Plant functional traits as indicators of restoration success in pine barrens under prescribed fire management

Lake States Fire Science Consortium Intern Program webinar
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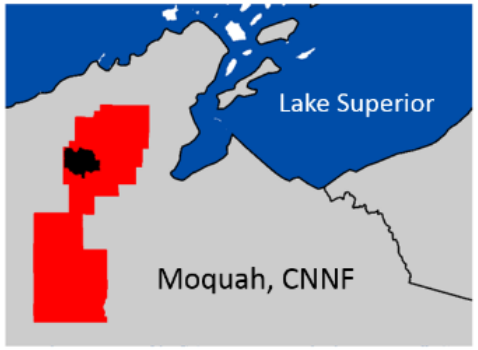
Presentation overview

- Study area
- Project objectives
- Methods
- Results
- Implications & future directions

Moquah barrens



Moquah – Ojibwe ‘makwa’ for bear

Barrens = savanna habitat on nutrient-poor soils

Mean annual temperature: 5 °C (41 F)

Mean annual precipitation: 780 mm (30 in)

Moquah barrens – not *just* barrens

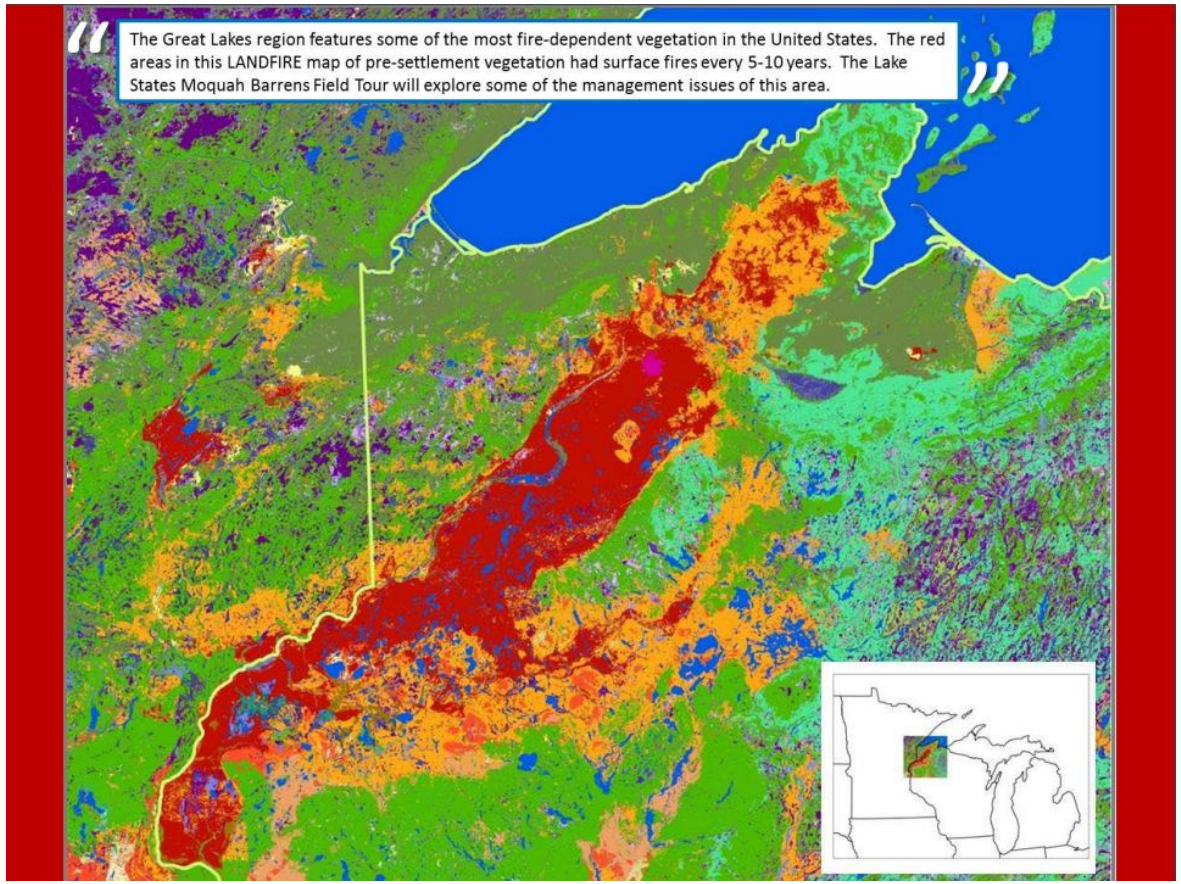
Barrens
Predominantly herbaceous
< 50 trees per acre
< 30 ft^2 basal area per acre
< 30 % shrub/sapling cover

Pine woodlands
Red and jack pine plantations
≥ 40 trees per acre
30 – 60 ft^2 basal area per acre

Brush
≥ 30 % shrub/sapling cover
≥ 4.5 inch stem diam DBH
70% cover = brush cutting

Deciduous woodland & forest
Aspen, birch, oak, and maple
≥ 40 trees per acre
≥ 30 ft^2 basal area per acre

Barrens are an imperiled habitat type



Landfire map of fire return interval; Red = 5-10 year FRI

Source: Lake States Fire Science Network

Less than 1 % of pre-settlement extent remains

Widespread loss due to land use & ***fire suppression***

~23,000 acres of barrens & savanna under restoration

Objectives

<u>From June – August 2019:</u>

- Monitor phenology ~ weekly
  - Time of leaf out, flowering, and fruiting
- Measure leaf traits monthly
- Collect whole plant traits at end of study
- Relate traits to fire tolerance

What are plant functional traits?

PFTs are traits that represent functional specialization

Ex: Adaptations to local conditions

→ resource availability, disturbance, stress

Tradeoffs occur among traits, so they are interrelated

Ex: Greater investment in roots = less in shoots

Ex: Thick, high-quality leaves = slow-growing

We know that different plant communities have different trait means, *but* ***Do barrens plant communities show variation in plant functional traits along a gradient of prescribed burn history?***

Why do plant traits matter?

Species composition does not necessarily provide information about resiliency

Phenology and leaf-level traits reflect plant resource acquisition, growth, and persistence

Is the community adapted to fire?

Plant traits can vary according to:

Disturbance – grazing, **fire**, etc.

