# Does LANDSCAPE SPATIAL HETEROGENEITY OF FOREST STRUCTURES influence TREE and SHRUB regeneration?

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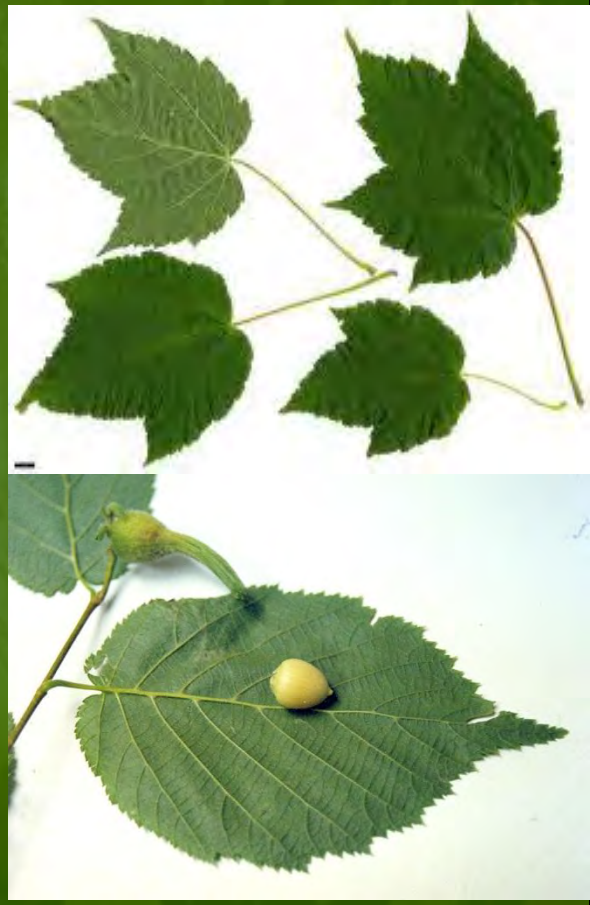
# COMPETITIVE SHRUBS

- **Extensive shrub monolayers can be caused by disturbance**
  *(Royo and Carson, 2006)*

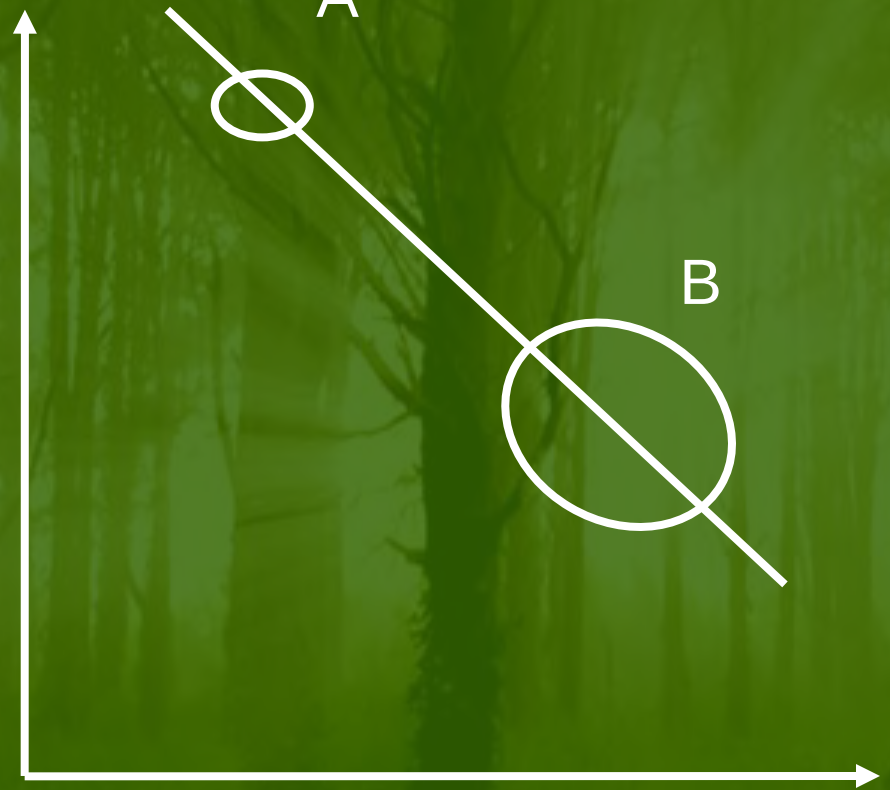
- **Specific competitive shrubs traits: fast vegetative growth, protection from fire/browsing and relatively long life spans**
  *(Young and Peffer, 2010)*



# SOUTHERN MIXEDWOODS

- **Bf-Yb climax stands are typically an uneven age structure** *(Prévost et al. 2003)*
- **These stands are therefore inherently HETEROGENEOUS**
- **Vulnerable to competitive shrubs?**

# THE IMPORTANCE OF SPATIAL SCALES




A. Frequent small scale disturbances - Heterogeneous

B. Less frequent large scale disturbances - Homogenous

## FOREST STRUCTURE

- Tree density
- Tree height
- Canopy cover
- Tree DBH
- Tree spacing
- Tree species

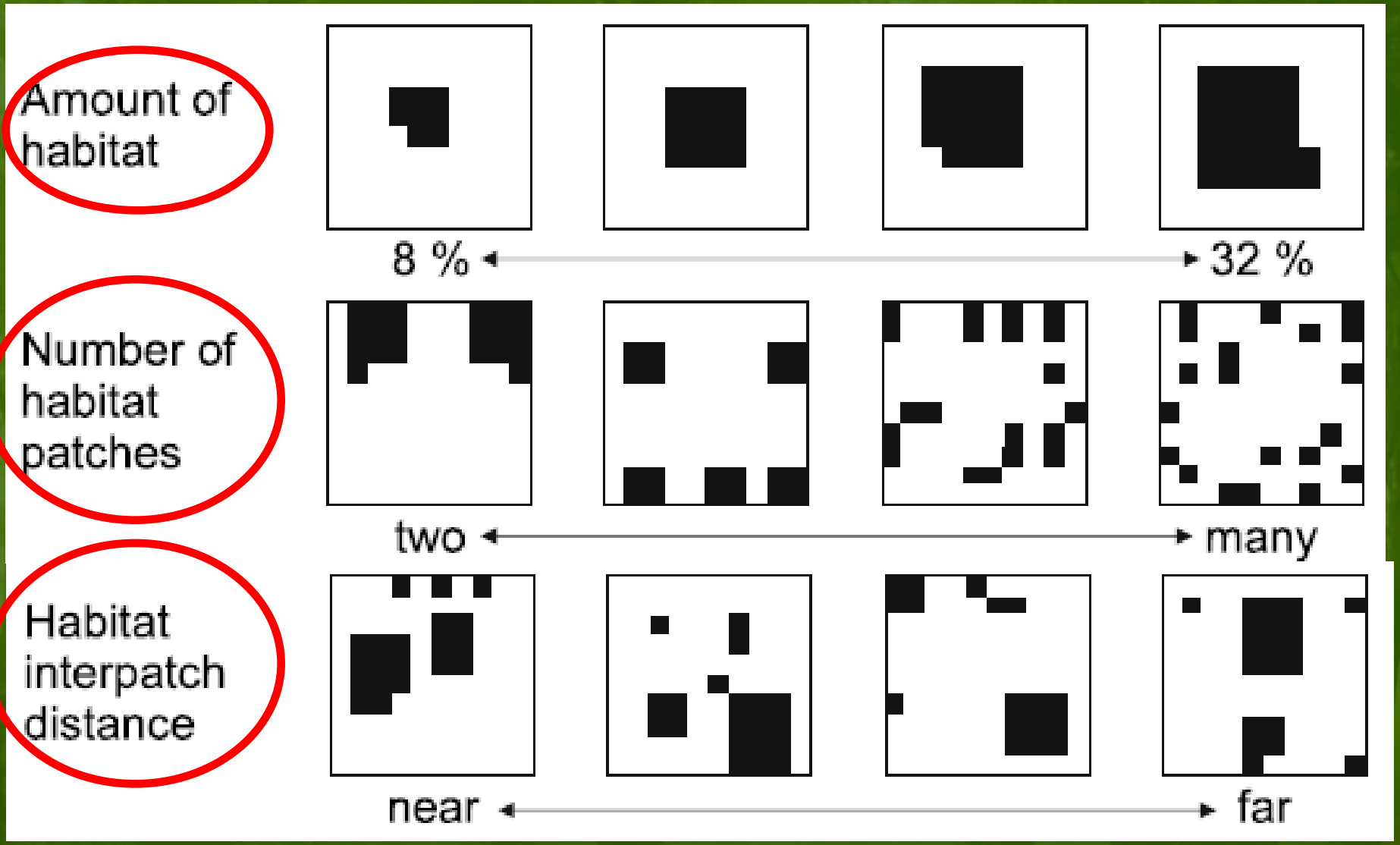
*(McElhinny et al. 2005)*

## LANDSCAPE STRUCTURE

- Patch size
- Amount of habitat
- Number of habitat patches
- Habitat interpatch distance
- Patch size distribution
- Edge to interior ratio

*(Goodwin and Fahrig, 2002)*

# LANDSCAPE SPATIAL STRUCTURE




*(Goodwin and Fahrig, 2002)*

# GENERAL HYPOTHESIS

The spatio-temporal organisation of canopy openings will influence tree and shrub regeneration

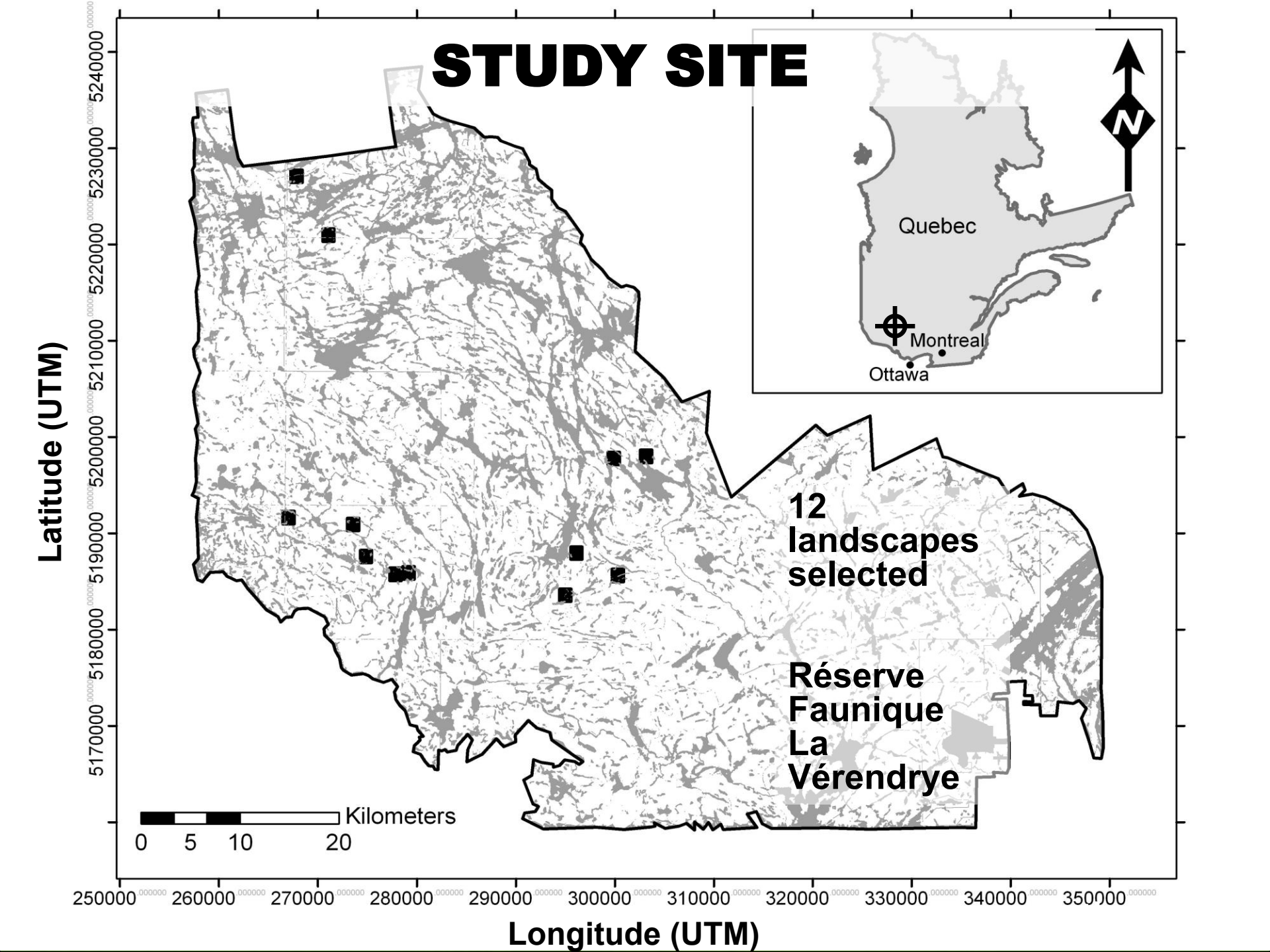
Cumulated effects of natural and anthropogenic disturbance at the landscape scale results in a build-up of shrub populations

