

Upland Catchment Liming in Mooseland, NS

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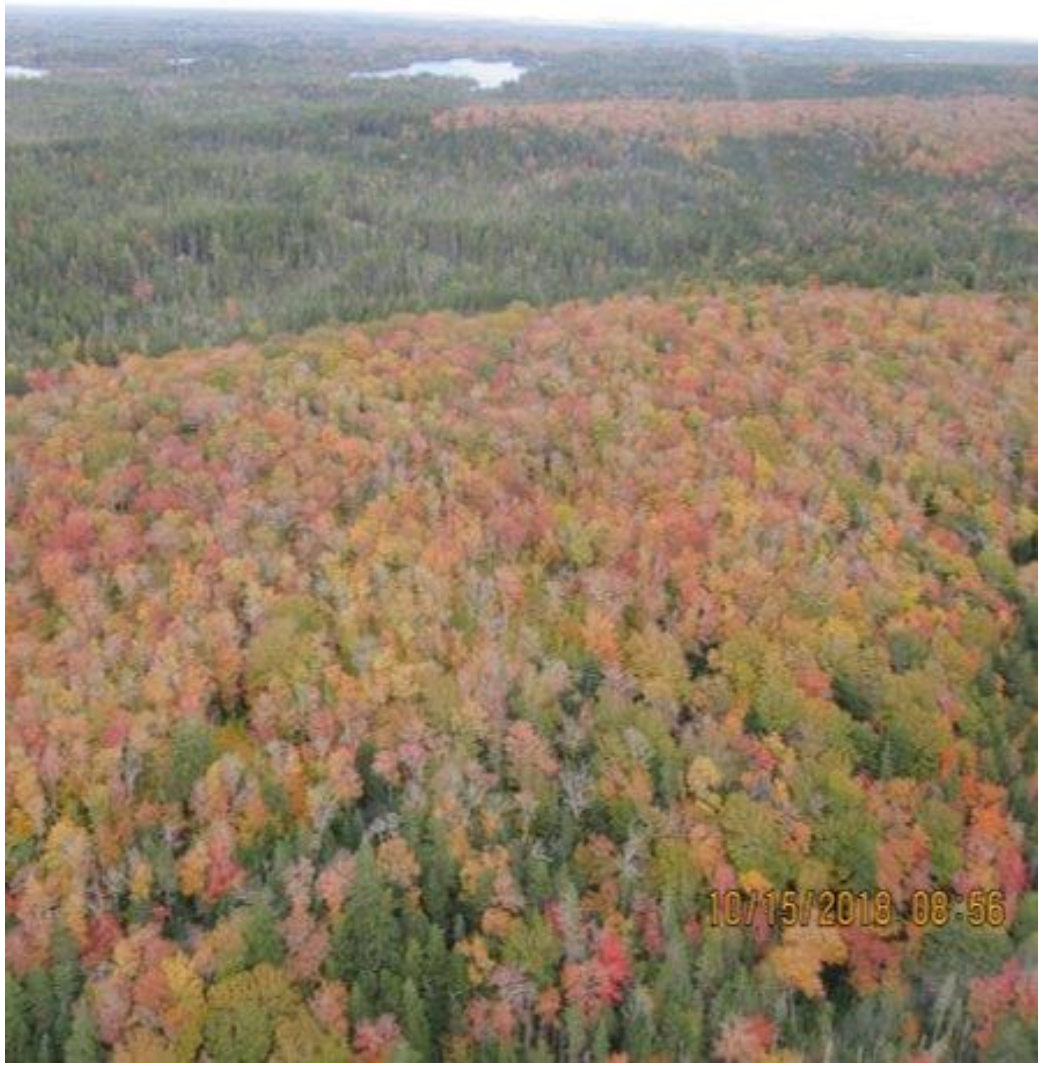
Project Overview

- Helicopter liming trial for remediation of ecosystems impacted by acid deposition
- Background (Why?)
- Objectives (What?)
- Methods/ Plot Design (How?)
- Expected results
- Preliminary results
- Significance
- Timeline (When?)

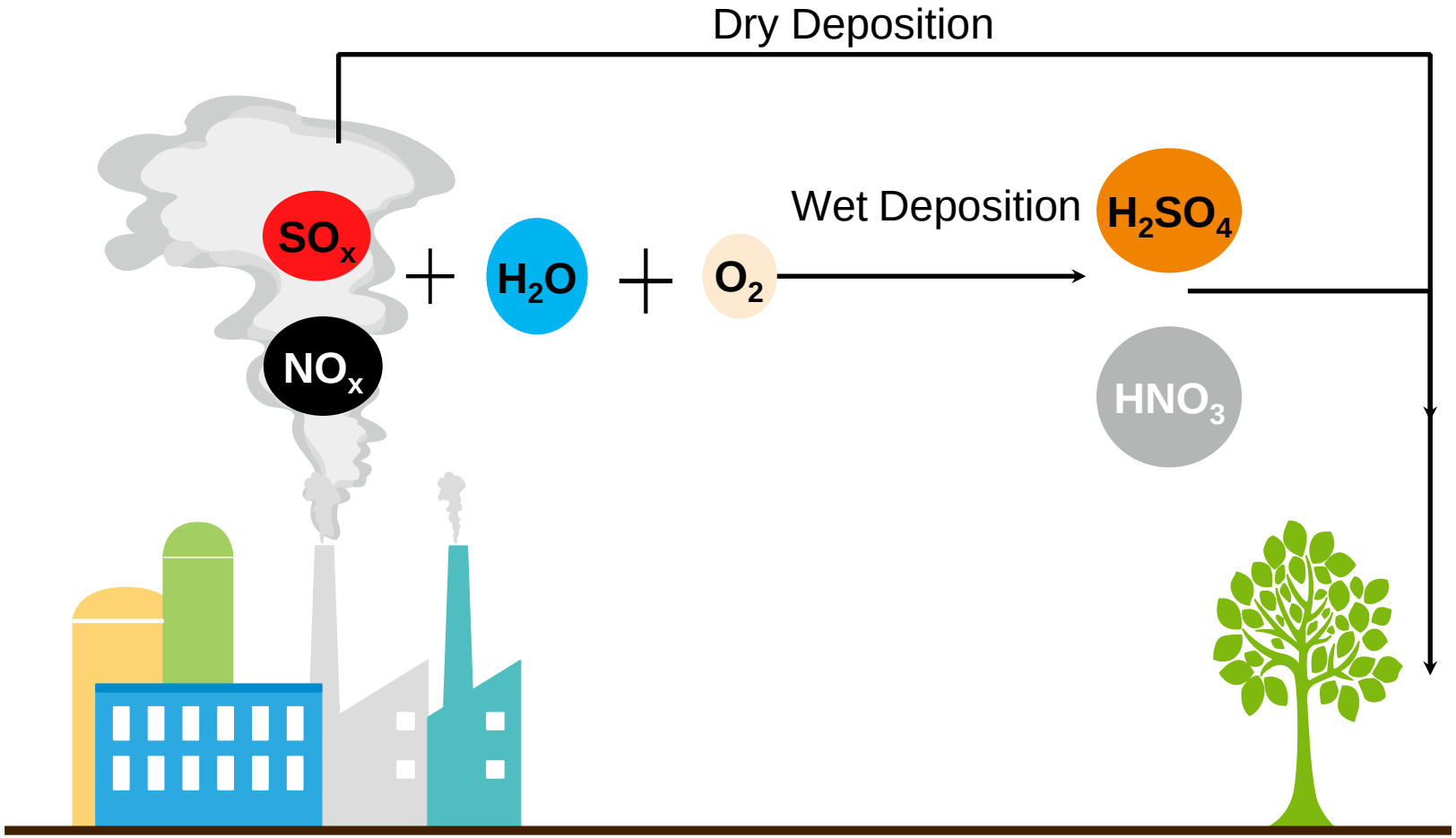


Problem

- Lingering effects from acid deposition has led to slow ecosystem recovery of
  - Soil
  - Forests
  - Aquatic systems

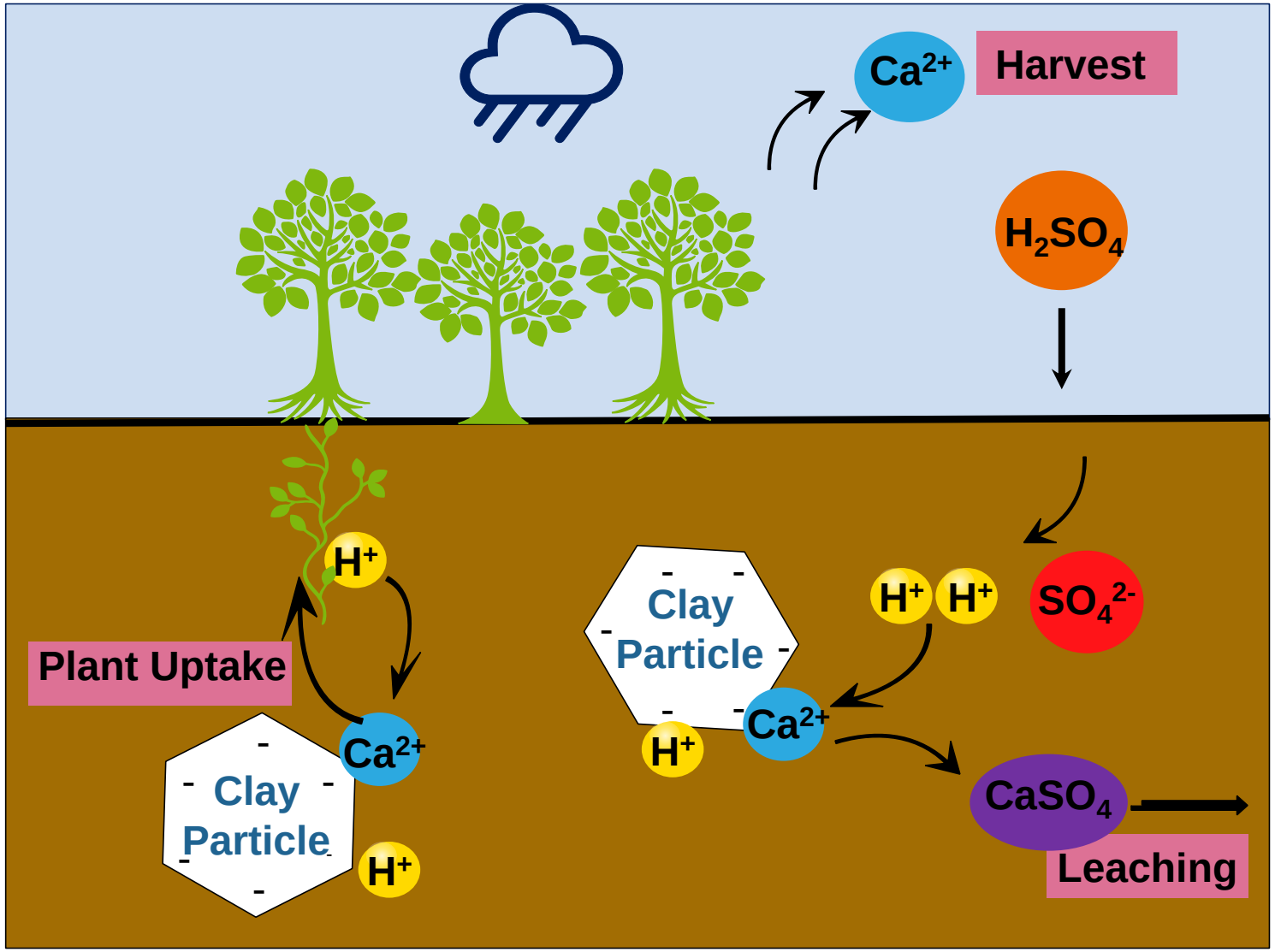
Acid Deposition

- “Acid rain” crisis in 1970
- 1990 Policy
  - Clean Air Act
  - Reduced emissions

