Special Session: Alternative Silvicultural Systems, Tree Regeneration Success, and Deer Use in Northern Hardwood Forests

Preharvest Stand Regeneration Composition and Associated Driving Factors

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INTRODUCTION

Concerning trends in natural tree regeneration emerged over the last few decades following a long history of single-tree selection silviculture in northern hardwood forests. Regeneration in these systems varies geographically and is often inadequate. For example, sapling classes may be understocked, absent, or dominated by a few relatively undesirable species (e.g., American beech [*Fagus grandifolia*], ironwood [*Ostrya virginiana*]). Multiple interacting factors may explain these troubling regeneration patterns, including silvicultural practices that provide insufficient light/disturbance, competition from shrubs and undesirable advance regeneration, site quality, seed availability, and browsing from high white-tailed deer (*Odocoileus virginianus*) populations. Understanding where regeneration is failing under single-tree selection and associated predictors is key for guiding future management, including implementation of alternative harvesting regimes. We aim to characterize overall species diversity of tree regeneration and patterns of species distributions in northern hardwood forests managed by single-tree selection. We hypothesize that deer use and high basal area correlate with low densities of desirable species and that overall species diversity is low.

METHODS

Drawing on a dataset of 141 northern hardwood stands throughout northern Michigan, we analyzed patterns of tree regeneration composition, structure, and diversity following decades of management by single-tree selection. Data were collected in summer 2017 to quantify vegetation, with 25 survey points per stand, and variable radii fixed-area plots at each survey point. We also conducted deer-pellet transect surveys to assess winter deer use in spring 2017. We conducted generalized linear modeling using a Bayesian framework to assess how stand-basal area, stand-basal area heterogeneity, winter deer use, conspecific-canopy density, and shrub coverage associate with stem densities of individual species for key regeneration size classes. For each species × size class, we compared a negative binomial distribution versus a zero-inflated Poisson model and chose the model with the superior deviance information criterion (DIC).

RESULTS

Overall, species diversity was low in our stands. We had 29 tree species present in our stands (excluding woody shrub species) across all size classes. Species diversity measures were uniformly low and mean species richness declined with increasing regeneration size class. Individual species models revealed associations which matched species' autecologies and notions regarding limiting factors in northern hardwood forests. For seedlings (i.e., stems <50 cm tall), we saw positive

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associations between seedlings and conspecific counts of sawtimber (i.e., stems > 24 cm d.b.h.) for most species, including sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*), and basswood (*Tilia americana*). Species which typically have lower maximum diameters had positive associations with conspecific poletimber (i.e., 11–24 cm d.b.h.) counts, such as ironwood and balsam fir (*Abies balsamea)*. These results suggest local seed sources limit seedling density. For saplings (i.e., >50 cm tall and <5 cm diameter at breast height), we saw similar positive associations with conspecific poletimber and sawtimber stem counts. There were also negative associations with total stand basal area for key species such as sugar maple, red oak (*Quercus rubra*), and cherry species (*Prunus* spp.), and negative associations with sugar maple and yellow birch with winter-deer use. Deer use was positively associated with density for some species undesirable for management, including ironwood and ash.

Our results suggest that alternative management is needed throughout much of the range of northern hardwood forests in northern Michigan. Evidence suggests winter-deer browsing may be selectively inhibiting regeneration, particularly saplings (i.e., >50 cm tall and <5 cm diameter at breast height). Northern hardwood forests in regions of high deer populations may be particularly difficult to effectively manage. However, strategies such as leaving tops as barriers to browsing may be effective at promoting regeneration establishment and recruitment. Our results also indicate that basal area may negatively influence regeneration density, given the negative associations between stand-basal area and several key species. Harvests that remove a greater percentage of a stand's basal area may promote more diverse and abundant regeneration in the future. Seed source may be limiting for many species, as seedlings were positively associated with the density of conspecific-canopy trees. Promoting greater species diversity may therefore require active seeding or planting of more diverse species in the understory, as this would indicate that a species-poor canopy is likely to promote species-poor tree regeneration. These data can be used to guide future management in northern Michigan and the wider Great Lakes region.

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