Chinese Privet (*Ligustrum sinense*) Removal and its Effect on Native Plant Communities of Riparian Forests

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Chinese privet is a major invasive shrub within riparian zones throughout the southeastern United States. We removed privet shrubs from four riparian forests in October 2005 with a Gyrotrac® mulching machine or by hand-felling with chainsaws and machetes to determine how well these treatments controlled privet and how they affected plant community recovery. One year after shrub removal a foliar application of 2% glyphosate was applied to privet remaining in the herbaceous layer. Three ''desired-future-condition'' plots were also measured to assess how well treatments shifted plant communities toward a desirable outcome. Both methods completely removed privet from the shrub layer without reducing nonprivet shrub cover and diversity below levels on the untreated control plots. Nonprivet plant cover on the mulched plots was > 60% by 2007, similar to the desired-future-condition plots and higher than the hand-felling plots. Both treatments resulted in higher nonprivet plant cover than the untreated controls. Ordination showed that after 2 yr privet removal plots were tightly grouped, suggesting that the two removal techniques resulted in the same plant communities, which were distinctly different from both the untreated controls and the desired-future-condition. Both treatments created open streamside forests usable for recreation and other human activities. However, much longer periods of time or active management of the understory plant communities, or both, will be required to change the forests to typical mature forest plant communities.

Nomenclature: Glyphosate; Chinese privet, *Ligustrum sinense* Lour.

Key words: Nonnative, invasive, exotic, restoration, diversity, species richness.

Although most alien plants were introduced to North America for beneficial reasons, as many as 5,000 species have now escaped cultivation and are established in native landscapes (Pimentel et al. 2000). Riparian areas worldwide are particularly vulnerable to invasion by alien plants due to frequent disturbances from periodic flooding that favor high species richness (Hood and Naiman 2000; Hulme and Bremner 2006; Planty-Tabacchi et al. 1996; Pyšek and Prach 1994). These areas are important because the vegetation along streams controls the flow of water, nutrients, and sediments into streams, and stream corridors enable species movement (Hood and Naiman 2000 and references therein).

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Chinese privet (*Ligustrum sinense* Lour.), is a common shade-tolerant evergreen shrub found invading riparian forests throughout the southeastern United States, where it often forms monotypic stands in the understory that crowd out native plants. A study of the Upper Oconee River floodplain in northern Georgia in 1999 found Chinese privet covering 59% of the floodplain, an 8% increase from a 1951 aerial survey (Ward 2002). In South Carolina, plots with abundant Chinese privet had less-diverse herbaceous and shrub layers compared to plots not yet invaded, and privet-infested plots had lower densities of tree seedlings indicating that Chinese privet negatively impacts forest regeneration (Kittell 2001). Likewise, Merriam and Feil (2003) found Chinese privet in North Carolina resulted in decreased plant species richness and abundance, and Wilcox and Beck (2007) found similar results in the Georgia piedmont.

Large-scale management options include chainsaw felling followed by stump treatment with herbicide, basal bark applications of herbicide in oil, and mowing followed later by foliar applications of herbicide to kill sprouts and seedlings. All of these options require a second-year foliar application to kill all seedlings and stump spouts. The most

Interpretive Summary

Chinese privet was removed from heavily infested streamside forests by either hand-felling followed by stump treatment with herbicide or grinding up the privet using a Gyrotrac® mulching machine. Both treatments resulted in complete removal of the privet shrub layer without damaging the remaining nonprivet shrubs, but neither method reduced the amount of privet in the herbaceous plant layer. A foliar herbicide application approximately 1 yr later in early winter 2006 reduced the herbaceous privet cover to less than 1% the following summer. Both treatments increased plant diversity compared to privet-infested control sites. Plots receiving hand-felling and mulching had similar plant communities, primarily composed of early colonizing plant species. However, these plant communities were very different from those on the untreated controls and on the reference forests that had never been infested with privet. Both treatments created open streamside forests usable for recreation and other human activities. However, much longer periods of time or active management of the understory plant community, or both, will be required to change the forest to a typical mature forest plant community.

commonly used method is chemical control. A study by Harrington and Miller (2005) found foliar herbicide control worked well when privet was treated in the dormant season, effectively killing it while most nontarget plants remain unharmed.