*(Royo and Carson, 2006)*

# SPECIFIC HYPOTHESIS

(1) Heterogeneous landscapes would contain a greater density of competitive clonal shrubs, because of the greater concentration of gap openings

(2) Large shrub populations would reduce the growth of tree species in heterogeneous landscapes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Quebec
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landscapes
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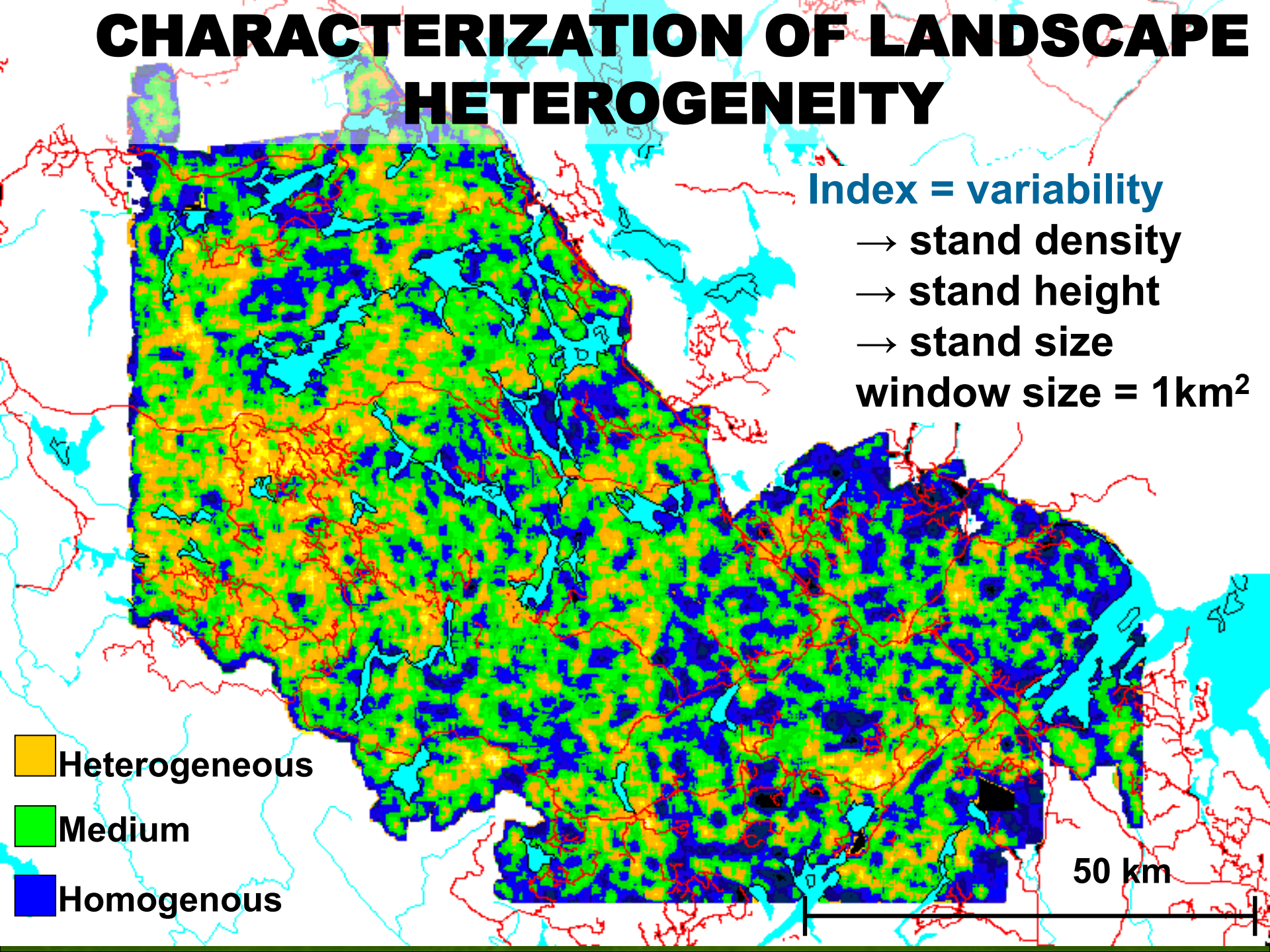
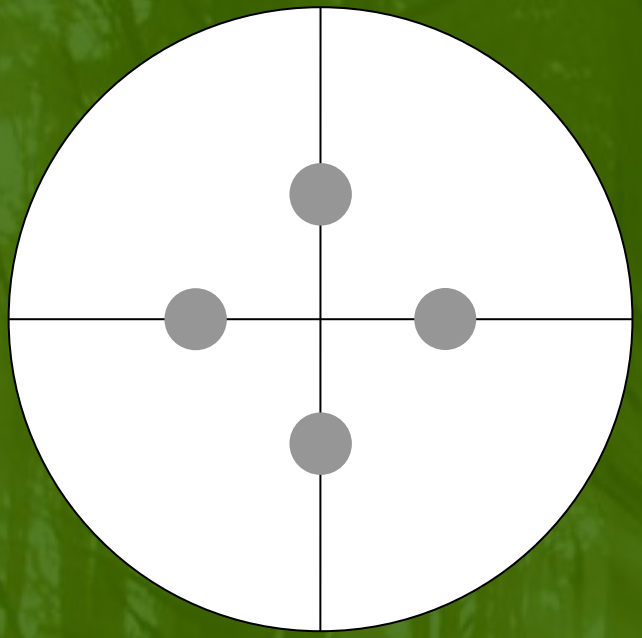
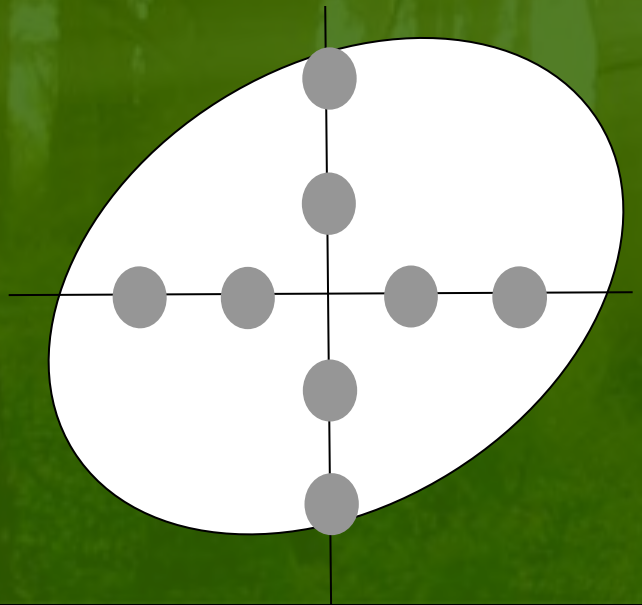
# CHARACTERIZATION OF LANDSCAPE HETEROGENEITY



Forest site



Gap site



# SAMPLING

Response variables:

- density
- growth
- species {YB, WS, SM, RM, WB, MM, BF, WC}

Explanatory variables:

- landscape heterogeneity
- gap size
- gap position
- competition
- browsing

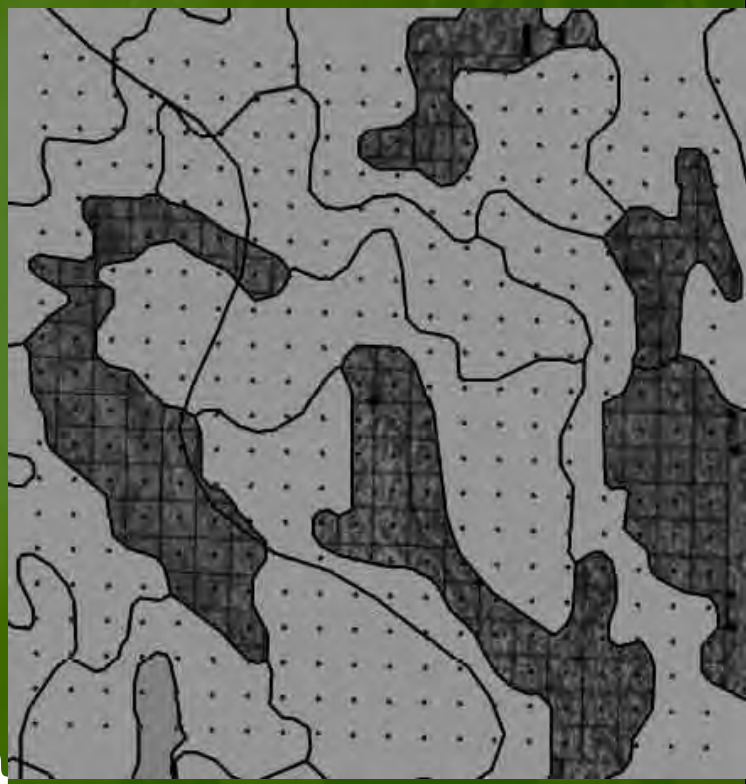
Statistics:

- Poisson mixed regression (density)
- AIC model selection (growth)
- ANOVA mixed model (growth)
- Random factor site nested in landscape
- $P(f) < 0.05$