*Site quality – light, nutrients, moisture

Site quality can also be affected by fire, and feedbacks (mesophication) can occur

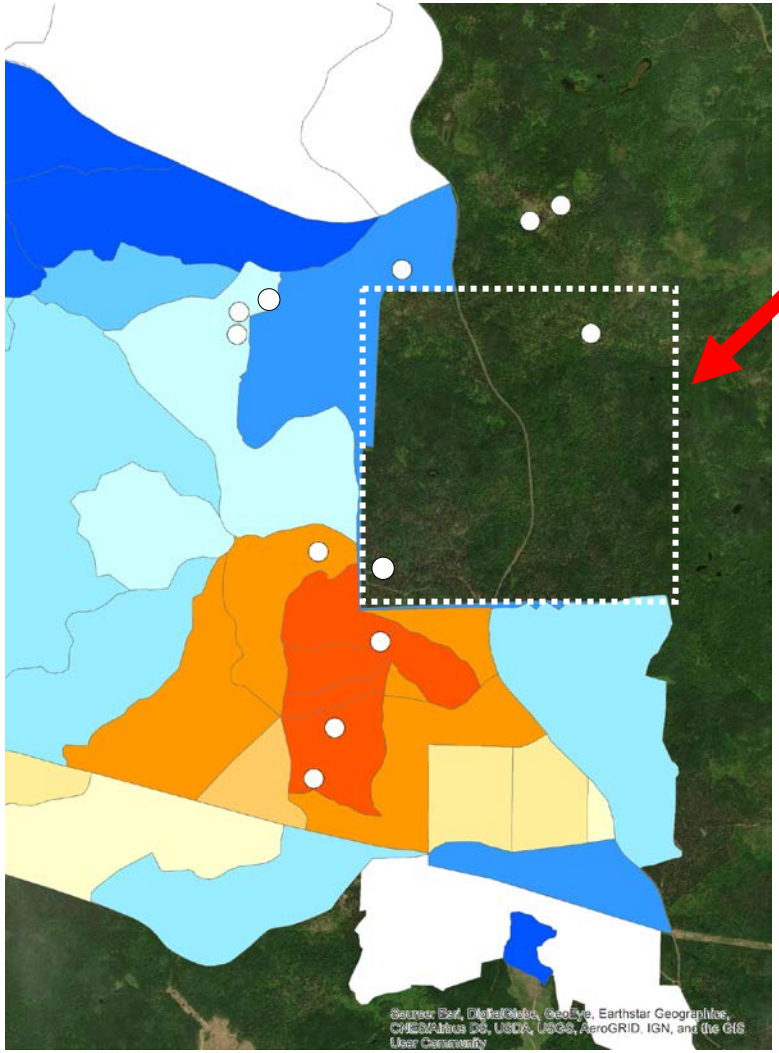
Intern training objectives

- Plant identification
- Interpreting primary literature
- Data collection
- Data entry
- Image analysis software
- Introduction to academic and federal careers in land management and research

Study sites

Established 12 study sites within and adjacent to management area

- Long unburned
- Early restoration (blue)
  2 – 4 burns
- Late restoration (orange)
  9 – 10 burns



Study sites all have open canopy, *but* large differences in extent of openness

Left: Long-unburned sites represent small fragments within a forested landscape

Right: Sites burned 9-10 times represent well-maintained, historic barrens

Study species

Identified and tagged focal plant species at each study site:

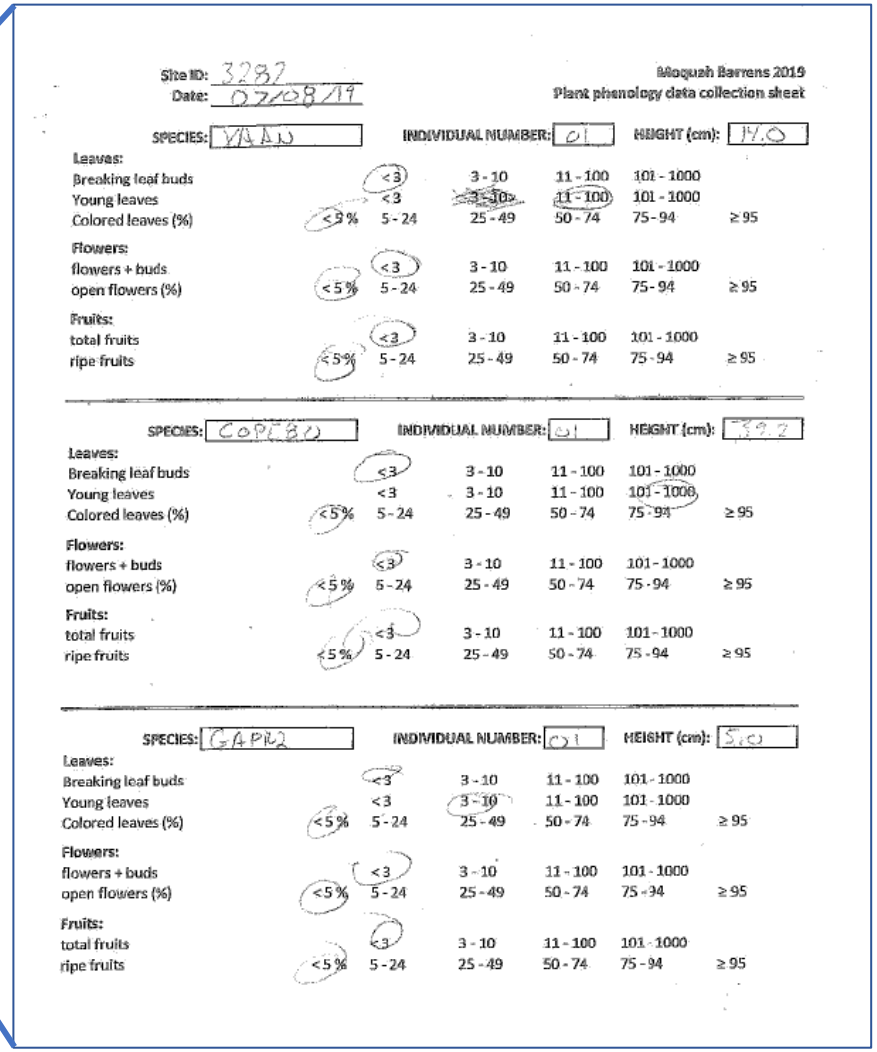
- Bracken fern (*Pteridium aquilinum*)
- Blueberry (*Vaccinium angustifolium*)
- Sweet fern (*Comptonia peregrina*)
- Bearberry (*Arctostaphylos uva-ursi*)
- Wintergreen (*Gaultheria procumbens*)
- Grass (*Danthonia spp*)

