Identification and Control of Invasive Plant Species

2000 Annual Report

November 21, 2000

20900-RP-0012
Revision 0

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PURPOSE & SCOPE

The purpose of this research was to: (1) identify all vascular plant species present in the North Woodlot of the Fernald Environmental Management Project, (2) assess which species were non-indigenous and to evaluate their threat via relative abundance, (3) conduct a literature search for control methods, and (4) implement a 3-year experimental study on species control.

The design of this research called for a four-year timeline with two major phases. Phase-I (Objectives 1 and 2) was conducted in 1998 and 1999 and was directed primarily at the identification and evaluation of invasive species along with site reconnaissance and assessment of vegetation-environment relations. The final report for Phase-I was provided in the 1999 Annual Report. Phase-II was initiated in the spring of 1999 and planned to run through the end of the field season of 2001. Thus, most of the effort during 2000 consisted of monitoring the Amur honeysuckle control experiment established in 1999 and is thus the primary focus of this report.

METHODS, PROGRESS, and RESULTS

The experimental study of Amur honeysuckle removal was designed to investigate how the native understory of hardwood species might best be restored. Here we review the rationale, design, and implementation of this experiment and present our results from the 1999 and 2000 field seasons.

Amur honeysuckle is one of the most problematic invasive species in southwestern Ohio. This species has come to dominate the understory and midstory of many hardwood stands both locally at FEMP, and regionally. Numerous studies have shown that this plant can reduce the natural germination, recruitment, and growth of native trees and herbs (Luken 1990, Nyboer 1992, Luken and Goessling 1995, Luken and Thieret 1996, Hutchinson and Vankat 1997). The net result is an overall reduction in biodiversity, both locally and regionally, as well as disruption to a variety of ecosystem functions (Luken and Mattimiro 1991, Luken et. al. 1997).

There were three specific goals of this experiment: (1) to evaluate the efficacy of methods to control Amur honeysuckle (2) to compare the survival and growth of six species of native tree seedlings planted in plots where honeysuckle was subjected to different eradication measures, and (3) to evaluate the effectiveness of plastic browse tubes to control deer herbivory on planted 1-year tree seedlings.

This experiment was established as a completely randomized block design (Sokal and Rohlf 1995). This is the most appropriate design when dealing with heterogeneous forest conditions. Eight, 5.5 × 13.5 m blocks were established throughout two stands on the eastern side of the North Woodlot. Each block was then fenced with two strands of barbwire below 1 m to exclude cattle but not deer. Each block was sub-divided in to three equal sized plots and treatments were randomly assigned to each plot. The treatments consisted of an experimental "control" (no manipulation of honeysuckle), and two eradication treatments, "cut" (honeysuckle was cut at ground level and removed from the plots, then stumps were painted with herbicide), and "injection" (honeysuckle was killed in plots via herbicide injection, but left standing *in situ*). In each treatment plot, ten seedlings of the following six species of native trees were planted: Chinquapin oak (*Quercus muehlenbergii*), black walnut (*Juglans nigra*), black cherry (*Prunus serotina*), green ash (*Fraxinus pennsylvanica*), flowering dogwood (*Cornus florida*), and redbud (*Cercis canadensis*). All six species are known from the flora of the Northern Woodlot (see appendix for species list); therefore, these species were appropriate selections for restoration efforts at FEMP. Deer browse tubes were added to half of the seedlings in each plot. As per FEMP regulations, the maintenance crew applied the cut and injection treatments to the appropriate plots (March 24, 1999) and planted the seedlings (March 24, 1999 to March 30, 1999). The crew also staked and applied the browse tubes to the tree seedlings (March 31, 1999 to April 13, 1999).

To determine if honeysuckle was equally abundant in all plots prior to treatment application, we constructed a regression model from plants harvested on site. Basal diameter was able to explain a significant portion of the variance in biomass (N=32 plants, $R^2 = 0.99$). Thus, basal diameter measurements were collected for all honeysuckle plants in all treatment plots. Subsequently, an analysis of variance indicated that there was an equivalent biomass of honeysuckle in all blocks and all treatment plots ($P > 0.10$). Thus, we were able to confirm at the beginning of the experiment that there were no pretreatment differences in honeysuckle biomass that needed to be considered prior to implementation of the design.