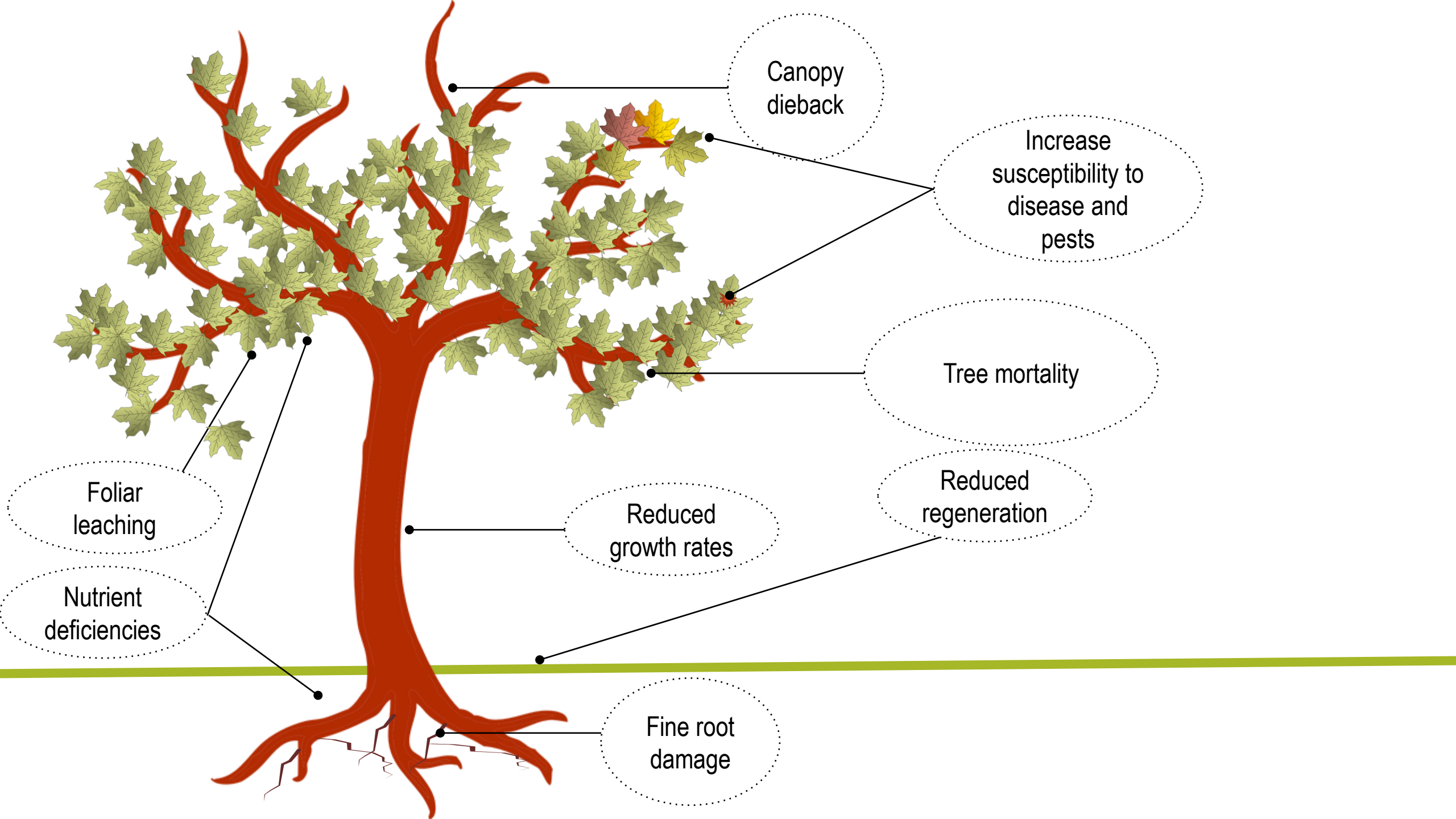


Soil Acidification

1. Decreased pH
2. Leaching of essential nutrients such as calcium (Ca), magnesium (Mg), and potassium (K)
3. Mobilization of toxic aluminum (Al)

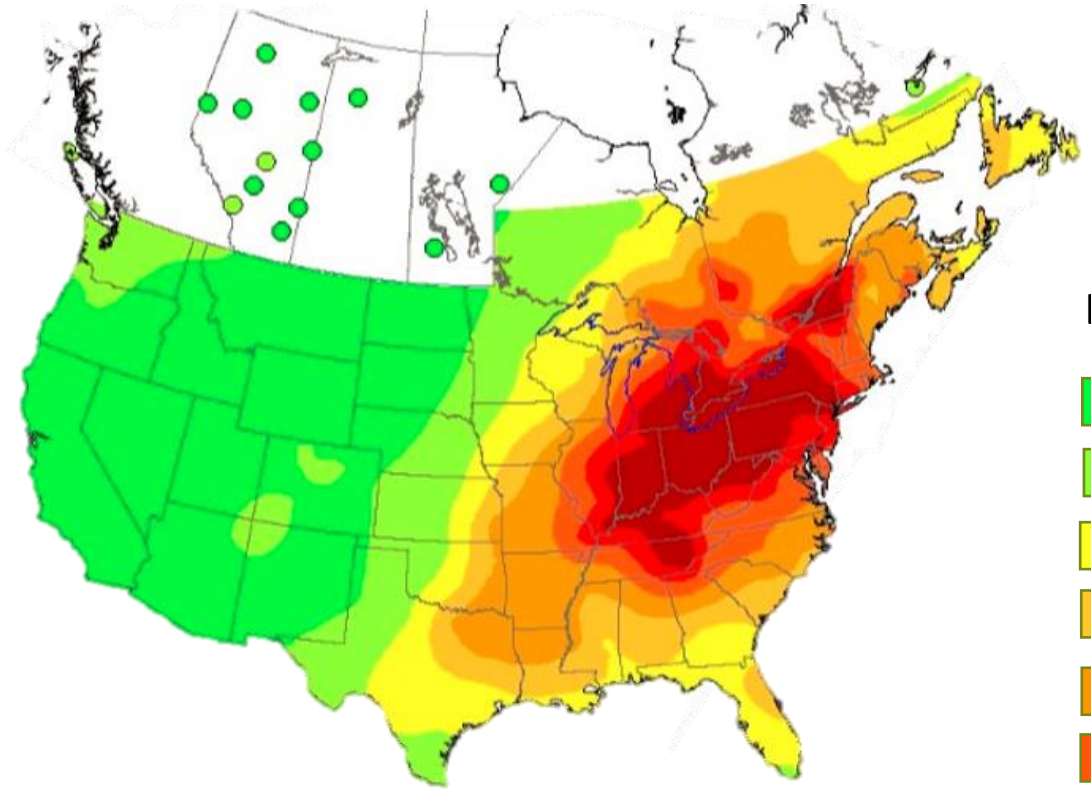


(Sterling et al., 2014; NCC 2010; Moore, 2014)


Canopy dieback
Increase susceptibility to disease and pests
Tree mortality
Reduced regeneration
Reduced growth rates
Foliar leaching
Nutrient deficiencies
Fine root damage