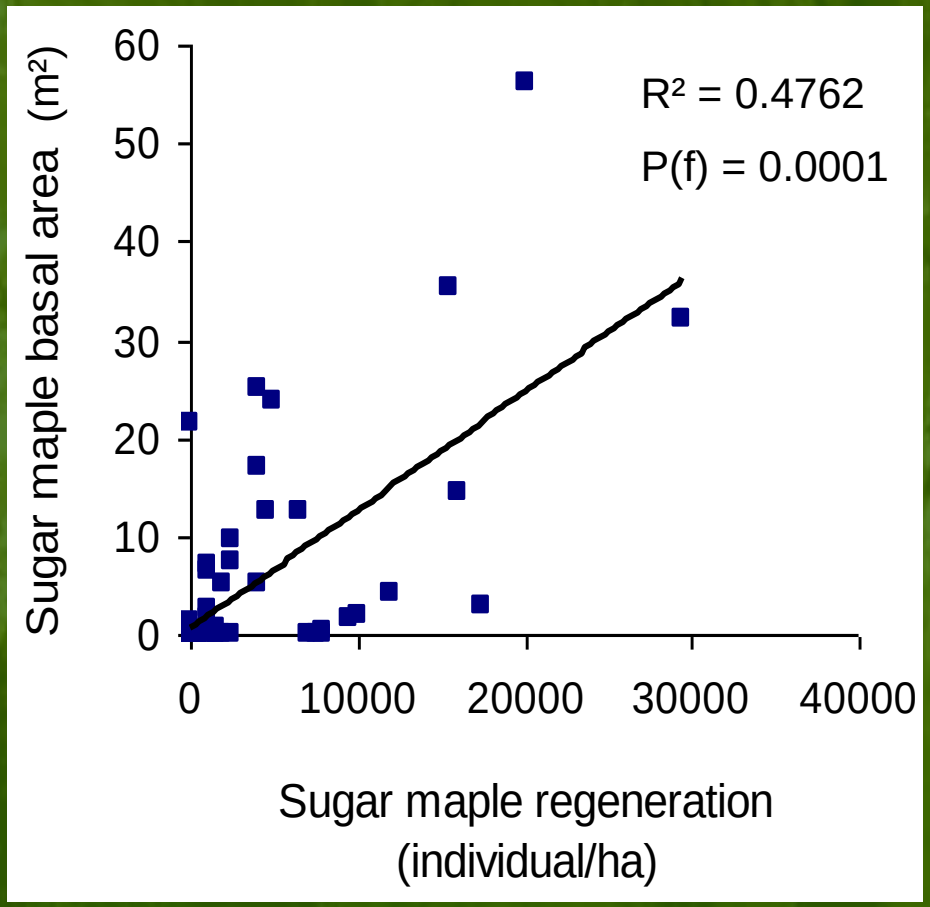
# LANDSCAPE LEVEL CONTROLS

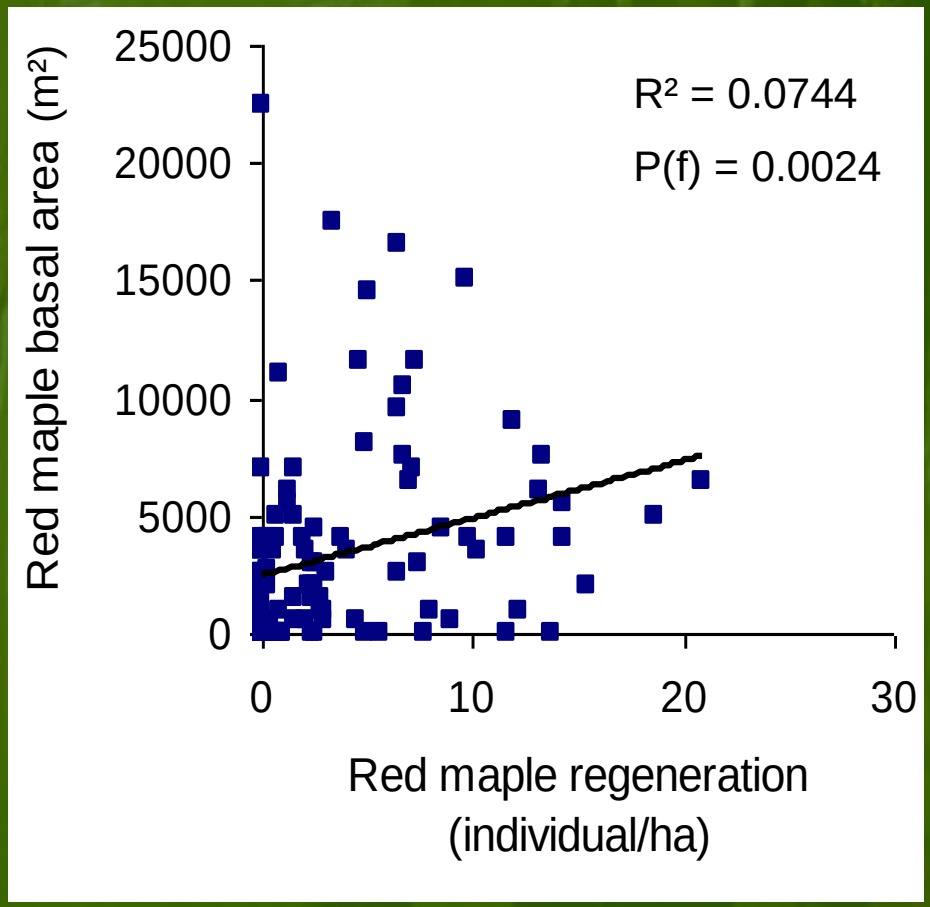
Criteria selected via GIS:

- Composition {> 50% Yb/Bf/Wb}
- Age {> 70 years}
- Disturbance {partial cutting, diameter limit, spruce budworm}
- Drainage {medium, classes 2 & 3}
- Till deposits {1A/1AR > 0.5m till}