Within blocks, all honeysuckle plants were tagged to facilitate subsequent monitoring of treatment efficacy and evaluation of any new honeysuckle recruits (untagged) in to the blocks. All tree seedlings were also provided with a numbered aluminum tag to monitor individual survival, growth, and recruitment. Initial height and diameter of all tree seedlings were measured at the beginning of the experiment to determine if seedlings were homogenous in size distributions across all blocks and plots. The size (height and diameter) of tree seedlings was not found to differ significantly ($P > 0.10$) among blocks or plots.

A number of microenvironmental factors were also analyzed to understand the variation among blocks and conditions affecting the tree seedlings in treatment plots. Soils were assessed for moisture, nitrate nitrogen, and pH (in both 1999 and 2000). All soil analyses were conducted at the Forest Ecology Laboratory at Ohio University using the methods of McCarthy (1997).

Soil moisture (Fig. 1D) was examined three times during the growing season of 1999 (May 30, June 25, and August 21, 1999) and twice during 2000 (July 29 and August 29). Percent soil moisture was determined gravimetrically. Some blocks were found to be significantly ($P < 0.05$) wetter than others in 1999. This same pattern held true in 2000. As expected, there was a significant ($P < 0.05$) year effect in the model because considerably more moisture was available in the growing season of 2000. There was no year × block interaction for moisture indicating that drier blocks are drier, regardless of year.

Nitrate nitrogen (Fig. 1B) was sampled using Rexyn-300 resin enclosed in nylon mesh bags buried in the A-horizon for 30 days. Nitrate was then extracted from the resin using 2M KCl and analyzed for nitrate concentration using a cadmium reduction protocol (McCarthy 1997). Like moisture, there was a significant ($P < 0.05$) year effect and block effect, but no significant interaction. Again, this suggests that nitrogen levels vary from year to year (likely associated with the below average moisture availability in the growing season of 1999 and lower soil biological activity) and from block to block, but that this pattern is consistent over time (i.e., blocks low in nitrate one year are also low in nitrate the next). Thus, the relative relationships of soil fertility among blocks seem relatively stable.

The pH (Figure 1C) was determined by using a corning pH meter in a 1:1 soil and water solution. Likewise, pH exhibited a significant ($P < 0.001$) block and year ($P < 0.001$) effect, but no interaction. Understory light conditions (Figure 1A) were measured indirectly using hemispherical photography. Canopy images were captured on 35 mm film (July 30, 1999, and July 27, 2000) using a hemispherical fisheye lens (8mm), digitized, and evaluated using the GLIC software of Canham (1988). This is one of the few methods that adequately describes both direct and indirect solar radiation available at ground level. A full description of the protocol can be found in Robison and McCarthy (1999). There was no difference in canopy coverage from year to year (as expected), but the same pattern of block effect was observed in 2000 as seen in 1999.

Overall, we found that the microenvironment differed among blocks and between years. The block pattern was well established in 1999. Blocks 1-5 are environmentally different than 6-8 (each set is in separate but adjacent stands with slightly different soil types, history, and presence of an upslope seep in the latter). The moisture conditions during much of the 1999 growing season were quite low (NOAA 2000) and Palmer

Drought Severity Indices regularly fell below –3.0. The growing season of 2000 was much more typical with PDSI values within the range of |1|. Thus, we expected a change in conditions between the two years and this was borne out. Interestingly, despite the drought of 1999, there were no significant year × block interactions. From this, we can conclude that there is little value in continuing microenvironmental monitoring during 2001 and propose that this segment be dropped with attention turned towards honeysuckle monitoring and seedling survival and growth assessment.

Mortality of honeysuckle in the two treatment plots was found to be 99 percent at the end of the 1999 growing season. At the end of the 2000 growing season, 98% of the stems remained dead in the injection treatment and 94% in the cut and paint treatment (due to resprouting). This is slightly different from appearances in the field, because misapplied injection treatments were not counted (i.e., when there was obvious operator error because the stem was too narrow to be injected or the capsule did not make solid contact and glanced along the edge it was not counted). Still, given that there was no significant ($P > 0.10$) difference between the two eradication methods in either 1999 or 2000, and given the expediency and cost effectiveness of the injection method, this remains as the most economical means of controlling honeysuckle, particularly for large plants. Small plants will still require a cut and herbicide approach.

In addition to the initial measurements, the 1,440 experimental seedlings were monitored at two times during the 1999 (May 27-28, 1999 and October 10-11, 1999) and 2000 (May 21-22, 2000 and September 23-24) growing seasons to assess survivorship. We examined each seedling, determined whether it was alive or dead (via a top-kill designation) and noted mode of mortality, if relevant. By the end of the first growing season, seedling mortality was ca. 50%. Only an additional 7% of seedlings died during 2000 (Figure 2A). This is likely explained by the differences in moisture availability from one year to the next and the stability of established seedlings.