Acid Deposition: Sulfate

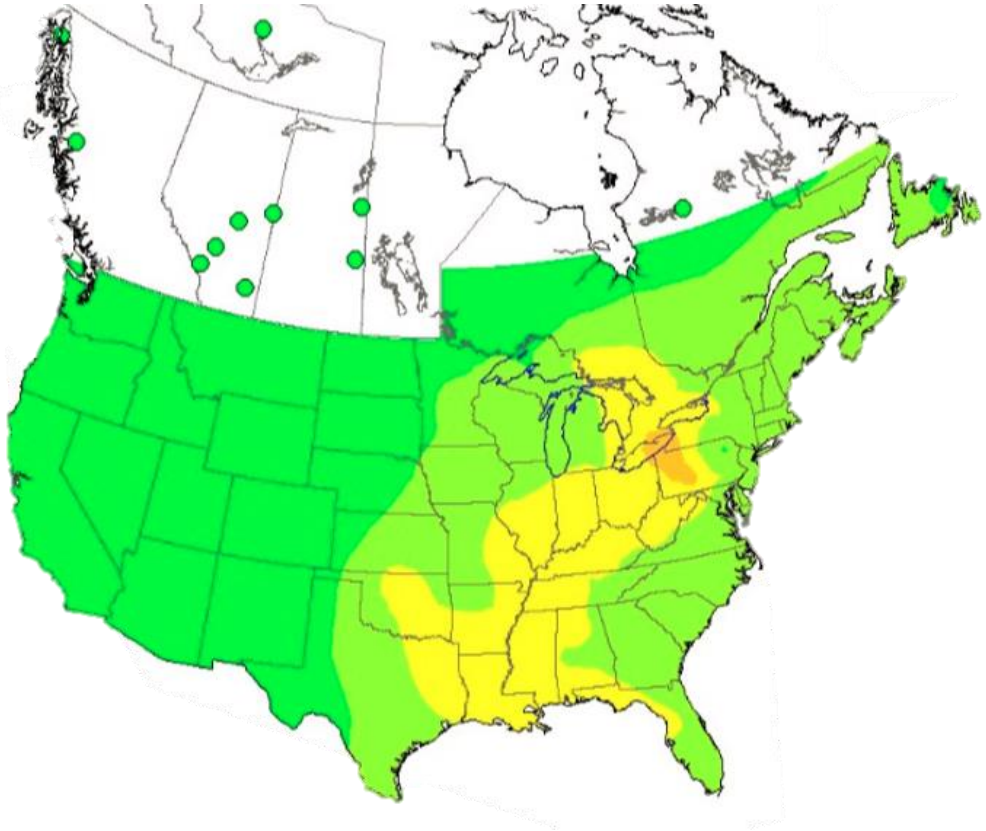
1990



Kg/ha/yr

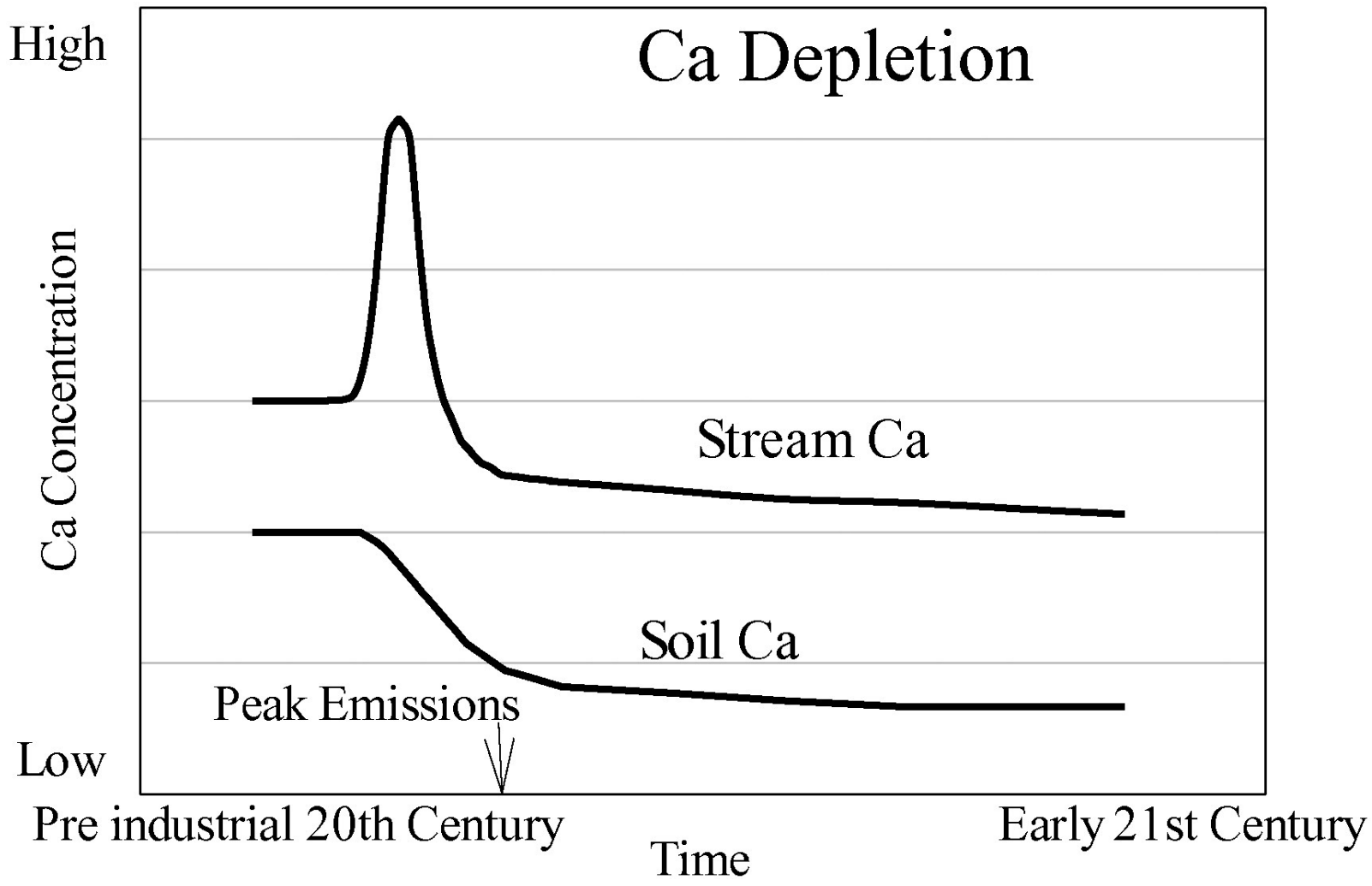
- 0.4-4
- 4-8
- 8-12
- 12-16
- 16-20
- 20-24
- 24-28
- 28-44.8

2014

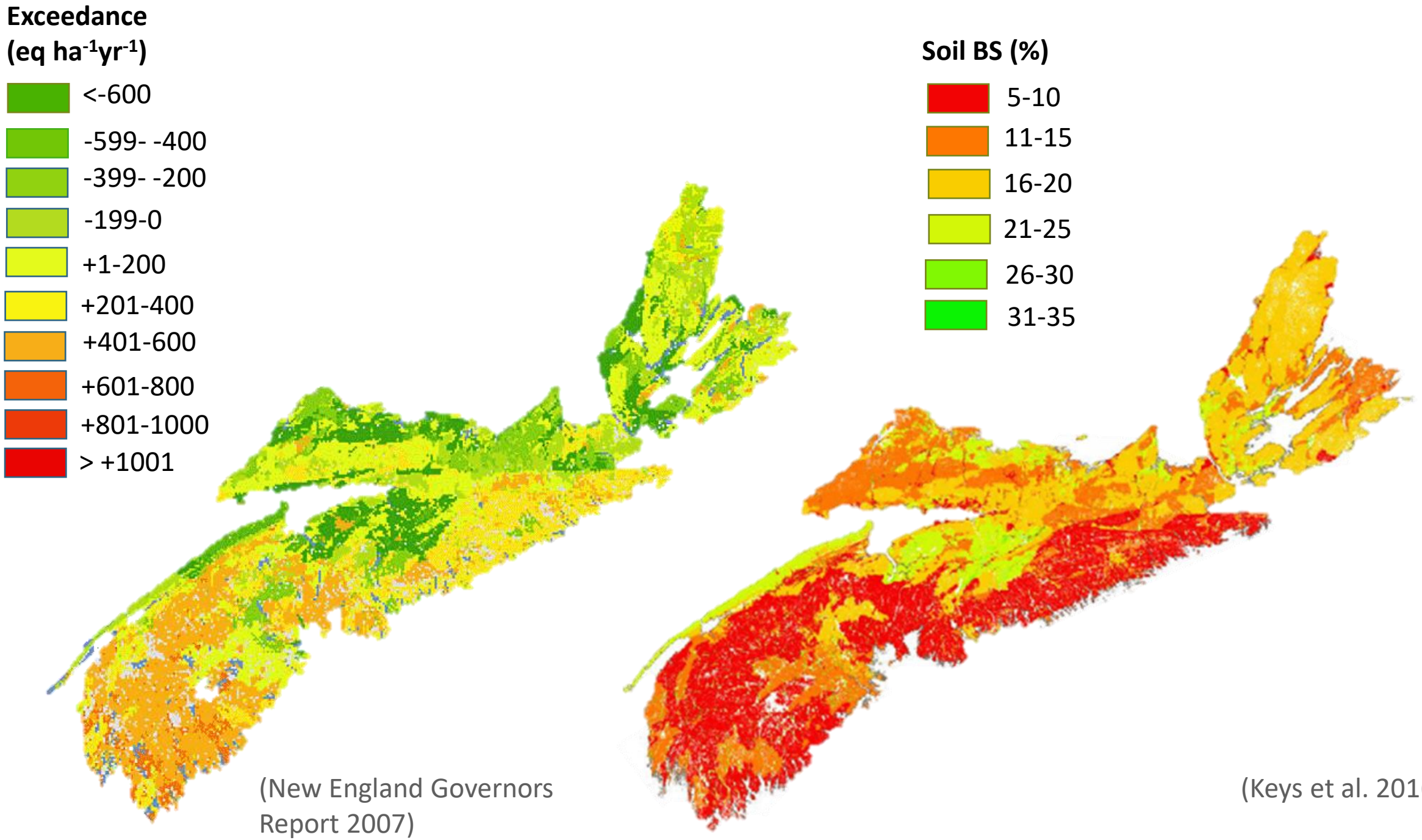


Canada-US Air Quality Agreement

Have reductions in emissions been enough to allow forests to recover?

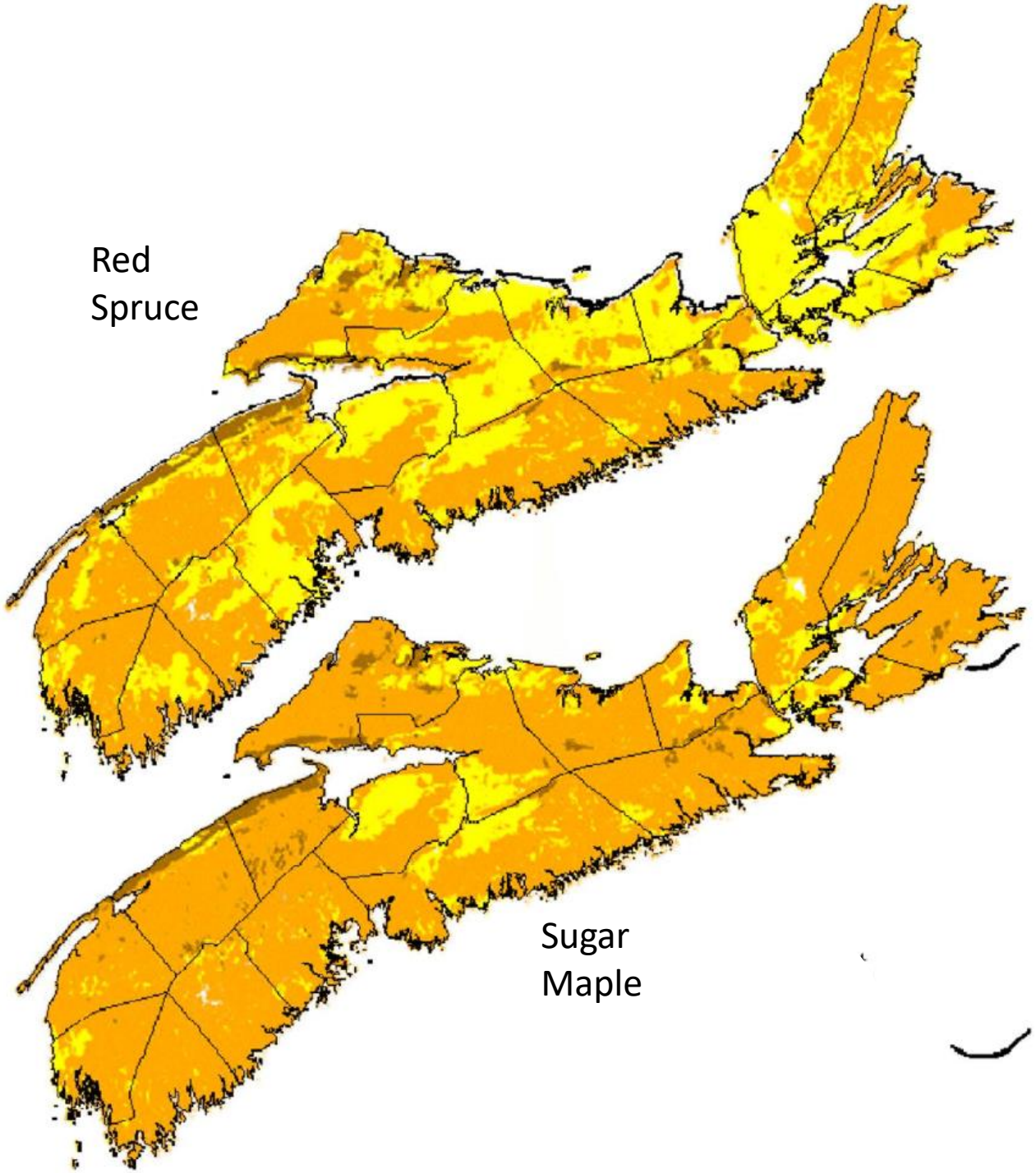


(Lawrence et al. 2016)



(New England Governors Report 2007)

(Keys et al. 2016)



Ca

K

N

Mean Annual Increment (MAI) Limiting Nutrient in Nova Scotia

(Keys et al. 2016)

Liming as a Soil Amendment

- Commonly used in agriculture
- Dolomitic limestone
- The application of a Ca/Mg carbonate amendment to deacidify soil through proton buffering

$$CaMg(CO_3)_2 + 2H^+ \rightarrow Ca^{2+} + Mg^{2+} + 2HCO_3^-$$

Liming as a Soil Amendment

- Lime has been used in many areas of the world to help restore damaged ecosystems
- Direct stream liming is currently being done is Nova Scotia
- The effects of liming are variable depending on site conditions
  - Naturally acidic soils
  - Acid sensitive species (sugar maple)
- Potential down stream effects