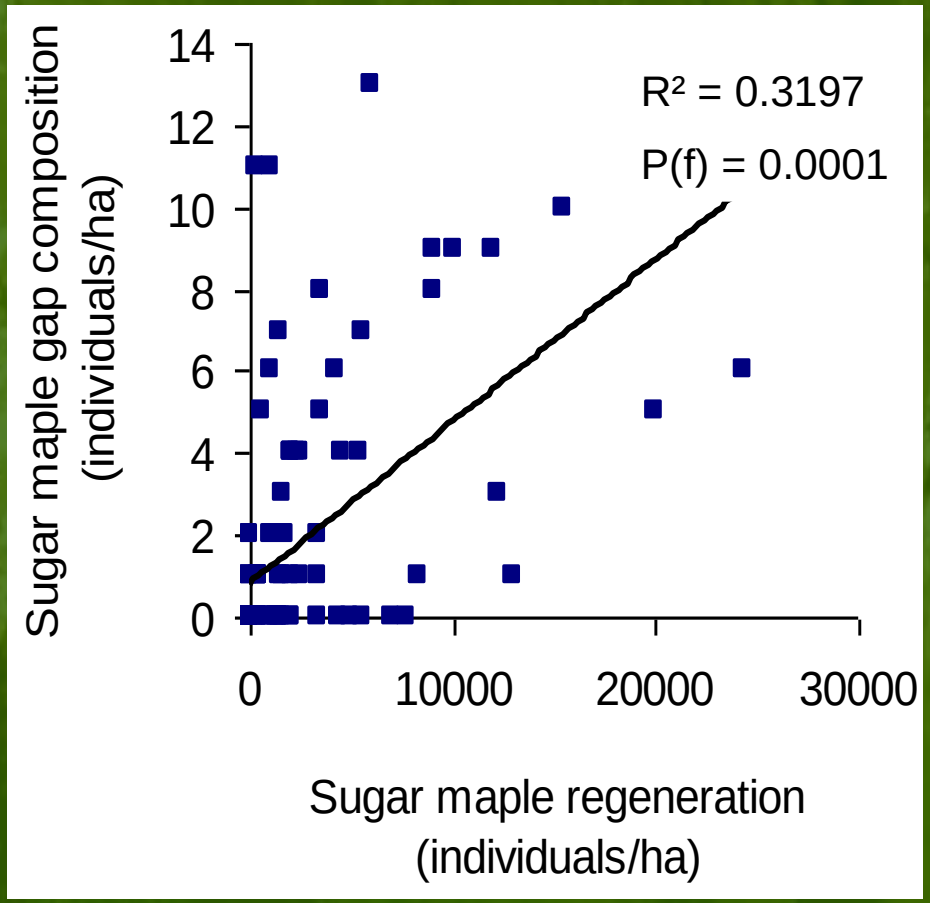


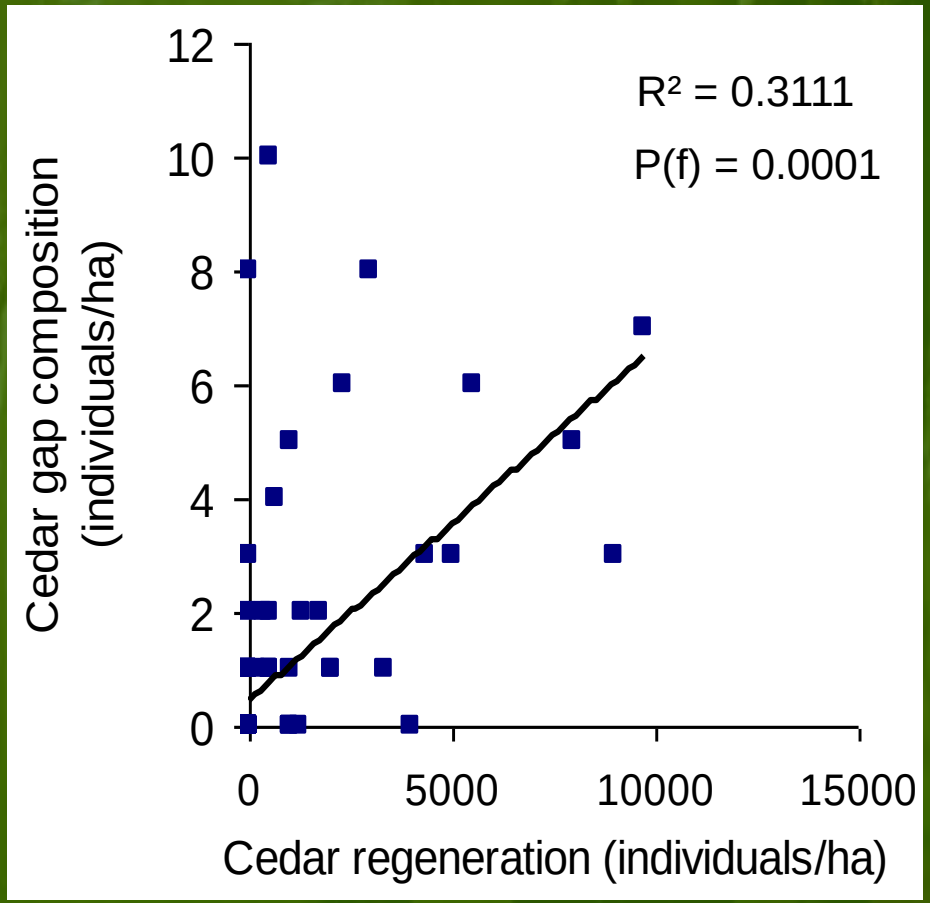
# REGENERATION DENSITY RESPONSE TO FOREST TREE COMPOSITION



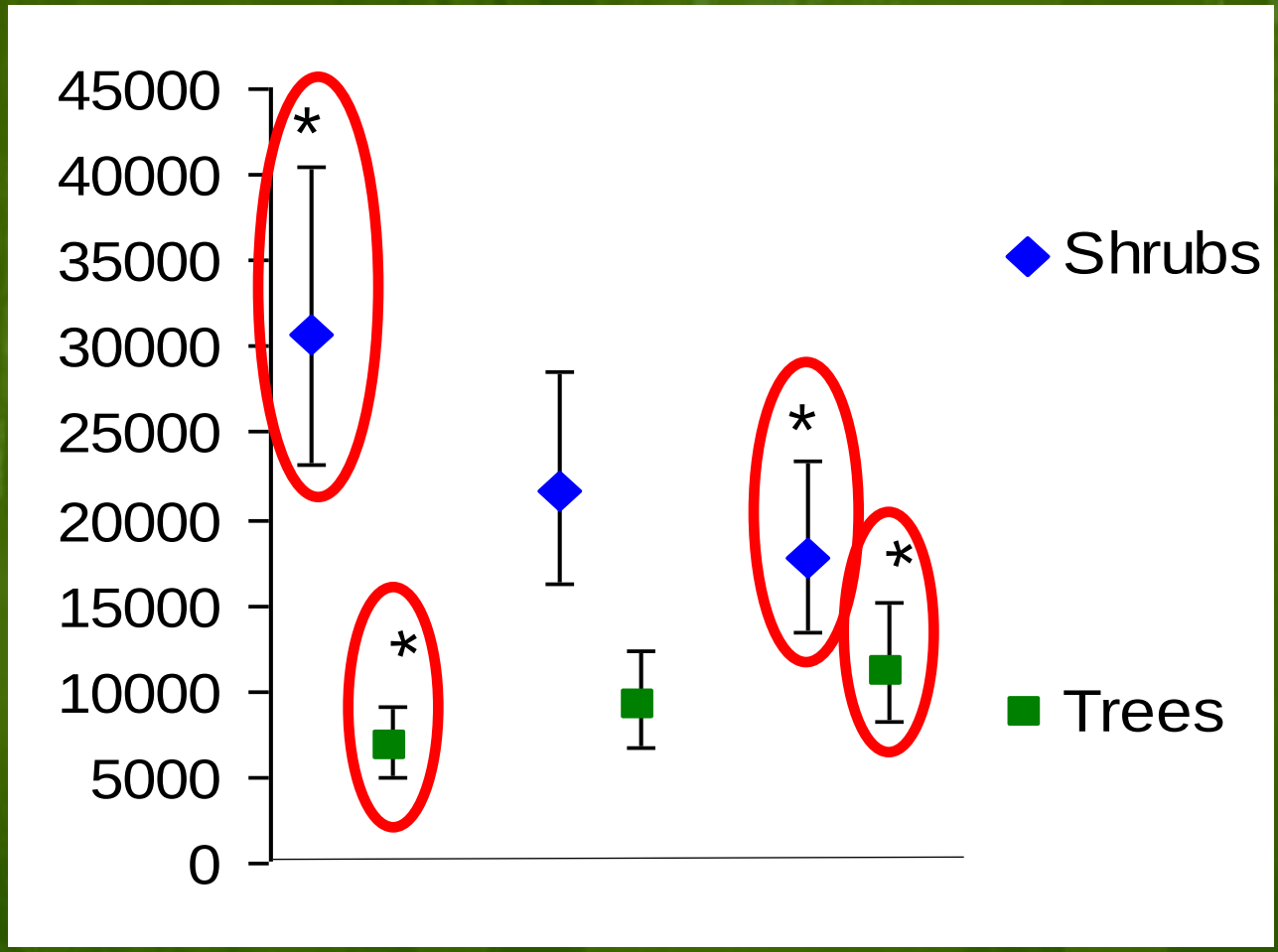



# REGENERATION DENSITY RESPONSE TO GAP TREE COMPOSITION



# REGENERATION DENSITY RESPONDS TO LANDSCAPE HETEROGENEITY



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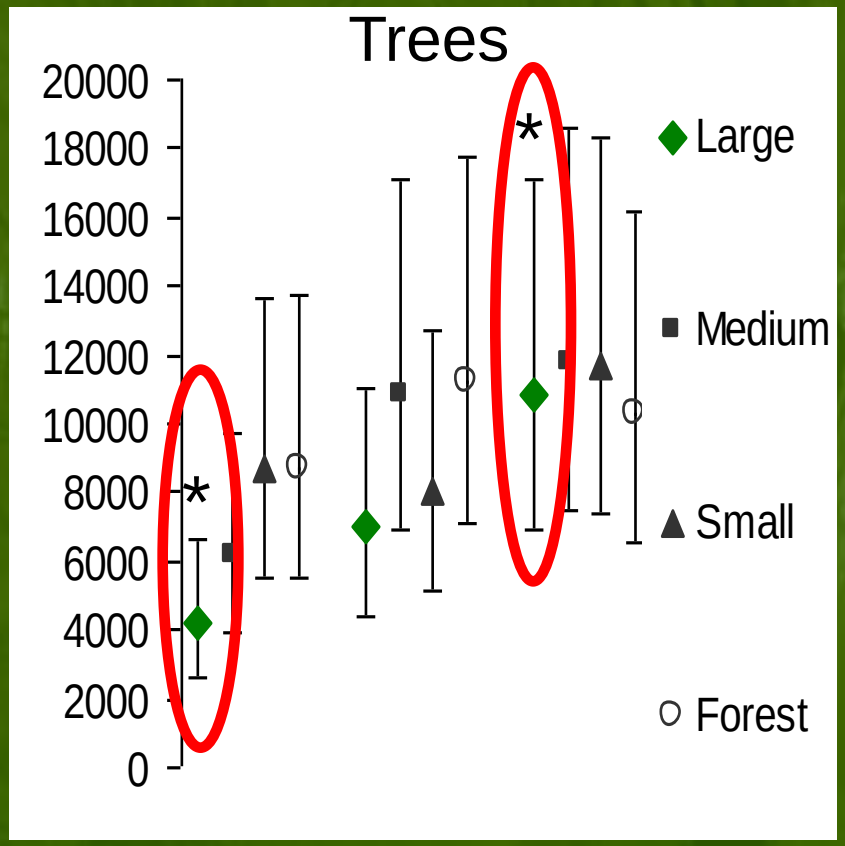
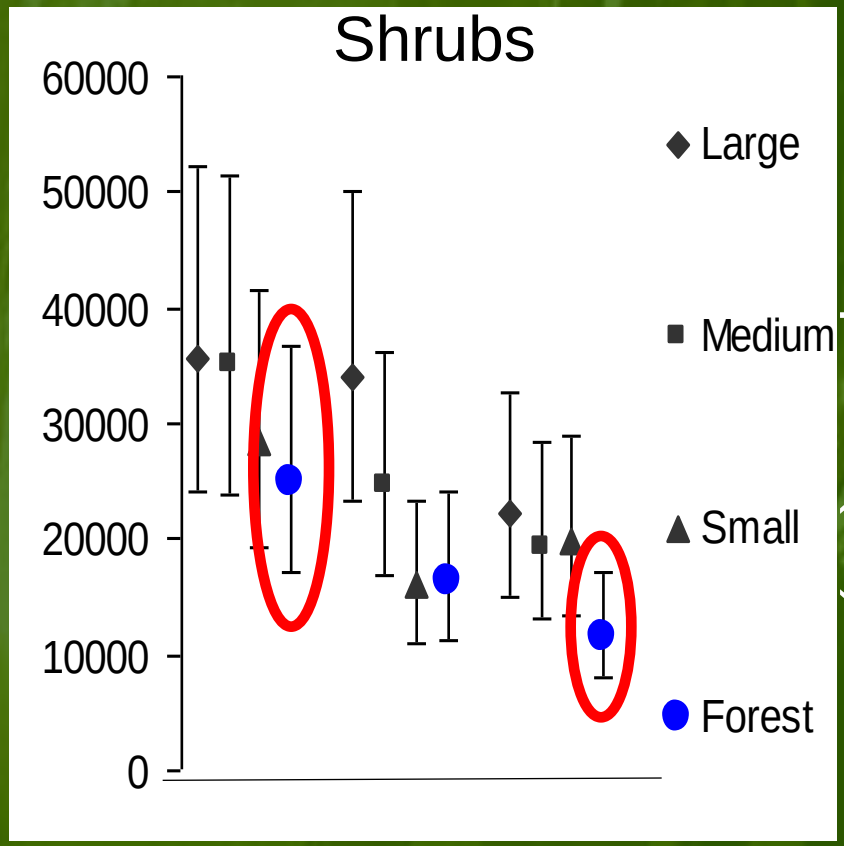
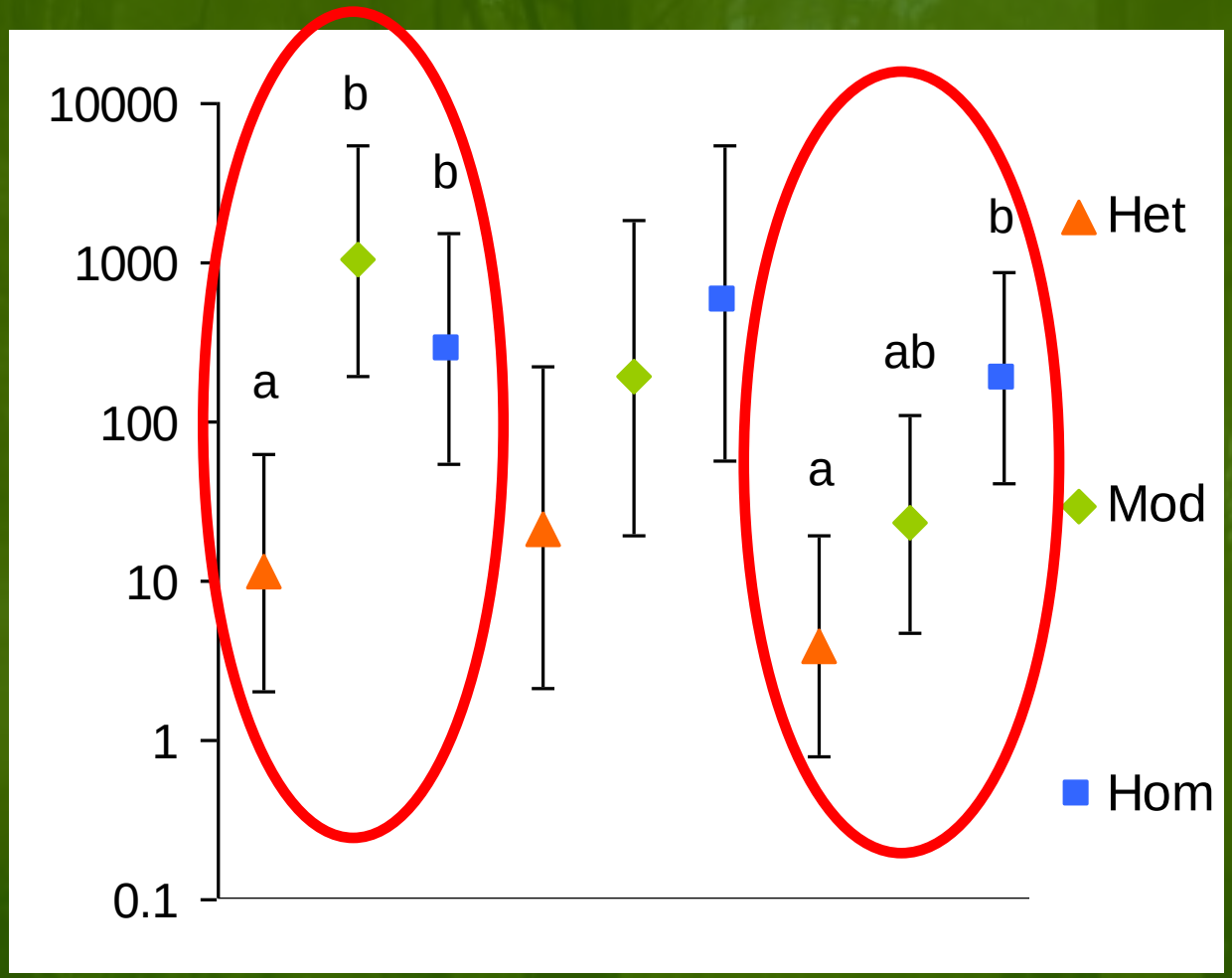