As in 1999, we also noted differential survival among blocks, treatments, species, and tubed seedlings in 2000 (Figure 2); in fact, the patterns reported in the 1999 Annual Report remain virtually unchanged (i.e., the survivorship response remains consistent across treatment combinations). The differences among blocks (Figure 2B) can be attributed to environmental heterogeneity (Figure 1). Survival trajectories remained indistinguishable for all species (Figure 2C); i.e., the relative ranking in survival is the same. Survival remains highest in the two treatment categories relative to the un-manipulated control (Figure 2D) and survival remains slightly greater in the un-tubed treatments, especially for redbud, dogwood, black walnut, and black cherry.

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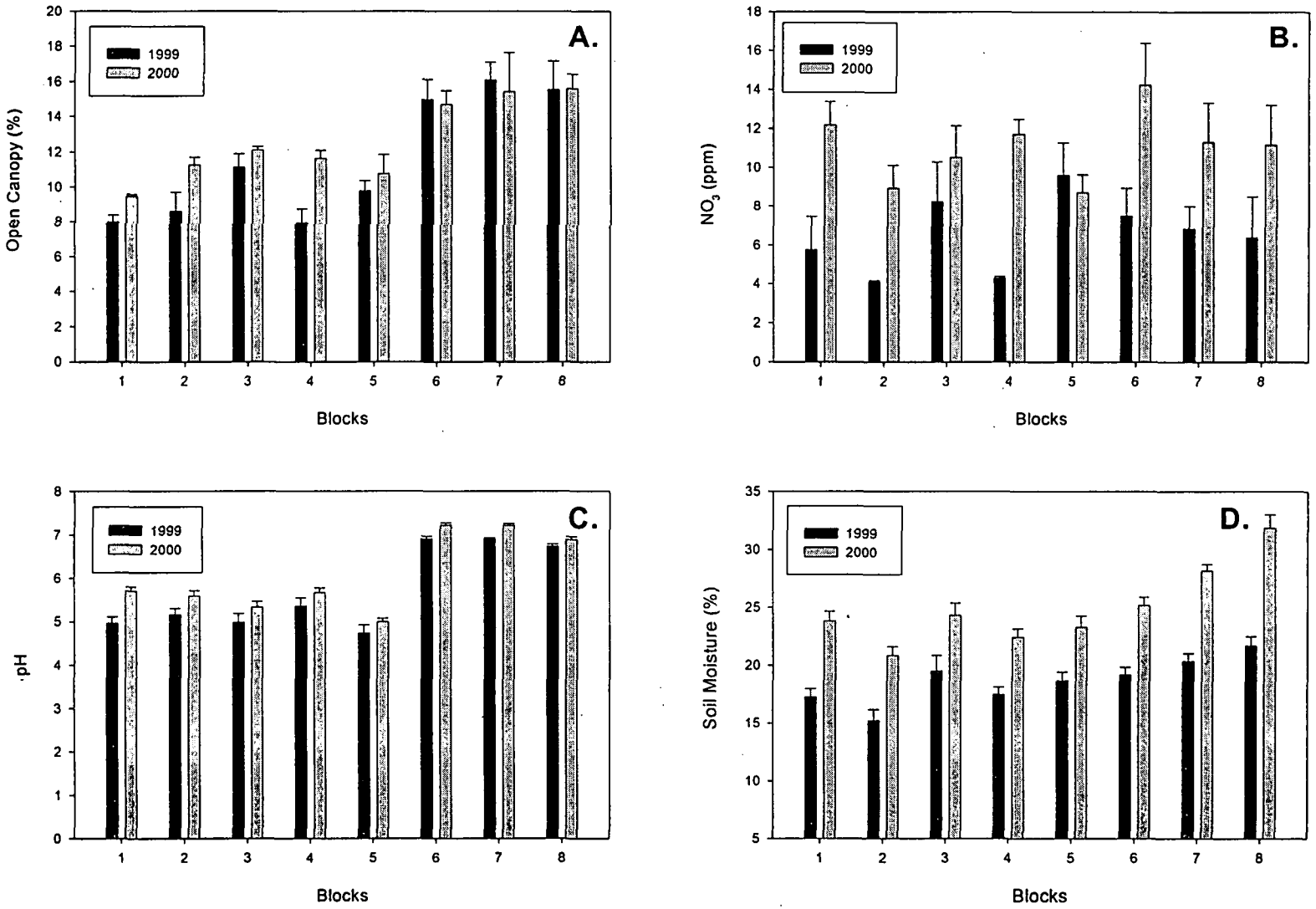

Figure 1. Mean (± SE) of measured microenvironmental variables on the 8 experimental blocks in the North Woodlot of FEMP for 1999 and 2000.

