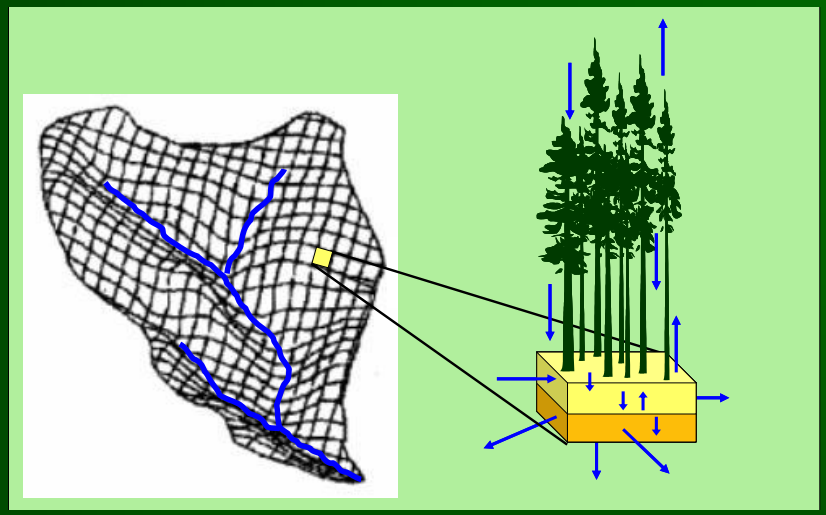
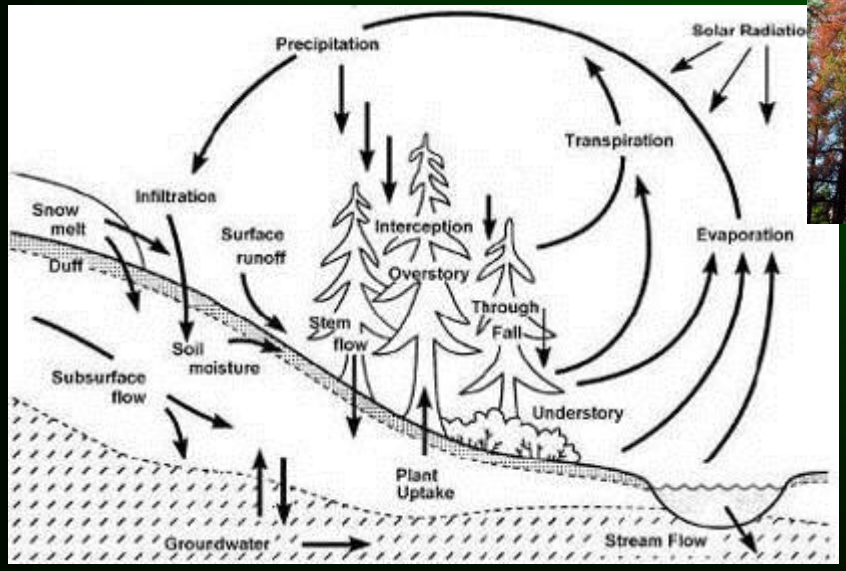
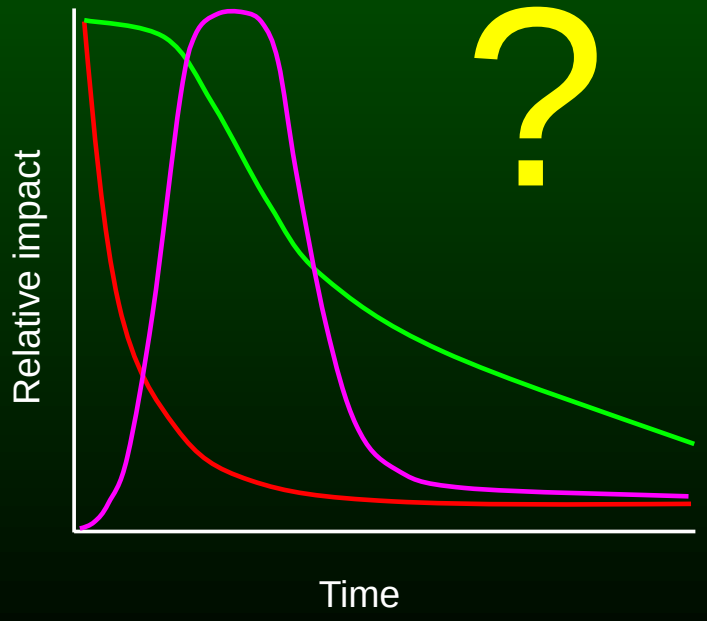
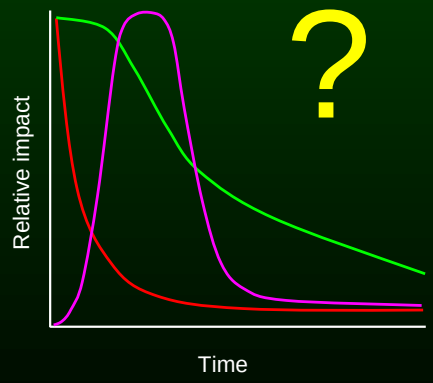



Precipitation
Solar Radiation
Transpiration
Infiltration
Snow melt
Surface runoff
Interception
Evaporation
Duff
Overstory
Through Fall
Stem flow
Soil moisture
Subsurface flow
Understory
Plant Uptake
Groundwater
Stream Flow


?
Relative impact
Time

# MPB - Unique disturbance agent

- Larger & older trees selectively killed – but remain standing (vs logging) → needles can remain 3-5 yrs+
- Understory & soil layers not directly affected (vs logging or fire)
- Return of nonvolatile nutrients to the soil & response of vegetation production are slower (vs stand-replacing fire)



# Broad research questions

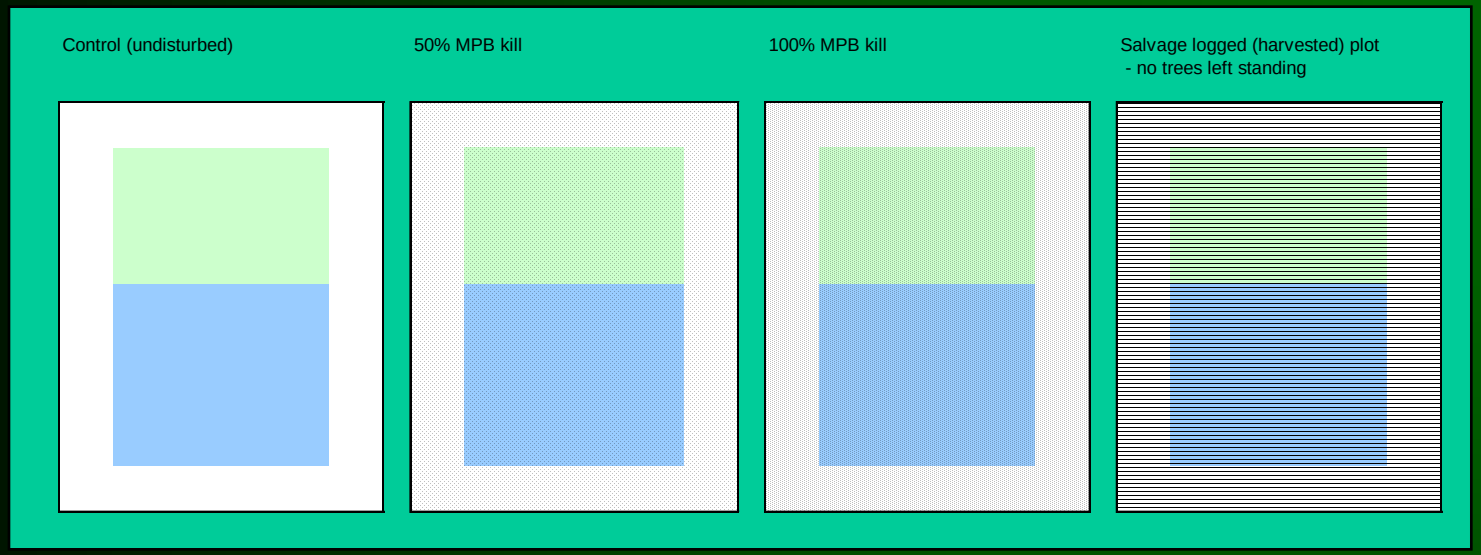
- *How much extra water is produced after different levels of "red attack" ?* (Pablo Piña)

- *What are the early trajectories of post-attack vegetation and below-ground responses after different levels of "red attack" ?* (Anne McIntosh)

# Approach & treatments

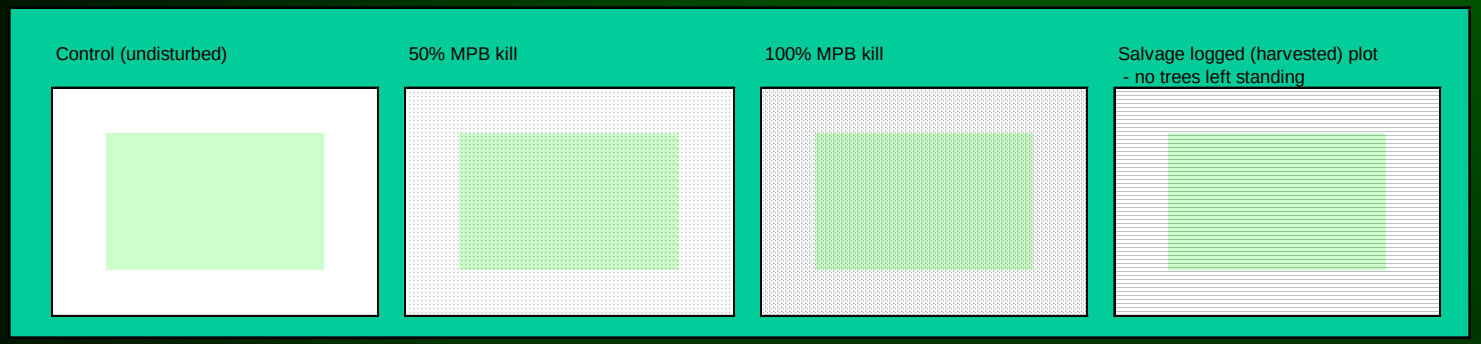
- Don't wait for MPB (issue of "control"; B.C.)
- Simulate MPB attack – variable density herbicide treatment
  - Control (untreated)
  - Simulated MPB attack (50% overstory kill)
  - Simulated MPB attack (100% overstory kill)
  - Clearcut - harvested to simulate "salvage logging" management

2.2 ha




x 1

1.2 ha



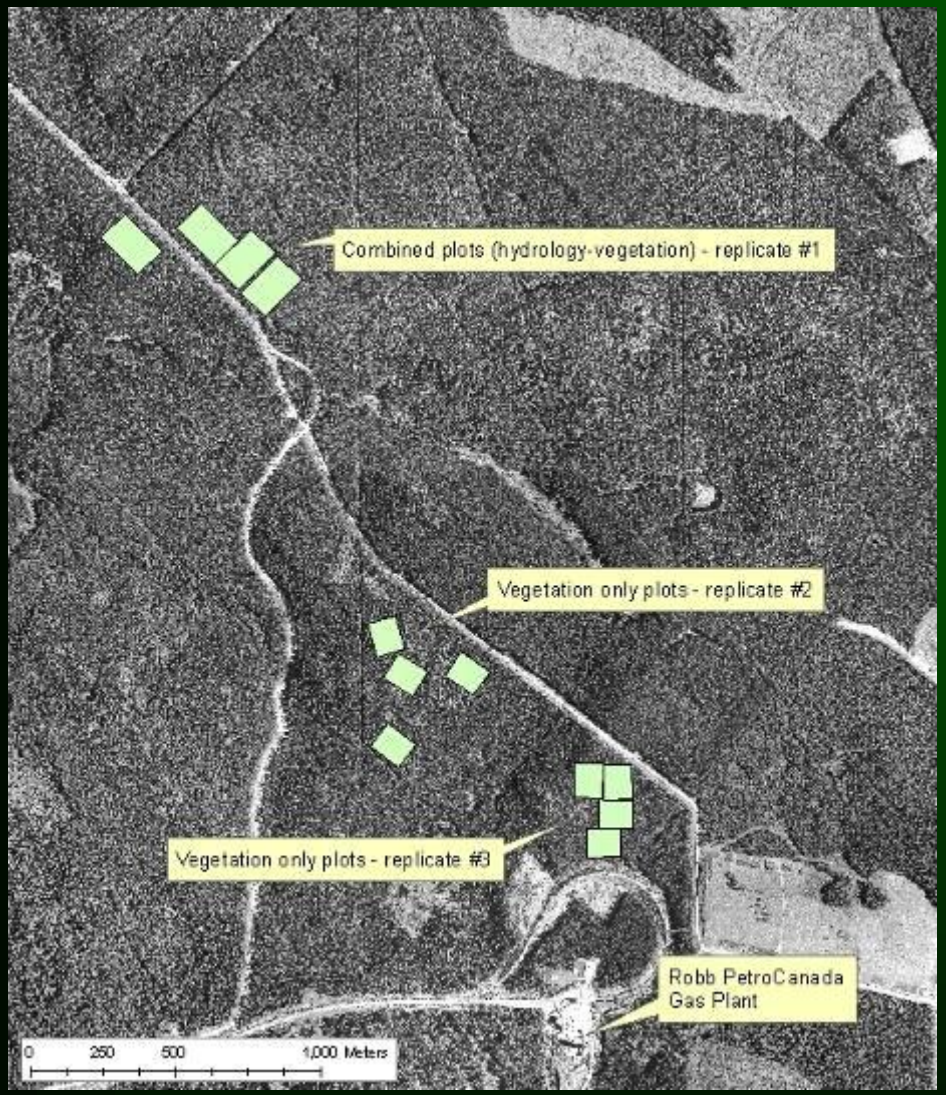

x 2

- 1 year pre-treatment measurements
- 2 years post-treatment measurements

12 stands

| 2008 | | | | | | | | | | | | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | | 2011 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Au |
| instrumentation | | | Pre-Treatment year | | | | | | | | Post-Treatment Year 1 | | | | | | | | | | | | Post-Treatment Year 2 | | | | | | | | | | | | | | | | | | | |

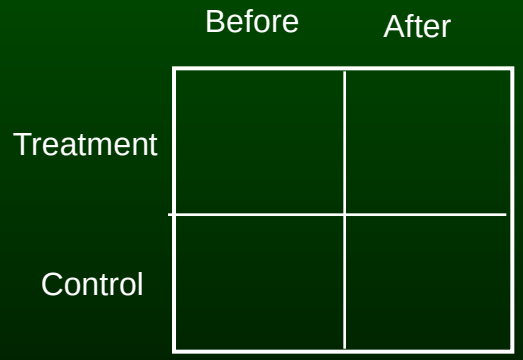
# Study area & design




- Pure pine ~ 120 yrs
- Medium site index
- 22-24 m height

- Process studies

- Water balance
  - before-after: treatment-control



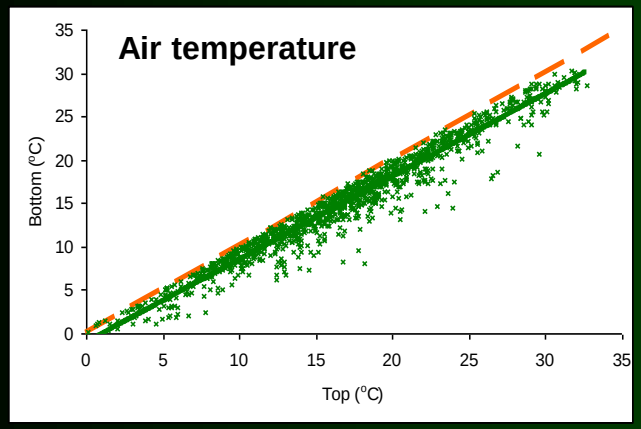

- Understory vegetation
  - replicated (repeated measures)

