Early Vegetation Responses to Canopy and Soil Disturbances

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INTRODUCTION

Long-term implementation of uniform silvicultural systems can reduce species (Crow et al. 2002, Leak and Sendak 2002, Schulte et al. 2007) and structural (Angers et al. 2005, Hupperts et al. 2018, Montes et al. 2005) diversity. Diversity loss leads to less resilient forest ecosystems (Holling 1973), especially with increasing challenges due to climate change. Implementation of natural disturbance-based management could be beneficial for biodiversity by emulating natural stand conditions that prevailed before the species decline (Hupperts et al. 2018). Therefore, we sought to answer the question: Can artificial soil disturbance and the removal of canopy trees sufficiently emulate natural disturbances and create suitable seedbeds for declining tree species in a managed Great Lakes northern hardwood forest? To address this objective, an experiment was established with three different levels of soil disturbance nested within four different levels of residual canopy.

METHODS AND RESULTS

To investigate the utility of novel silvicultural approaches, we conducted the research on the 111 acres spanning the Northern Hardwoods Silviculture Experiment to Enhance Diversity (NH-SEED) research trial at the Ford Forest Research Center in Alberta, MI (46°37', 88°29'W). The average daily temperature (1981–2010) ranges from −10.8 °C in January to 18.1 °C in July for a yearly average of 4.7 °C. The annual total precipitation 2007–2016 averaged 88.9 cm, including considerable annual snowfall averaging 390.1 cm (NOAA 2016). The site is dominated by sugar maple (*Acer saccharum* Marsh). Other common species are red maple (*Acer rubrum* L.), yellow birch (*Betula alleghaniensis* Britton), eastern hemlock (*Tsuga canadensis* L.), balsam fir (*Abies balsamea* L.), black cherry (*Prunus serotina* Ehrh.), eastern white pine (*Pinus strobus* L.), ironwood (*Ostrya virginia* Mill.), trembling aspen (*Populus tremuloides* Michx.), paper birch (*Betula papyrifera* Marsh.), and white spruce (*Picea glauca* Voss).

The nested experiment was designed as a Before-After-Control-Impact (BACI) experiment, set up in a randomized complete block (RCB) design. Four different levels of canopy removal and three different levels of soil disturbance were implemented over a total of 54 treatment units, each ~2 acres in size, in 2016/2017. The canopy removal treatments are clearcutting three replicates) shelterwood with either 30 percent or 60 percent residual canopy (six replicates each) and single-tree selection as control treatment (three replicates). Nested in every canopy treatment unit are three different levels of soil disturbance: untreated control, soil scarification, and artificial tip-up mounds. The initial harvest was applied in February and March 2017 with a cut-to-length system. Saplings (>30 cm in height but <5 cm d.b.h.) were removed in August 2017 in all treatments but the singletree selection. The artificial tip-up mounds were implemented during the initial harvest

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by pulling about 30 trees per acre out of the ground and placing the root ball within ~5 m of the created pit. Soil scarification was implemented using a salmon blade in October 2017.

A setup of two randomly placed circular 3 m^2 plots in each of the 54 treatment units showed initial vegetation response during the first two years following treatments (Hupperts et al. 2020). Seedling (< 30 cm tall) tallies for all species were taken in each plot during the growing season in 2016 (one growing season pretreatment) and 2018 (two growing seasons post-treatment). Also several environmental variables (i.e., canopy openness, litter depth, soil water content, cover of exposed soil and coarse woody debris, and residual overstory basal area) were measured. Overall, silvicultural treatments had little relation to seedling density. Only sugar maple seedling density was related to silvicultural treatments and was lower in clearcuts as compared to other canopy treatments ($\chi2 = 12.484$, $p > \chi2 = 0.006$). Sugar maple seedling density displayed a marginally significant relationship with soil treatments ($\chi^2 = 5.621$, $p > \chi^2 = 0.060$) and tended to decline or have greater variation in scarification treatments. Yellow birch seedling density was not statistically related to silvicultural treatment. In contrast, the authors found microsite variables postharvest to be correlated with seedling density for three tree species. In their experiment, yellow birch seedling density was positively correlated with litter depth variation ($z = 2.244$, $p = 0.029$), and the basal area of residual mature yellow birch trees in the stand had a slight positive effect on yellow birch seedling density ($z = 1.940$, $p = 0.053$). Canopy openness was found to be negatively correlated with red maple ($z = -2.487$, $p < 0.015$) and sugar maple ($z = -3.352$, $p < 0.001$) seedling density. Average litter depth, exposed soil cover, coarse woody debris cover, and soil water content were not significantly correlated with seedling densities in this experiment.

