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ORIGINAL PAPER

Effects of Chinese privet (*Ligustrum sinense*) invasion on decomposition and litter-dwelling invertebrates in Southeastern U.S. floodplain forests

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Abstract Chinese privet (*Ligustrum sinense*) is one of the most problematic invasive plants in many parts of the world where it often dominates the shrub layer in riparian forests. We aimed to evaluate the role of privet invasion on litter inputs, rates of litter decomposition and litter-dwelling arthropods in the Southeastern United States. To do this we: (1) evaluated the relative contribution of privet to total litter-fall, (2) compared breakdown of artificial leaves (filter paper) in plots which had or had not been subjected to experimental privet removal, and (3) compared litter breakdown and arthropod communities among the following litter types: (a) native sweetgum, (b) invasive Chinese privet, and (c) a mixed sweetgum–privet litter treatment. Privet accounted for 10% of annual litter-fall at our study sites and leaf fall phenology differed from native species. Filter paper decomposed about twice as quickly in reference compared to removal plots but there were no differences between plot types in litter decomposition. This difference may relate to flooding during the litter bag experiment. In both plot types, privet litter decomposed faster than sweetgum or mixed litter but there were no differences in decay rates between the latter two litter types, suggesting that sweet gum may slow the rate of decomposition in mixed bags. There were no differences among litter or plot types in invertebrate community composition or overall abundances, but detritivores were marginally more abundant in the reference plots. Our findings suggest that flooding may affect the impact of privet invasion on litter decay rates and associated invertebrate communities.

Keywords Leaf litter · Wetland · Arthropod · *Liquidambar styraciflua* · Litter fall · Decay

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Introduction

Floodplain wetlands are among the most valuable ecosystems on earth in terms of ecosystem services (Costanza et al. 2014) but are also one of the most threatened. Floodplain area has declined by 106 million hectares globally between 1997 and 2011 (Costanza et al. 2014) and is additionally being impacted by a myriad of other threats including invasion by exotic species. Wetlands are especially vulnerable to invasive plant species, which frequently form monotypic stands able to impact biodiversity, food webs, and nutrient cycling (Zedler and Kercher 2004). Additionally, projected changes in hydropattern resulting from climate change are predicted to reduce competitiveness of native Southeastern U.S. plant species and increase the competitiveness of invasive plants (Flanagan et al. 2015). Given the susceptibility of floodplain wetlands to invasive plant species it is important to understand their impacts on wetland ecosystem function and to explore options for restoration.

Chinese privet (*Ligustrum sinense*) is a widely invasive plant in the Southeastern U.S., estimated to cover > 1.09 million forested hectares as of 2008 (Miller et al. 2008). Chinese Privet (hereafter referred to as "privet") is an ornamental shrub introduced into the U.S. in the 1850s that grows rapidly and can reach 9 m (Greene and Blossey 2014). In Georgia, our study location, privet is listed as a category one (most serious threat) invasive plant by the Georgia Exotic Pest Plant Council (GA-EPPC 2010) and is reported in 95% of counties in Georgia (EDDMapS 2018). It is especially prevalent in riparian areas. For example, as of 1999 privet covered 59% of the upper Oconee River Floodplain in north Georgia (Ward 2002). Because of its dominance in floodplain areas there is potential for privet to contribute significantly to litter inputs. Privet-invaded floodplain sites in western Georgia reported privet to account for 3.6–15% of annual litter fall in moderately invaded plots (29–76% of understory stems) and 7.8–29.9% in those that were severely invaded (> 76% of understory stems; Mitchell et al. 2011). While several studies have examined the impacts of privet on native plant communities in the Southeastern U.S. (Hanula et al. 2009; Greene and Blossey 2012, 2014; Hudson et al. 2014), few have examined the impact of this highly invasive shrub on wetland ecosystem processes such as leaf litter breakdown, which may impact nutrient cycling and carbon storage, both important ecosystem services of floodplains.