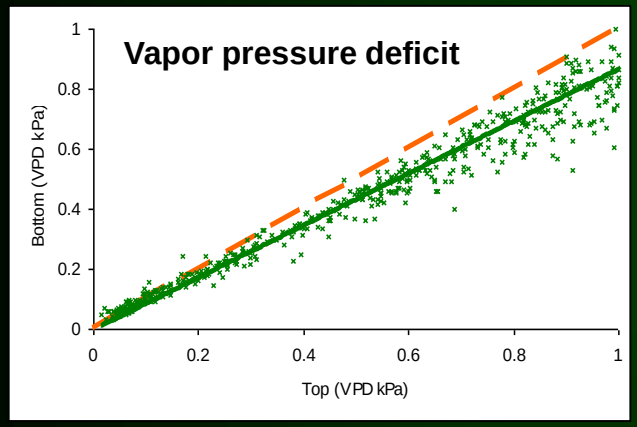
| 2008 | | | | | | | | | | | | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | | 2011 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Au |
| instrumentation | | | | | Pre-Treatment year | | | | | | | | | | | | Post-Treatment Year 1 | | | | | | | | | | | | Post-Treatment Year 2 | | | | | | | | | | | | | |

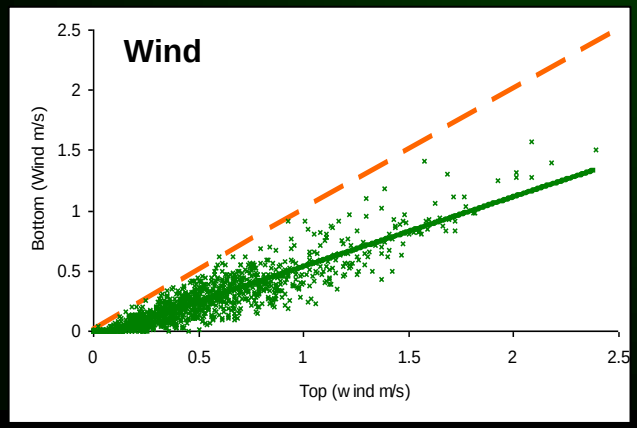
- Glyphosate – late June ’09
- Harvest – July ‘09

| 2008 | | | | | | | | | | | | 2009 | | | | | | | | | | | | 2010 | | | | | | | | | | | | 2011 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Au |
| instrumentation | | | Pre-Treatment year | | | | | | | | | Post-Treatment Year 1 | | | | | | | | | | | | Post-Treatment Year 2 | | | | | | | | | | | | | | | | | | |

# Canopy regulated environmental factors



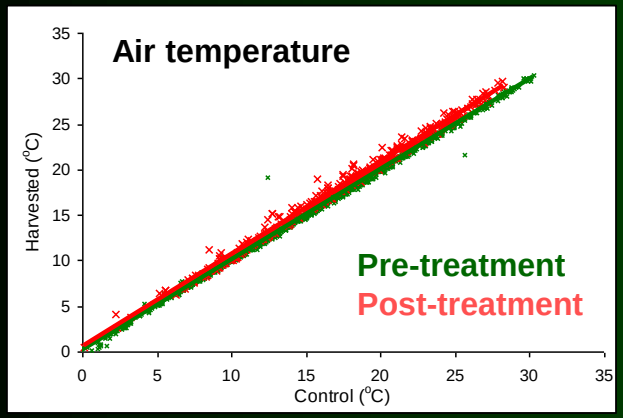



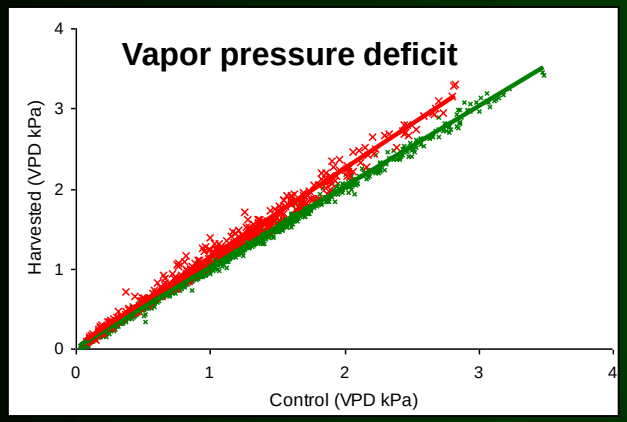



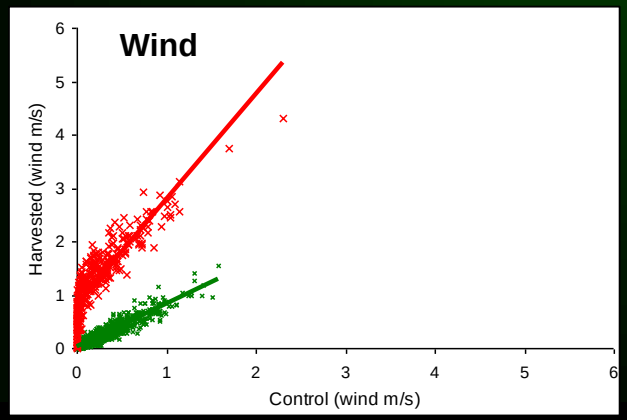

- Understory light, air temperature, humidity, wind, etc.

- Understory microclimate (compared to canopy)
  - Air temperature (11 % lower, 1-2 °C)
  - Moisture demand (14 % lower)
  - Wind (51 % lower)

# Canopy regulated environmental factors




- Understory light, air temperature, humidity, wind, etc.

| | Before | After |
|---|---|---|
| Treatment | | |
| Control | | |

- *Change in* understory microclimate (@3 m ht)
  - Air temperature - Tiny increase
  - Moisture demand – small/moderate increase
  - Wind – large increase
- BATC – powerful approach to document changes

# Post-attack hydrologic response
# Pablo Pina, PhD Student

***How much extra water is produced after different levels of "red attack" ?***

1. Changes in overstory rainfall interception
2. Changes individual tree & stand level transpiration
   - *Can surviving trees compensate (use more water)*
3. Changes in forest floor and soil moisture storage
4. Changes in water table level, groundwater

# Vertical water balance framework

Gross precipitation + Evaporative demand

Overstory transpiration

Canopy interception

Forest floor interception

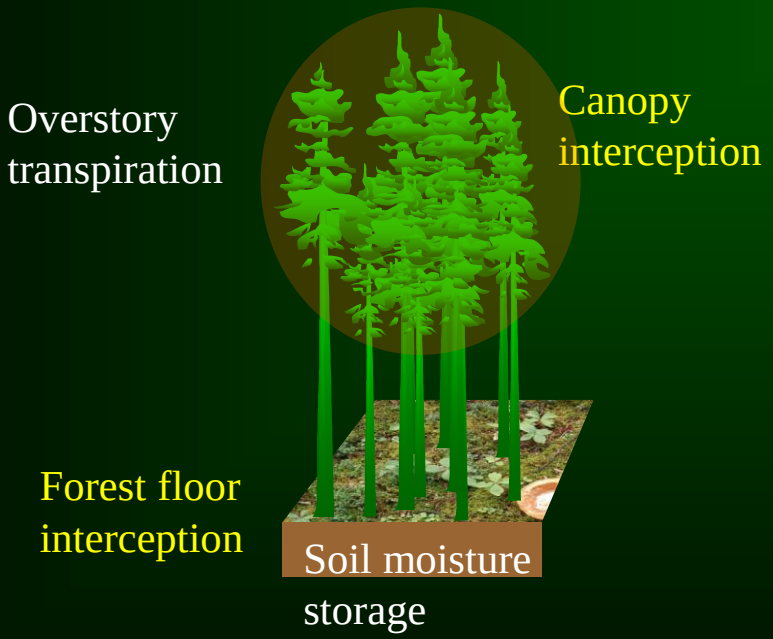
Soil moisture storage

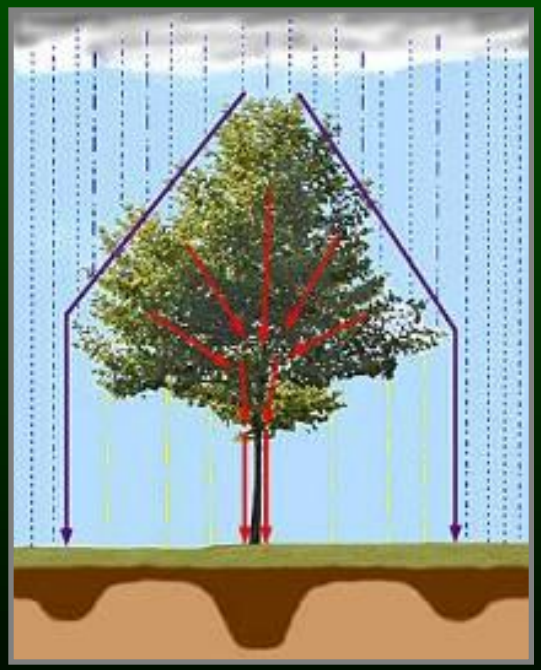
# Rainfall interception

Interception = Gross precipitation – (Stemflow+Throughfall)-(Throughfall-Forest floor flow)