Tracking plants

Visited sites weekly to:

- conduct **phenology surveys** on tagged plants

Surveys created based on the National Phenology Network



Site ID: 3287
Date: 07/08/19

Mequon Barrens 2019
Plant phenology data collection sheet

SPECIES: VIAU | INDIVIDUAL NUMBER: 01 | HEIGHT (cm): 14.0

Leaves:						
Breaking leaf buds		<3	3 - 10	11 - 100	101 - 1000	
Young leaves		<3	3 - 10	11 - 100	101 - 1000	
Colored leaves (%)	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95
Flowers:						
flowers + buds		<3	3 - 10	11 - 100	101 - 1000	
open flowers (%)	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95
Fruits:						
total fruits		<3	3 - 10	11 - 100	101 - 1000	
ripe fruits	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95

SPECIES: COPE80 | INDIVIDUAL NUMBER: 01 | HEIGHT (cm): 39.2

Leaves:						
Breaking leaf buds		<3	3 - 10	11 - 100	101 - 1000	
Young leaves		<3	3 - 10	11 - 100	101 - 1000	
Colored leaves (%)	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95
Flowers:						
flowers + buds		<3	3 - 10	11 - 100	101 - 1000	
open flowers (%)	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95
Fruits:						
total fruits		<3	3 - 10	11 - 100	101 - 1000	
ripe fruits	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95

SPECIES: GAPU2 | INDIVIDUAL NUMBER: 01 | HEIGHT (cm): 5.0

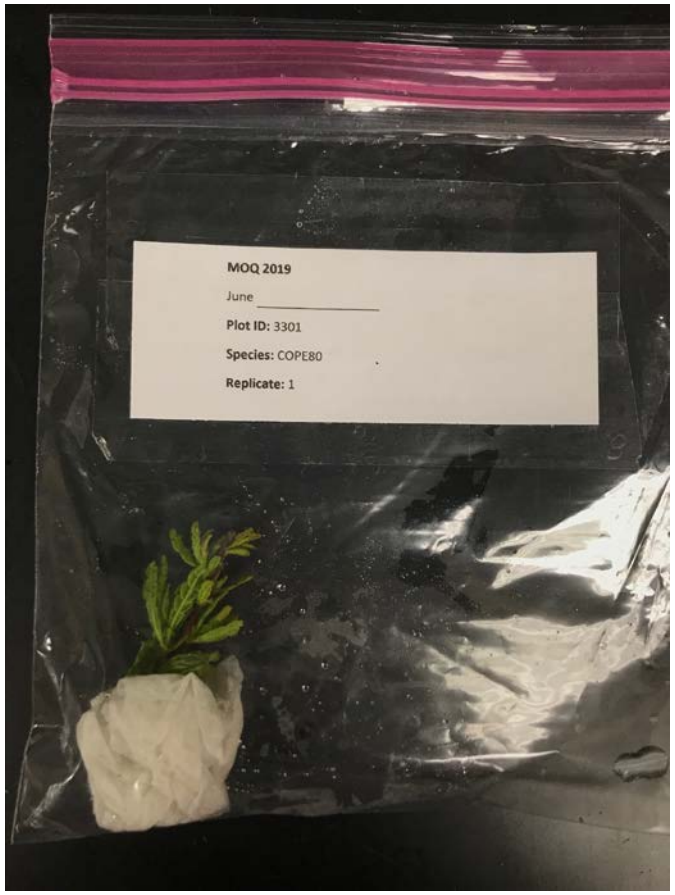
Leaves:						
Breaking leaf buds		<3	3 - 10	11 - 100	101 - 1000	
Young leaves		<3	3 - 10	11 - 100	101 - 1000	
Colored leaves (%)	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95
Flowers:						
flowers + buds		<3	3 - 10	11 - 100	101 - 1000	
open flowers (%)	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95
Fruits:						
total fruits		<3	3 - 10	11 - 100	101 - 1000	
ripe fruits	<5%	5 - 24	25 - 49	50 - 74	75 - 94	≥ 95

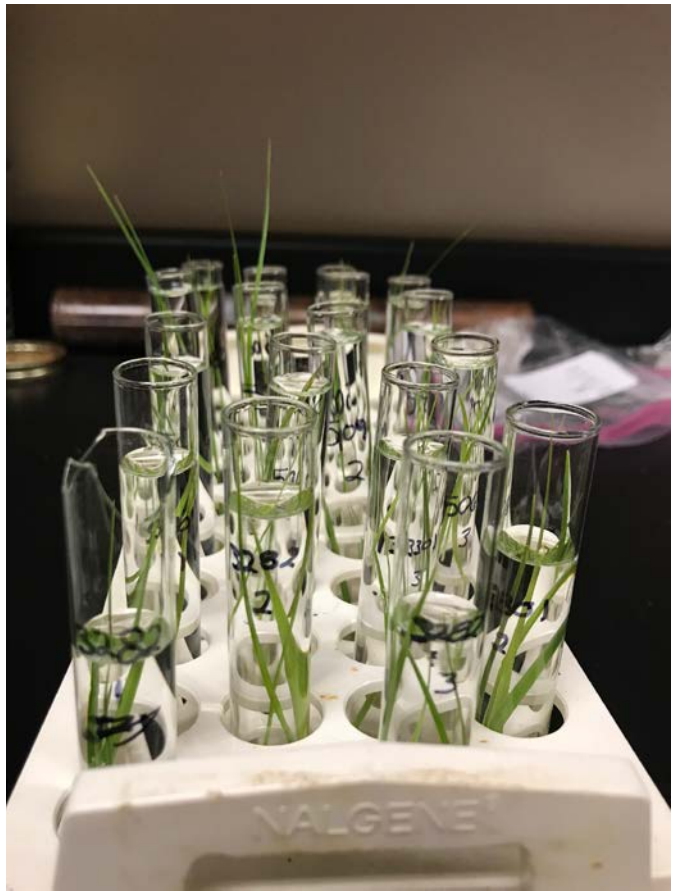
Timing of leaves, flowers, and fruits + plant height

Collecting leaves

Visited sites monthly to:

- Collect plant leaves for laboratory-based trait analysis
- Measure soil moisture & temperature



