

# Simulated interactions between spruce budworm & fire: Comparing the past with the future

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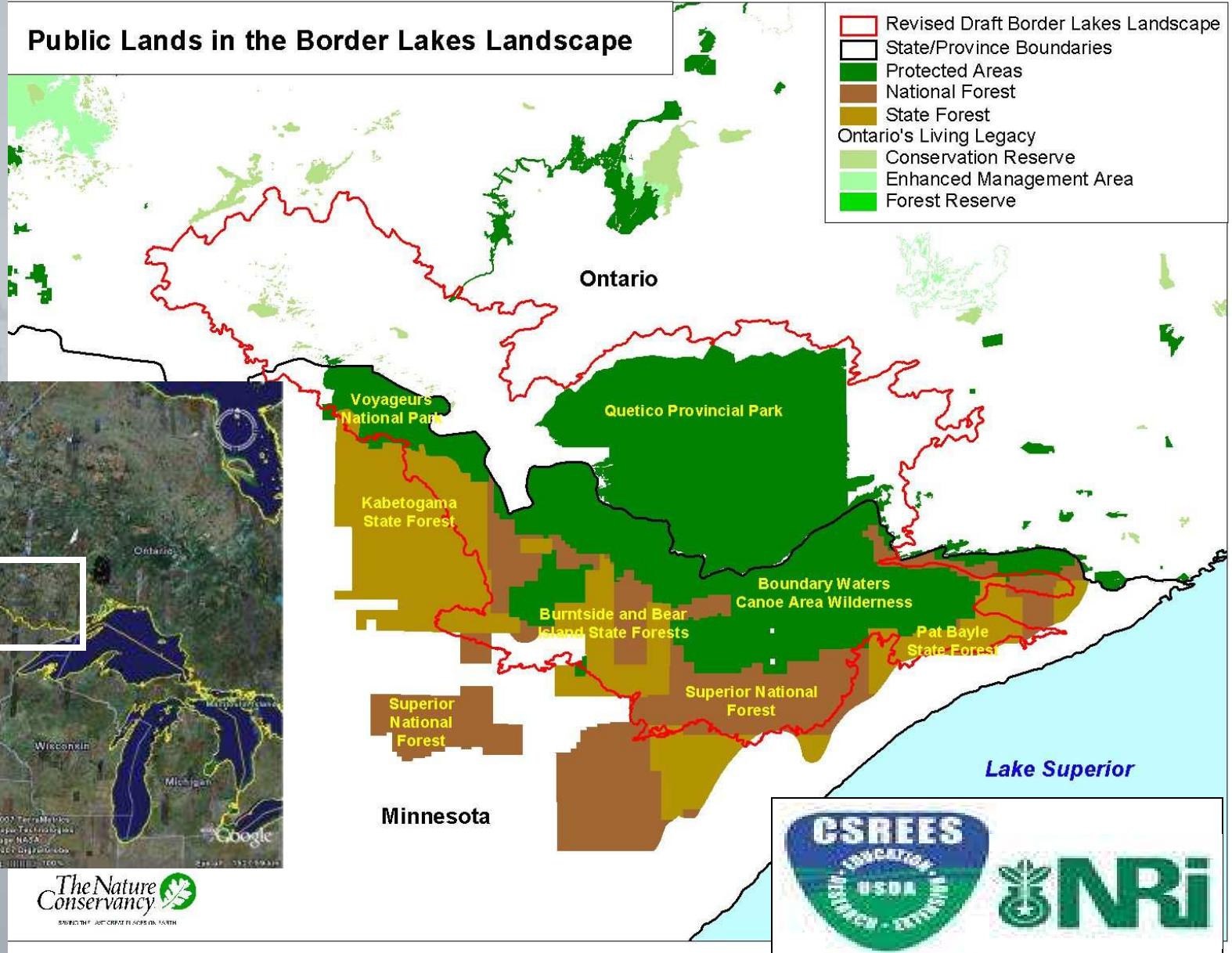
# Eastern Spruce Budworm



# Border Lakes Landscape

## Public Lands in the Border Lakes Landscape

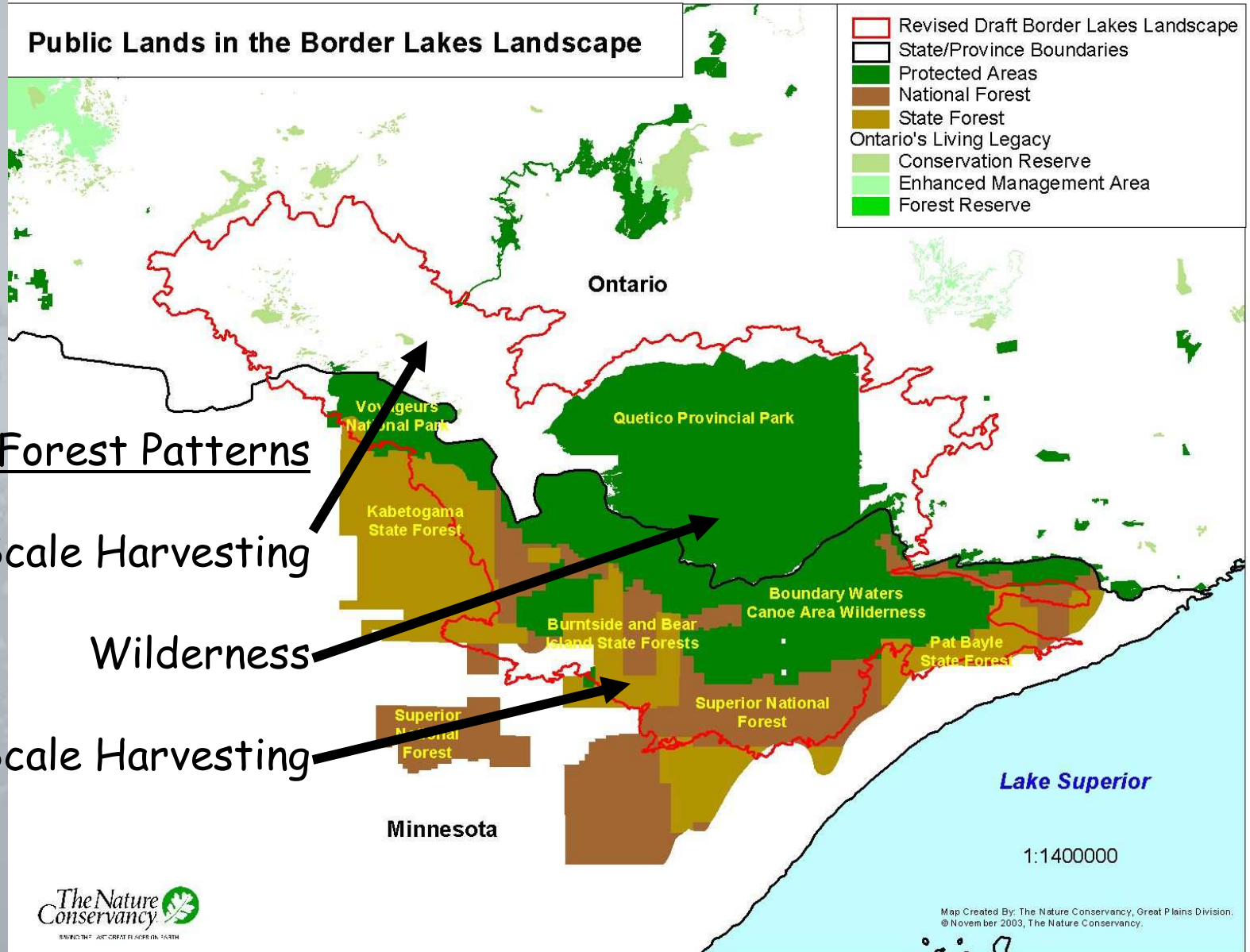
-  Revised Draft Border Lakes Landscape
-  State/Province Boundaries
-  Protected Areas
-  National Forest
-  State Forest
-  Ontario's Living Legacy
-  Conservation Reserve
-  Enhanced Management Area
-  Forest Reserve