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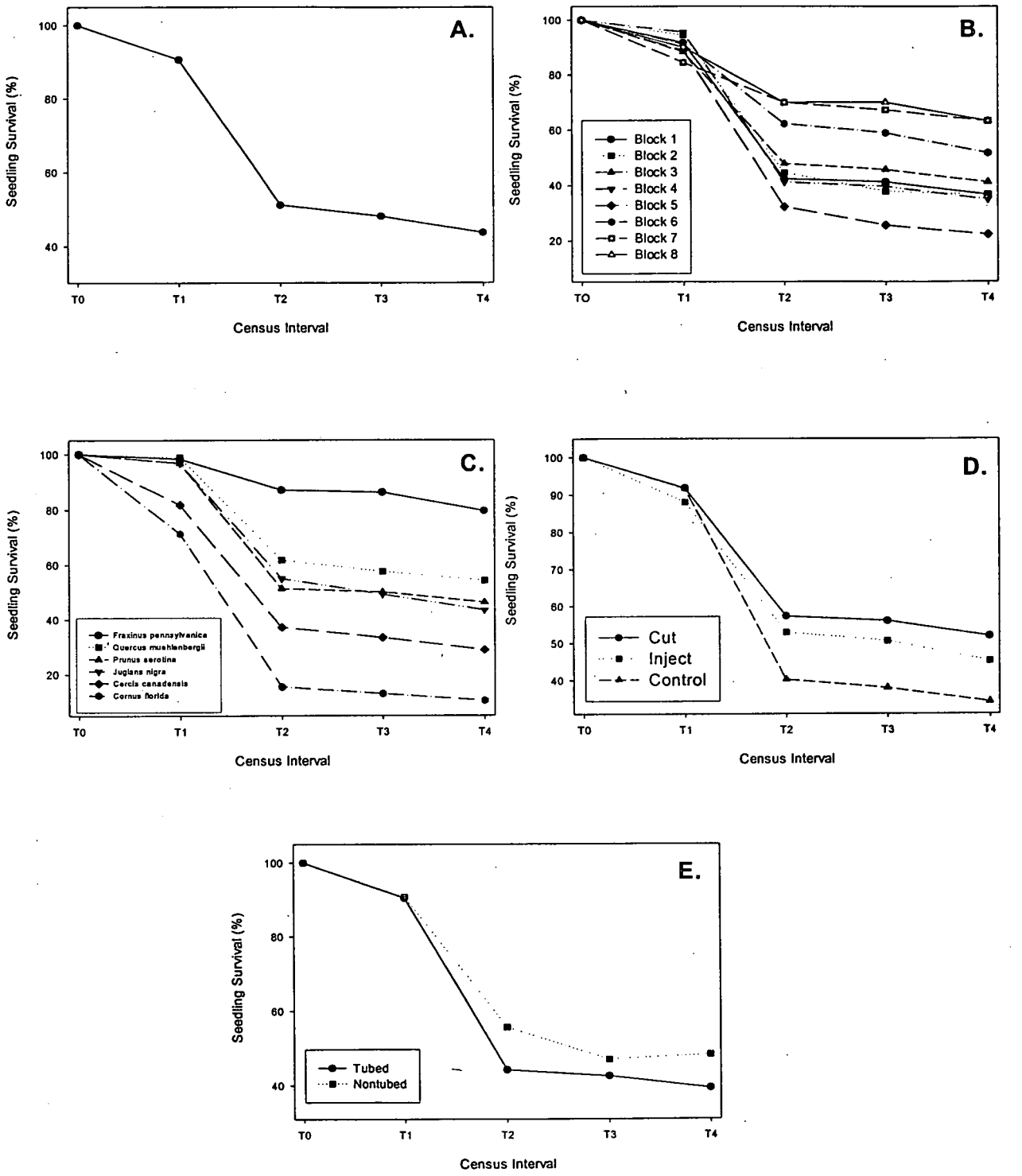

Figure 2. Cumulative survival (%) by treatment category. Census intervals are: T0 (time of planting), T1 and T2 are spring and summer 1999, respectively; T3 and T4 are spring and summer 2000, respectively.