

# Effects of Spruce Budworm Outbreaks on Stand Dynamics in Balsam Fir & Red Spruce Mixedwoods

Amanda Colford-Gilks<sup>1</sup>, David MacLean<sup>1</sup>, John Kershaw<sup>1</sup>, Martin Beland<sup>2</sup>

<sup>1</sup> UNB Faculty of Forestry & Environmental Mgmt., Fredericton

<sup>2</sup> Université de Moncton Faculty of Forestry, Edmunston

# Introduction

- Mixedwood stand dynamics of Acadian forest: strongly influenced by periodic spruce budworm outbreaks

(Erdle and MacLean 1999)

- Spruce Budworm Outbreaks:
  - Kill spruce-fir but only indirectly hardwoods
  - Change overstory composition
  - Lead to change in understory

(Taylor and MacLean 2005)



# Effect of hardwood (HW) content

- Observations :
  - Less mortality in stands as HW increases  
(MacLean 1980)
  - Less defoliation as HW increases  
(Su et al. 1996)
  - Higher parasitism rate of budworm  
as HW increases  
(Cappuccino et al. 1998)





- Mortality: trees that died since last measurement
- Survivor growth: growth of trees  $\geq 5.1\text{cm dbh}$
- Ingrowth: trees that enter the  $\geq 5.1\text{cm dbh}$  size class
- → All calculated by basal area ( $\text{m}^2/\text{ha}$ ), measurement interval, plot and species. Mortality also by cause of death.



- Hardwood content: calculated by basal area ( $\text{m}^2/\text{ha}$ ); % of total plot basal area

# Objective

- To directly contrast development of balsam fir and spruce mixedwood stands in New Brunswick by:
  - 1) quantifying mortality, survivor growth and ingrowth using existing permanent sample plots (PSPs), and
  - 2) determining the influence of these variables on stand dynamics:
    - stand hardwood content
    - spruce budworm defoliation
    - insecticide spraying occurrences
    - ecosite
    - depth to watertable



# Hypotheses

- 1) Balsam fir mixedwood will have higher mortality rates and lower growth rates of balsam fir/spruce species than red spruce mixedwood
  - $bF > wS > rS > bS$  (Hennigar et al. 2008)  
100% 72% 41% 28%
- 2) Balsam fir and red spruce mixedwood with higher hardwood content will have lower budworm-caused mortality rates and higher survivor growth rates of balsam fir/spruce trees
  - Parasitism  $\rightarrow$  Less defoliation  $\rightarrow$  More growth /Less mortality  
(Cappuccino et al. 1998) (Su et al. 1996)