# Border Lakes Landscape

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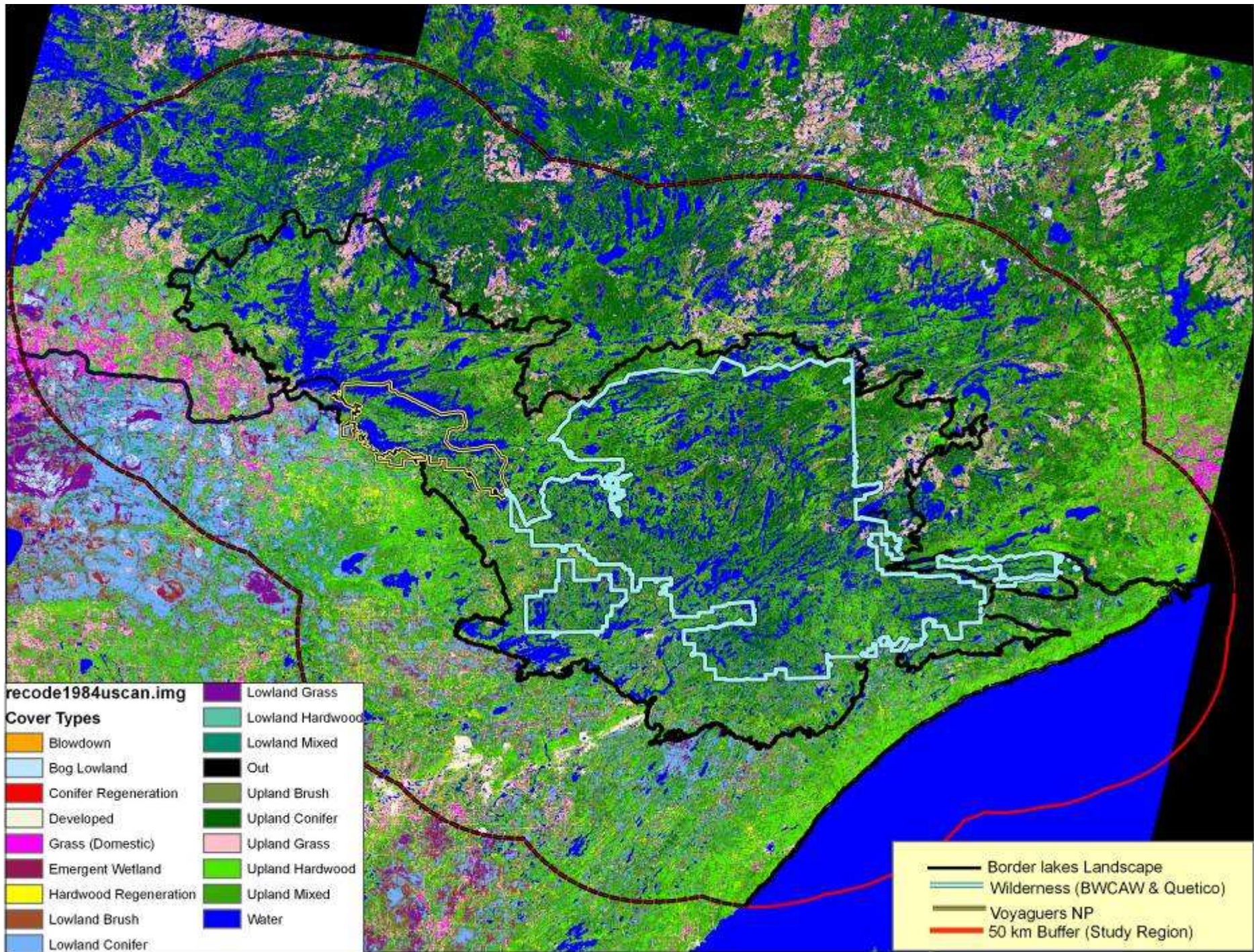


Contrasting Forest Patterns

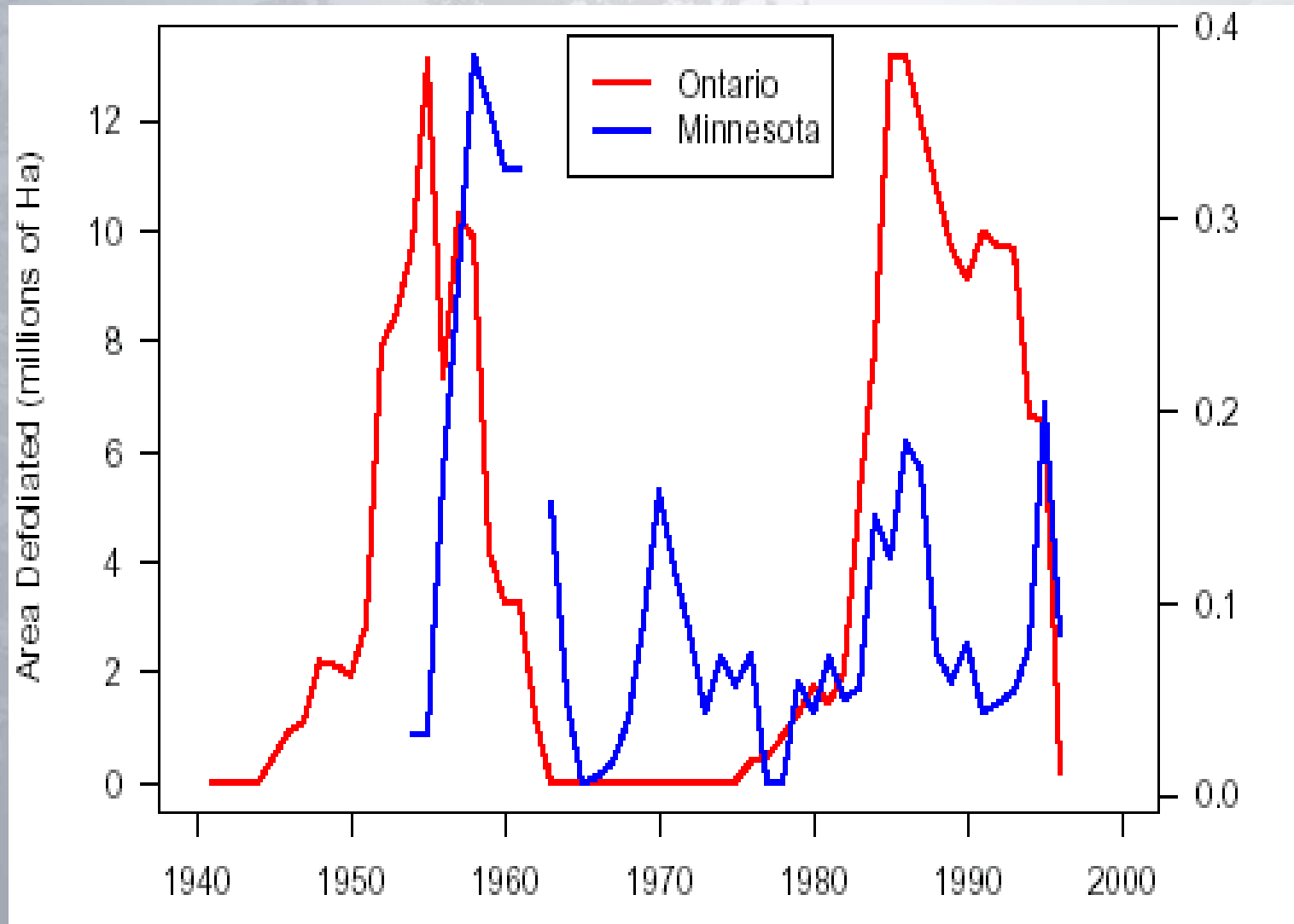
Coarse-Scale Harvesting

Wilderness

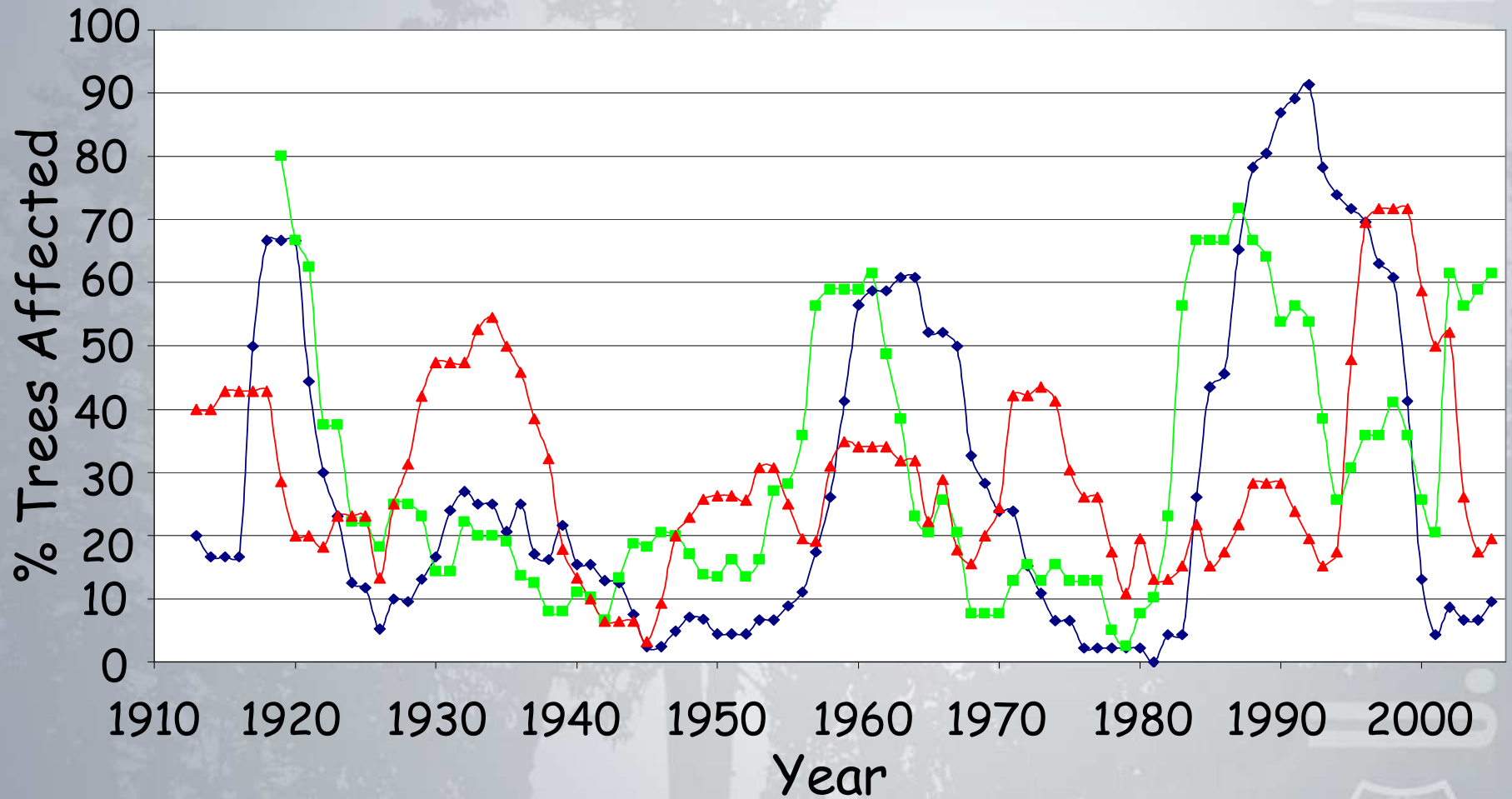
Fine-Scale Harvesting



# Different Scales of Outbreak Synchrony



# First Results



Blue = Wilderness Green = Ontario Red = Minnesota



Remote Sensing



Host Distribution  
(pre and post outbreak)