Objectives

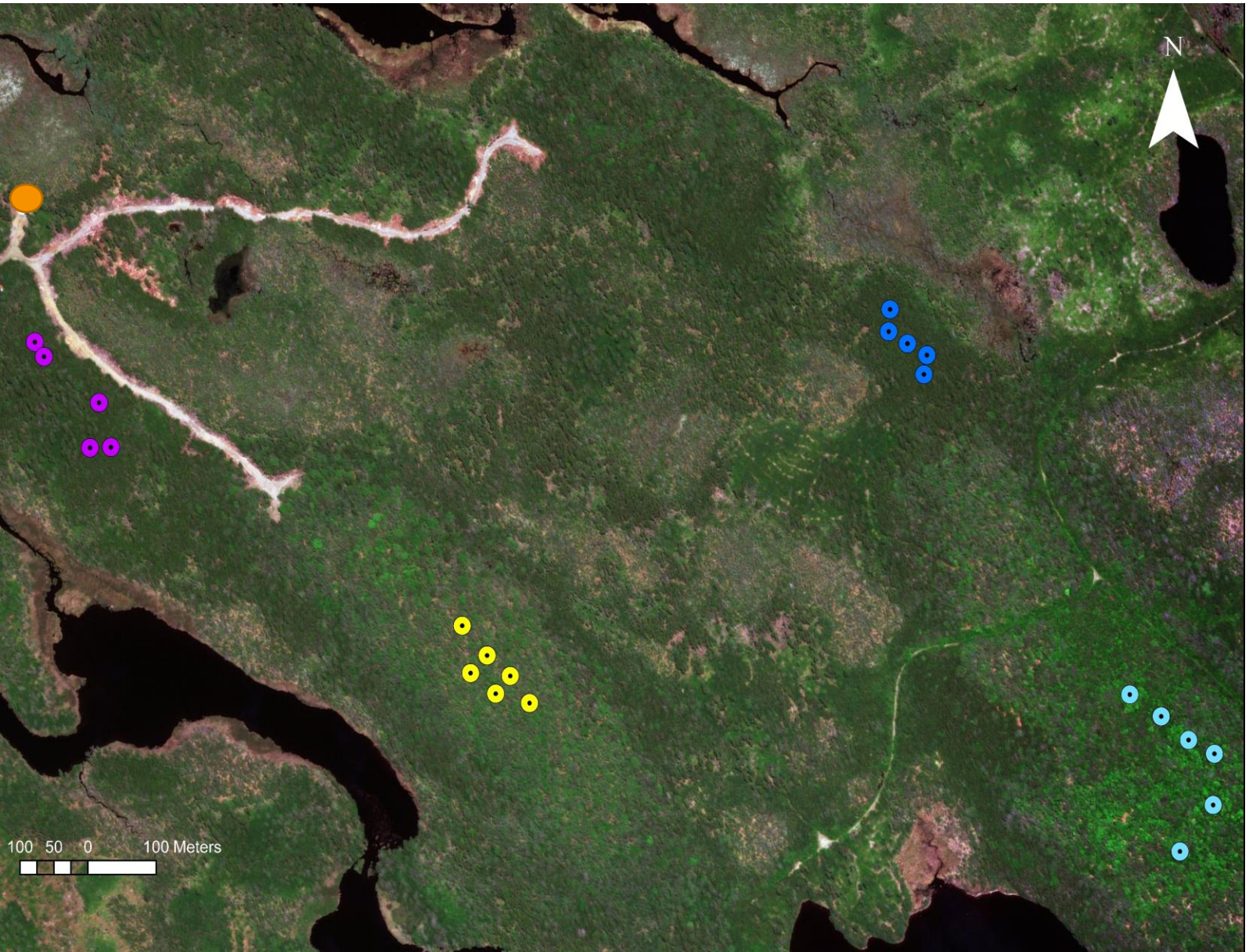
To set-up and monitor a long-term liming trial in Mooseland, NS to assess whether it is an effective ecosystem restoration tool.

- **Long-term RQ:** How does this forest and other ecosystems respond to liming?
- **Short-term RQ:** What is the short-term effects of dolomitic limestone application on forest floor, mineral soil and foliar nutritional status?

Location (Why Otter Ponds?)

- Both Softwood and Hardwood Plots
- Sugar maple and red spruce
- Soils with low base saturation
- Near lime site
- Associated with West River liming project

Experimental Design



- Hardwood Control
- Softwood Control
- Hardwood Treatment
- Softwood Treatment
- Gazebo

Treatment: Dolomite ($CaMg(CO_3)_2$)

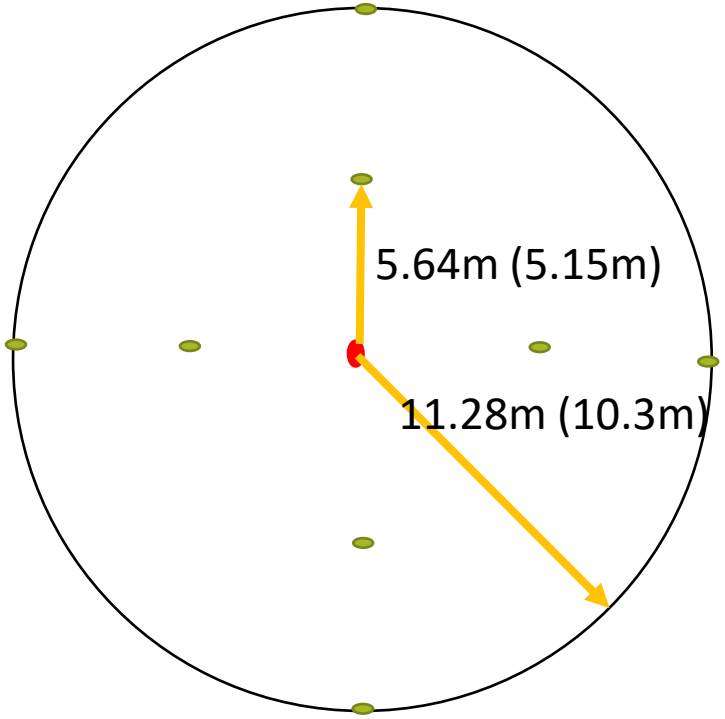
October 2018

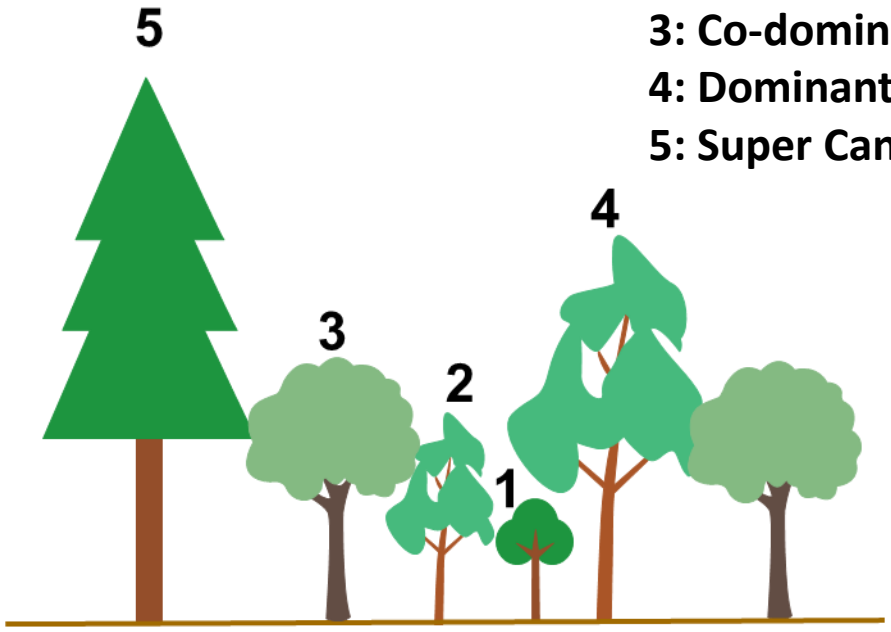
Permanent Sample Plots (Growth Plots)

NSDNR (2006)

Data Collection (Growth Plots)

- Species
- Height
- DBH
- Class
- Tree health
  - Crown health
  - Defects
- Regeneration
- Forest floor analysis





1: Suppressed
2: Intermediate
3: Co-dominant
4: Dominant
5: Super Canopy

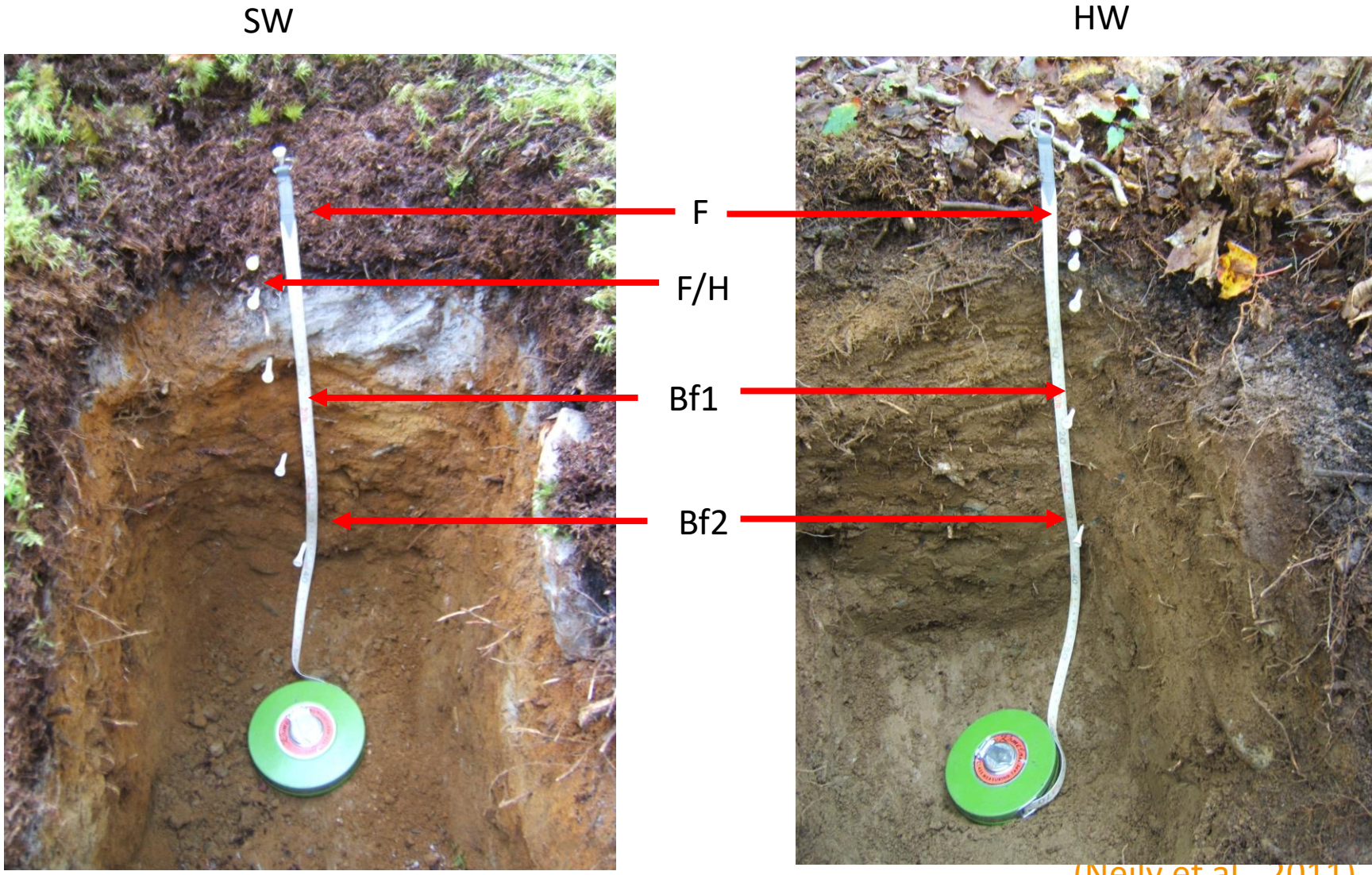
(Korhonen and Keikkinen, 2009; Zarnoch et al, 2004; NSDNR, 2006)

Sample Collection

Site	
Hardwood	Softwood
Tree Species	
Sugar maple, Red maple	Red spruce
Class	
Intermediate, Co-dominant	Co-dominant
Samples	
Foliage, Wood, Bark	Foliage, Wood, Bark
Vegetation	
Wood fern	Schreber's moss

Sample Collection

- Horizons identified and measured
- Hardwood
  - F
  - Bf1
  - Bf2
- Softwood
  - F
  - F/H transition
  - Bf1
  - Bf2



(Neily et al., 2011)