Thus far most studies of the impacts of privet invasion on ecosystems have relied on comparisons of infested areas to uninfested areas (e.g., Kittell 2001; Wilcox and Beck 2007). However, Levine and D'Antonio (1999) point out the difficulties in assessing why communities in these studies differ: infested and uninfested areas may have differed prior to invasion, and these differences could contribute to successful invasion, making it difficult to determine cause and effect. Hulme and Bremner (2006) found removal experiments were particularly useful for assessing the impacts of herbaceous nonnative plants on ruderal communities but cautioned that management might lead to compensatory increases in other nonnative species. Likewise, Rinella et al. (2009) showed that control of some invasive species may negatively affect remaining desirable species. Both of these studies focused on invasive herbaceous plants or grasses, but effects of removing invasive shrub species have also been reported (e.g., Hartman and McCarthy 2004; Kasmer and Shefferson 2002; Love and Anderson 2008; Miller and Gorchov 2004). Here we report on the effectiveness of two methods of controlling the invasive shrub, Chinese privet, in riparian forests of the Oconee River watershed near Athens, GA, and the effect of removal on initial plant community recovery. We compare our results thus far to reference plots with little or no privet as a method of assessing how treatments are affecting plant community recovery toward a desirable outcome.

Materials and Methods

Four study sites within the Oconee River watershed in northeastern Georgia (Figure 1) were selected based on their extensive privet infestations, access for machinery, and potential for public visitation and use in education and outreach programs. The sites were the Sandy Creek Nature Center on the North Oconee River north of Athens, GA; the Georgia State Botanical Gardens on the Middle Oconee River south of Athens; the Scull Shoals Experimental Forest on the Oconee River in the Oconee National Forest; and the University of Georgia Warnell School of Forest Resources' Watson Springs Forest, also along the Oconee River. Common overstory tree species in the treatment areas were ash (*Fraxinus* spp.), willow oak (*Quercus phellos* L.), sugarberry (*Celtis laevigata* Willd.), American sycamore (*Platanus occidentalis* L.), and loblolly pine (*Pinus taeda* L.). Within each site three homogeneous plots approximately 2 ha in size were located in areas with the heaviest privet infestation. All plots were located to provide at least a 10-m (33 ft) buffer of untreated area between the plot boundary and the stream bank to reduce stream edge effects on the plant communities and to minimize potential soil movement into the streams resulting from soil disturbance by heavy machinery.

We also selected three "desired-future-condition" plots on the Oconee National Forest near the Scull Shoals and Watson Springs treatment sites. Desired-future-condition plots were areas of mature riparian hardwood forest with little or no privet. These plots were used for comparison and as representatives of the forest type and plant community in the absence of privet. All plots were located at least 10 m from rivers. Two plots were in Greene County, GA: one plot along Harris Creek and a second adjacent to the Apalachee River; the third plot was next to Falling Creek in Oglethorpe County, GA. Only the Falling Creek plot had detectable levels of privet with 1.4% privet shrub cover and 0.35% privet cover in the herbaceous layer.

Treatments. Initial treatments were applied in October and November 2005 and consisted of mechanical removal of privet, hand-felling of privet, or no treatment. Specifics of the mechanical removal can be found in Klepac et al. (2007). Briefly, mechanical removal was done with a Gyrotrac® mulching machine[1] that had a 110-horsepower engine mounted on rubber tracks resulting in 4.2 psi ground pressure. The mulching head contained 24 flail-type teeth mounted on a horizontal shaft that rotated at 2,200 rpm. The contractor (GFA Land Clearing, Inc., Palm Bay, FL) was asked to remove all privet possible but