Host Mortality



Defoliation History

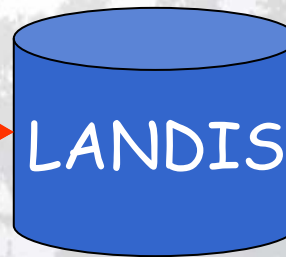


Population Connectivity



# Designing Pest-Resistant Landscapes

Disturbance  
Rules



Landscape  
Management

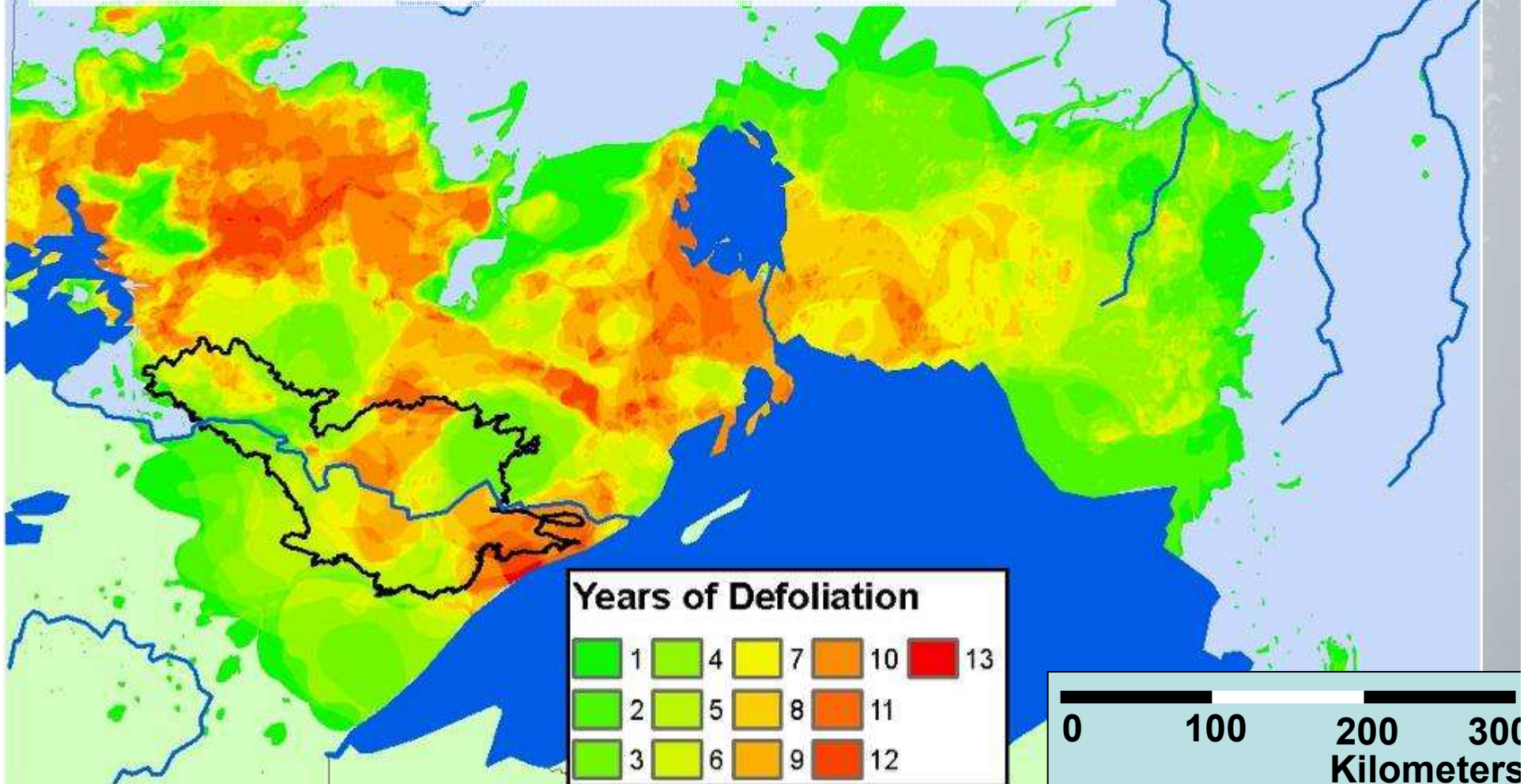
*Hypothesis:  
The use of mixed-species  
stands and mosaics  
makes for healthier and  
pest-resistant forests*



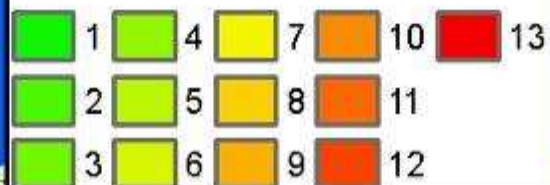
1984 - 1996

## Large fires occur more often following budworm outbreaks

(Fleming et al. 2002 *Climatic Change* 55:251-272)

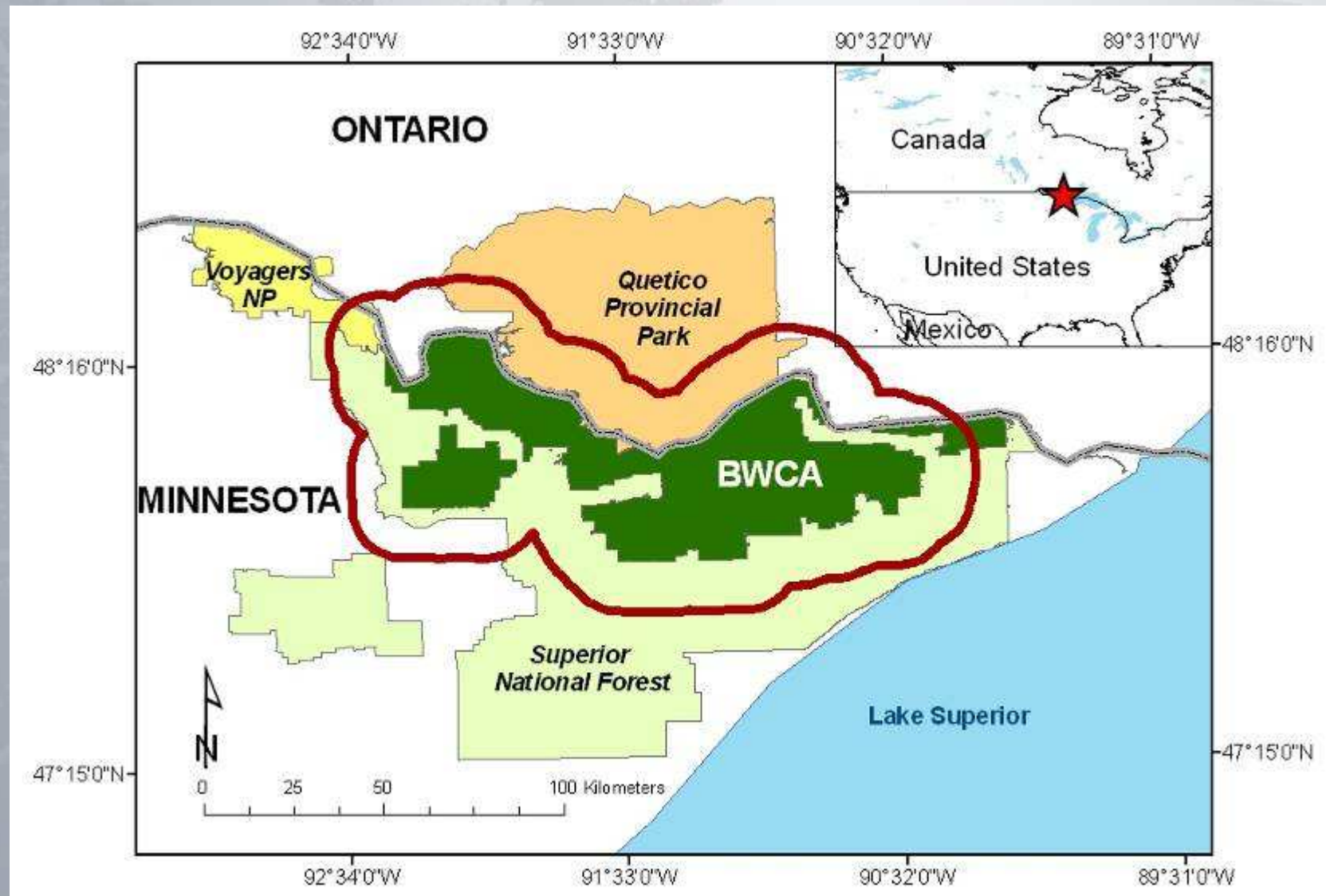


### Years of Defoliation



0 100 200 300  
Kilometers

# Boundary Waters Canoe Area Wilderness





# Reciprocal Interactions: *Budworm-Fire-Succession*

- Fire suppression encourages fir & spruce
  - Ladder fuels  $\Rightarrow$  Larger, more intense fires
- More intensive budworm outbreaks
  - Periodic pulses of fuel
  - Fir dieback decreases ladder fuels



?

