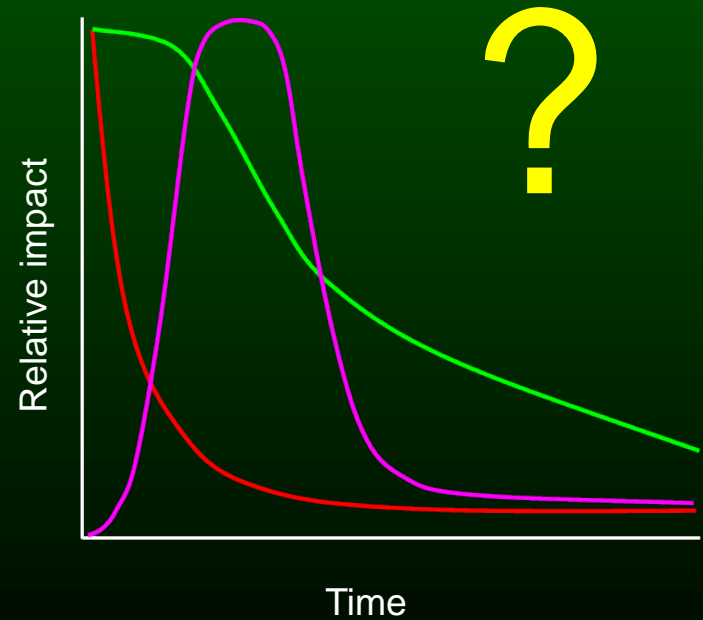
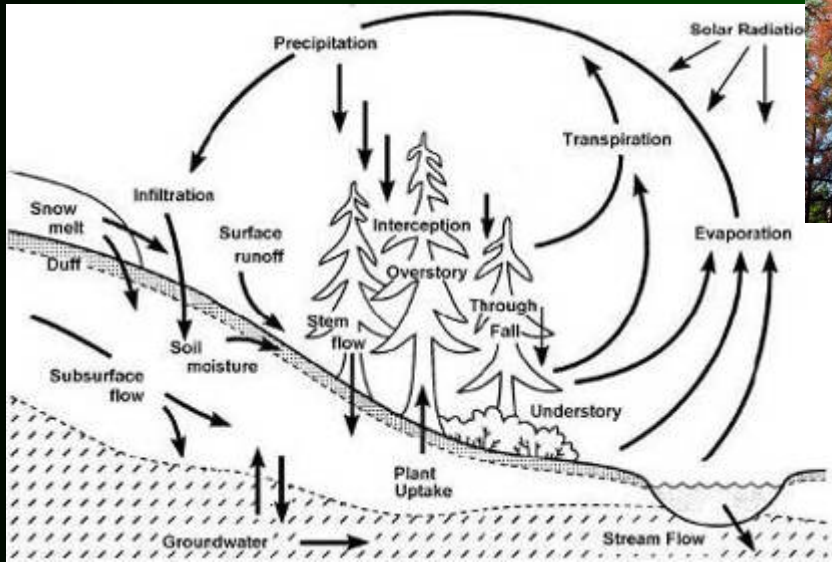
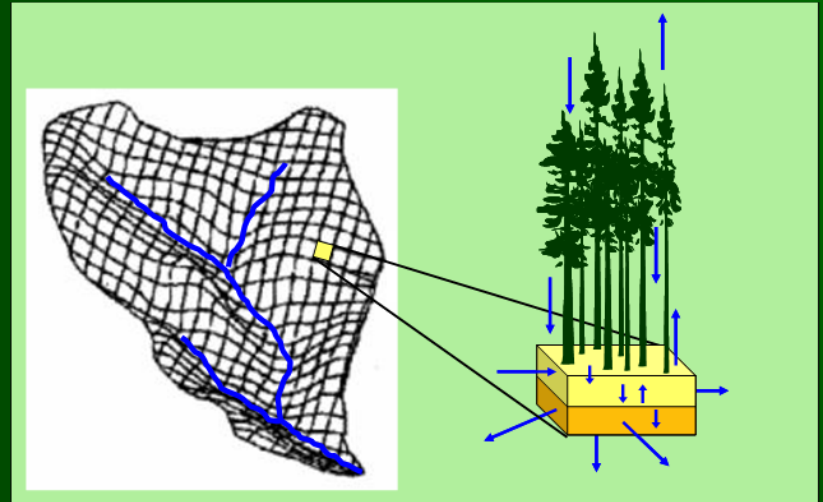


Effects of Simulated MPB on Hydrology and Post-attack Vegetation & Below-ground Dynamics

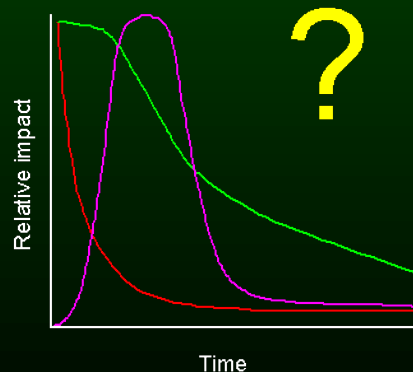


Principal investigators: Uldis Silins and Ellen Macdonald
Ph.D. projects: Anne McIntosh and Pablo Piña
Lead field technician: Pete Present



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

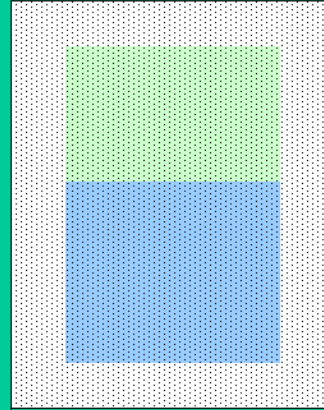
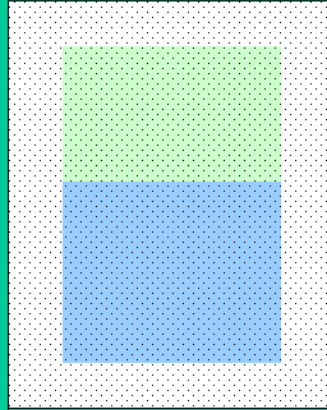
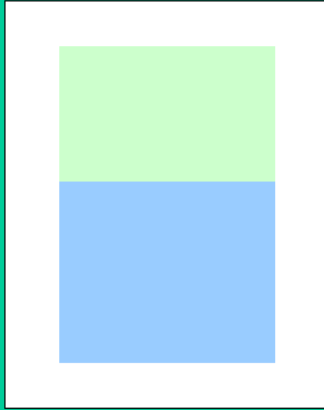


Control (undisturbed)

50% MPB kill

100% MPB kill

Salvage logged (harvested) plot
- no trees left standing



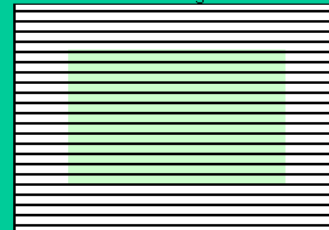
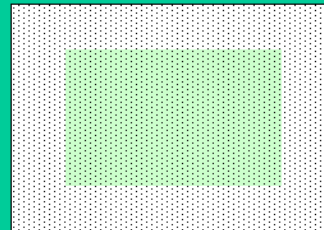
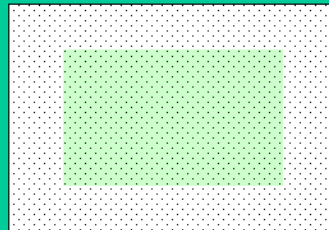
x 1

Control (undisturbed)

50% MPB kill

100% MPB kill

Salvage logged (harvested) plot
- no trees left standing



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
instrumentation					Pre-Treatment year					Post-Treatment Year 1					Post-Treatment Year 2															

Study area & design



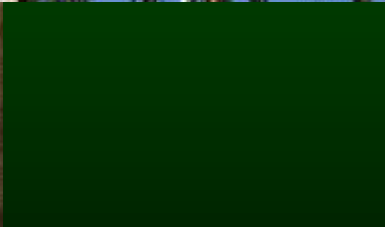
- Pure pine ~ 120 yrs
- Medium site index
- 22-24 m height



- Process studies
- Water balance
 - before-after: treatment-control

	Before	After
Treatment		
Control		

- Understory vegetation
 - replicated (repeated measures)



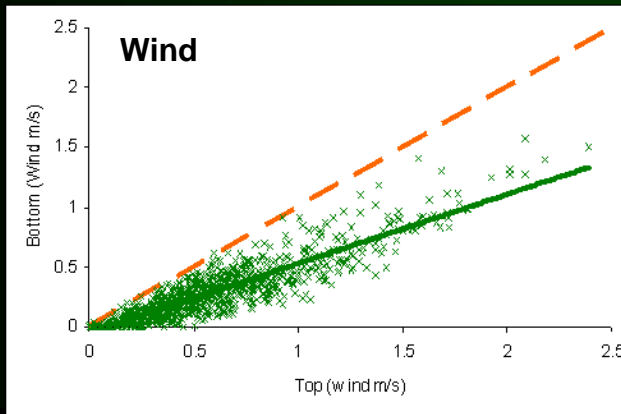
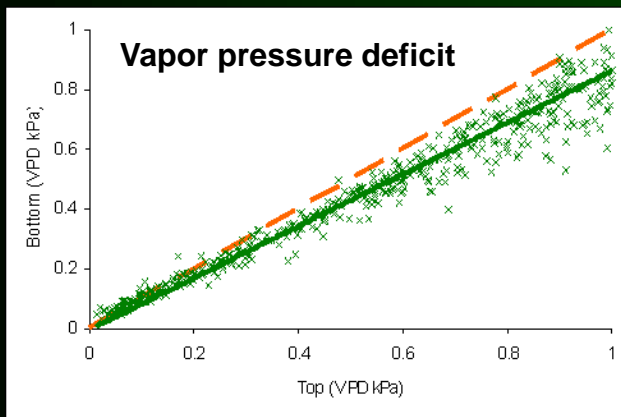
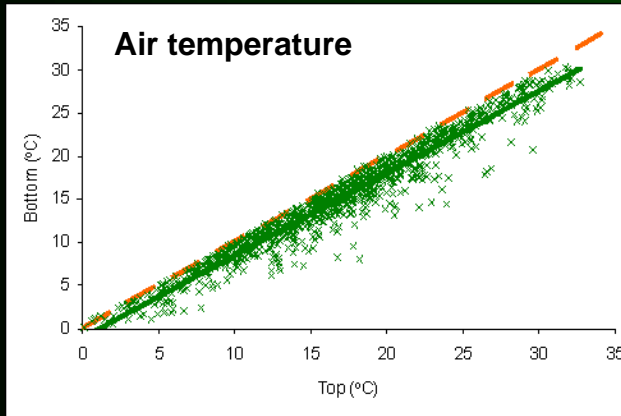
2008				2009				2010				2011																		
Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
instrumentation				Pre-Treatment year				Post-Treatment Year 1				Post-Treatment Year 2																		



- 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	Au
instrumentation				Pre-Treatment year				Post-Treatment Year 1				Post-Treatment Year 2						

Canopy regulated environmental factors



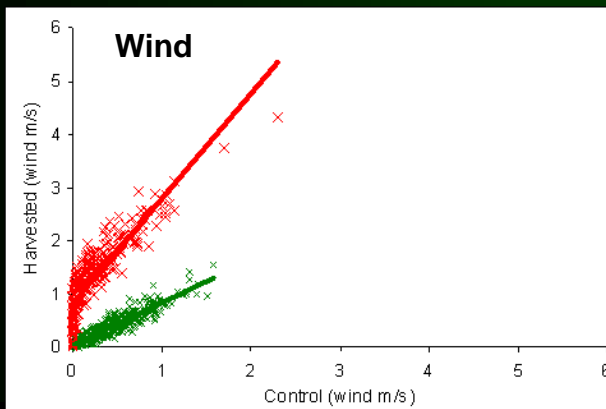
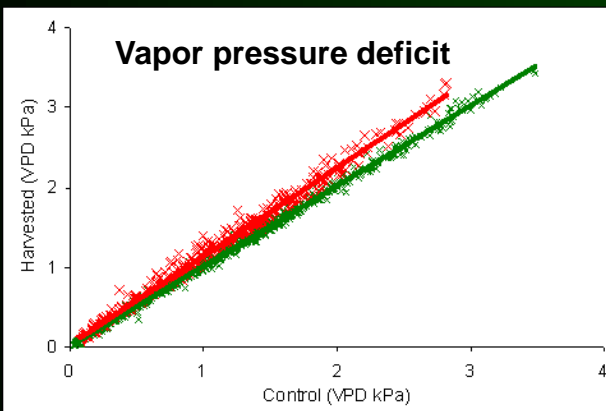
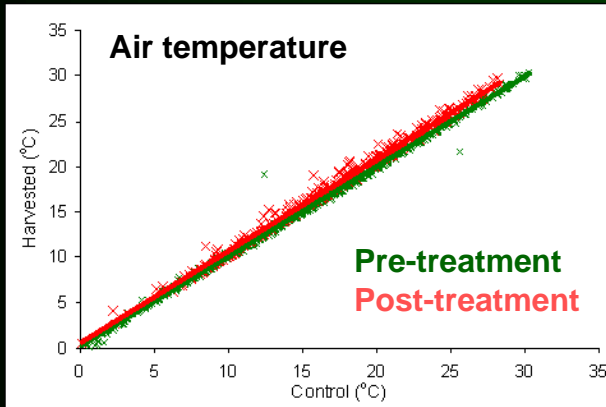
- Understory light, air temperature, humidity, wind, etc.



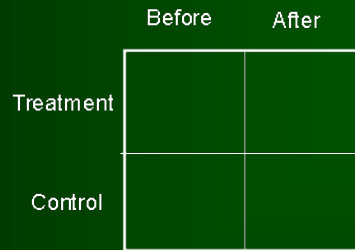
- Understory microclimate (compared to canopy)

- 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.