Canopy interception

Forest floor interception

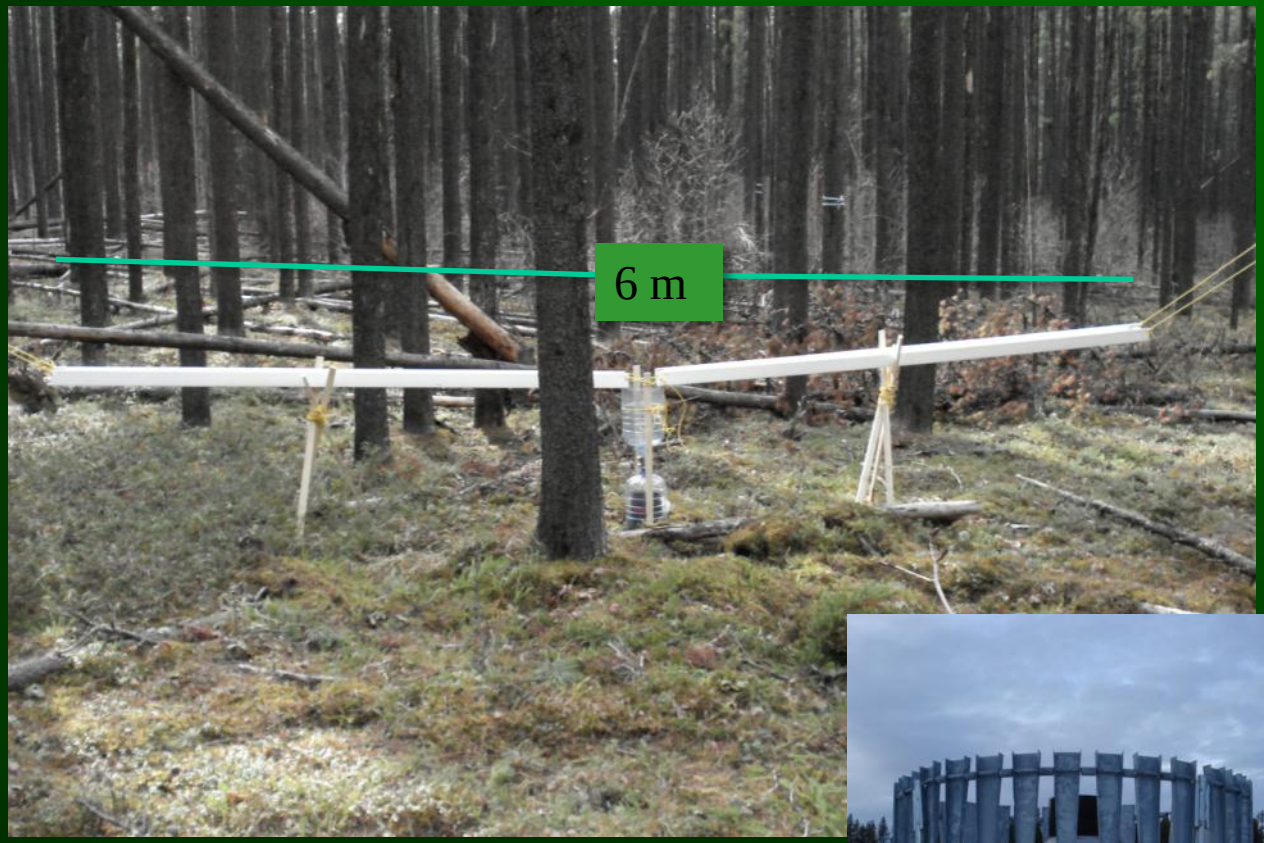


# Canopy interception

Stemflow

N =3

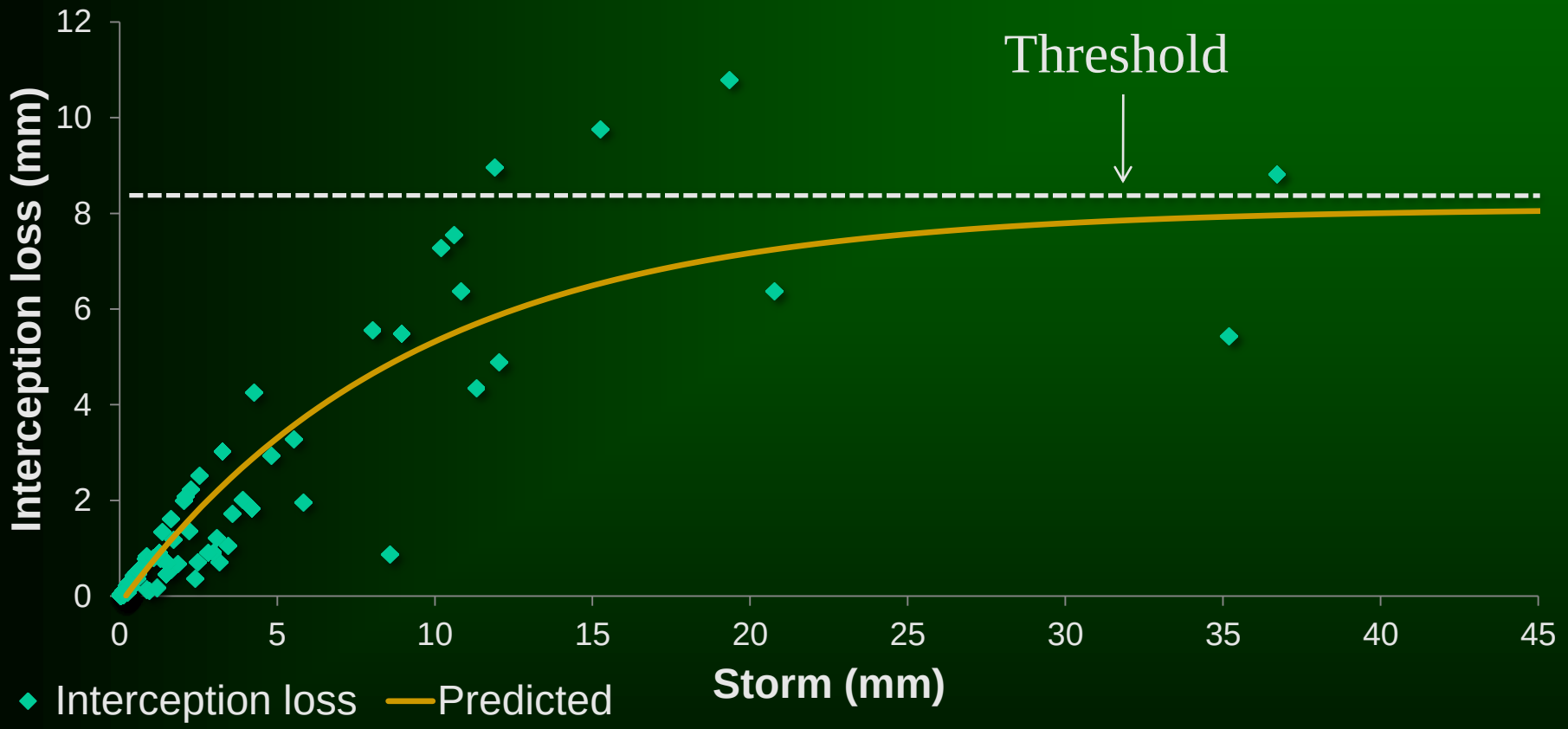



Throughfall

N= 4


Gross precipitation

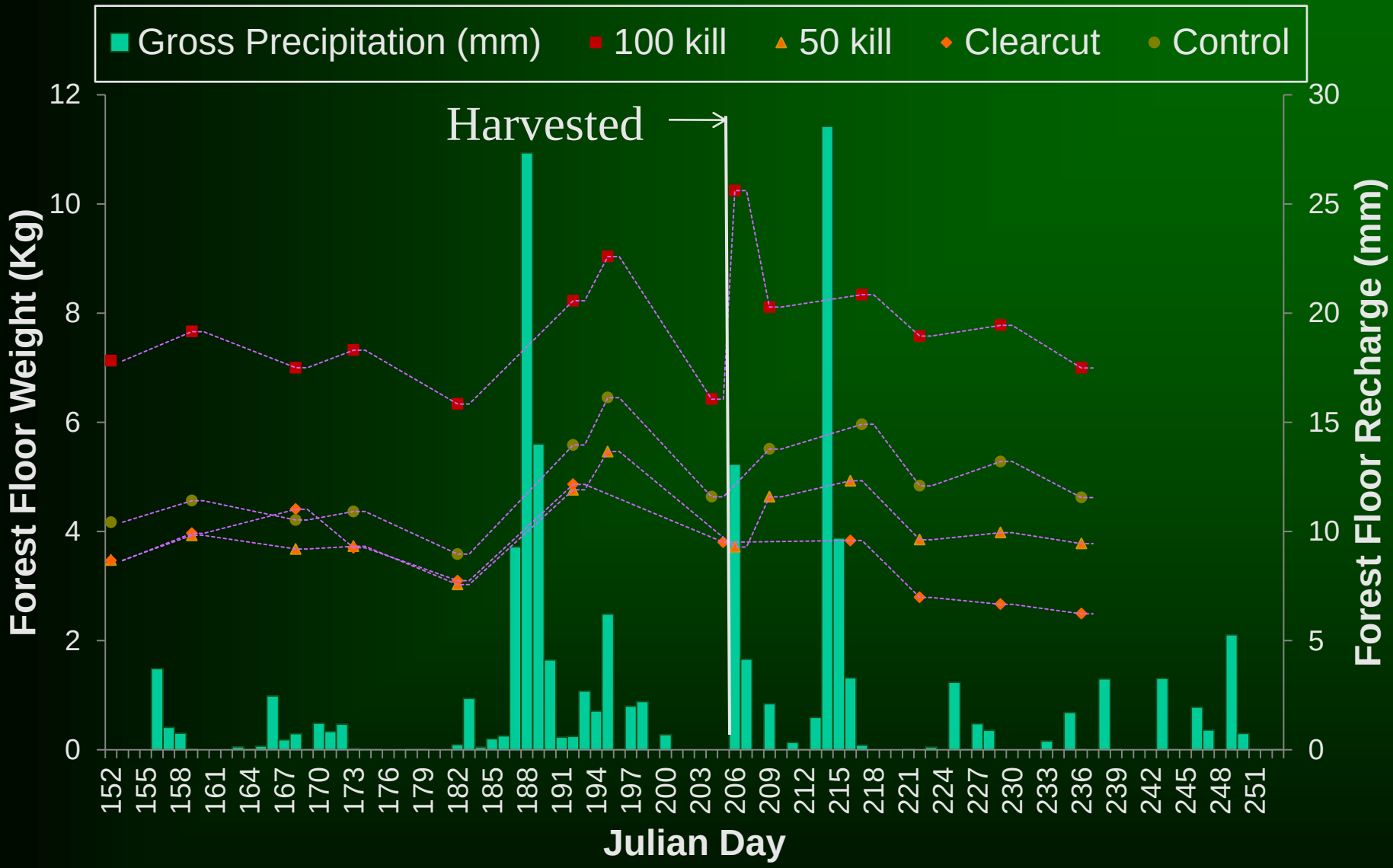
# Canopy storage capacity (*S*) = 8.1 mm