Photos: Canadian Forest Service



# Scenario Comparison

## *Modern vs Presettlement*

***Budworm vs No Budworm***

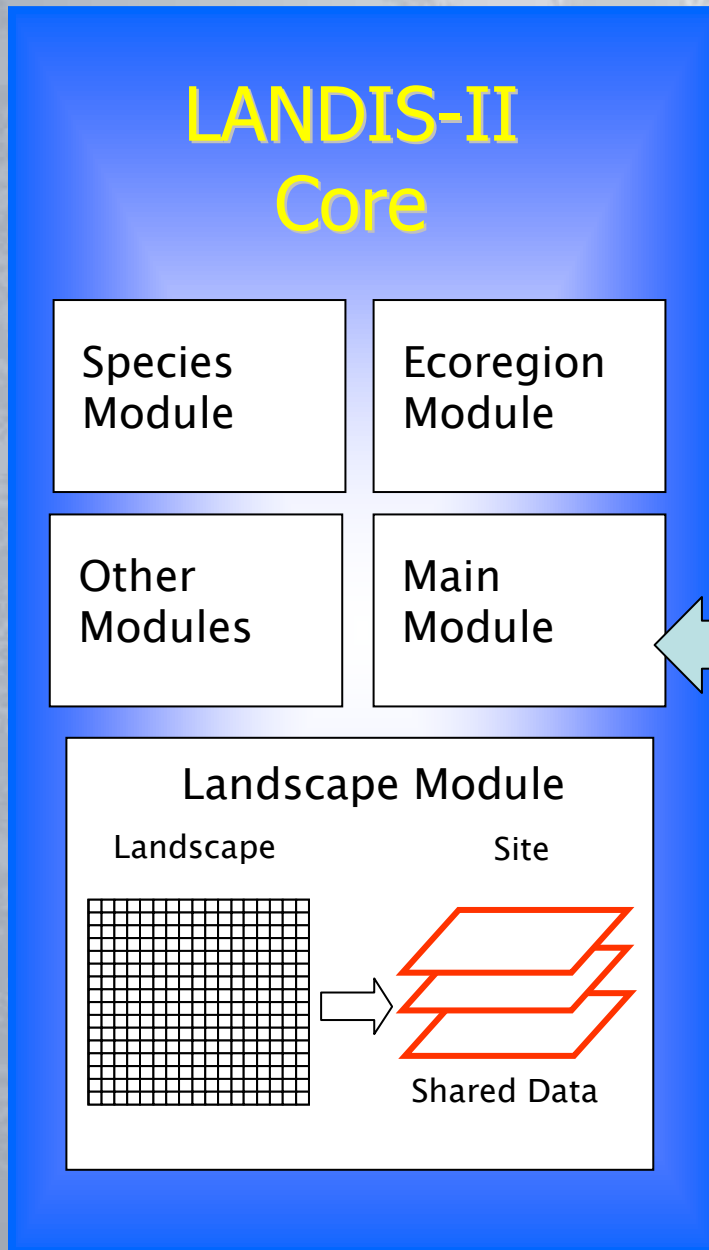
<b>Modern Forests Suppressed Fire Regime</b>	<b>Presettlement Forests Unrestricted Fire</b>
<b>Modern Forests, Fire &amp; Spruce Budworm</b>	<b>Presettlement Forests, Fire + Spruce Budworm</b>

# LANdscape Disturbance & Succession (LANDIS)

- Designed to investigate interactions between tree species succession and different disturbances at landscape scales
- Fundamental Assumptions:
  - Species age cohorts respond individually to light conditions and different disturbances
  - Seed dispersal  $f(\text{distance to cells w/ mature cohorts})$
  - Species establishment is a probabilistic function of discrete “ecoregions” or “land types”



# LANDIS-II Core and Extension Interactions



## "Plug-in Extensions"

Succession Extension

Fire Disturbance Extension

Insect Disturbance Extension

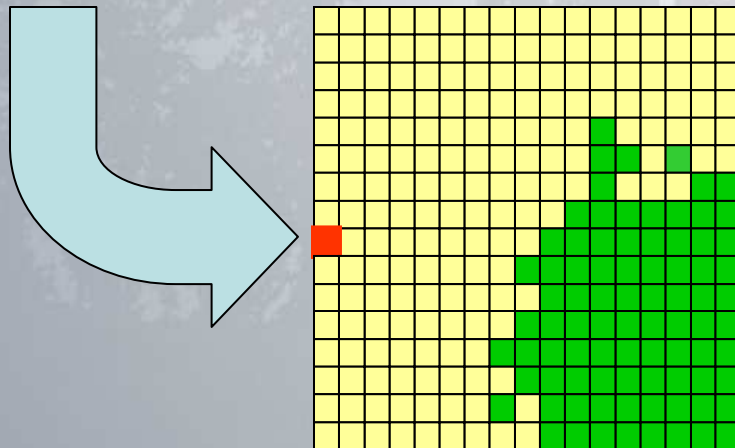
Time Step Defined by User for Each Extension

<http://www.landis-ii.org/>



# Age-List Succession

(Species / Age Cohort List)



## *Vital Attributes*

- Shade Tolerance
- Fire Tolerance
- Longevity
- Seed Dispersal
- Vegetative Reproduction
- Serotiny

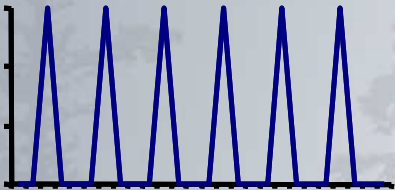
## Ecoregion

- Probability of Establishment
- Soils / Topography / Climate



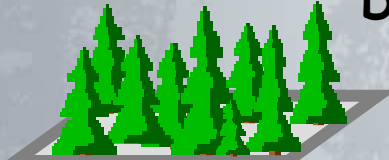
# Insect Disturbance

*Temporal Pattern*

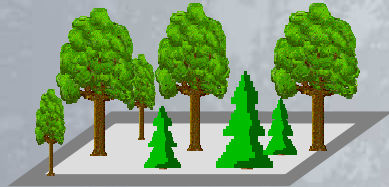


↓ *Outbreak?*

**Site Resource Dominance**

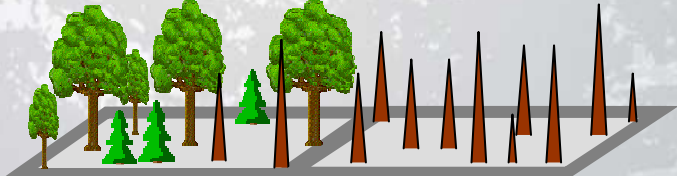
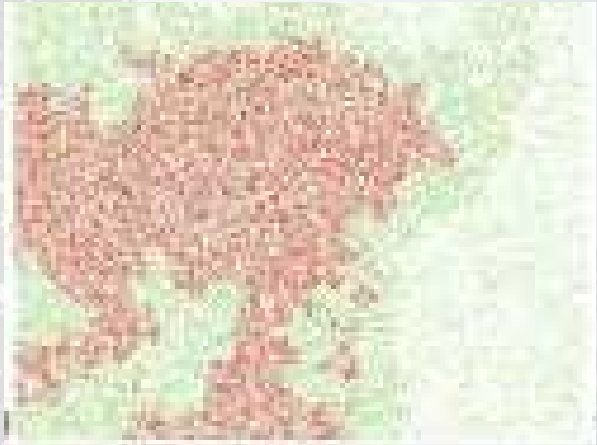
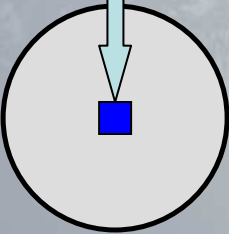


High



Low

**Neighborhood Effects**



*Probabilistic Disturbance*



**Site Vulnerability**



# Spruce Budworm Disturbance Rules

- Site Vulnerability
  - Mature host > Young host
  - Reduced by deciduous species
- Neighborhood Influence
  - Local (adjacent cells)

*Parameters derived from empirical relationships published by MacLean and Colleagues for New Brunswick, Canada*



# Balsam Fir Regeneration



UGA2714025

# Fire Disturbance

- Fuel extension translates species age-list into fuel types of the Canadian Forest Fire Prediction (FBP) System
  - % “dead fir” for budworm-disturbed sites
- Seasonality
  - fire weather and fuel conditions
    - (leaf-on, leaf-off, fuel moisture)
- Fire Events
  - Probabilistic ignition
  - Randomly selected weather
  - Elliptical fire spread
  - Fire severity is a combined function of rate spread and fuel type



