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Impacts of removing Chinese privet from riparian forests on plant communities and tree growth five years later

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ABSTRACT

An invasive shrub, Chinese privet (*Ligustrum sinense* Lour.), was removed from heavily infested riparian forests in the Georgia Piedmont in 2005 by mulching machine or chainsaw felling. Subsequent herbicide treatment eliminated almost all privet by 2007. Recovery of plant communities, return of Chinese privet, and canopy tree growth were measured on removal plots and heavily invaded control plots in 2012 approximately five years after complete removal of privet. Plant communities were also measured on three 'desired future condition' plots which were never heavily infested with privet. These areas provided a goal condition for plant communities on removal plots. Approximately 7% of mulched plots and 3% of felling plots were re-infested by Chinese privet. In contrast, non-privet herbaceous plants covered 70% of mulched plots and 60% of felling plots compared to only 20% of untreated control plots and 70% in desired plots. Both mulched and felled plots had more plant species than the control plots, and mulched plots had more species than felled plots. Analysis of similarity (ANOSIM) and non-metric multidimensional scaling (NMS) ordination indicated that control, removal, and desired future condition plots had three distinct plant communities but the methods used to remove privet did not result in different communities. There was no difference in growth of canopy trees in removal and control plots five years after removal. Removing Chinese privet from riparian areas is beneficial to plant communities, promoting biodiversity and secondary succession while progressing toward a desired condition regardless of the method used to remove it.

1. Introduction

Chinese privet, *Ligustrum sinense* Lour. (Oleaceae), was first introduced as an ornamental plant in 1852 (Dirr, 1983). By the 1930s, it had escaped cultivation and was widely established in floodplains across the Southeastern U.S. (Small, 1933). It is now estimated to inhabit 1 million ha in the southeast (Miller et al., 2008). These estimates are misleading however, due to the underestimated area that privet inhabits in cities, towns, and along roadsides.

Privet is common in riparian areas, possibly because they are similar to its native habitat in China (Langeland and Burkes, 1998). These areas also appear to be susceptible to invasion (Stroh and Struckhoff, 2009), probably due to the same factors that contribute to the overall increased biodiversity that occurs in them (Planty-Tabacchi et al., 1996; Hood and Naiman, 2000). Favorable habitat combined with less herbivory on privet and greater fruit production, when compared to native shrubs of the same family (Morris et al., 2002), result in the formation of dense, single species shrub layers that reduce native herbaceous vegetation (Merriam and Feil, 2002; Hanula et al., 2009; Greene and Blossey, 2012).

Chinese privet is the primary cause of the decline in the abundance and diversity of native herbaceous plants and native tree seedlings in infested riparian areas (Merriam and Feil, 2002; Hanula et al., 2009; Greene and Blossey, 2012) and increasing levels of infestation result in declining abundance of canopy trees (Hanula et al., 2009). Few studies, however, have sought to determine how native flora might respond over time (>2 years) to complete removal of privet. Merriam and Feil (2002) measured plant communities with or without privet in adjacent areas where they found that areas with privet had 41% less herbaceous plants and 42% less herbaceous species. They also found 75% fewer woody stems in privet areas than in privet free areas. After removing privet, they saw a substantial increase in herbaceous plants one year later. Similarly, Hanula et al. (2009) found greater than 60% increase in overall plant cover two years after removing privet

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which was similar to plots that had historically no privet infestation.

An important aspect of privet infestation that has yet to be studied is its impact on tree growth. Recent work with hardwood tree species has focused on sapling growth and survival. Galbraith-Kent and Handel (2008) found that native sapling growth and survival was higher under a native canopy while Hartman and McCarthy (2004) found that when the invasive shrub amur honeysuckle (*Lonicera maacki*) was removed the growth and survival of saplings of six native hardwood species could be increased. Conversely, 63 weeks after transplanting native hardwood saplings under a privet canopy, Greene and Blossey (2012) saw minimal survival of the natives.

While this work is important for forest regeneration after invasive removal, the impact of removing invasive plants on the growth of mature, canopy trees is unknown. Hartman and McCarthy (2007) compared mature hardwood tree growth on sites that were invaded by *L. maacki* or not and found tree growth was negatively impacted by infestation. If removing Chinese privet from heavily infested areas produced similar results it could provide economic incentive for doing so.

Previous study into the mechanism of privet infestation of un-colonized areas has primarily focused on landscape factors contributing to susceptibility of invasion (Merriam, 2003; Stroh and Struckhoff, 2009; Wang and Grant, 2012). Their findings are important for preventing the spread of Chinese privet into un-colonized areas, but provide no evidence on the rate at which privet might re-invade an area after complete removal (Gabler and Siemann, 2012). Panetta (2000) reported that seeds of Chinese privet are relatively short lived in the seed bank (1 year) and therefore privet must rely on dispersal from local infestations to facilitate reinvasion (Panetta and Sparkes, 2001). Birds and small mammals are probably the primary vehicle for the spread of Chinese privet (Gosper et al., 2005) yet the rate and pattern of dispersal has received little attention probably due to lack of areas to evaluate reinvasion.