- 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

$$\text{Interception} = \text{Gross precipitation} - (\text{Stemflow} + \text{Throughfall}) - (\text{Throughfall} - \text{Forest floor flow})$$

Canopy interception

Forest floor interception

Overstory transpiration

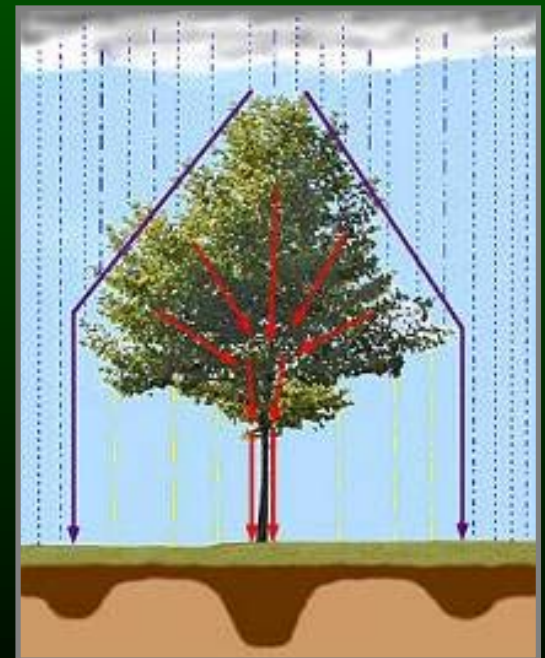


Canopy interception

Forest floor interception



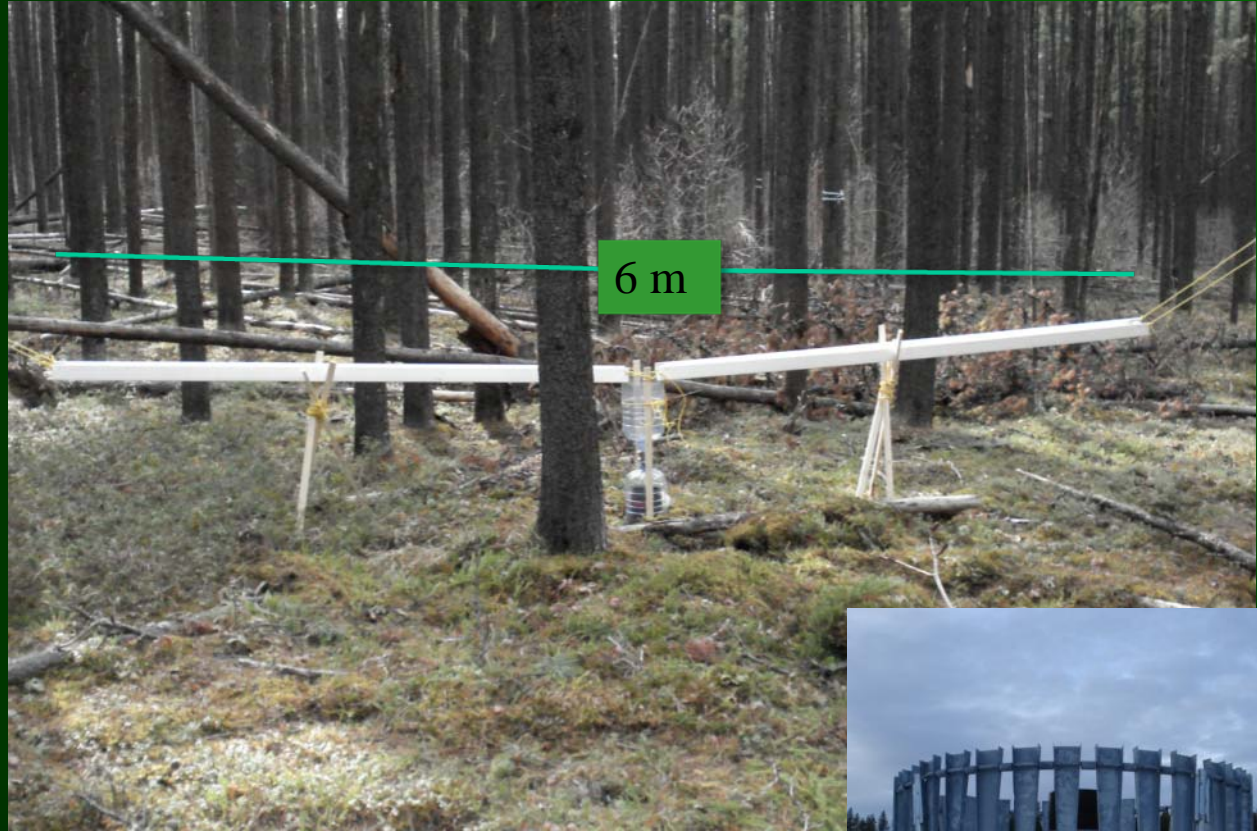
Soil moisture storage



Canopy interception



Stemflow
N = 3

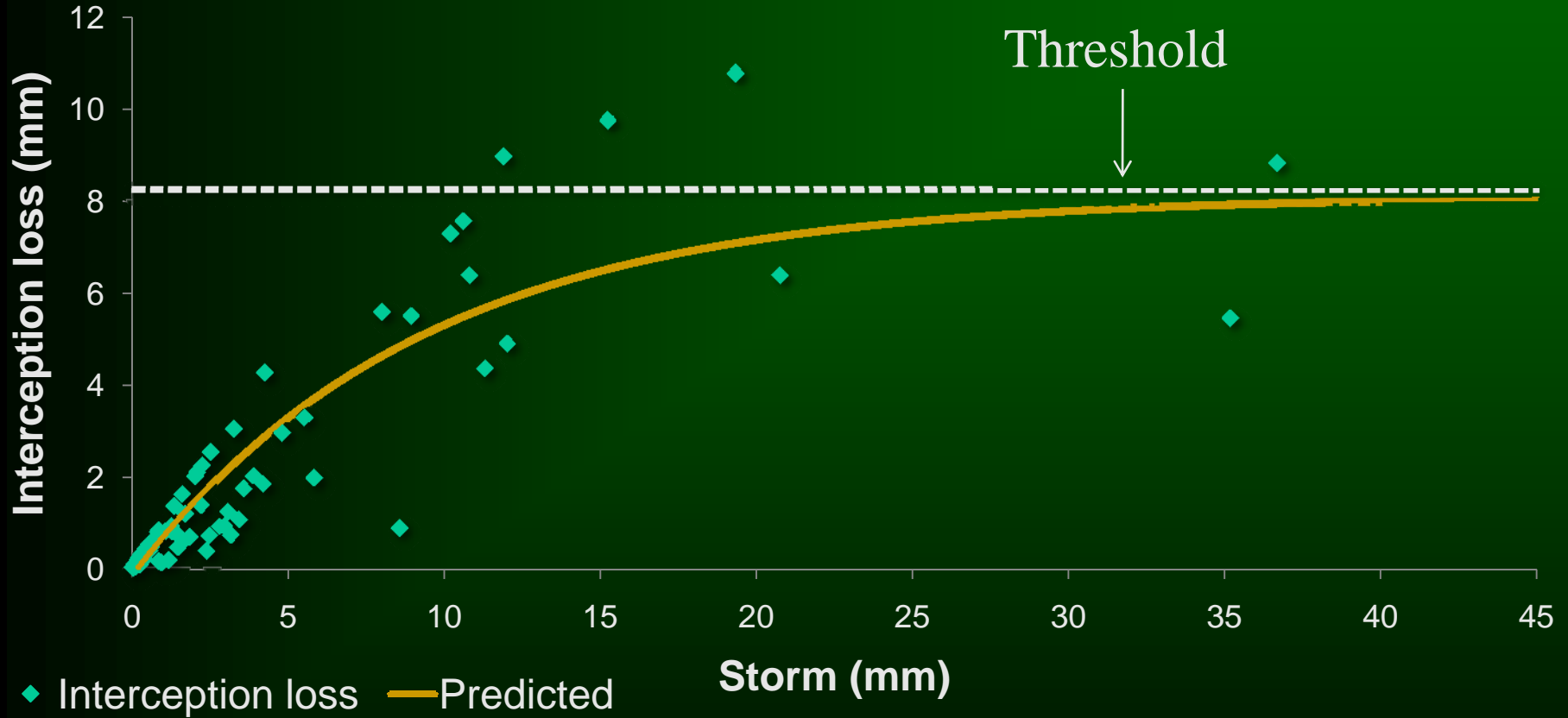


Throughfall
N = 4



Gross precipitation

Canopy storage capacity (S) = 8.1 mm

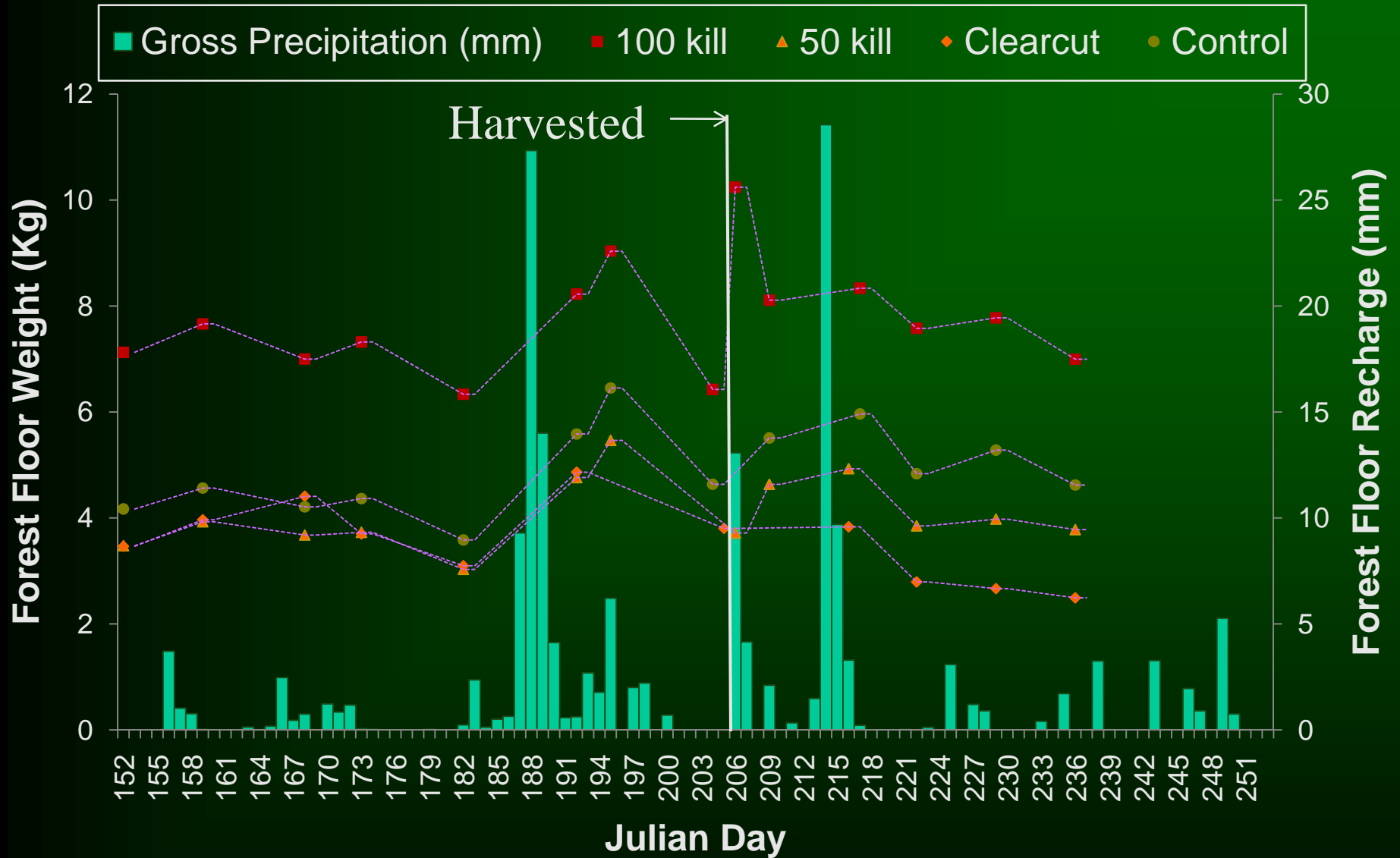


Forest floor interception