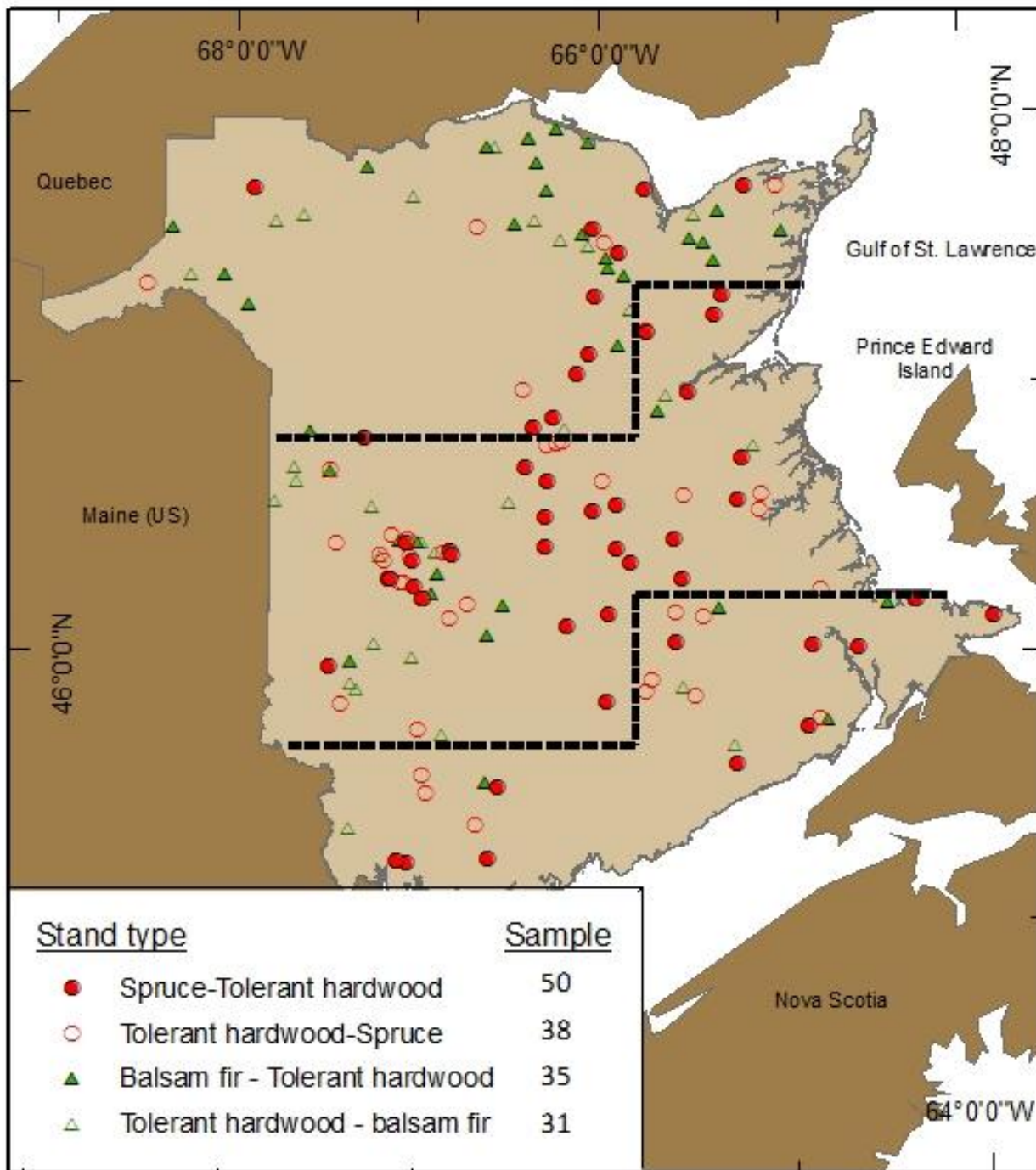


# Methods

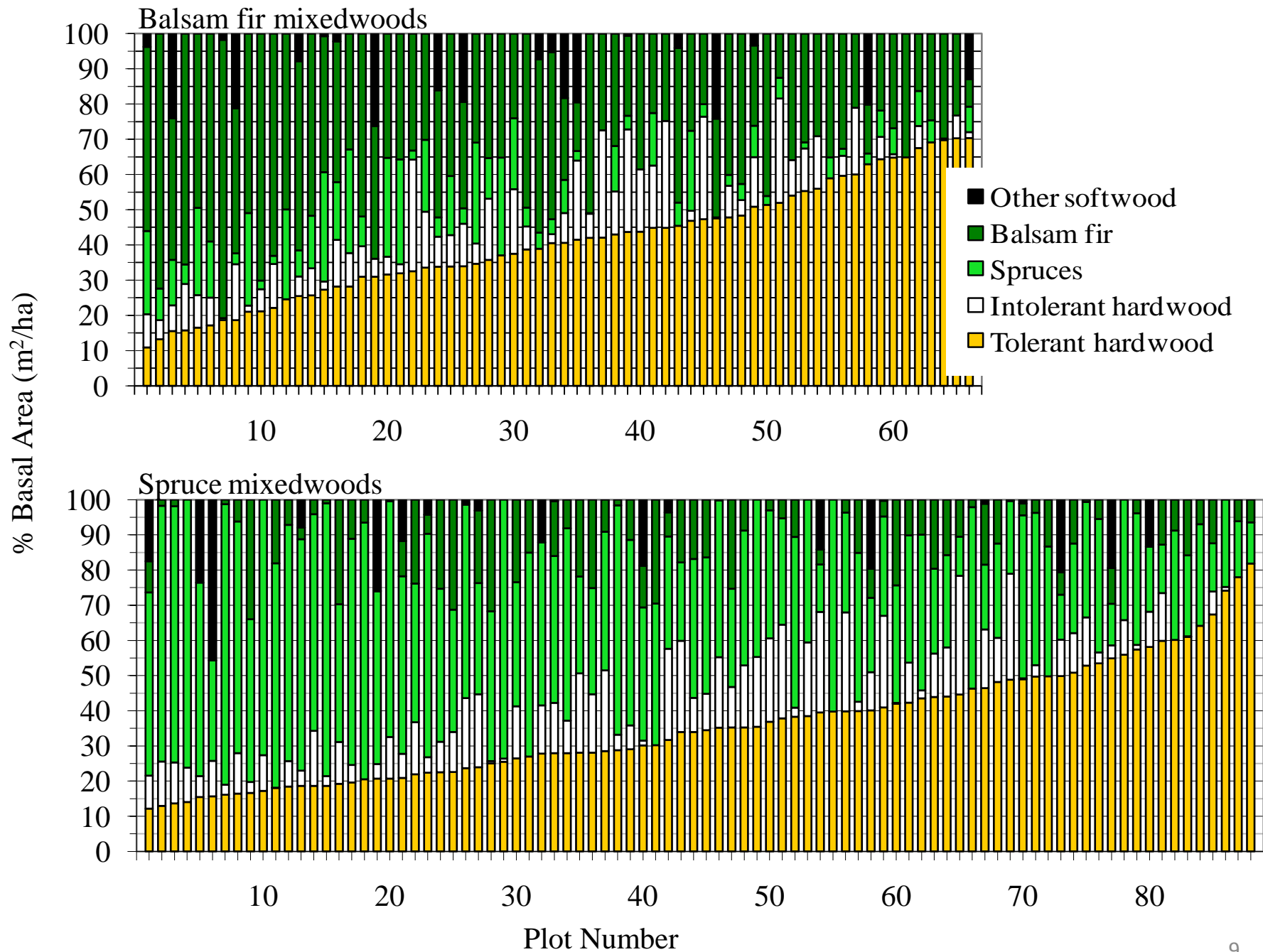
- 2688 PSPs (NB DNR) were established from 1987-1990; data are collected from plots every 3 to 5 years
  - Existing data: ELC, species, age, dbh, height, cause of death
  - PSPs of Interest
    - Plot type = unmanaged
    - Primary development stage: mature and over-mature
    - At least 2 successive measurements
    - Forest types = Balsam fir-tolerant hardwood and spruce-tolerant hardwood mixedwoods
- 154 plots met criteria