Laboratory Analysis

Plant Tissue

- Total C/N/S
- Total **Ca**/**Mg**/K/Na/P/**Al**/Mn

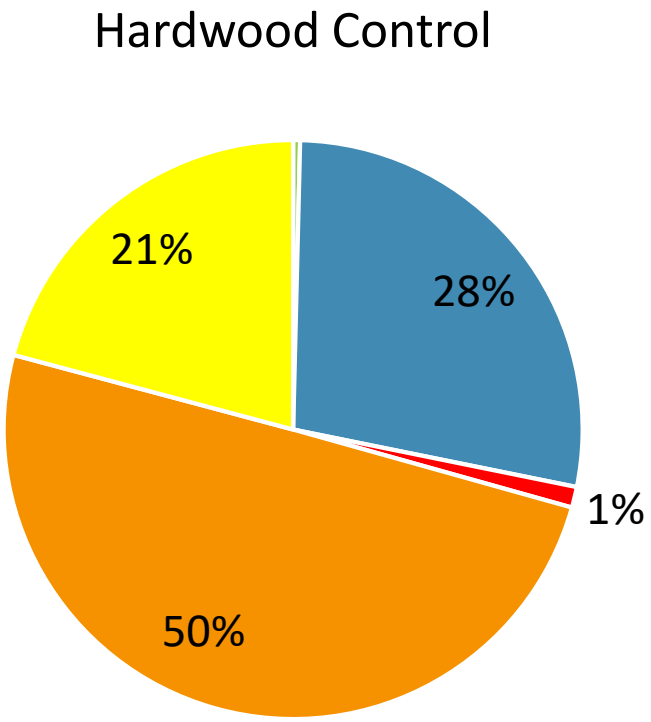
Soil (forest floor + mineral soil)

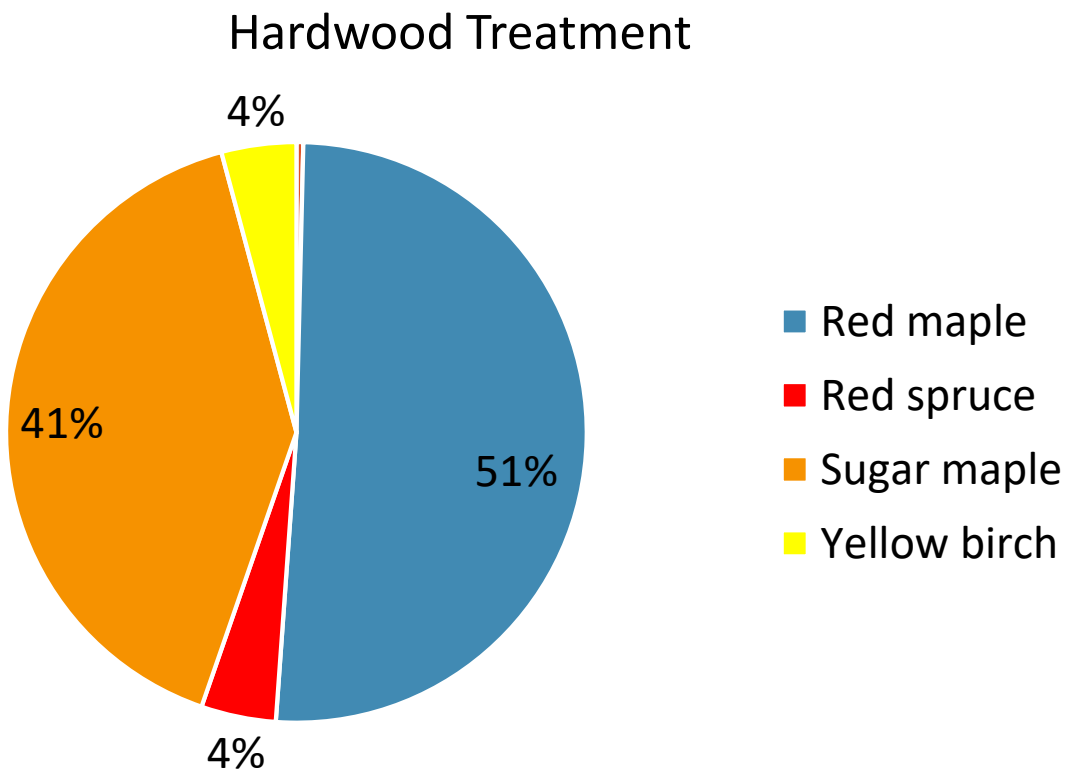
- pH
- Base cation concentrations
- Total C/N/S
- Exchangeable NH_4^+ and NO_3^-
- Exchangeable acidity and Al^{3+}
- Texture

Preliminary Data

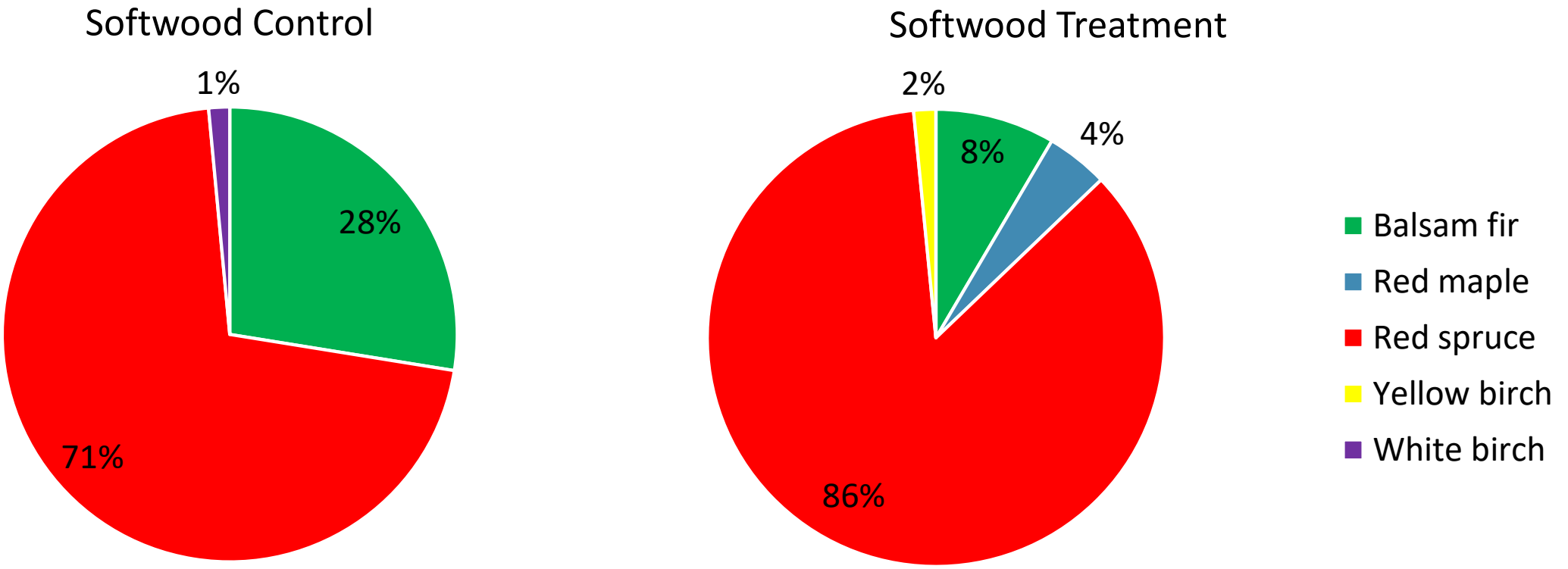
- What has been collected?
  - First year samples
    - Waiting get data back from lab
  - DBH
  - Species
  - First year regeneration

