SAMPLING FOREST REGENERATION ACROSS NORTHERN U.S. FORESTS: FILLING A VOID IN REGENERATION MODEL INPUT

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Abstract.—The Forest Inventory and Analysis Program of the Northern Research Station (NRS-FIA) has implemented new Advance Tree Seedling Regeneration (ATSR) protocols that include measurements of seedlings down to 2 inches in height. The addition of ATSR protocols is part of an evaluation of NRS-FIA Phase 3 indicator variables to increase sampling intensity from 1/96,000 acres to 1/24,000 acres per sample location. The sampling scheme for understory vegetation consists of (1) estimating canopy-cover percent for six vegetation growth habits on 24-foot-radius subplots in four height classes and as an aerial view and (2) measuring tree saplings and seedlings on 6.8-foot-radius microplots. The Pennsylvania Regeneration Study has used ATSR and competing vegetation measurements to evaluate regeneration for 16.7 million acres of northern hardwood and mixed-oak forest. The findings revealed that only about half the State's forest had adequate advance regeneration for replacement of canopy species if the overstory were removed. The ATSR protocols provide estimates of the number of seedlings by species and height class, as well as a flexible method for evaluating regeneration adequacy. The level of detail of the measurements is expected to provide input that has not been available in the past for models that require tree regeneration information.

INTRODUCTION

The Forest Inventory and Analysis Program of the Northern Research Station (NRS-FIA) ceased collection of Phase 3 (P3) data in 2011 for budgetary reasons. Based on an evaluation of costs, time, and efficiencies, a modified suite of existing P3 variables and new Advance Tree Seedling Regeneration (ATSR) protocols were implemented in 2012. The sampling intensity for the modified suite will be as high as 1/24,000 acres, which is between 1/96,000 acres for P3 samples and 1/6,000 for standard Phase 2 (P2) samples, referred to as Phase 2+ (P2+). This intensity is based on the maximum number of plots that can be measured in a 3-month leaf-on summer window. As of this writing, the 2012 field season is just beginning. In 2012, one-eighth of the forested sample conditions are being visited as P2+ samples; in 2013 and beyond, the sample will be expanded to include up to one-fourth of the conditions.

This paper focuses on the ATSR sample methodology. More specifically, ATSR sampling protocols, preliminary results, and applications for assessing forest regenerative capacity are discussed along with the utility for use in eco-process and other models that require regeneration information.

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METHODS

The sampling scheme includes (1) estimating canopy-cover percent for six vegetation growth habits on 24-foot-radius subplots in four height classes (Vegetation Profile) and as an aerial view, and (2) measuring tree saplings and tree seedlings on 6.8-foot-radius microplots. The study design for the P2+ Vegetation Profile was adapted from and integrated with the national P3 Vegetation Diversity and Structure protocols (USDA Forest Service 2012). The seedling protocols were adapted from the Pennsylvania Regeneration Study (PRS)—a 12-year study of regenerative capacity for forests under high deer browse conditions (McWilliams et al., in press; Westfall and McWilliams 2011). The underlying ecological and silvicultural relationships used for evaluating regeneration are described by Brose et al. (2008) and Marquis (1994). The approach for ATSR evaluation was developed during debate within the environmental community over the impact of deer on forest regeneration (Frye 2006).

Tree seedlings are defined as all stems at least 2 inches tall and up to 1 inch in diameter at breast height (d.b.h.) that have survived for at least a year. The ATSR sample provides the number of established and competitive seedlings by length class (2 to 6 inches, 6 inches to 1 foot, 1 to 3 feet, 3 to 5 feet, 5 to 10 feet, and greater than 10 feet). In addition, a browse impact code (five levels from very low to very high) is recorded for accessible forest land for all four subplots. The code was developed for white-tailed deer (*Odecoleus virginianus* Zimmerman) and may be adaptable for other ungulates. Other herbivores (such as hare and rodents) impact tree seedlings, but are not specifically addressed in the estimate of browse impact.