Invasive plants are known to alter the timing of leaf senescence and litter chemistry in forested systems (Ehrenfeld 2003), which is likely to alter the dynamics of litter breakdown because plant traits significantly influence rates of decomposition (Cornwell et al. 2008). The few studies that have examined the effect of exotic plant species on decomposition have found that invasive plants are frequently more labile and decompose more quickly than native plant litter (Cameron and Spencer 1989; Ehrenfeld 2003; Allison and Vitousek 2004; Ashton et al. 2005; Mitchell et al. 2011). However, in an in-situ study of 78 deciduous forest plant species, Jo et al. (2016) found no overall differences in decomposition rates between native and non-natives with only a few non-native plants decaying more quickly than natives. To our knowledge, only Mitchell et al. (2011) and Lobe (2012) have examined the impacts of privet on litter breakdown. Privet had a higher litter quality than any native species (lower C:N ratio, lower lignin content, and higher N content) and as the ratio of privet to native litter increased, decomposition rate also increased (Mitchell et al. 2011). When privet accounted for 30% of leaf litter the carbon turnover rate was 2.6 times that of uninvaded plots (Mitchell et al. 2011). While these results are compelling, minimal data exist on litter-associated arthropods that are known drivers of decomposition; these organisms may also be affected by changes in litter quality due to invasive privet.

In 2005, an experiment investigating the ecological impacts of Chinese privet removal was initiated in floodplain forests in northeastern Georgia. So far, the study has consistently shown that privet removal strongly benefits native plant and flying insect communities (Hanula et al. 2009; Ulyshen et al. 2010; Hanula and Horn 2011a, b; Hudson et al. 2013). Some non-native invertebrates, by contrast, may benefit from privet. For example, Ulyshen et al. (2010) found an association between privet invasion and abundance of the non-native ambrosia beetle, *Xylosandrus crassiusculus*. Similarly, Lobe (2012) found exotic earthworms to be more common at sites invaded by privet whereas native earthworms were more abundant at sites never invaded by the species. Additionally, Lobe (2012) found that freshly harvested privet leaves decomposed at similar rates at sites that had or had not been cleared of privet. However, leaves from native tree species were not included in that study and no published efforts have explored the effects of privet on arthropods in the litter or soil layers.

The goal of our study was to evaluate the effect of privet invasion on decomposition rates and litter-associated arthropods in the context of a long-term privet removal experiment. To do this we: (1) evaluated the relative contribution of privet to total litterfall among our invaded study sites (2) compared breakdown of cellulose (using filter paper) in plots which had or had not been subjected to experimental privet removal, and (3) compared litter breakdown and arthropod communities among litter types: (a) native sweetgum (found at all study sites), (b) invasive Chinese privet, and (c) a mixed sweetgum-privet litter treatment (to examine the effect of privet litter on sweetgum breakdown) in plots which had or had not undergone privet removal.

Methods

Study sites

Four study sites were selected on floodplains of the severely privet-invaded Oconee-River Watershed in the Northeast Georgia Piedmont region (Athens-Clarke and Greene Counties). All selected sites are part of a long-term experimental privet removal study started in 2005 by Hanula et al. (2009) using one of three plot types: (1) reference, no privet was removed, (2) mulch, mechanical removal of all privet which was then mulched and layered on the soil surface, and (3) chainsaw, hand removal of all privet using saws and leaving piles of cut privet on the soil surface. Both removal treatments (mulch and chainsaw) remained relatively privet-free at the beginning of our experiment, nearly ten years after the removal experiment began. Because the mulch and chainsaw treatments were visually very similar, only the mulch and reference treatments were used to compare conditions without and with privet (see Hanula et al. 2009 for site descriptions).

Litter-fall

To estimate the proportion of privet litter to both sweetgum and overall litter-fall at our study sites, we collected litter in leaf traps for approximately one year using protocol adapted from Harrison (2013) and the Center for Tropical Forest Science (CTFS)—Forest Global Earth Observatory (ForestGEO; Anderson-Teixeira et al. 2015). Leaf traps consisted of a polyvinyl chloride (PVC) frame, with a 1-m^2, 1-mm nylon mesh surface, which captured leaves, and was 1-m above ground. Four traps were placed within reference plots at each of the four sites (16 traps total) in subplots established by Hanula et al. (2009). Traps were placed on 20 October 2014 and litter was collected approximately once a month, except during peak leaf fall when it was collected every 2 weeks, until 21 October 2015. Leaves were transported from the field in cloth bags, dried at 55°C until a constant mass was reached (usually 72 h), sorted, and weighed.