Species Composition

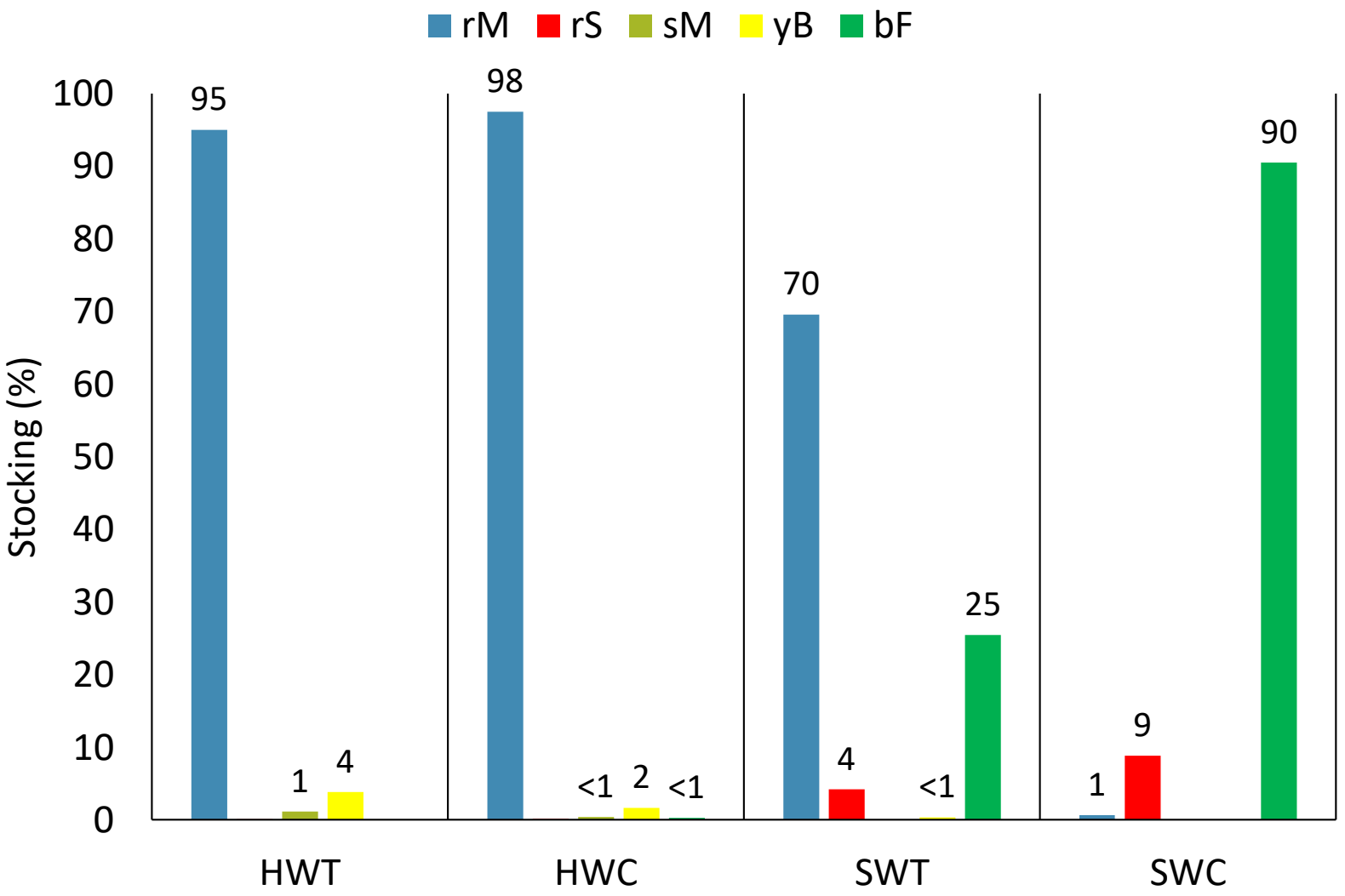




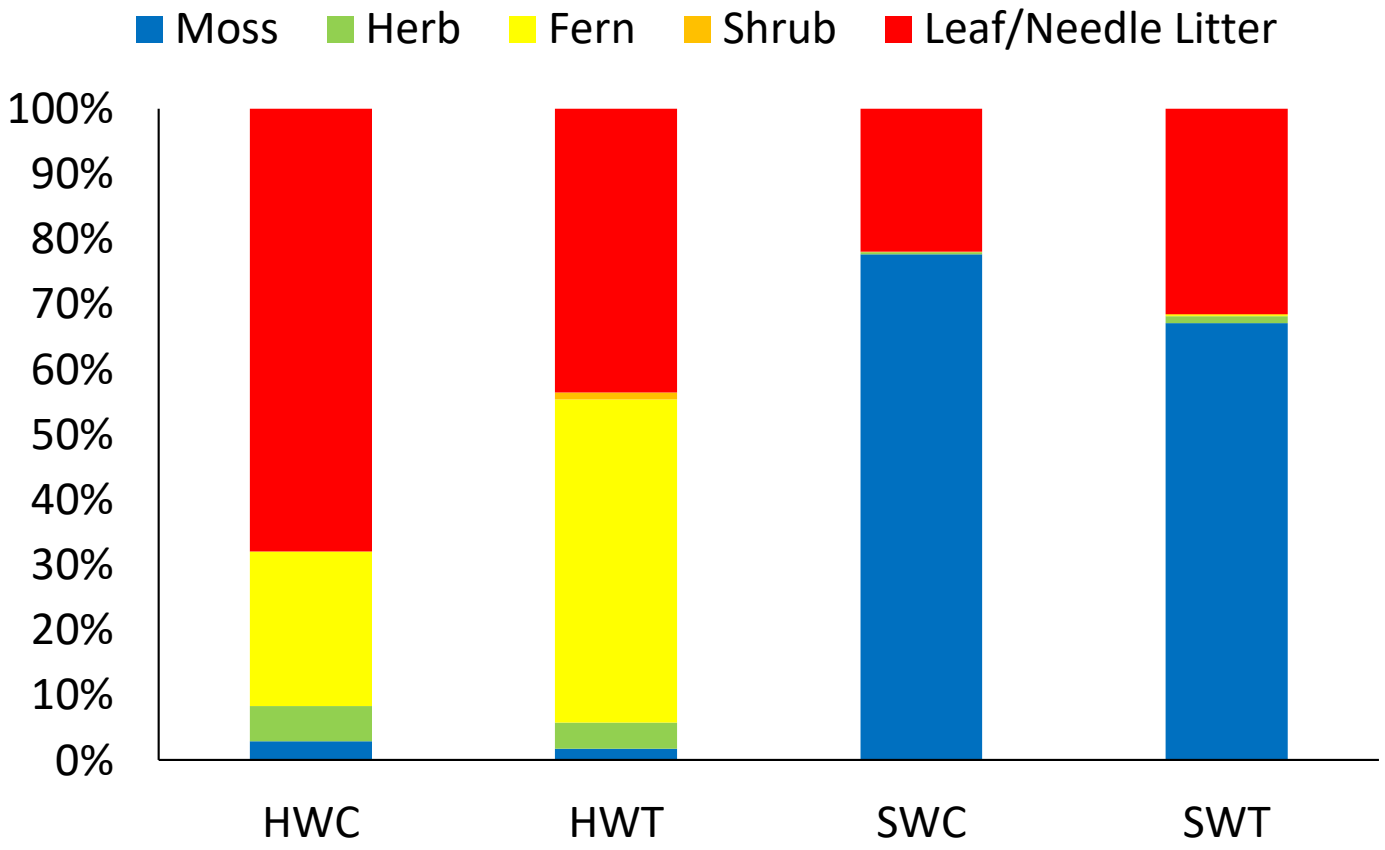
Species Composition



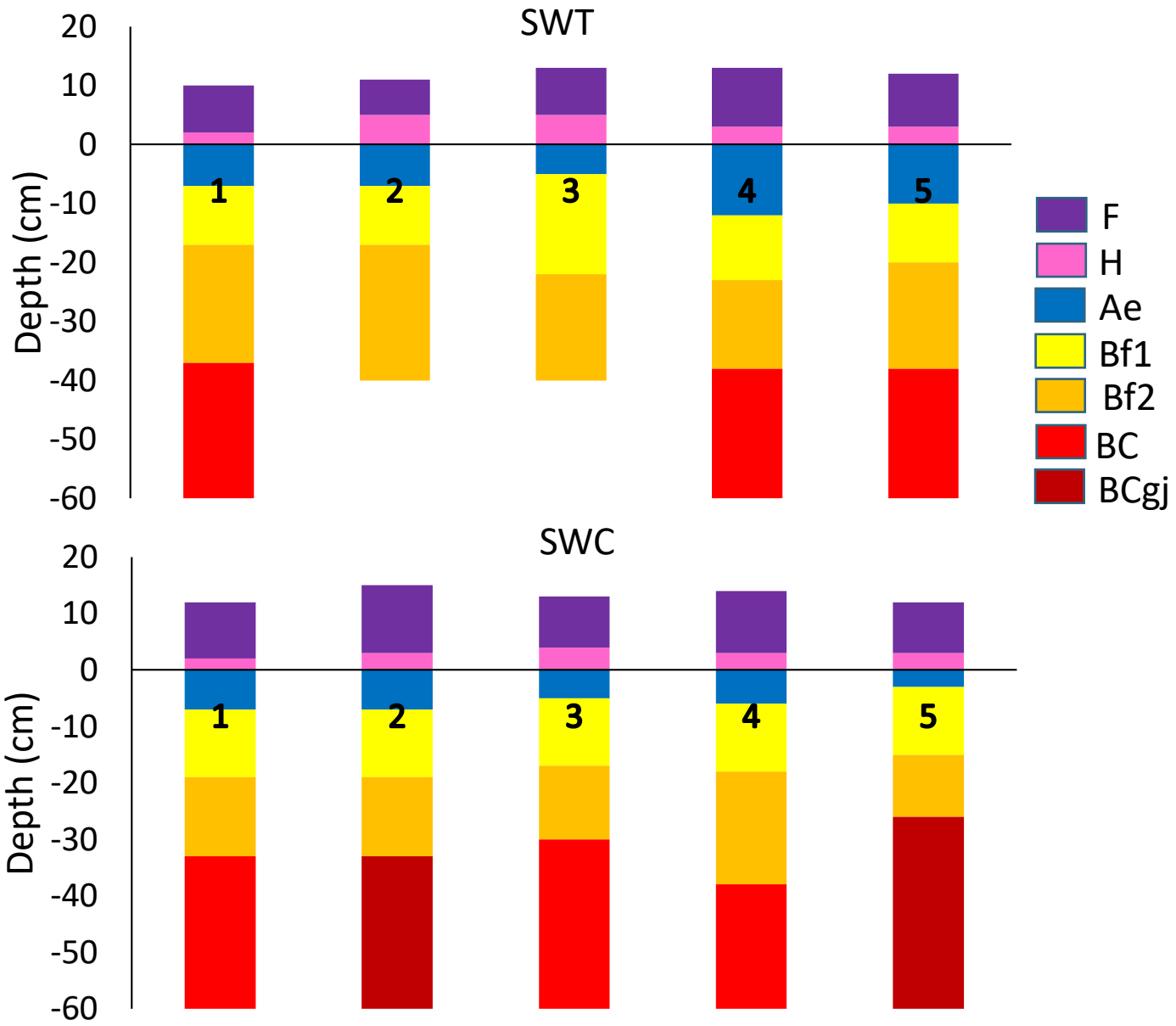
Regeneration



Ground Vegetation

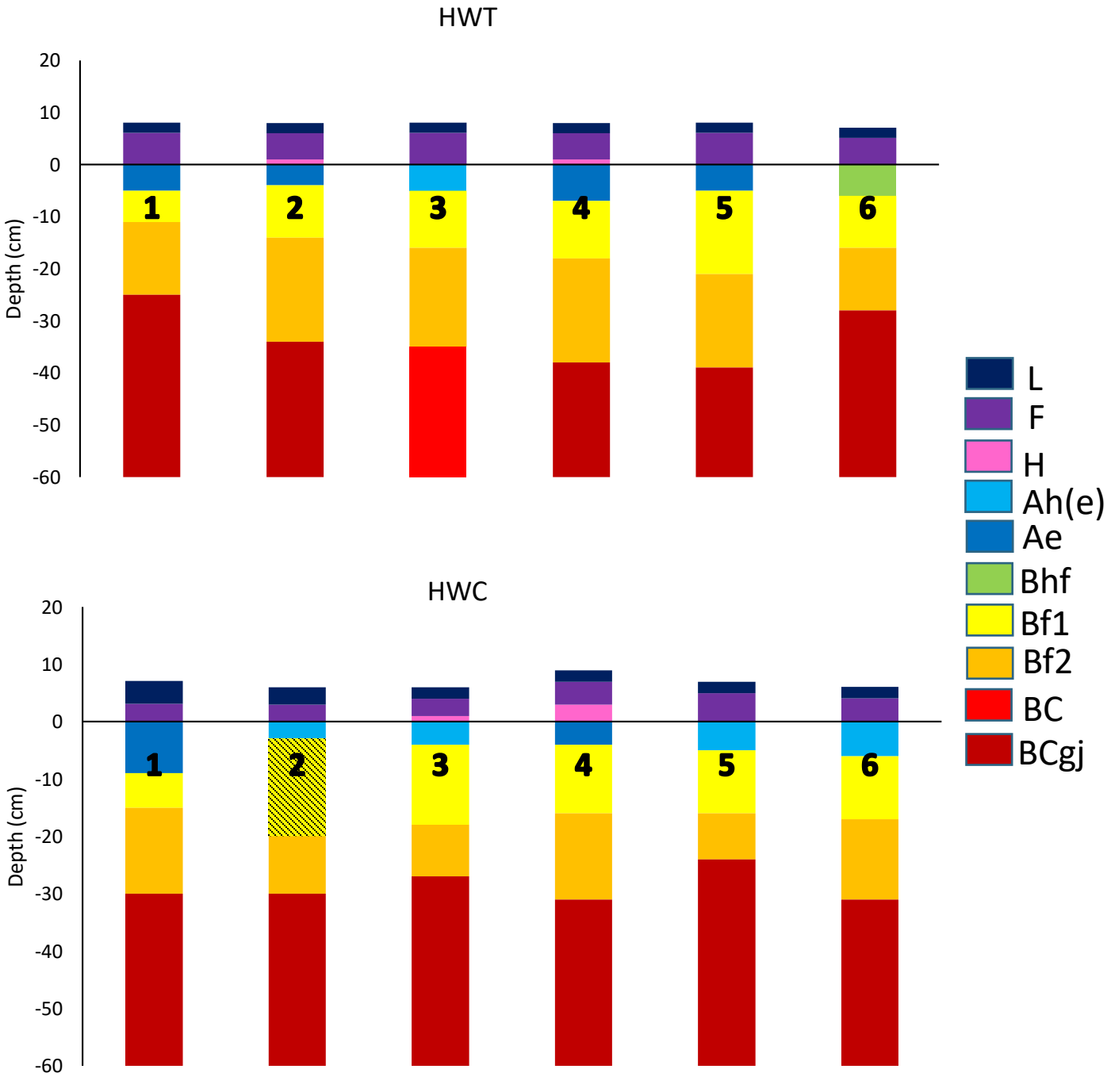


Soil Sampling



SWT 5

SWC 1


HWT
20
10
0
-10
-20
-30
-40
-50
-60
Depth (cm)
1
2
3
4
5
6
HWC
20
10
0
-10
-20
-30
-40
-50
-60
Depth (cm)
1
2
3
4
5
6
L
F
H
Ah(e)
Ae
Bhf
Bf1
Bf2
BC
BCgj

HWT 6

HWC 1

Expected Results

- Short-term
  - Potential increase in forest floor and mineral soil
    - pH
    - BS
    - CEC
    - Ca, Mg
  - Potential decrease in soil exchangeable acidity
  - Nutrient ratios
    - Al: Ca/Mg decrease
    - Increases in Ca/Mg/K (Ca:K antagonism)
    - Decrease in Al, Mn
- Long-term
  - Tree growth
  - Tree health
  - Regeneration
  - Mineral soil chemical analysis
  - Forest floor morphology and chemical analysis
  - Tree tissue chemistry

Timeline

- May 2019-Oct 2019
  - Year 2 of sample and data collection
- Oct 2019-Apr 2020
  - Data analysis and writing
- Summer/Fall 2021
  - Soil and vegetation sampling
- Summer/Fall 2023+
  - Soil/ Vegetation sampling

Significance

- Mitigation of acid deposition effects on forest health and productivity
  - Potential for use in forestry
- Trickle-down effect to streams and other ecosystems
  - Improve forest and stream habitats for acid sensitive species

Thank You

Questions?