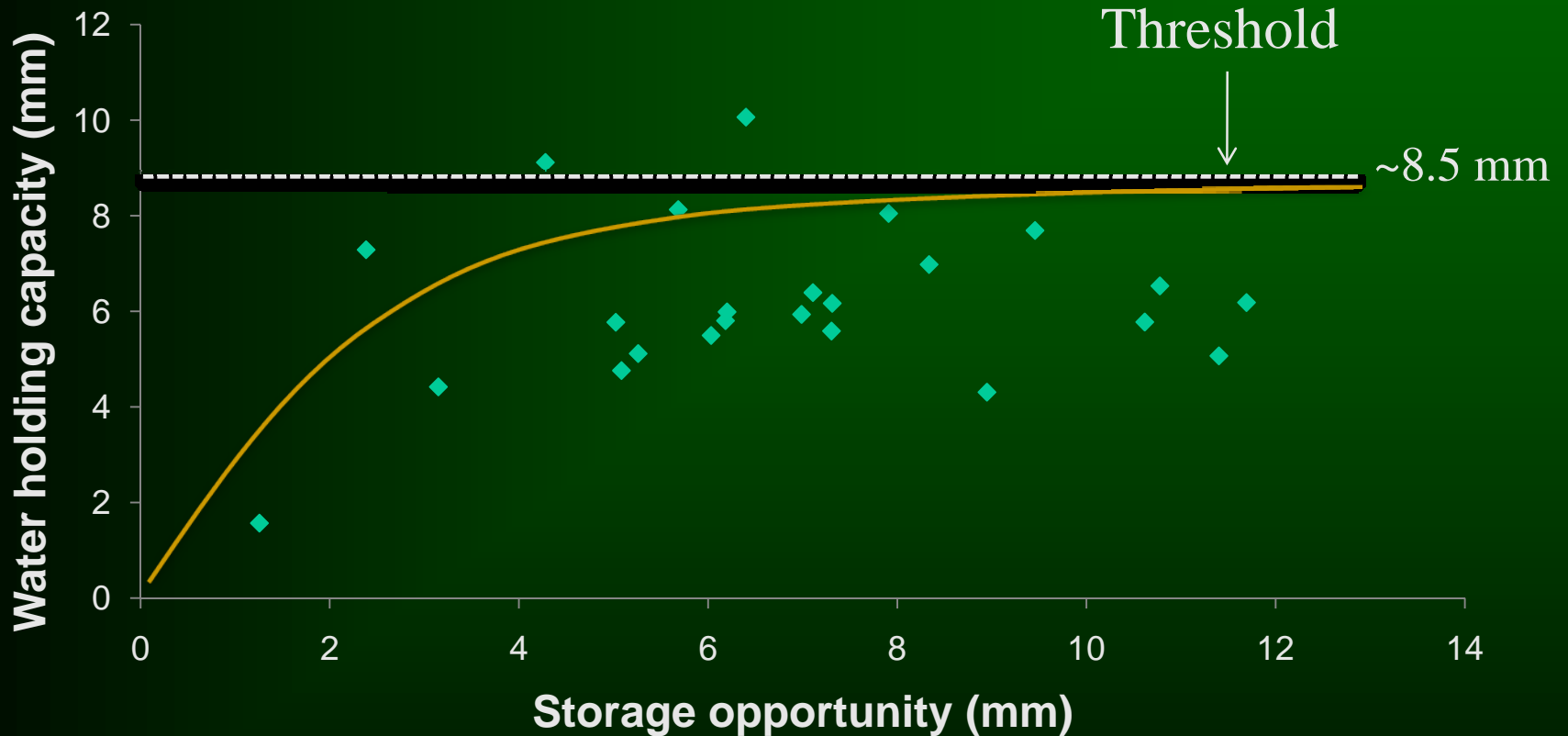
Monitoring quadrats
N = 4



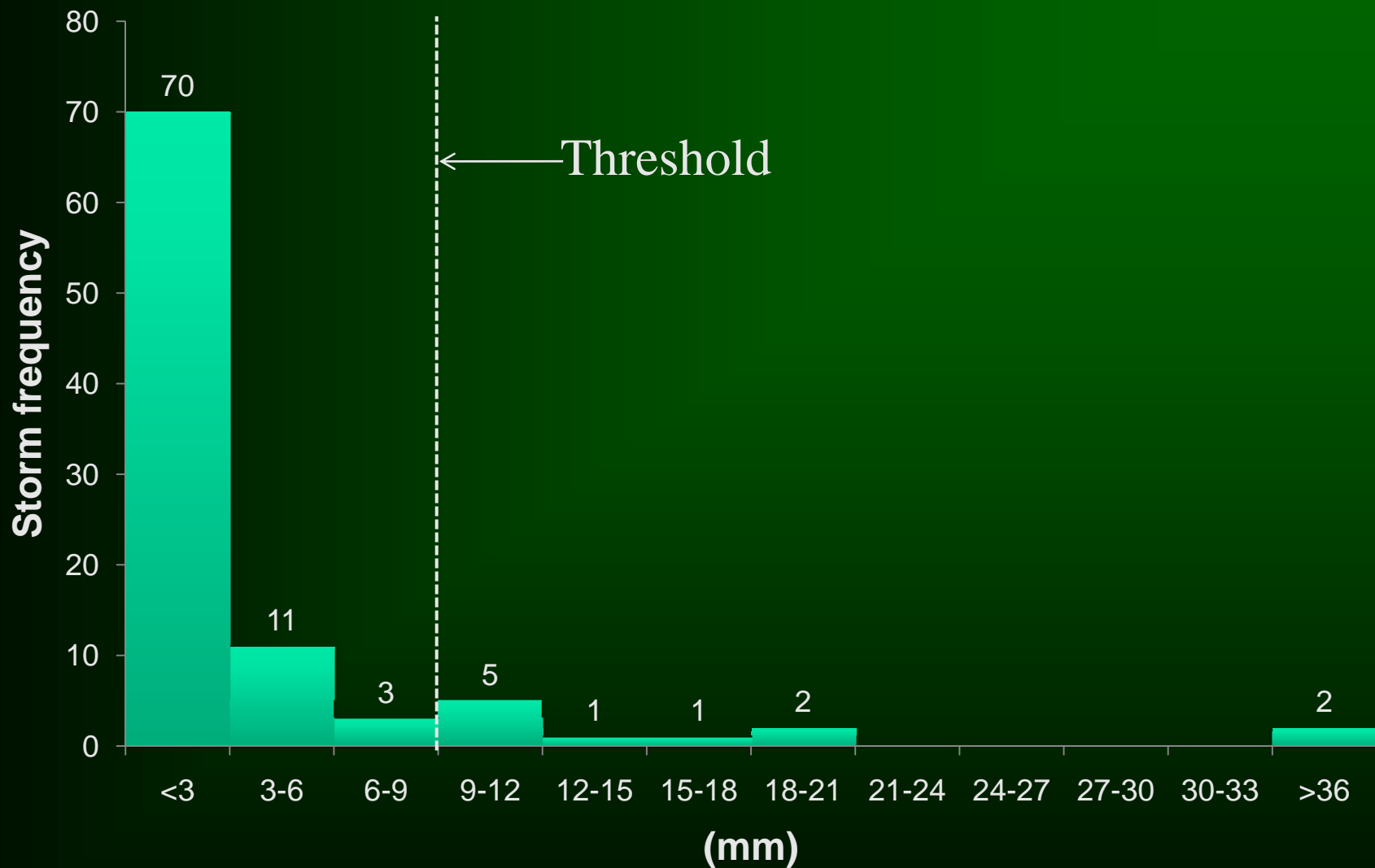
Post-treatment forest floor seasonal weight trends



Forest floor water holding capacity



Storm frequency distribution based on rainfall intensity



Overstory transpiration



N = 7



Overstory transpiration

Canopy interception



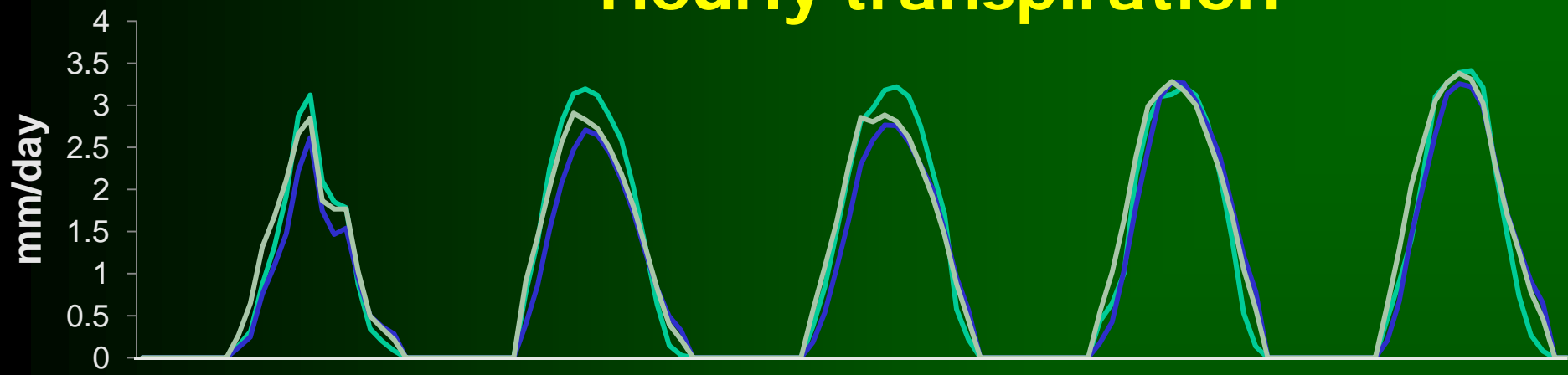
Forest floor interception

Soil moisture storage



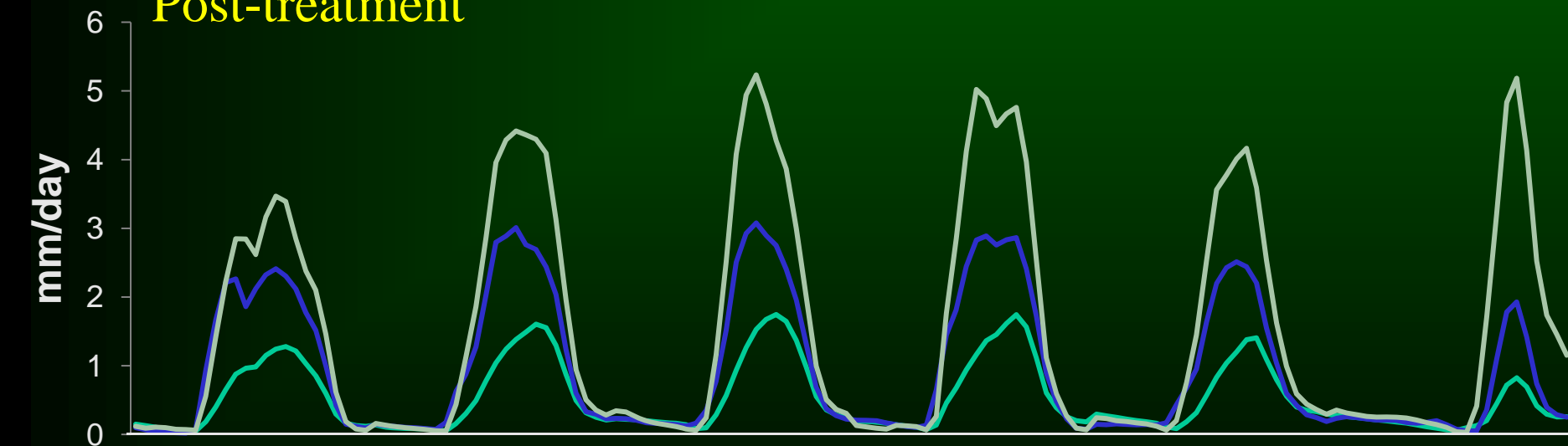
Pre-treatment

Hourly transpiration



— 100% Kill — 50% Kill — Control

Post-treatment



Soil moisture storage



Time continuous
soil moisture (WCR)



Overstory
transpiration



Spot measurements
soil moisture (TDR)