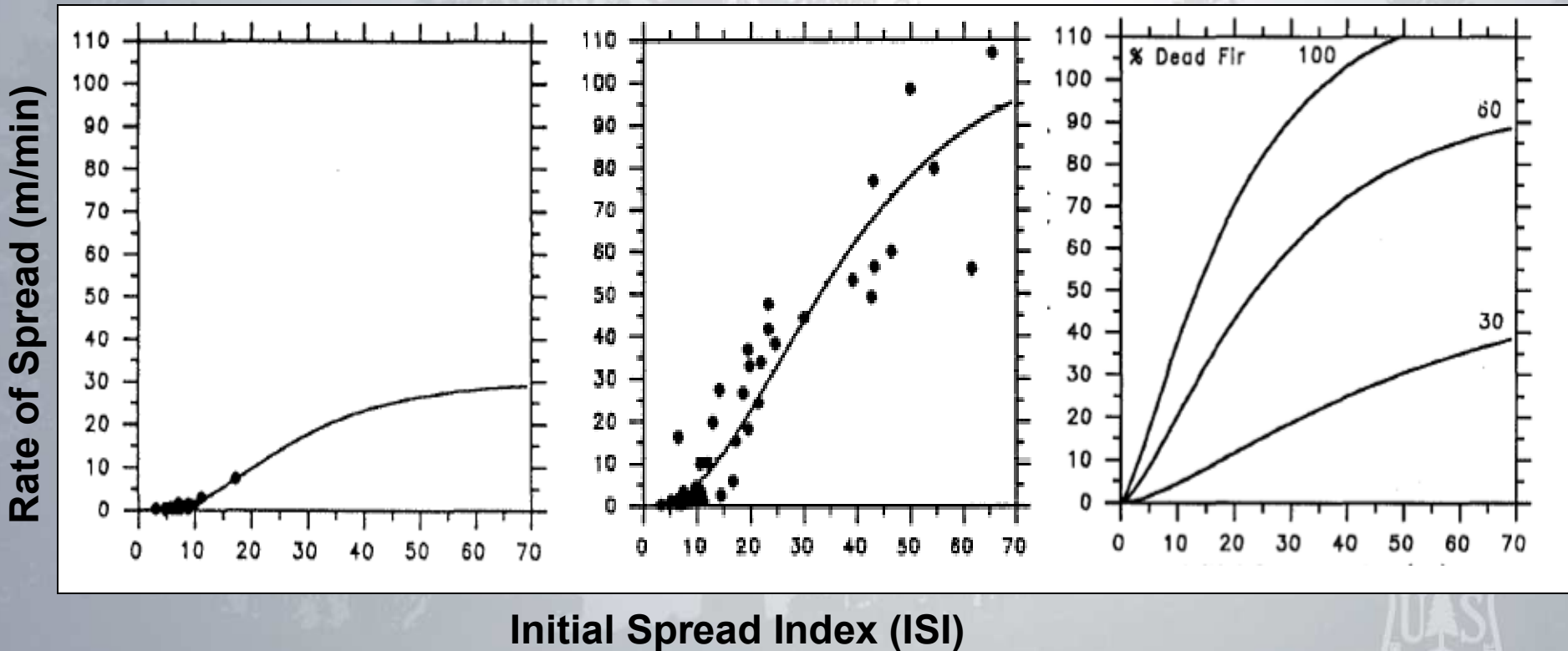
# Rate of Spread

- Fire weather variables, in combination with fuel types, determine fire spread rates

C-5 Red or White Pine

C-3 Mature Jack Pine

M-3 Dead Balsam Fir  
Mixedwood-Leafless



Forestry Canada Fire Danger Group (1992)



# Scenarios

- Modern
  - Initial conditions circa 2000
    - Remote sensing
  - Fire suppression regime
    - 400 year rotation
- Presettlement
  - Initial conditions circa 1860
    - General Land Office Survey
  - Unrestricted fire regime
    - Heinselman ~ 120 year rotation
- Spruce Budworm Scenarios
  - Average outbreak interval 33 yrs (stdev 10.6)
    - *L-E. Robert, University of Quebec, unpublished data*



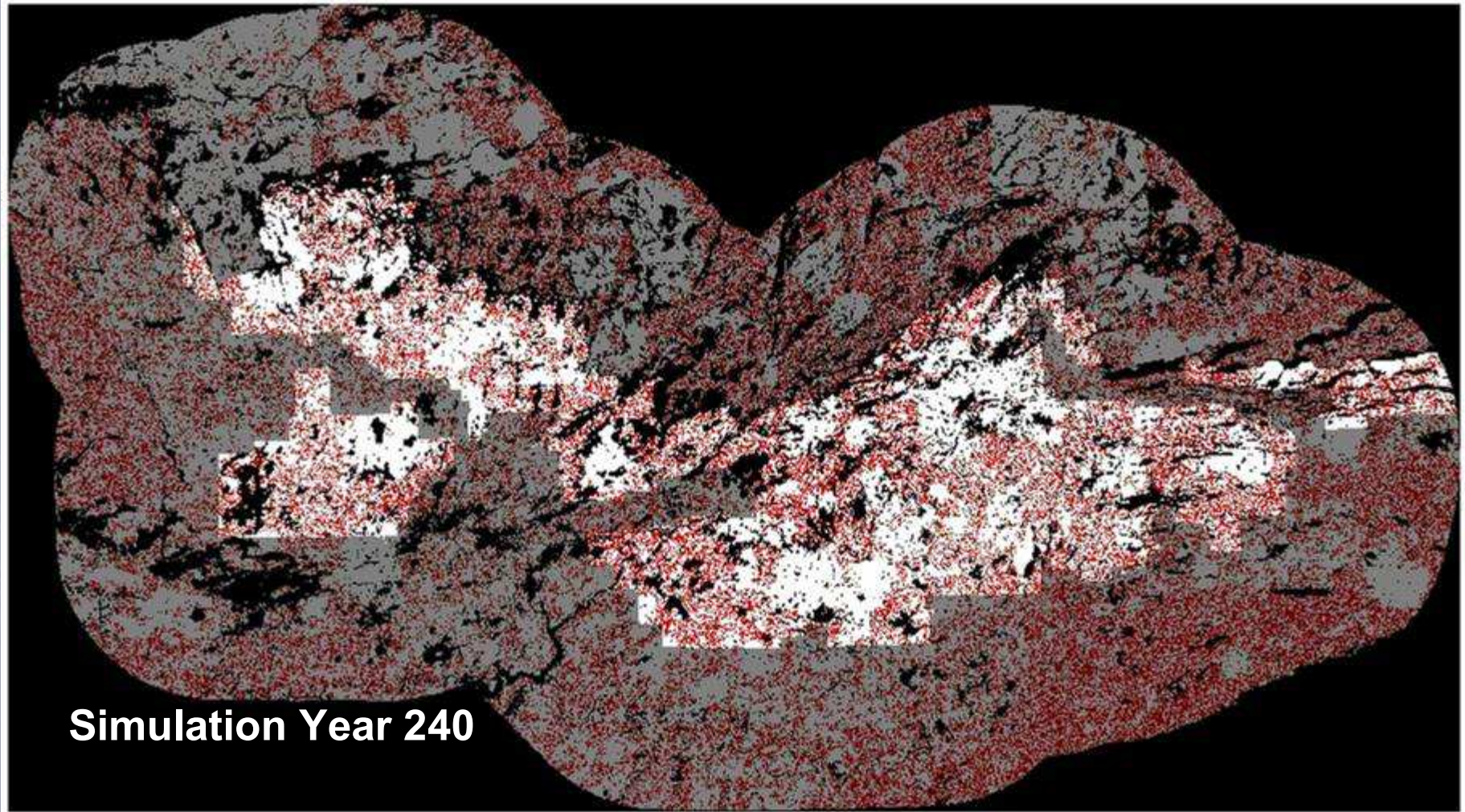
# Approach

- Three replicate 250-year simulations for each scenario
- Response Variables
  - Forest Composition
  - Area Burned
  - Area Disturbed by Budworm
- Edge effects are minimized by adding a 14km buffer
  - Results reported for the area within the BWCAW boundary



# Spruce Budworm Disturbance

*Modern Scenario*



**Simulation Year 240**

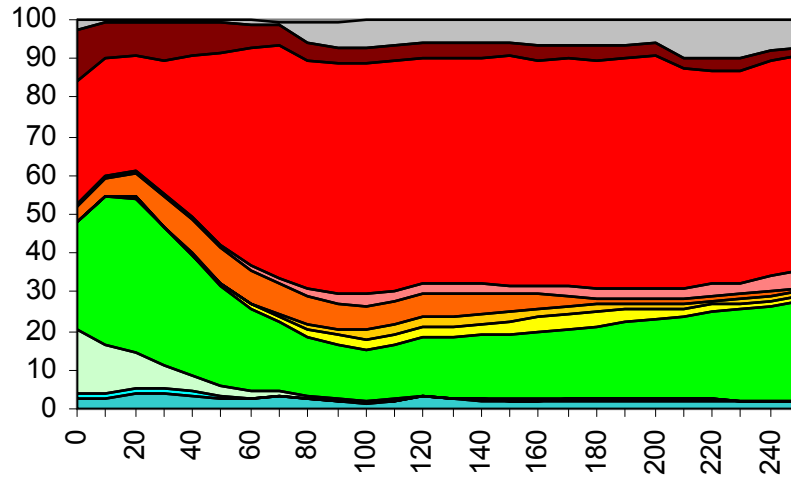




# Vegetation Trends Modern Scenarios

Percent of BWCAW

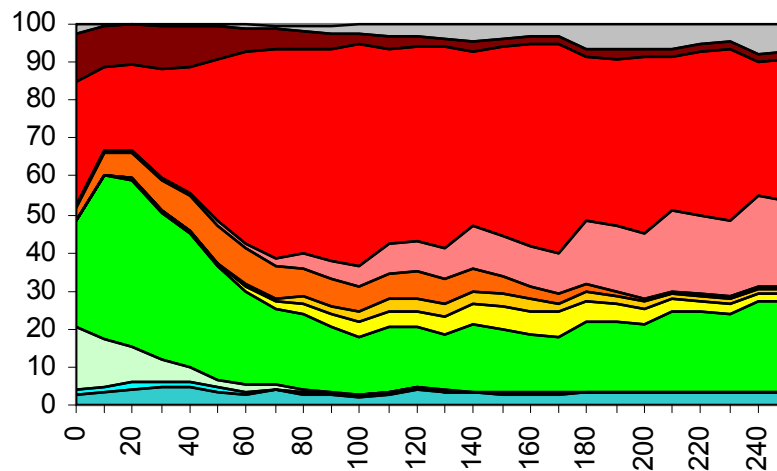
## Fire Only Scenario



- Unoccupied Forest
- Jack Pine
- Spruce-Fir
- Cedar
- Mixed Pine
- Red Pine
- White Pine
- Aspen-Birch
- Maple Harw oods
- Ash
- Tamarack