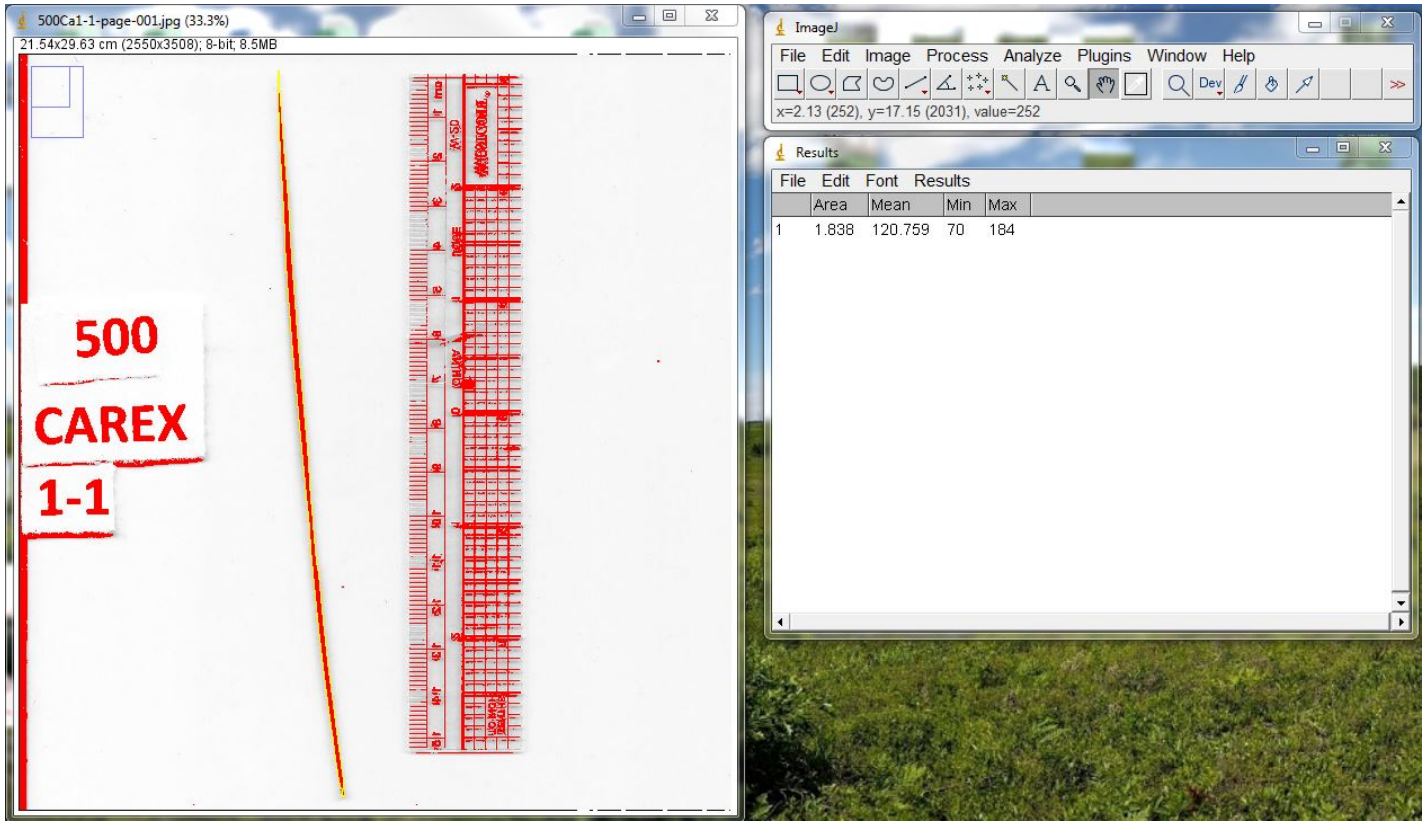


Leaf wet mass
Leaf dry mass
Leaf **D**ry **M**atter **C**ontent (dry wt / wet wt)

Measuring leaves

Leaf area: freshly collected leaves scanned & analyzed using ImageJ

-in progress at Northland College
-June and August leaf area estimates complete



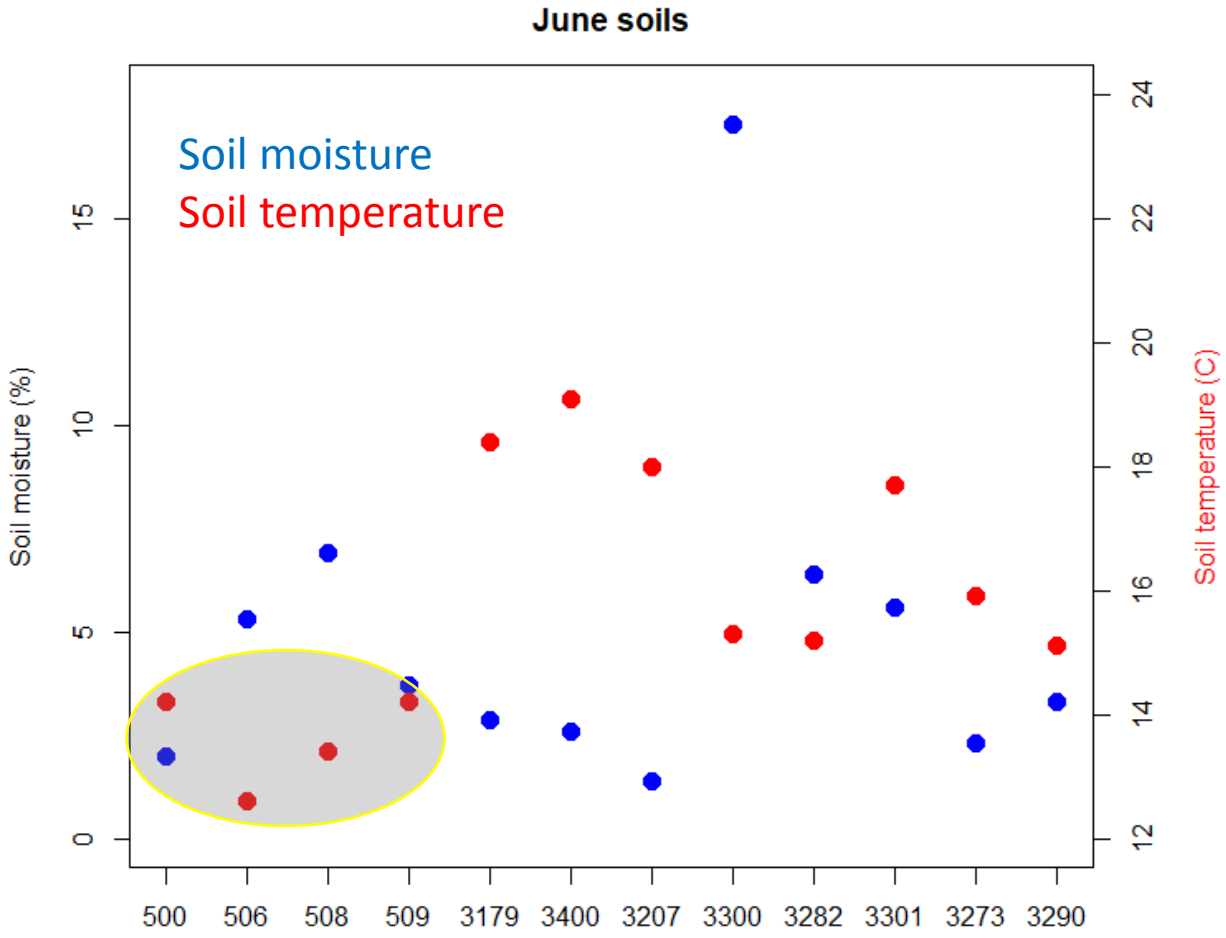
Specific **L**eaf **A**rea = surface area per mass ($mm^2\ g^{-1}$)