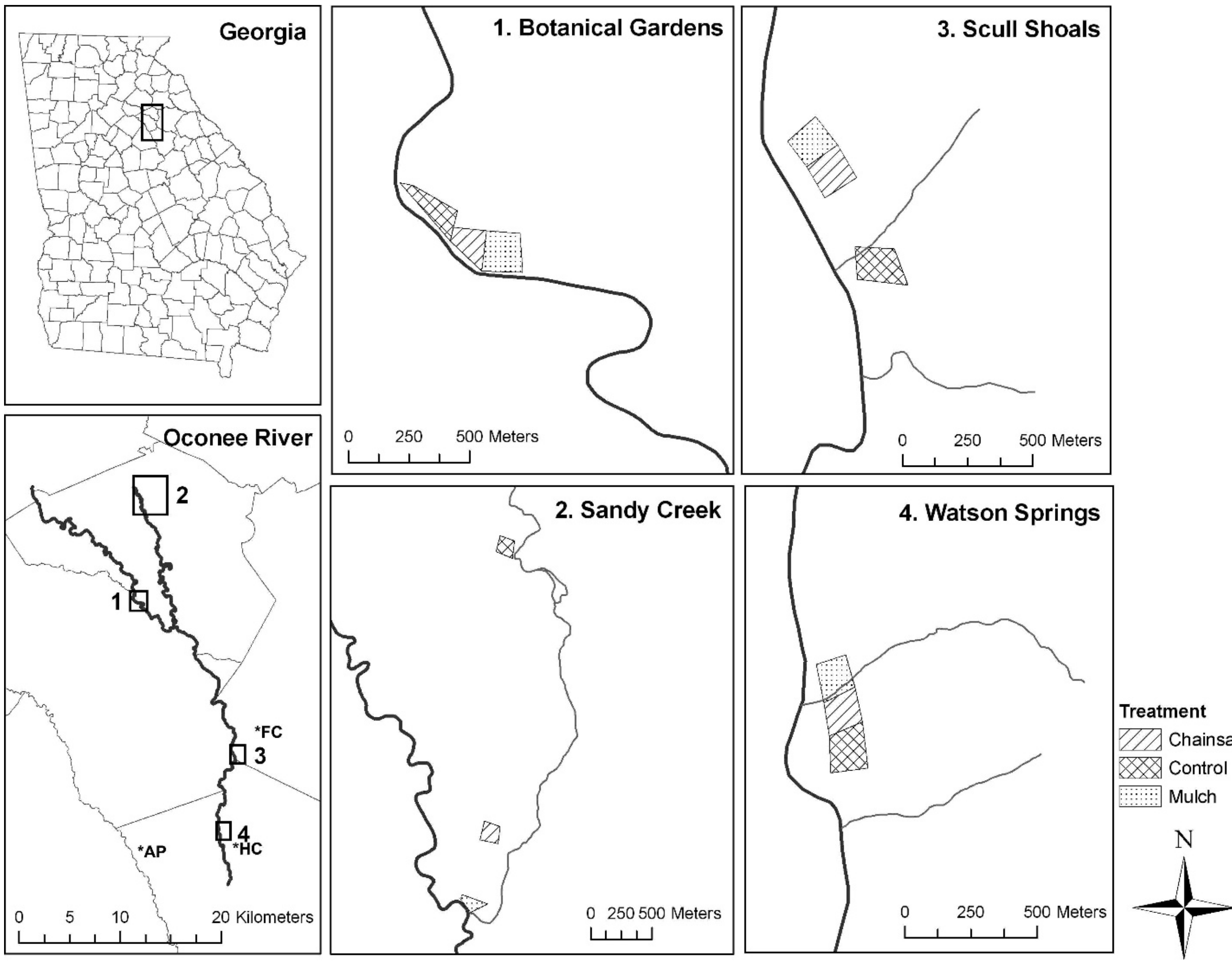

Figure 1. Maps showing the location of the study area in Georgia and the distribution of plots within each location. Desired-future-condition plots on Harris Creek (HC), Falling Creek (FC), and the Apalachee River (AR) are marked with asterisks.

to avoid removing trees 10 cm (4 in) or larger and all large logs lying on the ground because of the ecological importance of coarse woody debris. Initially we treated stumps on three of the sites with 30% triclopyr[2] (Garlon® 4). On the fourth site, the Oconee National Forest, stumps were treated with 30% glyphosate (Foresters'®) herbicide[3] at the request of the forest manager. The mulching machine ground stumps to the soil surface and covered them with mulch, making them difficult to find, so only about 5% of the stumps were treated. Also, because of the danger in working near the machine, stumps that could be found were treated up to 30 min after they were cut. This combination of factors limited the usefulness of stump treatments on machine-treated plots.

Hand-felling was accomplished using chainsaws, brush saws, or machetes depending on the size of the stem. All stems 1.5 cm diam or larger near ground level were cut and left in place. Large plants were cut up further so that the total height of the remaining brush was 1 m or less. The surfaces of cut stumps were treated with 30% triclopyr (three sites) or 30% glyphosate (Oconee National Forest site) herbicide immediately after cutting to reduce stump sprouting.

Following the initial treatments newly sprouted seedlings, root and stump sprouts, or seedlings and saplings, left because they were smaller than specified in the hand-felling contract, were abundant throughout the plots. In December 2006, both the mechanical and hand-felled plots were treated with a foliar spray of 2% glyphosate plus 0.5% nonionic surfactant[4] (Timberland 90®) applied with backpack sprayers[5] or Solo backpack mistblowers[6] to rid the plots of this low-growing privet layer. Approximately 300 to 800 L/ha of herbicide mixture were applied per plot depending on the amount of privet treated.

Data Collection. *Plant Diversity and Abundance.* The understory herbaceous plant community and shrub layer were surveyed on all plots in late June 2006 and 2007. Trees were surveyed in September 2007. Desired-future-condition plots were only sampled once in June 2006 because they were used as an example of what the composition of these forests should be, so we were not interested in how they changed. Herbaceous plant and shrub community surveys were completed at the same time using the line–point intercept method (Godinez-Alvarez 2009). Starting points for three permanent transects were located along one boundary of each plot so they were equidistant from one another and from the plot edges. Transects ran the complete length of the plot. During surveys we stretched a measuring tape along transects and stopped at every 1.5-m interval to record presence or absence of plants, plant species, and height. Shrub and tree sapling cover was measured at the same points and consisted of shrubs or small trees ($<$ 4 m tall) whose canopy extended over the sample point. Plants were identified to species or the lowest taxonomic level possible using field guides and taxonomic references. Plants not identified in the field were placed in a plant press and identified later.

