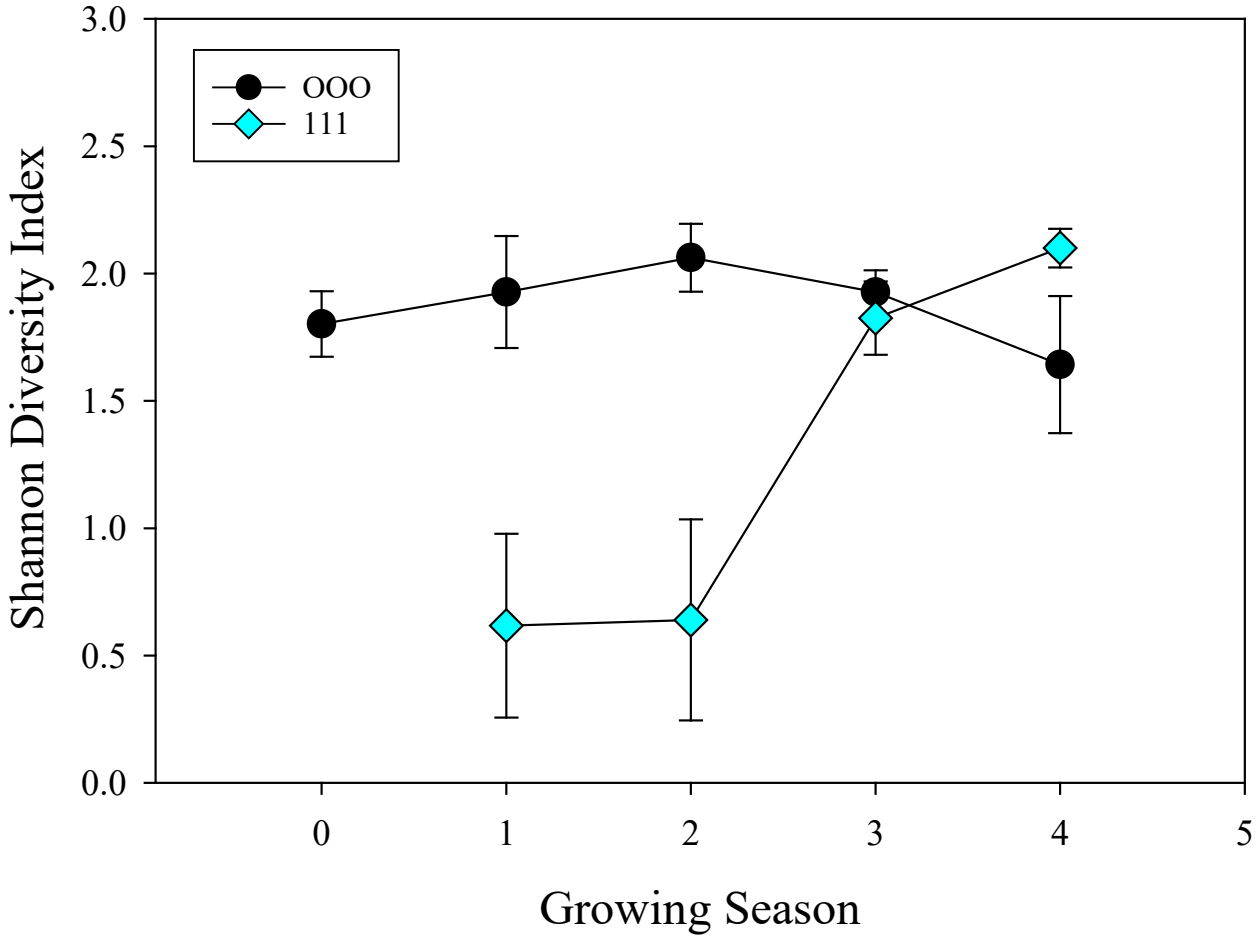
Rayonier
Roseburg Forests Resources
Silver Butte
Starker Forests
Stimpson Lumber
Washington DNR
Weyerhaeuser

Results from a VMRC study demonstrate the potential for vegetation management to increase species diversity