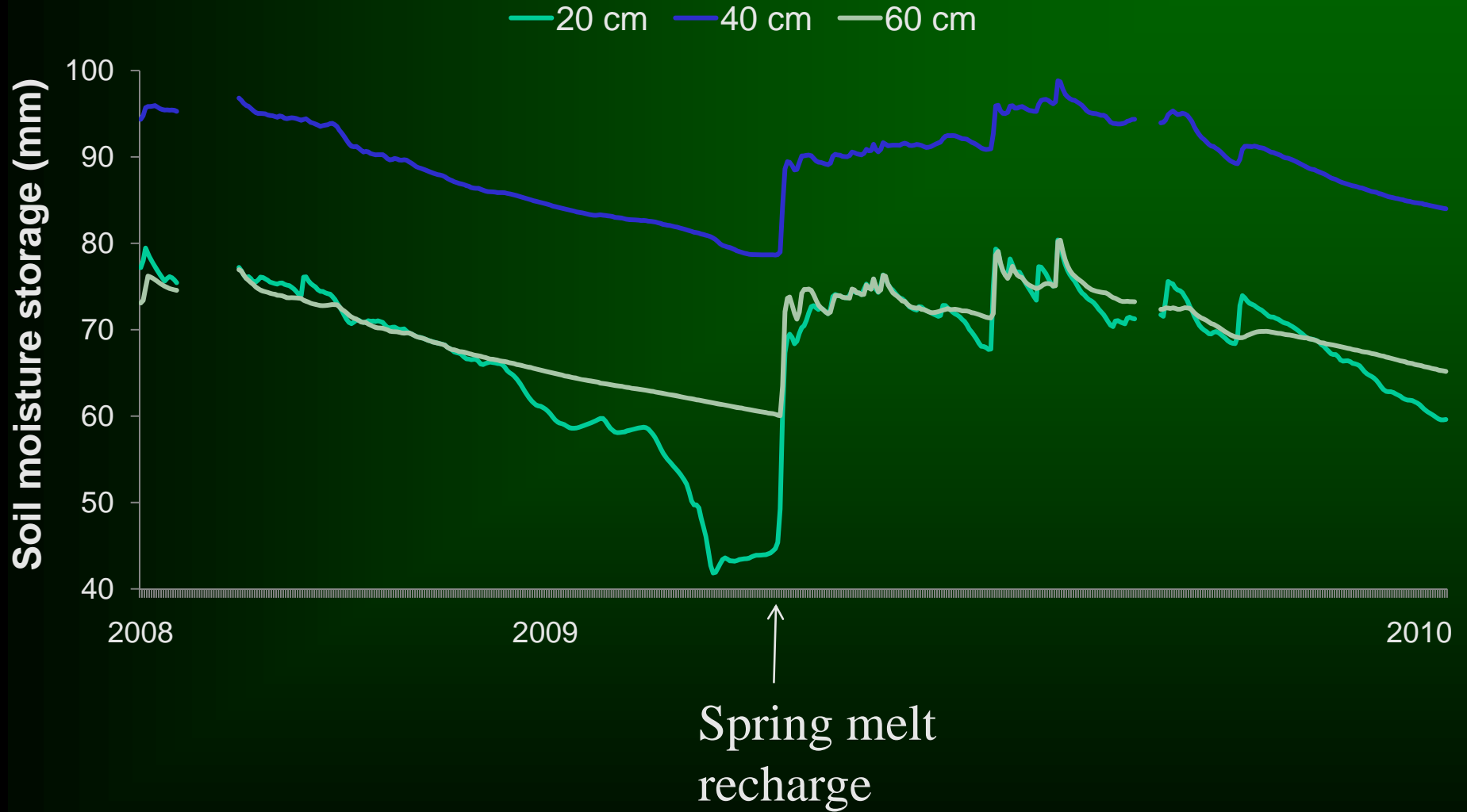


Canopy
interception

Forest floor
interception

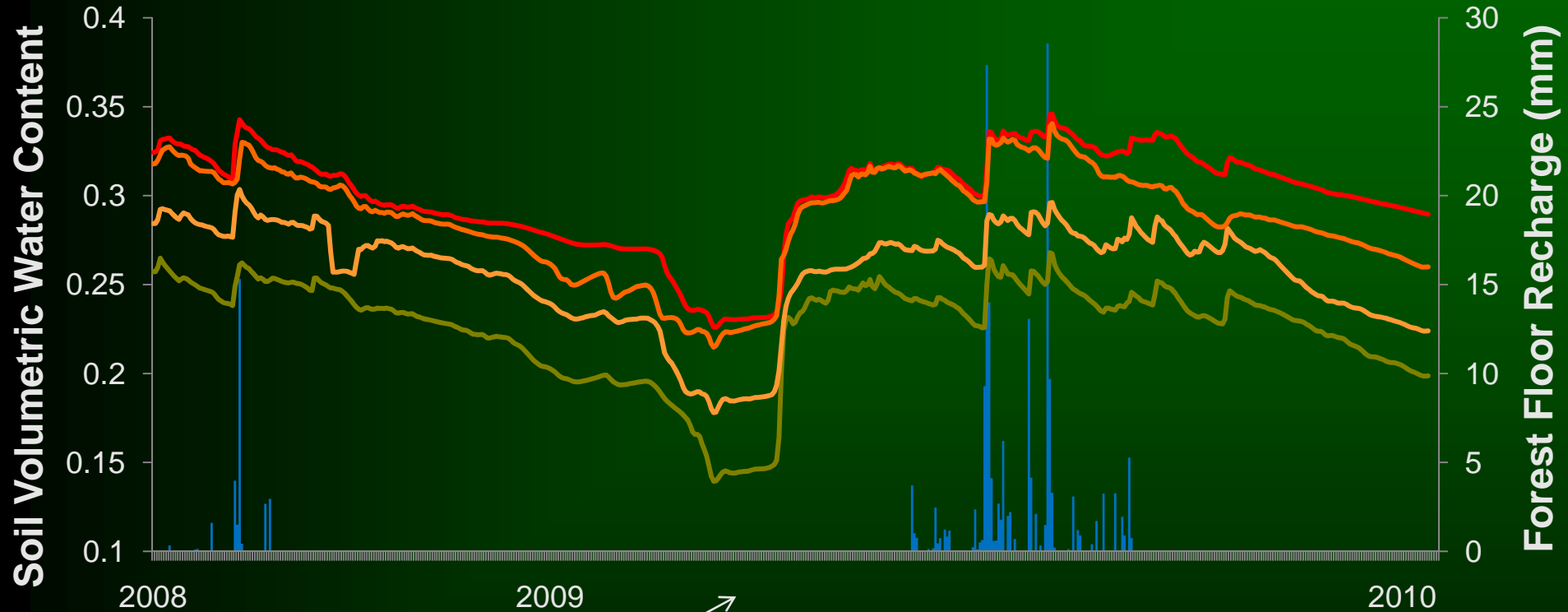
Soil moisture
storage

Soil moisture at the Control plot



Soil Moisture at 20 cm depth

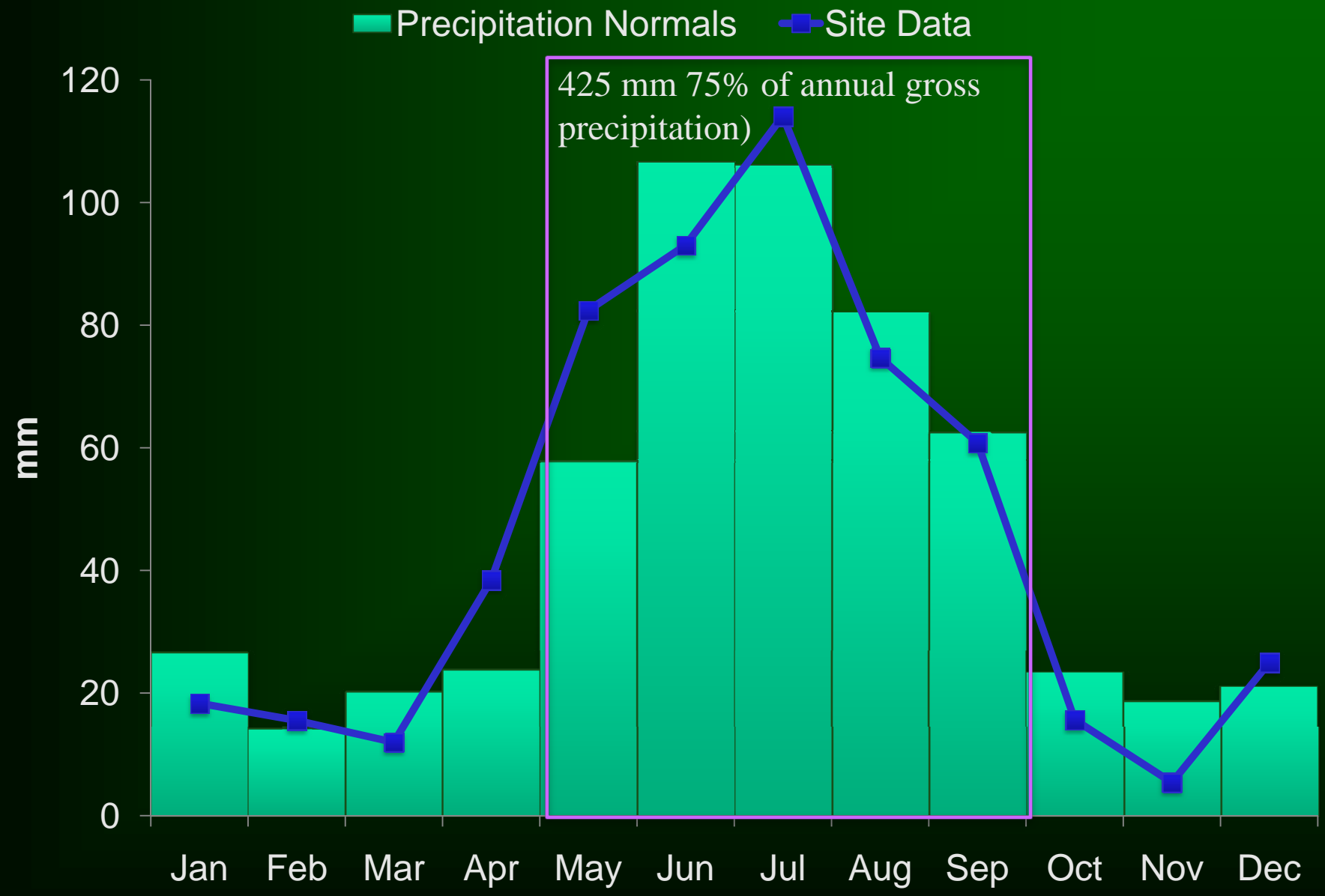
Forest Floor Recharge Control 100 Kill Clearcut 50 Kill



Spring melt
recharge

Year

What will happen when the MPB kills the trees?



Conclusions:

Overstory
transpiration

Canopy
interception



Forest floor
interception

Soil moisture
storage

During the growing season:

- Canopy interception \approx 49% of Precip
- Forest floor interception could be as high as canopy interception
- An average tree transpires 5.5 liters/day = $>$ \approx 0.7 liters/m² 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" ?





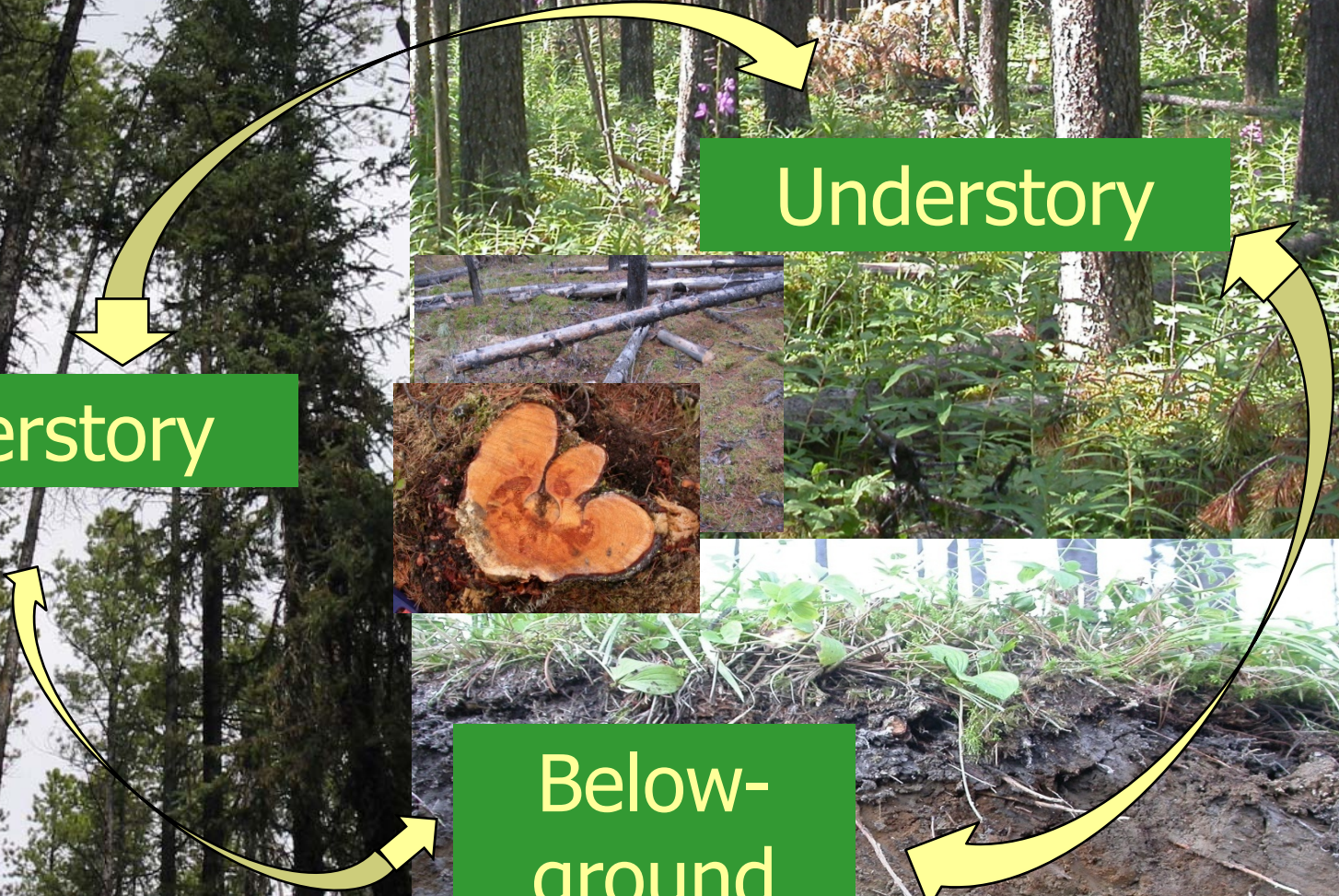
Overstory



Understory

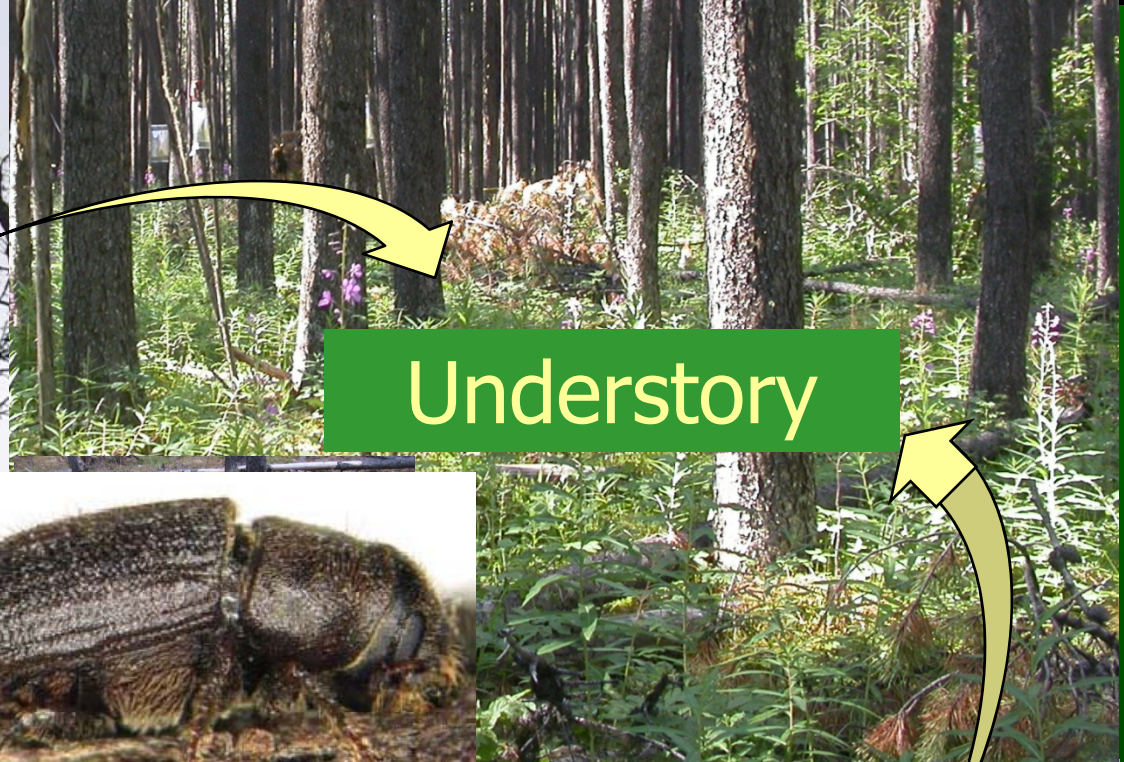


Below-ground





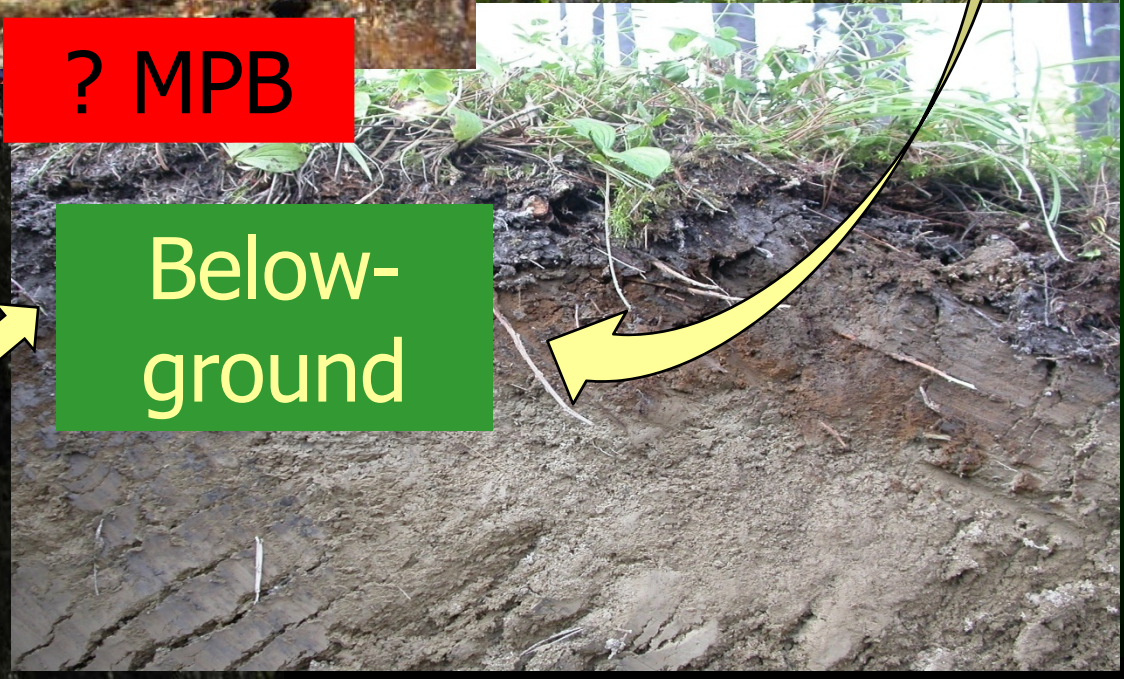
Overstory



Understory



? 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)

