INVASIVE PLANT MONITORING FOR NORTHERN U.S. FORESTS

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Abstract.—Invasive plants are monitored through canopy cover estimates for a list of species developed by FIA for the northern region of the U.S. that is integrated with a national list. Nearly all of the invasive plants on the NRS-FIA list are exotic species, but a few native species are listed. Highly invasive native species such as rhizomatous fern are absent, making the list limited in scope. Some useful applications include describing all vegetation other than trees, competing vegetation, as well as indices for "invasive-ness," "native-ness," and others. The major advantage of the invasive survey is a fourfold increase in sample size. The primary disadvantage is that the list of invasive species does not include several important native species at the regional level. The invasive protocols offer a flexible system for estimating occurrence and abundance that can be segmented to address a wide array of questions.

INTRODUCTION

Understanding the composition and cover of the forest understory helps explain future forest canopy composition and structure, particularly the number of established seedlings and the character of other vegetation. An underlying objective is to describe where the more invasive species are and their impact on native forest flora. This information is important for managers and policy makers evaluating broad-scale forest health, as well as scientists working on forest dynamics models that require information on forest vegetation.

The history of invasive plant survey for Northern Research Station Forest Inventory and Analysis (NRS-FIA) includes methods that have changed over time and space, but this has been minimized through careful field manual preparation, training, and attention to the need for "trend." Invasive trees have been part of the standard FIA tree list for many decades, including important species like tree-of-heaven (*Ailanthus altissimma*), Norway maple (*Acer platanoides*), and paulownia (*Paulownia tomentosa*). Invasive plants survey efforts began in earnest during the 1990s and have continued to develop regionally and nationally since then. For NRS-FIA, the methodology and list of invasive plants has been relatively consistent over time and space. Exotic and native species are included in the invasive plant survey.

METHODS

NRS-FIA ceased collection of Phase 3 (P3) data in 2011 for budgetary reasons. To maintain some of the P3 indicators into the future, a modified suite of indicators, referred to as Phase 2+ (P2+), was developed for the 2012 field season. The sampling intensity for P2+ is one plot per 24,000 acres, a level that falls between the 1/96,000 acres for P3 samples and 1/6,000 for standard Phase 2 (P2) samples. This sampling intensity is based on the maximum number of plots that can be measured in a 3-month

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leaf-on summer window. The P2+ design includes measurement of a vegetation profile and adult trees on the 24-ft radius subplots, as well as seedlings and saplings on 6.8-foot radius micro-plots (USDA Forest Service 2012). This paper focuses the invasive survey in the context of other measures of vegetation character.

The P2+ design includes the following components for vegetation other than adult trees:

1. Invasive plant areal canopy cover
2. Percentage canopy cover for vegetation growth habits (trees, shrubs, woody vines, forbs, fern, and graminoids) on a 24-ft radius plot in four height classes
3. Advance tree seedling regeneration (ATSR) on 6.8-ft radius plot in six height classes with a browse impact code (USDA Forest Service 2012)

Invasive plants are monitored by collecting canopy cover for a list that includes exotic and native species. NRS-FIA has adopted a list of invasive plants developed by screening variables according to methodology of Morse et al. (2004). The list was developed for the northern United States region and is integrated with a national list (Table 1). The definitions and conventions used in naming species are adapted from the USDA Natural Resources Conservation Service, Plants Database (NRCS 2012).

In 2012, one-eighth of the forested sample conditions are being visited as P2+ samples and beginning in 2013, the percentage will be expanded to include up to one-fourth of the conditions.

RESULTS AND DISCUSSION

Perhaps the most important indicators of forest understory health are species composition and abundance. Vegetation other than trees is vital for wildlife food and cover, tree seedling development, and native plant diversity. Competing vegetation often inhibits native tree regeneration (Jackson and

