OCCURRENCE AND GROWTH DYNAMICS OF NATURAL REGENERATION IN AN EAST TEXAS BOTTOMLAND HARDWOOD FOREST

Lydia J. Voth Rurup, Kathryn R. Kidd, Jeremy P. Stovall, Brian P. Oswald, and Steven B. Jack

ABSTRACT

Bottomland hardwood forests provide critical ecosystem services such as water quality improvement, nutrient cycling, flood and erosion control, carbon sequestration, and support of biodiversity. In recent decades, these systems have been reduced due to land conversion or negatively impacted by river regulation, which alters hydrology and flooding patterns and allows the invasion of species such as Chinese tallow (*Triadica sebifera* L.). As a result, these forests have experienced declines in productivity and regeneration potentials of desired species. This study quantified density, height, and diameter of natural regeneration of native and non-native species among two areas previously treated for Chinese tallow and an untreated area along the Neches River in east Texas. Chinese tallow, green ash, (*Fraxinus pennsylvanica* Marsh.). and the white oak (*Quercus alba*) group varied in density among treatments for the seedling size classes. Tallow sapling height was lower in the twice-treated area, while tallow seedling basal diameter was greater in the same area. Other species groups did not differ in density or size among treatment areas in any strata. Future management to increase light availability to the forest floor and repeated control of undesired species will be necessary to ensure that desired native species will be positioned to be recruited as canopy gaps are created.

INTRODUCTION

Riparian forests are key ecosystems worldwide. Floodplain forests, frequently bottomland hardwood forests, occur along meandering streams and rivers and are dependent on seasonal flooding for their characteristic formation and processes (Kroschel and others 2016, Romano 2010). These forests provide an array of important ecosystem services, such as water quality improvement, nutrient cycling, chemical conversion, flood and erosion control, carbon sequestration, biodiversity, and aesthetic and recreational value (Dybala and others 2019, Kellison and Young 1997, Kozlowski 2002, Lowrance and others 1984, Schindler and others 2014). Unfortunately, these diverse and essential values of floodplain forests have not always been realized and, thus, protected.

A significant portion of floodplain forests in the United States has been lost due to land conversion and urban development. Due to their productive soils, many bottomland hardwood forests have been converted to agriculture (Dybala and others 2019, Kellison and Young 1997). The construction of river-regulating structures such as dams, levees, and reservoirs has altered the natural river hydrology that these forests developed under and have become adapted to (Kozlowski 2002, Nilsson and Berggren 2000). Decades of high-grading have also decreased the quality and value of trees in many hardwood forests in the Eastern United States (Kellison and Young 1997). These issues combined have led to a lack of adequate desired, native natural regeneration in many bottomland hardwood forests. Additionally, the presence of invasive species can have negative implications for native regeneration. Floodplains are susceptible to plant invasions due to their connectivity, facilitating widespread seed dispersal, frequent disturbances, and high availability of water (Predick and Turner 2008, Repka and others 2015). Once established, invasive plants can outcompete native plant communities. Chinese tallow (*Triadica sebifera* L.) is a prevalent non-native invader in east Texas, the region in which this study was conducted. As a woody invader, Chinese tallow threatens to impact multiple forest strata, from the ground layer to the overstory canopy (Boyce 2015, Greene and Blossey 2012).

In light of these concerns, research is needed to evaluate the impacts of both prior treatments to control invasive species and associated environmental conditions on natural regeneration dynamics in floodplain forests. As Chinese tallow becomes more prevalent, specific research on these

Author Information: Lydia J. Voth Rurup, Graduate Research Assistant, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962; Kathryn R. Kidd, Associate Professor, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962; Jeremy P. Stovall, Professor, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962; Brian P. Oswald, Professor, Arthur Temple College of Forestry and Agriculture, Stephen F. Austin State University, Nacogdoches, TX 75962; and Steven B. Jack, Executive Director, Boggy Slough Conservation Area, T.L.L. Temple Foundation, Lufkin, TX 75901.

Citation for proceedings: Willis, John L.; Self, Andrew B.; Siegert, Courtney M., eds. 2022. Proceedings of the 21st Biennial Southern Silvicultural Research Conference. Gen. Tech. Rep. SRS-268. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 262 p. https://doi.org/10.2737/SRS-GTR-268.

topics is important in the ecosystems that this species has invaded in order for managers to identify effective strategies to promote native regeneration. This research examined natural regeneration dynamics in a bottomland hardwood forest adjacent to a river. The objectives of this study were to (1) evaluate species composition, density, height, and diameter of native and non-native seedlings and saplings, and (2) determine impacts of past treatments used to reduce the abundance of Chinese tallow.

