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Northern Forest Composition, but Not Productivity, Altered by Harvesting Methods and Prescribed Burning

Whole-tree harvesting, in which the trunk of the tree and woody residues from the canopy and branches are removed from the site and used to make various products, is a common harvesting practice in the northeastern United States. Concerns have arisen, however, around the long-term impact of removing this material from the forest, especially in clearcuts where all trees are harvested, as doing so could reduce soil nutrient availability and carbon. These concerns are especially relevant for poorly drained, conifer-dominated sites, which tend to be nutrient poor.

One long-term study at the Penobscot Experimental Forest in Maine puts these concerns to the test. This experiment, which started in 1964, compares no harvesting and clearcutting with whole-tree harvesting, stem-only harvesting (in which branches and residues are left on site), and stem-only harvesting with prescribed burning over time in a spruce-fir forest. The 50-year results of this experiment, and data from repeated treatments implemented in 2018, demonstrate that whole-tree harvesting had a smaller impact on forest productivity, both in terms of stand structure and nutrient availability, than expected.

KEY MANAGEMENT IMPLICATIONS

- After 50 years, stand stocking and structure in clearcuts following whole-tree harvesting and stem-only harvesting with prescribed burning treatments did not differ from that of stands in which only tree stems were harvested.
- All treatments increased the proportion of early-successional hardwoods, with the highest proportions in stands where prescribed burns had been conducted after stem-only harvesting.
- While soil nutrient availability did not differ between harvesting treatments 50 years later, concentrations of some elements were higher one year after the stem-only harvesting with prescribed burning treatment was repeated in 2018.

A Rare Record

This long-term study was revisited in 2014, 50 years after it was established, by Forest Service scientists Laura Kenefic and Bethany Muñoz Delgado, in collaboration with colleagues from the University of Maine. They remeasured forest productivity, foliar nutrients, and soil nutrients. Remeasurements taken 50 years after clearcutting with whole tree harvesting are rare in the northeastern United States.

Researchers repeated the original treatments in 2018, re-harvesting and reburning each plot, and then measured soil chemistry. They also remeasured regenerating vegetation in 2025. This study can consequently address concerns about the effects of repeated whole-tree harvesting over time.

Aerial view of a portion of the Penobscot Experimental Forest harvesting study showing blocks with different harvesting treatments in 2020, taken 2 years after the second harvest. Forest Service photo.

Changes in Composition but Not Productivity

Surprisingly, the researchers did not find differences in stand stocking or structure between whole-tree and both stem-only harvesting treatments 50 years after clearcutting. They did, however, detect differences in species composition among treatments and compared to pre-treatment and unharvested conditions. All clearcutting treatments had a higher proportion of early successional hardwood basal area than previously existed on the site. Also, the whole-tree harvesting treatments had more white pine (*Pinus strobus*) trees than the stem-only harvesting and stem-only harvesting with prescribed burning treatments. The white pine result may be due to disturbance of the soil surface during whole-tree harvesting that exposes mineral soil favored by white pine seeds (scarification).

Seven years after the second clearcut harvests, all harvesting treatments had more early successional and sprouting tree species, such as red maple (*Acer rubrum*), aspen (*Populus* spp.), and paper birch (*Betula papyrifera*), compared to the unharvested forest. The whole-tree harvesting and stem-only harvesting plots also had higher densities of seedlings and saplings than either the unharvested plots or the stem-only harvesting with prescribed burning plots.

Soil Nutrients Varied with Site Factors and Fire

The researchers did not detect consistent differences in nutrient availability that could be attributed to treatment between whole-tree harvesting and both stem-only harvesting treatments 50 years after clearcutting. They did detect differences related to the geology and hydrology of the site, specifically the depth-to-water table and soil parent material. These results suggest that site factors influence soil nutrient availability more than disturbance in the long term. Although the researchers did not detect long-term differences in soil nutrients due to treatment, they do not rule out the possibility that the high variability of soil nutrients in their forest could make it difficult to detect clear differences, a possibility that can be resolved by continued monitoring.

One year after the second harvesting treatments, soil in the stem-only harvesting with prescribed burning treatment showed higher soil pH and concentrations of ammonium, phosphorus, potassium, and sulfur in areas where the water table was shallow. Prescribed burning may therefore influence soil nutrient availability in the short term, but these changes might not persist over decades.

Value of Long-Term Research

These results suggest that tree species composition in spruce-fir forests may change after clearcutting, shifting towards early successional tree species in the long-term study reported here, but stand stocking and structure may not differ between stands that were whole-tree harvested and stands where treetops and branches were either left on site or burned. These results also provide insights into short- and long-term effects of harvesting and prescribed burning on soil nutrient availability. In doing so, this experiment addresses longstanding questions about the effects of whole-tree harvesting on productivity and soil. Long-term experiments are uncommon but vital to understanding and predicting outcomes of forest management and ensuring productive forests in the future.

FURTHER READING

Muñoz Delgado, B.L.; Kenefic, L.S.; Weiskittel, A.R.; Fernandez, I.J.; Benjamin, J.G.; Dibble, A.C. 2019. Northern mixedwood composition and productivity 50 years after whole-tree and stem-only harvesting with and without post-harvest prescribed burning**.** Forest Ecology and Management. 441: 155-166. https://doi.org/10.1016/j.foreco.2019.03.032.

Abramoff, R.Z.; Muñoz Delgado, B.L.; Kenefic, L.S.; Fernandez, I.J. 2026. Nutrient and regeneration responses to biomass harvesting and prescribed fire in a northern mixedwood forest**.** Forest Ecology and Management. 618: 123980. 14 p. https://doi.org/10.1016/j.foreco.2026.123980.

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For questions on Rooted in Research, please contact Jenna Zukswert. Technical editing by Susan Barro. Design and layout by Jeremy Siegrist.

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