While the study conducted by Hupperts et al. (2020) investigated the effect of different nested treatment combinations, none of the randomly placed plots were actually positioned on artificial tip-up mounds. In 2017, to study vegetation dynamics on actual mounds within the canopy treatments we randomly chose 66 artificial tip-up mounds (12 in clearcuts, 20 in single-tree selection, 17 in each shelterwood) and set up a permanent 3 m^2 plot on each. These were compared to 36 untreated control plots. Cover of ground layer vegetation (i.e., herbaceous, shrub, grass, sedge, rush, nonvascular), exposed soil, exposed rock, leaf litter, and coarse woody debris, as well as the seedling and sapling abundance by species have been monitored yearly during the growing season since 2017. Physical properties of the tip-up mounds were also measured in 2017 after implementation and remeasured in 2021 to document change in mound size and shape over time.

Preliminary data available from our study suggests there might be an effect on seedling abundance by artificial mounds. A nonmetric multidimensional ordination (not shown here) revealed that control plots have shifted toward less diverse species composition since the initial harvest. Red maple and sugar maple are common in areas of undisturbed soil, whereas yellow birch tends to be more common on tip-up mounds 3 years after implementation (Fig. 1). Of interest the number of seedlings in the control also went up, but there was notable high variation. Further analysis of the data will reveal if this effect might be linked to an abundance of propagules in the stand.