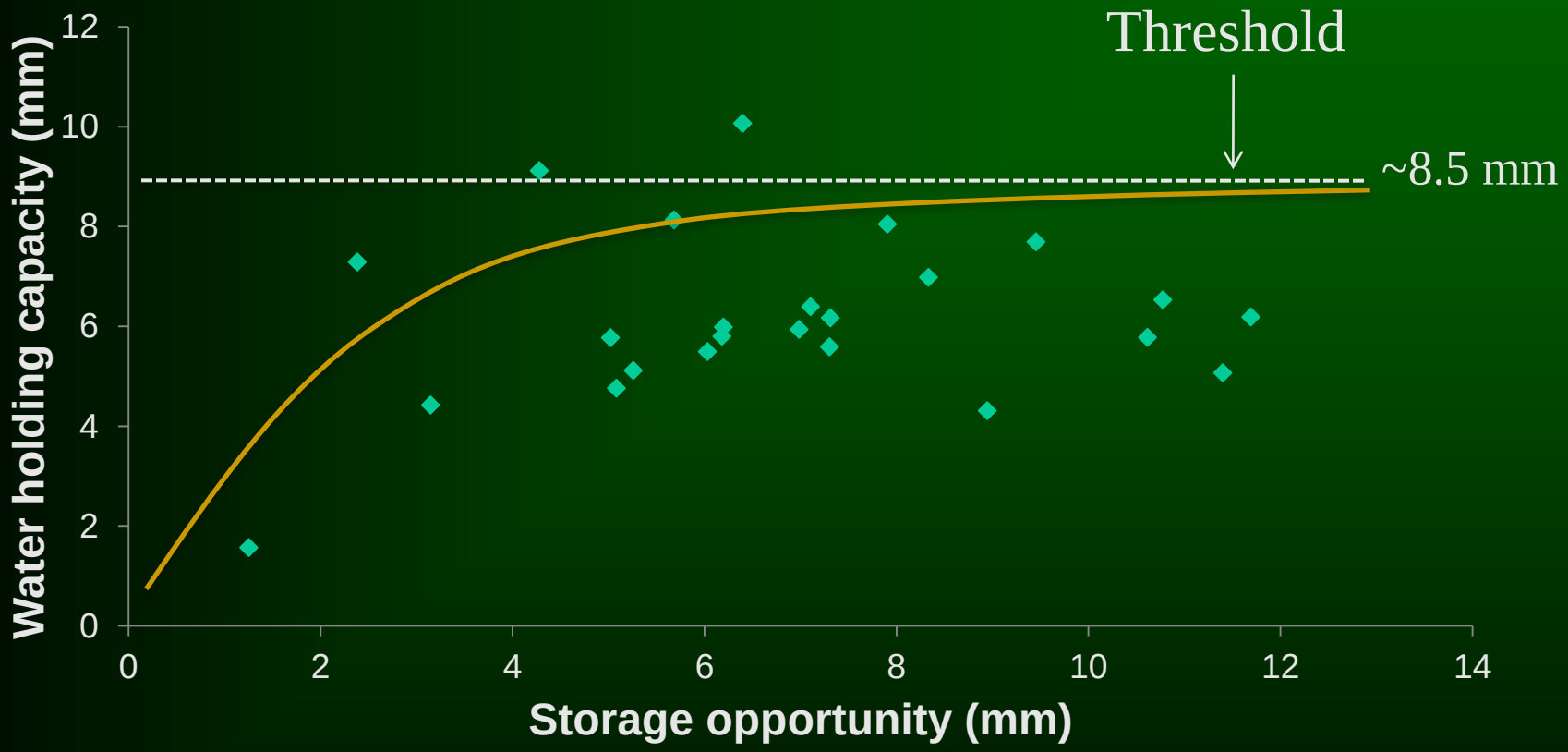
# Forest floor interception

Monitoring quadrats
N =4

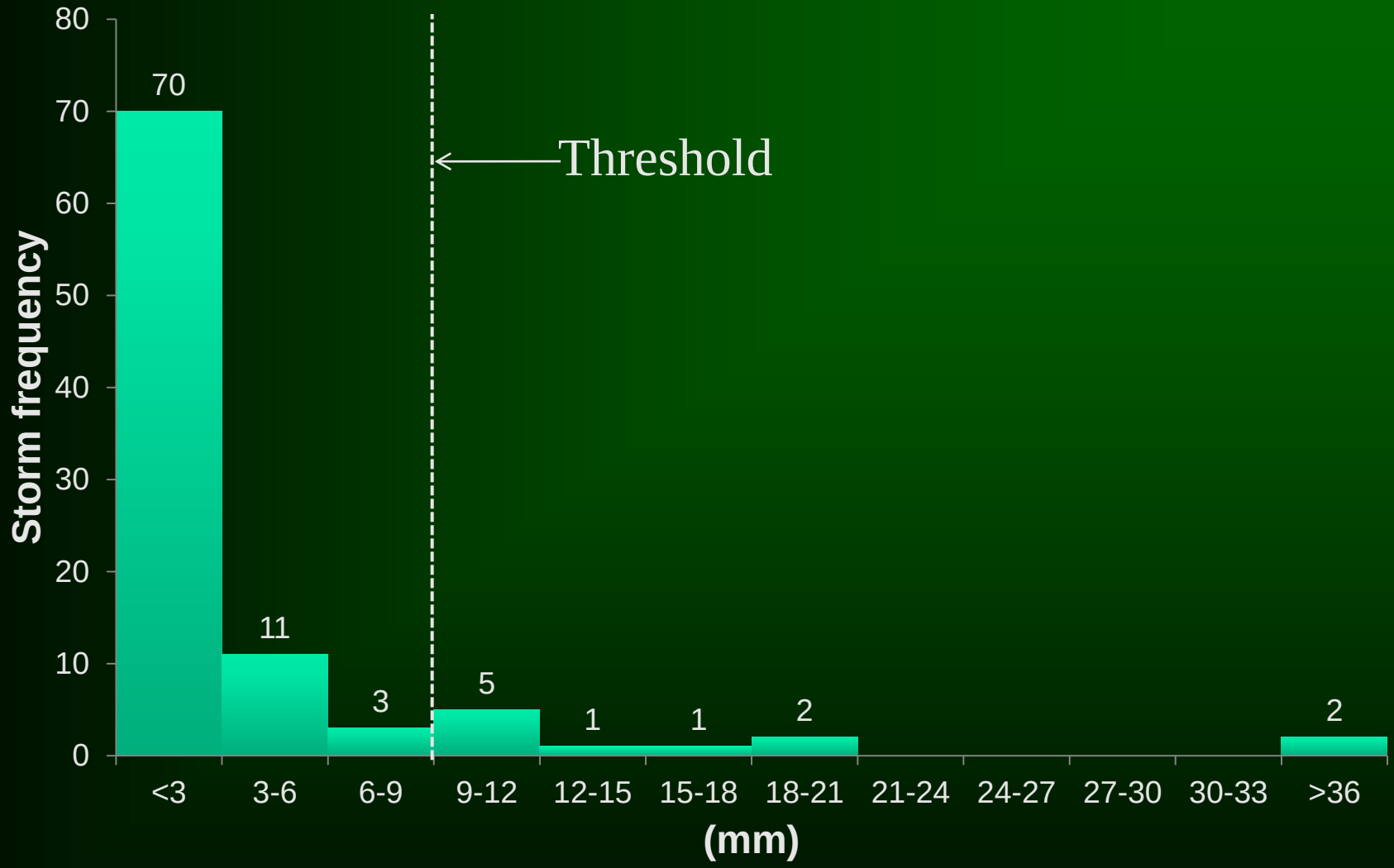

# Post-treatment forest floor seasonal weight trends



# Forest floor water holding capacity

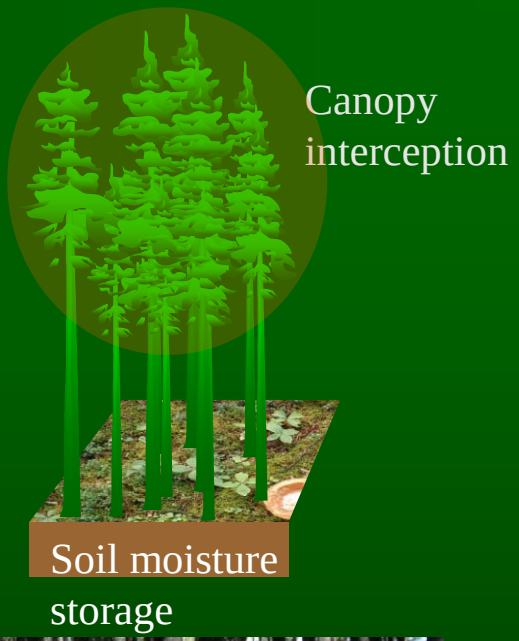


# Storm frequency distribution based on rainfall intensity

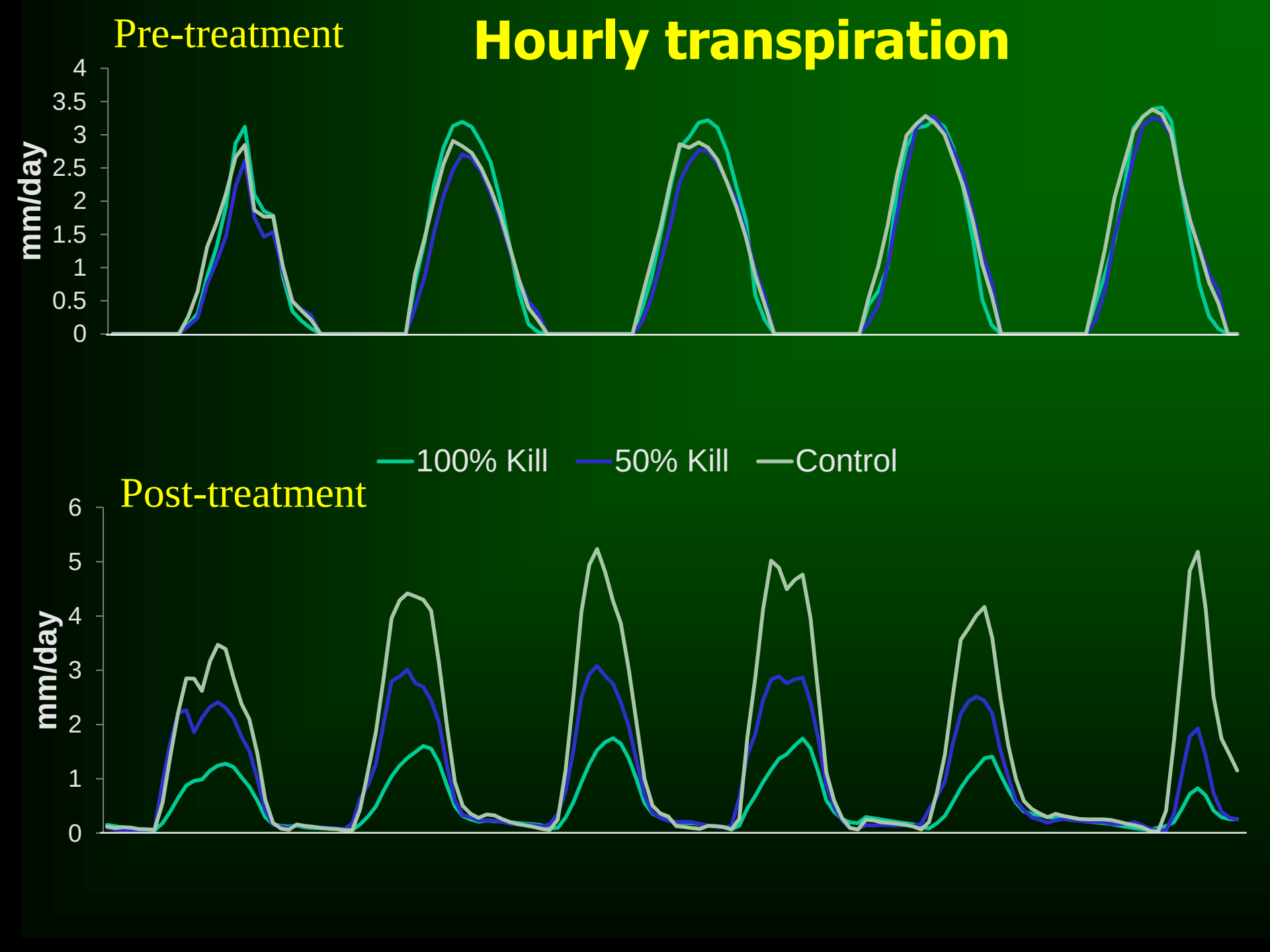


# Overstory transpiration

N = 7




# Hourly transpiration

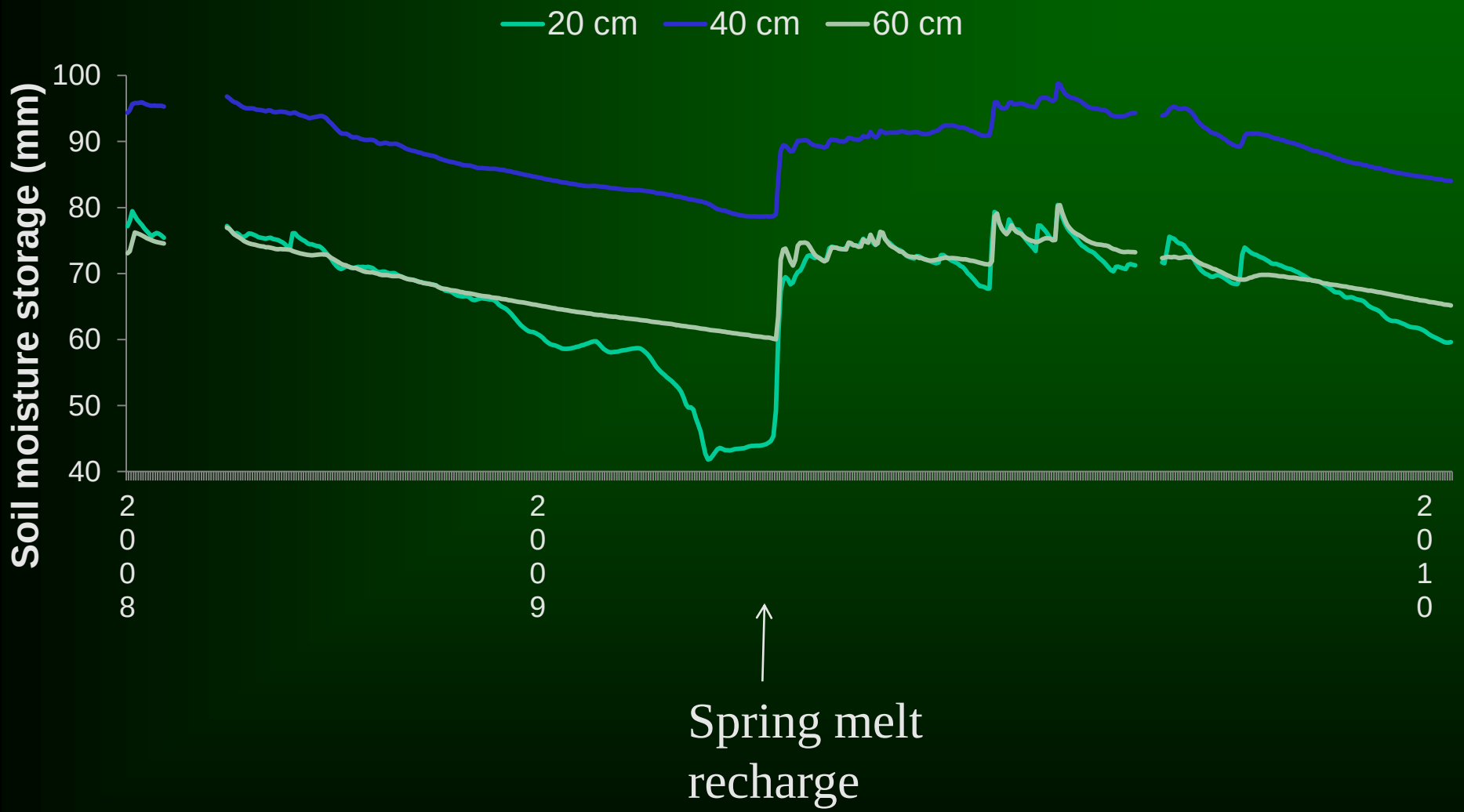


# Soil moisture storage

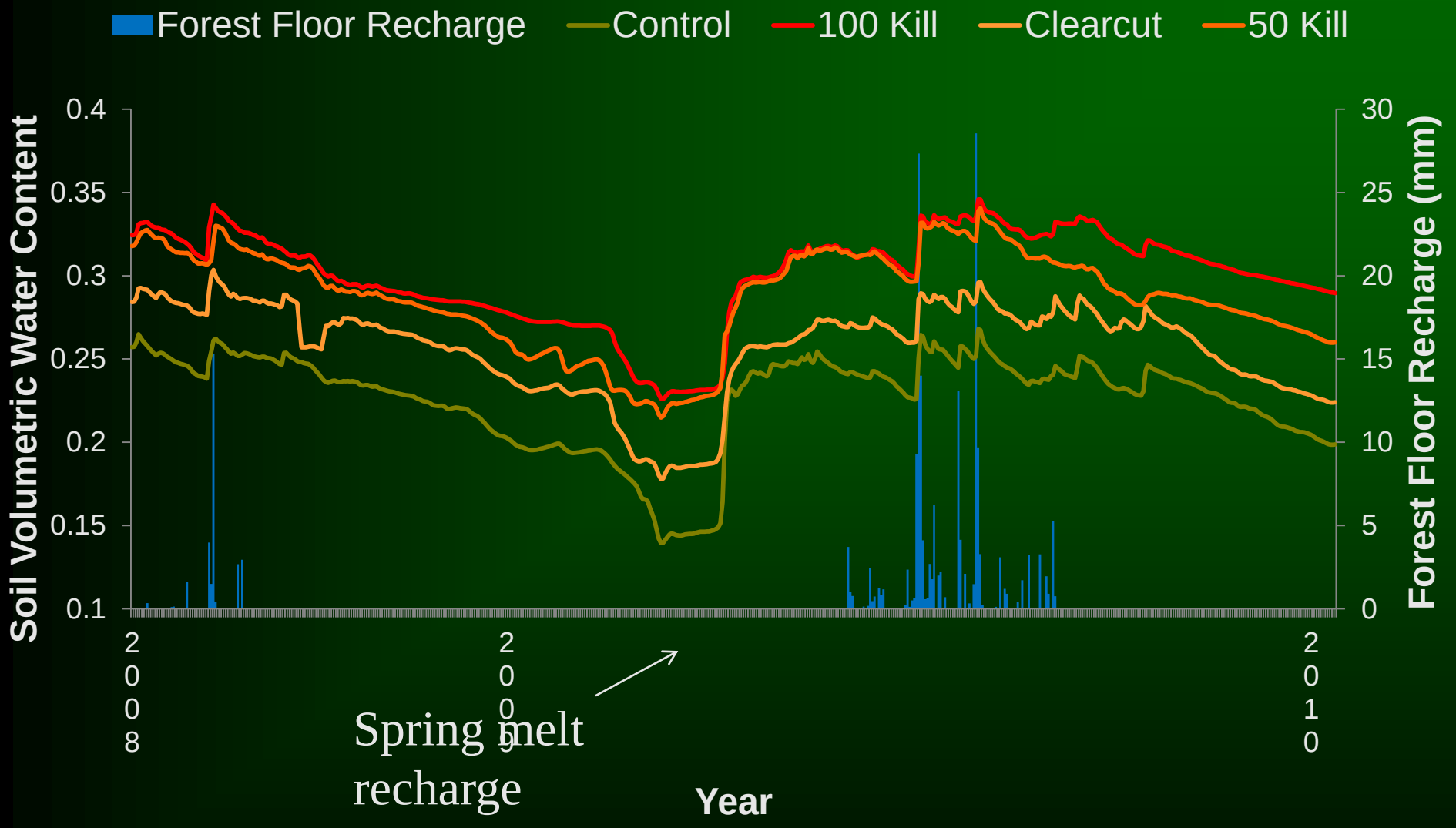
Spot measurements
soil moisture (TDR)

Time continuous
soil moisture (WCR)

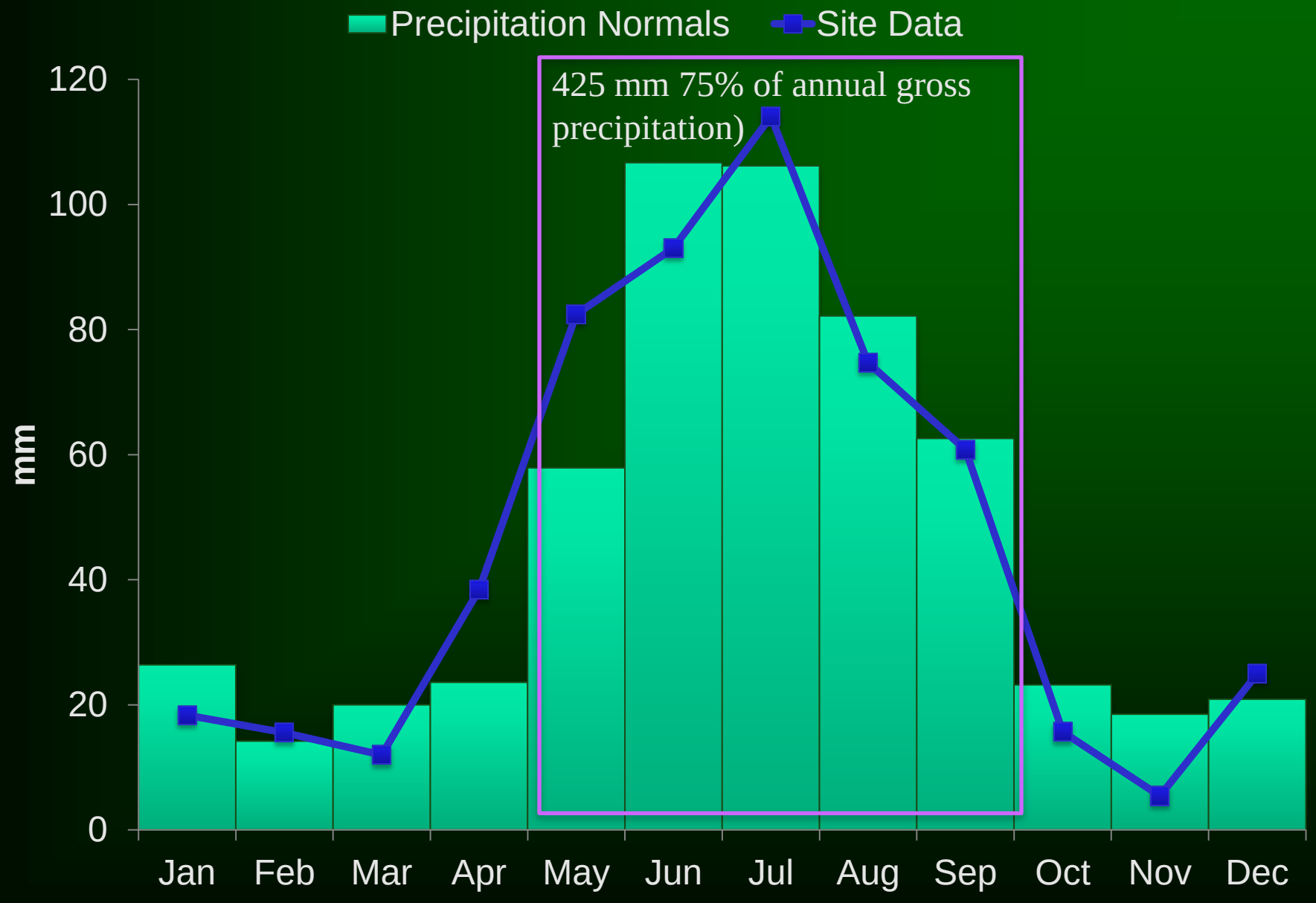
# Soil moisture at the Control plot



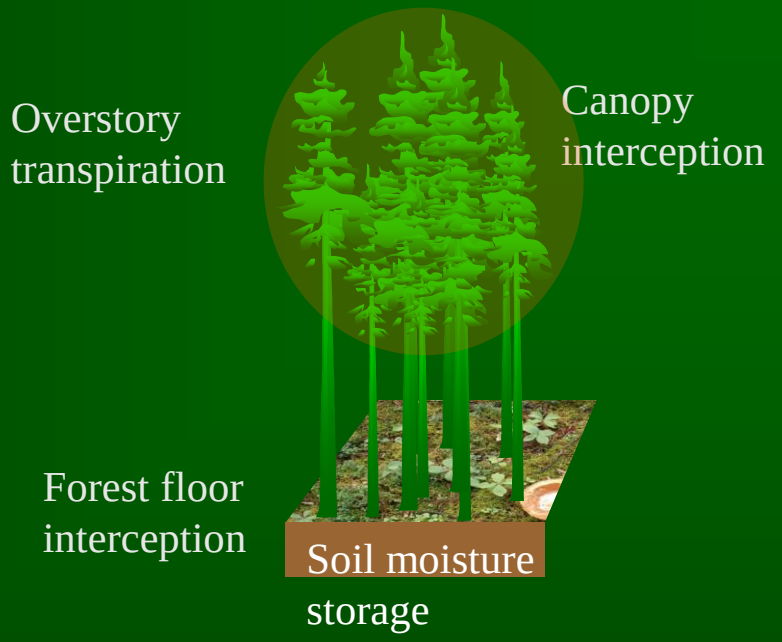
# Soil Moisture at 20 cm depth



# What will happen when the MPB kills the trees?



# Conclusions:



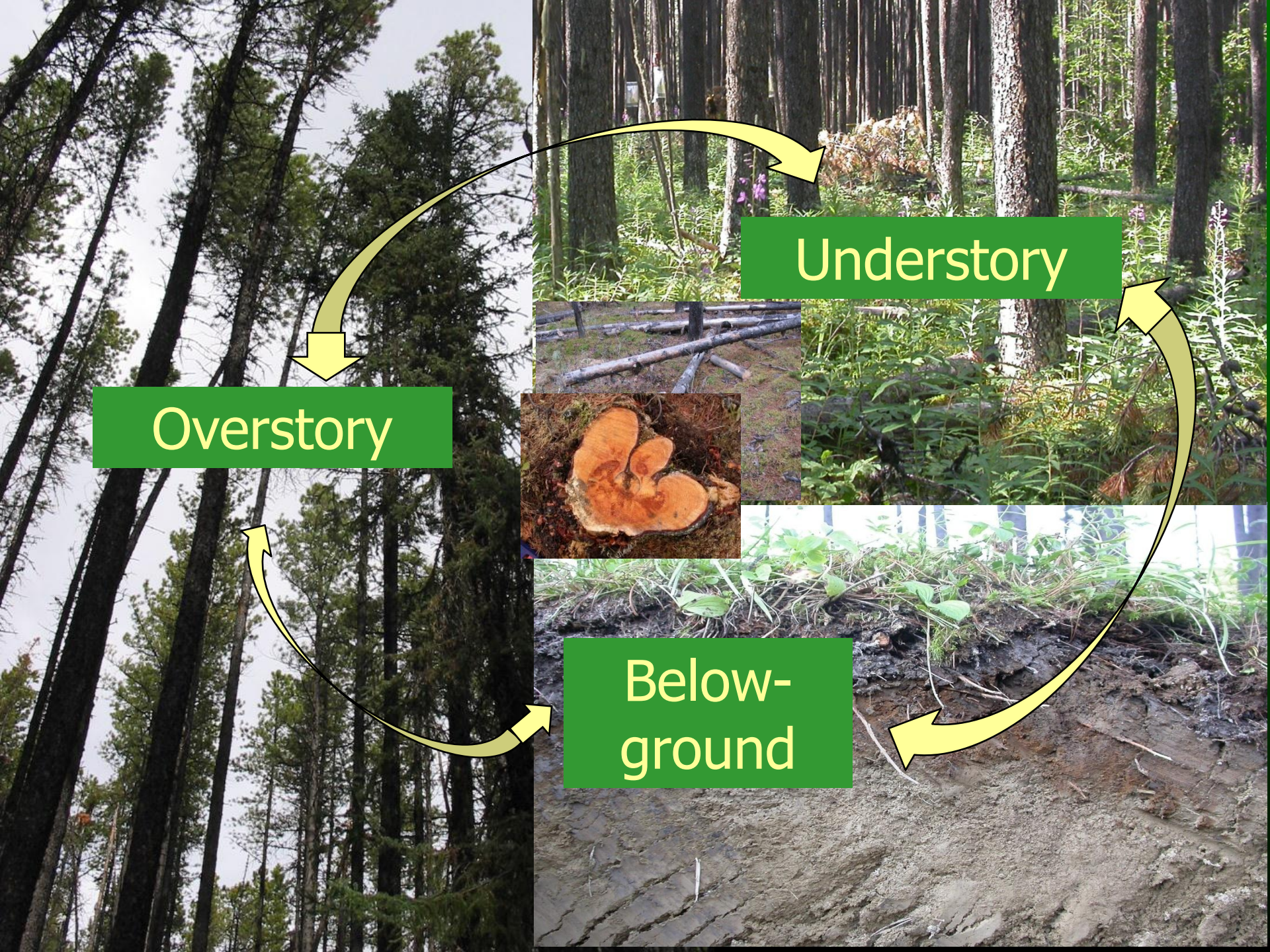

During the growing season:

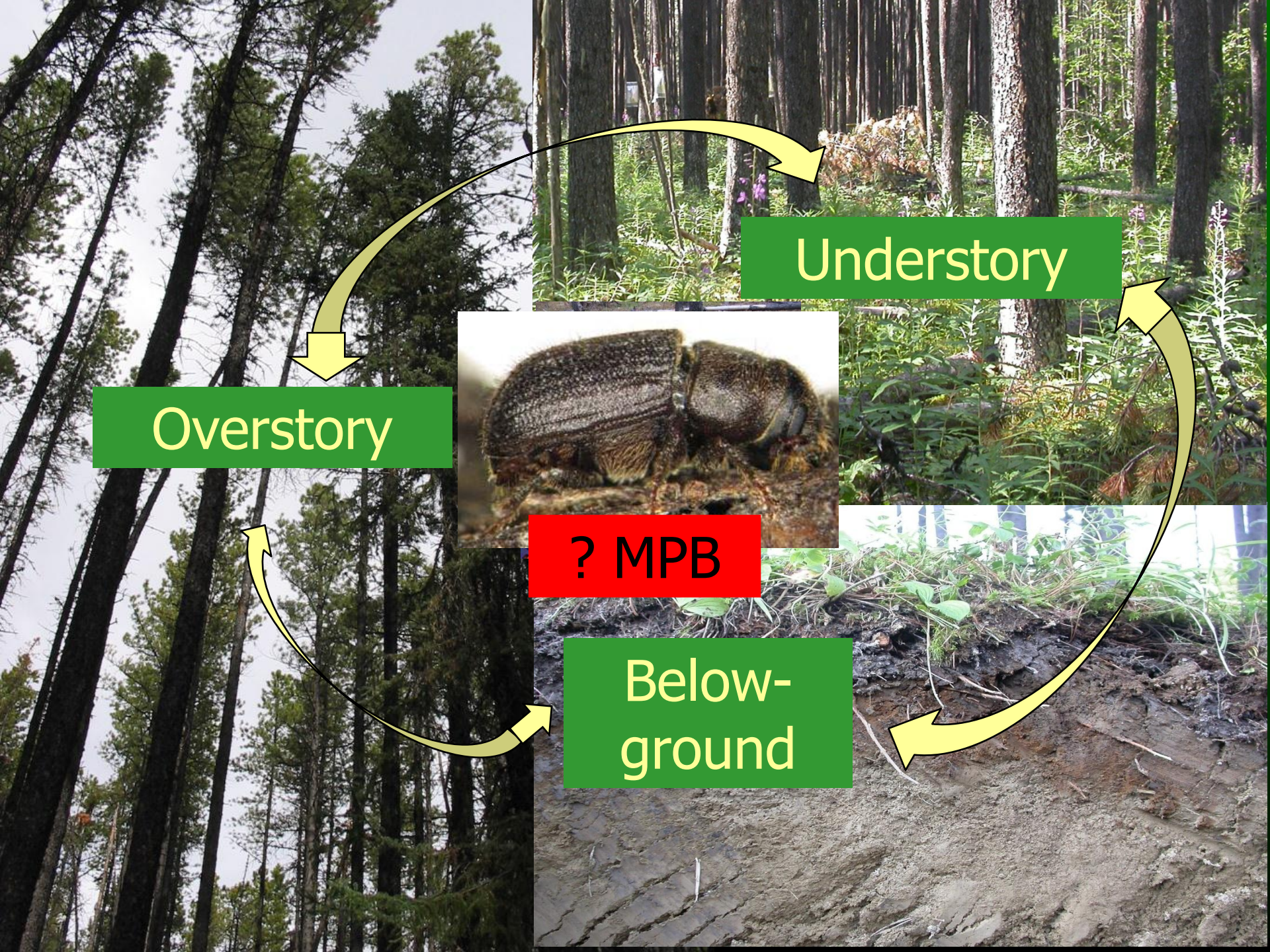
- Canopy interception ≈ 49% of Precip
- Forest floor interception could be as high as canopy interception
- An average tree transpires 5.5 liters/day = > ≈0.7 liters/$m^2$ day
- Transpiration could be 41% of precipitation
- Understory evaporation?
- Soil moisture recharge is mainly driven by spring snowmelt

# Post-attack vegetation & below-ground responses

**Anne McIntosh, PhD Student**

*What are the early trajectories of post-attack vegetation and below-ground responses after different levels of "red attack" ?*

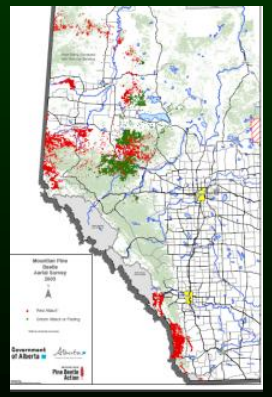

Understory
Overstory
Below-
ground


Understory
Overstory
? MPB
Below-
ground

# MPB as a disturbance agent

- Larger & older trees selectively killed but remain standing (vs logging)
- Understory & soil layers not directly affected (vs logging or fire)
- Return of nonvolatile nutrients to the soil & response of vegetation production are slower (vs stand-replacing fire)

⇒ OUTSIDE HISTORICAL RANGE: HOW WILL STANDS IN AB RESPOND ?



# Post-attack vegetation & below-ground response objectives

*What are the early trajectories of post-attack vegetation and below-ground responses after different levels of "red attack" ?*

1. Changes in overstory forest structure
2. Changes in understory plant community composition (shrubs, seedlings, plants (herbs, grasses, bryophytes)
3. Recruitment of downed woody debris (DWD)
4. Changes in below-ground processes (nutrient availability, microbial community, decomposition)

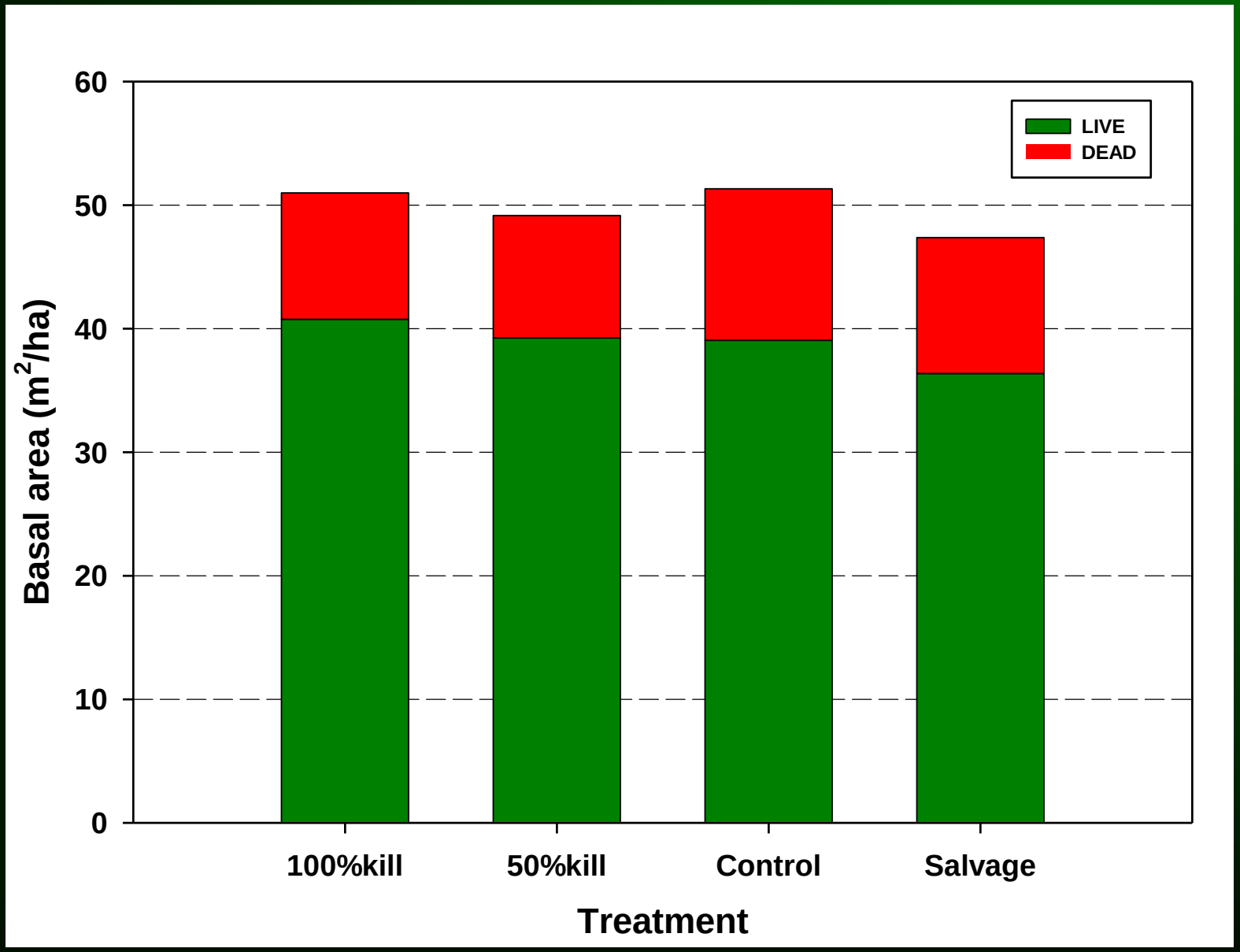
# Objective 1: Overstory

Characterize the overstory forest structure (0.02 ha plots)

- Species
- Live status
- Dbh
- Height
- Crown vigor
- Cover (hemispherical photos)

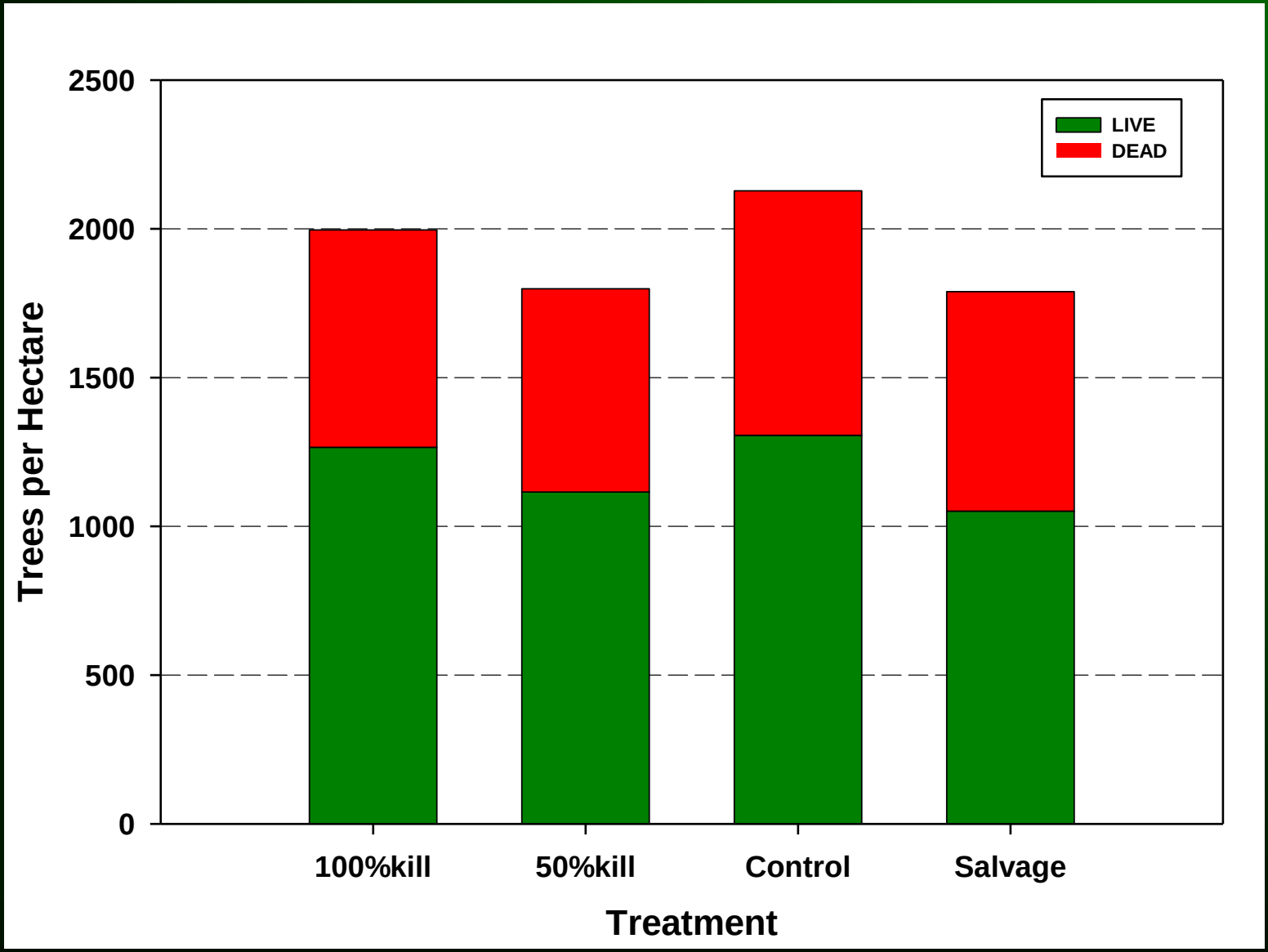
Measured before (2008) & after (2010) treatment