METHODS

Study Area

This study was conducted within the Pineywoods Ecoregion of east Texas, which has a subtropical humid climate and receives 40 to 60 inches of precipitation annually (Diggs and others 2006). The study site, Boggy Slough Conservation Area (BSCA), is located in Trinity and Houston Counties, Texas, approximately 7 miles northeast of Apple Springs, TX. The eastern border of BSCA is formed by the Neches River, with areas adjacent to the river characterized by seasonally flooded bottomland hardwood forests. The overstory cover is comprised of mesic to flood-tolerant species, including several oaks (*Quercus* spp.), sweetgum (*Liquidambar styraciflua* L.), and green ash (*Fraxinus pennsylvanica* Marsh.). American hornbeam (*Carpinus caroliniana* Walt.) and water-elm (*Planera aquatica* J.F.Gmel.) are common species in the midstory. Chinese tallow is present at variable densities throughout the bottomlands at the study site. Herbicide (primarily triclopyr) treatments have been applied to different areas of BSCA annually since 2014. These treatments are a combination of broadcast spraying with a 2.5 percent Garlon® XRT solution in areas with small, dense tallow stems and hack-and-squirt application of a 30 percent Garlon® XRT solution in areas with more variable density and poor tractor access.

Field Methods

Sampling was conducted across three treatment areas directly adjacent to the Neches River: (1) an untreated control (Ctrl), and areas treated for Chinese tallow in (2) 2019 (1-Trt), and (3) both 2015 and 2018 (2-Trt). In each treatment area, 12 plots were established along four transects located perpendicular to the river. Along each transect, plots were systematically spaced 164, 492, and 984 feet (50, 150, and 300 m) from the river to account for variation in microtopography and sedimentation patterns.

Plots were inventoried in August 2020. Overstory trees [diameter at breast height (DBH) ≥ 4 inches] were tallied via point-sampling at plot center using a 10 basal area factor prism. The species and DBH of tallied trees were recorded. Regeneration was inventoried in a 1/100th-acre circular plot. Saplings were classified by a DBH of 0.6 to 3.9 inches and measured throughout the entire plot. Seedlings (DBH ≤ 0.6 inches) were classified as ephemeral (height < 6 inches) or non-ephemeral (height ≥6 inches). Both seedling size classes were assessed in the northeast and southwest quadrants of the 1/100th-acre regeneration plot. The species were recorded for living stems of all regeneration classes; height and basal diameter were measured for non-ephemeral seedlings and saplings.

Data Analysis

Data were analyzed using JMP® Pro 14.0.0 (SAS Institute Inc., Cary, NC). Density (stems per acre) of each regeneration-size class, seedling-basal diameter, and sapling height were compared by species group among the three treatment areas. Normal data were analyzed with a one-way ANOVA by treatment and Tukey's honestly significant difference (HSD) post-hoc test. Non-normal data (Chinese tallow density and size for all groups) were analyzed with a nonparametric Kruskal-Wallis test by treatment with a Wilcoxon post-hoc test. All tests were conducted at a significance level of $\alpha = 0.10$.

The oak species recorded at the site were divided into two groups. The white oak group consisted of overcup oak (*Quercus lyrata* Walt.), swamp chestnut oak (*Quercus michauxii* Nutt.), and bottomland post oak (*Quercus similis* Ashe.). Only overcup oak was observed for the white oak group for the regeneration classes. The red oak group consisted of willow oak (*Quercus phellos* L.), water oak (*Quercus nigra* L.), and cherrybark oak (*Quercus pagoda* Raf.). Green ash and sweetgum were prominent non-oak native species. Other commonly observed native species, grouped into an "other" category, were water hickory (*Carya aquatica* (Mich. f.) Nutt.), blackgum (*Nyssa sylvatica* Marsh.), American hornbeam, common persimmon (*Diospyros virginiana* L.), American elm (*Ulmus americana* L.), and water-elm. For the ephemeral and non-ephemeral seedling classes, American elm and water-elm were separately classified as the "elm family" (Ulmaceae) due to greater abundance.

RESULTS AND DISCUSSION

Overstory basal area ranged from approximately 70 to 100 square feet per acre among the three areas. Density of each overstory species group was fairly consistent across the treatments (fig. 1). The density of Chinese tallow overstory was low (<15 square feet per acre) in all areas. Sapling density did not significantly differ among treatments for any species group (fig. 2). However, the "other group" had a noticeably high sapling density in the control; this was primarily due to very high densities of water-elm, hornbeam, and persimmon. Among all treatments, there was a relatively low proportion of oak saplings (i.e., overcup oak) compared to the overstory, suggesting future recruitment issues for