## Spruce Budworm & Fire Scenario

Percent of BWCAW



- Unoccupied Forest
- Jack Pine
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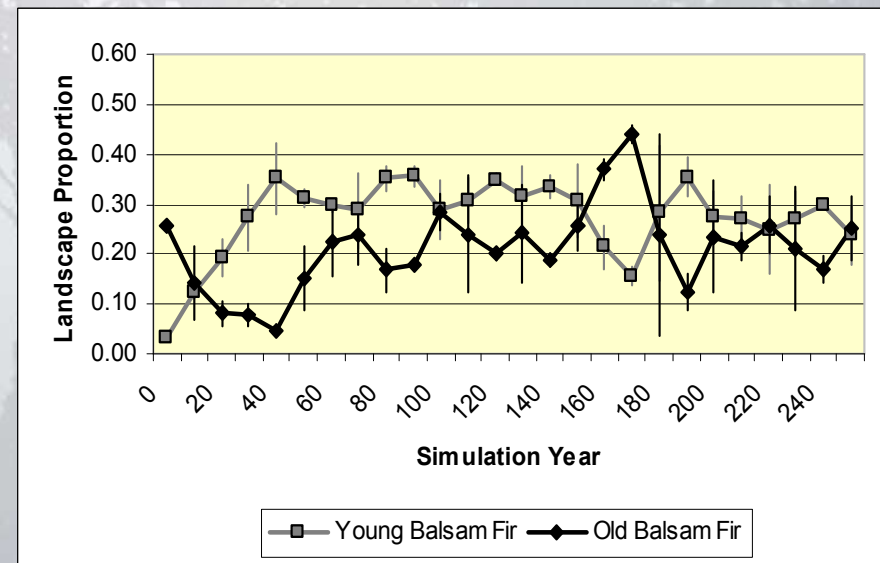
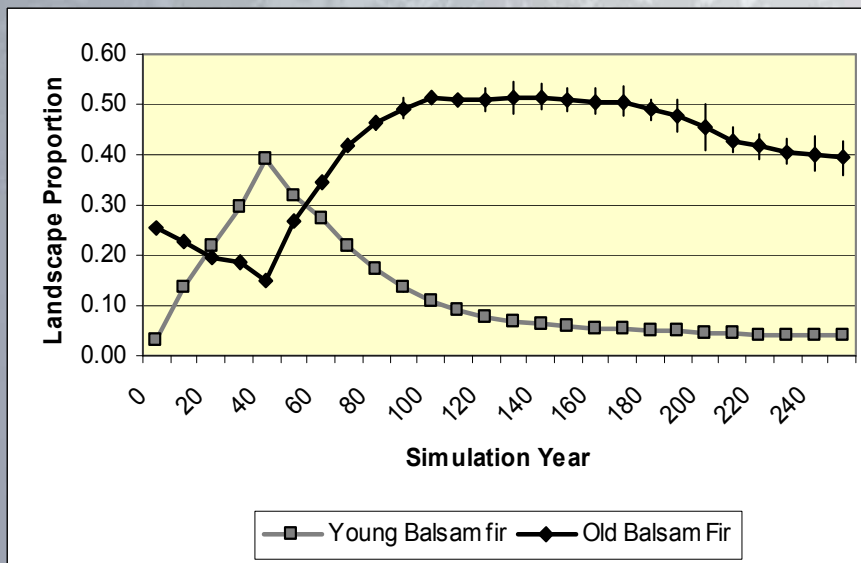
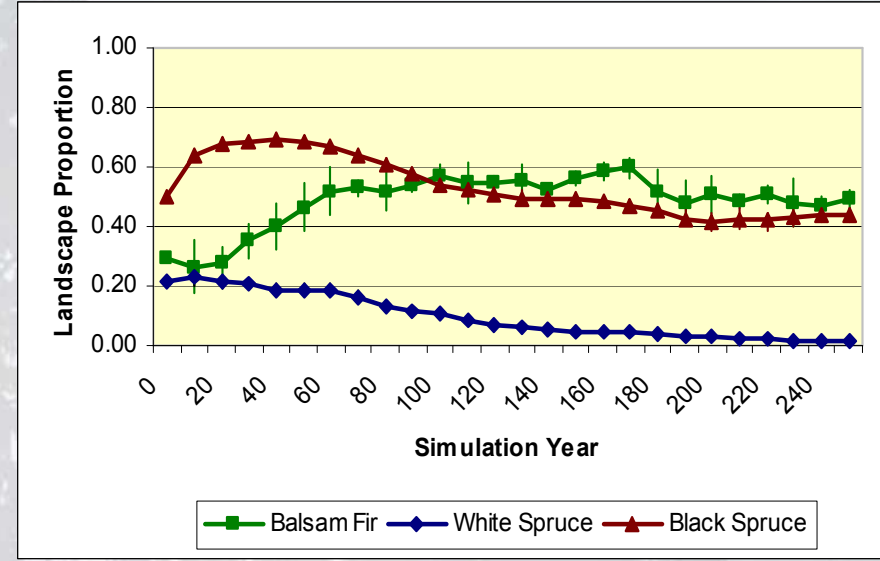
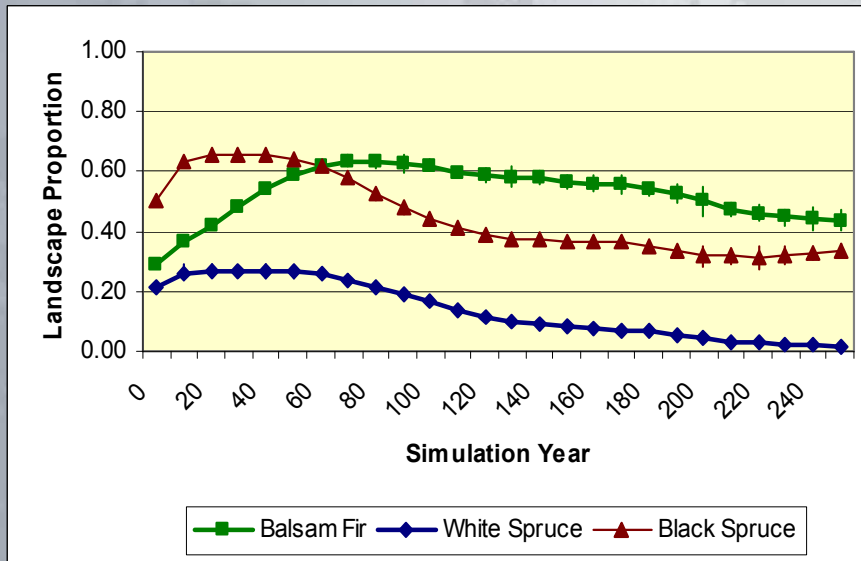
Simulation Year



