AUBURN UNIVERSITY
FOREST HEALTH COOPERATIVE

RESEARCH REPORT 2013-03

PRETREATMENT INVASIVE PLANT SURVEY AT THE OAKMULGEE RANGER DISTRICT

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ABSTRACT
Non-native invasive plant species are considered to be one of the greatest threats to native biodiversity. Despite an increased focus on invasive plants, most research efforts have been directed toward wild areas. However, many of the forests of the eastern United States are commercially managed and are exposed to some of the known vectors of invasive plants (man-made paths, transport of equipment). An experimental biomass removal that would be more intensive than conventional thinning was scheduled to take place at the Oakmulgee Ranger District in the Talladega National Forest in west-central Alabama. Pre-treatment non-native plant surveys were conducted during summer and fall 2008 and spring, summer and fall 2009. Surveys revealed few non-native plants with *Lespedeza cuneata*, *Lonicera japonica*, *Lespedeza bicolor* and *Albizia julibrissin* present; all of which are widely distributed through the region. Many non-native plants were observed where roads passed through research plots and a higher number were present in compartments predicted to be in loblolly pine decline. Adjoining private property did not have an effect on the presence of non-native invasive plants.

INTRODUCTION

Overview

Invasive plants are exotic, non-native species that colonize and persist in a new environment (Mooney and Drake, 1989). Increases in travel and trade, habitat fragmentation and disturbance escalate opportunities for invaders to expand their ranges and invade forests (Chornesky et al., 2005). Invasive species directly compete with native species for resources, alter ecosystem processes, hybridize with natives and affect gene pools (Richberg and Patterson, 2003). Early successional invaders often opportunistically occupy openings following large disturbances. Non-native exotic plants often grow faster and are subject to less predation than native plants upon arrival in a new habitat (Flory and Clay, 2009). Invaders which eventually become dominant in their new habitat may be capable of making permanent changes in their ecosystems through such means as nitrogen fixation, physical exclusion of native plants or changes in fire regimes (Brown et al., 2006). Techniques used to manage forests facilitate the spread and establishment of invasive species through introduction via contaminated machinery, equipment or materials and canopy and soil disturbance. Right of ways, stream banks, roads and trails are important pathways in the movement of invasive plant species (Miller, 2002). Areas of urban/forest interface, sometimes near commercial forestry operations, are also known to be especially vulnerable to invasive species. Many invasive species, especially those at the urban/forest interface, are escaped ornamental species, many of which are still legally sold by the landscaping industry (Miller, 2002).

Causes of invasiveness and resistance of native ecosystems

Susceptibility of ecosystems to invasion by non-native organisms is affected by a variety of factors including climate, disturbance regime and competitiveness of native species (Lonsdale, 1999). Various theories suggest that invaders are superior competitors for limited resources, that new environments enable invasive plants to escape natural enemies or even that invasiveness is an inherited characteristic and survival strategy (Inderjit et al., 2005). In some instances co-introduced enemies of the invading plant species may also attack native plants as well.

Humans transport plants to new environments regularly but of thousands of introduced species, relatively few survive outside of cultivation in their new habitat. Of those that survive, few become established and only a small proportion of those become invasive (Williamson and Fitter, 1996). The numerous theories explaining success or failure of invasions are not mutually exclusive. So many site specific and sometimes confounding factors are involved with each individual invasion that broad generalizations are difficult to make (Ewers and Didham, 2006) and global hypotheses are difficult to test in isolation (Inderjit et al., 2005). In addition, the lag between initial introduction and when a species becomes invasive can be long, adding to the challenge of identifying problem species (Mack et al., 2008).

Land management and its effects

Difficulties inherent in long-term monitoring and translation of results of studies conducted in different regions have resulted in little analysis of long-term effects of forest management on invasive plants. The effects of commercial forestry activities on invasive species are poorly understood (Ohio Invasive Plant Conference, 2005). In lodgepole pine *(Pinus contorta* Dougl) stands in British Columbia, Canada overall species richness and diversity were higher in thinned stands than in unthinned stands. While few of the plants in the study were invasive, invasives were more prevalent after the treatment (Lindgren et al., 2006). A study using a wider variety of treatments in Oregon found that the only management activities to facilitate invasion were those that created gap environments (Boggs and Puettmann, 2005).