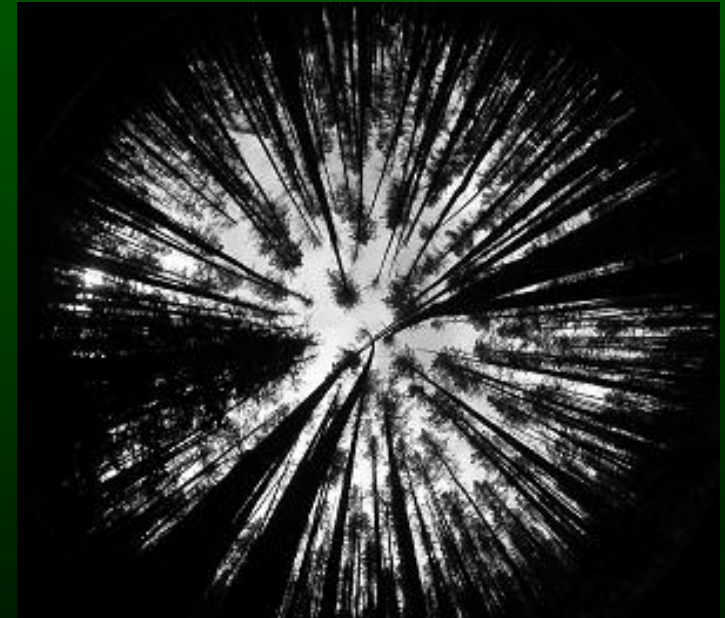




Objective 1: Overstory

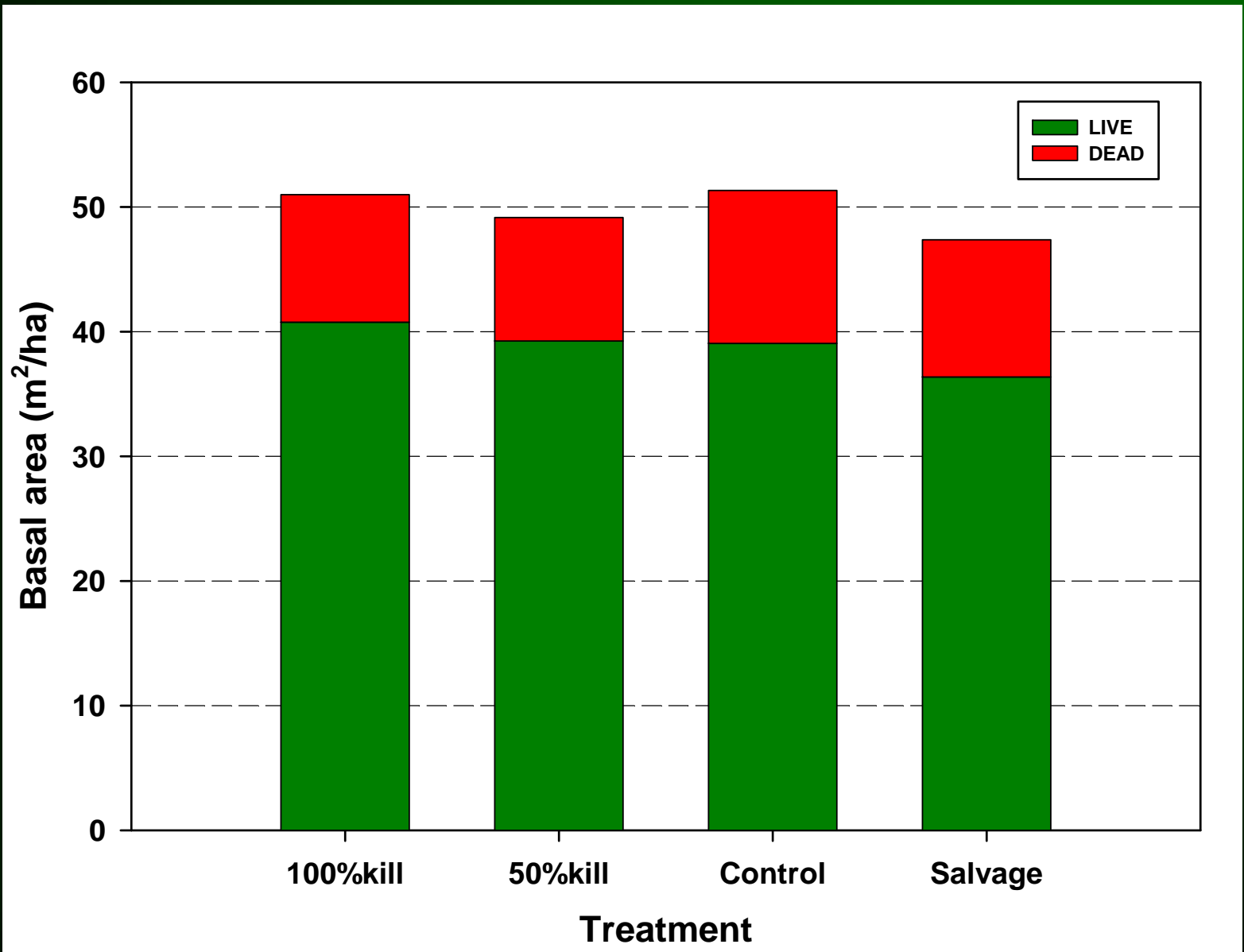
Characterize the overstory forest structure (0.02 ha plots)

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



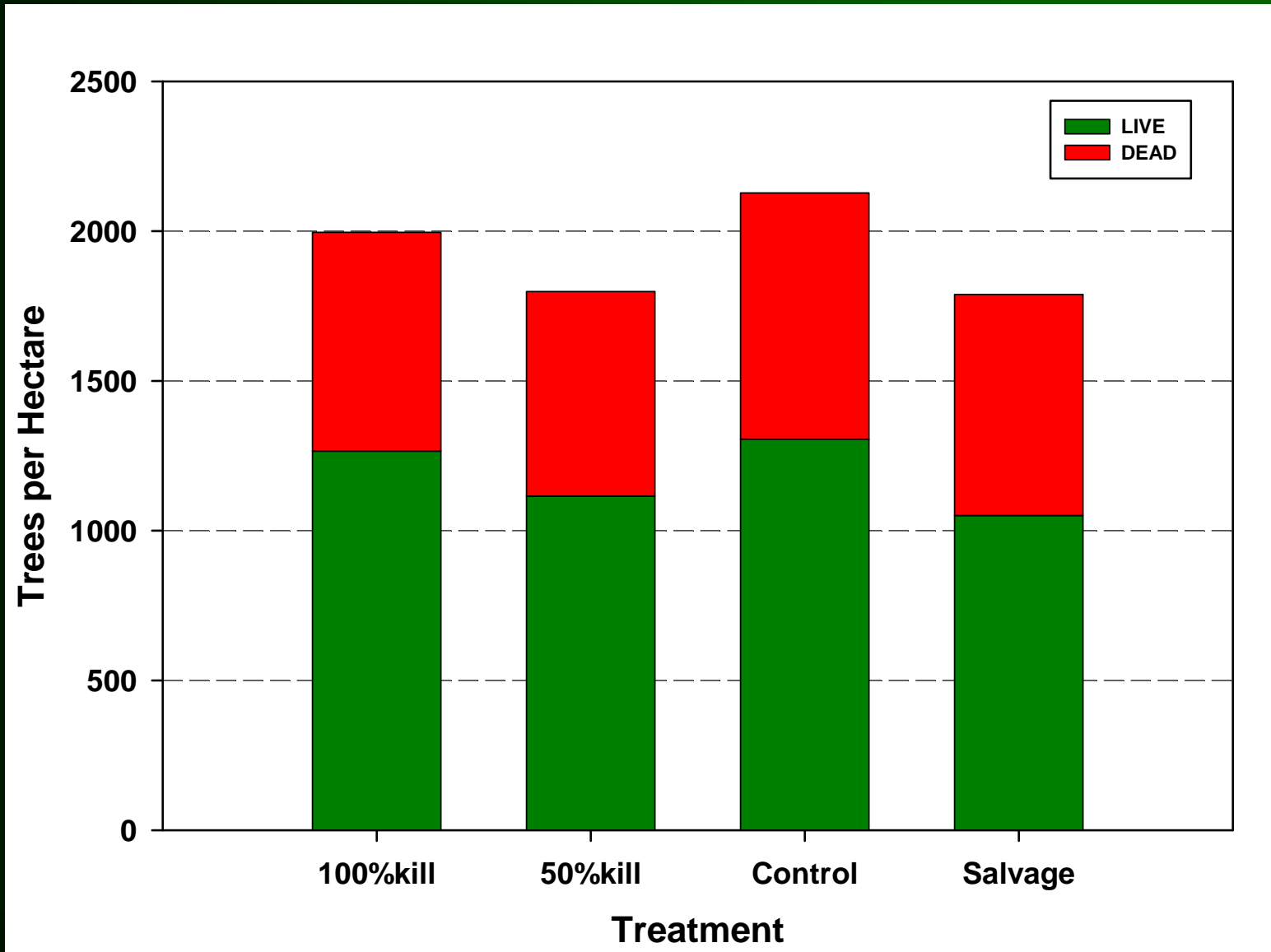
Measured before (2008) & after (2010)
treatment

Basal area



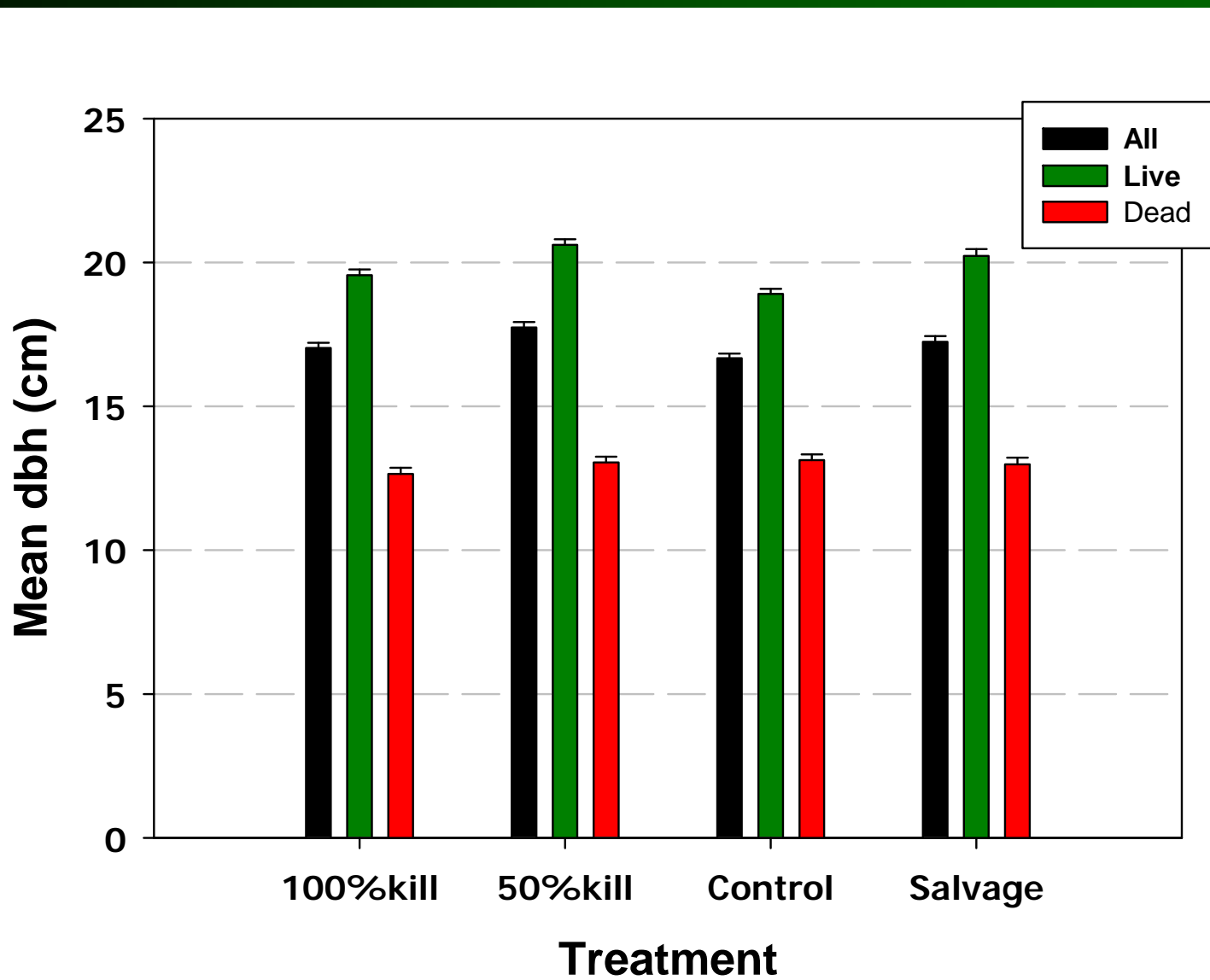
* Post-treatment will be measured in 2010

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?