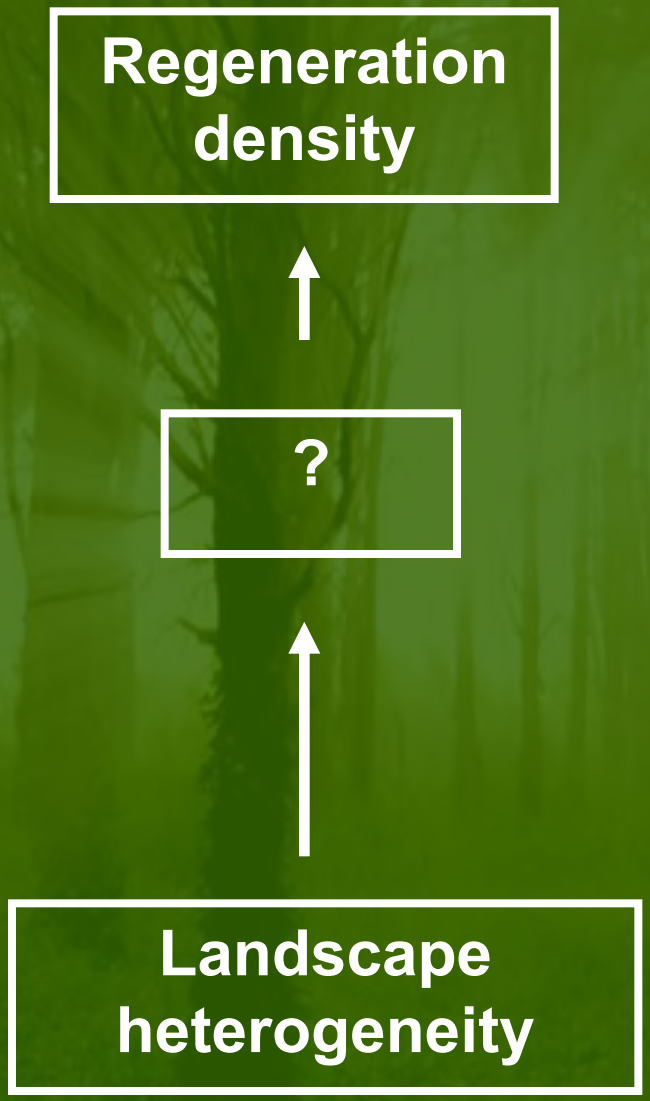




***Results***

# SPECIES RESPONSE TO LANDSCAPE HETEROGENEITY



# WHAT CAUSES DENSITY RESPONSE TO LANDSCAPE HETEROGENEITY?




*Results*

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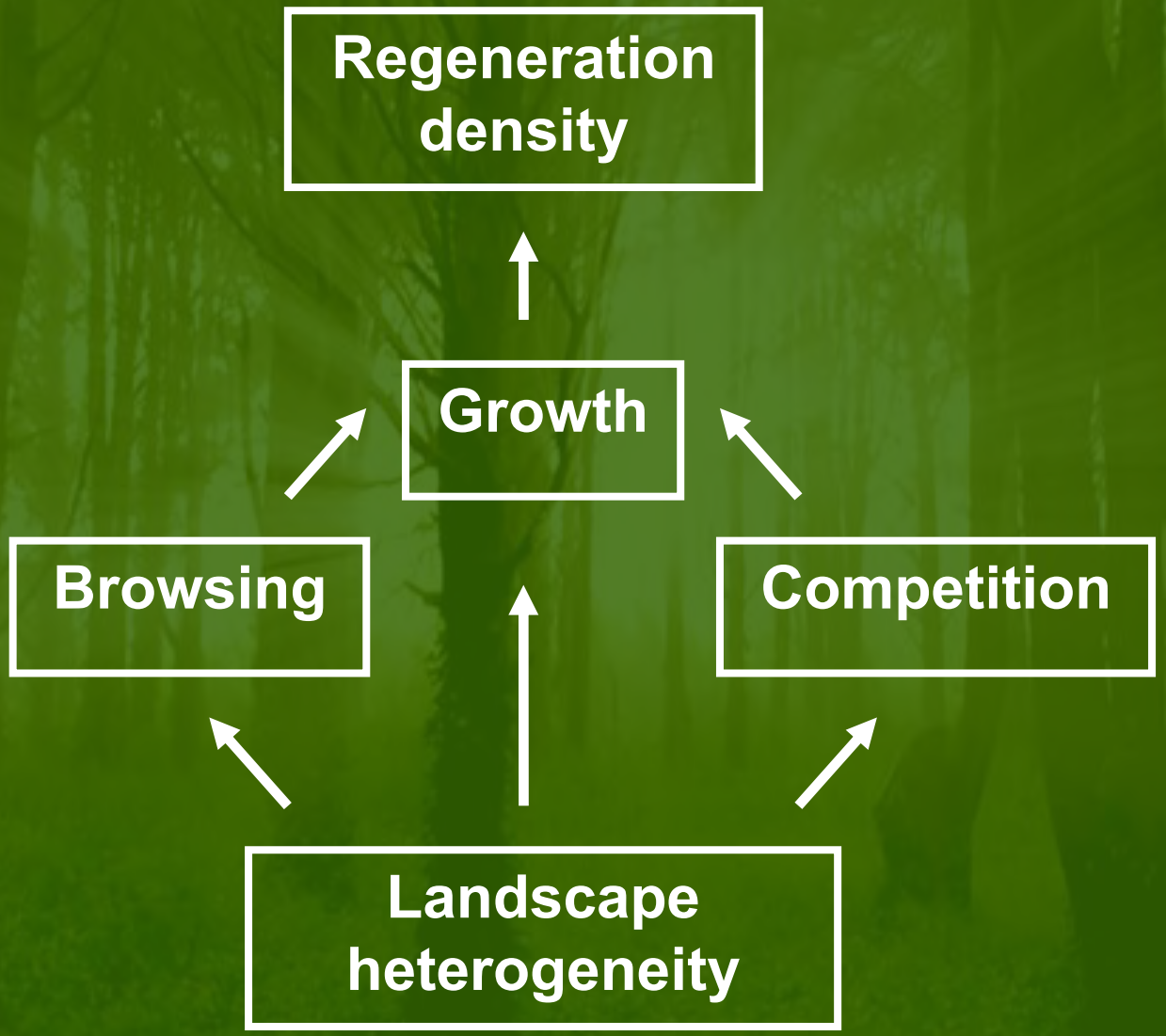


# REGENERATION GROWTH AIC MODEL SELECTION

1 Competition + Gap size

2 Competition

3 Landscape heterogeneity + Competition

4 Landscape heterogeneity + Gap size + Gap position + Competition + Browsing

5 Gap size

6 Gap size + Gap position

7 Landscape heterogeneity

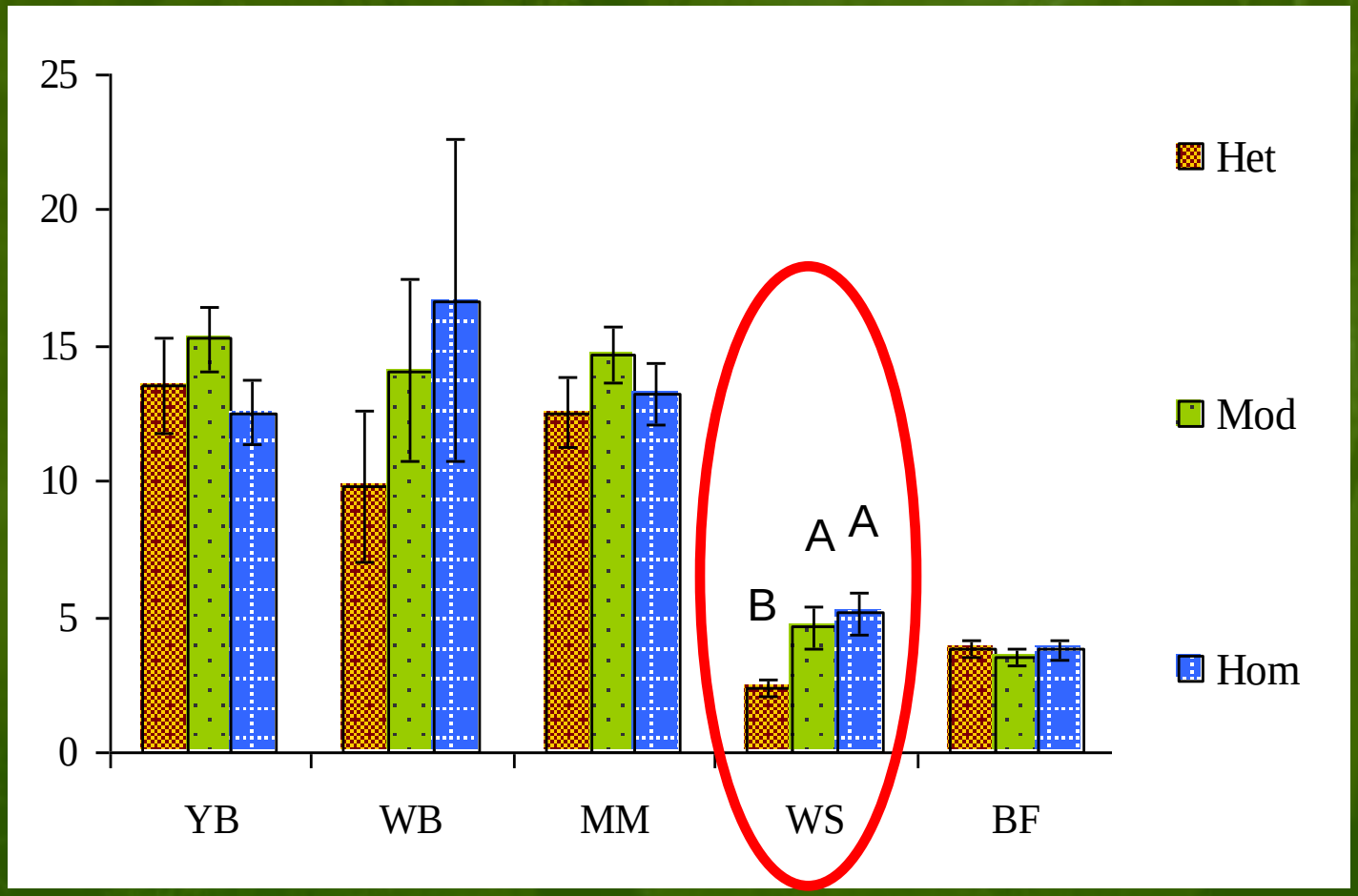
8 Landscape heterogeneity + Browsing

# REGENERATION GROWTH AIC MODEL SELECTION

| | Top Models Yellow birch seedlings | Delta AICc | AICc Wt | Cum Wt |
|---|---|---|---|---|
| 1 | Landscape heterogeneity + Browsing | 0 | 0.64 | 0.64 |
| 2 | All factors | 3.82 | 0.09 | 0.73 |
| 3 | Competition | 3.9 | 0.09 | 0.82 |

| | Top Models White spruce seedlings | | | |
|---|---|---|---|---|
| 1 | Competition | 0 | 0.44 | 0.44 |
| 2 | Landscape heterogeneity + Competition | 0.01 | 0.44 | 0.88 |
| 3 | Competition + Gap size | 3.55 | 0.07 | 0.95 |