Filter paper experiment

In the summer of 2015, prior to evaluating different litter types, we placed 10 fine-mesh (300 μm mesh) bags filled with 10 filter paper discs each (Fisherbrand, medium porosity, 9-cm diameter, Fisher Scientific, Waltham, MA) in the center of each of the eight plots (described by Hanula et al. 2009) as a cellulose control. Bags were placed along a transect at 1-m intervals. Fine-mesh bags were used to exclude most macroinvertebrates while still allowing moisture and gas exchange. These fine-mesh, filter paper bags allowed us to examine the effect of plot type (reference or mulch, hereafter privet removal plot) while minimizing potential impacts of litter chemistry and macroinvertebrate community differences. Filter paper bags were placed in situ on 13 May 2015 and left in place until 24 September 2015, a total of 134 days. Immediately after retrieval, filter paper was dried at 55 °C for ca. 24 h and subsequently weighed, ashed in a muffle furnace at 550 °C for 4 h and reweighed to determine ash free dry mass (AFDM) remaining.

Leaf litter experiment

Leaf litter breakdown was evaluated using the litter-bag method. Leaves were collected at abscission and air dried. Leaf litter was placed within 5-mm mesh bags (the smallest size mesh that would both contain privet litter and allow access to large invertebrates) and consisted of 10 g of leaf litter from: (A) privet, (B) sweetgum, or (C) a 50% mixture of privet and sweetgum. A 50% mixture was chosen because it was approximately the average proportion, by dry weight, of privet to sweetgum that fell across the four sites over the course of the previous year (informed by litter-fall results, see above). Due to the small size of privet leaves (some < 5 mm), litter was first sifted through 5-mm mesh before weighing so as not to cause an overestimate of mass-change via loss through mesh-bag windows.

Samples were placed at one randomly selected subplot within each reference and privet removal plot at all four sites (8 plots total). At each of the 8 subplots (four privet removal, four reference, one each at each of four sites), six bags each of the three litter treatments (privet, sweetgum, and mixture) were randomly placed on the soil surface at 1-m intervals along transects in two randomly chosen cardinal directions (n = 144).

Litter bags were deployed in the field in January of 2016 and collected initially at approximately 2 weeks, and then approximately once a month depending on hydrologic conditions with a total time of 166 days in-situ. An additional set of 24 litter bags (1 bag for each litter type, brought to each of the 8 subplots) were also transported into the field in January 2016, placed on the substrates as per other bags, but then immediately retrieved to estimate handling loss. Upon retrieval (either at the start or end of the trial), litter bags were sealed in paper bags, returned to the laboratory, and placed immediately in Berlese funnels (BioQuip Products, Rancho Dominguez, CA) for ca. 48 h to extract invertebrates. Extracted invertebrates were retained in 70% ethanol and then counted, identified (typically to family, but sometimes order or class), and categorized into trophic groups. After Berlese extraction, leaves were handled similarly to filter paper.

Statistical analysis

Litter-fall data were used primarily to inform the contents of the mixed litter treatment, so mass of three litter categories (privet, sweetgum, and all other litter) were totaled and proportions of each were determined.

Filter paper bags and leaf litter bags experienced different hydrological conditions because flooding levels were low in 2015 (filter paper data), compared to 2016 (leaf litter data). However, field conditions during the leaf litter study (2016 data) influenced how we ran analysis for both experiments.