Invasive plant observations and mapping

Before invasive species can be treated they must be found and mapped. Many surveying techniques exist, but ideal methods of invasive plant monitoring should combine efficiency and accuracy. Of seven tested survey methods, the most consistent invasive plant population estimates were obtained by using a grid and random points following targeted transects (Rew et al., 2006). Surveying areas with no known populations of non-native invasive plants is believed to better detect outlying populations (Maxwell et al., 2009). Finding satellite populations is important as these areas have the greatest potential to increase the overall range of the species (Radosevich et al. 2003). Monitoring of outlying areas may be useful for this reason, even if nothing is found.

Biomass removal treatments are to occur on the Oakmulgee study plots, reducing plot basal area from approximately 120 to 70 sq.^{2}/ac. (37 to 21 m^2/ha). Effects of forest thinning on invasive plant populations have been studied infrequently (Ohio Invasive Plant Research Conference, 2005) and those studies have produced inconsistent results (Beggs and Puettmann,2005). Even less is known about the effects of biomass removal on invasive plant presence. The objective of this study is to determine levels of invasive non-native plant populations. Aspects of thinnings that can increase invasive plants may be amplified in a biomass removal. Because of the creation of roads and the presence of machinery that may transport plants and propagules, the presence of invasive plants is expected to be greater following these treatments.

METHODS AND MATERIALS

The study was conducted at the Oakmulgee Ranger District of the Talladega National Forest in Bibb, Perry and Chilton counties in west-central Alabama on 24 plots located within the district. Eighteen plots were located within compartments considered to be in pine decline while 6 plots were in predicted non-declining compartments. Invasive non-native plant surveys were conducted in research plots, where insect collection traps were already established (RR13-01).

Invasive plant surveys were conducted during June and November 2008 and May, August and November 2009. Four transects extending 122 m north, east, south and west from plot center were marked and non-native plants within 0.3 m on either side of the transect were noted. Occurrence of invasive plants was monitored along transects that extended 37 m from center plots to the insect traps at 120, 240 and 360 degrees supplemented by a circular transect between the traps themselves (Figure 1). Transect lines were abbreviated when steep terrain, large creeks or private property boundaries were encountered. Intersections with roads (timber or public) were recorded. Private property within 122 m was also noted. Representative plant specimens of known invasive and unidentified species were placed in a paper bag, pressed and taken to the Auburn University Herbarium (Auburn, AL) for confirmation of field identifications.

STATISTICS

Binomial logistic regression on SAS 9.1 (SAS Institute, Cary, NC) was used due to the extremely frequent occurrences of zeroes in the data set (no invasive species). This enabled the data to be analyzed on a presence/absence basis and also enabled species which grow as individual shoots (e.g. *Albizia julibrissin* Durazz.) to be considered on the same scale as clonal species which spread via underground rhizomes (e.g. *Lespedeza cuneata* (Dum. Cours.) G. Don. var. *cuneata*). When binomial regression was performed, maximum likelihood and odds ratio findings were often absent, making statistical analysis impractical.

RESULTS

Overall observations

Total observations of non-native plants varied by season in which the survey occurred. The total number of non-native plant observations were greatest during the August 2009 survey (56 total observations), followed by the May 2009 survey (37 total observations), October 2009 survey (31 total observations), June 2008 survey (28 observations) and November 2008 survey (10 observations) (Table 1). Non-native plants were most common during the summer months.

Invasive plants and loblolly pine decline

There were a greater number of non-native plants in the predicted decline plots compared to the predicted non-decline plots. Every non-native species was more common in the predicted decline plots and that was not a function of a greater number of predicted decline plots. For example, during the summer of 2009, predicted decline plots contained all observations of *Lonicera japonica* Thunb., all 17 observations of *Lespedeza bicolor* Turcz., 13 of 17 observations of *L. cuneata*, and 9 of 10 observations of *A. julibriisin*. These disproportionate findings were representative of the overall findings (Table 2).