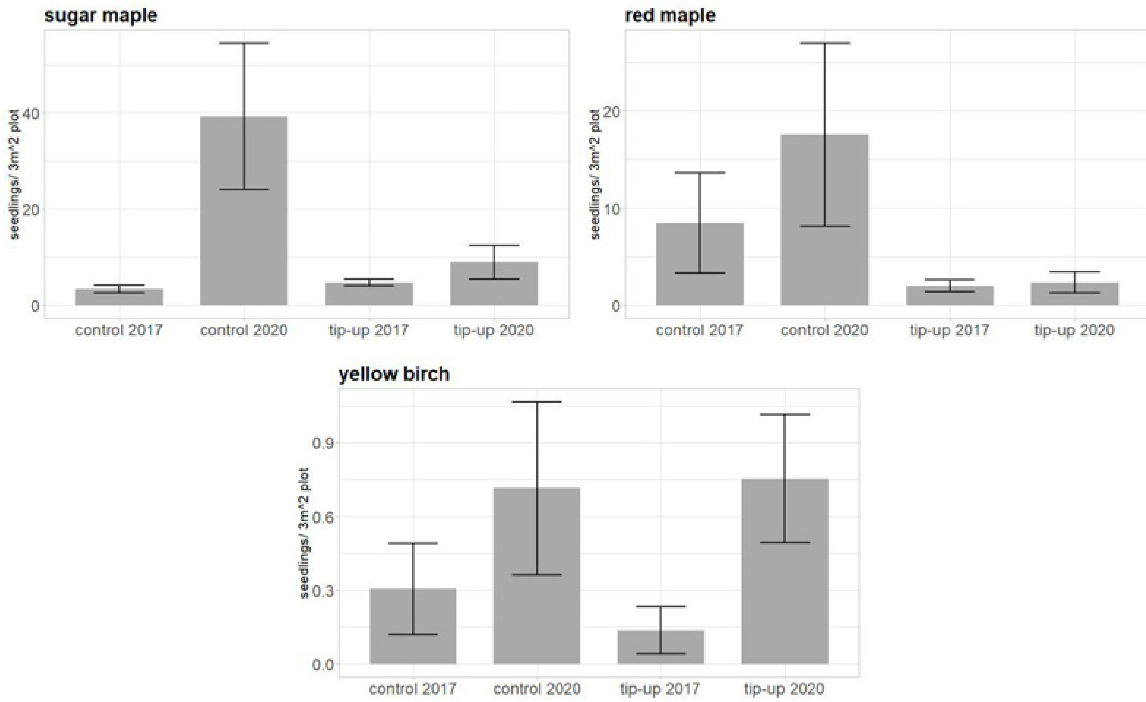

Figure 1.—Mean seedling (<30 cm tall) density and standard error on artificial tip-up mounds and control plots in a managed northern hardwood forest in upper Michigan. All data are preliminary. Note species-specific y-axis ranges. Only the three most abundant species were included.

CONCLUSION

Results reported by Hupperts et al. (2020) suggest that sugar maple will likely maintain dominance. In contrast to their hypotheses, treatments had little relation to yellow birch seedling density. Yellow birch seedling density was best predicted by residual basal area of nearby conspecific trees and within-plot litter depth variation, suggesting that propagule availability and microsite heterogeneity are more important determinants of yellow birch seedling recruitment than treatments alone. Additionally, recent preliminary findings suggest that yellow birch might benefit from reduced competition on artificial tip-up mounds. Nevertheless it will be crucial to monitor if germinated seedlings on artificial tip-up mounds will be able to successfully recruit into larger-size classes and remain competitive in the developing cohort.

LITERATURE CITED

Angers, V.A.; Messier, C.; Beaudet, M.; Leduc, A. 2005. **Comparing composition and structure in old-growth and harvested (selection and diameter-limit cuts) northern hardwood stands in Quebec.** Forest Ecology and Management. 217(2-3): 275–293. https://doi.org/10.1016/j.foreco.2005.06.008.

Crow, T.R.; Buckley, D.S.; Nauertz, E.A.; Zasada, J.C. 2002. **Effects of management on the composition and structure of northern hardwood forests in upper Michigan.** Forest Science. 48(1): 129–145.

Holling, C.S. 1973. **Resilience and stability of ecological systems.** Annual Review of Ecology and Systematics. 4(1): 1–23. https://doi.org/10.1146/annurev.es.04.110173.000245.

Hupperts, S.F.; Dickinson, Y.L.; Webster, C.R.; Kern, C.C. 2018. **Promoting structural and species diversity in Great Lakes northern hardwoods: a conceptual model and its application.** Forestry: An International Journal of Forest Research. 92(1): 16–25. https://doi.org/10.1093/forestry/cpy026.

Hupperts, S.F.; Webster, C.R.; Froese, R.F.; Dickinson, Y.L. 2020. **Seedling and sapling recruitment following novel silvicultural treatments in Great Lakes northern hardwoods.** Forest Ecology and Management. 462: 117983. https://doi.org/10.1016/j.foreco.2020.117983.

Leak, W.B.; Sendak, P.E. 2002. **Changes in species, grade, and structure over 48 years in a managed New England northern hardwood stand.** Northern Journal of Applied Forestry. 19(1): 25–27. https://doi.org/10.1093/njaf/19.1.25.

Montes, F.; Sánchez, M.; Del Río, M.; Cañellas, I. 2005. **Using historic management records to characterize the effects of management on the structural diversity of forests.** Forest Ecology and Management. 207(1-2): 279–93. https://doi.org/10.1016/j.foreco.2004.10.031.

Schulte, L.A.; Mladenoff, D.J.; Crow, T.R.; Merrick, L.C.; Cleland, D.T. 2007. **Homogenization of northern U.S. Great Lakes Forests Due to Land Use.** Landscape Ecology. 22 (7): 1089–1103. https://doi.org/10.1007/s10980-007-9095-5.

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