Table 1.—List of NRS-FIA invasive plants

Species	Common name
Microstegium vimineum	Japanese stiltgrass, Nepalese browntop
Phalaris arundinacea	reed canarygrass
Phragmites australis	common reed, phragmites
Alliaria petiolata	garlic mustard
Centaurea biebersteinii	spotted knapweed
Cirsium arvense	Canada thistle
Cirsium vulgare	bull thistle
Cynanchum louiseae	Louise's or black swallow-wort
Cynanchum rossicum	European swallow-wort
Euphorbia esula	leafy spurge
Hesperis matronalis	Dame's rocket
Lysimachia nummularia	creeping jenny
Lythrum salicaria	purple loosestrife
Polygonum cuspidatum	Japanese knotweed
Polygonum x *bohemicum*	(*P. cuspidatum* x *P. sachalinense* hybrid)
Polygonum sachalinense	giant knotweed
Berberis thunbergii	Japanese barberry
Berberis vulgaris	common barberry
Elaeagnus umbellata	autumn olive
Frangula alnus	glossy buckthorn
Ligustrum vulgare	European privet
Lonicera maackii	Amur honeysuckle
Lonicera tatarica	Tatarian bush honeysuckle
Lonicera x *bella*	Showy fly honeysuckle
Lonicera morrowii	Morrow's honeysuckle
Rhamnus cathartica	common buckthorn
Rosa multiflora	multiflora rose
Spiraea japonica	Japanese meadowsweet
Viburnum opulus	European cranberrybush
Acer platanoides	Norway maple
Ailanthus altissima	tree-of-heaven
Albizia julibrissin	silktree
Elaeagnus angustifolia	Russian olive
Melaleuca quinquenervia	punktree
Melia azedarach	Chinaberry
Paulownia tomentosa	princesstree
Robinia pseudoacacia	black locust
Tamarix ramosissima	saltcedar
Triadica sebifera	tallow tree
Ulmus pumila	Siberian elm
Celastrus orbiculatus	oriental bittersweet
Hedera helix	English ivy
Lonicera japonica	Japanese honeysuckle

Finley 2005). Understory flora can include both invasive and non-invasive plants, as well as exotic and native species, thus complicating the analysis of impacts. Combining invasive survey data with vegetation profile estimates of cover and advance tree seedling regeneration (ATSR) data provides a useful characterization of forest understory vegetation. To illustrate, the following list shows a simple, but useful, breakdown of commonly found species:

- Native/non-invasive: witch-hazel (*Hamamelis virginiana*), lowbush blueberry (*Vaccinium angustifolium*)
- Native/invasive: hay-scented fern (*Dennstaedtia punctilobula*), grape vine, (*Vitis vinifera*)
- Exotic/non-invasive: dandelion (*Taraxacum officinale*)
- Exotic/invasive: Garlic mustard (*Alliaria officialis*), Japanese stiltgrass (*Microstegium vimineum*), oriental bittersweet (*Celastrus orbiculatus*), and tree-of-heaven

The NRS-FIA invasive species and vegetation profile tallies address a broad range of needs. However, some filtering is suggested for concise analyses, e.g., screen out the native species from the list of invasive plants. The vegetation indicator and its use are well described by Schulz and others (2009).

Nearly all of the invasive plants on the NRS-FIA list are exotic species (USDA Forest Service 2012), but some native species are included, such as black locust (*Robinia pseudoacacia*). Some highly invasive native species, such as rhizomatous fern in the Mid-Atlantic region, are absent thus limiting scope. This complicates the analysis, but does not preclude development of indices of "invasive-ness," and "native-ness" of understory vegetation. To illustrate, Figure 1 depicts the invasive survey nested within the vegetation profile and includes most of the growth habits encountered. The computations are relatively simple, but cover estimates must be adjusted to account for overlap since total cover can be greater than 100 percent:

- Vegetation other than trees = total cover *minus* cover of tally trees
- Invasive-ness = invasive plant cover/vegetation other than trees
- Native-ness = native plant cover/vegetation other than trees.

Other potential analyses include indices for special studies of ecoregions, major forest types or species, or areas of forest health concern. Assessments of wildlife habitat, biomass, forage availability, grazing potential, fuel loadings, and potential site productivity are other possible uses.

The advantages of the invasive survey include:

1. The methodology and list of invasive plants is consistent over time and space
2. The results can be used with results from other FIA regions to fill national needs; regional lists will differ
3. Estimates of invasiveness, native-ness, and other indices of interest can be derived

Since the invasive plant protocols are nested within the 24-foot radius subplot used for vegetation and tree monitoring, there are further advantages associated with the P2+ framework:

4. Fourfold increase in sample size, allowing finer-scale estimates and geo-spatial products
5. Cost reduction by limiting the time for measuring vegetation and invasive plants to 1 hour
6. Integration of all measurements of vegetation, including trees
7. Simplification of training and species identification
8. Allows development of new improved methods of estimating the competing vegetation layer, e.g., assigning more weight to woody vines that are found above 16 feet

Legend

- Tally Tree (> 5.0 inches DBH)
- Non-Tally Tree (> 5.0 inches DBH)
- Tally Tree (>= 1.0 inch length and < 5.0 inches d.b.h.
- Tally Tree (<1.0 inch HT)
- Exotic
- Vine (Woody)
- Vine (Non-woody)
- Sample footprint
- Shrub (> 0.5 meters)
- Shrub (< 0.5 meters)
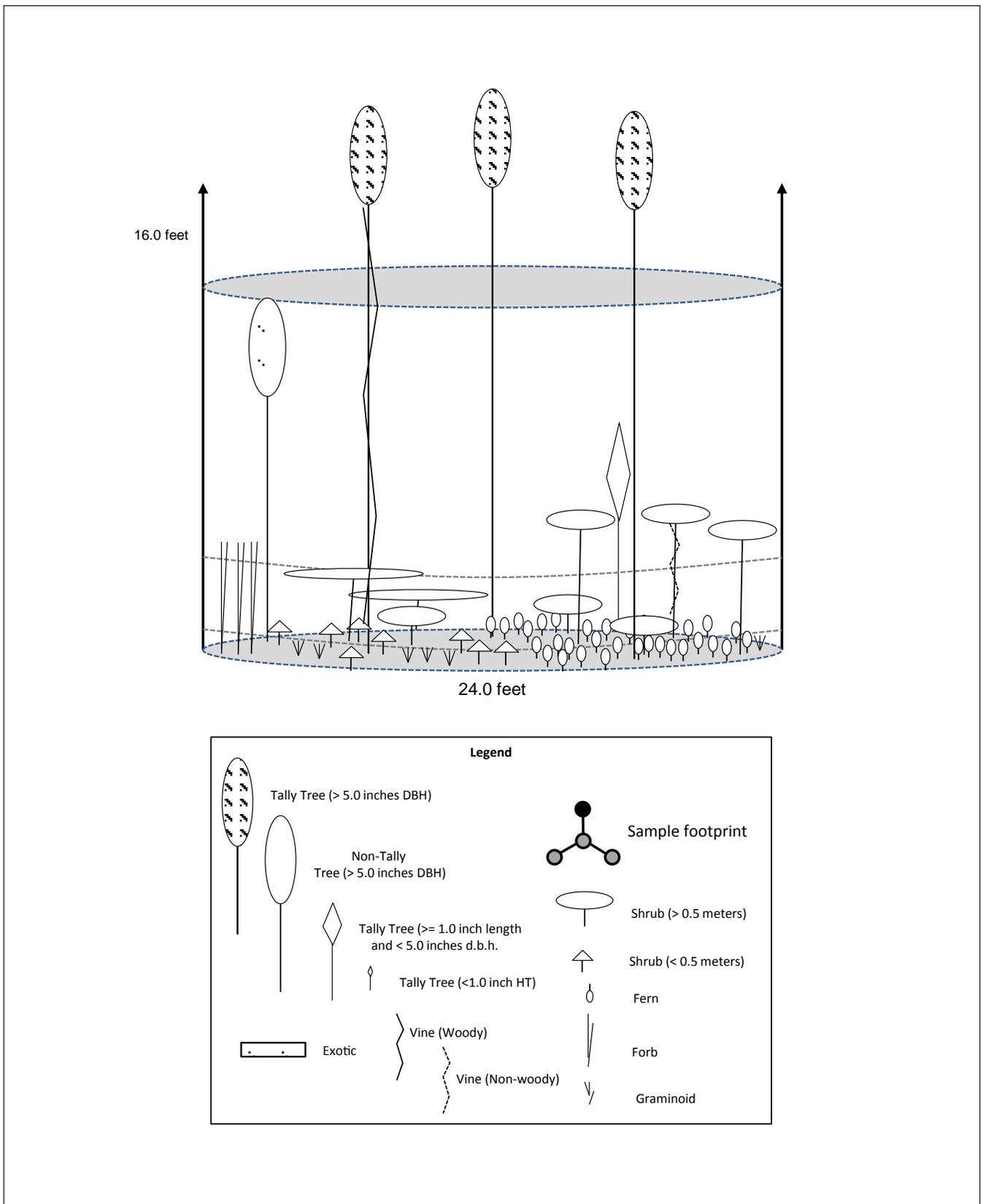- Fern
- Forb
- Graminoid

16.0 feet

24.0 feet

Figure 1.—Example of NRS-FIA nested vegetation samples, including the vegetation profile and exotic/invasive survey for a single FIA subplot.

Disadvantages of the invasive plant survey are generally limited to the technique that was used to define "invasive," a common issue in plant surveys:

1. The list is not complete and ignores several important regional species which limits full accounting of the impact on native flora

2. The list includes only three native species

3. The list includes species that are rare on forest land, e.g., purple loosestrife (*Lythrum salicaria*) that is a wetland obligate, and bull thistle (*Cirsium vulgare*) that occurs primarily on land other than forest

The invasive protocols offer a flexible system for estimating occurrence and abundance that can be utilized to address a wide array of questions. The system will provide for core national products and novel regional analyses.

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