Here we examine the status of the herbaceous plant community five years after removal of Chinese privet and how two methods of removal affected plant community response. Plant communities were compared among removal plots, untreated control plots, and plots with historically little or no privet. We also report on the growth of canopy trees five years after removal of Chinese privet to those in untreated control plots. In addition, we measured Chinese privet reinvasion of cleared areas and if this invasion was associated with proximity to other heavily infested areas.

2. Materials and methods

2.1. Study areas

This study was part of a long-term project investigating the effects of privet removal on plant and animal communities, so the study design and locations are described in detail by Hanula et al. (2009). Briefly, four study areas were chosen along the Oconee River in northeast Georgia (Fig. S1). Two of these areas, the Botanical Gardens of Georgia (N33° 54.046′, W083° 23.435′) and Sandy Creek Nature Center (N33° 59.167′, W083° 22.865′), are located near Athens, Georgia in Clarke County. The other two areas, Watson Springs Forest (N33° 41.908′, W083° 17.695′) and Scull Shoals Experimental Area (N33° 46.132′, W083° 16.897′), are located in Greene County and in more continuously forested areas. The canopy of these study areas are dominated by green ash (*Fraxinus pennsylvanica*), sweet-gum (*Liquidambar styraciflua*), water oak (*Quercus nigra*), willow oak (*Quercus phellos*), box elder (*Acer negundo*), and loblolly pine (*Pinus taeda*). Stand conditions and overstory tree composition were measured in 2007 on five 0.04 ha subplots per treatment plot (Hanula et al., 2009) and are provided as supplementary data (Tables S1–S3). In addition, three areas of the Oconee National Forest with historically little or no privet invasion were chosen as “desired future condition” plots and were included as a reference to what treatment areas might look like long-term without privet (see Hudson, 2013 for complete list of plant species). All three sites are located at least 10 m from a river or stream.

2.2. Privet removal

The treatments consisted of heavily infested untreated controls (approximately 34% herbaceous privet cover and 62% privet shrub cover) and two methods of Chinese privet removal applied October 2005 on 2 ha plots. Privet removal was done by either mechanical mulching or hand-felling. Specifics of removal can be found in Hanula et al. (2009). Briefly, a mechanical Gyrotrac® mulching machine was used to grind up privet to ground level and created the treatment plots hereafter referred to as “mulched”. Mulched residue was left in the plots. At the same time in nearby similar sized plots, crews with chainsaws and machetes hand-felled privet and left the debris in the plots (these are referred to as “hand-felling” plots). Stumps in both treatment plots were sprayed with either 30% triclopyr (Garlon® 4) or 30% glyphosate (Foresters®) herbicide to prevent re-sprouting. The herbicide was selected by the location’s manager.

One year later, in December 2006, privet sprouts and seedlings were treated with a foliar application of 2% glyphosate using back pack sprayers or mist blowers. By the next summer (2007), less than 1% the plots were covered by privet in the shrub or herbaceous layer (Hanula et al., 2009).

2.3. Measuring plant communities

The plant communities in the herbaceous and shrub layer were measured using the line-point intercept method (Godínez-Alvarez et al., 2009; Outcalt and Brockway, 2010) in July 2012. Presence or absence of plants and shrubs and the species present were recorded at points every 1.5 m along three transects that spanned the length of each plot. Transects were located equidistant from each other and the plot boundary and were the same as those used previously (Hanula et al., 2009). Percent plant cover was determined by dividing the number of points with a plant by the total points sampled per plot.

2.4. Measuring tree growth

Tree growth from 2006 to 2011 was measured in treatment and control plots to determine if trees grew faster where privet was removed. Trees >4 cm DBH that were located in five 0.4 ha subplots, designated at the beginning of the study (Hanula et al., 2009), were cored with a Mattson® increment corer with a 5.15 mm core diameter to a depth sufficient to include at least 10 years of growth. Not all tree species occurred in all of the plots so we examined cores of red oaks (primarily water and willow oaks), pines, and green ash which were common to all plots. Other common species such as sweet-gum, box elder, sycamore (*Plantanus occidentalis*), river birch (*Betula nigra*), and red maple (*Acer rubrum*) were present on all plots but were not measured because growth rings were not detectable. In total, 142 cores of oaks, pines, and green ash were X-rayed so growth rings could be observed more easily.

2.5. Chinese privet reinvasion

Both removal methods created distinct edges between heavily privet infested and privet free areas. These characteristics provided