Plant collection

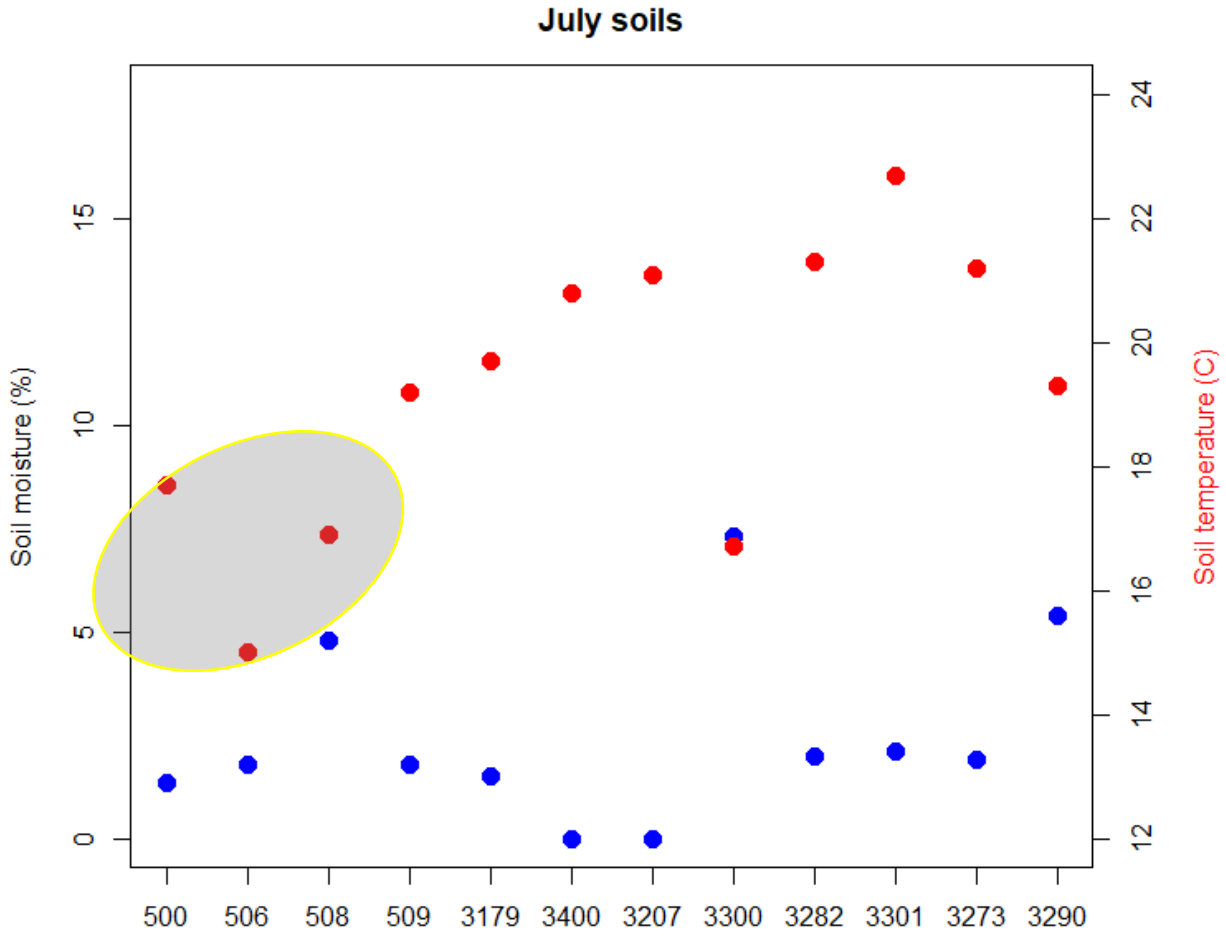
Harvested tagged plants at end of study to determine aboveground (shoot), belowground (root) biomass, and root:shoot ratio

Results: sites/soils

Long-unburned sites tend to be cooler than burned sites, despite similar moisture content