Crown height

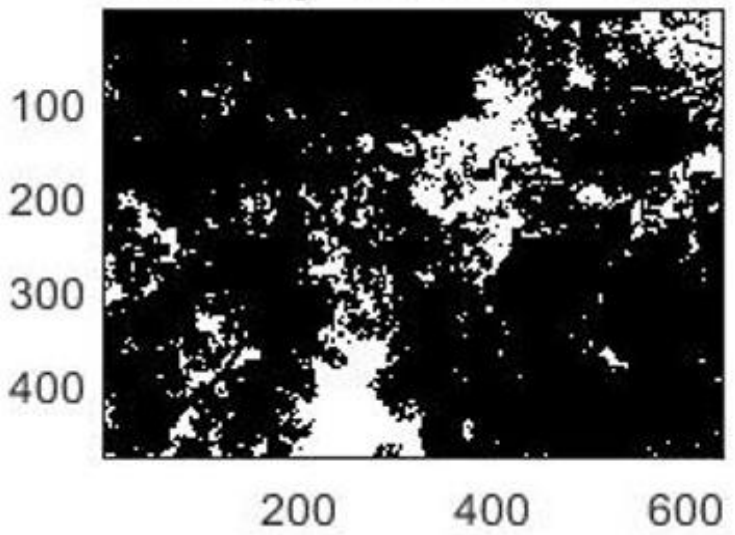
Crown dieback

Crown diameter

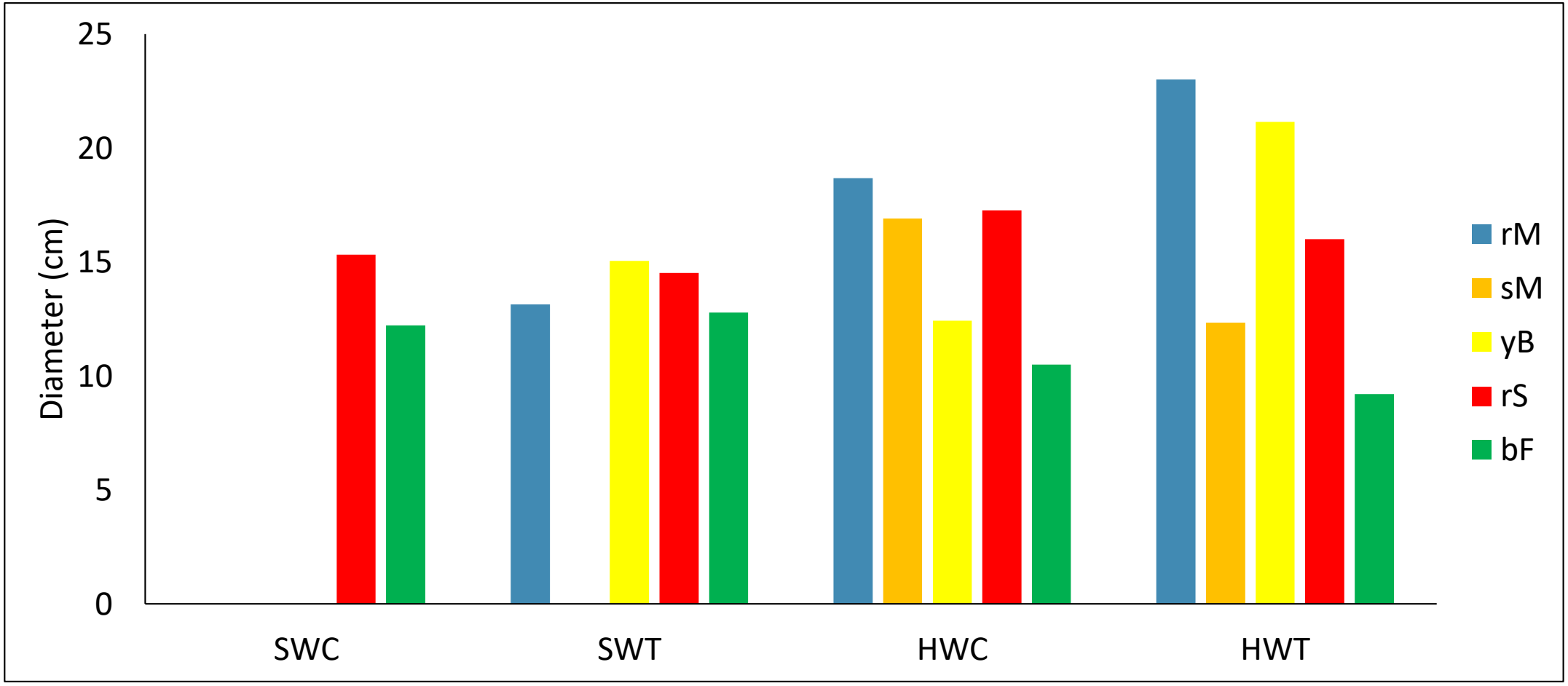
Crown transparency

Defects

Canopy closure =84%

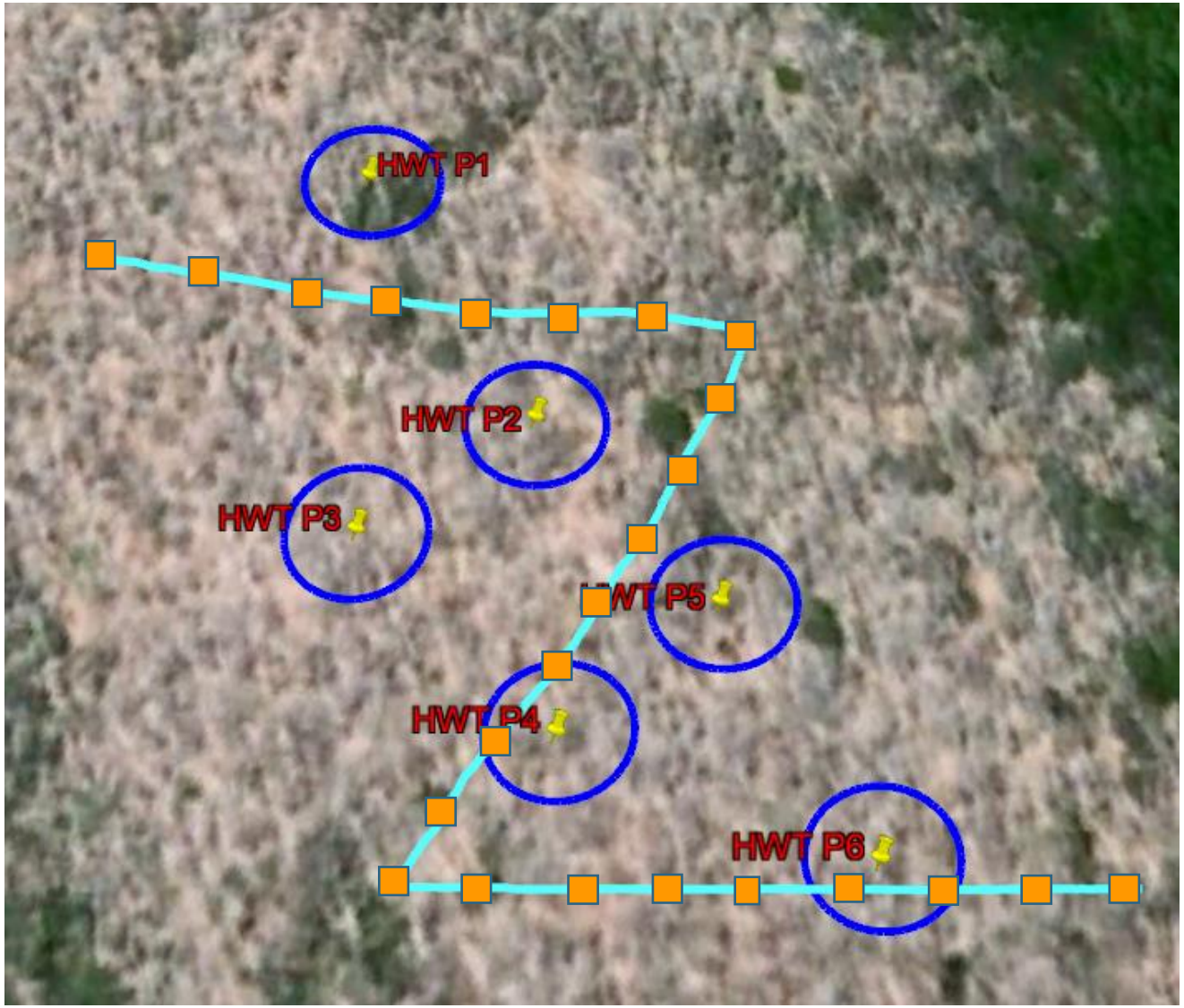


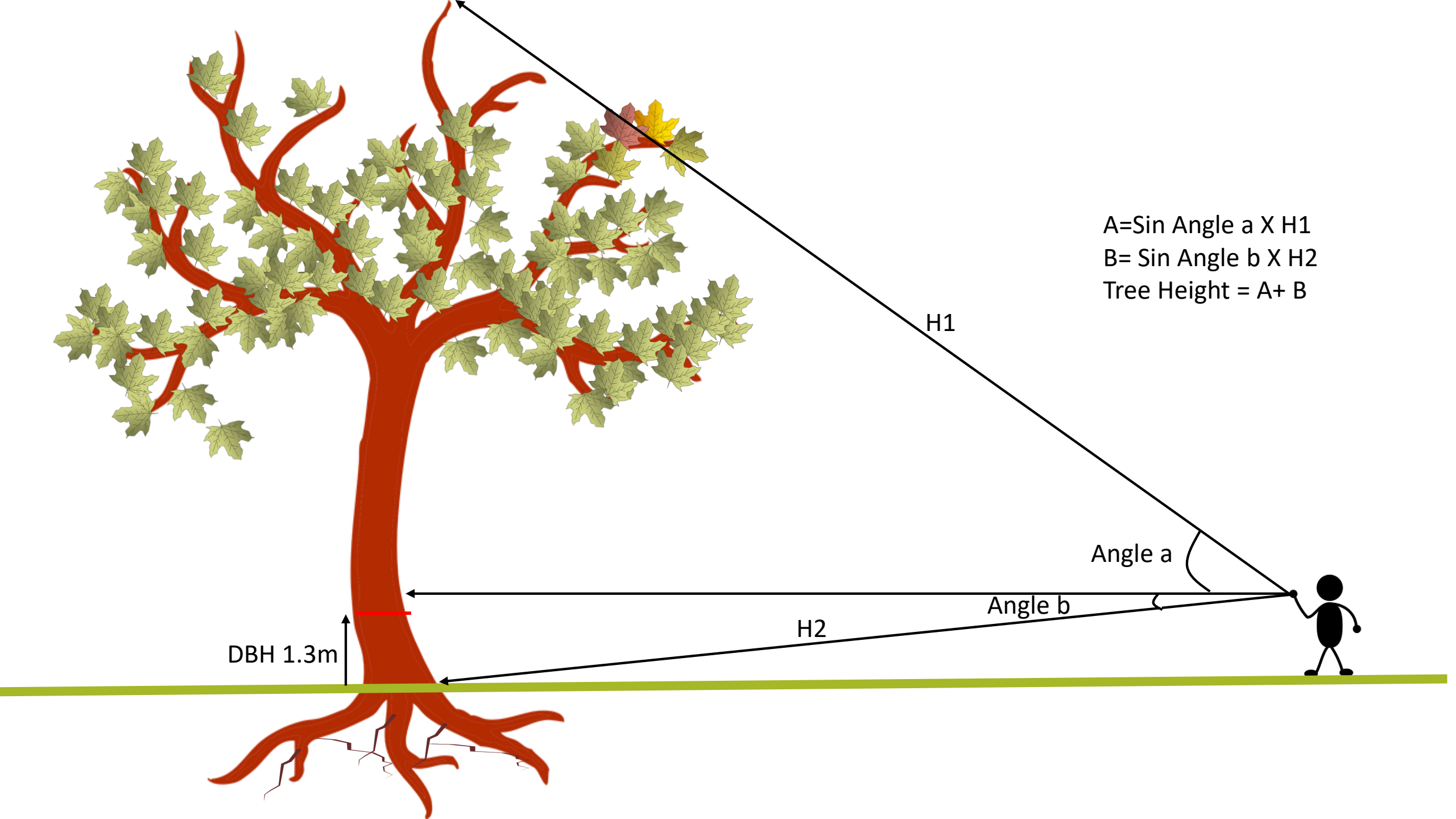
DBH



Data Collection (FF)