The ATSR protocols recognize that all seedlings are not the same. The study uses an "established" and "competitive" class for heavy seeded species, such as oak, walnut, and hickory (Fig. 1). The determination of seedling establishment and competitive status for

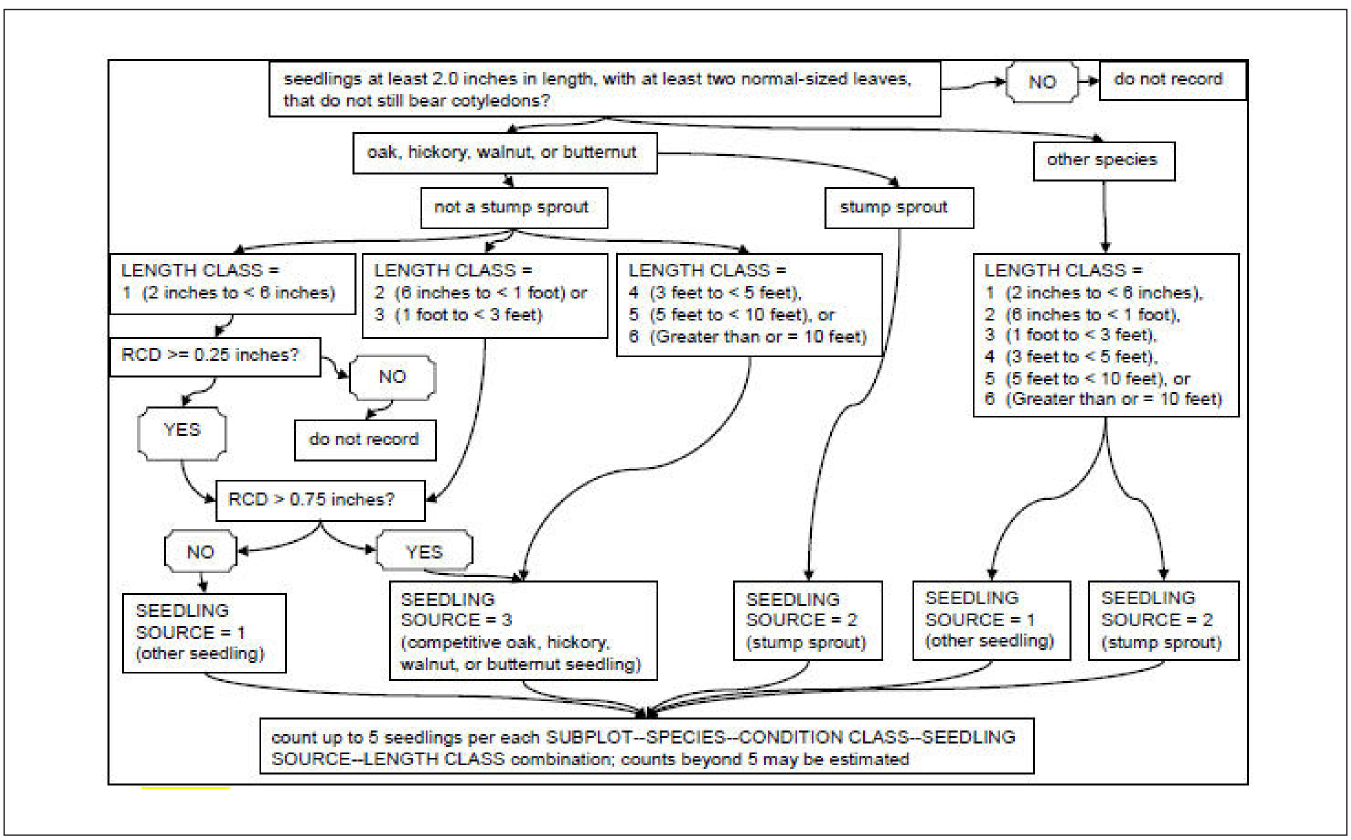

Figure 1.—Advance tree seedling regeneration seedling count guide (USDA Forest Service, Northern Research Station 2012).

large seeded species depends on the diameter at root collar, a better predictor of the future status than height for these species (Brose et al. 2008). Only a single dominant stem is counted when multiple sprouts are encountered. Undetached branches covered with soil, or layered stems, are not counted.

When combined with an estimate of “competing vegetation” from the Vegetation Profile and the browse impact code, the microplots can be evaluated for regeneration adequacy using thresholds for the number of seedlings by length class. The thresholds are determined by the level of browse, i.e., more seedlings are needed when browse impacts are higher. Samples are further screened for light levels conducive to seedling development (from 40 to 75 percent stocked with adult trees).

RESULTS

The underlying assumption for analysis of advance regeneration is that forest stands encountered will eventually have overstory removal or mortality and need advance regeneration to replace adult trees. Past results of the PRS have provided vital information for planners and inter-agency decisions on ameliorating the impacts of deer on forest regeneration. ATSR is used along with the tally of saplings for full evaluation of advance regeneration. Saplings are defined as trees larger than 1 inch d.b.h. up to 4.9 inches. In Pennsylvania, it was found that only about half of the forest land that is receiving adequate light for establishment and development of regeneration had adequate regeneration (Fig. 2) (McWilliams et al., in press). These results are subject to confidence intervals of +/- 4 percentage points at the 95-percent confidence level or +/- 2 percentage points at the 67 percent level.