Shortly after litter samples were placed in the field, major natural flooding occurred (pulses ranged from ca. 0.5–4.5 m high, lasting ca. 7–10 days each), which infiltrated litter bags with an abundance of fine, highly organic sediment. This intrusion resulted in some litter samples having higher ash-free dry masses relative to the baseline (i.e. handling loss bags), rather than a decreasing mass. Given that it was not possible to calculate the relative proportions of organic material from sediment versus experimental litter, we were prevented from calculating conventional litter breakdown coefficients (k) to compare breakdown rates among treatments. Instead, we compared percent AFDM remaining among treatments using a linear mixed-effects model (LME) with the nlme package (Pinheiro et al. 2017) in R (version 3.4.0; R Core Development Team 2017) with plot type, litter type, and days exposure as categorical fixed effects, a plot and litter type interaction, and site as a random effect. To minimize the effects of extreme values found in some bags (resulting from complete burial by sediment), values for percent AFDM remaining were capped at 150%. We did, however, test differences among treatments at both 200% AFDM remaining and without any caps on values (as well as other data transformations), and the significance of our tests remained similar.

Filter paper bags were not inundated. However, for ease of comparison to leaf litter treatments (2016 data), we compared percent AFDM remaining between plot types for filter paper bags as well, using LME in R with site as a random effect. For all analyses, bags that were damaged or lost were omitted. Data for both litter and filter paper bags were square root transformed prior to analyses to meet statistical assumptions.

Invertebrate abundance data (individuals per sample) were pooled across sampling dates prior to all analyses and additionally, were log $(x + 1)$ transformed to satisfy statistical assumptions and minimize the influence of highly abundant taxa. Immature invertebrates too small to be reliably identified were left out of analyses (< 1% of the total). Invertebrate community structure (based on relative abundances of taxa present) within litter bags was compared among plot and litter treatments via a two-way analysis of similarity (ANOSIM; Bray-Curtis similarity, Kruskal fit scheme 1,25 restarts), and non-metric multidimensional scaling (NMS, Bray-Curtis similarity, Kruskal fit scheme 1,25 restarts) was used to visualize patterns among treatments. All identifiable taxa were included in the analysis at the family level, except for several taxa which were only identified to order or class (in this case all individuals within that group were combined at the higher level of organization).

Invertebrate trophic group abundances (detritivores, predators) were compared among plot and litter treatments using LME in R with plot type and litter type as categorical fixed effects, with plot and litter interaction, and site as a random effect. NMS ordination and ANOSIM analyses were performed using PRIMER v6 software (Clarke and Gorley 2006). Post-hoc tests for LME models were done using the emmeans package (Length 2019).

Results

Litter-fall

In total, after pooling results from the 16 traps, privet and sweetgum accounted for 10 and 13% total annual litter-fall, respectively, with all other leaf types comprising the remaining 77%. Privet leaf-fall peaked twice; first in December 2014–January 2015 when 34% of privet litter fell, and again in March–May 2015 accounting for another 44% of annual privet litter. However, 95% of sweetgum and 93% of other litter fell between the months of October and December.

Filter Paper experiment

The percent AFDM remaining of filter paper ranged from 0.4 to 95.7% after 134 days. Additionally, the percent AFDM remaining in privet removal plots was approximately twice as high as those in reference plots ($F_{1,70}$ = 10.271, P = 0.002; Fig. 1).

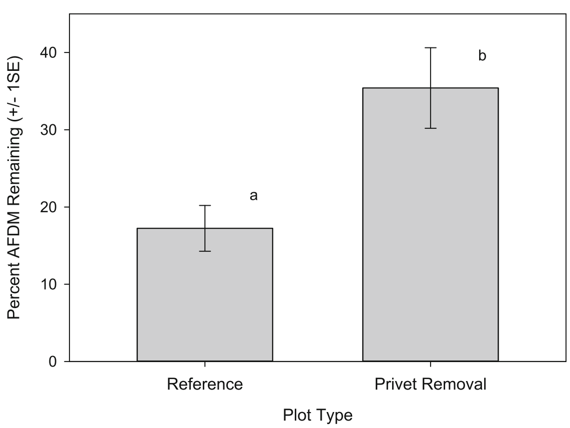

Fig. 1 Average percent ash-free dry mass (AFDM) remaining (± 1 SE) of filter paper bags after 134 days. Bars indicated by the same letter are not significantly different

Litter Bag experiment

The percent AFDM remaining in litter bags after 166 days ranged from 4.9 – 363.6%. Across all dates, percent AFDM ranged from 4.9–551%. The percent AFDM remaining varied significantly among litter types (privet, sweetgum, mixed privet and sweetgum; $F_{2,130}$ = 10.3, $P < 0.001$) and there was no significant interaction between litter type and plot type ($F_{2,130}$ = 0.5, P = 0.623). Post-hoc testing showed that privet bags had significantly less ($\sim$ 20%) AFDM remaining than sweetgum bags, or mixed bags. However, sweetgum and mixed bags were not significantly different from one another (Fig. 2). Proportion AFDM remaining in litter bags did not significantly vary by plot type (reference or privet removal; $F_{1,130}$ = 0.3, P = 0.599).

