Future Stand Development and Economic Consequences of Single-Tree Selection

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INTRODUCTION

The tree selection method for harvesting during all-aged management in the northern hardwood forest type has been well studied on research forests throughout the Lake States region. Many of these methods, developed in the 1950s, have been widely accepted and implemented by foresters who are working to develop quality sawn hardwood products. More recent research has indicated that forest managers are not always applying these all-aged approaches explicitly. Moreover, in many cases, the resulting stand conditions found in the years following individual tree selection practices do not result in the conditions anticipated by the forester.

Recent work completed by Steigerwaldt Lake Services LLC (Tomahawk, WI) as part of the Wisconsin Forest Practices Study (WFPS) evaluated alternative marking scenarios from tree inventory data collected on county, state, and private lands enrolled in the Wisconsin forest tax law programs (for more detailed explanation, see https://councilonforestry.wi.gov/Documents/PracticesStudy/6522%20WFPS%20NorthernHardwood_Modeling_12.01.2020.pdf).

In this paper, we review varying maximum tree size criteria and residual stocking generally following the single-tree selection method. These approaches were simulated into the future using FVS (forest vegetation simulator) and a custom model over a series of entries. Future stand structural elements and the present value of the forest products are compared to evaluate the sustainability of various tree selection approaches.

METHODS

This study utilized data from nine 1-acre plots (three plots per landowner class: county, private, and state) captured in 2015 as the baseline data, using the alternative harvest model previously developed. Eligible stands included those typed as northern hardwood forest, dominated by the sawtimber-size class, and managed under all-aged silviculture. Using the 1-acre plots provides a total sample size of 1,752 trees (trees 5 inches d.b.h. and larger), which provided a robust sample for the comparative modeling.

Two alternative selection scenarios were applied to each study. Each alternative marking scenario was primarily defined by maximum tree size and residual basal area (BA). These approaches are presented below.

- Scenario 1: Maximum tree size = 17 inches d.b.h. Residual BA of 75 ft^2 per acre
- Scenario 2: Maximum tree size =19 inches d.b.h. Residual BA of 82 ft^2 per acre

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The "cut" versus "leave" designations were determined using a tree selection model built in Microsoft Excel®. Trees were prioritized for harvest based on three indices: removing risk (Index 1), harvesting mature trees (Index 2), and releasing crop trees (Index 3); harvest criteria were applied in this order of priority. Each index had an associated formula to determine the tree's ranking, which was independently applied to each tree. Trees that received higher ratings were prioritized for harvest first. Selection was determined between trees of equal rating using the random number applied to each tree.

In the selection model, a proportion of total BA to be harvested (current BA minus residual) was assigned to each rule. The rules focused on removing trees classified as having high risk (60 to 65 percent of the BA), meet conditions to be considered mature (17 to 19 inches d.b.h., 25 percent of the BA), and release of crop trees (10 to 15 percent of BA).

Future stand conditions were modeled and used to test the viability of the alternative harvest scenarios developed in the 2016 study. FVS regeneration requires custom settings in many cases. Considering challenges throughout the Lake States with northern hardwood regeneration due to deer herbivory, gap success, and invasive competition, among other constraints, we chose to control how FVS established regeneration following silvicultural treatments. We chose intentional natural "planting" keywords in FVS to trigger tree regeneration using assumptions derived from northern hardwood research (Knapp et al. 2019) coupled with dominant tree stocking from the plot data.

For the existing marking scenario, or Scenario 0, tree growth and harvest prescriptions are completed in FVS. Following the initial cut in 2015, the residual tree list was grown in FVS through 2075. There were three cuts performed in 2035, 2055, and 2075. Seedling regeneration was introduced 5 years following harvests in 2020, 2040, and 2060. Five years after regeneration seedlings were introduced, the model included adjusted mortality settings in FVS to introduce 99 percent mortality for white ash and 65 percent for sugar maple, which was focused in the 1- to 4-inch diameter classes. Mortality was added to the model in 2025, 2045, and 2065. This research effort evaluated the following scenarios:

- Scenario 0 (existing marking scenario, or base case): existing marking condition modeled forward using FVS single-tree selection harvest treatment, following the Q-factor method
- Scenario 1: applied Scenario 1 alternative tree selection model for harvests and FVS between treatments
- Scenario 2: applied Scenario 2 alternative tree selection model for harvests and FVS between treatments

RESULTS

The projected harvests modeled (Table 1) using the alternative harvest approaches produced greater total present value of harvest revenue in all ownerships for Scenario 1, while Scenario 2 was higher on state and private lands when compared to Scenario 0 (the projected existing stand condition sampled in 2015).

The residual forest stumpage value in 2075 averaged 2 percent higher in Scenario 1 and 3 percent lower in Scenario 2 when compared to Scenario 0.

The residual forest structure of the scenarios differs more over time, resulting in a final forest condition in 2075 where Scenarios 1 and 2 carry ±30 to 56 percent more sawtimber on two of the three ownership classes compared to Scenario 0.

Table 1.— Value at present (2015) and projected values based on alternative harvest approaches

	All Cuts (2015 Dollars)
County	**Value Per Acre**
Scenario 0 - Cut	$988.89
Scenario 1 - Cut	$1,145.61
Scenario 2 - Cut	$919.25
Private	**Value Per Acre**
Scenario 0 - Cut	$780.52
Scenario 1 - Cut	$1,029.15
Scenario 2 - Cut	$797.26
State	**Value Per Acre**
Scenario 0 - Cut	$981.81
Scenario 1 - Cut	$1,340.87
Scenario 2 - Cut	$1,207.64

CONCLUSIONS

Harvest volumes of both poletimber and sawtimber varied across the model period. However, harvest value was found to generally increase with time. While the alternative harvest scenarios focused on removing larger trees, the model suggests that the approach can be sustained over time without compromising future harvest opportunities.

The study suggests that alternative harvest approaches that focus on tree quality and economics with less focus on stand structure can produce long-term sustainable forest conditions that do not jeopardize forest harvest potential and sustainable tree stocking levels.

LITERATURE CITED

Knapp, S.P.; Webster, C.R.; Kern, C.C. 2019. **Can group selection with legacy retention change compositional trajectories in conventionally managed hardwoods?** Forest Ecology and Management. 448: 174–186. https://doi.org/10.1016/j.foreco.2019.06.005.

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