Effects of road and private property interceptions

Non-native plants were more common in plots where roads passed within 37 m of plot center (n=14) than plots in which roads were further away (n=10) (Table 3). While the majority of plots had a road within 37 m, a disproportional number of non-native plant observations came from these plots. During the summer 2009 survey, all 12 *L. japonica* observations, all 17 *L. bicolor* observations, 15 of 17 *L. cuneata* observations and all 10 *A. julibrissin* observations were at plots transected by roads. A large majority of non-native plants were observed by roadsides in other study periods.

Effects of prior thinning

In addition to roads, some of the plots were exposed to additional disturbance and possible introduction to non-native plants when stands were thinned. While only a third (8 of 24) plots had been thinned, the majority of non-native plant observations were made in stands that had been thinned (Table 4). Aside from a greater number of *L. japonica* in unthinned plots and an equal number of *L. bicolor* in thinned and unthinned plots during the summer 2009 surveys, greater totals of non-native plants were detected in the thinned plots.

DISCUSSION

Many prominent invasive species in Alabama were not observed on the study sites. While the possibily exists that non-native plant observations may increase following thinning or biomass removal, only a few species of non-native plants were regularly observed along the research transects. Many of the observations were unsurprising given the widespread distribution of species such as *L. japonica* (Schierenbeck, 2004). As expected, these species were most common along roadsides and in previously disturbed areas but surprisingly, non- native presence was all but non-existant in the few plots bordering private lands. It is hypothesized that follow up surveys expected to follow thinning and biomass removal will detect more invasive plants and that biomass removal will increase non-native plant presence more than conventional thinning.

The species currently at the plots are capable of quickly responding to disturbance and may rapidly fill openings that this work leaves behind. Follow up studies may subsequently test if non-native plants respond to thinning as expected and increase from their current low populations.

Thinning operations and biomass removal are expected to occur at the Oakmulgee Ranger District but little is known of the effects these treatments have on invasive plants. Most observations of invasive plants were associated with either roads or past stand disturbance, indicating that additional management may introduce non-native plants into new areas. Invasive species were rarely observed on transects that were not intercepted by a road within 132 m of plot center. Several invasive species observed in this study are shade intolerant and benefit from open areas along roadsides. Even plant species capable of thriving under shade, such as Japanese honeysuckle, were more abundant by roadsides exposed to light and disturbance. This indicates openings created in the forest by a biomass removal project could facilitate the spread and establishment of both shade tolerant and shade intolerant species.

Previous forest management activities in the National Forest may have contributed to the establishment of non-native plants. Plots that were thinned in 1996 and 1999 tended to have greater numbers of invasive plants compared to those which had not been thinned since regeneration. Thinnings may have created opportunities for invasive plants through either increased light or through movement of propagules on machinery. Species such as *L. cuneata* may have spread along logging roads used during the thinning operations. The previous thinning conducted at the plots appears to have had long term consequences, a pattern not always observed following thinning (Dodson, 2004), but worth considering as further work is conducted at the plots.

More invasive plants were observed in plots located in predicted loblolly pine decline compartments, even when considering the larger sample size of predicted decline plots compared to predicted non-decline plots. Potential associations between pine decline and increased presence of invasive plants have not been tested but under decline conditions loblolly pine crowns are less dense and more sunlight passes through. Increased light penetration to the forest floor may benefit the invasive plants (Snitzer et al., 2005). However, none of the three predicted non-decline pairs were within 122 m of a public road. That decline is a factor in invasive plant presence cannot be stated with confidence until tested without confounding factors such as the effects of roads. Loblolly pine has been so widely distributed across both the area and region that any hypothetical widespread dieoff could be expected to create openings in many areas for opportunistic species, including many invasives.