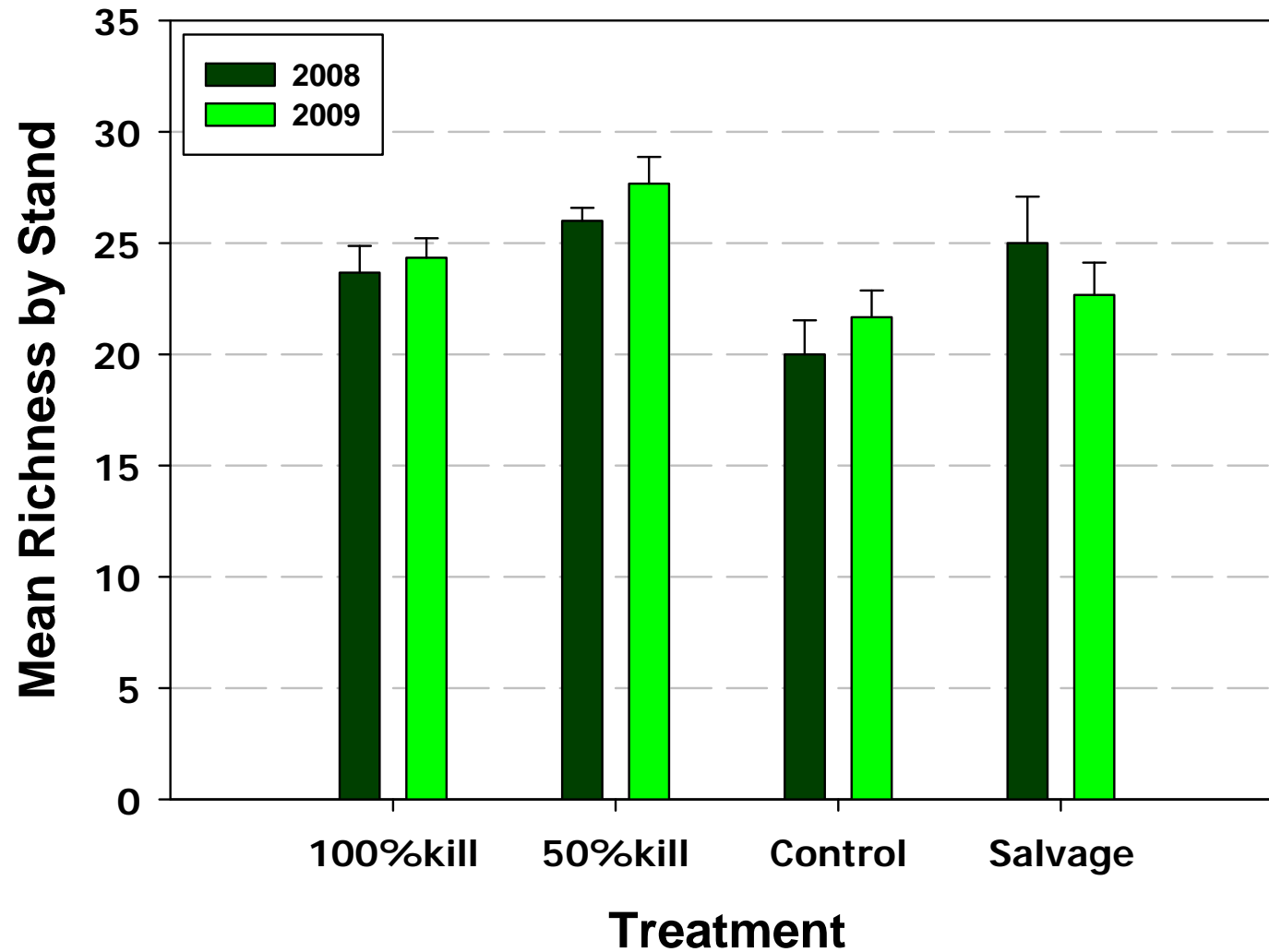
Quadrats on 5 substrates sowed with seed:

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

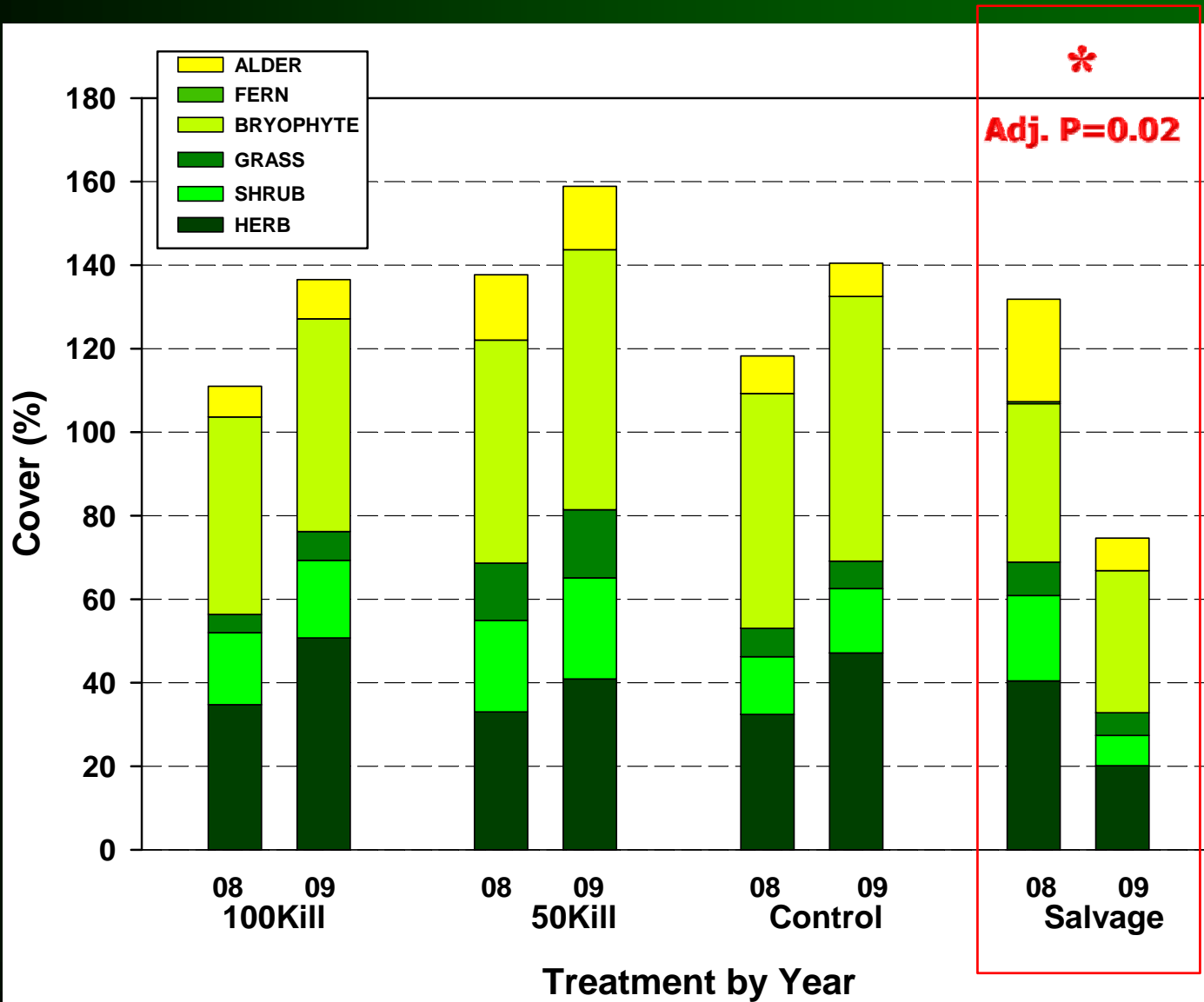
Monitor germination weekly



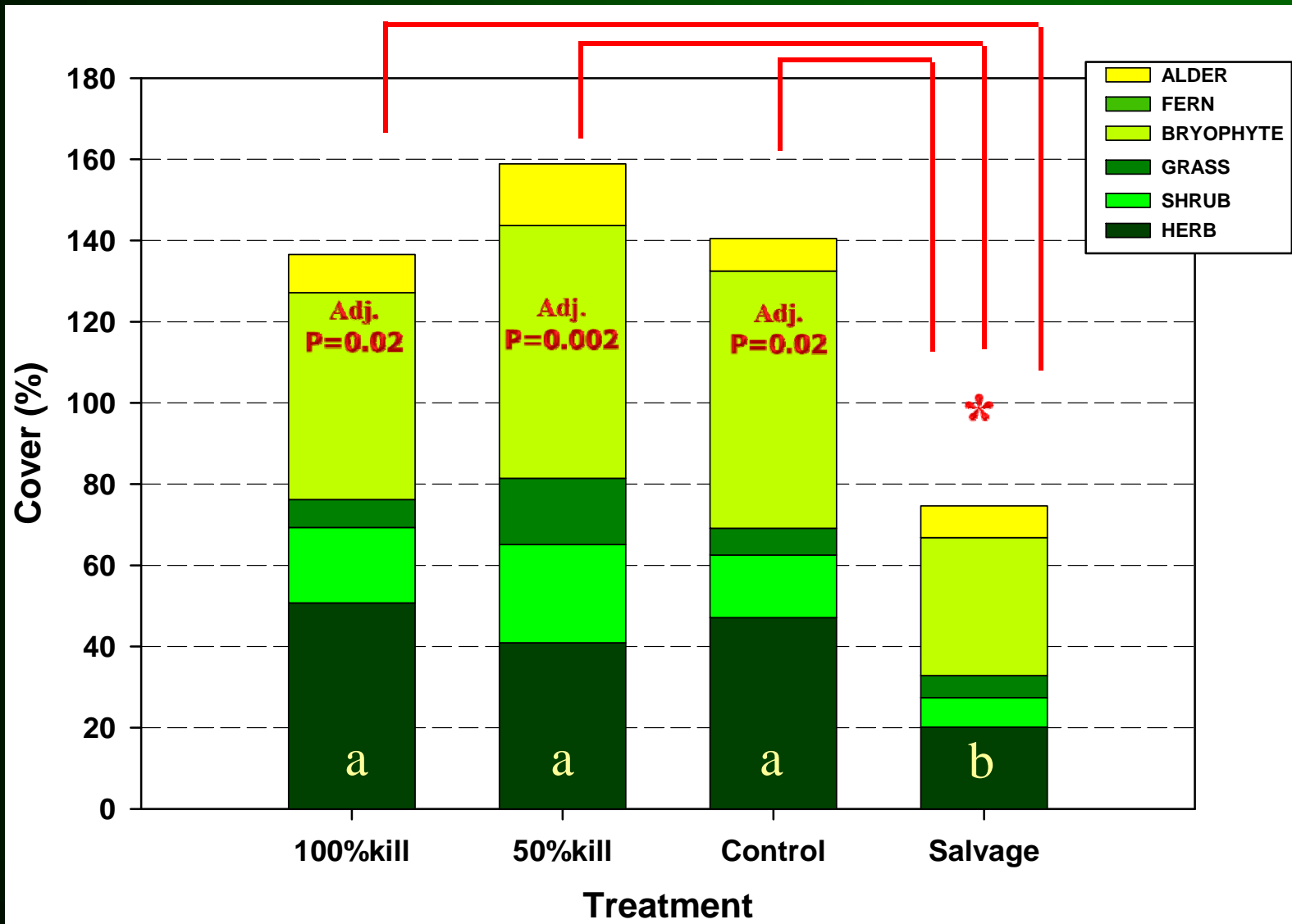
Understory richness



Understory cover



Understory cover: post-treatment (2009)



Objective 3: Downed woody debris



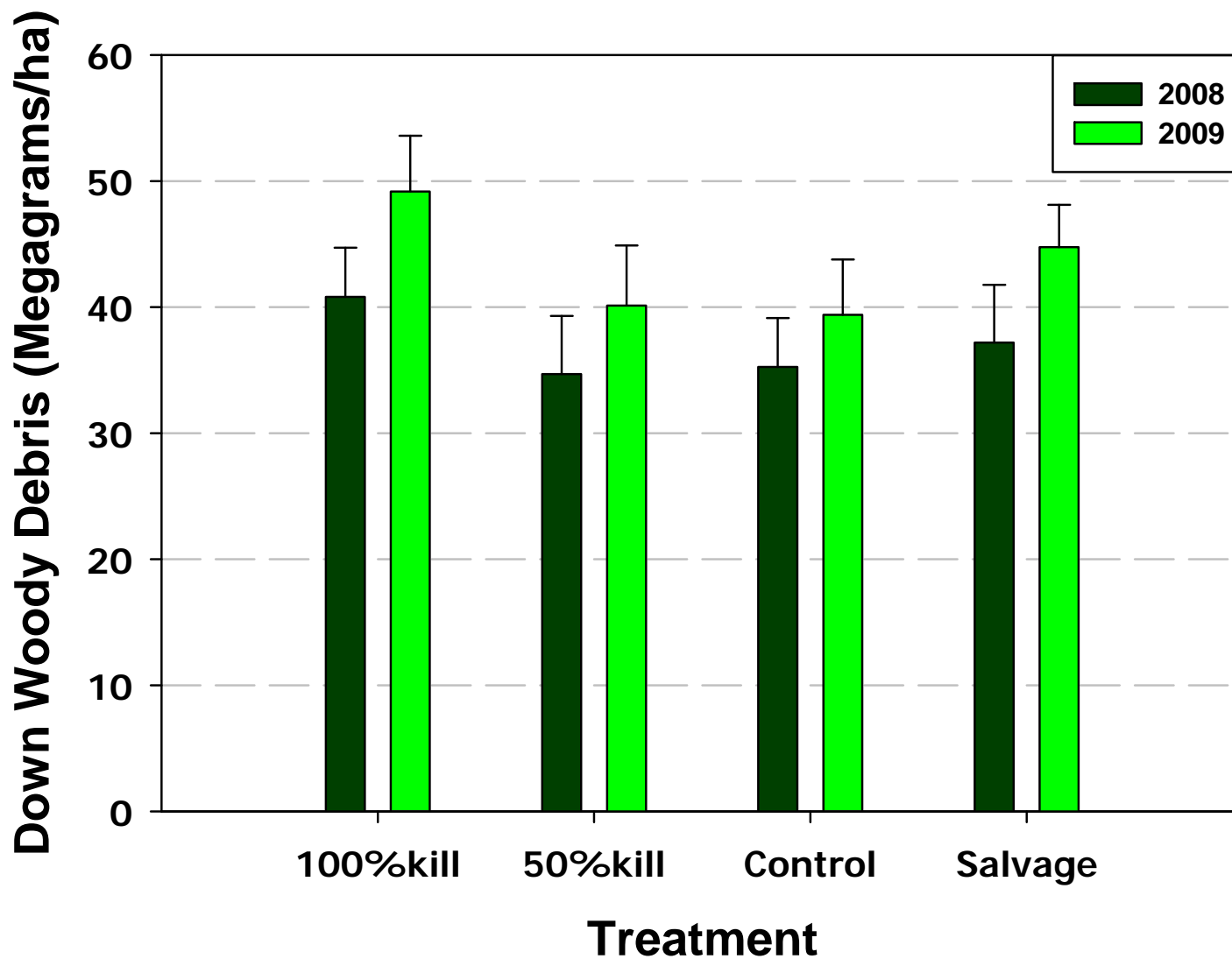
Quantify DWD

- Transects: biomass estimates (Megagrams/ha)