# Basal area



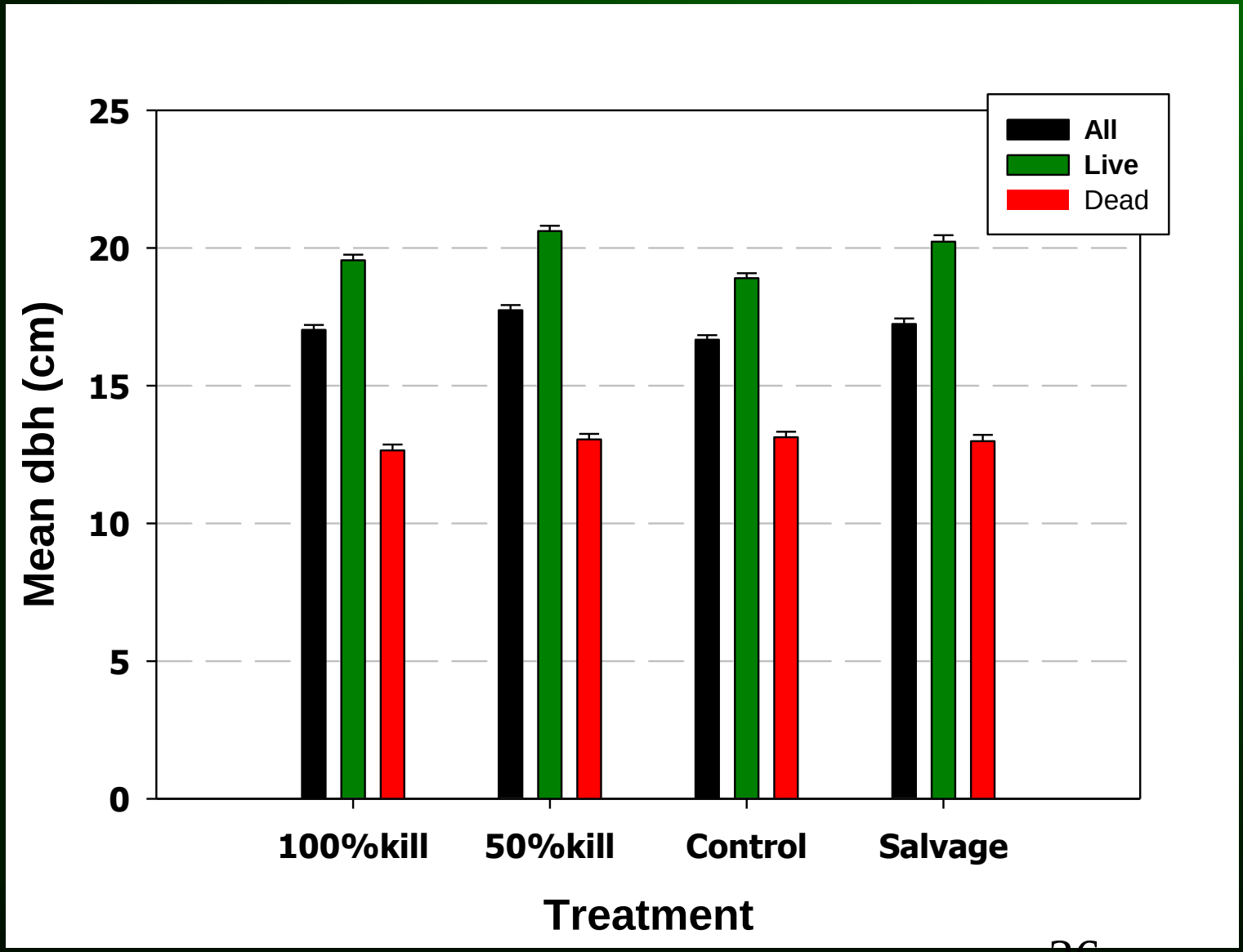

* Post-treatment will be measured in 2010

# Trees per hectare




* Post-treatment will be measured in 2010

# Mean DBH




* Post-treatment will be measured in 2010

# Objective 2: Understory

Quantify differences in the understory plant community composition

- Seedlings/Saplings (pine)
  - Advanced regeneration?  MINIMAL
  - Germination study (future regeneration potential)
- Plants (shrubs, forbs, graminoids, bryophytes, lichens)
  - Richness
  - Abundance (% cover) by species
  - Basal area (large shrubs, e.g., alder)

# Germination study (2010)

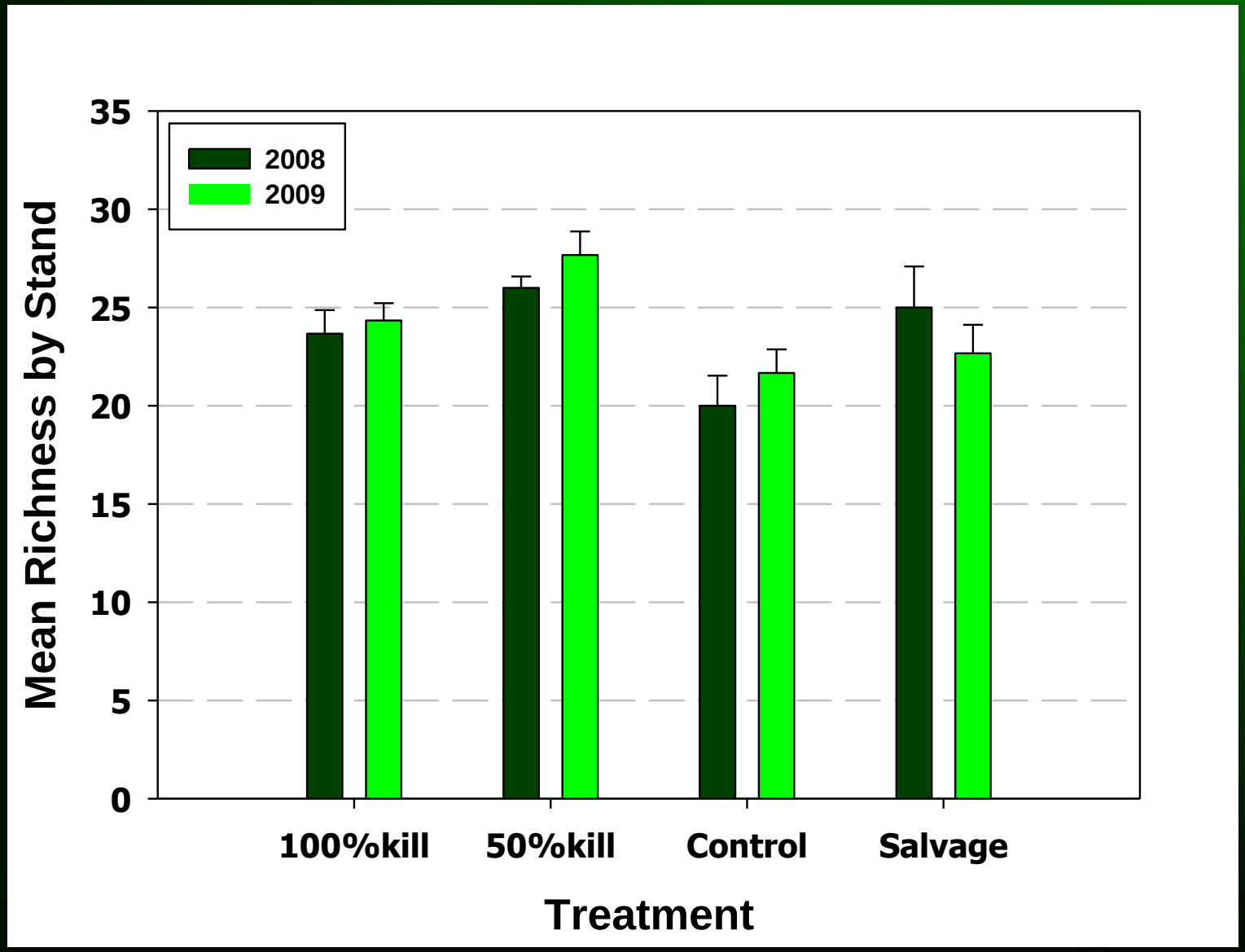
What is the regeneration potential of these stands after MPB?

Quadrats on 5 substrates sowed with seed:

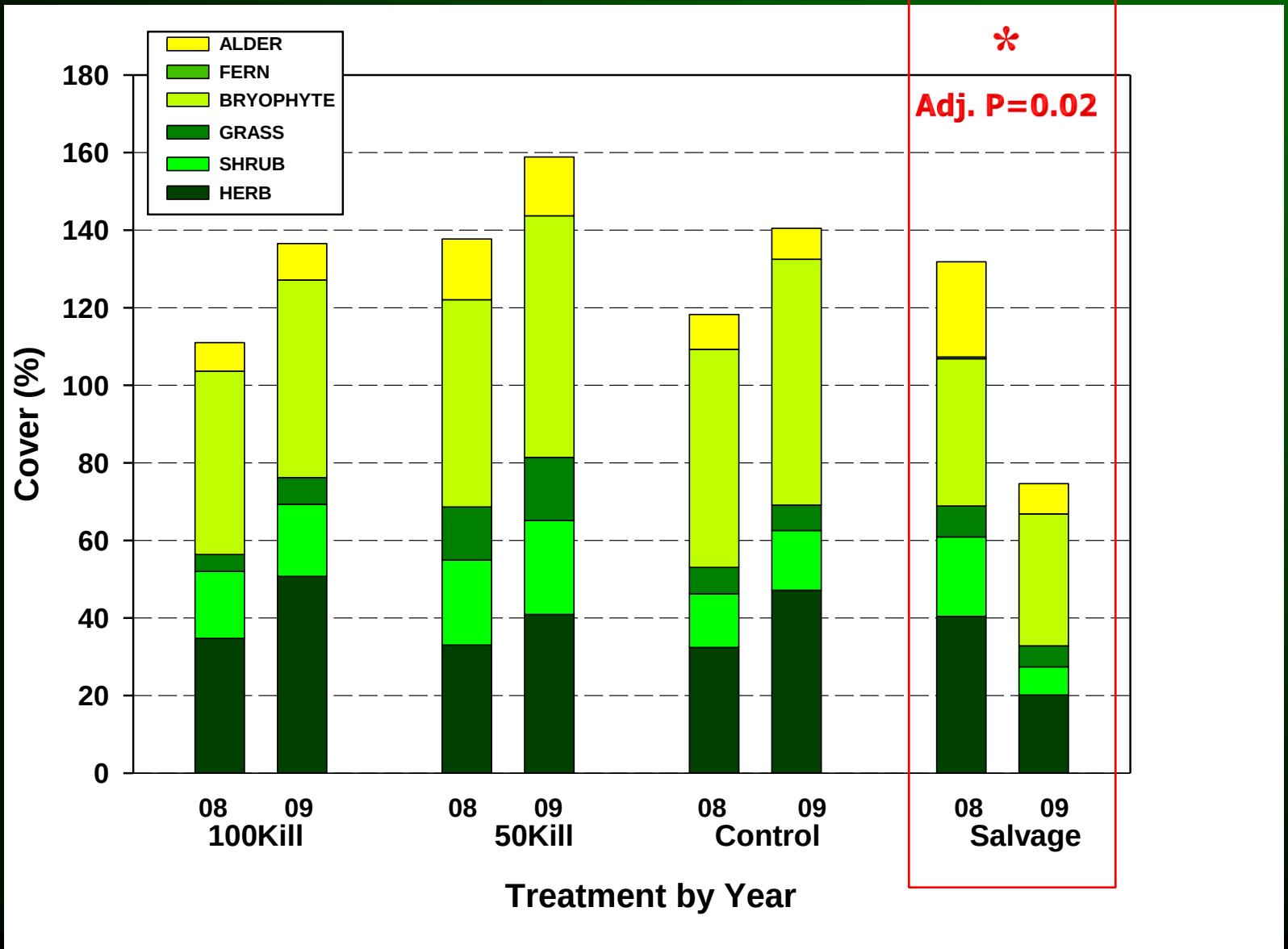
- LFH < 2.5 cm
- LFH > 2.5 cm
- Mineral soil
- Moss
- Dead wood (decay class 4-5)