# WEAK RESPONSE OF GROWTH TO LANDSCAPE HETEROGENEITY




*Results*

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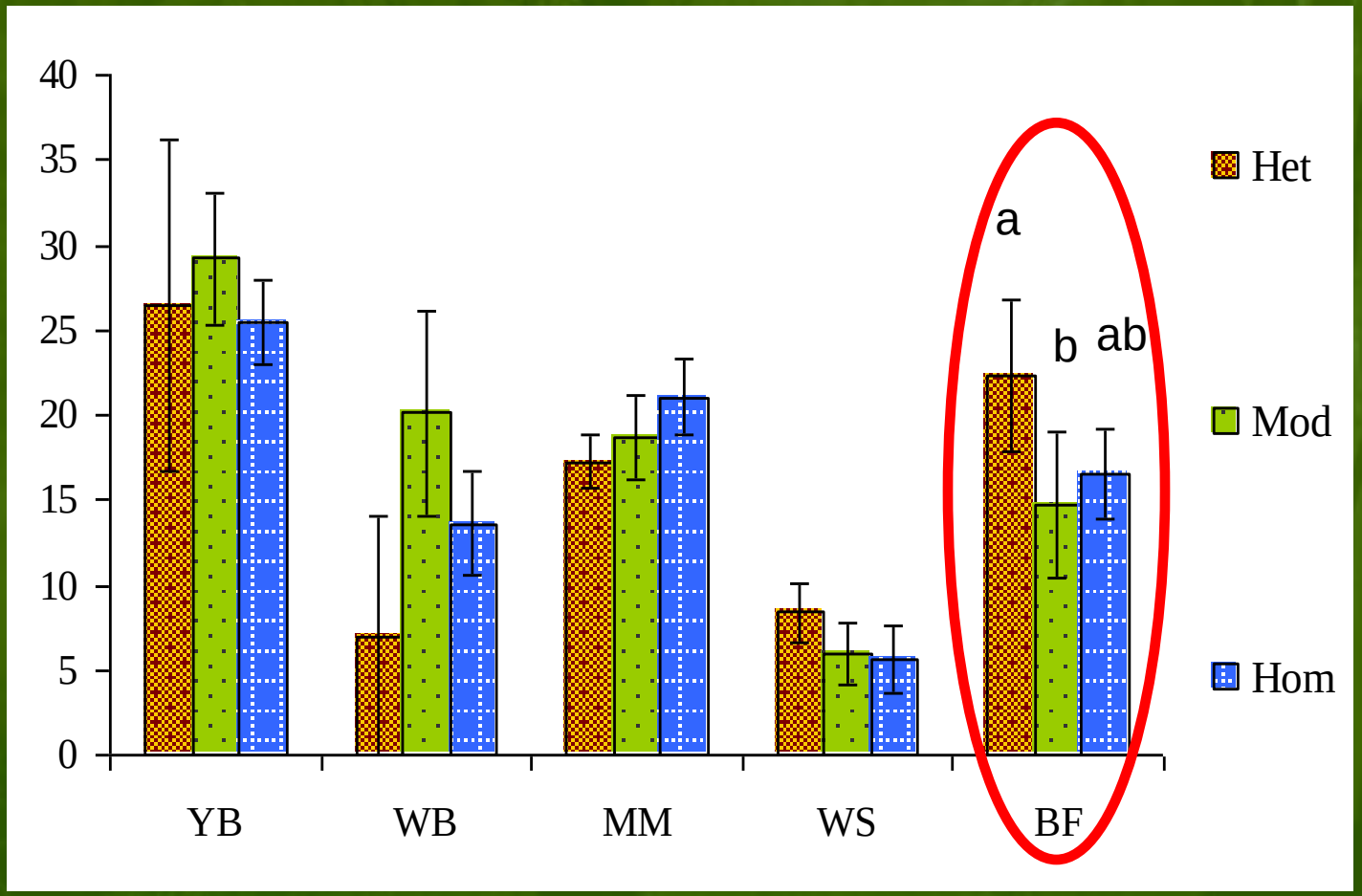


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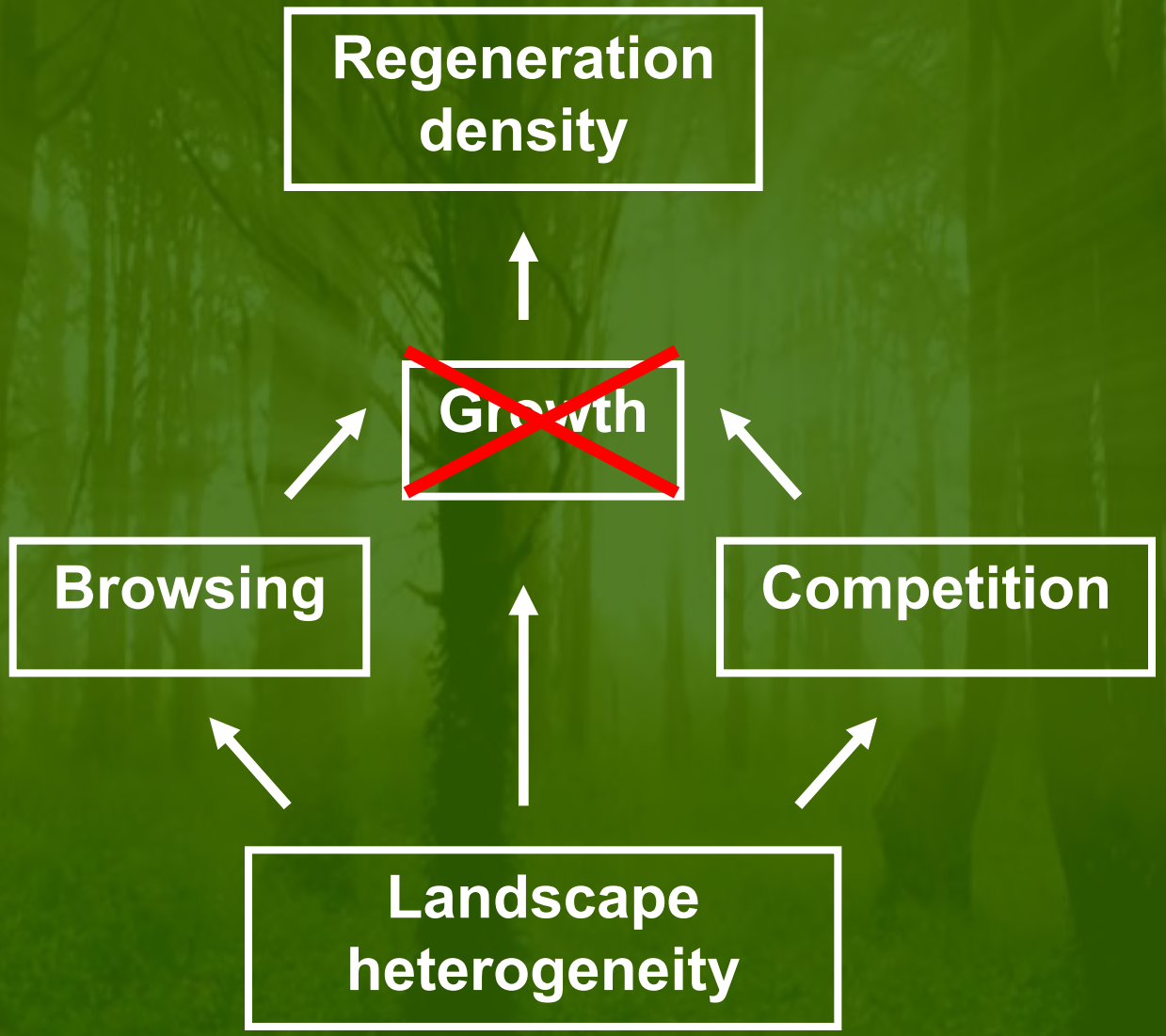

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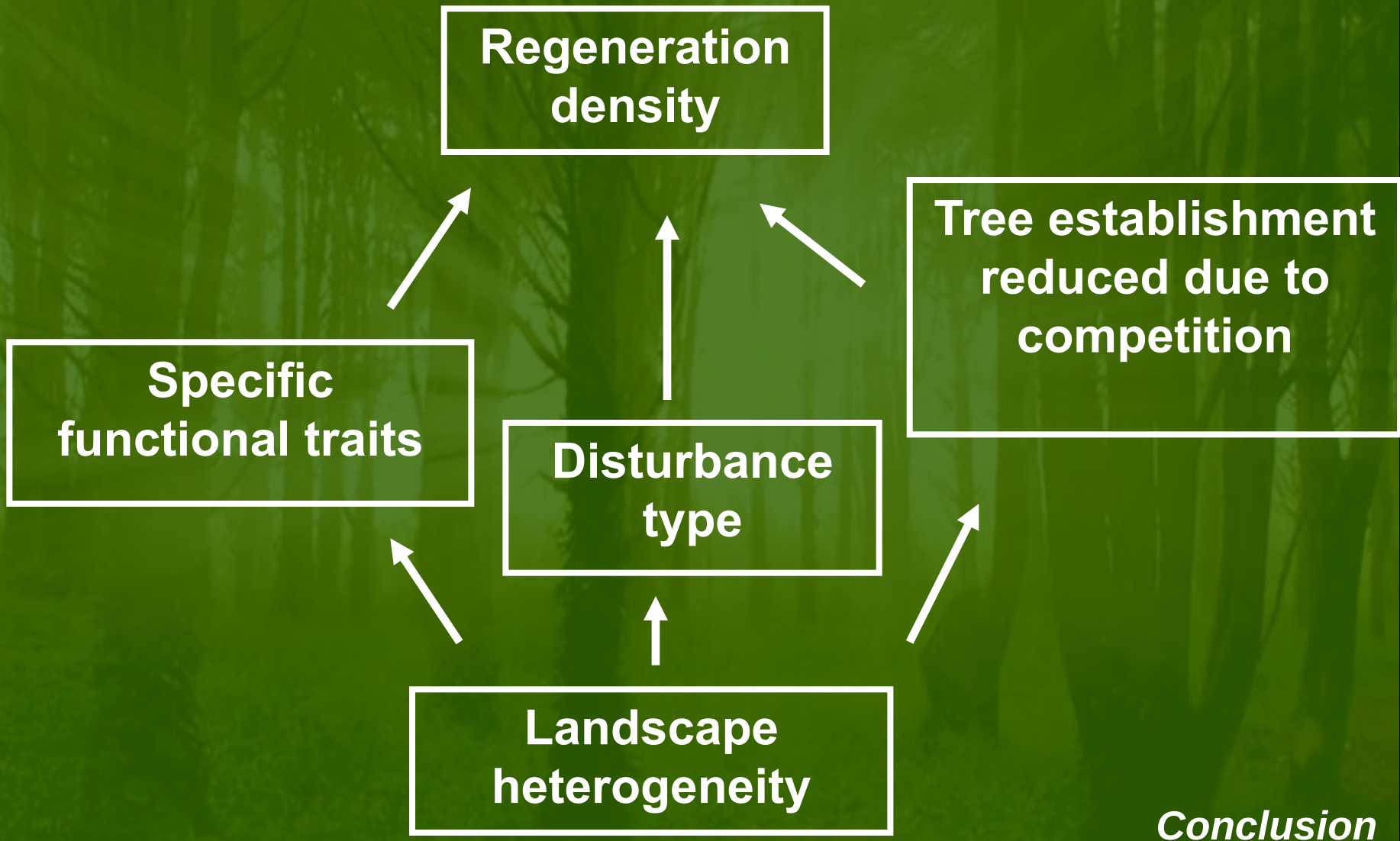