- Depth
- Bulk density
- Morphology



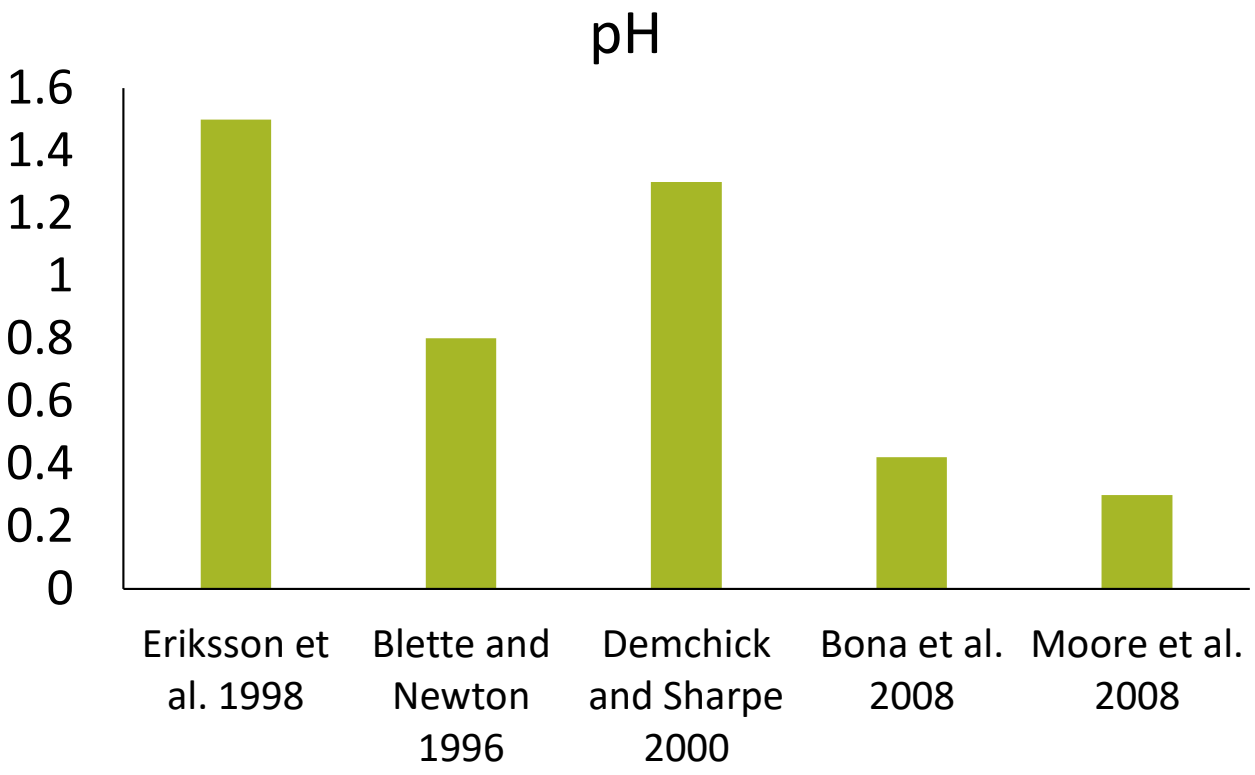

A=Sin Angle a X H1
B= Sin Angle b X H2
Tree Height = A+ B
H1
Angle a
Angle b
H2
DBH 1.3m

Sample Collection

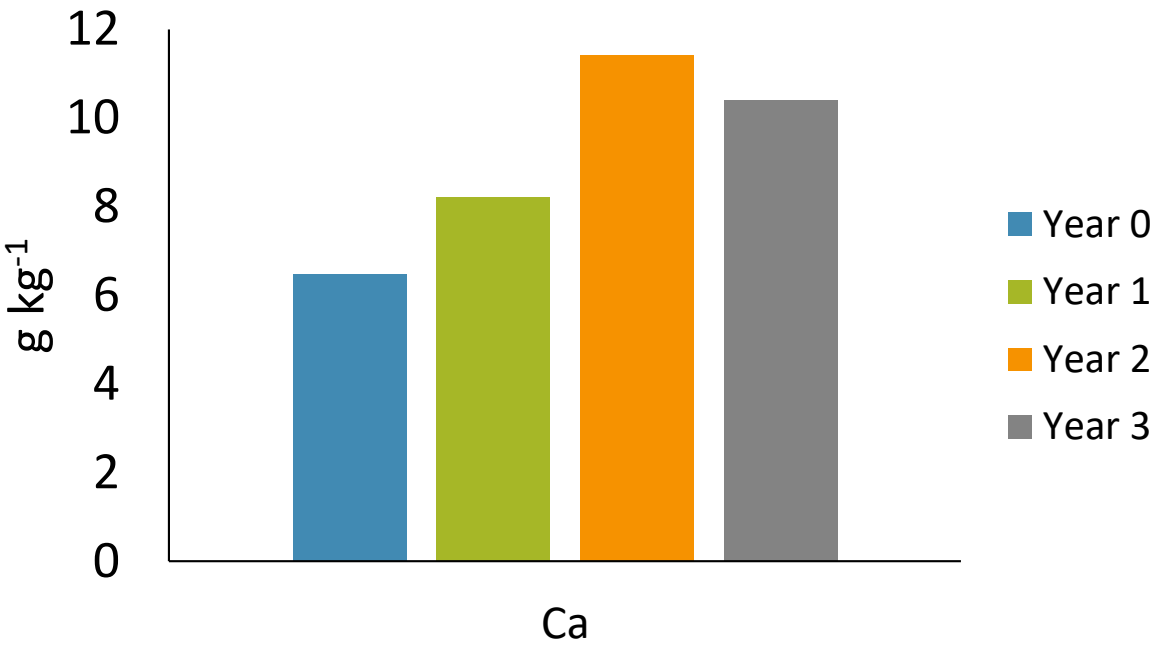
Site	# of Plots	Plot Radius (m)	Trees Per Plot	Foliage Samples	Bark Samples	Wood Samples	Vegetation Samples	Total Tissue Sample	Mineral Soil Samples	Forest Floor Samples (Outside Plots)	Total Soil Samples (Outside Plots)	Total Samples Per Plot
HWC	6	11.28	401	48	24	24	12	108	12	6	18	**126**
HWT	6	11.28	319	48	24	24	12	108	12	6	18	**126**
SWC	5	10.3	259	10	10	10	10	40	10	10	20	**60**
SWT	5	10.3	274	10	10	10	10	40	10	10	20	**60**
Total	**N/A**	**N/A**	**1253**	**116**	**68**	**68**	**44**	**296**	**44**	**32**	**76**	**372**

Impacts of Liming (Short-term)

Forest Floor

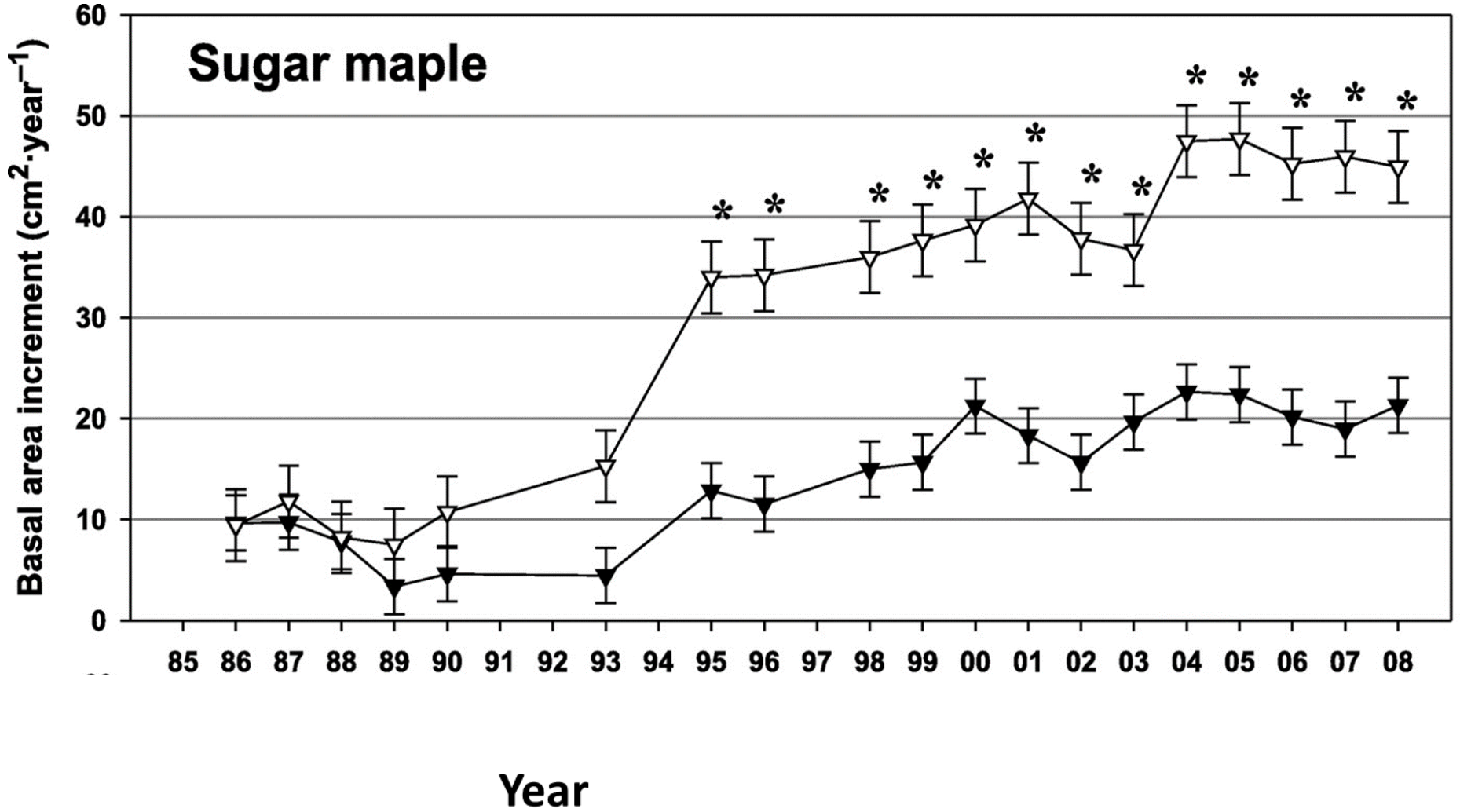


Foliage



(Moore et al. 2008)

Impacts of Liming (Long-term)



(Long et al. 2011)