Adjacent private property was expected to facilitate the spread of non-native plants. Adjoining private areas included recently thinned private forests near several research plots and a residential lawn bordered another plot. While many invasive species have been introduced to new environments as escaped ornamentals, ornamental species did not appear to be invading National Forest land from private property. Plots that bounded private property did not have higher totals of invasive species. There were no non-native plant observations at any plots with private property within 122 m of plot center. This was probably because all three of these plots were located more than 122 m from roads. Given that in some instances the plot bordered either private yards or stands that had been recently thinned, road effect appeared to be stronger. Only two of the plots, however, directly bordered residential yards, so it may not be possible to make a strong comparison. The eastern half of the District in particular, however, has many houses surrounded by public land so a stronger comparison could be made if different study areas were selected.

Increases in survey counts of perennial non-native plants may have been as much a function of human error as actual population increase given the difficulty of walking identical transects between different survey periods. Multiple pretreatment surveys occurred because thinning treatments were expected to take place between the first and second years of the study. If transects can be followed with more accuracy in different surveys, the method used to survey invasive plants in this study is still expected to capture non-native plant diversity in both thinned areas and unthinned areas nearby. Potential changes outside the treatment areas could indicate the extent to which changes in non-native plant populations in disturbed areas can affect adjoining non-disturbed areas.

A biomass removal study consisting of a complete removal of all woody material greater than 7.5 inches in diameter at breast height may be conducted in the near future. The level of disturbance associated with roads and other access, the use of off-site machinery and the opening of the overstory all could increase the presence of invasive plants. In light of the shortage of research regarding the impact of forest management on invasive plant levels (Ohio Invasive Plant Conference, 2005) a follow up survey investigating the effect of biomass removal on invasive plant species would be of great interest. Few studies have considered the response of invasive plant species to management, despite the widespread belief that disturbance facilitates invasion. Dodson (2004) found that invasive plants spread after thinning treatments, particularly when burning accompanied thinning. However, general studies show inconsistent response of non-native plants to thinning. In an Oregon study conducted five years after several different types of thinning, the overall presence of herbaceous plants increased but few long-term changes persisted in the understory (Beggs and Puettmanm, 2005). Because of the inconsistent response of non-native invasive plants to forest management, potential changes in the presence of invasive plants following biomass removal treatment are difficult to predict and unlikely to become apparent until years after the treatment. Because non-native plants were more prevalent in previously thinned plots, one could reasonably predict that a more intensive treatment such as biomass removal would result in an increase in invasive plants.

CONCLUSION

Many of the non-native species observed in this study are widely distributed species associated with disturbance but none are considered to be among the most ecologically harmful Overall, the plots appeared to be relatively free of invasive plants but non-native species were generally more common where thinning had been conducted in close proximity to roads. Private property boundaries were not associated with elevated numbers of invasive plants. Areas that had been thinned tended to have greater numbers of invasive plants, primarily along old logging roads. National Forest lands often have fewer human disturbances and roads than surrounding areas but even on the National Forest plots, roads and thinning appeared to influence the distribution of invasive plants. Additional disturbances or road construction following biomass removal treatments are likely to increase numbers of invasive species. The probability that invasive plants will exploit disturbances relating from future management will be affected by the degree of disturbance, the response of native plants to the treatments and the dispersal of invasive plant propagules onto the site. The response of invasive plants to biomass removal is important to understand given the increasingly widespread public discussion of harvesting biomass for fuel.

