

# Developing parameters to simulate trees with SWAT





# Integrating the ALMANAC model, adapted for Canadian forests, with SWAT

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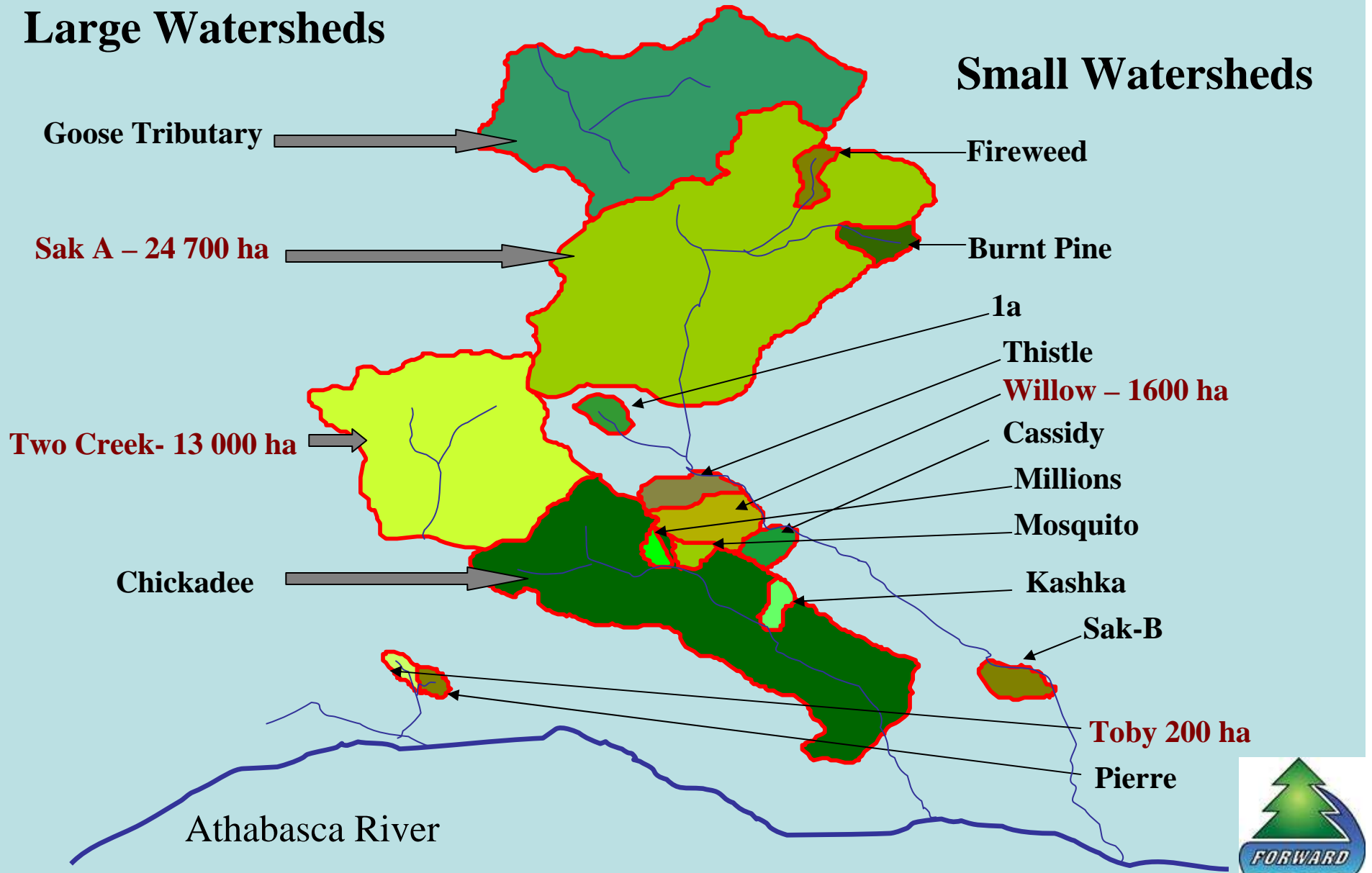
# **ALMANAC/SWAT**

- **Watershed scale models such as SWAT can be adapted for forest management.**
- **SWAT is being evaluated for its ability to simulate impacts of forest harvest patterns on streamflow and water quality on the Boreal Plain, in Alberta, Canada.**

# The FORWARD Modelling Program

## Large Watersheds

## Small Watersheds



# ALMANAC/SWAT

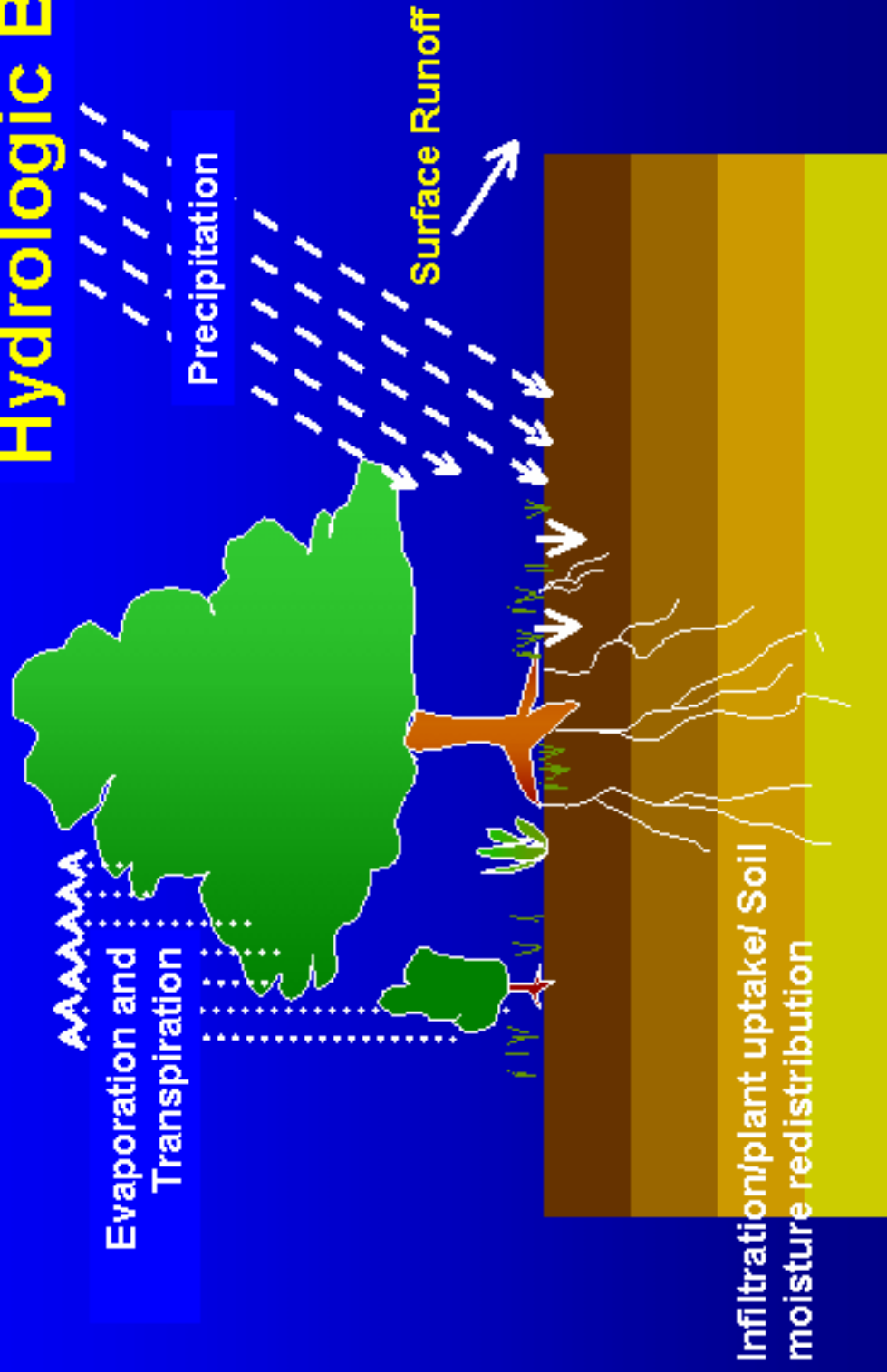
- Forests are diverse mixtures of species.
- After forest disturbance sites are invaded by herbaceous vegetation that strongly competes with crop trees.
- This application requires a detailed description of forest growth dynamics.
- We modified ALMANAC (ALMANAC<sub>BF</sub>) to simulate forest growth on the Boreal Plain.
- We have modified SWAT to use data simulated by a more complete growth model, ALMANAC.

# **General Description of Original ALMANAC Model**

- **Simulates plant growth through leaf area, light interception, biomass production and stress simulation**
- **Water balance, nutrient cycling, and temperature responses**
- **Can simulate competition among species**

# ALMANAC

# Hydrologic Balance



# ALMANAC Model

- **Uses commonly available soil inputs, with soil characteristics varying with soil depth**
- **Uses daily maximum and minimum temperature, solar radiation, and rainfall**
- **Field Scale, daily time step**



## Processes described

**Light interception description using Beer's Law, with LAI and  $k$ .**

**Radiation use efficiency.**

# ALMANAC<sub>BF</sub>/SWAT

Developed parameters for:

- Lodgepole pine (*Pinus contorta*)
- White spruce (*Picea glauca* )
- Black spruce (*Picea mariana*),
- Trembling aspen (*Populus tremuloides*)
- Generic low and high woody shrubs,
- Grasses (*Calamagrostis canadensis*) and generic forbs

# ALMANAC<sub>BF</sub>/SWAT

Forest disturbance and regrowth is simulated by passing data between the two models. This hybrid model will simulate the impact of forestry practices on watershed hydrology and water quality

Incorporated the forest stand into the model by estimating the number of stems per hectare and made this number vary based on site index and the age of the stand.

The Alberta Forest Inventory contained values for number of species per hectare for three different site classes.

Uses stem number and allometric equations to calculate:

- Diameter Breast Height (DBH)
- Foliar biomass
- Annual stem mortality.
- Stem/foilage relationships, which modifies leaf area index (LAI) for different stand densities.

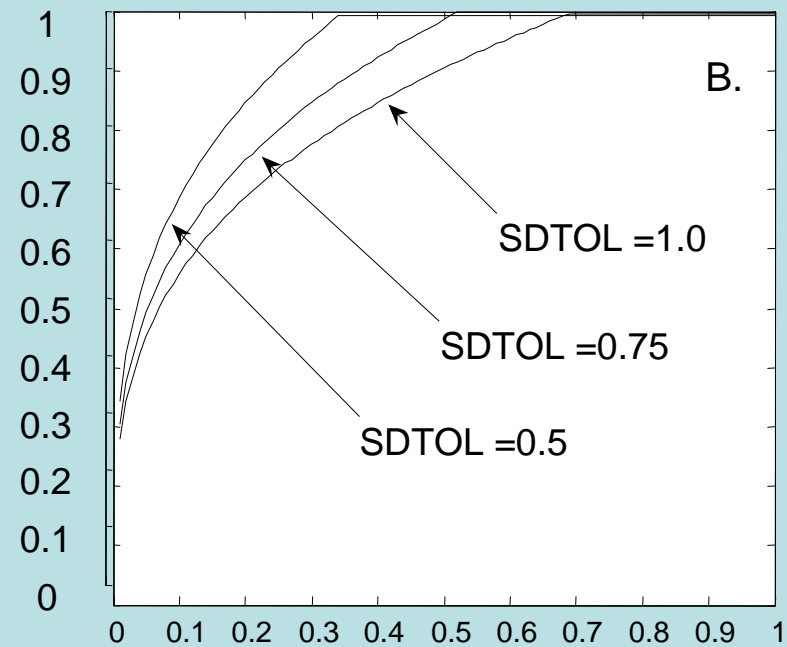
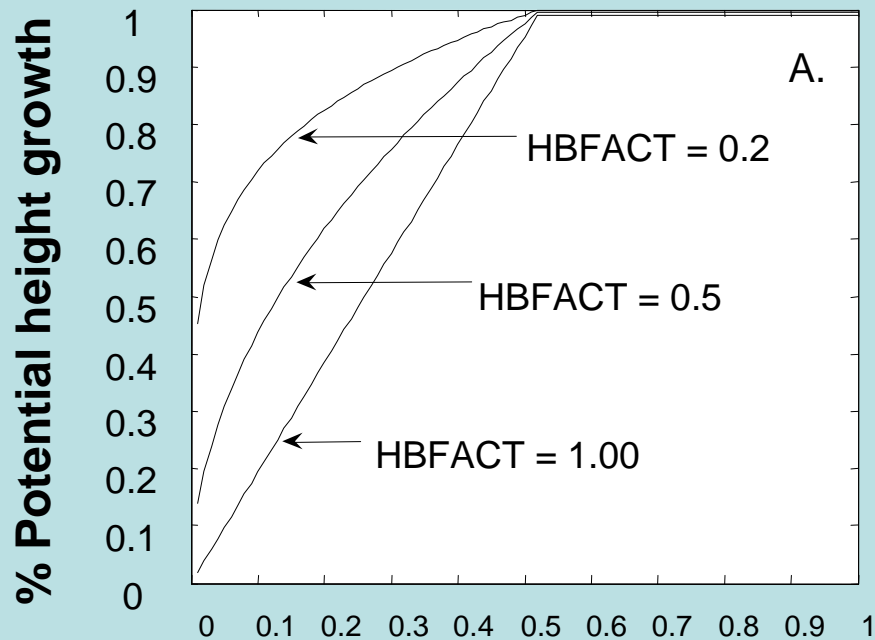


# Simulation of tree growth against calibration data set.

The challenge in simulating tree growth was the ability to proceed through initial stand conditions of shrub and grass cover, and then differentiate growth rates once the trees out-compete lower vegetation layers (for example, simulate Aspen/White Spruce competition after shrubs and grasses have been cleared).

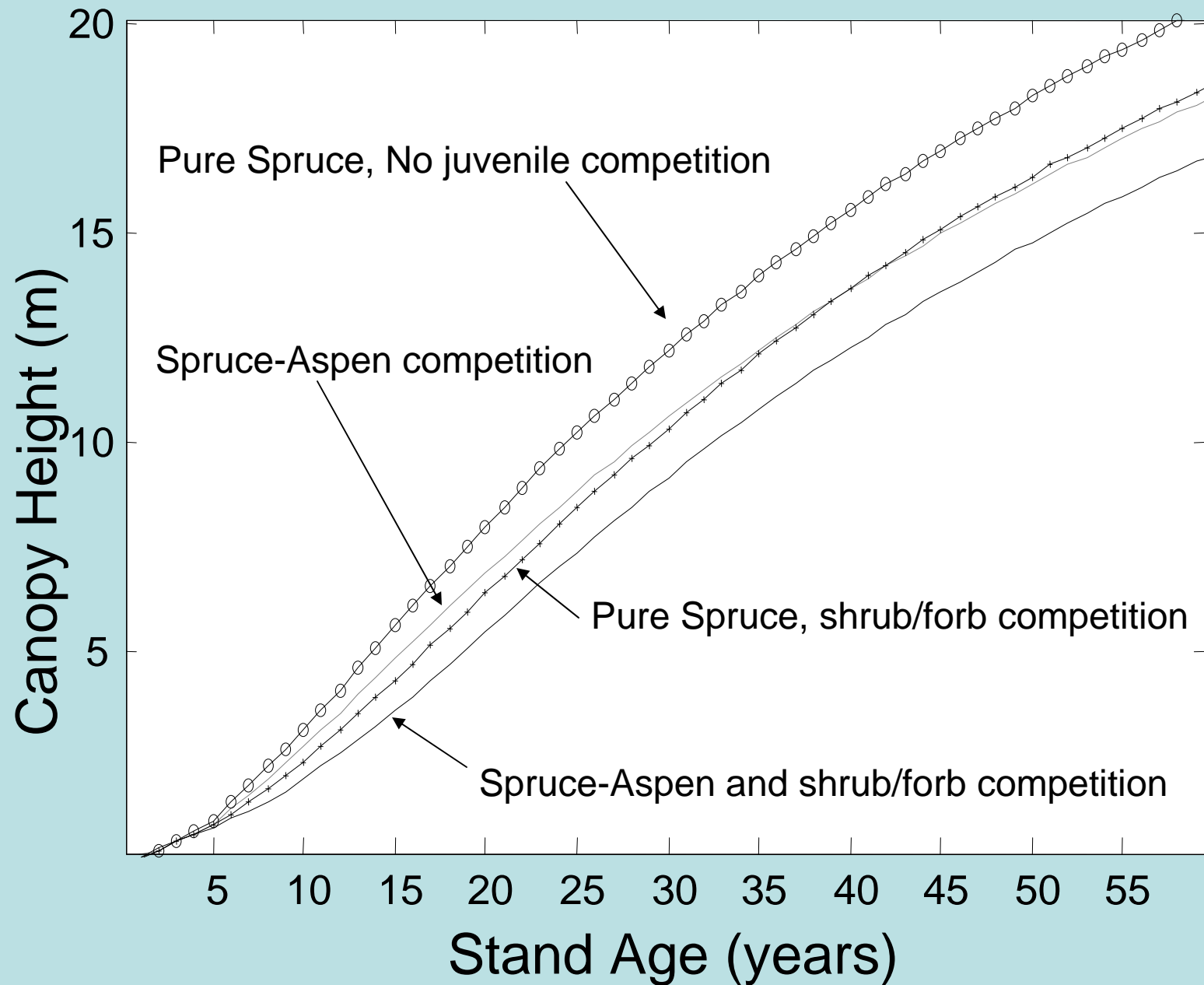
# Height Competition Equation

$$HTINCR_{A(n)} = HTINCR_{P(n)} * \left( \frac{HTMOD_{(n)}}{HTMOD_{MAX} * SDTOL_{(n)}} \right)^{HBFACT_{(n)}}$$

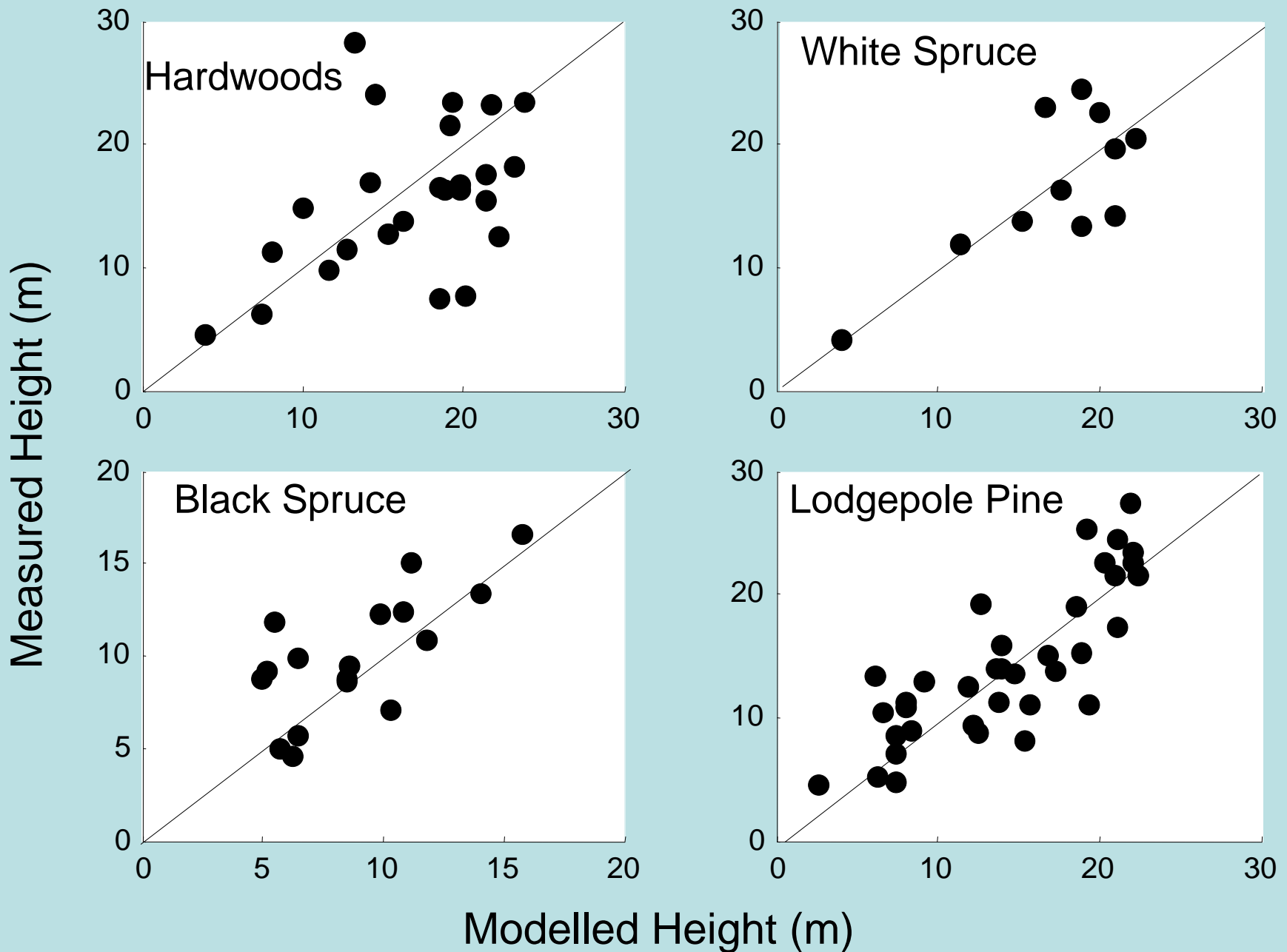


HTMOD<sub>n</sub> / HTMOD<sub>MAX</sub>

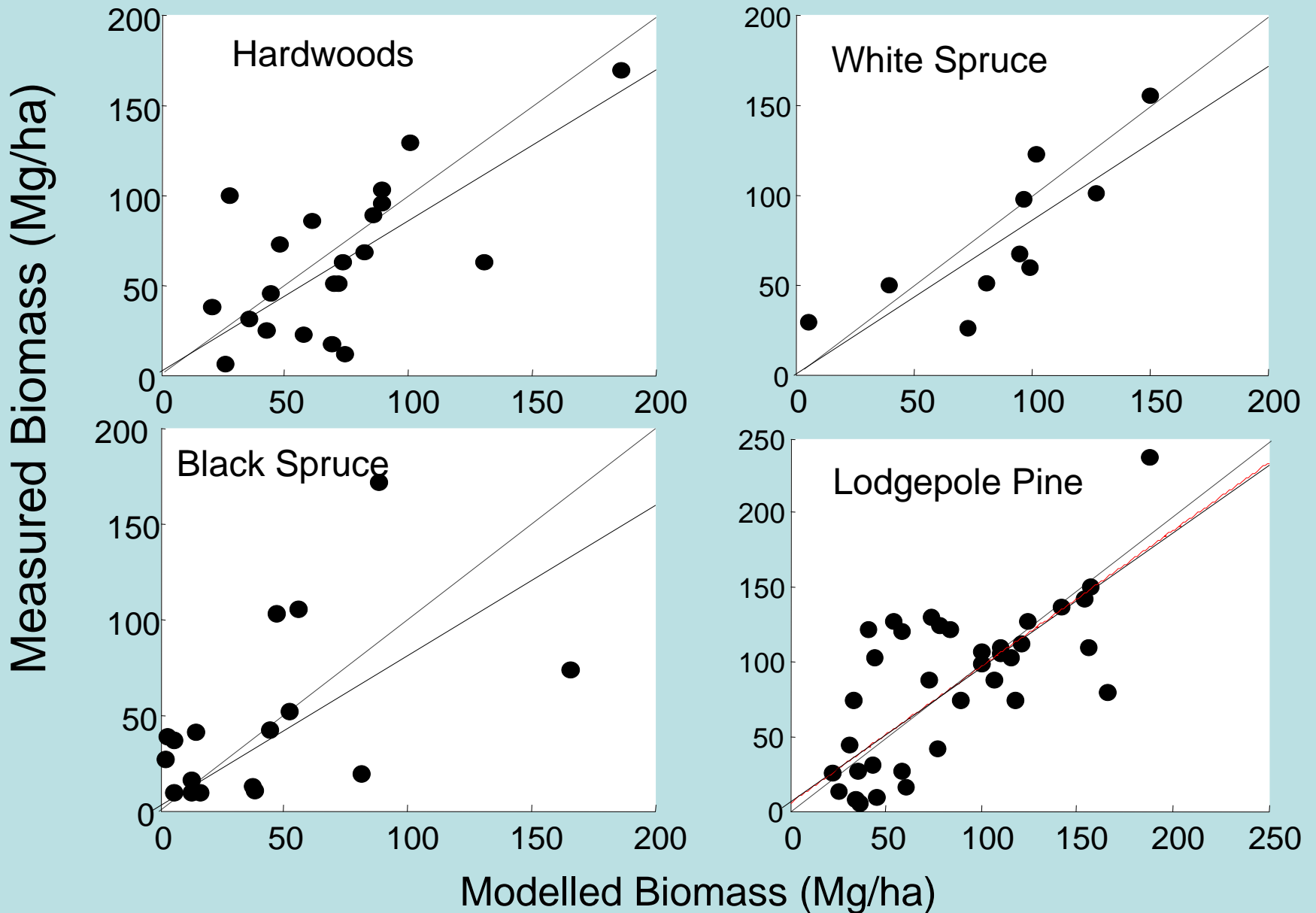
# Simulating Spruce/Aspen/Low Vegetation Competition



# Simulation of tree height against calibration data set.

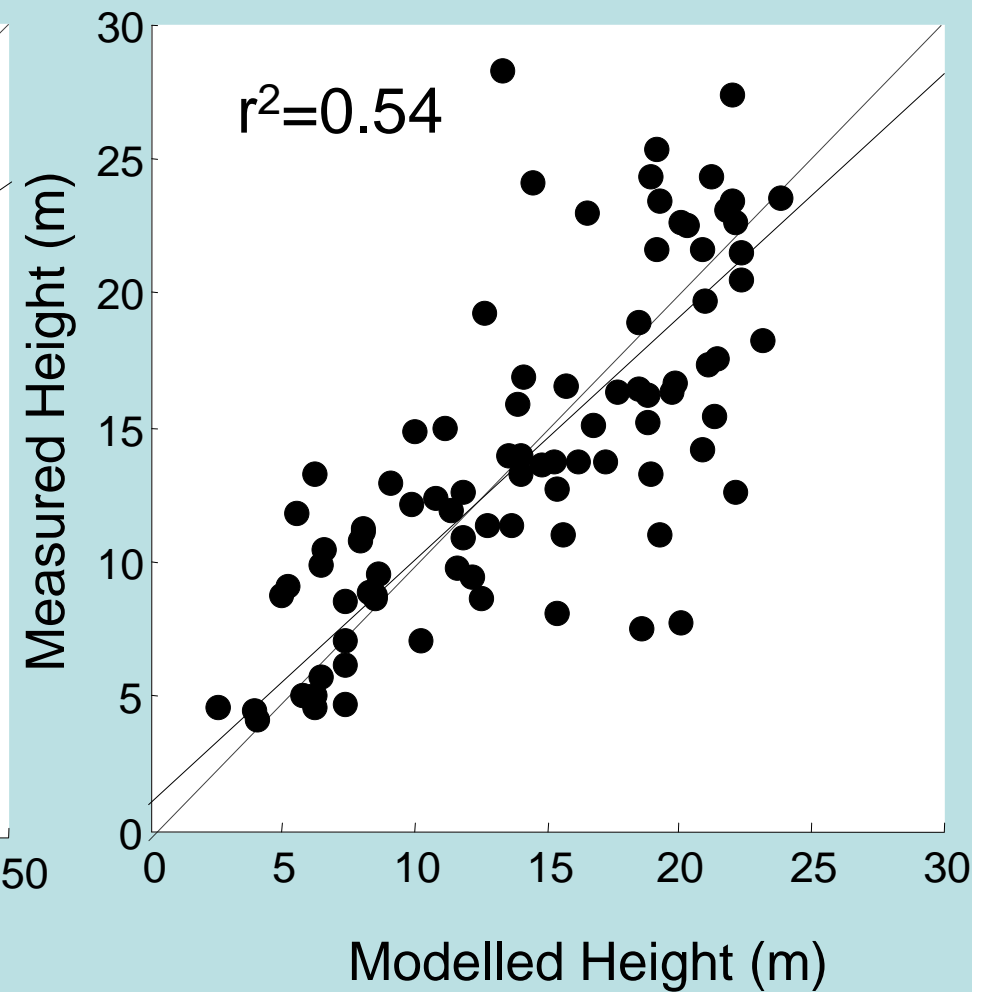
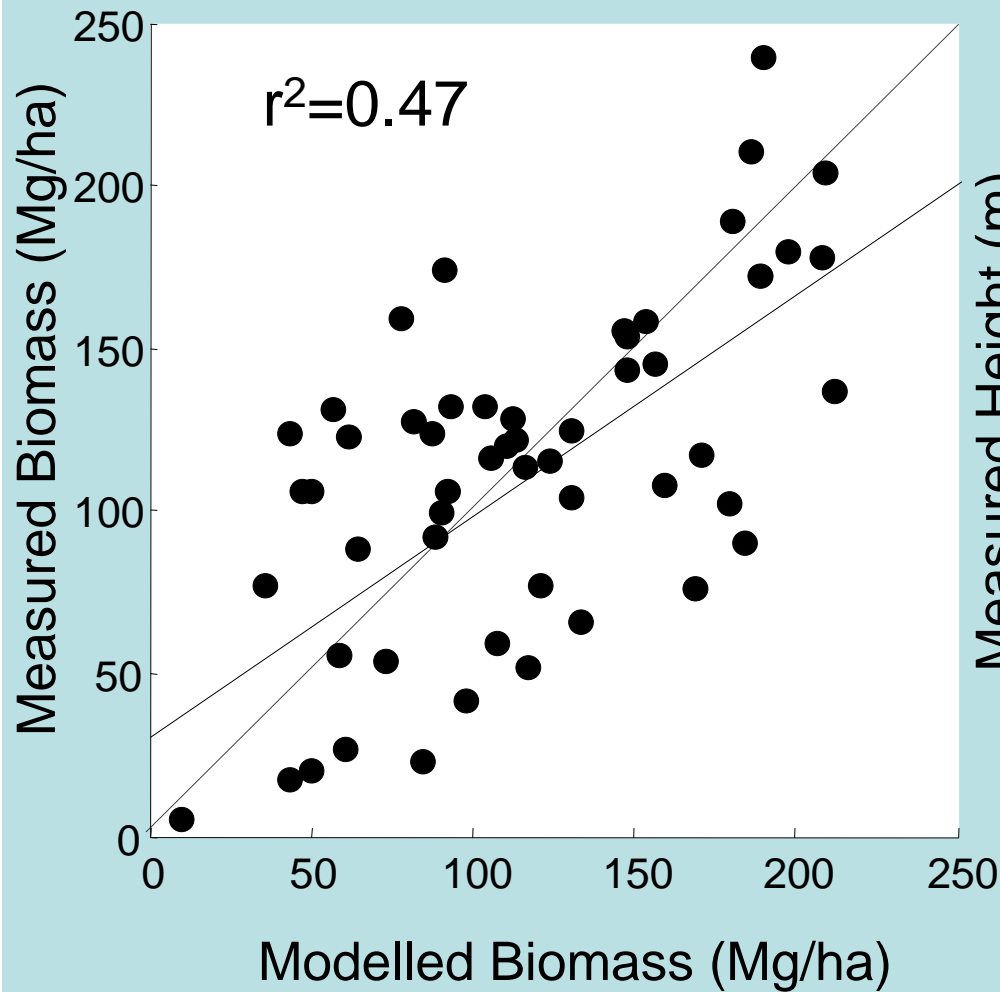


# Simulation of tree biomass against calibration data set.

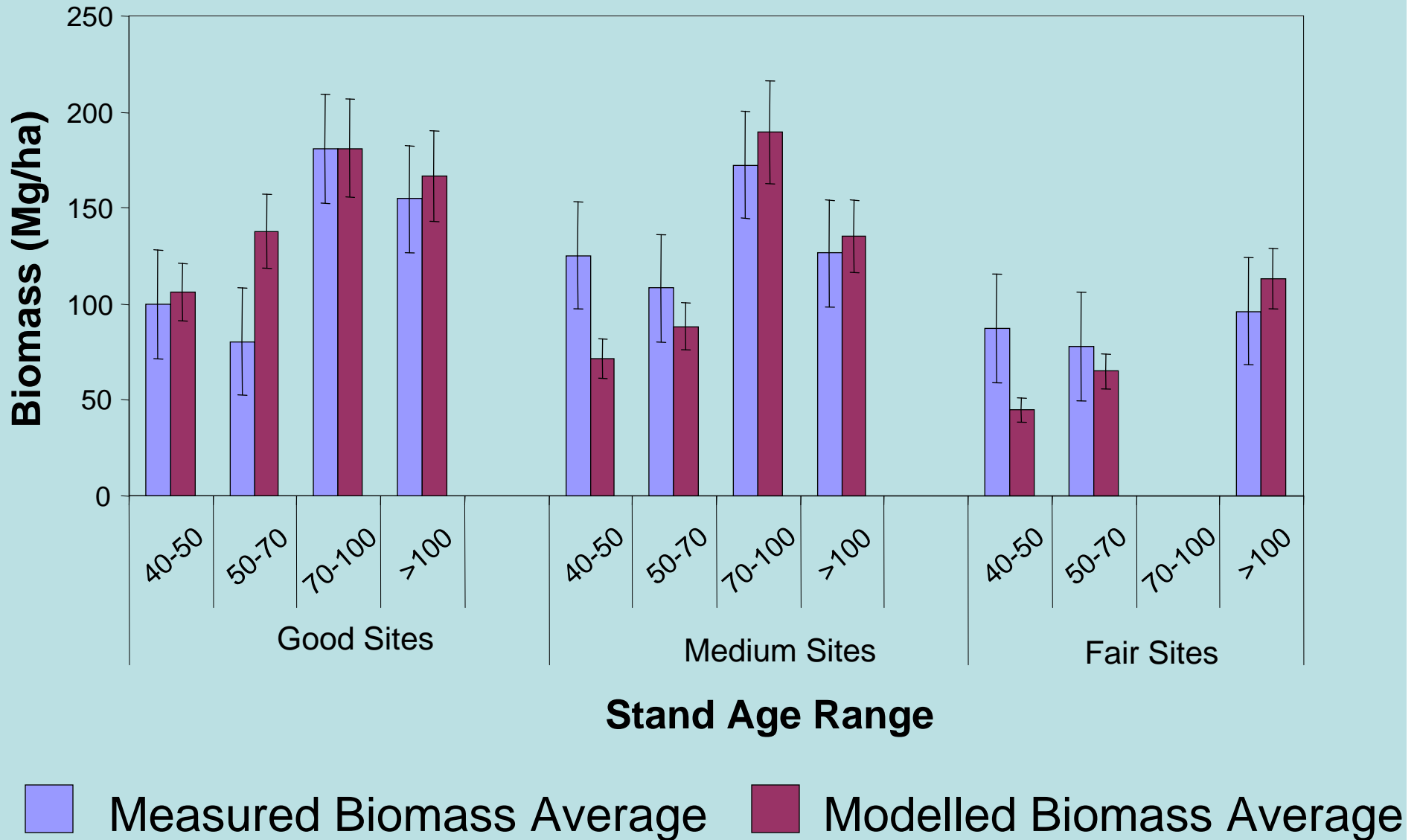




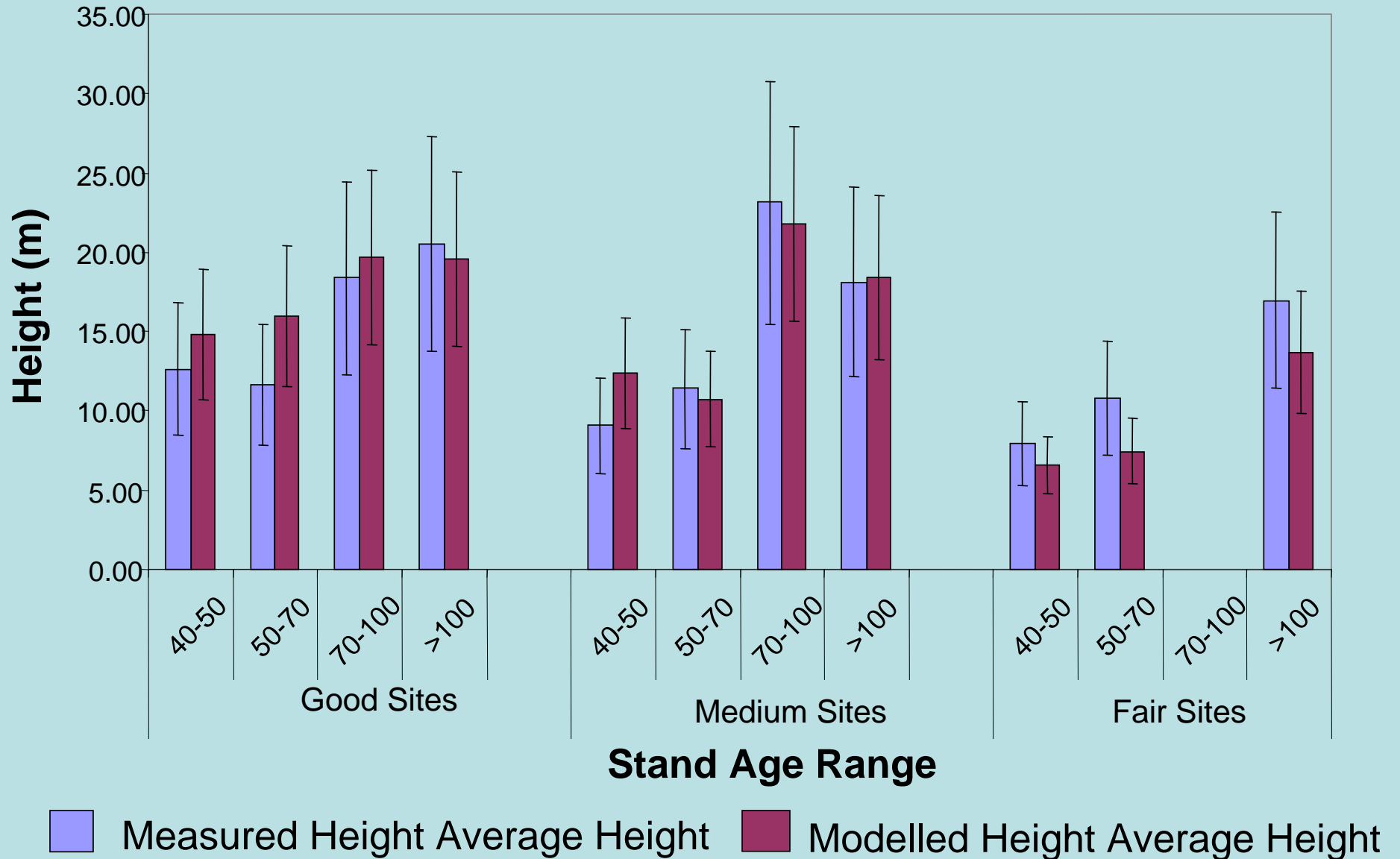
# Simulation of tree growth against calibration data set.



# Averaged measured data vs. simulation Results



# Averaged measured data vs. simulation results.



ALMANAC<sub>BF</sub> simulated the variability in height and biomass observed in an area of the Boreal Plain of Northern Alberta, Canada.

ALMANAC<sub>BF</sub> is an improvement over the existing crop model in SWAT.

Work will begin on the SWAT/ALMANAC<sub>BF</sub> interface and simulation of harvest impacts on water discharge from forested watersheds on the Boreal Plain.

# **SWAT/ALMANAC<sub>BF</sub> Interface**

**Each HRU is simulated individually by  
ALMANAC**

**Doug can batch run ALMANAC, process  
and save data.**



## Planned Improvements in ALMANAC<sub>BF</sub>

- ❑ Improve estimates of basal area and stem return calculations (stem number calculations).
- ❑ Improve simulations of Black Spruce growth in wetlands.

# Upcoming Work on ALMANAC<sub>BF</sub>

- Verify the parameters we've developed for ALMANAC against an independent data set from Millar Western's PSP data.
- Validate plant parameters for forbs, grasses and woody shrubs to improve simulations of evapotranspiration on sites for the 20-year period following harvest activity.
- Addition of subroutines simulating silvicultural practices such as herbicide application and stand thinning.
- Sensitivity analyses to explore the importance of species composition and age class on evapotranspiration estimates for forest stands.