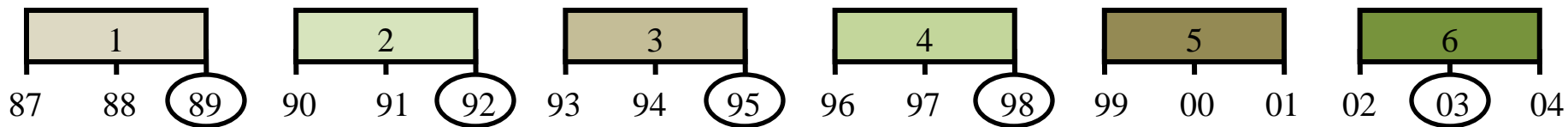












Measurement interval

1 - 2

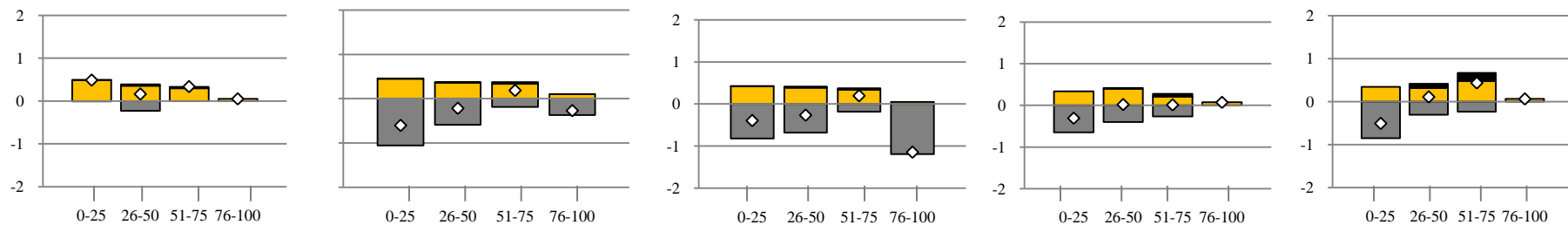
2 - 3

3 - 4

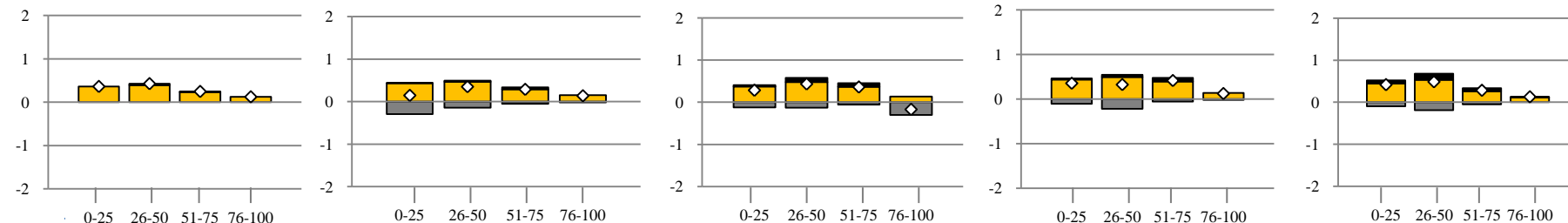
4 - 5

5 - 6

Balsam fir mixedwood



Spruce mixedwood



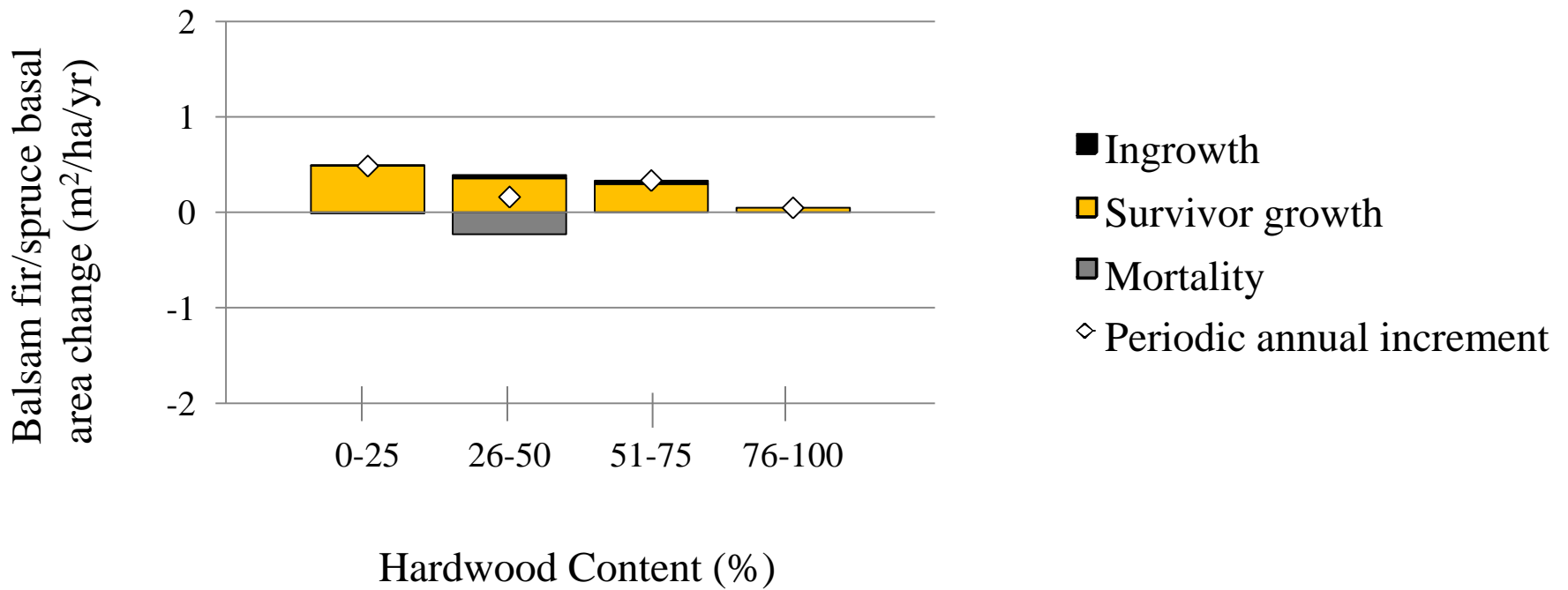
Hardwood Content (%)