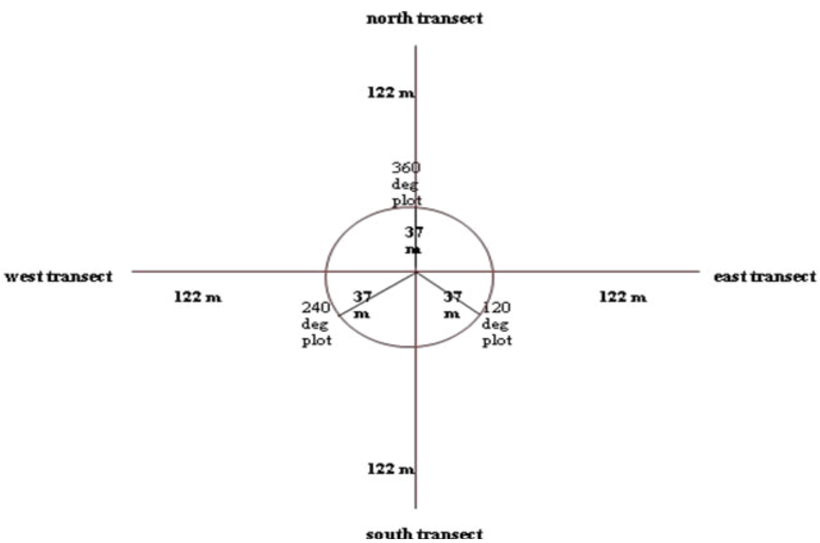

Figure 1. Invasive plant transect layout at Oakmulgee Ranger District Research Plots 2008-2009.

Table 1. Total number of observations of non-native species by survey season at research plots at the Oakmulgee Ranger District, Talladega National Forest.

Species	Summer 2008	Fall 2008	Spring 2009	Summer 2009	Fall 2009
Lonicera japonica	4	4	15	12	5
Ligustrum sinense	0	0	0	0	1
Lespedeza bicolor	8	0	10	17	10
Lespedeza cuneata	12	6	10	17	12
Paspalum dilatatum	1	0	0	0	0
Paspalum notatum	3	0	0	0	0
Albizia julibrissin	0	0	2	10	3

Table 2. Comparison of non-native plant observations in plots with or without loblolly pine decline by survey season at research plots at the Oakmulgee Ranger District, Talladega National Forest. D (n=18) indicates declining plots, N (n=6) indicates non-declining plots.

Season		***L. japonica***	***L. sinense***	***L. bicolor***	***L. cuneata***	***P. dilatatum***	***P. notatum***	***A. julibrissin***
Sum 08	D	3	0	7	12	1	2	0
	N	1	0	1	0	0	1	0
Fall 08	D	4	0	0	6	0	0	0
	N	0	0	0	0	0	0	0
Spr 09	D	10	0	7	9	0	0	2
	N	5	0	3	1	0	0	0
Sum 09	D	12	0	17	13	0	0	9
	N	0	0	0	4	0	0	1
Fall 09	D	5	1	8	12	0	0	3
	N	0	0	2	0	0	0	0

Table 3. Comparison of non-native plot observations between plots with or without roads within 37 m of plot center at the Oakmulgee Ranger District, Talladega National Forest. 'Yes' (n=14) indicates roads within 37 m of plot center, 'No' (n=10) indicates no road. Roads consisted of logging trails, unpaved public roads and paved public roads.

Season	Road	***L. japonica***	***L. sinense***	***L. bicolor***	***L. cuneata***	***P. dilatatum***	***P. notatum***	***A. julibrissin***
Sum 08	Yes	3	0	8	12	1	3	0
	No	1	0	1	0	0	0	0
Fall 08	Yes	4	0	0	6	0	0	0
	No	0	0	0	0	0	0	0
Spr 09	Yes	10	0	8	9	0	0	2
	No	5	0	2	1	0	0	0
Sum 09	Yes	12	0	17	15	0	0	10
	No	0	0	0	2	0	0	0
Fall 09	Yes	4	0	8	12	0	0	3
	No	0	1	2	0	0	0	0

Table 4. Comparison of non-native plot observations between thinned in and unthinned plots at the Oakmulgee Ranger District, Talladega National Forest. 'T' (n=8) indicates thinning had occurred at the plots, 'U' (n=16) indicates plots had never been thinned.

Season		***L. japonica***	***L. sinense***	***L. bicolor***	***L. cuneata***	***P. dilatatu***	***P. notatum***	***A. julibrissi***
Sum 08	T	3	0	5	7	1	2	0
	U	1	0	3	5	0	1	0
Fall 08	T	4	0	0	5	0	0	0
	U	0	0	0	1	0	0	0
Spr 09	T	6	0	5	8	0	0	1
	U	9	0	5	2	0	0	1
Sum 09	T	10	0	15	11	0	0	6
	U	2	0	2	6	0	0	4
Fall 09	T	3	1	6	8	0	0	3
	U	2	0	4	4	0	0	0