Monitor germination weekly

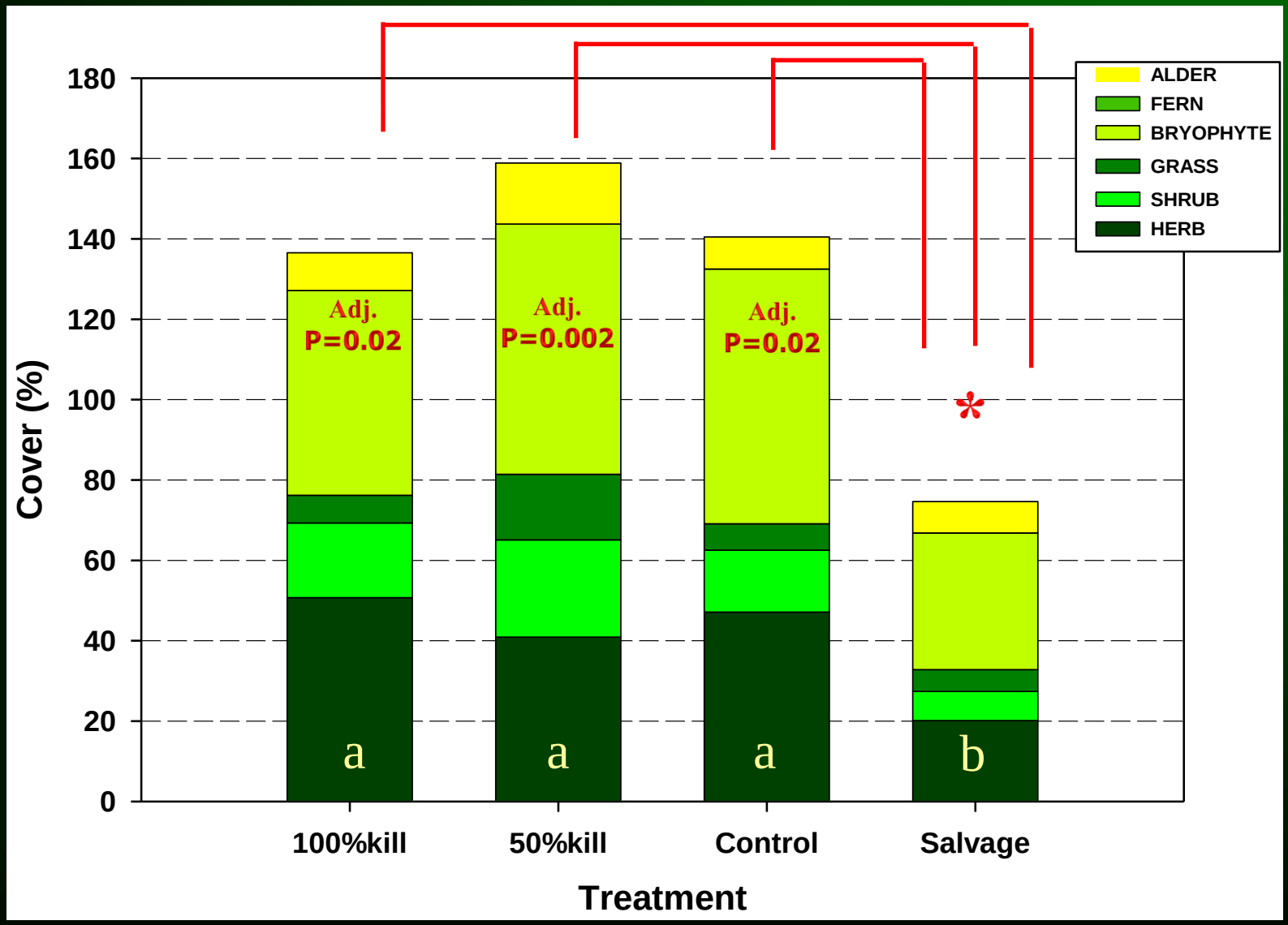
# Understory richness



# Understory cover



# Understory cover: post-treatment (2009)



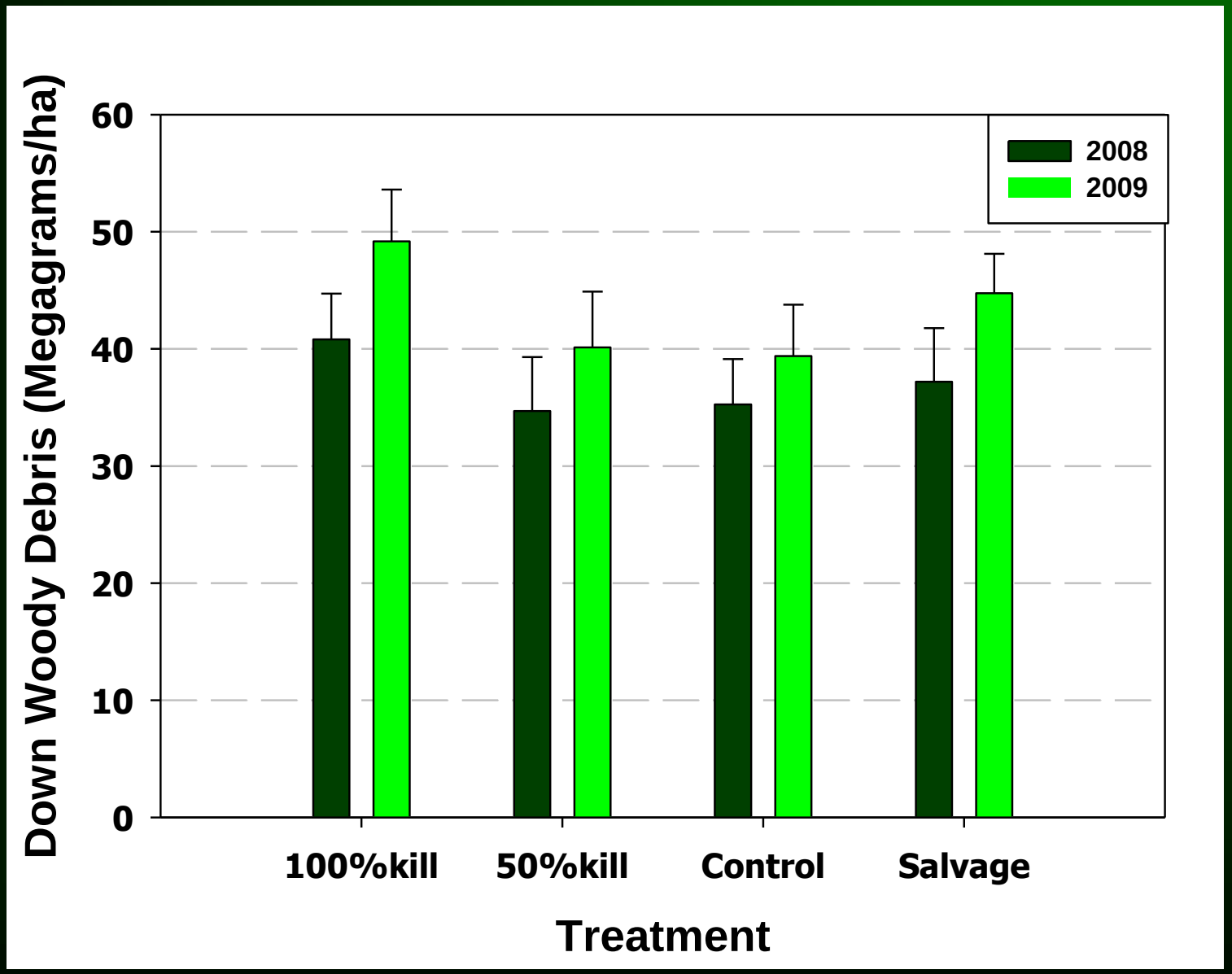
# Objective 3:
# Downed woody debris

Quantify DWD

- Transects: biomass estimates

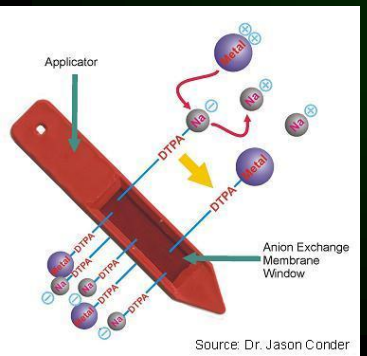
(Megagrams/ha)

# DWD biomass


Down Woody Debris (Megagrams/ha)
60
50
40
30
20
10
0
2008
2009
100%kill
50%kill
Control
Salvage
Treatment

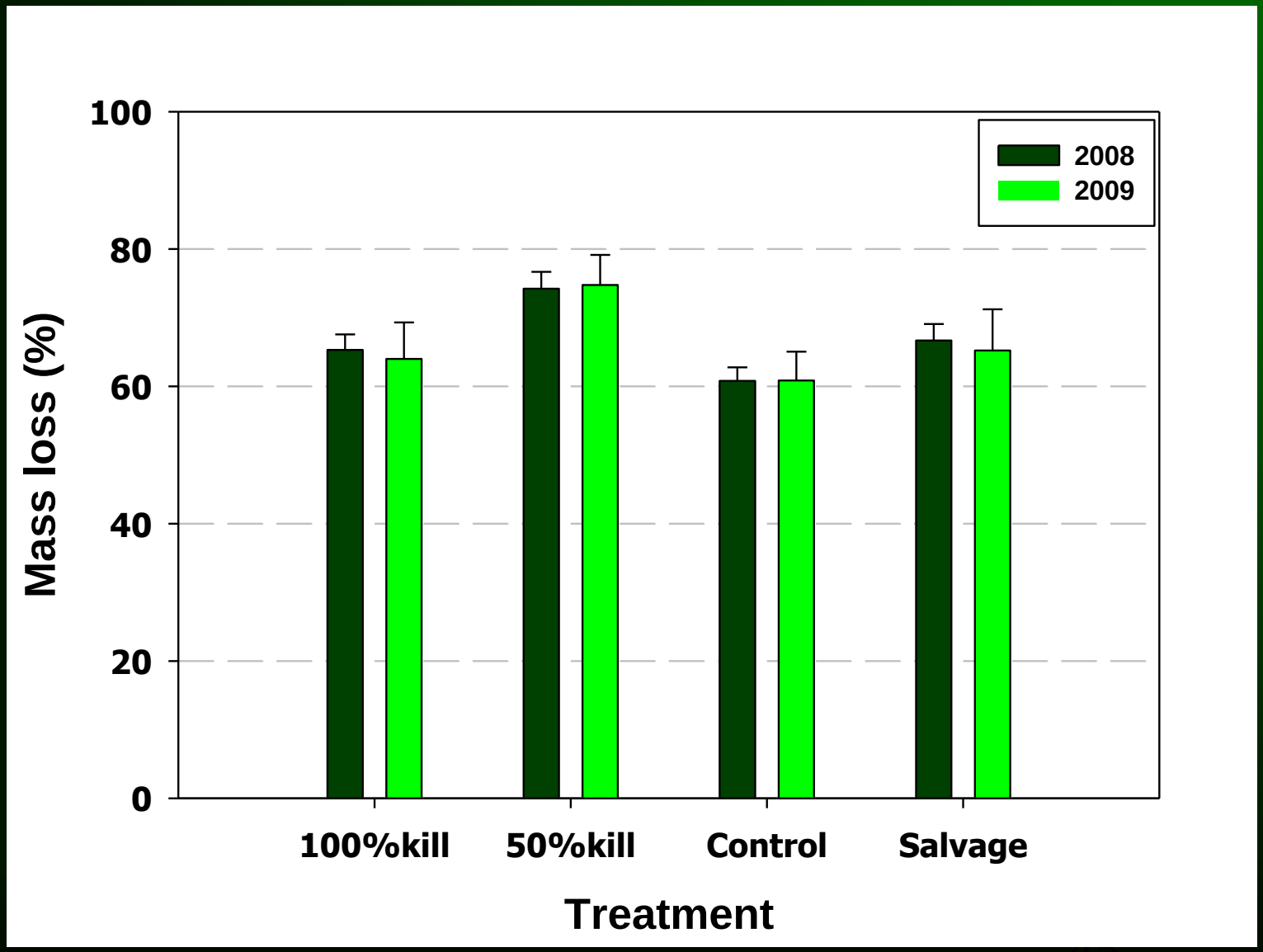
# Objective 4: Below-Ground

- Quantify differences in below-ground attributes
  - Decomposition (cellulose paper in mesh bags)
  - pH
  - Microbial biochemical activity & biomass
    - Community-level physiological profiles (CLPP)
    - Phospholipid fatty acid (PLFA) analysis
  - Nutrient availability (PRS probes)
  - Soil moisture (TDR)