- Ingrowth
- Survivor growth
- Mortality
- ◇ Periodic annual increment

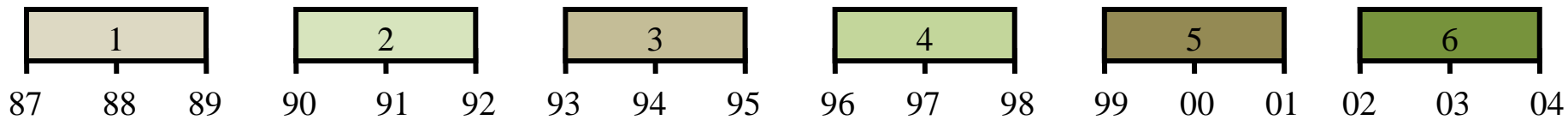
Measurement interval

1 - 2

Balsam fir mixedwood







Measurement interval

1 - 2

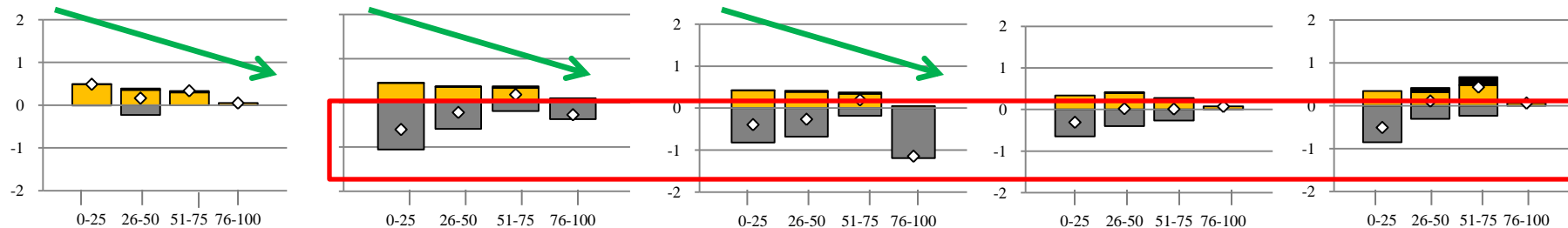
2 - 3

3 - 4

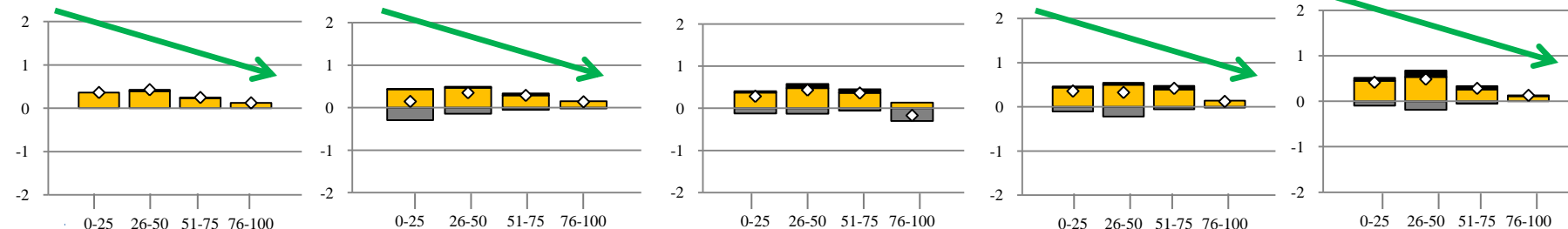
4 - 5

5 - 6

Balsam fir mixedwood

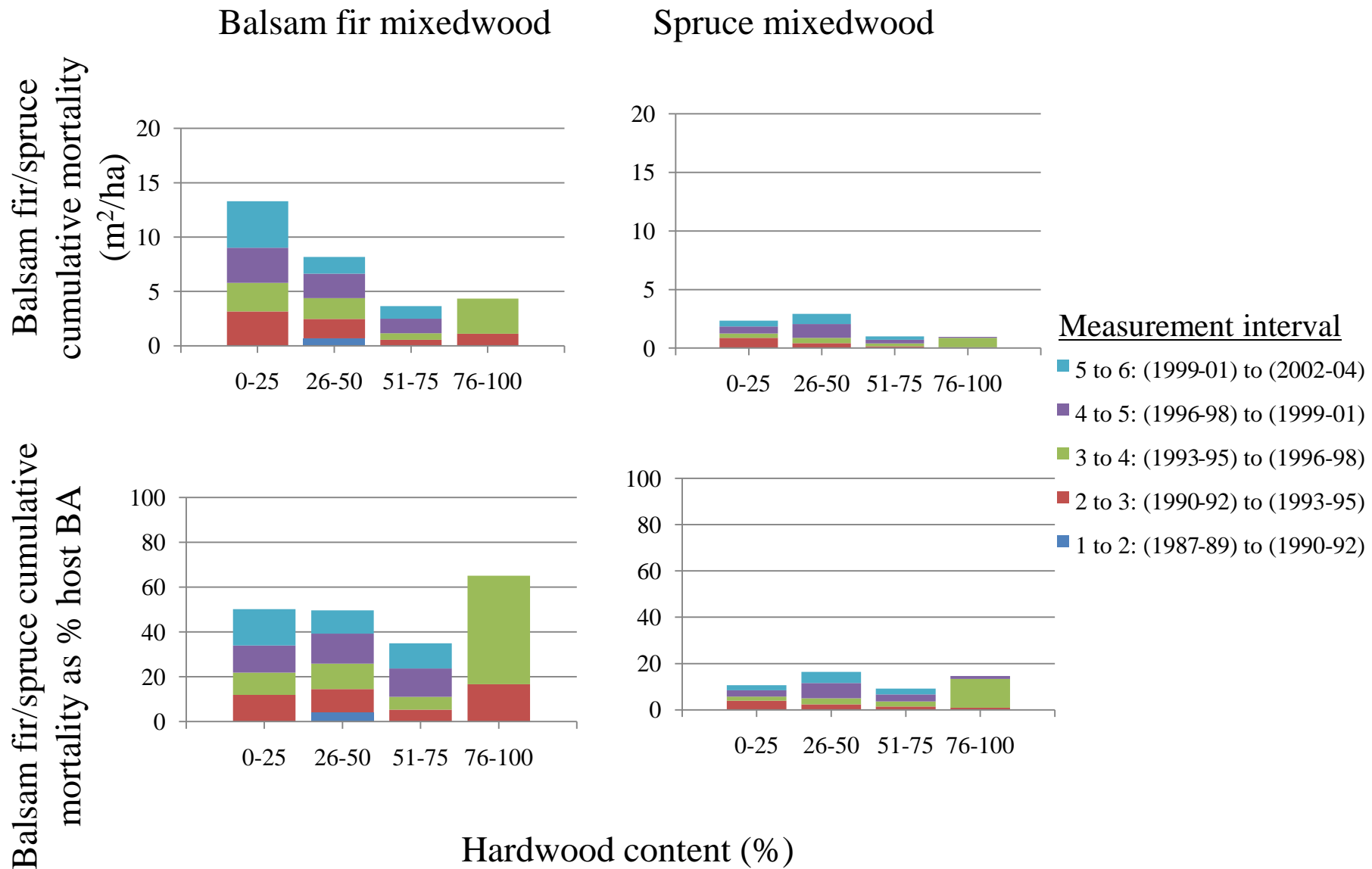


Spruce mixedwood



Hardwood Content (%)

- Ingrowth
- Survivor growth