Trees were surveyed on five permanent, fixed-size (0.04-ha; 0.1 ac) subplots within each plot. Subplots were located at plot centers and at half the distance from plot centers and plot corners. Within each subplot we identified trees and measured their diameters 1.4 m above ground for all trees $>$ 8 cm diam.

To measure the effect of privet infestation on tree abundance we recorded the level of privet infestation on each of the five subplots within the untreated control plots using a scale of 0 to 4, where 0 = no privet; 1 = some small privet, all less than 2.5 cm diam and $<$ 2 m in height; 2 = abundant privet with some stems $>$ 2 m in height but less than 2.5 cm diam; 3 = numerous privet plus some larger-diameter stems up to 3 m in height; and 4 = numerous large-diameter stems up to 3 m in height. Basal area and number of trees per subplot were compared to the level of privet infestation. Basal area is the cross-sectional area of the stems of all trees expressed as square units per unit area used to express the area of a given plot occupied by trees. Basal area for a tree was calculated from the diameter. Subplot basal area was the cumulative basal areas of all trees on the subplot.

Statistical Analyses. Data on the effects of the three treatments on privet abundance, and on nonprivet shrub and herbaceous plant abundance and diversity were subjected to ANOVA using the general linear models procedure of SAS.[7] We analyzed the data as a randomized complete block experiment with sites as blocks although plots were not randomized because not all plots were accessible to the mulching machinery. Plots within sites were selected to be homogeneous so randomization was not deemed to be essential. Means separation was achieved using the REGWQ multiple comparison procedure which is the most powerful multiple comparison procedure available (Day and Quinn 1989; SAS 1982). In addition to comparing the effects of treatments on privet control we examined their effects on several measures of the herbaceous plant community including species richness, the Chao 1 estimate of species richness (Chao 1984), Shannon diversity (H′), and evenness (J). Chao 1 estimates the total richness of a community from a sample. Shannon diversity quantifies species richness and the distribution of individuals among species. Shannon diversity is commonly used and meets all of the criteria established by Elliott (1990) for an effective diversity index. Evenness is a measure of the distribution of individuals among species. To determine if varying levels of privet infestation influenced tree density we used Proc GLM in SAS for simple linear regression analysis. Morista's index of similarity was used to compare the herbaceous plant community composition among treatments and between treatments and desired-future-condition plots. Similarity was calculated for plots within locations and then averaged across locations. Because there were three desired-future-condition plots, we randomly selected three of the four treatment locations and paired them with one of the desired-future-condition locations to calculate similarities between desired and treated plots. We used the PAST program (Hammer et al. 2001) to perform ANOSIM analyses with 10,000 permutations using the Morista distance measure to compare herbaceous plant community similarity among treated and desired plots for each year. ANOSIM provides a method for determining if plant communities within the various treatments are significantly dissimilar. Nonmetric multidimensional scaling (NMS) was used to further analyze herbaceous plant communities among plots using PC-ORD (McCune and Mefford 1999). Analyses were conducted for each year of sampling using the "slow and steady" autopilot feature on the complete dataset.

Results and Discussion

Privet Control. The initial treatments in 2005 had similar effects on Chinese privet in the shrub and herbaceous layers (Figure 2). As expected, the privet shrub layer was almost completely removed by both mechanical mulching and hand-felling (Figure 2A). However, the initial treatments had no effect on the amount of privet in the herbaceous layer when compared to untreated control plots (Figure 2B) despite the soil disturbance associated with mechanical mulching. Only after subsequent treatment with 2% glyphosate in winter 2006 did we see a significant