Dominant detritivores in litter bags, across dates and treatments, were spring tails (Collembola) and oribatid mites. Spiders (Araneae) and ants (Formicidae) were the dominant invertebrate predators. Approximately 30,000 total individuals were collected from litter bags, across 98 taxa (Online Resource 2). Invertebrate community analysis revealed no difference among litter types (R = − 0.027, P = 0.994) or plot types (R = 0.003, P = 0.369; Online Resource 3). Detritivore invertebrate abundance per sample did not vary among litter types ($F_{2,135}$ = 0.042, P = 0.959). However, detritivores were marginally more abundant in reference plots than in privet removal plots ($F_{1,135}$ = 3.848, P = 0.052; Fig. 3). Predator

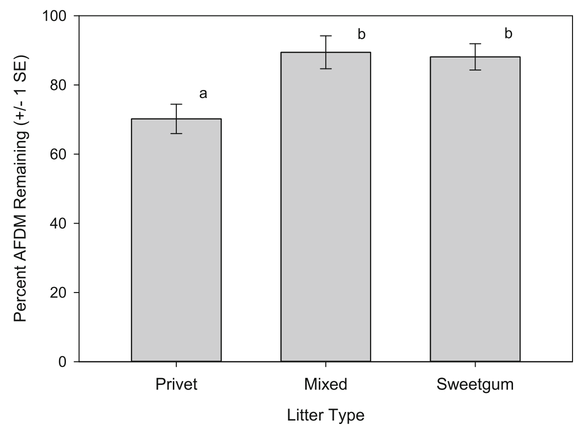

Fig. 2 Average percent ash-free dry mass (AFDM) remaining (± 1 SE) of privet, mixed, and sweet-gum litter bags averaged across all sampling dates and plot types. Bars indicated by the same letter are not significantly different

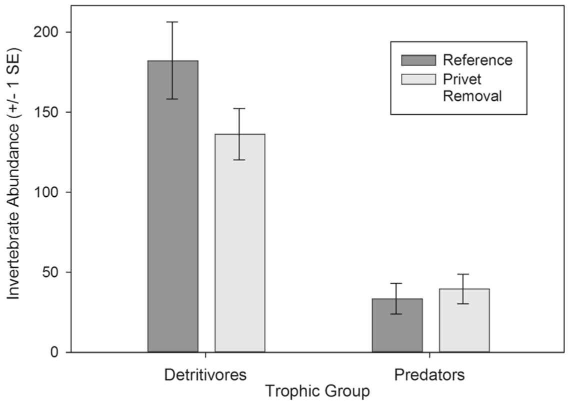

Fig. 3 Average invertebrate abundance per sample (± 1 SE) in reference or privet removal plots for detritivores ($P = 0.052$) and predators ($P = 0.527$), averaged across all sampling dates and litter types

abundance per sample did not vary among litter types ($F_{2,135} = 2.443$, $P = 0.091$) or plot types ($F_{1,135} = 0.402$, $P = 0.527$).