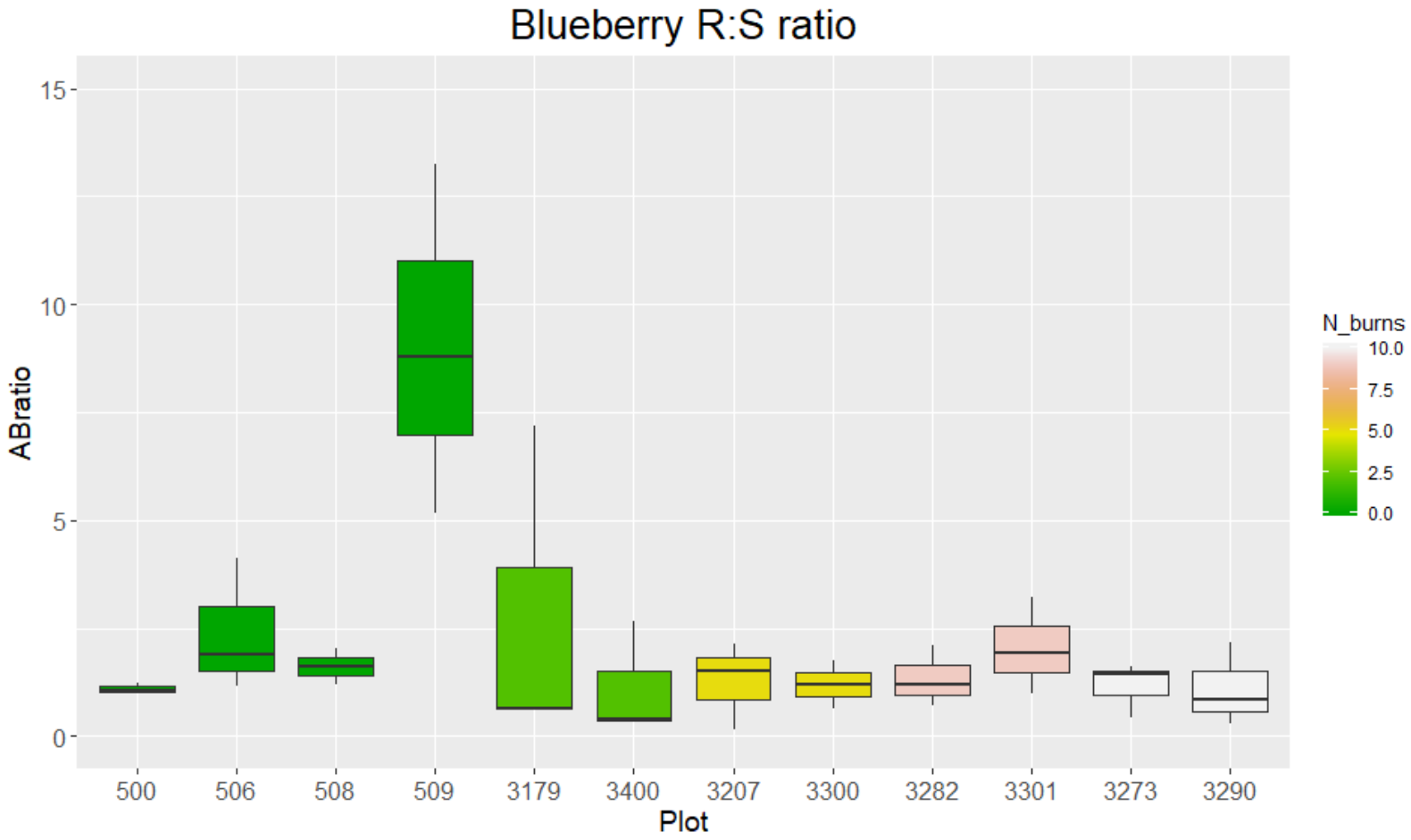


unburned 2 – 5 burns 9 – 10 burns



unburned 2 – 5 burns 9 – 10 burns

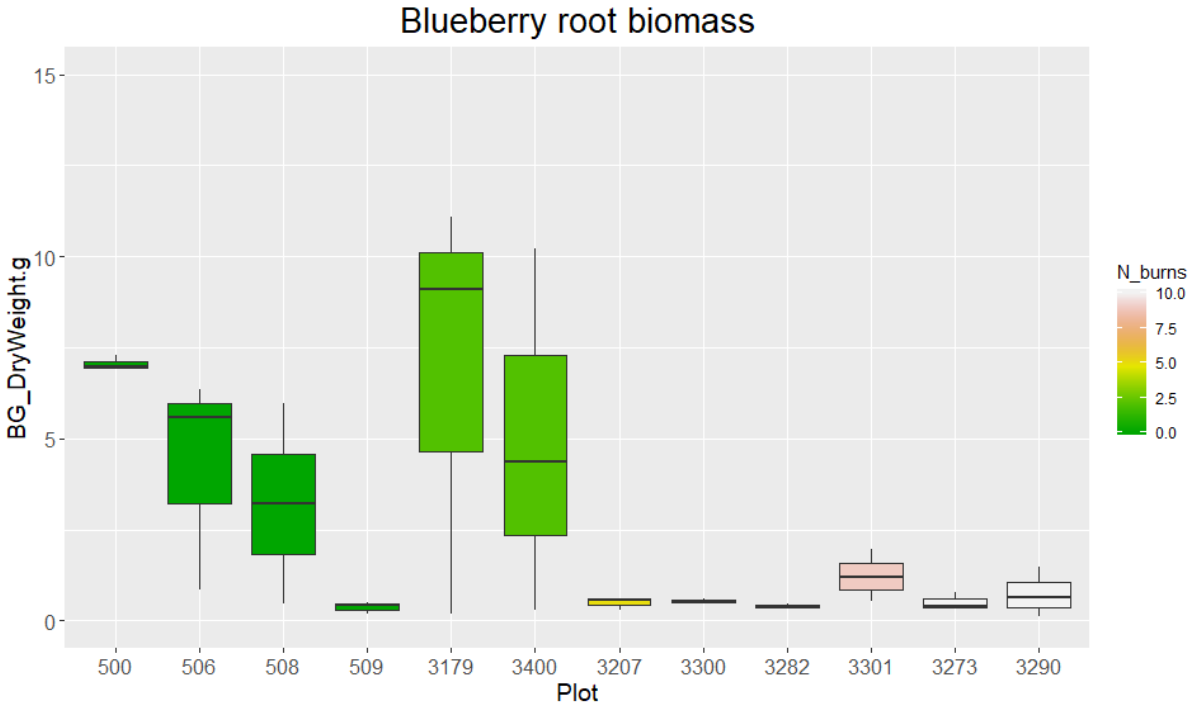
Results: Root:Shoot ratio

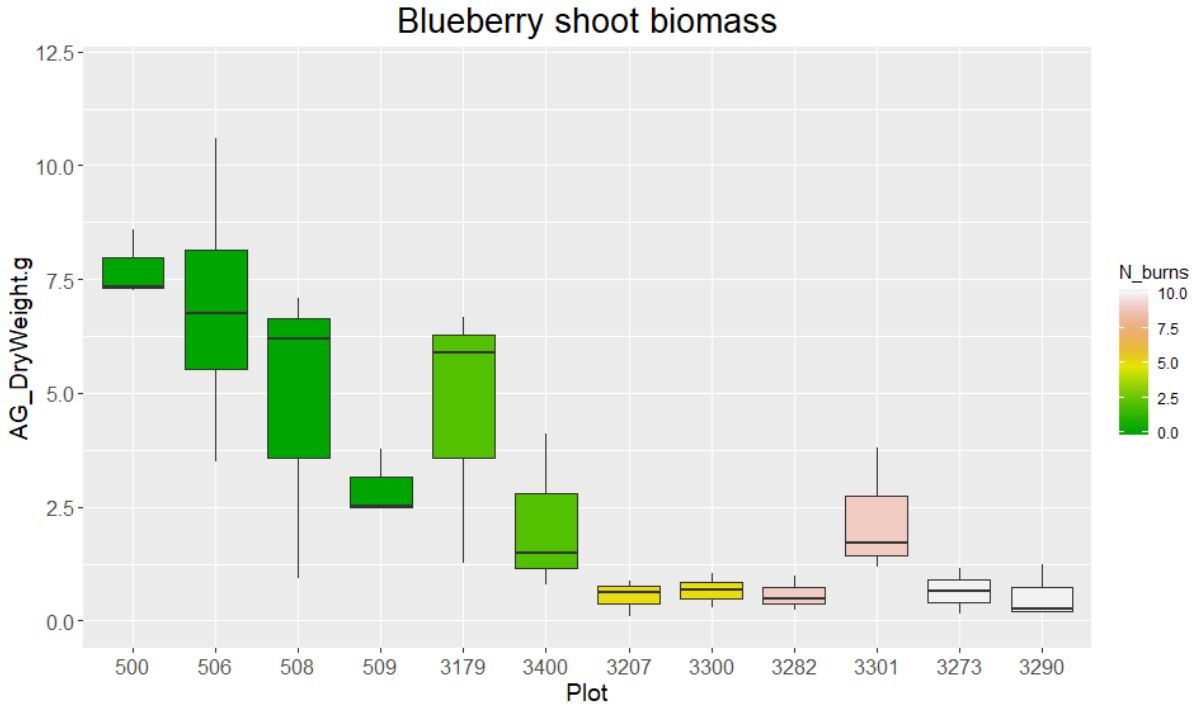


Where are plants investing their biomass (C)?