- Mortality
- ◇ Periodic annual increment



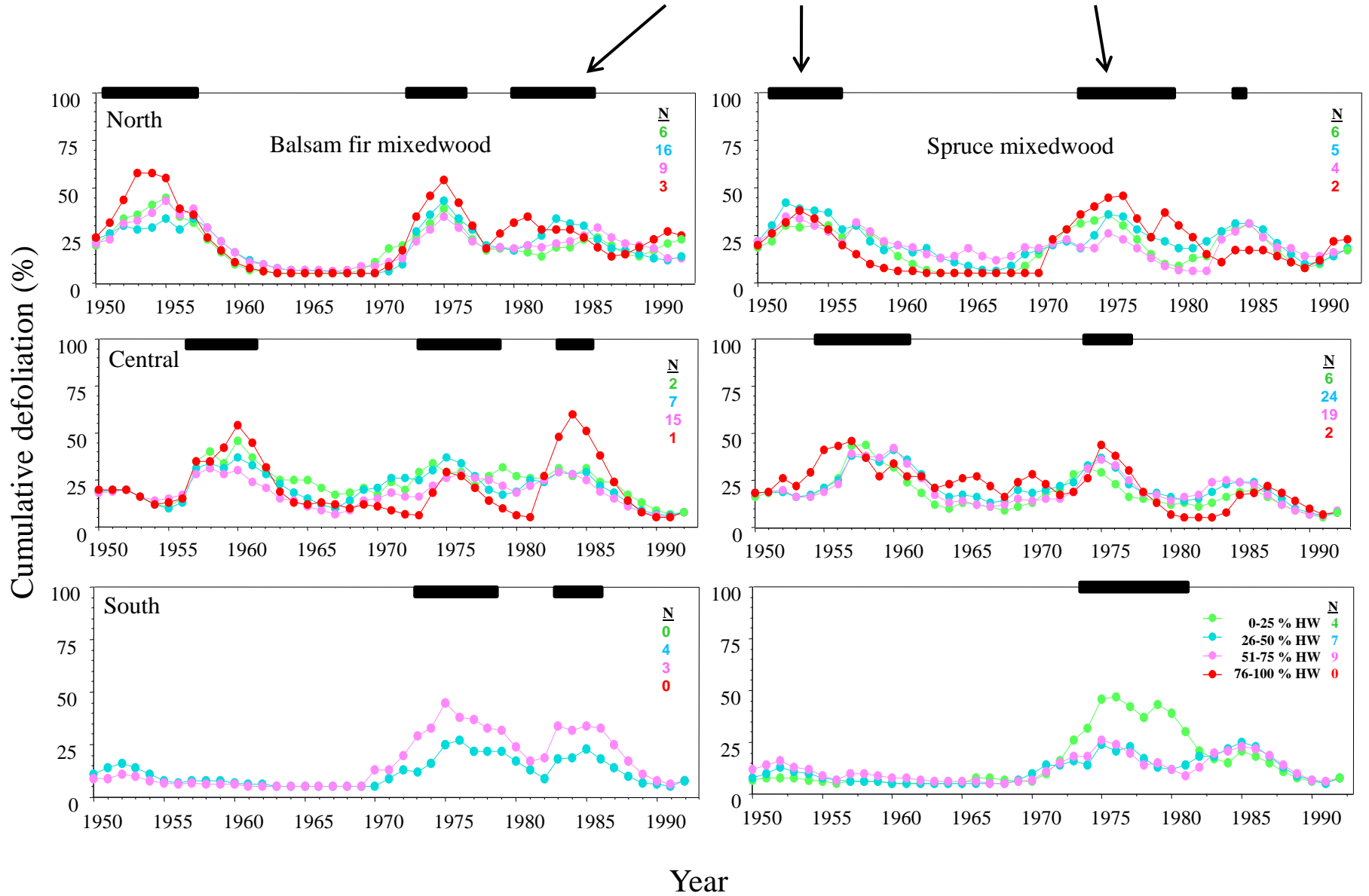
- Long-term indirect effect of spruce budworm on stand development → increased blowdown
  - 106 PSPs in balsam fir stands > 50 years old, northern NB
  - Trend and rate of volume development related to past outbreak severity
  - Higher levels of wind-caused mortality for 11-25 years after cessation of defoliation (peaking at 11 m<sup>3</sup>/ha/yr)