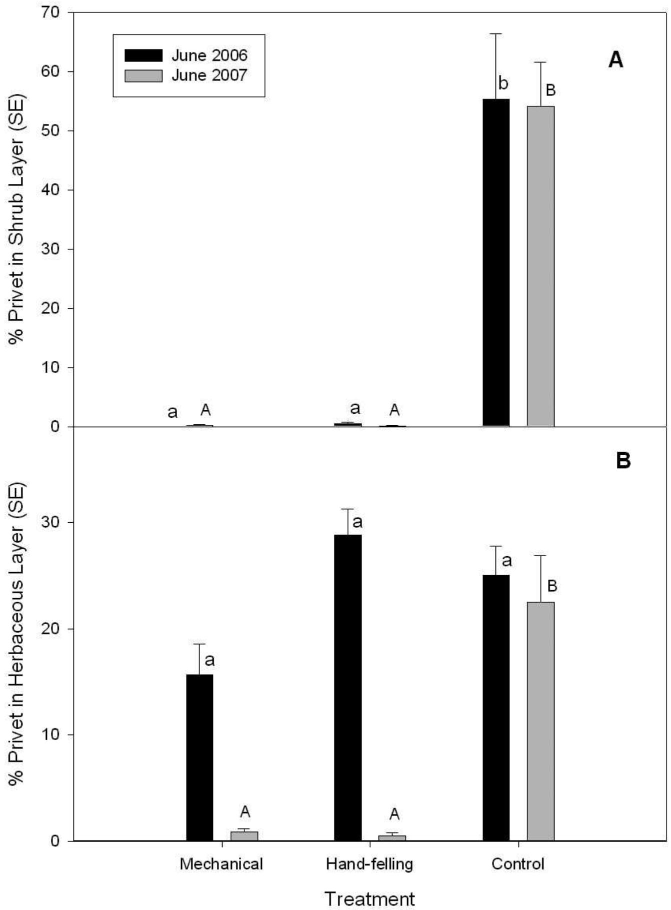

Figure 2. Mean percentage of Chinese privet cover in the (A) shrub and (B) herbaceous layers in June 2006 and 2007 following privet removal (October 2005) by hand-felling or mulching and subsequent herbicide treatment of privet in the herbaceous layer (December 2006). Histogram bars within the same year with the same letter are not significantly different according to the Ryan-Einot-Gabriel-Welch multiple range test ($P < 0.05$).

reduction in the herbaceous privet cover, which was reduced to less than 1% by June 2007. In contrast, desired-future-condition plots had an average of 0.5% (SE = 0.47%) cover of Chinese privet due to one plot with a light infestation (1.4%).

The large numbers of privet seedlings and saplings left by the initial treatments required an additional winter application of glyphosate to reduce privet cover to below 1%. Although the mulching machine made treating stumps difficult and probably ineffective, hand-felling followed by quick treatment of stump surfaces with herbicide did not result in lower amounts of privet in the herbaceous layer. Therefore, it might be more cost effective to simply cut large privet shrubs the first year and only apply herbicides the second year.

The cost of mechanical mulching was approximately twice that of hand-felling. We did not keep close records on the amount of herbicide used to treat the various plots but the hand-felling plots had more, taller privet saplings than the mulching plots, and they were much more difficult to walk through with backpack sprays. The jumble of stems that applicators had to walk through increased treatment time and the larger size of the remaining privet likely increased the amount of herbicide needed. However, despite the difficulty in treating stumps in mulched plots, the differences in cost and the ease of subsequent applications, both treatments resulted in almost complete elimination of privet after 2 yr.

Nonprivet Shrubs/Saplings. Mechanical mulching and hand-felling had no effect on nonprivet shrub/sapling cover 1 and 2 yr after treatment when compared to untreated controls. Although a welcome finding, one reason the shrub/sapling community was little affected was the highly degraded condition of the stands from long-term, heavy infestations of privet.

The shrub/sapling layer primarily consisted of sapling trees including eastern hophornbeam [*Ostrya virginiana* (Mill.) K. Koch], boxelder (*Acer negundo* L.), winged elm (*Ulmus alata* Michx.), slippery elm (*Ulmus rubra* Muhl.), and American hornbeam (*Carpinus caroliniana* Walt.). Plots with heavy infestations of privet had eight to nine shrub or sapling species/plot whereas desired-future-condition plots averaged 12 species/plot. Shrub/sapling species richness was not significantly different among treatments in 2006 ($F_{2,3} = 3.57$, $P = 0.11$) or 2007 ($F_{2,3} = 0.59$, $P = 0.58$). Likewise, percentage of nonprivet shrub/sapling cover was not different from the untreated control plots for either year (Figure 3A). Nonprivet shrub/sapling cover was below 20% on all plots and it was lowest on the mechanically mulched plots. However, neither the equipment operator nor the hand-felling crew significantly reduced the nonprivet shrub/sapling cover or species richness in comparison to untreated controls. Although the treatments did not reduce nonprivet shrub/sapling cover, our plots had low nonprivet shrub/sapling cover (~ 8 to 15%) compared to the desired-future-condition plots which had an average of almost 50% cover/plot.

Trees. Tree basal area of subplots within untreated control plots did not have a significant ($F_{1,18} = 1.91$, $P = 0.18$) linear relationship with privet cover rating. However, numbers of trees/0.04-ha subplot did exhibit a negative linear relationship (Figure 4), showing a decrease in tree abundance with increasing ratings of privet cover. Because tree species richness was not likely to be affected by the treatments, we calculated tree species richness for all of the treated plots for comparison to the desired-future-condition plots. All treatment plots combined ($n = 12$) had a mean tree species richness of 12.5 species/plot (SE = 0.84) compared to desired-future-condition plots ($n = 3$), where species richness was 15 species/plot (SE = 2.08).