Discussion

We did not find a significant difference in the percent AFDM remaining in leaf litter bags, regardless of litter type, between reference and privet removal plots. Similarly, Lobe (2012) did not find a difference in privet litter decomposition in plots with or without privet. However, our results were unexpected in comparison with the previous year (2015), when the percent AFDM remaining in filter paper bags was two-fold higher in privet removal plots than in reference plots. Results from our filter paper analyses are consistent with Mitchell et al. (2011) who found higher carbon turnover in privet invaded plots as well as higher microbial nitrogen, indicating that chemical and microbial differences among plot types influences decomposition. Differences between filter paper and litter bag studies may be related to flooding, possibly negating the effect of privet removal on decomposition. Flooding did not occur during the filter paper study, whereas multiple, large flood pulses took place during the litter bag study, depositing a great amount of highly organic soil onto the floodplain. It is widely accepted that flood pulses affect floodplain nutrient and organic matter cycling (Junk et al. 1989; Tockner et al. 2000) and temporary, intense floods have been shown to increase nitrogen mineralization and subsequent nitrification-denitrification processes during drying (Shrestha et al. 2014). Possibly, effects from large flood pulses experienced during our study, outweighed any impact of privet on floodplain soil nutrients and subsequent effects on litter decay that we may have otherwise detected.

Conversely, it is also possible that there is a difference in soil chemistry among plots, which impacts decay of cellulose (filter paper), but that soil chemistry may be less important than other factors influencing decomposition of more structurally and chemically complex leaf litter. For example, Pavao-Zuckerman and Coleman (2005) found that litter breakdown was not influenced by soil chemistry but was affected by soil moisture and organic matter content, both of which may have been similar between reference and privet removal plots following scouring and/or burial that resulted from flooding. These conditions may vary more during the dry phase, due to differences in vegetation density between plots. Unfortunately, we failed to measure these features, so we cannot say with any certainty what most influenced our results. Additional study of soil characteristics (and subsequent effects on microbial communities), comparing plot types in both wet and dry conditions, would provide more insight into the characteristics that govern litter breakdown most directly in invaded riparian forests.

We did not find significant differences between reference and privet removal plots in either invertebrate community composition or predator abundances, but detritivores were moderately more abundant in reference plots. Patterns of abundance and diversity of soil invertebrates is multifactorial, including soil (especially pH and moisture) and litter quality, microhabitat types, and microbial communities (Korboulewsky et al. 2016). So, the collective impact of one plant species, like privet, on soil invertebrates is likely influenced by the relative effects of its traits on a myriad of interacting factors. Because we did not measure differences among these features directly, it is difficult to say specifically why we did not see many differences in invertebrate patterns between plot types. Increased habitat heterogeneity of leaf litter and higher litter quality in reference plots, from the addition of privet, during dry periods of our study may be responsible for somewhat higher detritivore abundance. However, flooding could have affected the relative influence of privet invasion we were able to detect on invertebrate abundances and community composition. During our study, flooding resulted in partial or complete burial of many litter bags by fine sediment. Burial is common in riparian wetlands and can substantially alter ecological interactions, especially when compared with terrestrial or lotic systems (Keddy 2010). For example, burial can create anaerobic conditions (Keddy 2010) that would influence the microbial community and kill invertebrates, which both could subsequently alter trophic dynamics and litter decomposition.

Significantly less Chinese privet leaf litter remained in litter bags over time, than in bags containing native sweetgum or a privet–sweetgum mixture, in both reference and privet removal plots. We had expected privet litter to disappear faster than sweetgum because previous work has shown that privet has a higher litter quality (Mitchell et al. 2011) and exotic invasive plants are typically more labile, decaying more quickly (Cameron and Spencer 1989; Ehrenfeld 2003; Allison and Vitousek 2004; Mitchell et al. 2011). It was unexpected, however, that the proportion of leaf litter remaining in mixed litter bags would be similar to sweetgum bags. Mitchell et al. (2011) found that as the proportion of privet litter increased in mixed litter bags, the rate of decomposition also increased. We found a difference in percent AFDM remaining between mixed bags (50% privet) and sweetgum-only bags of only around 1%, which is striking considering an approximately 20% difference between privet-only litter and each of the other two litter treatments (sweetgum only and a privet–sweetgum mixture).