Relative investment in aboveground (photosynthetic) vs. belowground (storage) tissue similar across sites

Results: biomass

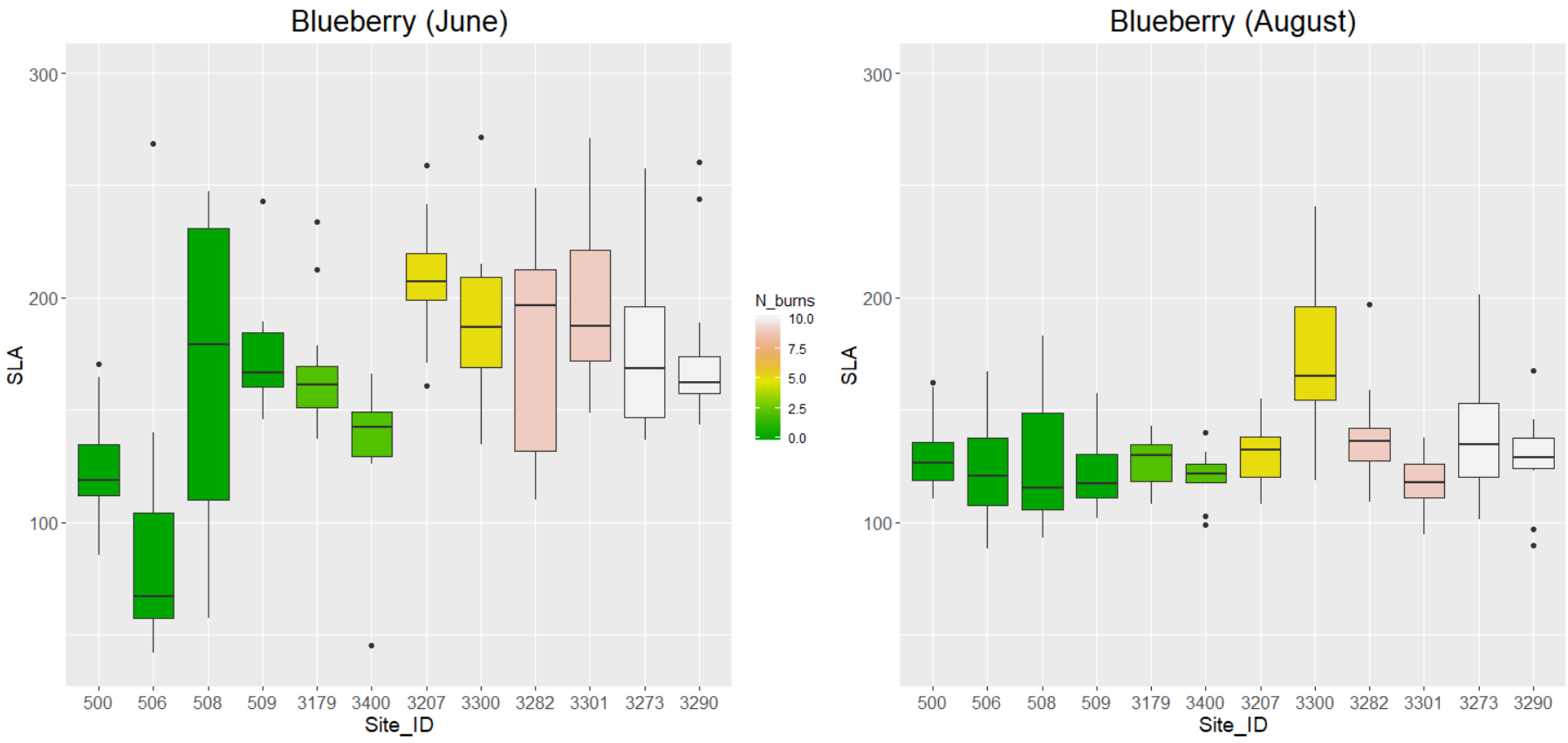




BUT, plants at sites with fewer burns had greater root and shoot biomass than frequently burned plots