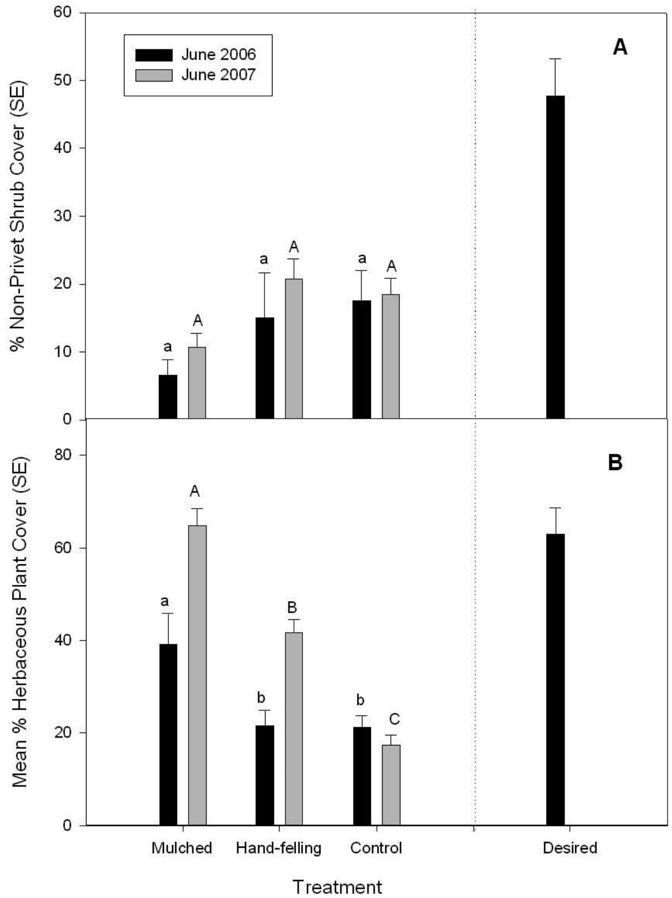

Figure 3. Mean percentage of cover of (A) nonprivet shrubs and (B) herbaceous plants in June 2006 and 2007 following privet removal (October 2005) by hand-felling or mulching and subsequent herbicide treatment of privet in the herbaceous layer (December 2006). Results from desired-future-condition plots are provided for comparison but were not included in statistical analyses. Histogram bars within the same year with the same letter are not significantly different according to the Ryan-Einot-Gabriel-Welch multiple range test (P < 0.05).

Kittel (2001) reported a reduced shrub layer in plots with extensive privet and Merriam and Feil (2003) reported tree seedling abundance also declined with increasing numbers of privet stems per square meter. Other invasive shrub species have similar effects on native tree and shrub species (Collier and Vankat 2002; Fagan and Peart 2004; Gorchov and Trisel 2003; Love and Anderson 2008; Woods 1993). Pattison et al. (1998) found that seedlings of invasive species had a 40% higher relative growth rate in partial shade than native Hawaiian rainforest species and they concluded that invasive species were better suited to capture and utilize light resources. Privet is also a highly shade-tolerant evergreen and likely functions in a similar manner. Thus, as trees die there is nothing in the gap to replace them except Chinese privet.

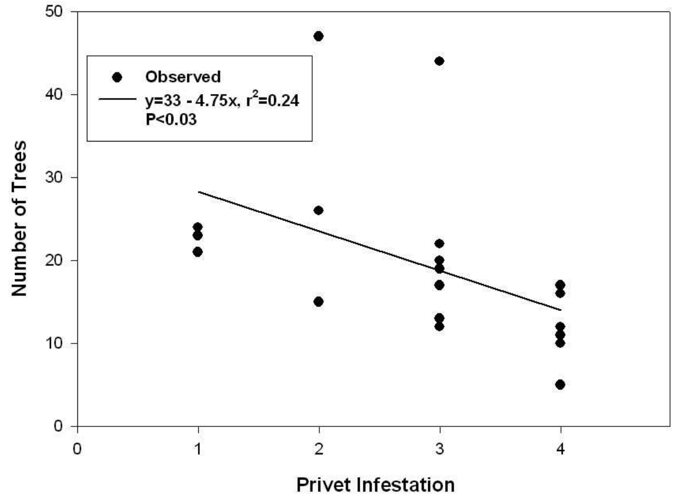

Figure 4. Linear regression of the number of trees > 8 cm diam at breast height on 0.04-ha subplots of untreated control plots vs. a visual rating (0 = no privet to 4 = numerous large-diameter stems up to 3 m in height) of the level of Chinese privet infestation within the subplots.

Herbaceous Understory. Nonprivet herbaceous plants in the understory were affected by removal of privet (Figure 3B). In 2006, nonprivet plant cover was higher on the mechanically mulched plots than on the hand-felled or untreated control plots. By 2007, nonprivet plant cover on the mulched plots was over 60%, similar to the desired-future-condition plots and higher than the hand-felled plots. Both hand-felled and mulched plots had higher plant cover than untreated control plots.