It seems that the presence of sweetgum dramatically mitigated the effect of high privet litter quality on breakdown, rather than privet accelerating sweetgum breakdown as we had expected. An analysis of 30 mixed-litter studies found that it was more common for mixed-litter bags to accelerate decomposition, especially if one or more species in the mixture has a higher litter quality (Gartner and Cardon 2004). However, that pattern was not ubiquitous and factors other than litter quality, such as secondary inhibitory compounds and physical structure, influenced the effects of litter mixtures on decay (Gartner and Cardon 2004). We hypothesize that, in our study, some influencing factors of litter mixture decomposition may have been affected by the extensive flooding seen during the study period. For example, McArthur et al. (1994) found that in stream and floodplain pools in South Carolina, water oak (*Quercus nigra*) had an inhibitory effect on decomposition of the more labile sweetgum in mixed litter bags. This was not the case on dry floodplains and addition of oak leachate (containing phenols and tannins) inhibited bacterial density in mixed-species packs. Flooding, which happened soon after litter placement in our study, had the potential to increase sweetgum leaching, subsequently decreasing the effect of privet litter chemistry on decomposition.

Additionally, physical qualities of litter mixtures, like structural heterogeneity, can impact colonization of leaf litter by decomposers (Gartner and Cardon 2004; Korboulewsky et al. 2016). Mixed-litter initially increased both habitat heterogeneity and microarthropod abundance in a Japanese mixed-oak forest, but over time compaction and fragmentation of leaf litter minimized the effect of mixed-litter heterogeneity on decay and soil arthropods (Kaneko and Salamanca 1999). Burial of litter in our study likely greatly increased the rate of compaction reducing the influence of structural benefits of mixed-litter bags on decomposers. This idea is supported by minimal or no differences found in invertebrate abundance and community composition among our litter treatments. However, the body of literature involving the effect of mixed-litter on soil invertebrates remains scant and results vary, showing either conflicting responses to mixed-litter or no discernable patterns (Gartner and Cardon 2004; Korboulewsky et al. 2016).

In general, we found relatively little impact of Chinese privet invasion on litter breakdown or litter associated arthropods. However, flooding greatly impacted our study, and we suspect that flooding masked the impacts of privet invasion that we may have seen during a dry phase; especially considering that during a dry phase, filter paper decayed significantly faster in plots that contained privet. Yet, because privet is widespread in riparian areas, the interplay of privet invasion and flooding is relevant to informing management decisions. Privet litter decomposes more rapidly than native litter, which can speed up nutrient cycling in invaded ecosystems, reducing carbon storage and long-term carbon availability to higher trophic levels. Yet, it seems that the presence of less labile native species, like sweet gum, may mitigate the impacts of privet, at least in active floodplains. Future research may be able to determine more specifically how management of native species may be used to help mitigate the impact of privet on ecosystem processes when removal is cost or labor prohibitive.

It may also be important to explore the role of differences in leaf-fall phenology among privet and native species, which to our knowledge had not yet been measured. Greater than 90% of native species' leaves fell in autumn, while privet litter-fall peaked first in spring and again in mid-winter. In spring, privet was the only species with significant leaf-fall, meaning moderation of litter decomposition by other species is likely limited and spring leaf-fall may instead act as a mechanism to increase soil nutrients in preparation for the growing season. In winter, privet falls on top of a layer of earlier-shed native leaves, which may slow decomposition. Furthermore, in the Southeastern U.S., the months immediately following the winter leaf-fall are characterized by flooding in most years. As a result, flooding may further diminish the influence of privet litter decomposition through scouring or burial. Additionally, winter privet-fall coinciding with the floodplain wet phase may influence wetland ecosystems beyond decomposition. For example, when larval amphibians were reared in aquatic environments with varying mixtures of leaf litter, the collective traits (like C:N:P ratios) of plants present within litter mixtures influenced aspects of larval development (Cohen et al. 2014). However, the relative influence of a plant's traits on amphibian development depended on the specific combination of litter present and if the combination of traits present in a litter mixture were favorable to amphibian development (Cohen et al. 2014). So, the relative influence of privet litter on higher trophic levels, like amphibians, during wet phases needs be tested directly.

We believe that flooding may have an important influence on ecosystem processes in privet-invaded riparian wetlands. To fully understand the relationship between privet invasion and floodplain ecosystem processes, we suggest on-going, long-term research among seasons in both wet and dry years. Previous privet-related decomposition studies have taken place during dry phases of the flood pulse, and our results serve as a baseline for future examination of the role of privet invasion in active floodplain zones, which have unique ecological conditions.

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