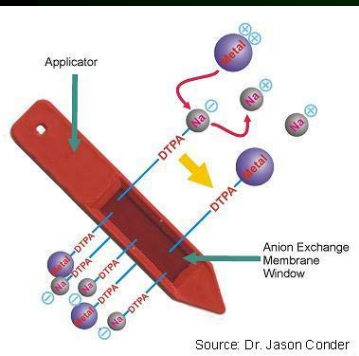


DWD biomass

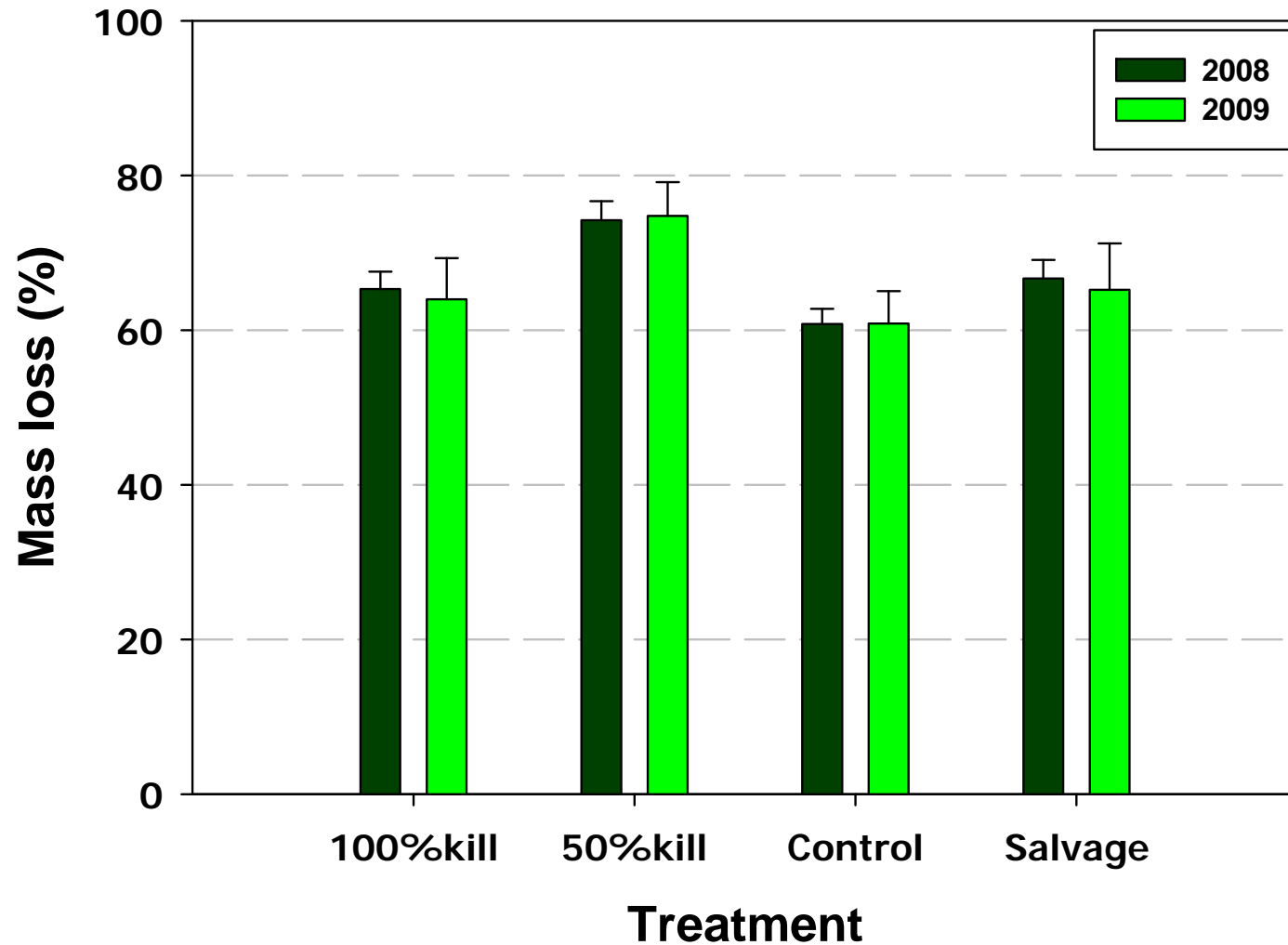


Objective 4: Below-Ground

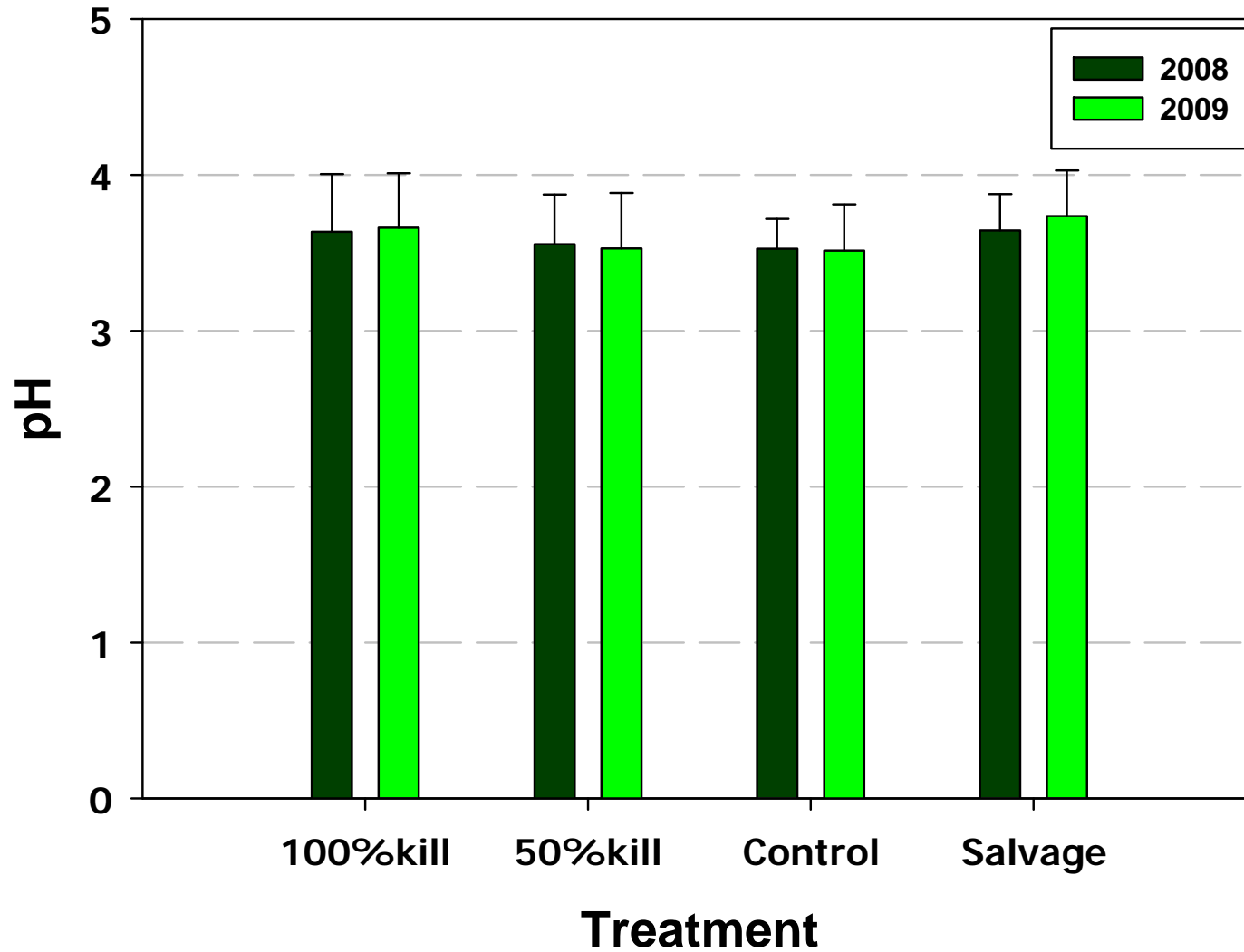
- Quantify differences in below-ground attributes
 - Decomposition (cellulose paper in mesh bags)
 - pH
 - Microbial biochemical activity & biomass
 - Community-level physiological profiles (CLPP)
 - Phospholipid fatty acid (PLFA) analysis
 - Nutrient availability (PRS probes)
 - Soil moisture (TDR)