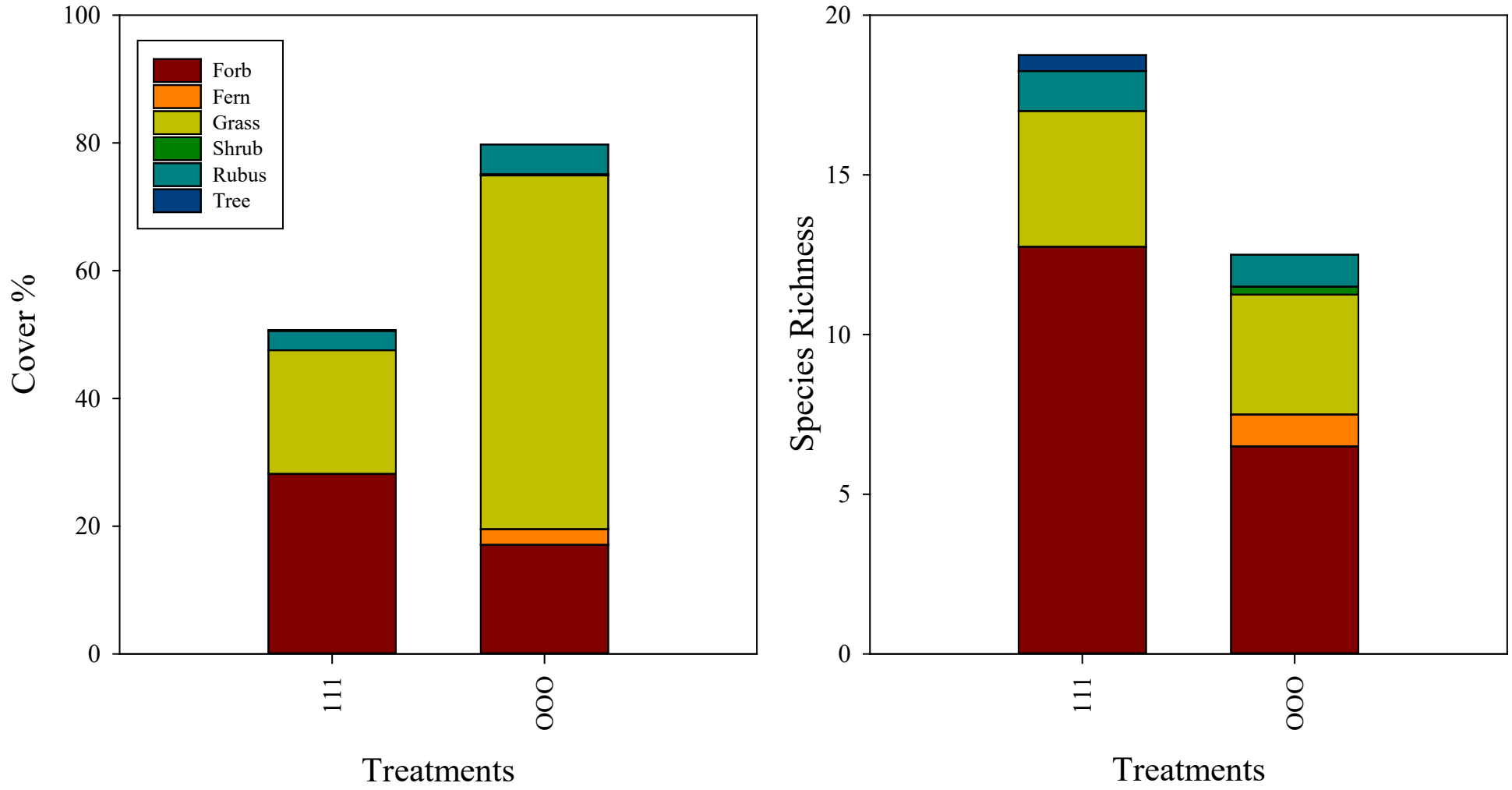
- Comparison of plots treated with herbicides during the first two years (111) and untreated plots (OOO)
- Diversity was low in treated plots during the first 2 years, but quickly increased after treatment stopped in year 3
- Diversity of untreated plots decreased sharply in year 4 and treated plots had higher diversity at that time
- Why is this?





The study site was located in an area surrounded by pastures and there was heavy grass pressure:

- The untreated plots came to be dominated by grass species which prevented the establishment of other species
- The lower grass cover in treated plots allows for the establishment of other species which lead to a higher diversity of forbs.



Growing Season 4

Untreated Control
- Dominated by grasses
- Lower diversity

Two years of vegetation control
- Lower grass cover
- Higher diversity