(Taylor and MacLean 2009)





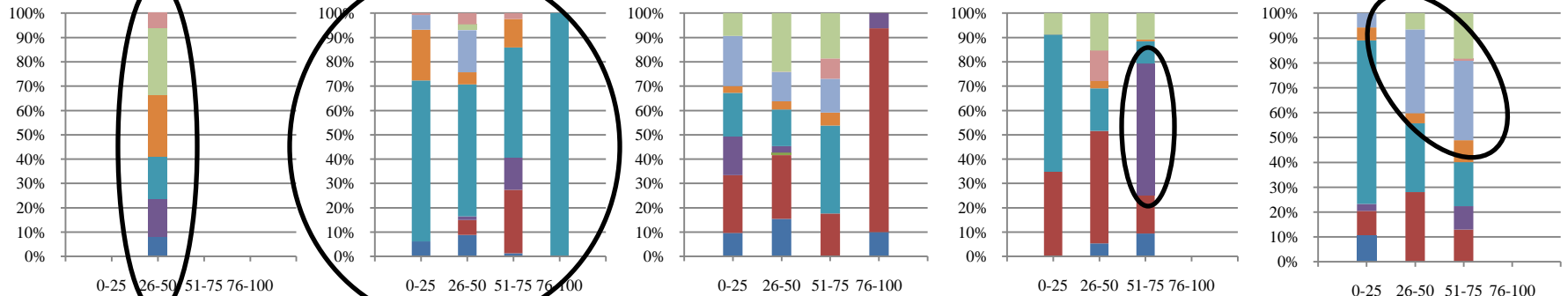
# Cumulative defoliation $\geq 30\%$



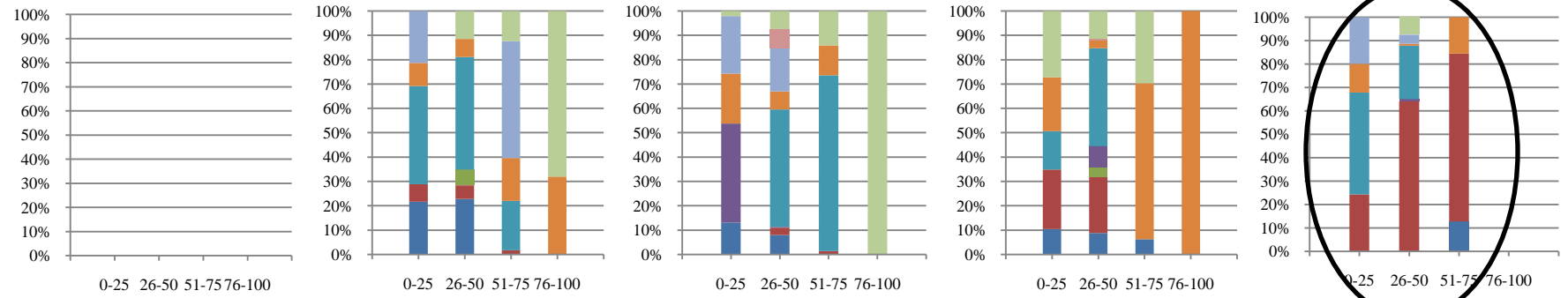
# Measurement interval

1 - 2                      2 - 3                      3 - 4                      4 - 5                      5 - 6