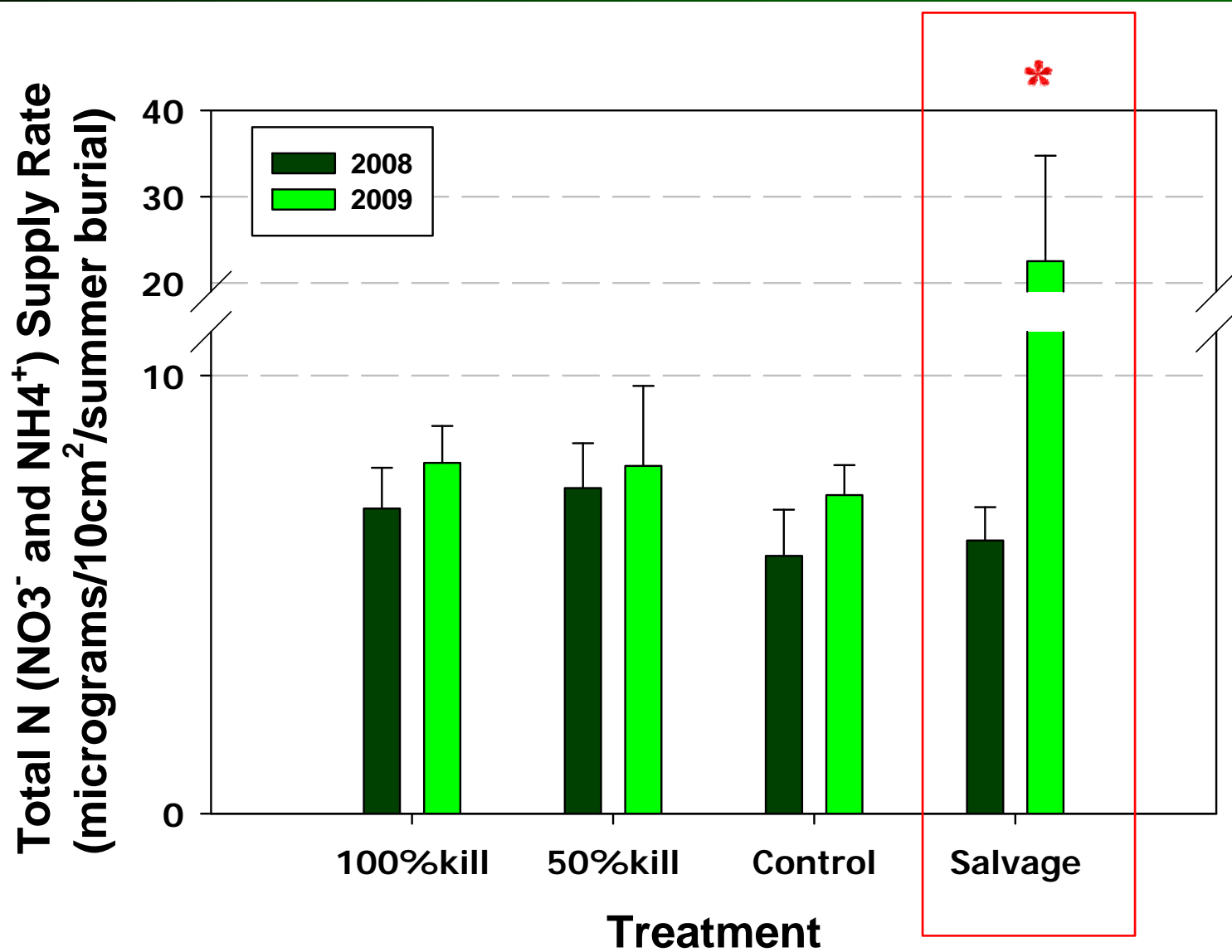
Decomposition



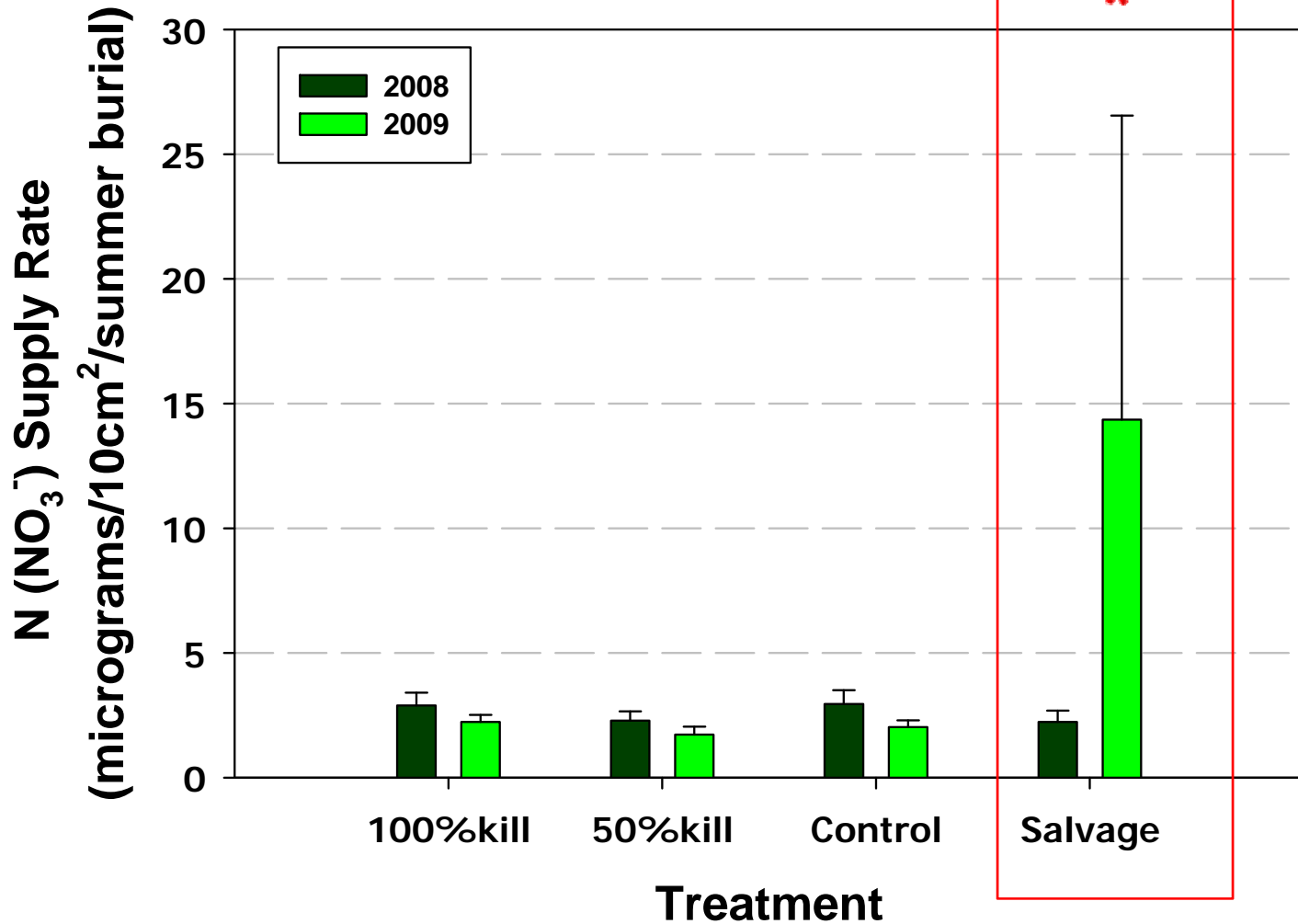
pH

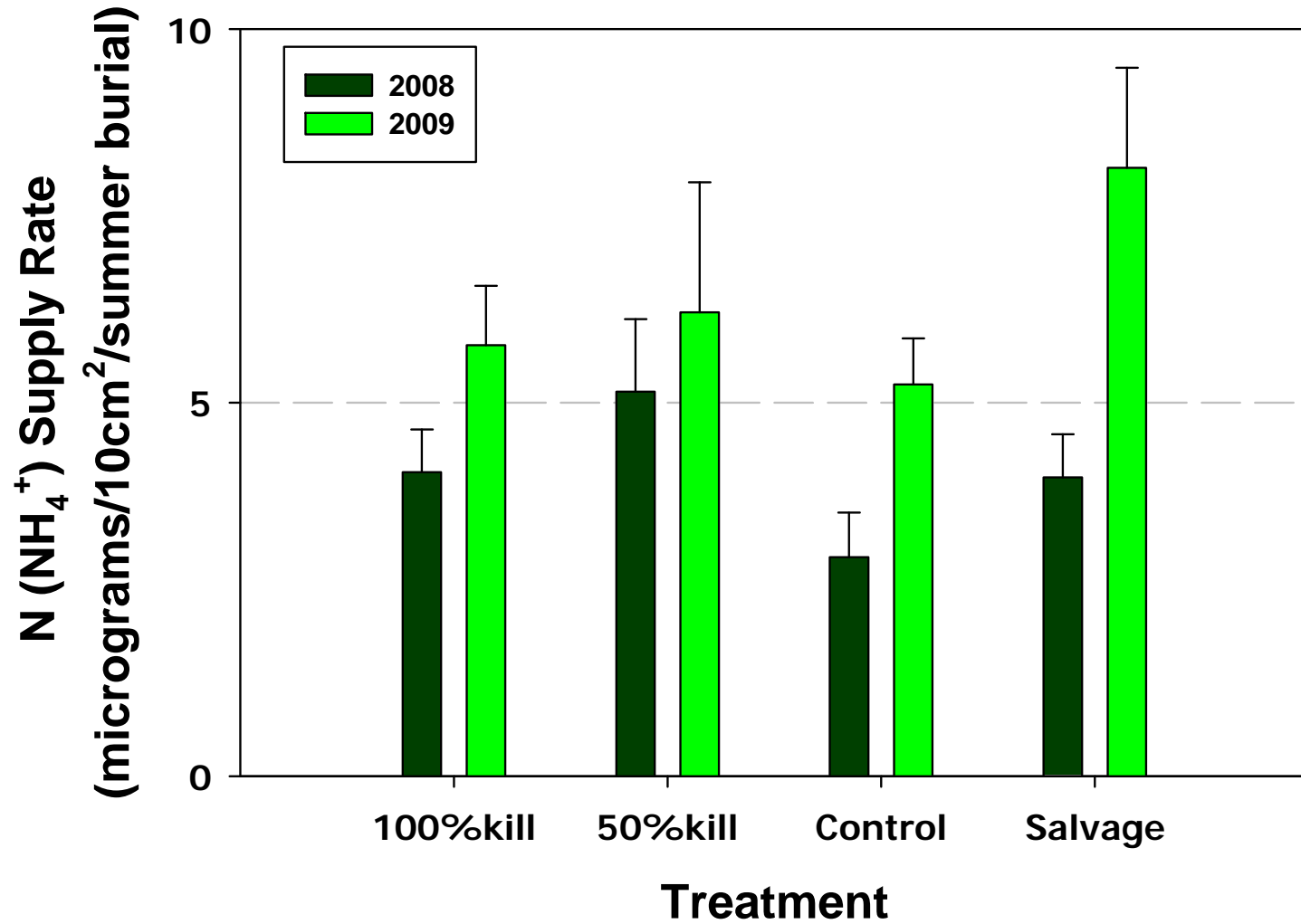


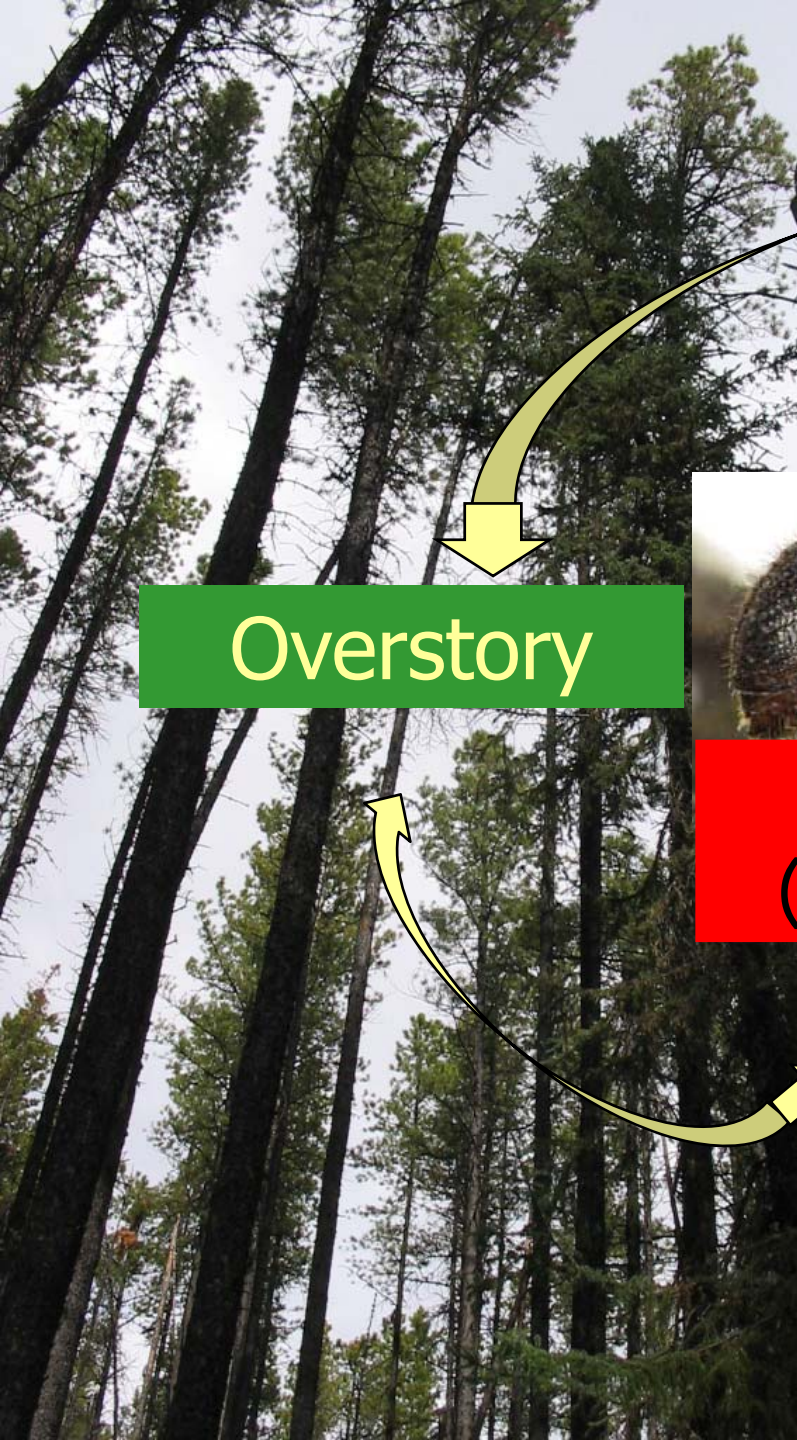
Total Nitrogen



NO₃⁻







Overstory



Understory



...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:

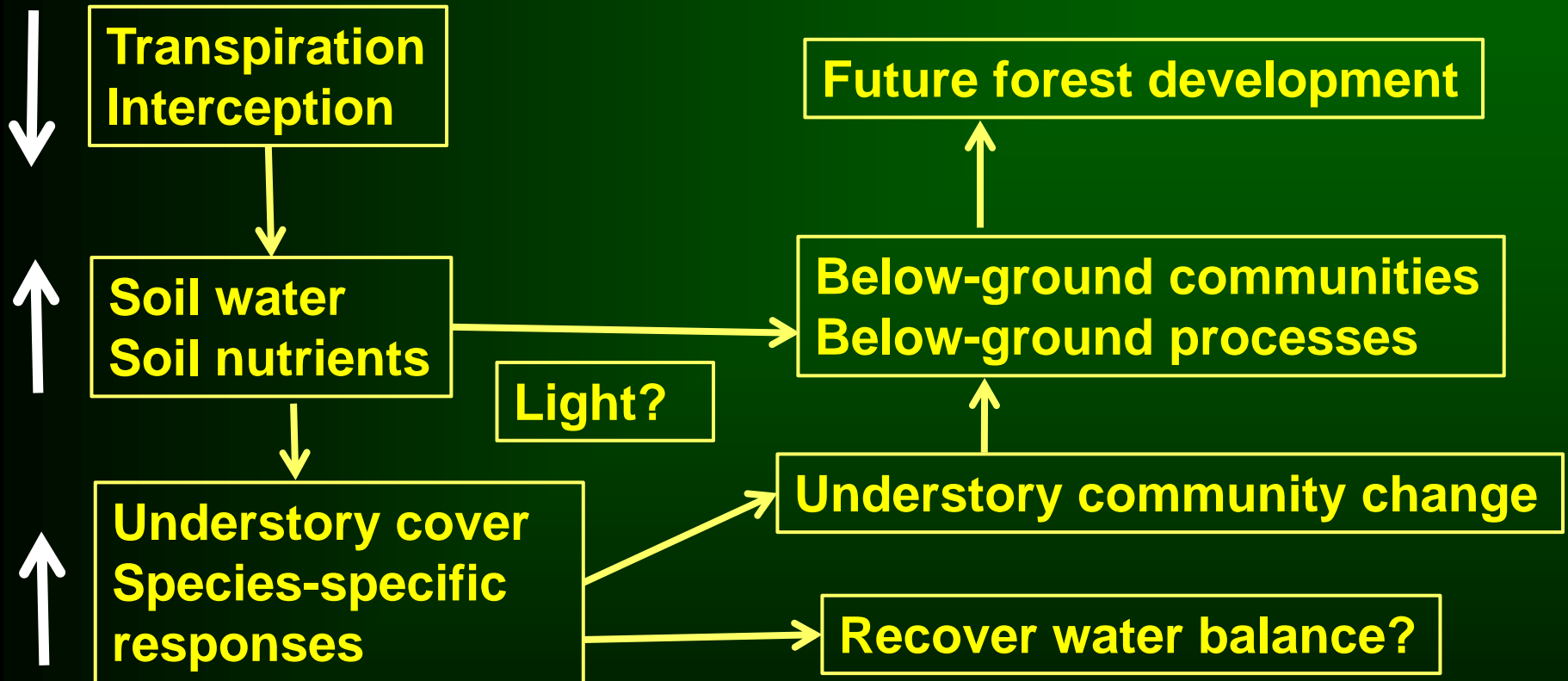
- Where the water is/goes
- How much water do they use?

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

For further information:

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amcintos "at" ualberta.ca