# Host Response

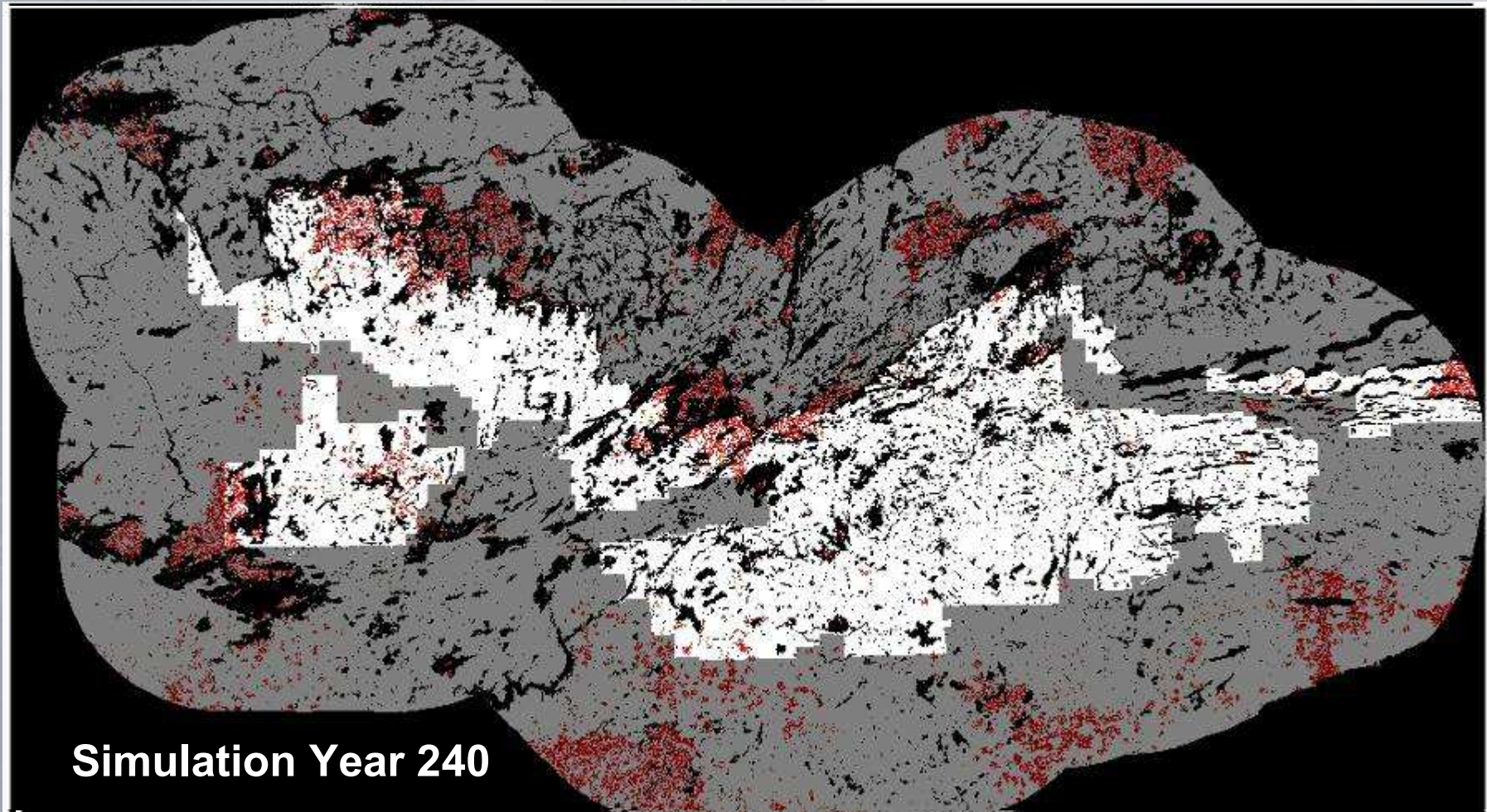
## Fire Only Scenario

## Spruce Budworm & Fire Scenario



# Spruce Budworm Disturbance

## *Presettlement Scenario*



**Simulation Year 240**

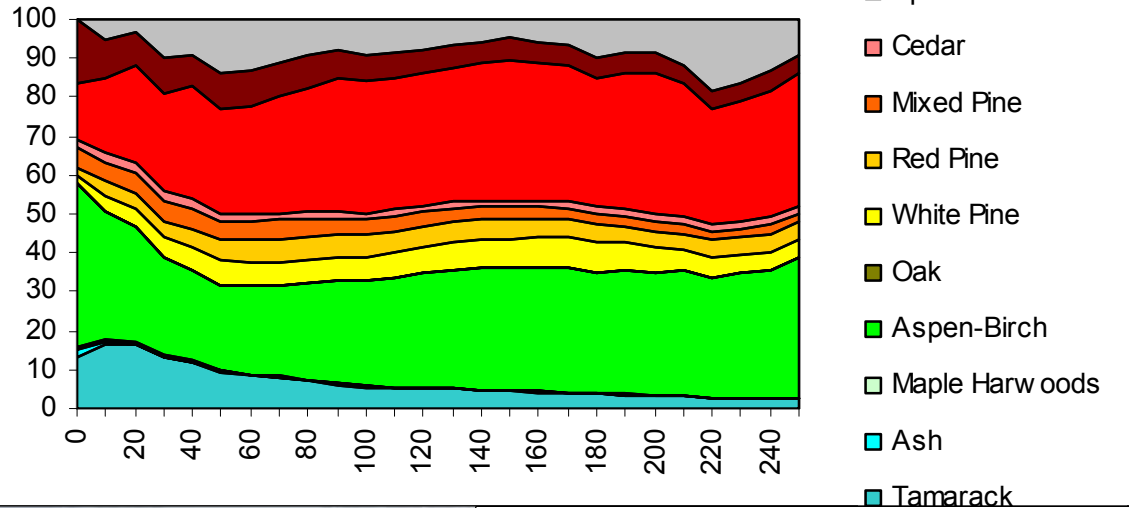


# Vegetation Trends

## *Presettlement Scenario*

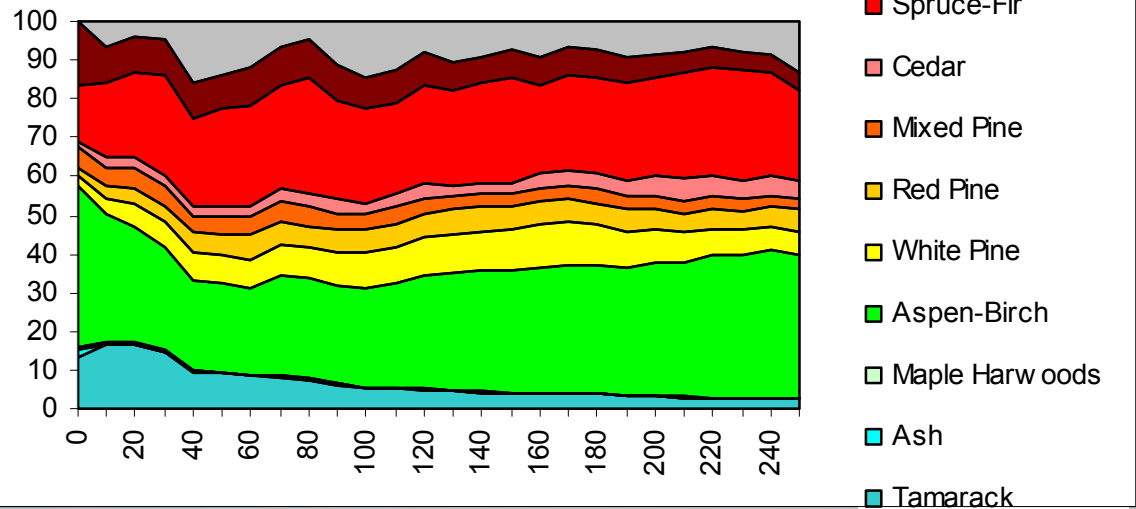
Percent of BWCAW

### Fire Only Scenario



### Spruce Budworm & Fire Scenario

Percent of BWCAW

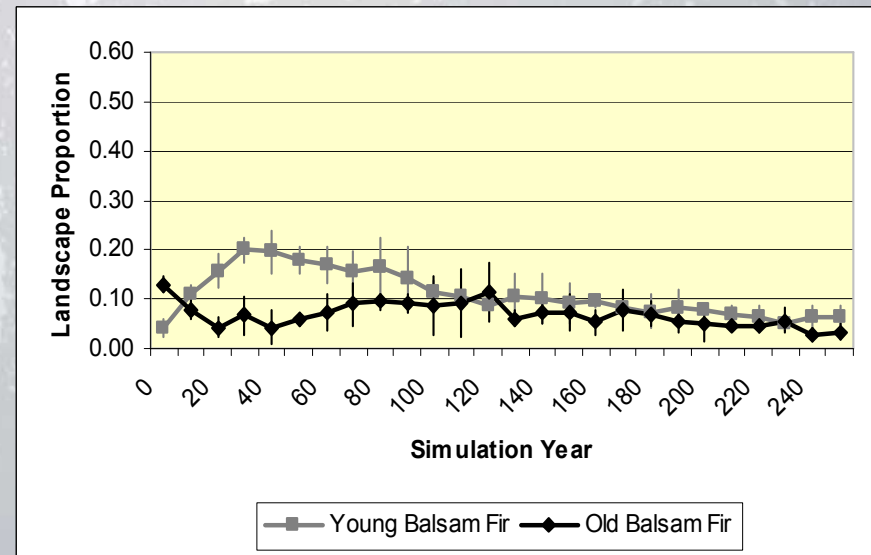
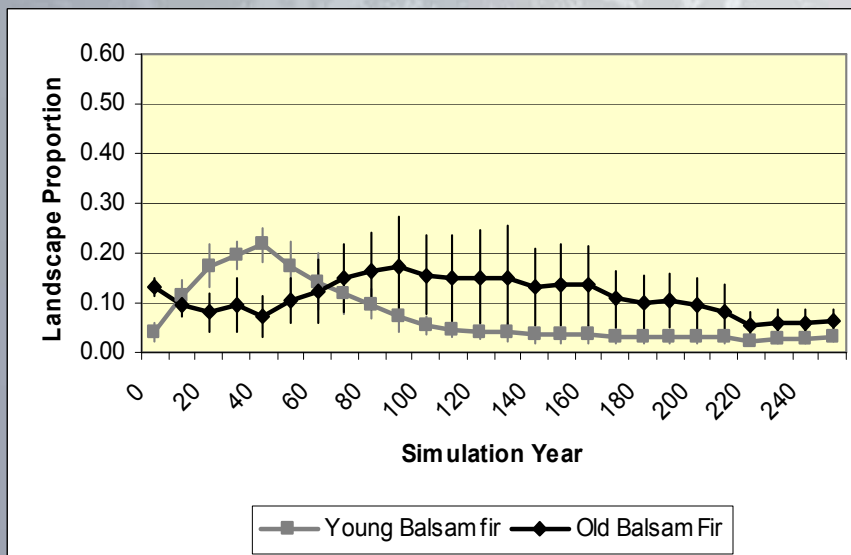
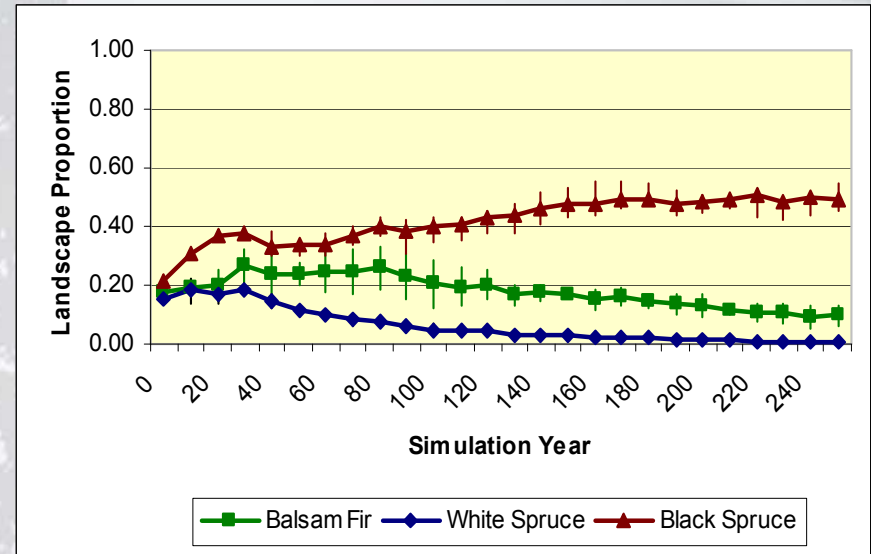
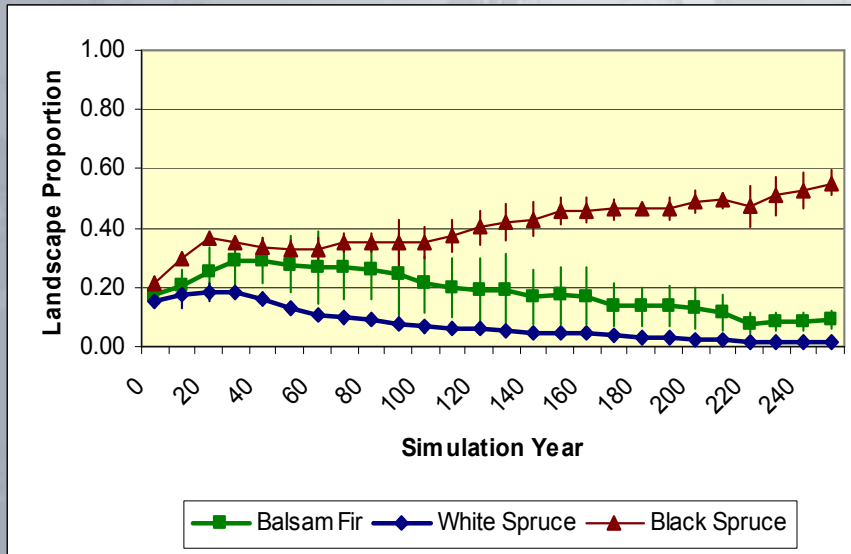