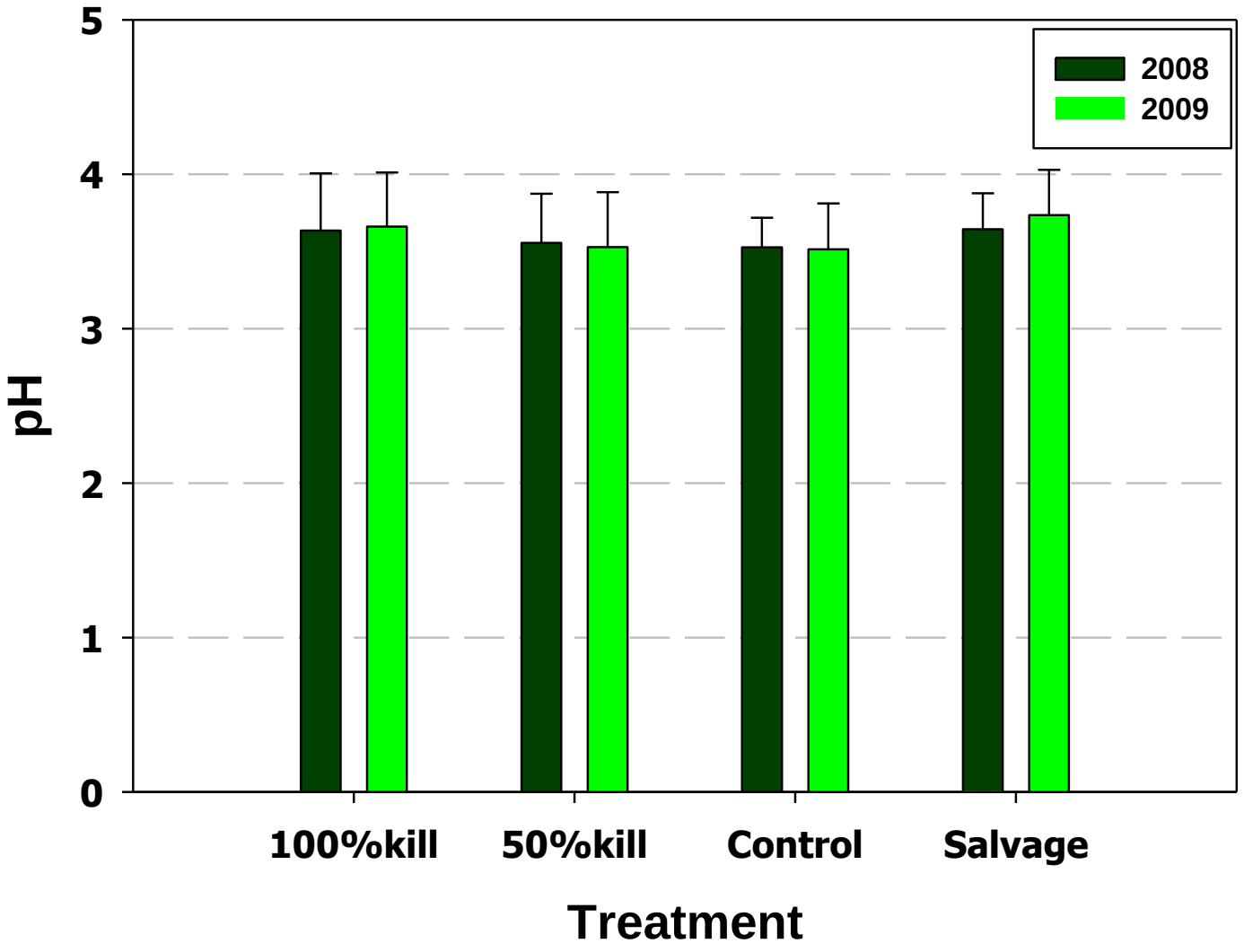


Source: Dr. Jason Conder

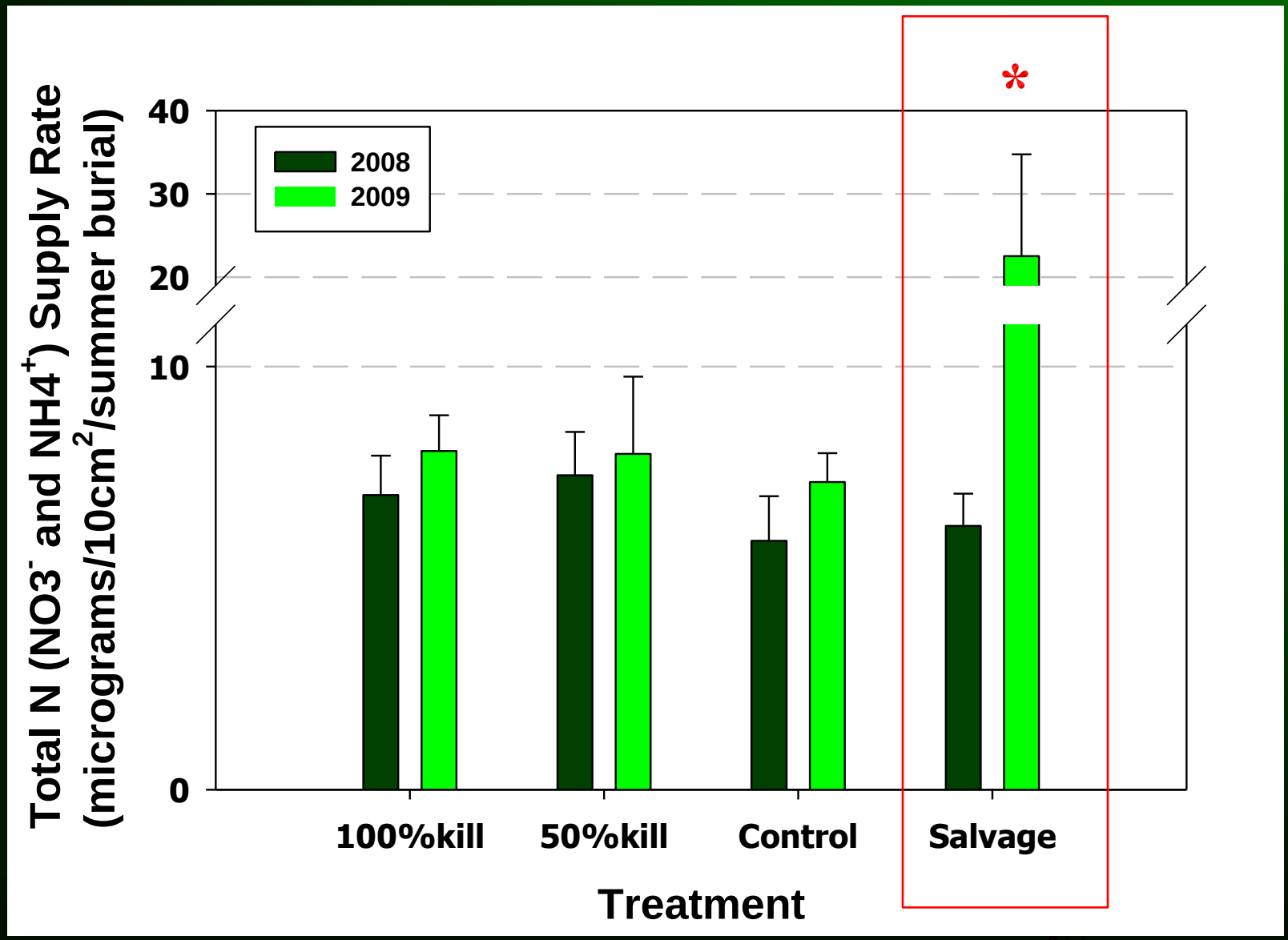
# Decomposition



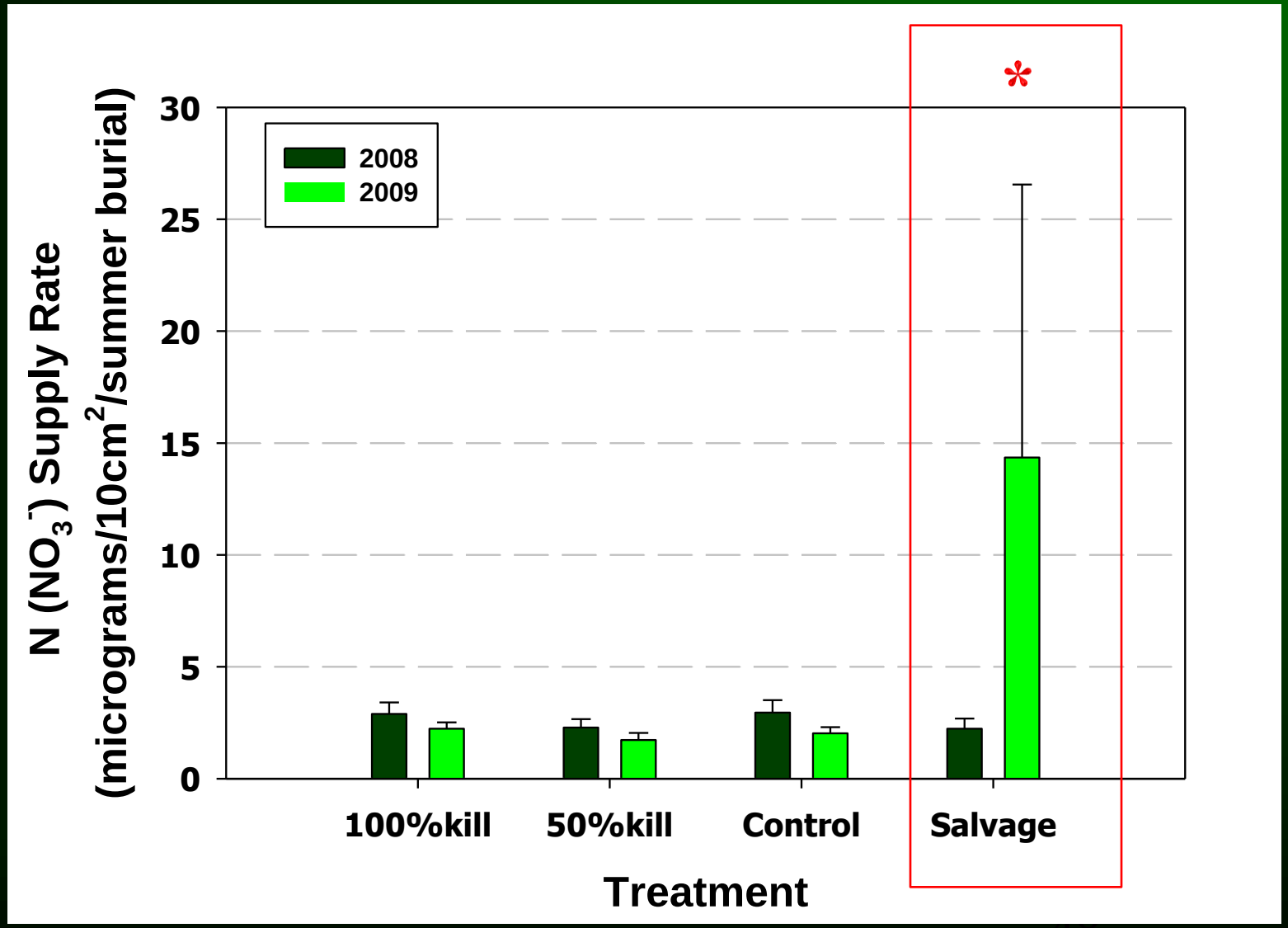
# pH


5
4
3
2
1
0
pH
2008
2009
100%kill
50%kill
Control
Salvage
Treatment

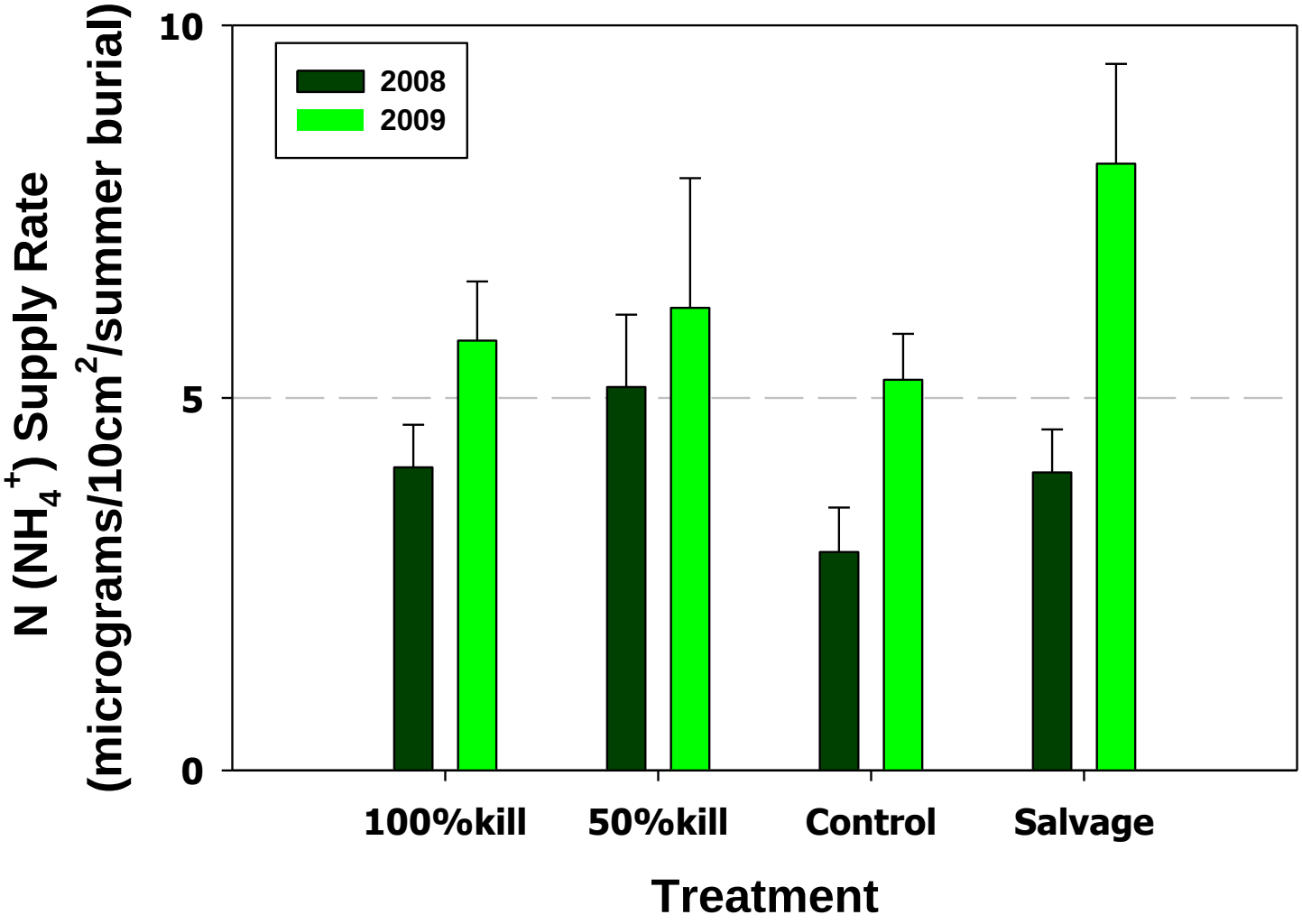
# Total Nitrogen

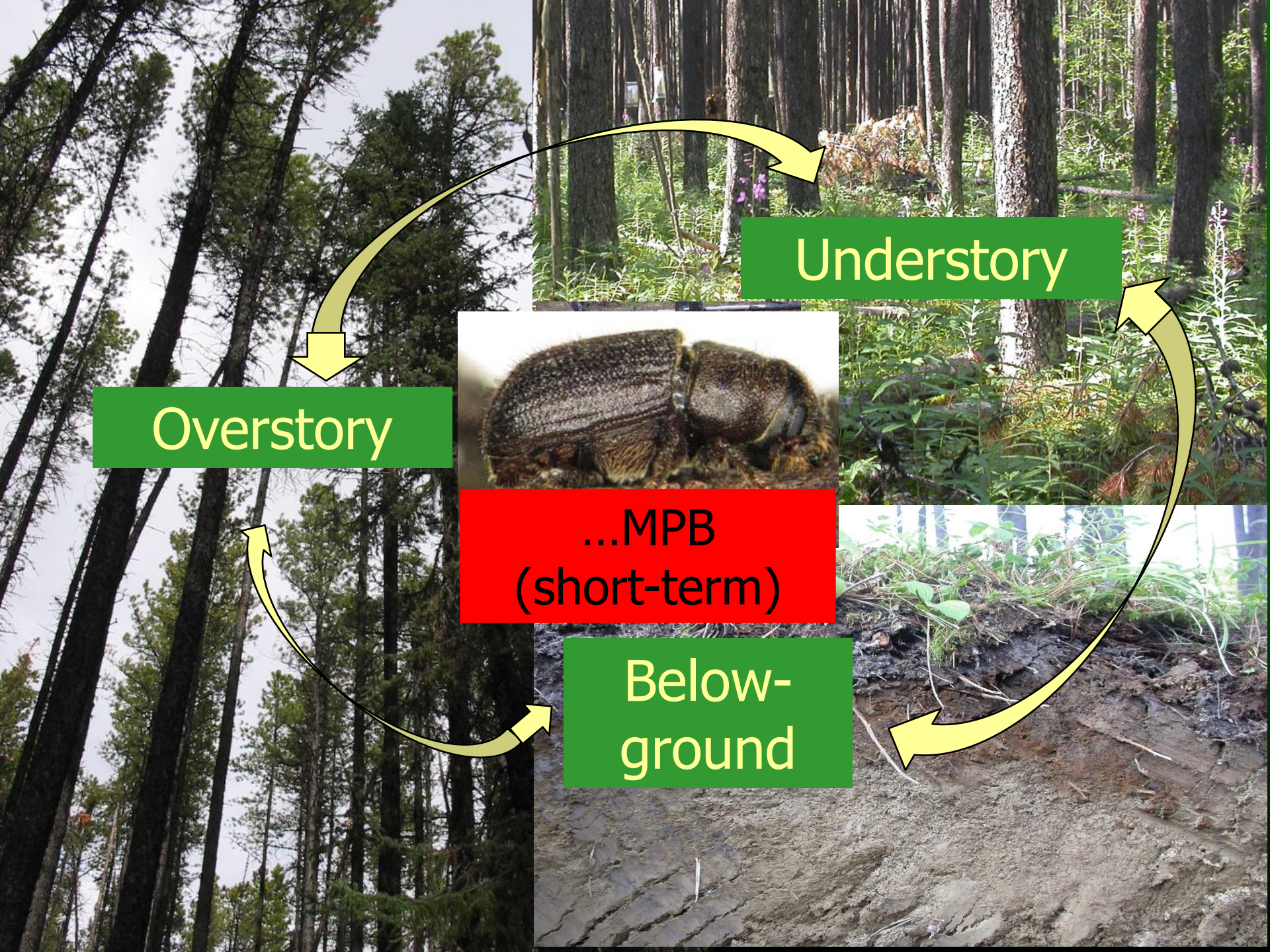


# $NO_3^-$


*
2008
2009
30
25
20
15
10
5
0
N ($NO_3^-$) Supply Rate
(micrograms/10cm$^2$/summer burial)
100%kill
50%kill
Control
Salvage
Treatment

# $NH_4^+$


10
5
0
2008
2009
N ($NH_4^+$) Supply Rate
(micrograms/10cm$^2$/summer burial)
100%kill
50%kill
Control
Salvage
Treatment


Understory
Overstory
…MPB
(short-term)
Below-
ground

# Recap & the future…



# Project timeline …

Fall 2007 – May 2008: site selection, plot layout, instrumentation
June 2008 – 2009: pre-treatment data collection
June 2009 – July 2009: treatment application
June 2009 – 2010: 1st post-treatment year data collection
June 2010 – 2011: 2nd post-treatment year data collection
June 2011 – Mar 2012: analysis and write-up

Subsequent data collection?

# What information will we have?

Characterize water balance of these forests:

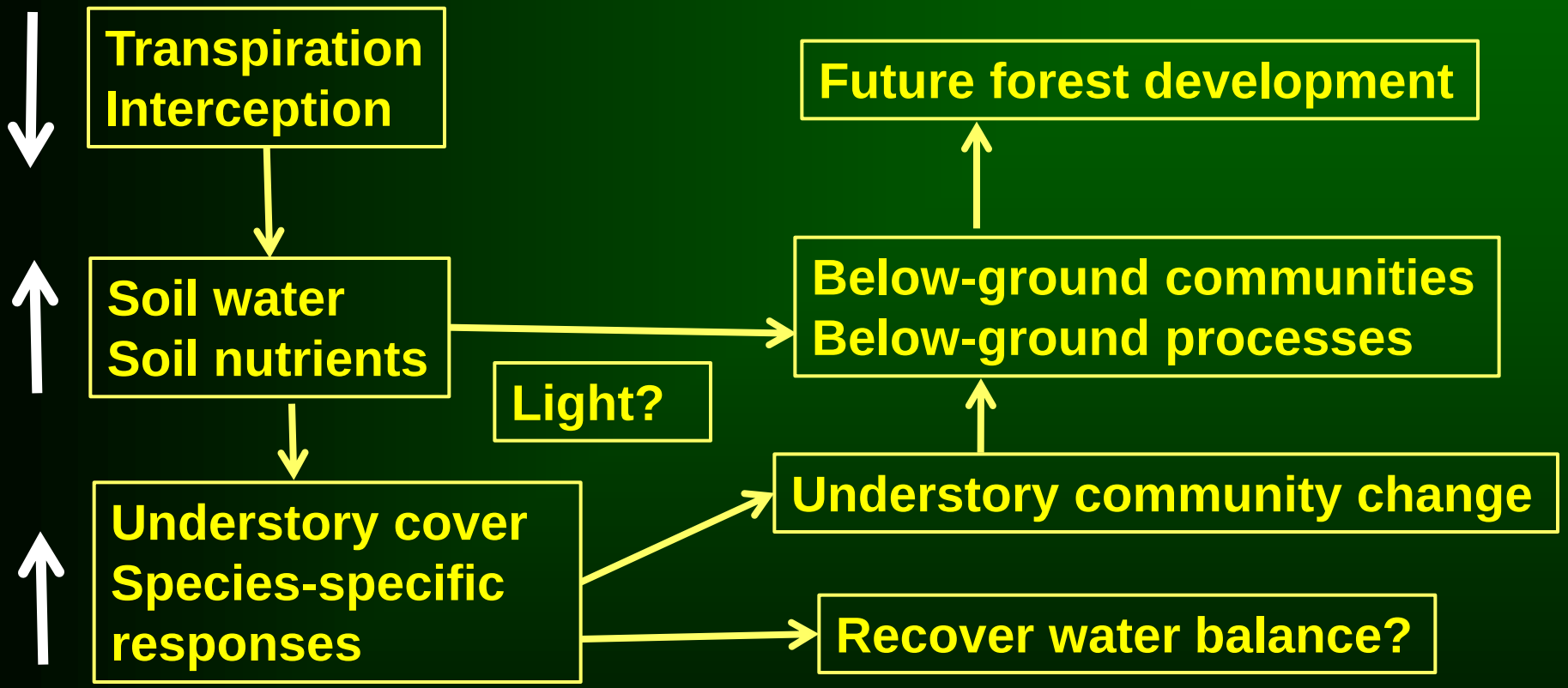
- Where the water is/goes
- How much water do they use?

Characterize forest structure, vegetation, below-ground

- Relationships: canopy, understory vegetation, soils
- Potential for tree regeneration

What happens when the trees die and stay standing?

# Short-term responses of lodgepole pine forests to this unique disturbance



# Short-term responses of lodgepole pine forests to this unique disturbance

Effects of gradient of disturbance:

Water yield?

Vegetation change?

Recovery of water balance?

Tree regeneration?

Future forest development?

LONGER TERM RESPONSES….?

# *Support for the work*

- Foothills Research Institute
- FRIAA / AB SRD
- West Fraser Timber Co. Ltd.
- NSERC
- CONACYT
- Milo Mihajlovich
- Field Assistants







## *…Thank you for listening*

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