# IMPLICATIONS

**Forest management:**

- **Inclusion of landscape heterogeneity and landscape level factors into forestry decisions**

**Forest ecology:**

- **Landscape level factors influence local phenomena**

# Thank you to...

- Christian Messier
- Isabelle Aubin
- Louis Archambault
- Sylvain Delagrange
- Marc Mazerole
- Dylan Craven
- Stéphane Daigle
- Marie-Eve Roy
- Pascal Rochon
- Regis Pouliot
- Julie Poirier
- Équipe “Thunder”
- ISFORT & UQAM
- FQRNT
- CEF

# R CODE FOR AIC MODEL

```
library(AICcmodavg)
library(lme4)
data1 <-read.table("fun", header = TRUE)
Cand.models <- list( )
Cand.models[[1]] <- glmer(specify variable ~
   specify factors + (1 | random factor), data =
   data1, REML = FALSE)
Cand.models[[2]] <- specify variable ~ specify
   factors2 + (1 | random factor), data = data1,
   REML = FALSE)
Modnames <- c("specify factors", "specify
   factors2")
aic.table.1 <- aictab(cand.set = Cand.models,
   modnames = Modnames)
aic.table.1
```

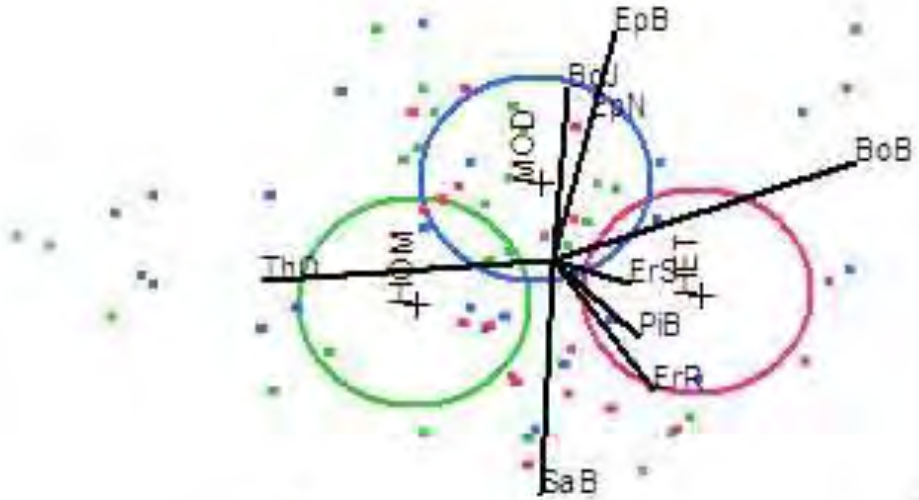
*Results*

# SUMMARY

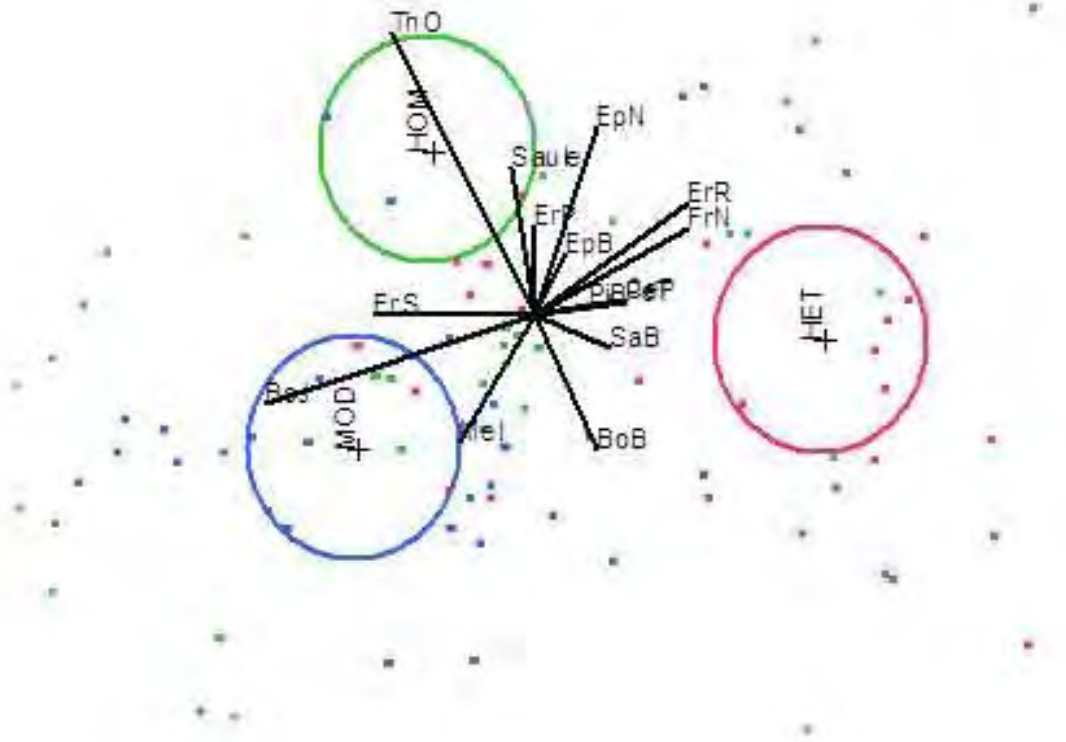
**Potential processes involved in density response to landscape heterogeneity:**

- **Possibility that large shrub populations impede tree ESTABLISHMENT…**
- **Species specific response to disturbance: the importance of FUNCTIONAL TRAITS**
- **METAPOPULATION DYNAMICS: the local extinction of seed trees and shrubs**

# DISCRIMINANT ANALYSIS – FOREST COMPOSITION AND LANDSCAPE HETEROGENEITY



# DISCRIMINANT ANALYSIS – GAP TREE COMPOSITION AND LANDSCAPE HETEROGENEITY



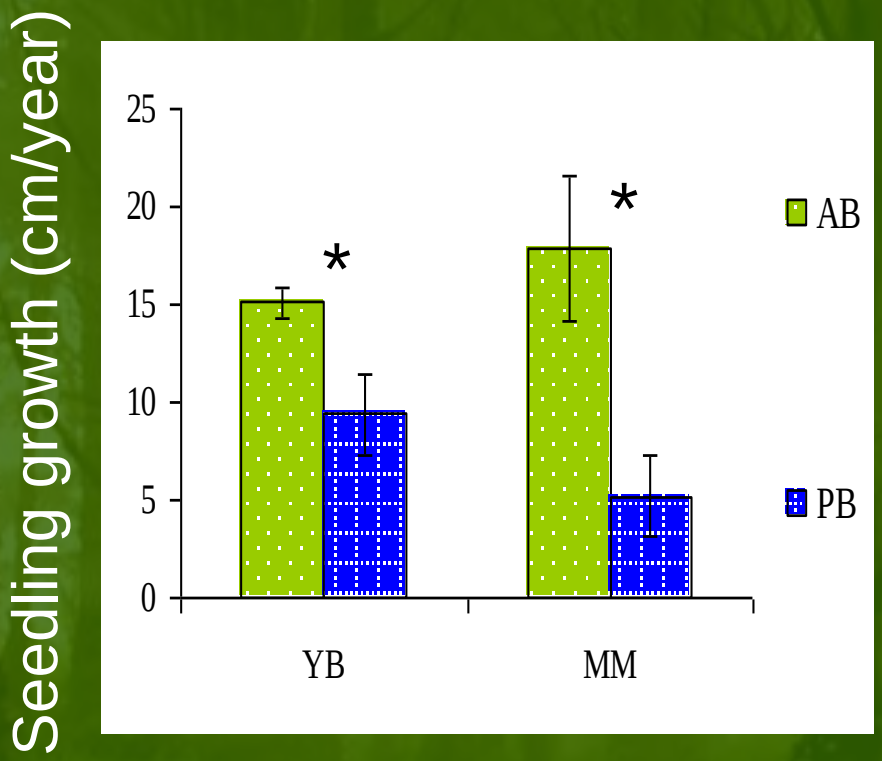
# REGENERATION GROWTH AIC MODEL SELECTION

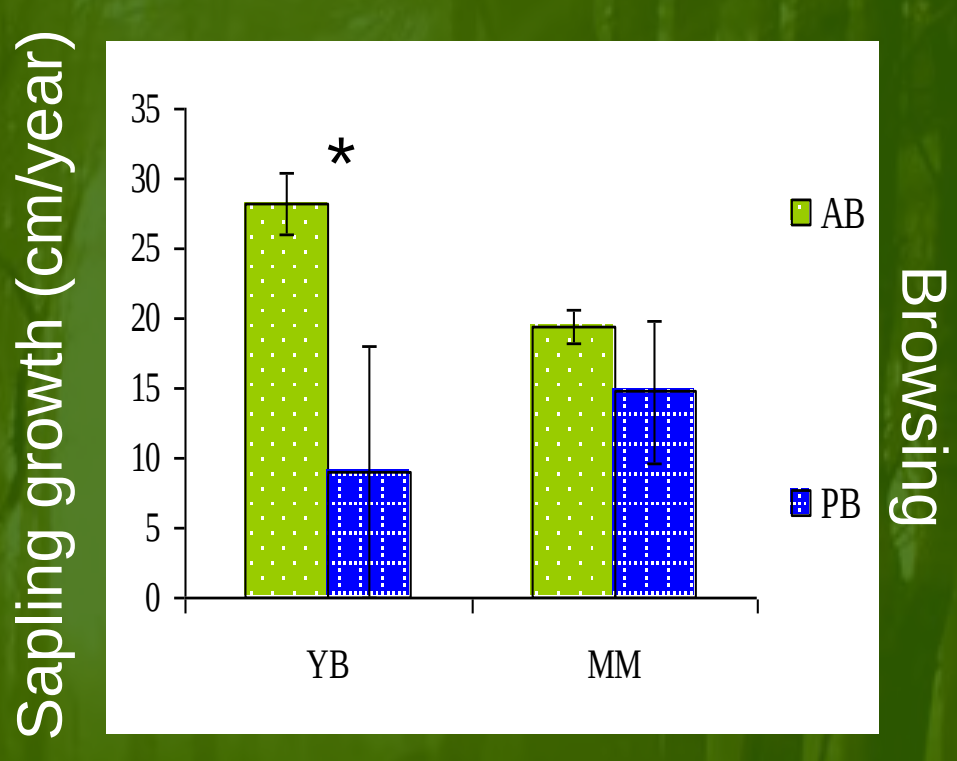
| | Suggested Models seedlings all species | Delta AICc | AICc Wt | Cum Wt |
|---|---|---|---|---|
| 1 | Competition + Gap size | 0 | 0.67 | 0.67 |
| 2 | Competition | 1.85 | 0.27 | 0.94 |
| 3 | Landscape heterogeneity + Competition | 4.93 | 0.06 | 0.99 |
| 4 | Landscape heterogeneity + Gap size + Gap position + Competition + Browsing | 9.16 | 0.01 | 1 |
| 5 | Gap size | 83.79 | 0 | 1 |