The results of the 2012 measurements will be the first NRS-FIA-wide dataset containing these new protocols. The full baseline measurements should be complete following the 2017 field season. At that point, full characterization of regeneration adequacy across the NRS-FIA region will be possible.

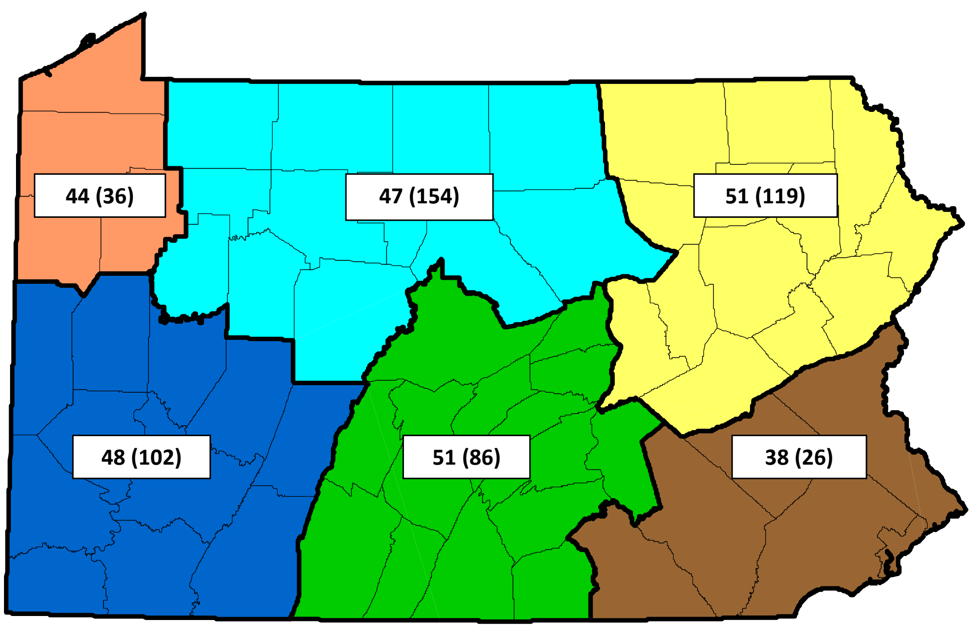

Figure 2.—Percent and number (in parentheses) of samples adequately stocked with advance tree seedling and sapling regeneration for canopy replacement species and samples 40 to 75 percent stocked with trees, Pennsylvania, 2006 to 2010.

DISCUSSION AND CONCLUSIONS

Seedlings less than 1 foot tall have not previously been included as a core variable in NRS-FIA inventories and seedling height has not been recorded. The new sample provides a flexible method for evaluating regeneration adequacy for dominant species subject to study assumptions, e.g., that overstory removal will occur. An advantage of the new P2+ samples is that all vegetation measurements are taken from the 24-foot or 6.8-foot-radius plots. This approach integrates P2 and P2+ measurements together for improved analyses of overstory and understory conditions.

The implementation of P2+ samples across the NRS-FIA region will cover 175.8 million acres of forest compared to 16.7 million acres for Pennsylvania. The expanded study area includes the Central Hardwood, Lake State, Mid-Atlantic, and New England areas; and four Plains States. Needed for regions and forest types outside the Mid-Atlantic are protocols and algorithms for analyzing and applying ecological thresholds for the number of seedlings by height class required for adequate regeneration to replace adult trees. The complexity and diversity of the Pennsylvania experience should provide a useful template for other NRS-FIA areas. For example, spruce-fir forests of Maine will need to use guidelines for size and density of regeneration of various species before overstory removal or destruction, such as those suggested by Seymour (1992, p. 236). The approach should also be adaptable to conditions in the Southern Appalachian Mountains, Piedmont, and Coastal Plain because advance regeneration is important for predicting future stand composition there. Additional research can be incorporated into the analyses to better match forest composition and silvicultural systems of interest.

The level of detail of the measurements is expected to provide input for eco-process and other models that has not been available in the past (Canham et al. 2006). This includes any model that attempts to characterize or project future conditions based on an inventory of vegetation and trees, including regeneration. Seedling height and competitive status are critical for addressing impacts of herbivory and the status of advance regeneration. The study will also provide input for developing regeneration modules for individual tree projection models, such as the Forest Vegetation Stimulator (Crookston and Dixon 2005). Further study by McDill (this proceedings) is addressing the ability to discern reliable trend information from the results.

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