Herbaceous plant species richness and the Chao1 estimator of species richness did not differ among treatments 1 or 2 yr after privet removal, although diversity (H′) and evenness were affected by the treatments (Table 1). Diversity was higher in the mulched and hand-felled treatments compared to the untreated control in 2007 but not in 2006. Diversity of treated plots in 2007 was similar to that in the desired-future-conditions plots as well. Evenness was higher in the mulched plots in 2006 compared to either the untreated control or hand-felling treatments. However, in 2007 evenness did not differ among plots receiving the two removal treatments, but both were higher than the untreated control and slightly higher than the desired-future-condition plots.

Morista's index of similarity showed that the herbaceous plant communities of plots treated by hand-felling and mulching in 2006 had a high degree of similarity to untreated control plots, and hand-felling and mulching plots were only slightly less similar (Table 1). ANOSIM analysis using Morista's index as the distance measure showed all treated plots were dissimilar from the desired-future-condition plots and the hand-felling and mulching

Table 1. Comparison of species richness, diversity and evenness of the herbaceous plant communities following removal of the Chinese privet shrub layer (fall 2005) and herbicide treatment of privet in the herbaceous plant layer (early winter 2006). Results from desired-future-condition plots are provided for comparison but were not included in statistical analyses.[a]

Treatment	Species richness	Chao1 richness estimate	Shannon diversity (H′)	Evenness (J)
2006				
Control	16.3 (3.52)a	26.8 (7.25)a	1.63 (0.23)a	0.60 (0.04)a
Mulching	21 (2.41)a	35.8 (7.89)a	2.16 (0.14)a	0.71 (0.03)b
Hand-felling	17 (1.78)a	32.5 (8.48)a	1.60 (0.13)a	0.57 (0.03)a
Desired	24 (2.65)	37.8 (9.70)	2.15 (0.11)	0.68 (0.06)
2007				
Control	15.5 (3.5)a	28.3 (8.94)a	1.64 (0.30)a	0.61 (0.05)a
Mulching	19.5 (0.96)a	34.3 (7.89)a	2.21 (0.74)b	0.74 (0.04)b
Hand-felling	19.5 (1.26)a	41.3 (8.66)a	2.26 (0.77)b	0.76 (0.04)b

[a] Values are expressed as mean (SE). Means followed by the same letter within a column in the same year are not significantly different according to the Ryan-Einot-Gabriel-Welch multiple range test ($P < 0.05$).

plots were dissimilar from one another although they had a relatively high similarity of 0.71 (Table 2).

In 2007, the desired-future-condition plots were again highly dissimilar from the treatment plots and the untreated controls (Table 2). However, unlike 2006, plant communities on the hand-felled and mulched plots were highly dissimilar from the untreated control plots, and the hand-felling and mulching plots were not dissimilar from one another.

NMS ordinations (Figure 5) showed that a two-dimensional solution was optimal for the 2006 (final stress = 13.1) and 2007 (final stress = 9.8) herbaceous plant community data. In 2006, plant communities of the desired-future-condition plots were distinctly separated from the treatment plots but there was no separation in composition among the three treatments. However, in 2007 NMS ordination showed desired-future-condition plots, untreated control plots, and privet removal plots all had distinct plant communities. Privet removal plots were tightly grouped, suggesting that the two removal techniques result in the same plant community.

Woods (1997) states that understanding whether removal of a nonindigenous species will allow reversion of communities to prior conditions is important to consider in restoration efforts. However, plant communities in our study area were altered significantly through past land use practices and disturbances prior to privet invasion (Colwell 1998) that can have long-lasting effects on forest herbs by themselves (Jacquemyn and Brys 2008; Runkle 1985) without the added effects of invasive species. In addition, invasive species effects on plant communities and underlying ecosystem processes (Ashton et al. 2005;

Table 2. Comparison of the herbaceous plant community similarity between plots with Chinese privet removed (hand-felled and mulched), untreated controls, and plots with negligible privet infestation (desired). The privet shrub layer was removed in fall 2005 and privet in the herbaceous layer was treated with herbicide in early winter 2006.

	Mean Morista's similarity index (SE)		
	Control	Felling	Mulch
2006			
Hand-felling	0.94 (0.02)	—	—
Mulching	0.73 (0.10)	0.71 (0.11)*	—
Desired	0.08 (0.04)*	0.02 (0.01)*	0.03 (0.05)*
2007			
Hand-felling	0.18 (0.02)*	—	—
Mulching	0.15 (0.03)*	0.73 (0.05)	—
Desired	0.04 (0.02)*	0.02 (0.01)*	0.18 (0.14)*

* Asterisks denote significant differences ($P < 0.05$) based on ANOSIM test of significant dissimilarity using Morista's index as the distance measure.