Simulation Year

# Host Response - *Presettlement Scenarios*

## Fire Only Scenario

## Spruce Budworm & Fire Scenario

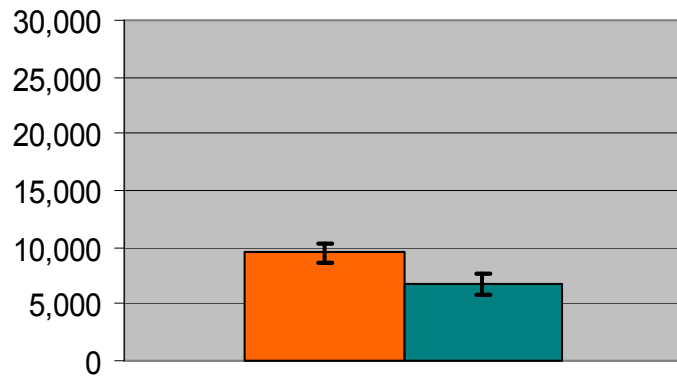


# Budworm Influence on Fire

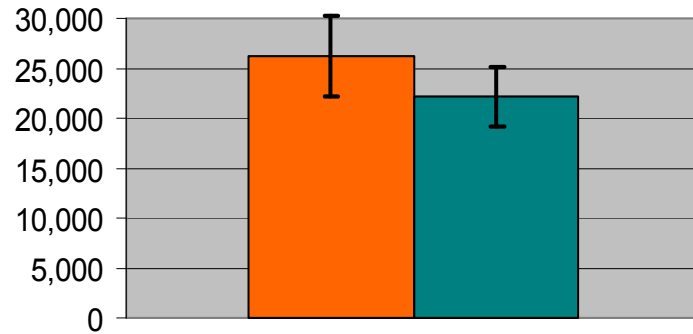
## Modern

## Presettlement

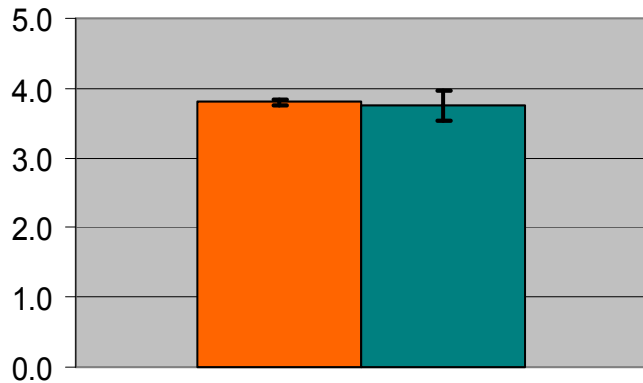
Mean Area (ha) Burned / Decade



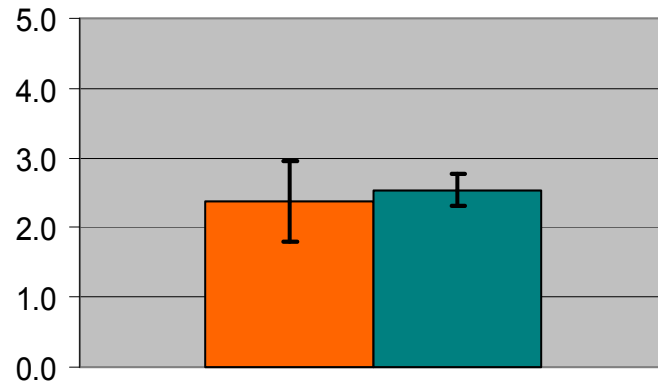
Mean Area (ha) Burned / Decade



Mean Fire Severity



Mean Fire Severity



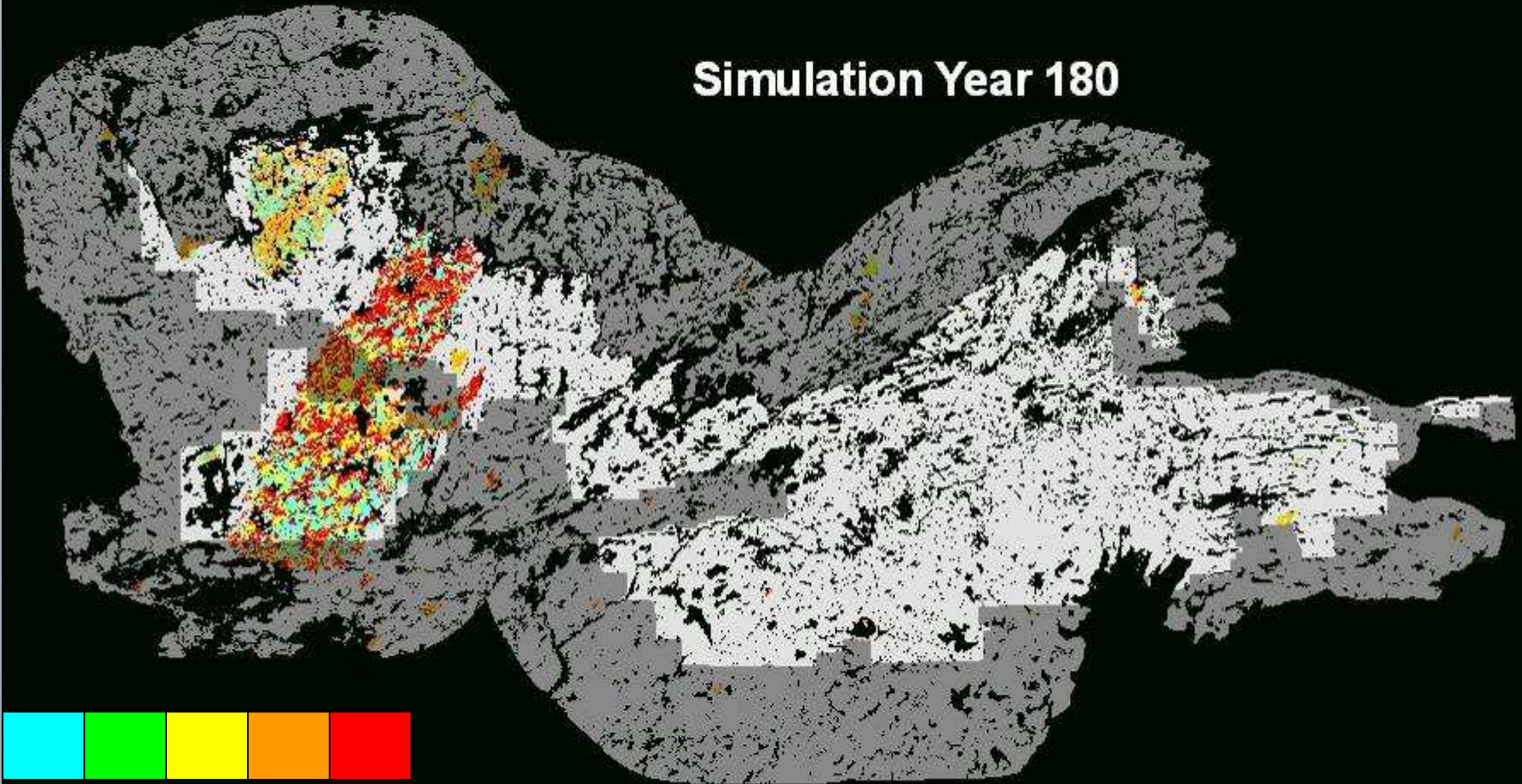
**Fire Only**

**Fire &  
Budworm**

# Fire Disturbance

1000  
1000  
1000

Simulation Year 180



Severity





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OFFENDING COMMAND: image

STACK: