Wisconsin State Forests Continuous Forest Inventory: A Look at the First Year

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Abstract: *The demand for timely, consistent, and reliable forest inventory and monitoring information for Wisconsin's state forests has increased significantly. A wide range of publics and partners, including businesses, organizations, and citizens alike are well aware of the benefits of sustainable forestry and are working together to increase knowledge through an annual comprehensive forest inventory and monitoring program. In response, the Wisconsin Department of Natural Resources (WDNR) and the National Inventory and Monitoring Applications Center (NIMAC) of the U.S. Forest Service, Forest Inventory and Analysis (FIA) program have developed a Wisconsin State Forest Continuous Forest Inventory (WisCFI) program for the 518,680 acres of land distributed across 10 state forests. To accomplish the monitoring objectives of the WDNR, NIMAC designed a survey of approximately 3,145 FIA-like plots to be measured over 5 years (1 plot per 165 acres). A limited suite of summer only variables (soils, understory vegetation, down woody materials, and crowns) will be measured on one-third of the plots. The first panel of data was collected in 2007. We used this first panel to describe the benefits of the intensification on the precision of forest-level estimates for state forest land. Additionally, estimates of species richness were compared for plots where introduced species were present versus those where they were absent.*

Keywords: continuous forest inventory, intensification, forest health, introduced species, species richness

Introduction

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The demand for timely, consistent, and reliable forest inventory and monitoring information for Wisconsin's state forests has increased significantly. A wide range of publics and partners, including businesses, organizations, and citizens alike are well aware of the benefits of sustainable forestry and are working together to increase knowledge through an annual comprehensive forest inventory and monitory program. The Wisconsin Department of Natural Resources (WDNR) is directed to protect and sustainably manage state forests to provide ecological, economic, and social benefits for current and future benefits (Wisconsin State Stature 28.04). Forest certification on state forest lands makes a continuous forest inventory an even more critical need. Additionally, managers face an increasing number and type of issues.

The WDNR and the National Inventory and Monitoring Applications Center (NIMAC) of the U.S. Department of Agriculture, Forest Service's Forest Inventory and Analysis (FIA) program have developed a Wisconsin State Forest Continuous Forest Inventory (WisCFI) program for the 518,680 acres of land distributed across 10 state forests (Table 1 and Fig. 1). The primary purpose of the WisCFI is to collect and report on the condition of the forest in a statistically sound manner on an annual basis for each state forest. The information will be used to track the status and trends in forest extent, cover, growth, mortality, habitat, and overall health. The WisCFI will provide unbiased, reliable information at the property level that will assist in planning, management, and monitoring. Because the method is parallel to FIA methods, the inventory will be able to address regional trends. Other goals of the WisCFI include providing information on the condition and health of the forest and tracking changes over time; integrating data, methods, and tools in the planning and decision-making processes; developing and maintaining data input, models, and methods for forestry analysis and planning; and developing up-to-date and easy-to-use information products and services for land managers and the public.

Table 1: Name and area of each Wisconsin state forest

State Forest Property	Acres
Black River State Forest	67,809
Brule River State Forest	40,881
Coulee Experimental Forest	2,972
Flambeau River State Forest	90,281
Governor Knowles State Forest	19,910
Northern Highland American Legion State Forest	223,294
Kettle Moraine State Forest - Northern Unit	29,275
Kettle Moraine State Forest - Southern Unit	20,939
Peshtigo River State Forest	5,871
Point Beach State Forest	2,902

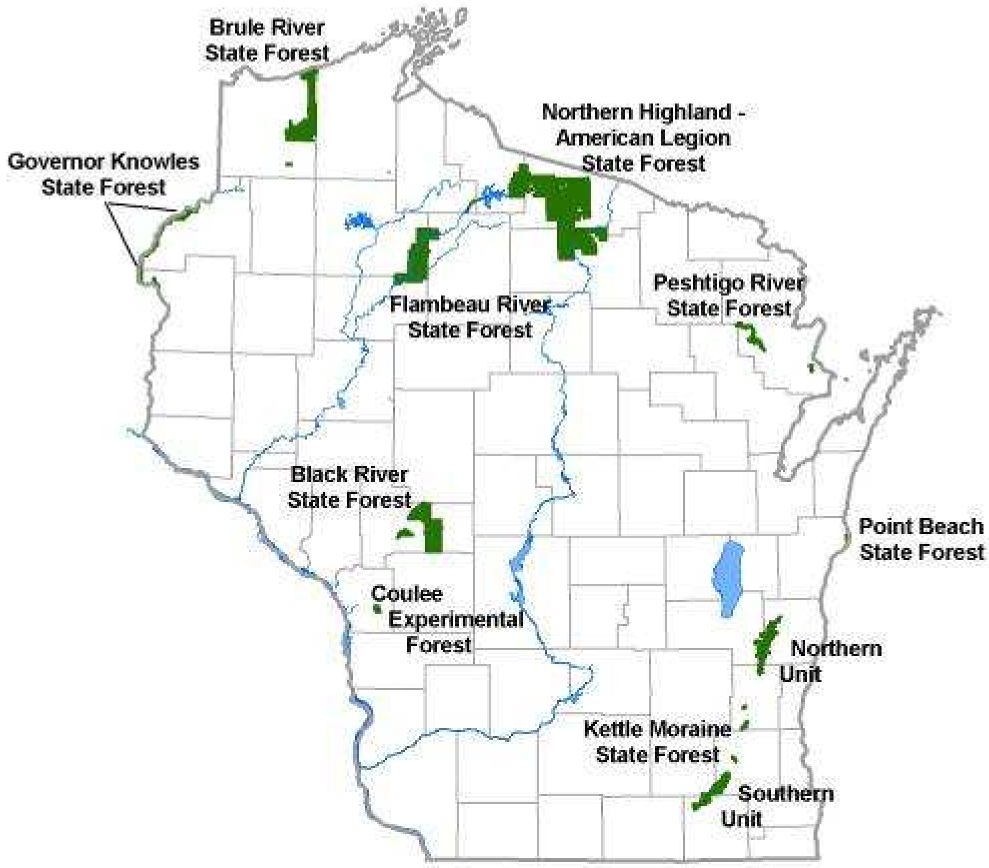

Figure 1: Map of Wisconsin's state forests.

The purpose of this study was to analyze the first year of data collected in the WisCFI to describe the benefits of the increased plot intensity (as compared to the FIA plot sample) on the precision of selected coarse forest-level estimates for state forest land. Additionally, estimates of understory species richness were compared among plots stratified by the presence of introduced vegetation species. Because these analyses are based on only one year of field data, the results are preliminary and incomplete. They are meant to illustrate the potential utility of the WisCFI.

Methods

The WDNR is using methods similar to the Forest Inventory and Analysis (FIA) program to conduct the WisCFI (U.S. Forest Service 2006 a, b). The FIA program of the U.S. Forest Service, the only congressionally mandated national inventory of U.S. forests, conducts a three-phase inventory of forest attributes of the country (Bechtold and Patterson 2005). The FIA sampling design is based on a tessellation of the United States into hexagons approximately 2,428 ha in size with at least one permanent plot established in each hexagon. In phase 1, the population of interest is stratified and plots are assigned to strata to increase the precision of estimates. In phase 2 (P2), tree and site attributes are measured for forested plots established in each hexagon. Phase 2 plots consist of four 24-ft fixed-radius subplots on which standing trees are inventoried, and phase 3 (P3) plots include an extended suite of forest health measurements. The WDNR elected to reduce the number of subplots from four to two to maximize field efficiency and precision of estimates.

To accomplish the monitoring objectives of the WDNR, NIMAC designed a survey of approximately 3,145 FIA-like plots to be measured over 5 years (1 plot per 165 acres). A limited suite of summer only P3 variables (soils, understory vegetation, down woody materials, and crowns) will be measured on one-third of the plots. This results in a 36x intensification of P2 plots and a 193x intensification of P3 plots.

The WisCFI surveyed 628 P2 plots in 2007. Estimates and sampling errors were generated separately for forest area (acres), net volume of all live trees on forest land (ft^3), and net volume of white pine on forest land (ft^3) using both the WisCFI plots (measured in 2007), the standard FIA P2 plots (measured in 2007 only), and the standard FIA P2 plots (measured in 2003-2007). The resulting estimates and sampling errors were evaluated.

The origin of each understory species sampled in the 200 P3 plots measured in 2007 was identified using the Natural Resources Conversation Service (NRCS) PLANTS database (USDA 2008). Total species richness, native species richness, and introduced species richness per plot were calculated for each state forest in Wisconsin, and the mean richness values were examined for spatial trends. Additionally, the mean native species richness values were compared for plots where introduced species were present versus those where they were absent for all state forest land.

Results

Forest Area and Volume Estimation

The state forests in Wisconsin cover 518,650 acres. In 2007, the WisCFI surveyed 628 P2 plots (of 3,145 projected for the complete 5-year inventory cycle), and the FIA program visited 19 plots on state forest-owned land as a part of the standard annual inventory system. When the entire 5-year annual inventory of Wisconsin (2003-2007) is included, the number of plots increases to 189. The single-year FIA estimate of forest land is within 10 percent of the WisCFI estimate, but the sampling error is nine times higher (Table 2). When the full cycle of FIA plots is used the estimate rises to within five percent of the WisCFI 1-year estimate, and the sampling error is reduced to 2.4 times the sampling error on the WisCFI 1-year estimate (Table 2).

The single-year FIA estimate of net volume of all live trees is only 1 percent higher than the WisCFI 1-year estimate, but the sampling error is more than five times higher (Table 2). When the full cycle of FIA plots is used the estimate decreases to 3.5 percent below the WisCFI 1-year estimate, but the sampling error is reduced to only two times the sampling error associated with the WisCFI 1-year estimate (Table 2).

The single-year FIA estimate of net volume of white pine is 83 percent lower than the WisCFI 1-year estimate, and the sampling error is nearly six times higher (Table 2). When the full cycle of FIA plots is used the estimate matches the WisCFI 1-year estimate, and the sampling error is only 1.3 times larger than the FIA sampling error (Table 2).

Table 2: Estimates and sampling errors of forest characteristics on State Forests in Wisconsin from WisCFI and FIA surveys

Variable	Survey	Estimate	Sampling Error
Acres of forest land	WisCFI (2007)	471,668 acres	1.1%
	FIA (2007)	422,730 acres	10.3%
	FIA (2003-2007)	450,238 acres	2.6%
Net volume of all live	WisCFI (2007)	654 million $ft.^3$	3.6%
	FIA (2007)	662 million $ft.^3$	18.6%
	FIA (2003-2007)	631 million $ft.^3$	6.3%
Net volume of white pine	WisCFI (2007)	98 million $ft.^3$	13.1%
	FIA (2007)	17 million $ft.^3$	75.9%
	FIA (2003-2007)	98 million $ft.^3$	17.5%

Understory Vegetation

The mean total species richness of vegetation plots is similar among most of Wisconsin's state forests (Fig. 2). A spatial trend is not evident, but there were some differences among the forests. The Black River, Point Beach, and Northern Highland-American Legion State Forests are the only forests that average fewer than 50 total species per plot.

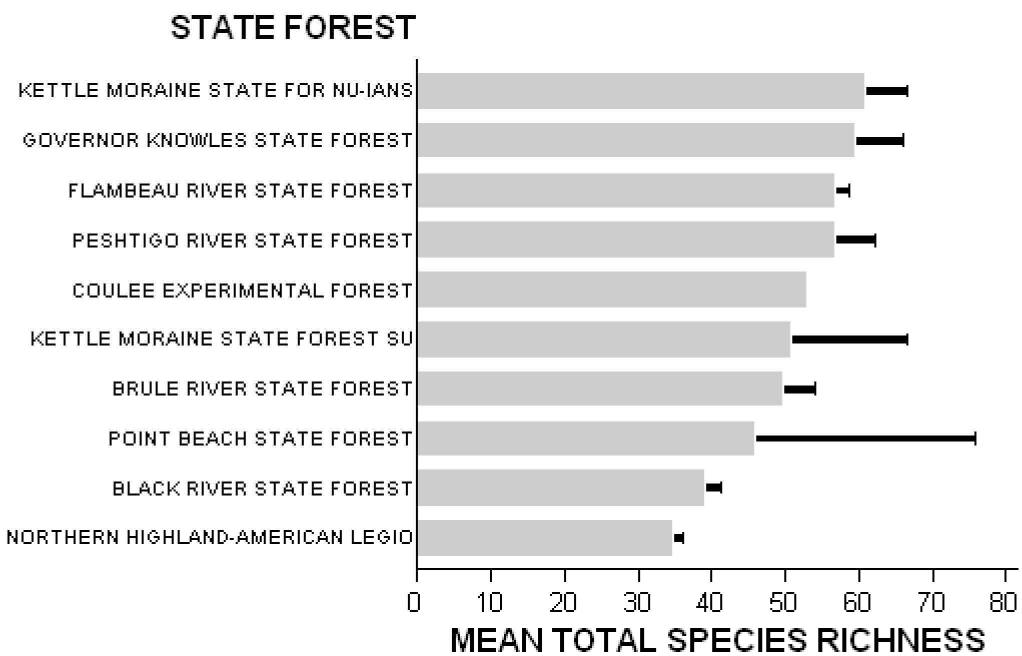

Figure 2: Mean total species richness per plot of understory vegetation by Wisconsin state forest, 2007.

Similarly, the mean native species richness of vegetation plots is similar among most of Wisconsin's state forests (Fig. 3). A spatial trend is not apparent, but the Black River, Point Beach, Kettle Moraine Southern Unit, and Northern Highland-American Legion State Forests are the only forests that average fewer than 42 native species per plot.

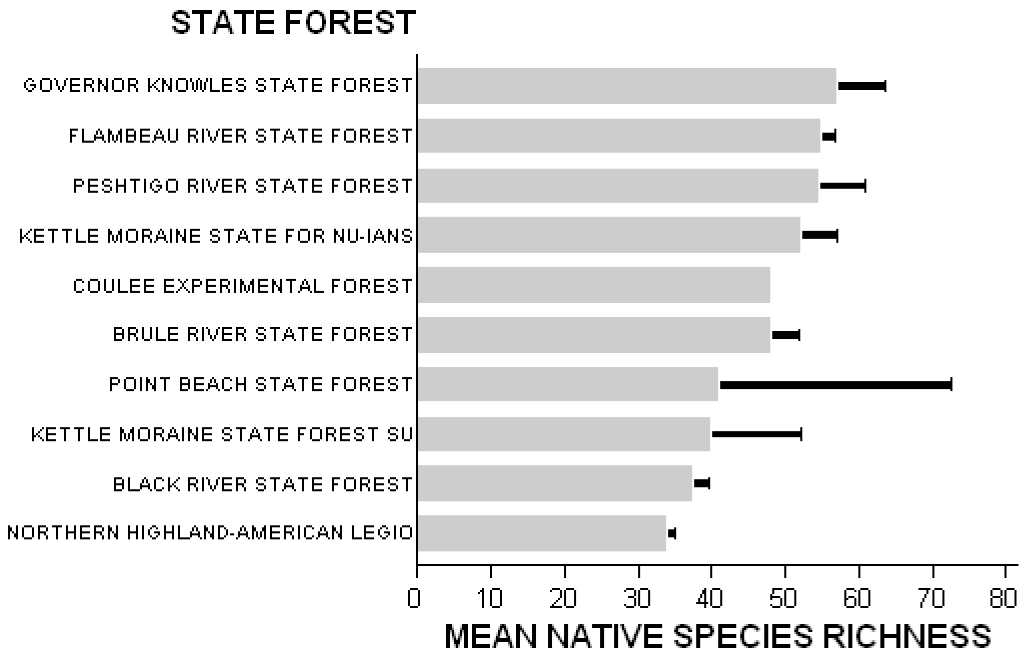

Figure 3: Mean native species richness per plot of understory vegetation by Wisconsin state forest, 2007.

By contrast, there are larger differences in the mean introduced species richness of vegetation plots in Wisconsin's state forests (Fig. 4). The mean introduced species richness on the northern and southern units of the Kettle Moraine State Forest is nearly double that on any of the other forests. There appears to be a spatial trend where state forests in the southern half of Wisconsin generally have higher mean introduced species richness values. The most common introduced species encountered were Japanese honeysuckle (*Lonicera japonica*), garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergii*), and several buckthorn species (*Rhamnus* spp. and *Frangula* spp.). Native species richness was higher on average when introduced species were present on plots (Fig. 5).

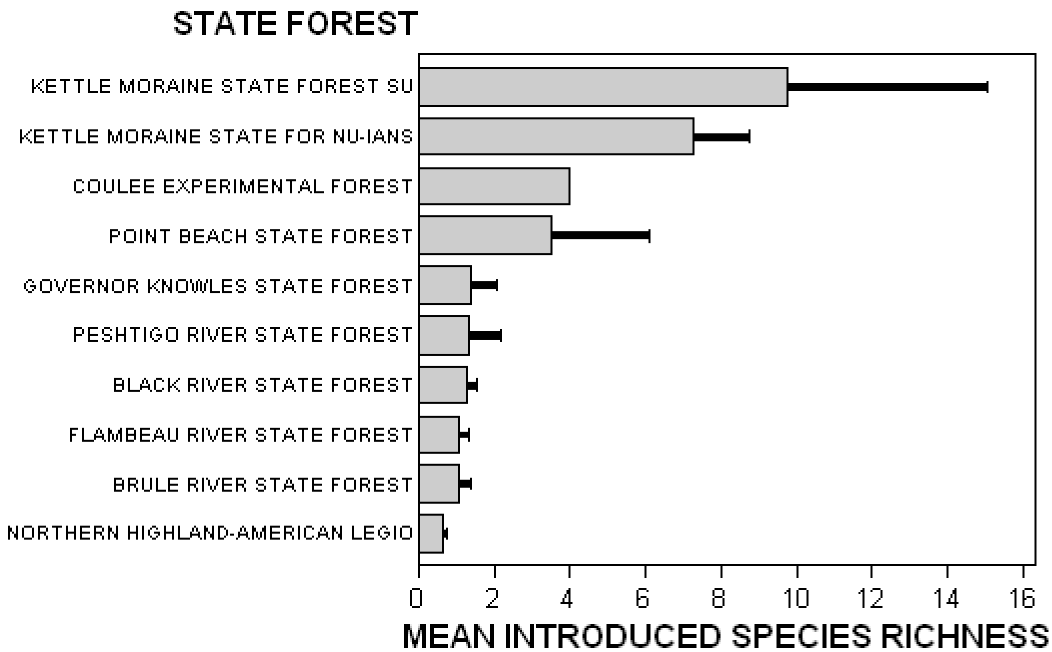

Figure 4: Mean introduced species richness per plot of understory vegetation by Wisconsin state forest, 2007.

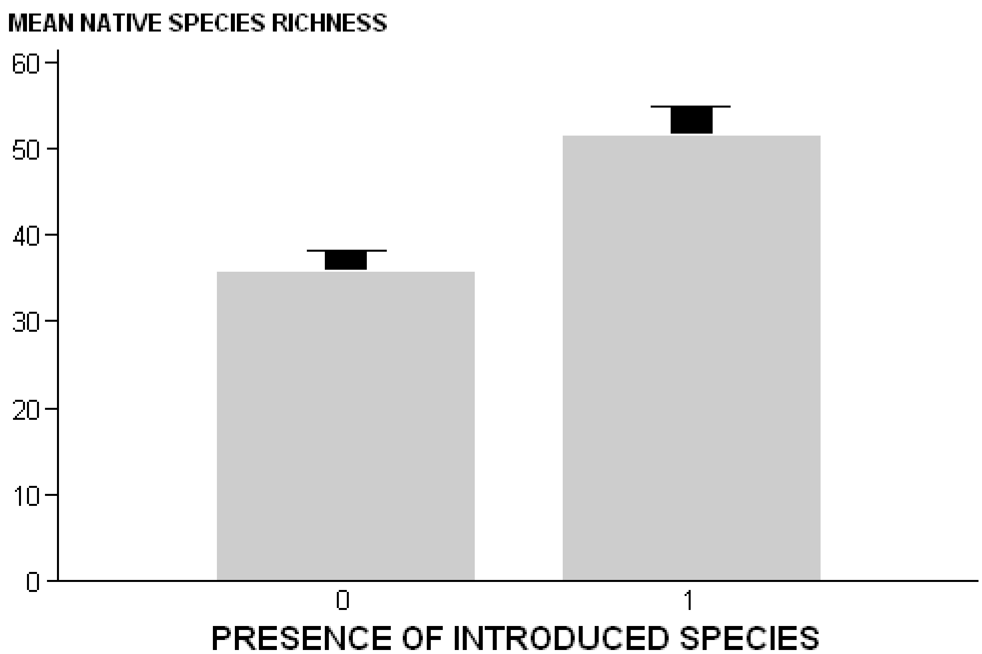

Figure 5: Mean native species richness per plot of understory vegetation by presence/absence of introduced species, Wisconsin state forests, 2007.

Discussion

The results of the estimation portion of the study indicate that a single year of WisCFI-intensified data yields more precise estimates that those generated from 1-year or a full 5-year cycle of FIA data (Table 2). Because the WisCFI is also on a 5-year cycle, year-to-year comparisons have the same sampling intensity as the two full 5-year cycles that will be achieved when the WisCFI is complete. Differences in sampling errors ranged from five times for net volume of live trees to nine times for forest land area. The precision of these estimates will improve as more data become available. In time, the WisCFI will allow for estimates of forest land, volume, and other important forest characteristics at the individual state forest level that would not be reasonable using the standard FIA grid because the sample is too limited.

Many introduced plant species have escaped and now exist in natural ecosystems in the United States, and some of those have displaced native plant species (Morse et al. 1995, Pimentel et al. 2000). To determine if the presence of introduced species is correlated with native species richness in the state forests of Wisconsin, we compared the average number of native species per plot. The plots were stratified by the presence and absence of introduced species. Total species richness and native species richness are similar among the Wisconsin state forests (Figs. 3, 4) and no spatial patterns are apparent. By contrast, there are differences in the mean introduced species richness of vegetation plots in Wisconsin's state forests (Fig. 4). There appears to be a spatial trend where state forests in the southern half of Wisconsin generally have higher mean introduced species richness values.

A widely recognized hypothesis that exotic species might more easily invade areas of low species diversity than areas of high species diversity has been supported by several studies (Case 1990, Stohlgren et al. 1999, Tilman 1997, Vitousek et al. 1996). Somewhat surprisingly, native species richness in our study was higher on average when introduced species were present on plots (Fig. 5). Other studies have yielded similar results where introduced species were more prevalent in areas of high native species richness (Huston and DeAngelis 1994, Stohlgren et al. 1999). In fact, Huebner et al. (2009) found a similar relationship between native species richness and presence of exotic species on the Allegheny National Forest in Pennsylvania using intensive FIA P3 plot data. However, disturbance may be a more important factor in invasibility than native species richness (Robinson et al. 1995; Ross et al. 2002).

Once completed, the WisCFI will provide more than 1,000 understory vegetation plots for analysis. Due to its high spatial intensity, this dataset will be statistically powerful and could be used for many purposes. A few suggestions are to re-visit the native species richness analysis with the full cycle of data (e.g., by forest type, stand size, disturbance, site quality, and/or forest fragmentation metrics), to study the effect of non-native invasive species on the distribution of native species, and to develop distribution maps of important, rare, and/or invasive plants for each state forest.

Literature Cited

Bechtold, W.A.; Patterson, P.L., eds. 2005. Forest Inventory and Analysis National Sample Design and Estimation Procedures. Gen. Tech. Rep. SRS-GTR-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 85 p.

Case, T.J. 1990. Invasion resistance arises in strongly interacting species-rich model competition communities. Proceedings of the National Academy of Science. 87: 9610–9614.

Huebner, C.D.; Morin, R.S.; Zurbriggen, A.; [et al.]. 2009. Patterns of exotic plant invasions in Pennsylvania's Allegheny National Forest using intensive Forest Inventory and Analysis plots. Forest Ecology and Management. 257: 258–270.

Huston, M. A.; DeAngelis, D. L. 1994. Competition and coexistence: the effects of resource transport and supply rates. American Naturalist. 144: 954–977.

Morse, L. E.; Kartesz, J. T.; Kutner, L. S. 1995. Native vascular plants. In: LaRoe, E. T.; Farris, G. S.; Puckett, C. E.; [et al.], eds. Our living resources: a report to the Nation on the distribution, abundance, and health of US plants, animals, and ecosystems. Washington, DC: U.S. Department of the Interior, National Biological Service: 205–209.

Pimentel, D.; Lach, L.; Zuniga, R.; [et al.]. 2000. Environmental and economic costs of nonindigenous species in the United States. BioScience. 50(1): 53–65.

Robinson, G.R.; Quinn, J.F.; Stanton, M.L. 1995. Invasibility of experimental habitat islands in a California winter annual grassland. Ecology. 76: 786–794.

Ross, K. A.; Fox, B.J.; Fox, M.D. 2002. Changes to plant species richness in forest fragments: fragment age, disturbance and fire history may be as important as area. Journal of Biogeography. 29: 749–765.

Stohlgren, T.J.; Binkley, D.; Chong, G.W.; [et al.]. 1999. Exotic plant species invade hot spots of native plant diversity. Ecological Monographs. 69(1): 25–46.

Tilman, D. 1997. Community invasibility, recruitment limitation, and grassland biodiversity. Ecology. 78: 81–92.

USDA NRCS. 2008. The PLANTS Database [online]. Available online at: http://plants.usda.gov [November 25, 2008].

U.S. Forest Service. 2006a. Forest Inventory and Analysis National Core Field Guide Volume I: Field Data and Analysis National Core Field Guide for Phase 2 Plots. Version 3.1. Northern Edition (modified for WisCFI). Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. 211 p.

U.S. Forest Service. 2006b. Forest Inventory and Analysis National Core Field Guide Volume I: Field Data and Analysis National Core Field Guide for Phase 3 Plots. Version 3.1. Northern Edition (modified for WisCFI). Unpublished paper on file at: U.S. Department of Agriculture, Forest Service, Northern Research Station, Newtown Square, PA. 89 p.

Vitousek, P. M.; D'Antonio, C. M.; Loope, L. L.; [et al.]. 1996. Biological invasions as global environmental change. American Scientist. 84: 468–478.