# REGENERATION GROWTH AIC MODEL SELECTION (FULL MODEL)

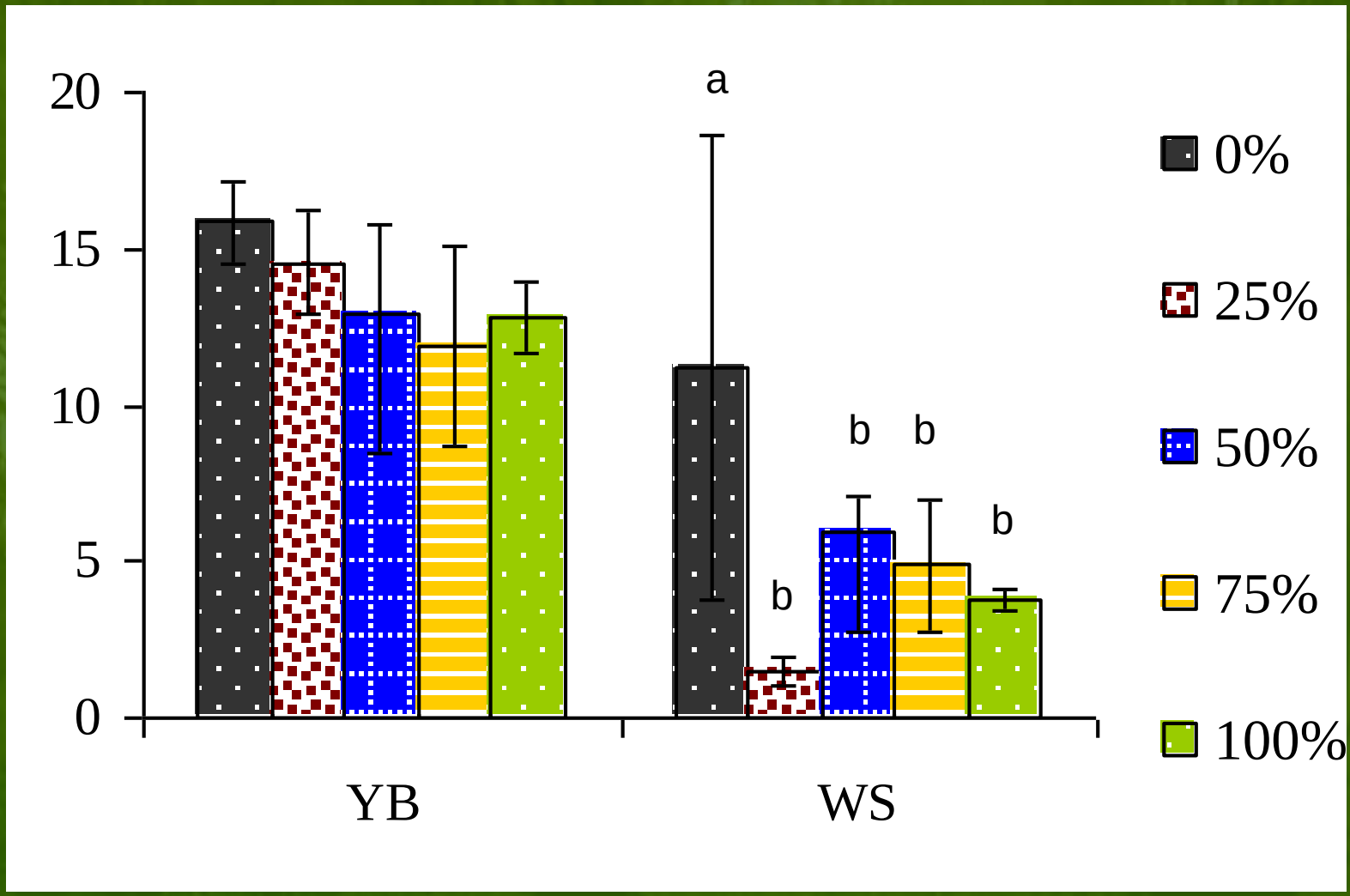
| | Suggested Models seedlings all species | Delta AICc | AICc Wt | Cum Wt |
|---|---|---|---|---|
| 1 | Competition + Gap size | 0 | 0.67 | 0.67 |
| 2 | Competition | 1.85 | 0.27 | 0.94 |
| 3 | Landscape heterogeneity + Competition | 4.93 | 0.06 | 0.99 |
| 4 | Landscape heterogeneity + Gap size + Gap position + Competition + Browsing | 9.16 | 0.01 | 1 |
| 5 | Gap size | 83.79 | 0 | 1 |
| 6 | Gap size + Gap position | 87.17 | 0 | 1 |
| 7 | Landscape heterogeneity | 108.68 | 0 | 1 |
| 8 | Landscape heterogeneity + Browsing | 108.98 | 0 | 1 |

# BROWSING REDUCES GROWTH



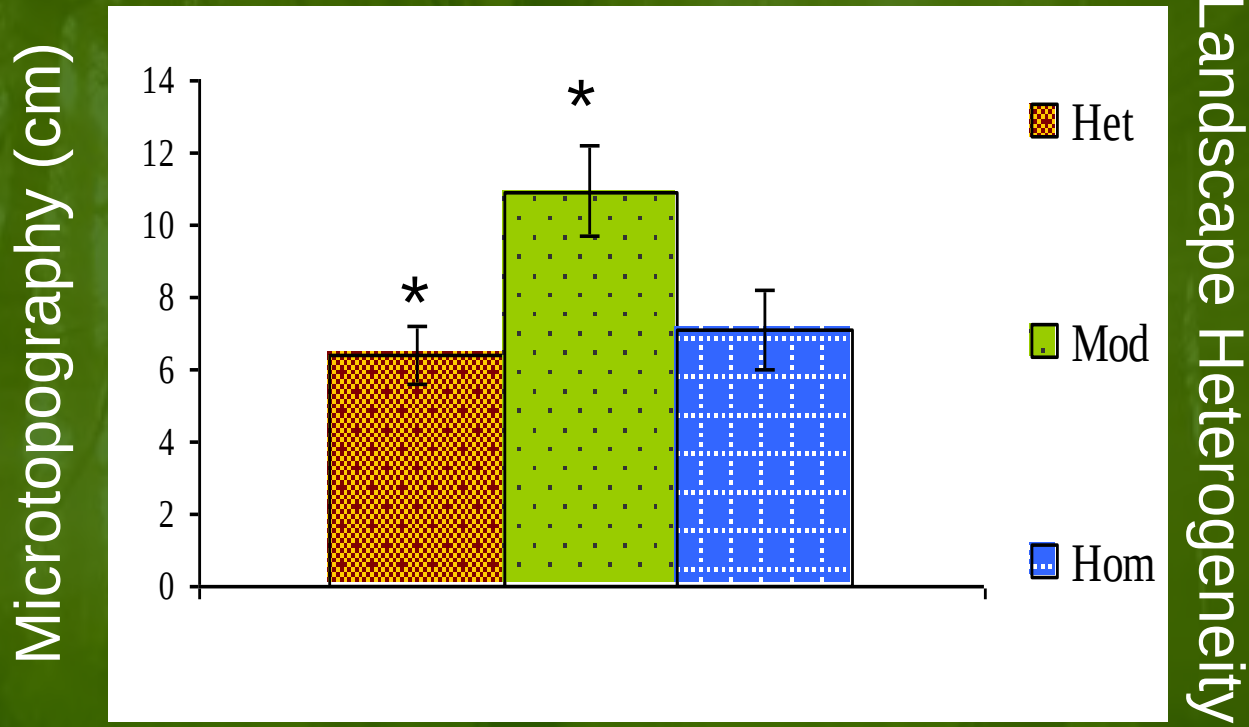



# COMPETITION REDUCES GROWTH




*Results*

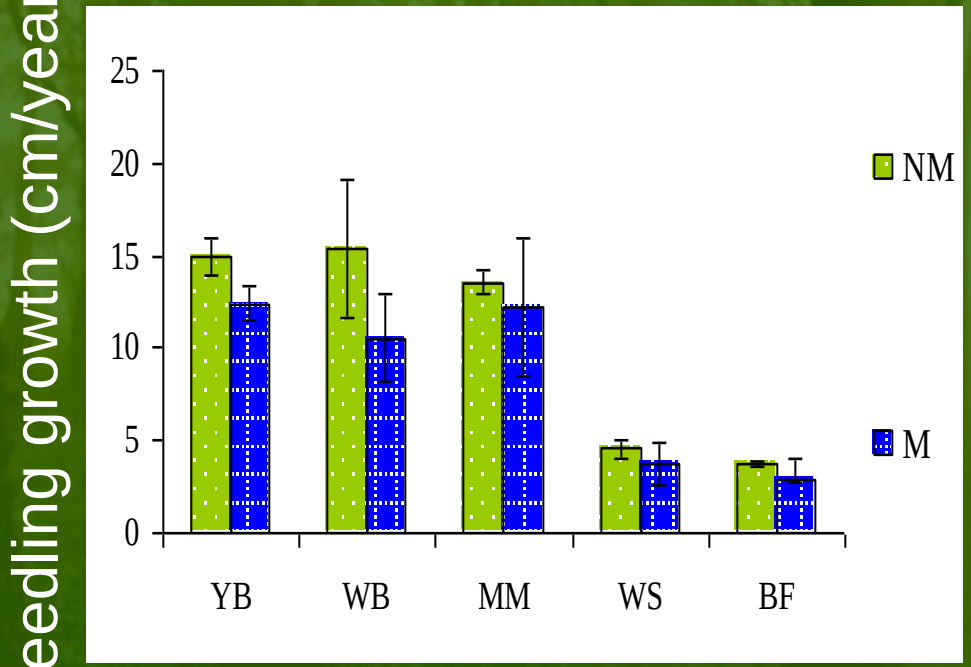
# IMPORTANCE OF MICROTOPOGRAPHY?

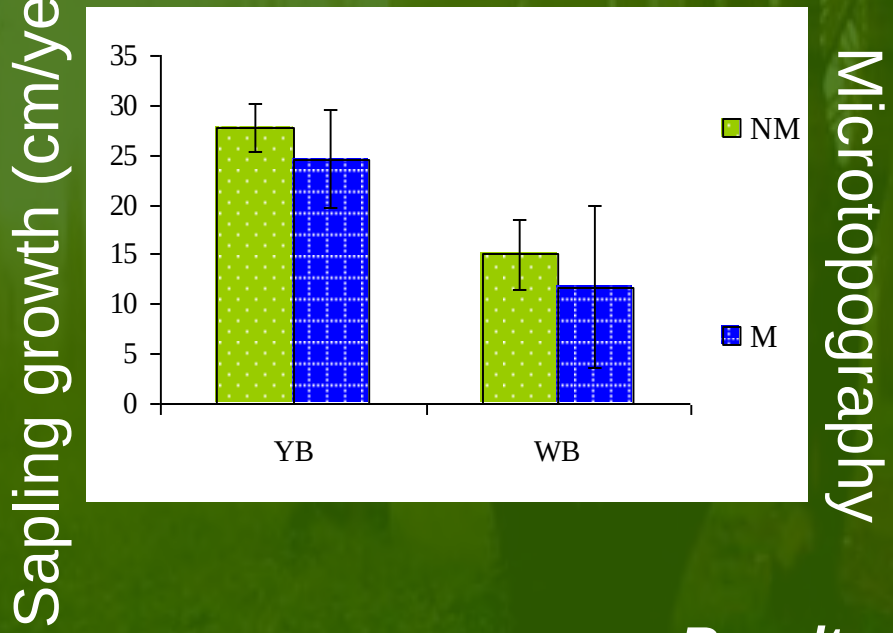



*Results*

# IMPORTANCE OF MICROTOPOGRAPHY?

- 30% of YB and 40% of WB were found on microtopographic features
- 7% increase in browsing in heterogeneous landscapes




*Results*