Results: leaf traits

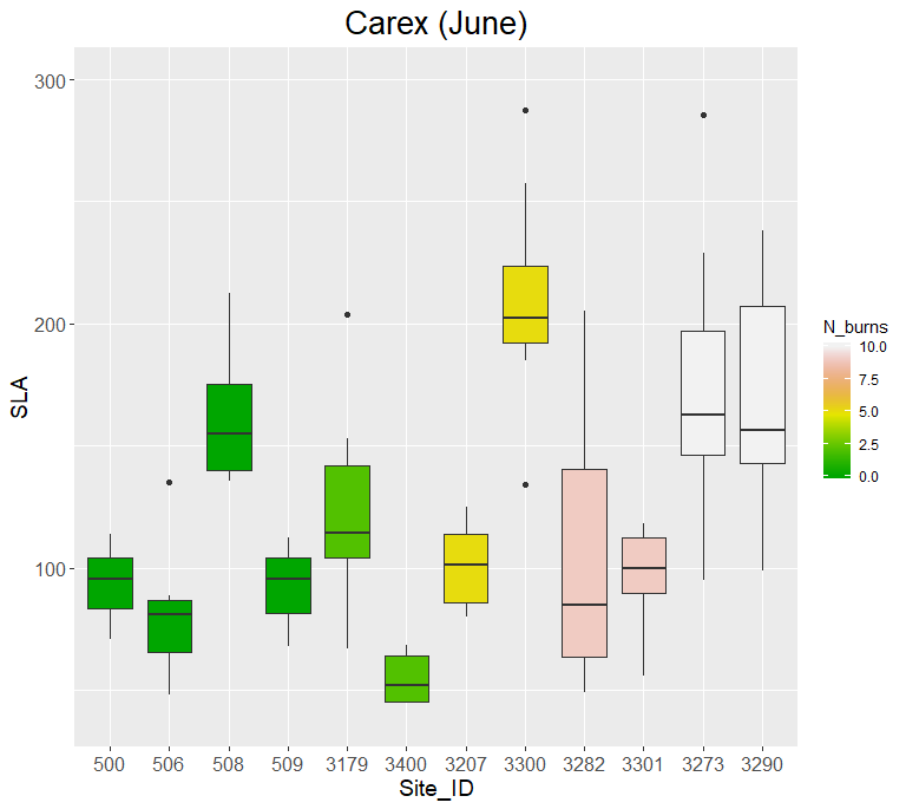
Example: specific leaf area → positively related to potential growth rate

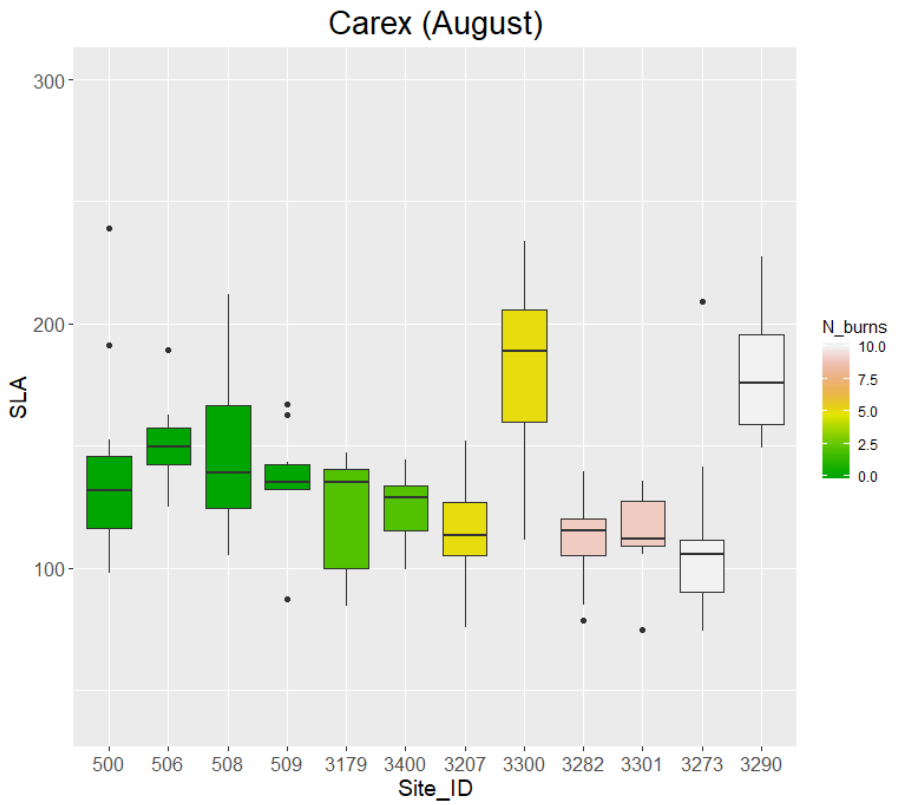


Noticeable differences in SLA in early growing season which diminished by late summer

Results: leaf traits

Example: specific leaf area





Carex SLA patterns appear to track soil moisture availability rather than differences in burn history

Phenology results: ongoing

<u>Current insights:</u>

Surveys started after some phenological events initiated

Very high initial mortality (extremely dry conditions)

100% mortality of bracken fern individuals tagged in June by July

Nature's Notebook survey categories not appropriate for Moquah

Plants here generally have stunted growth due to soil conditions

Ex: Flower/fruit counts never > 10 – 100 class

Summary of findings:

- Frequently burned sites tend to have more ‘extreme’ soil conditions
  - Hot and dry conditions might give natives a competitive advantage
- The most common barrens species (*Vaccinium*) showed the greatest amount of trait variation among study sites
- Some species showed very little trait variation
  - Evergreens (*Gaultheria*, *Arctostaphlyos*) less useful for PFT studies
- Some species more accurately reflected current site conditions
  - Grasses/sedge traits appear to be highly plastic; more sensitive to current conditions (i.e. water availability) than site-level differences

Management implications

- Tracking plant growth, phenology, and functional traits could provide useful information about resiliency of barrens communities
- Only certain species appear to respond to burn history and microclimate
  - Low, woody evergreens not informative
  - Blueberry showed greatest overall variation
  - Sand cherry (*P. pumila*) also widespread, but not investigated
- Timing, frequency, and categorical responses of phenology surveys should be adapted so appropriate for this system
  - Capture leaf bud breaking (early May)
  - Adjust survey response variables (*e.g.* count groups)

Acknowledgements

Lake States Fire Science Program - project funding
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Thank you! Any questions?