## Balsam fir mixedwood



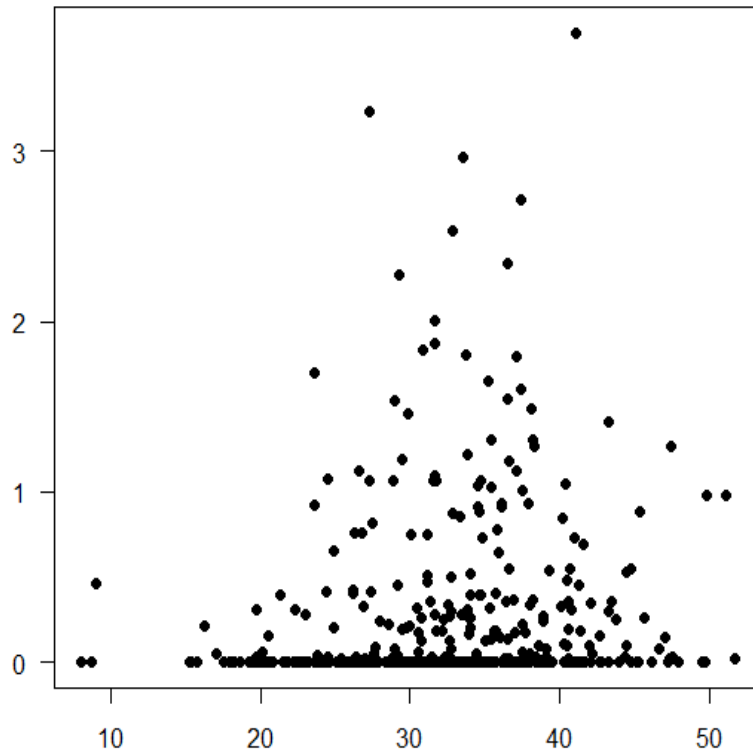
## Spruce mixedwood



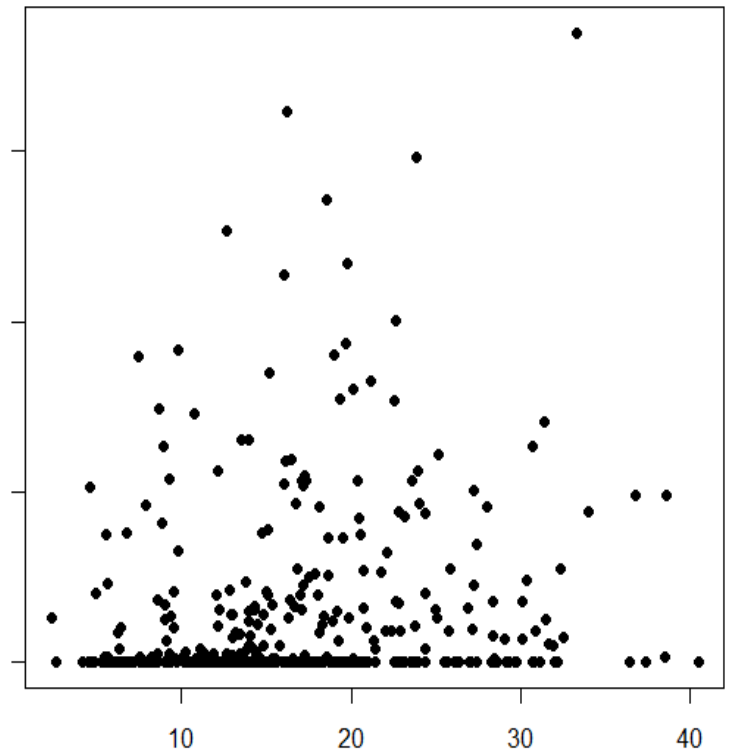
Hardwood Content (%)

- Insect damage
- Windthrow
- Stem wounds
- Broken top
- Stem breakage
- Suppression
- Overmature
- Other
- Unknown

Balsam fir/spruce Mortality ( $\text{m}^2/\text{ha}/\text{yr}$ )



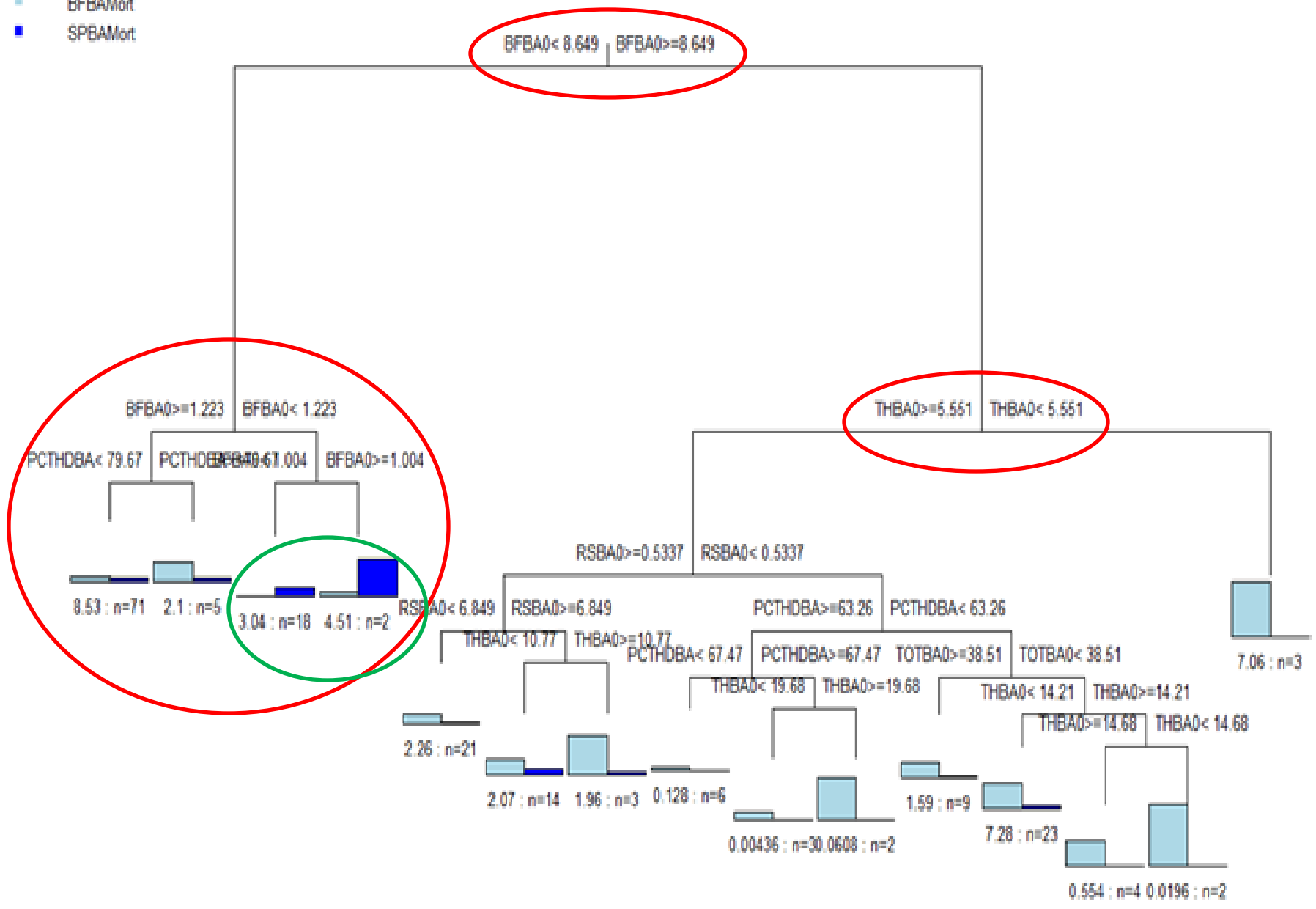
Total BA ( $\text{m}^2/\text{ha}$ )