# Upcoming Work on SWAT/ALMANAC<sub>BF</sub> Interface.

- Creation of a program that organizes data at the watershed scale for ALMANAC<sub>BF</sub>.
- Verifying that the soil water balance equations are providing similar estimates of soil water content and water stress on plants on a daily basis.
- Development of modelling scenarios to predict harvest impacts on hydrology in the FORWARD study watersheds.

# Summary

We developed parameters for white spruce, black spruce, lodgepole pine, and trembling aspen

# Summary

**ALMANAC<sub>BF</sub>** reasonably simulated light competition, variations in tree density, tree height, and biomass in Canada.

# Summary

ALMANAC<sub>BF</sub>/SWAT can simulate Forest disturbance and regrowth by passing data between the two models.

This hybrid model will simulate the impact of forestry practices on watershed hydrology and water quality



# HTMOD calculation

- An equation that relates reductions in the RATIO of intercepted PAR to reductions in height growth.
- Equation is normalized for the percent occupancy of the canopy of a species.
- First select the dominant shading species that receives the greatest amount of PAR and whose height growth is not limited by other species occupying the canopy (HTMODMAX)



- Height growth of other species is reduced relative to the species that dominates the canopy identified as HTMODMAX

- As HBF<sub>ACT</sub>(n) increases species “n” will invest less biomass in height growth and more in diameter growth