A Spatially Explicit Analysis Of Early Rotation Thinning For Black Walnut Plantations

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Abstract

In the Central Hardwood Region, the quantity and quality of hardwood timber critically depend on forest management decisions made by landowners. We fill a key gap in hardwood management by building a spatially explicit thinning model for black walnut to guide the first pre-commercial thin under user defined planting density, pre-establishment seedling survival and post establishment crop tree choices. We find that growth and yield of individual trees is influenced by multiple synergistic choices made during the pre-establishment and post establishment phase. Later, we link our model with the Forest Vegetation Simulator (FVS) to project stand attributes under the impact of future thinning and harvest decisions. We demonstrate a framework that could guide investments in hardwoods on private lands based on sound scientific evidence and tools that pinpoint forest management options over the plantation life cycle.

Introduction

The *main idea :*

Model a precommercial thin for different planting densities, survival and crop tree choices:

- *For* black walnut, widely planted in the Central States
- *To* grow trees based on their immediate neighborhood
- *Providing* scientific tools that enhance economic gains

Here is what we *did* :

- *Simulated* stand conditions based on our optimal plantation establishment model (Working Paper)
- *Demonstrated* a spatially explicit thinning approach
- *Dovetailed* thinning results with FVS
- *Estimated* mid rotation and stand structure at harvest

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Methodology

Model inputs/states (2*3*2 = 12 initial conditions tested)
- Tree x Row spacing (in feet) : 6 x 6 ; 8 x 8; 10 x 10
- No. of crop trees per acre – 30 ; 60
- Seedling Survival % at Age 5 - 60% and 80%

For e.g., initial state – 10_10_60_0.8 (State ID) denotes a 10 x 10 planting with 60 crop trees per acre and a seedling survival at age 5 of 80%.

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Step 1: Created a stand with tree locations randomly assigned

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Step 2: Randomly assigned DBH@ Age 5 from HTIRC DB

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Step 3: Imposed a spatial structure on DBH@10 using:
- Initial DBH @ Age 5 (Step 1) +
- Edge effects on DBH +
- Hegyi's Index (H) of density dependent (DD) competition
- Included a DD criterion for max 1% annual mortality rate
- ***Result* : A realistic 10-year-old plantation as input for subsequent spatially explicit thinning simulations**

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Step 4 : Crop Tree Release Thinning
- Identified crop trees based on DBH@10
- Mapped Euclidean distances to find 4 nearest neighbors of individual trees
- Identified trees for removal to release crop trees on a minimum of three sides
- Removed trees to target CCF = 80
- Ran 100 simulations for each state

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Step 5:
- Updated DBH annually till Age 18 using:
  - DBH of every preceding year +
  - Edge effects on DBH +
  - Hegyi's Index as *significant* predictors
- Accounted for pronounced DD mortality during stem exclusion phase (2% annual mortality rate)

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Step 6: Dovetailed stand attributes at Age 18 with FVS

Results

Key Finding 1 : Thinning strategy successfully redistributes growing space to fewer trees
- Average DBH at 18 (Fig 1)not only differs across initial conditions but is influenced by tree classification (crop/non crop) and location (edge/interior) in the stand.
- 6 x 6 plantings with 30 crop trees (CT) per acre with 80% seedling survival by year 5 has the highest tree DBHs.

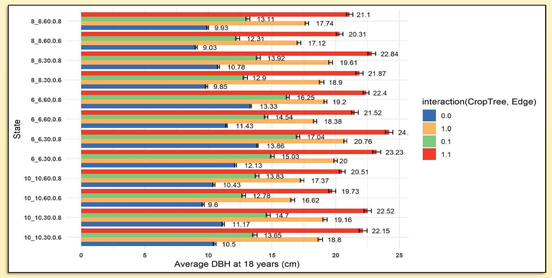

Fig 1 : Average DBH (cm) at Age 18 for a crop release thin at Age 10

- DBH under a no thin control at Age 18 (Fig 2) illustrates successful implementation of crown thinning strategy above. (Fig 1)

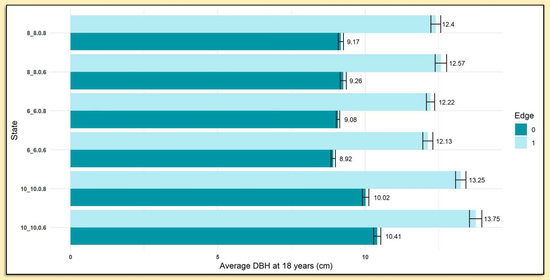

Fig 2 : Average DBH (cm) at Age 18 for a no thin baseline

Key Findings 2 : Though thinned at moderate to high intensity, denser plantings close crown again by year 18;

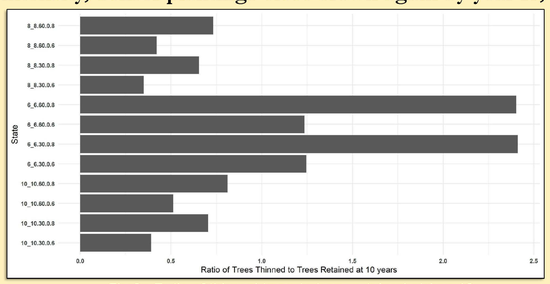

Fig 3 : Ratio of thinned trees to trees retained at Age 10

- For every tree retained at age 10, an average of 2.4 trees are removed under a 6 by 6 planting with 80% seedling survival at age 5. (Fig 3)

FVS Mid Rotation Thinning and Harvest Simulations
- High vs low density plantings under low survival scenario
- *1st Commercial Thin* : Before thin CCF=110; Stand Age 35 was the year of first pre commercial thin for the 10 x 10 planting (Fig 4)

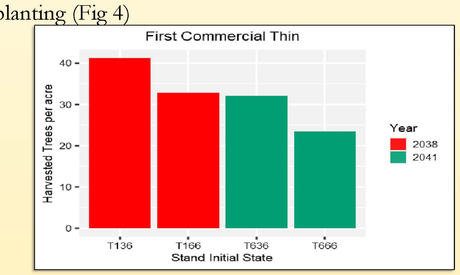

Fig 4 : DBH Class of trees harvested and residuals at 1st CT

- *2nd Commercial Thin* : Performed when non crop trees are 14" in diameter (sawlog grade No 1 and 2) on average leaving only crop trees for future harvest (Fig 5)

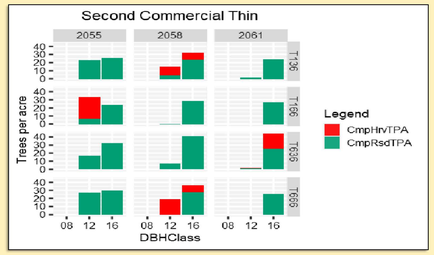

Fig 5 : DBH Class of trees harvested and residuals at 2nd CT

Key Finding 3 : Black Walnut rotation grown for 86 years yield ~25 trees per acre of veneer quality (18"+)

Discussion

This study contributed to forest science by :
- *Building* a spatially explicit model that can be used to evaluate the impact of simulated stand conditions under limited availability of hardwood tree data.

The model focused on :
- *Replicating* an operational thinning strategy and leveraged computing power to understand post thinning outcomes.
- Future work will quantify the cost, return and effectiveness of different thinning schedules to determine optimal one with highest profitability.