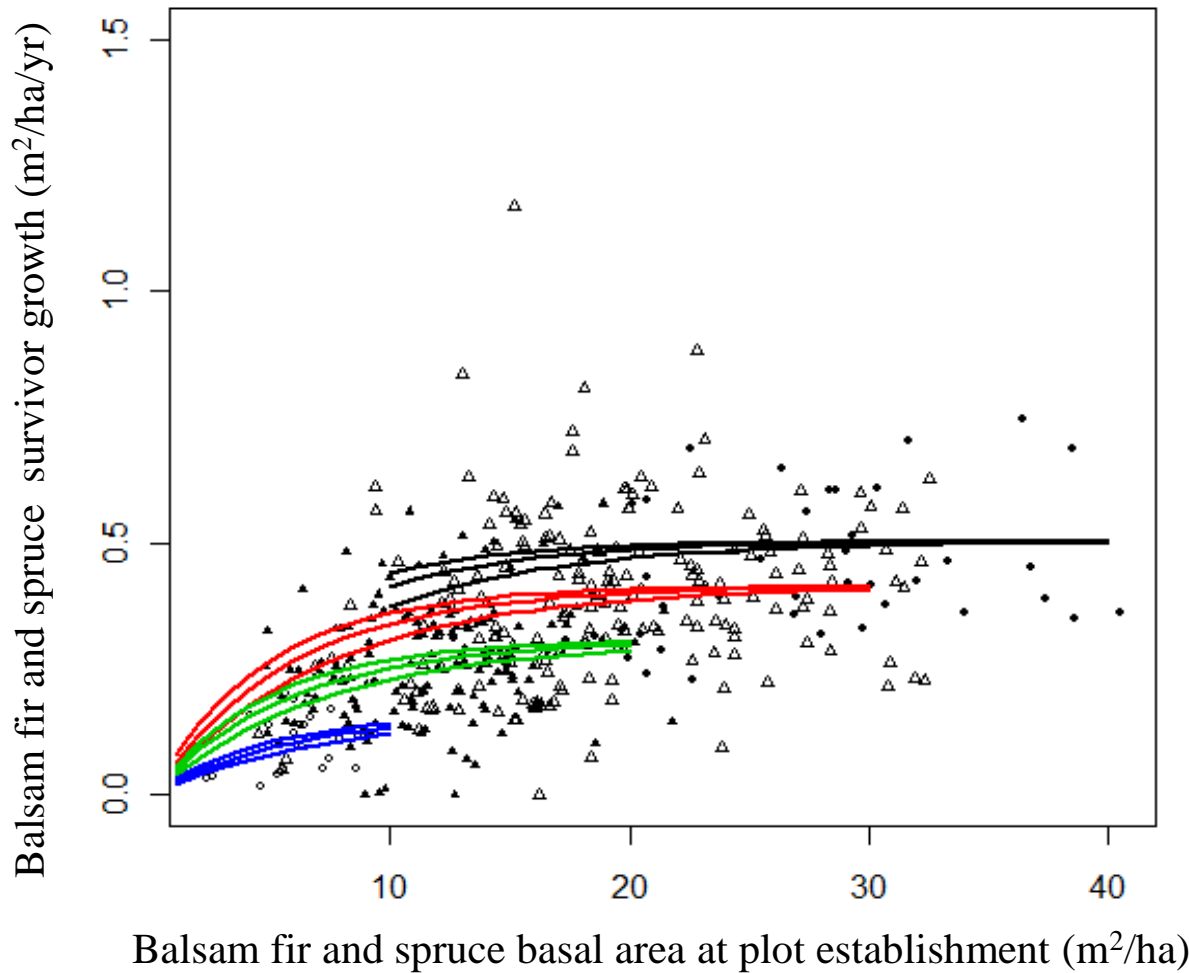


Balsam fir/spruce BA ( $\text{m}^2/\text{ha}$ )



■ BFBA\_Mort  
■ SPBA\_Mort





Species Composition

% BF / % SP

**75 / 25**

**50 / 50**    **in 0-25% HW**

**25 / 75**

**75 / 25**

**50 / 50**    **in 26-50% HW**

**25 / 75**

**75 / 25**

**50 / 50**    **in 51-75% HW**

**25 / 75**

**75 / 25**

**50 / 50**    **in 76-100% HW**

**25 / 75**

# Research Contribution

- We found evidence to support our hypotheses:
  - Stands with more bF had higher bF/spr mortality rates than those with less balsam fir,
  - bF had higher bF/spr mortality rates than spruce, and
  - Stands with more hardwood content had less spr mortality at all applicable terminal nodes
  - bF/spr survivor growth increased with increasing bF presence
- Directly contrasting and quantifying the spruce – fir component of mixedwood along the hardwood content range
- Directly contrasting two mixedwood types

# Acknowledgements

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