Predicting dynamics of eastern white pine (*Pinus strobus* L.) advance regeneration under shelterwood silviculture

Theme #: 3
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The synthesis of height growth and canopy openness predictions in this study allows for scientific estimation of the time required to grow saplings to 6 meters (one log) in height, based on overstory density. Thus rather than managing shelterwoods based on common sense, as is frequently practiced today, foresters can see the implications of leaving increased overstory density on the landscape now, and make informed decisions ahead of time.

Funding support for this project was provided by the Northeastern States Research Cooperative (NSRC), a partnership of Northern Forest states (New Hampshire, Vermont, Maine, and New York), in coordination with the U.S. Forest Service (http://www.nsrcforest.org), and by the Maine Agriculture and Forestry Experiment Station.

Project Summary

Despite the commercial importance, and abundant harvest, of eastern white pine (*Pinus strobus* L.) in Maine – and throughout New England – there has been little research investigating natural sapling dynamics of the species since Frothingham published height growth data in 1914. Given the prevalence of regeneration across Maine, it is beneficial for forest managers to possess the tools to properly harness the regenerative capability of their forests. For white pine, successful management is accomplished through shelterwood silviculture.

Results from this study are of considerable use to forest managers, whether the managers assume a hands-on approach through intense data collection, or a purely statistical approach, with growth and yield software and prior data. The synthesis of height growth and canopy openness predictions allows for perception of the time required to grow saplings to 6 meters (one log) in height, based on overstory density. Thus rather than managing shelterwoods based on "common sense and intuition," foresters can see the implications of leaving increased overstory density on the landscape now, and make informed decisions ahead of time.

Following model development, the study evaluated the small tree height growth model of the Forest Vegetation Simulator: Northeast Variant (FVS-NE), seeking to offer improved modeling capabilities to users of the software managing for white pine. The model, which has been found to be biased despite multiple revisions, is deemed fit for use from Maine to West Virginia, despite large differences within species' growth capabilities across this geographic range. This study's results signify drastic under prediction of height growth when growth exceeds one foot per year, despite a detailed and lengthy dataset. Therefore, the study recommends adoption of an alternate model form, rather than simple model calibration. Development of a Maine-specific variant of FVS is underway, presenting an opportunity for such a system overhaul.

Background and Justification

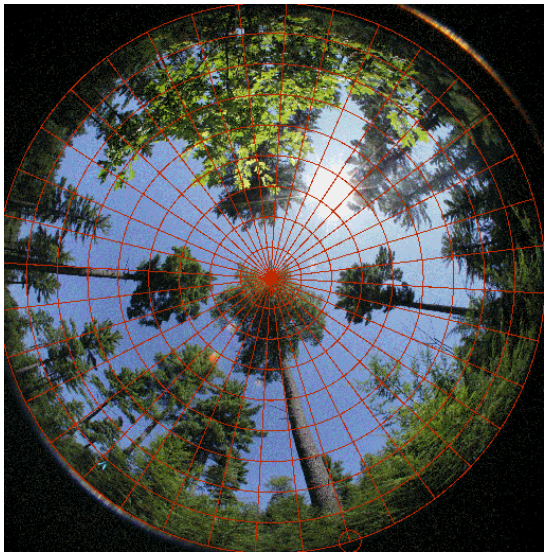
- Eastern white pine is common throughout the Northeast, and has long been a significant species
- While white pine weevil is an issue in more open stands, canopies with 50 to 75% openness can allow successful sapling growth with tolerable damage (Stiell and Berry 1985)
- 1978 white pine silvicultural guide for the Northeast used 1914 sapling height data – little added research since then

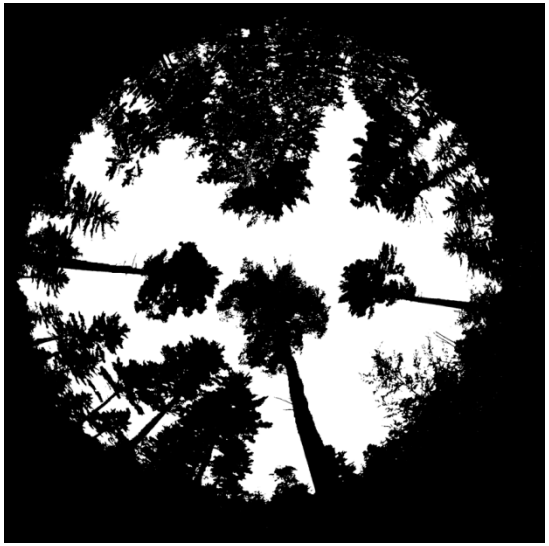
Background and Justification

- Shelterwood silviculture: information lacking on growth under various overwood densities, timing of overstory removals
- Can we provide managers with simple recommendations for applying shelterwood systems to regenerate white pine?

Methods: Sampling Stages

This study established plots in 9 white pine stands in central Maine





First Stage *(June/July 2010)*

- Total Height, Height Growth
- Diameter
- Estimated Age
- Damage, Severity

Second Stage *(Aug-Oct 2010)*

- Competitive Sapling Counts
- Understory Vegetative Cover
- Fisheye Photographs

Third Stage *(Dec 2010-May 2011)*

- Overstory Measurements (2 m^2/ha)

Methods: Analysis

Image analysis using GLA to calculate:

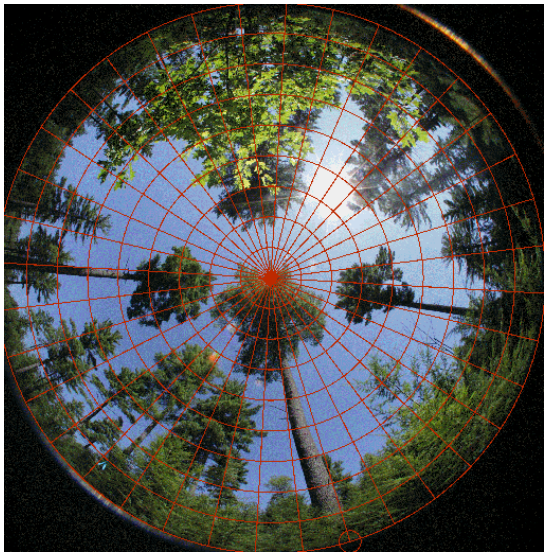
- Canopy Openness
- Gap Fraction

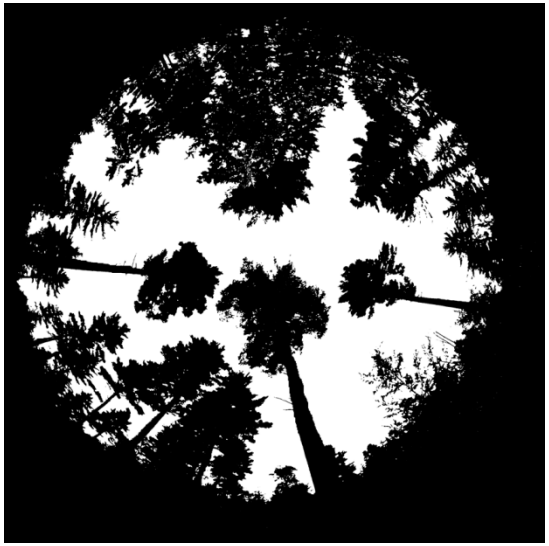
Mixed-effects models investigated to predict:

- Sapling height growth
- Canopy Openness
- Synthesis: Years to grow to 1 log in height

Sapling height growth simulated in the Forest Vegetation Simulator

- Compare to measured sapling dynamics

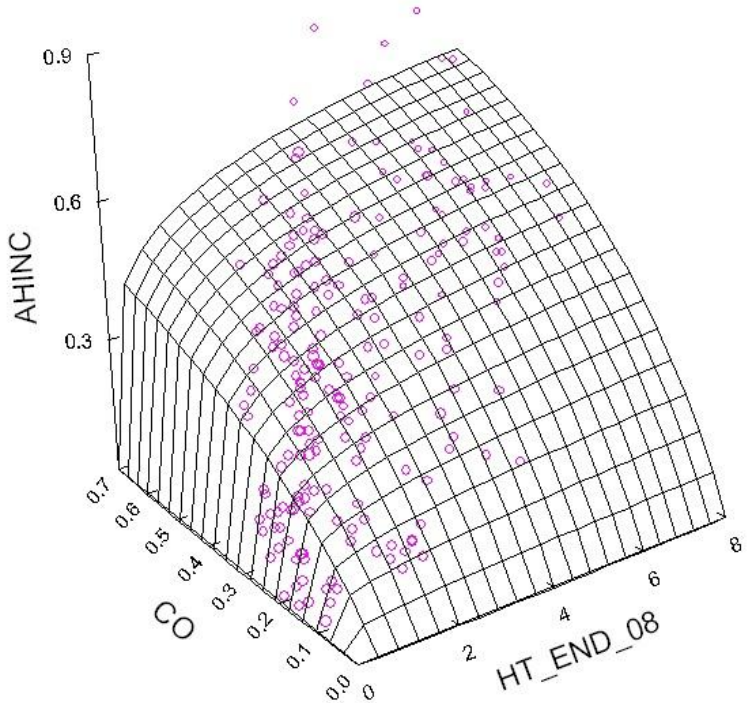


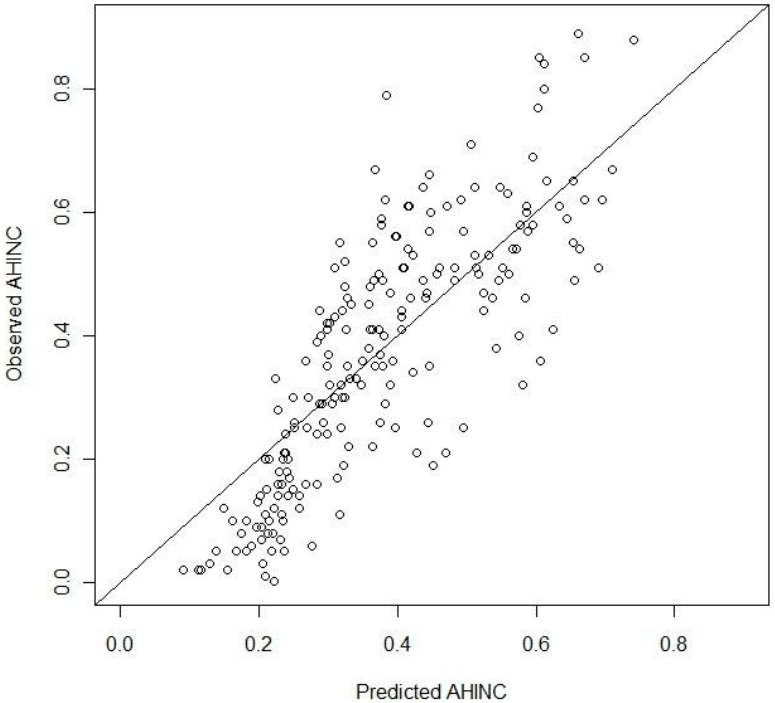


Results: Model Predictions

Predicting Height Growth

- As canopy openness increases, average height growth increases, tailing off near the upper limit of canopy openness. Height growth increases slightly with sapling height at the lower limit of canopy openness; as both canopy openness and sapling height increase, sapling height growth increment increases more steeply
- No models were found that did not over predict height growth at 0 – 0.2 m

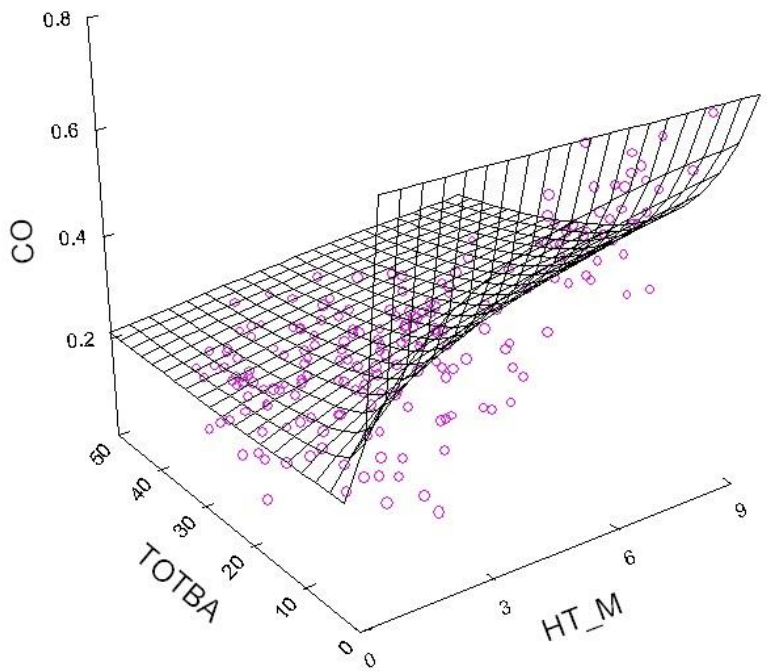


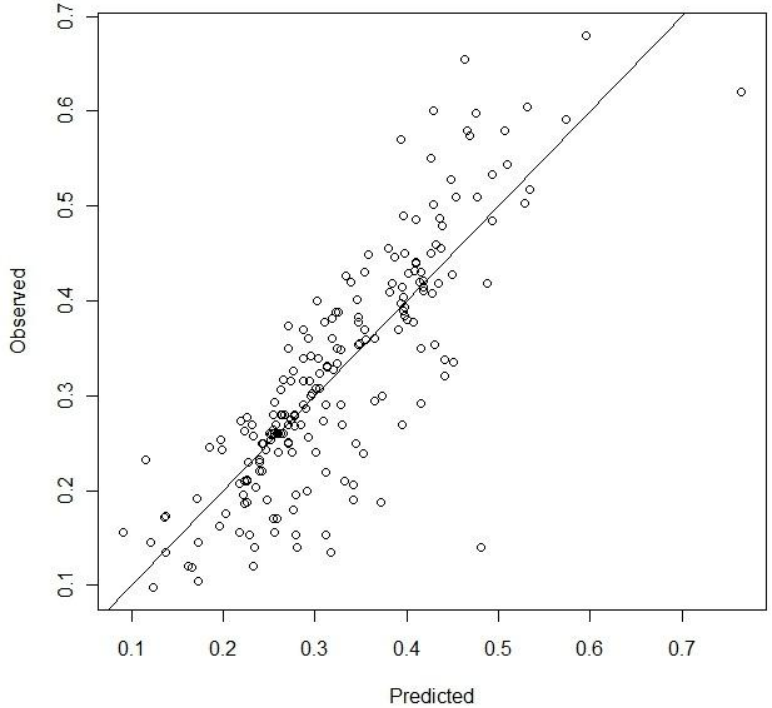


Results: Model Predictions

Predicting Canopy Openness

- Taller saplings and low basal area predict high levels of canopy openness
- Increasing basal area quickly reduces the prediction in canopy openness
- As evidenced, sapling height has a less drastic effect on canopy openness predictions than basal area does.

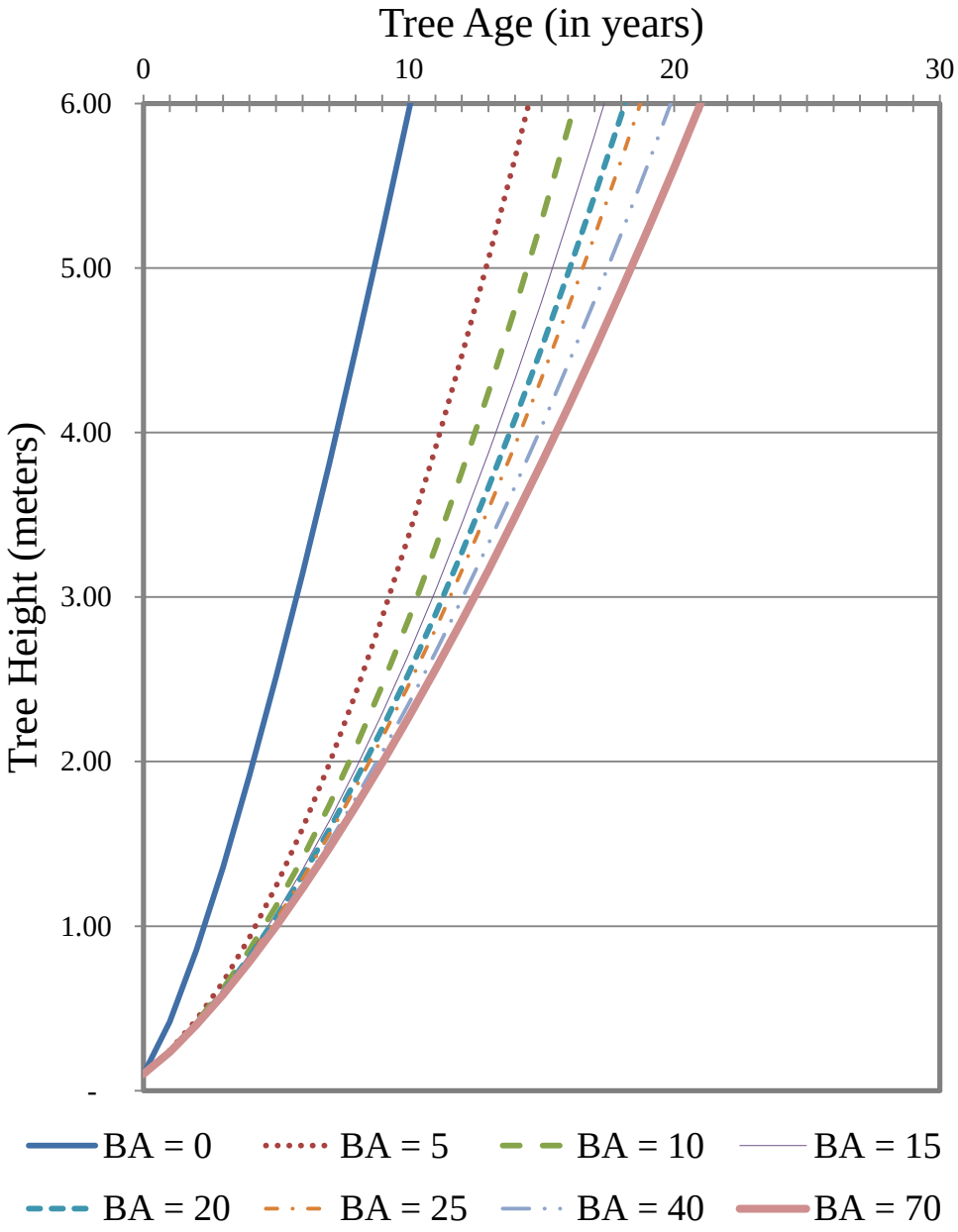




Results: Model Predictions

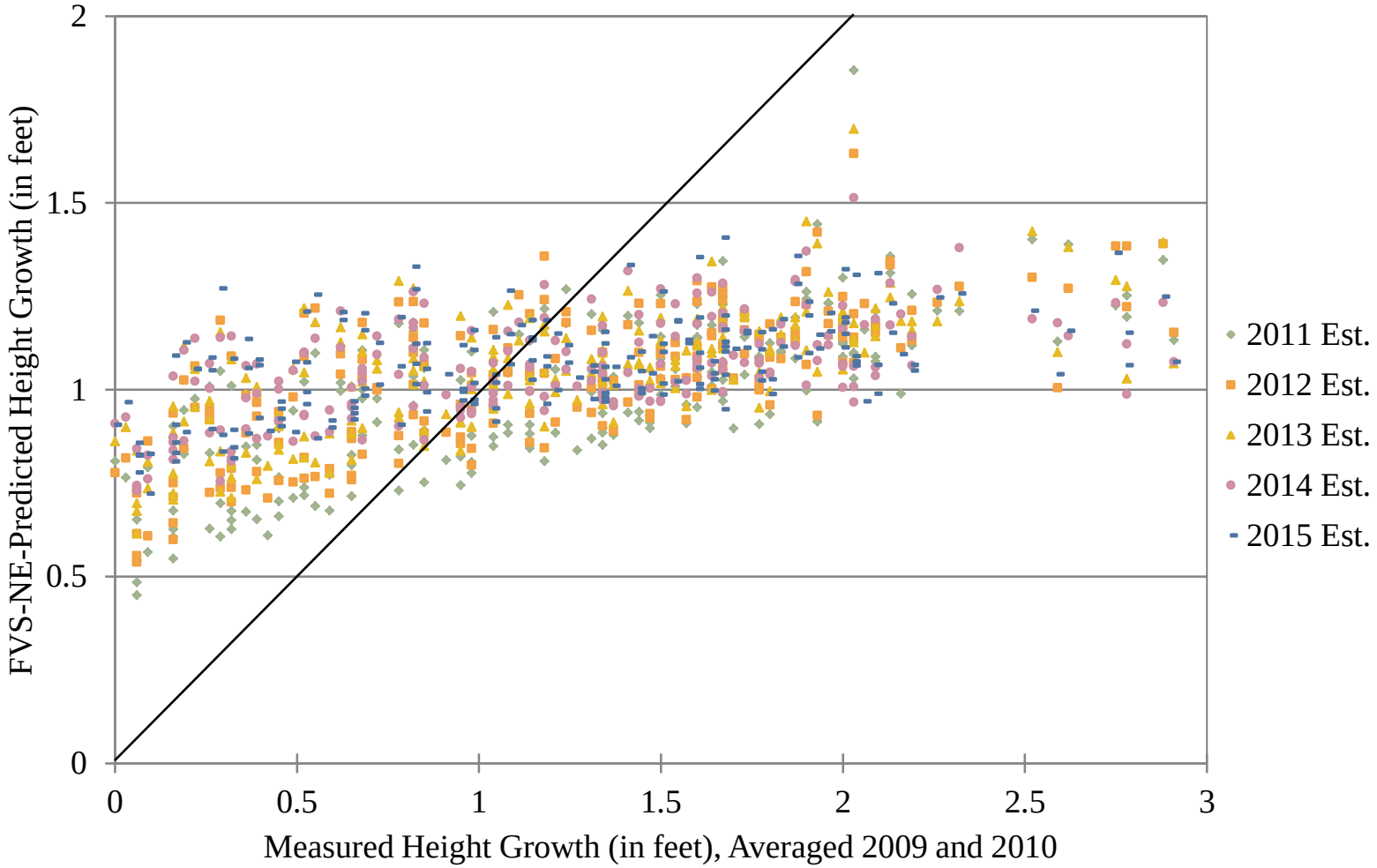
Solving the previous two models' equations recursively produces the figure at right

- Time to grow one log, dependent on overstory basal area
- If management objectives require that legacy trees (higher basal area) be left in the overstory, it may be important to know the implications of leaving such trees on the landscape
    - It takes nearly twice as many years to reach one log with an overstory basal area of 30 to 70 m^2/ha as it does with no overstory



Results: FVS Predictions

FVS-NE consistently predicts height growth ~ 1 foot, across a range of height growth conditions

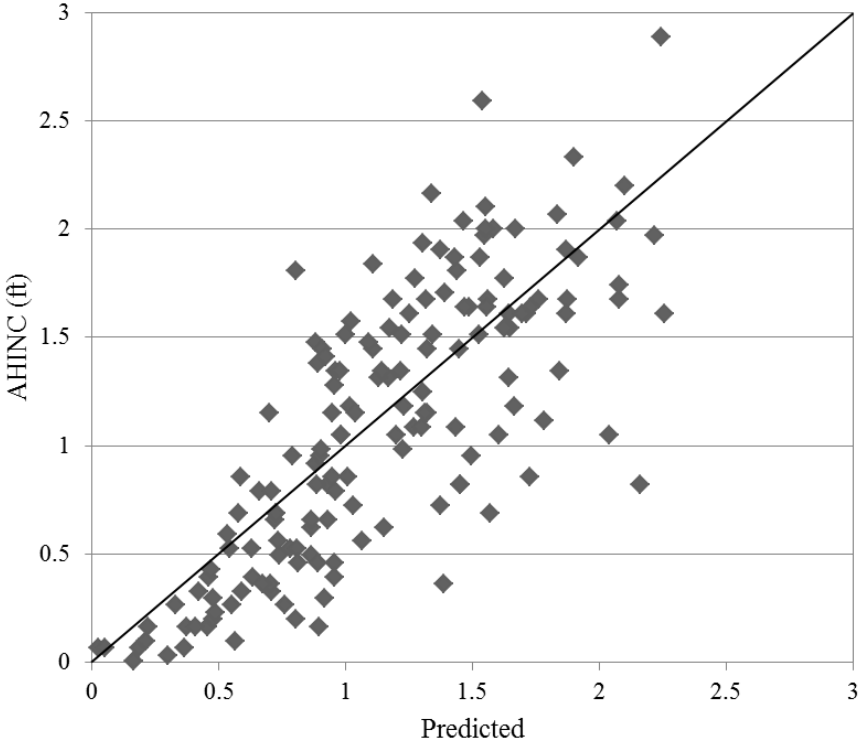


Results: FVS Predictions

By refitting old equations to the data better fits are easily obtained

Newly-proposed equations fit data even more successfully (see right)

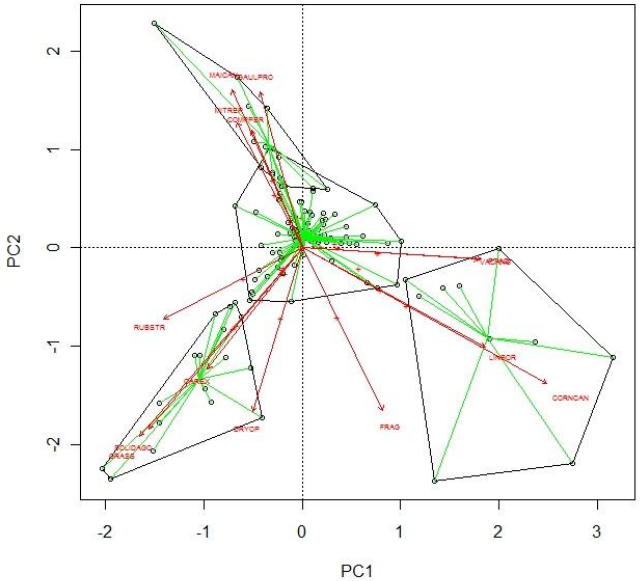
- Sapling traits prove important to model fit
- Current FVS-NE model derived from large-tree growth model; insufficient for modeling sapling dynamics



Results: Outreach Efforts

Outreach efforts have sought to present a balance of science, statistics, and artful application of silviculture

- Posters presented & presentations given locally, regionally and nationally
- Research discussed with state and private foresters
- Oral presentation given at UMaine Graduate Student Research Expo
  - Awarded Best Oral Presentation, 2011
  - Presented to the public in layman's terms; community-based outreach



Implications for Management in the Northern Forest Region

Pay more attention to the understory

- Grow regeneration to 6 meters, then remove the overstory

Data show that growth can be accelerated: extended rotation shelterwoods may be longer than necessary

- Especially when advance regeneration present

Question the reliability of growth and yield software

- If possible, compare predictions with inventoried data – if predictions are off, apply a calibration factor if possible
- Report findings to the FVS team – request better-predicting and more region-specific models

Future Directions

- Use of study data to aid in future FVS-NE revisions

- Implementation of local and regional shelterwood silviculture, utilizing study guidelines
  - Interest in adopting recommendations on the UMaine Dwight B. Demeritt University Forest

List of Products

- Peer-Reviewed Publications
  - Two expected articles: Schultz, E.L., and R.S. Seymour. In prep (*2013*).

- Other Publications
  - Schultz, E.L. 2012. Predicting dynamics of eastern white pine (*Pinus strobus* L.) advance regeneration under shelterwood silviculture. University of Maine, Orono, Maine. 111 p.
  - Schultz, E.L., Seymour, R.S., and A.R. Weiskittel. Poster presented at the Society of American Foresters National Convention, Honolulu, HI. Nov 2 – Nov 6, 2011.
  - Schultz, E.L., and R.S. Seymour. Predicting growth dynamics of eastern white pine (Pinus strobus L.) advance regeneration under shelterwood harvests in Maine. Paper presented at the North American Forest Ecology Workshop, Roanoke, VA. Jun 19 – 23, 2011.
  - Schultz, E.L., and R.S. Seymour. Analyzing Growth Dynamics of Eastern Pine Advance Regeneration. Paper presented at the 2011 University of Maine GradExpo, Orono, ME. Apr 11 – 12, 2011.
  - Schultz, E.L, and R.S. Seymour. Predicting dynamics of eastern white pine (Pinus strobus L.) advance regeneration. Paper and poster session presented at the New England Society of American Foresters 91st Winter Meeting, Forestry: The Original Green Profession, Fairlee, VT. Mar 29 – Apr 1, 2011.

Literature Cited

Frothingham, E.H. 1914. White pine under forest management. Bulletin 13, United States Department of Agriculture. 70 p.

Stiell, W. M., and Berry, A. B., 1985. Limiting white pine weevil attacks by side shade. Forestry Chronicle, 61: 5–9.