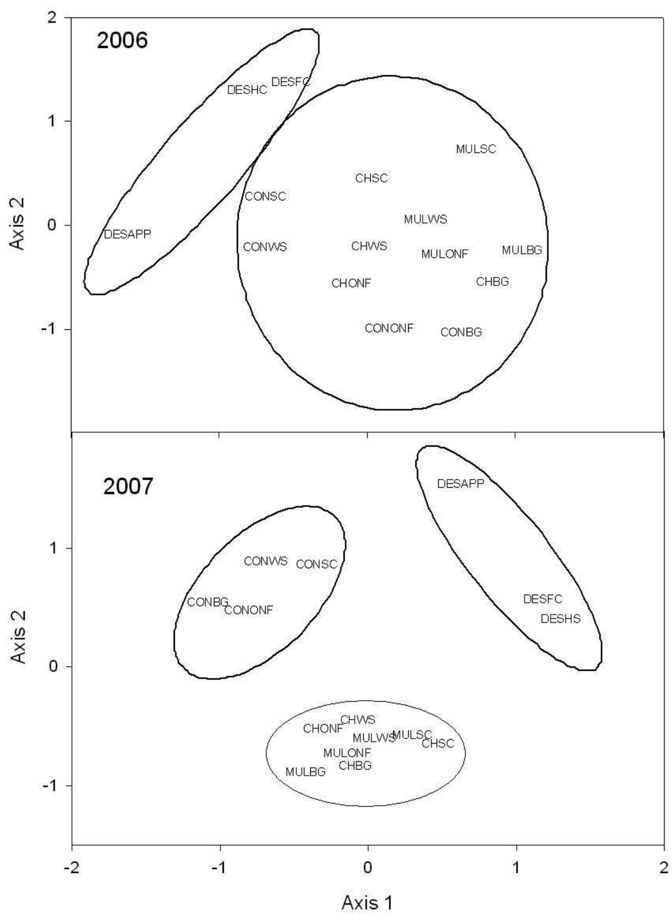

Figure 5. Nonmetric multidimensional scaling ordination graphs of the herbaceous plant communities in June 2006 and 2007 on plots receiving privet removal (October 2005) by hand-felling or mulching and subsequent herbicide treatment of privet in the herbaceous layer (December 2006). Groups were circled to show plots with similar plant communities. Plot abbreviations starting with DES = desired-future-condition; CON = control; MUL = mulched; and CH = chainsaw or hand-felled.

Ehrenfeld et al. 2001; Gordon 1998; Heneghan et al. 2004) may make restoration to some idealized condition or community composition difficult or impossible. We found 2 yr after privet removal that the herbaceous plant community was composed primarily of early colonizers common in disturbed areas, and privet removal, regardless of the method, resulted in communities highly dissimilar from both the privet-infested controls and desired-future-condition plots. Plant community succession is a long-term process and 2 yr is insufficient time to expect recovery.

One concern when removing an invasive species is that it will favor establishment or spread of other nonnative species. For example, Rinella et al. (2009) found that *Euphorbia esula* and other nonnative species recovered from herbicide control whereas several native forbs became rare. In our study, Japanese stiltgrass [*Microstegium vimineum* (Trin.) A. Camus], an invasive annual that responds positively to winter litter disturbance and increased sunlight (Oswalt and Oswalt 2007), was more abundant on some treated plots. However, this species is also common in areas lacking privet that are exposed to periodic flooding. For example, two of our three desired-future-condition plots have substantial stiltgrass populations. Although Japanese stiltgrass was undesirable, its overall impact on the ecosystem may not be as severe as Chinese privet.

Mann (2005) points out that restoring North American forests to pre-European conditions is unlikely and may be unwise. Instead he suggests ‘‘shaping a world to live in for the future.’’ Likewise, Luken (1997) concludes that management of nonnative invasive species should move toward a dynamic system that satisfies explicit management goals. In 2 yr our treatments restored forests, which were choked by Chinese privet and nearly impassable, to open bottomland hardwood forests that make human recreation possible and enjoyable. Also, two of our sites are used for educational purposes so our plots now provide excellent outdoor laboratories. Future management of these sites should focus on restoring ecosystem processes that will support desired plant and animal communities.

Sources of Materials

[1] Gyrotrac® mulching machine, Summerville, SC.
[2] Triclopyr, Garlon® 4. Dow AgroSciences LLC, Indianapolis, IN.
[3] Glyphosate, Foresters'®, Riverdale Chemical Co., Burr Ridge, IL.
[4] Nonionic surfactant, Timberland 90®, Timberland Enterprises, Monticello, AR.
[5] Solo® Backpack sprayer, Newport News, VA.
[6] Solo® backpack mistblowers, Newport News, VA.
[7] SAS version 8.1, SAS Institute, Cary, NC.

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