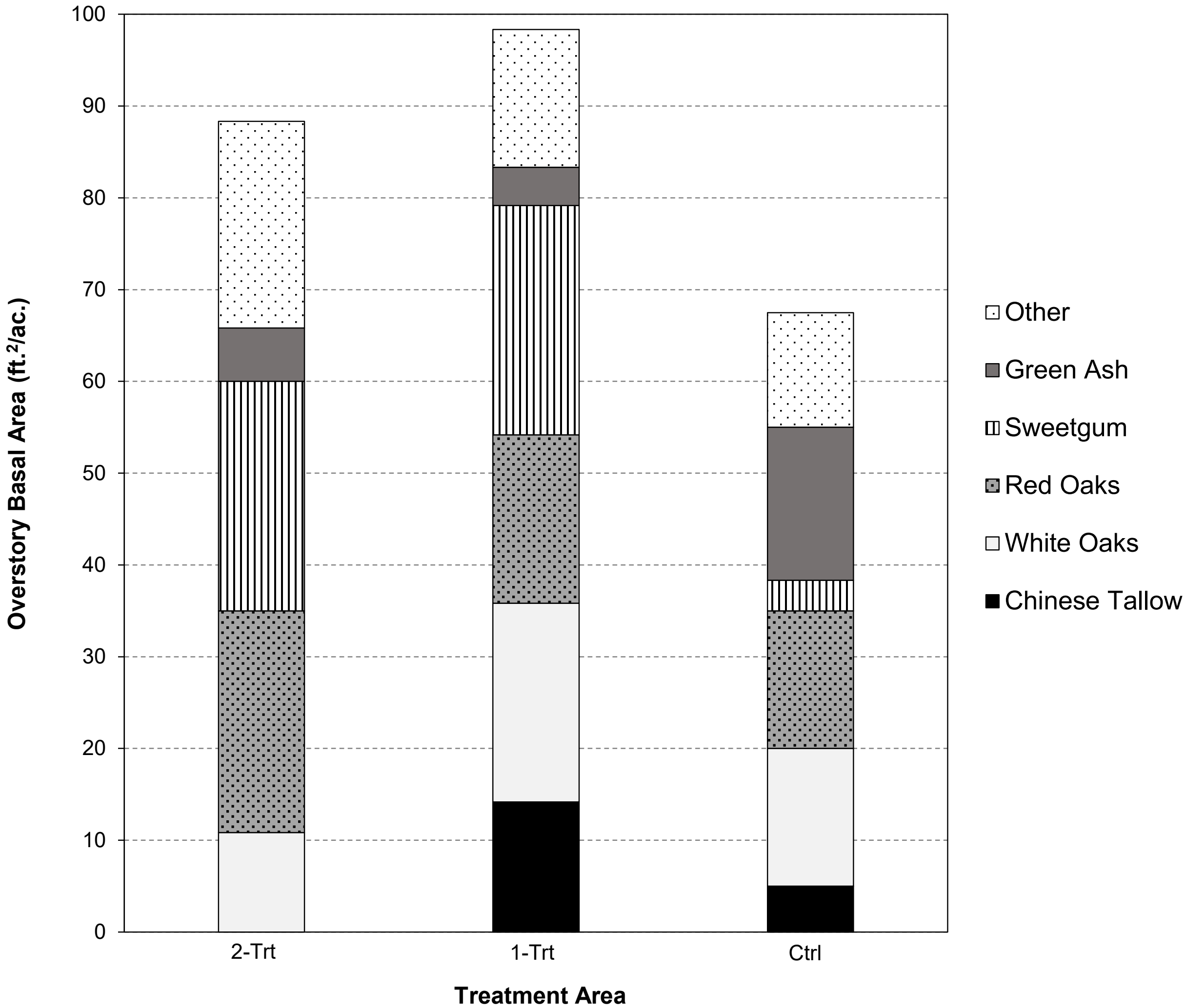

Figure 1—Mean basal area (square feet per acre) for overstory trees for native and non-native species groups among two areas treated for Chinese tallow and an untreated control area at Boggy Slough Conservation Area.

oaks. This finding echoes the results of Oliver and others (2005), who found that red oak regeneration was not sufficient to replace the overstory in the Mississippi Delta. The high density of very shade-tolerant species in the "other" group also indicates a lack of desired species positioned to be recruited into the overstory.

Non-ephemeral seedling densities were significantly different among treatments for three species groups. Chinese tallow density was greater in the 2-Trt area compared to the control ($p=0.04$). The density of white oaks was greater in the control area ($p<0.01$) than two treatment areas, while green ash density was greater in the 2-Trt area ($p=0.06$) than 1-Trt or Ctrl. In the ephemeral seedling class, Chinese tallow density was significantly lower in the 2-Trt area ($p=0.03$) than 1-Trt or Ctrl, and the density of white oaks was greater in the control ($p<0.01$) than in the treatment areas (fig. 3).

Though tallow seedling density differed among the areas, the higher density of the non-ephemeral class in the 2-Trt area indicates that tallow regeneration is still prevalent in the post-herbicide areas. There may also be a tradeoff occurring, where the treatments create an environment that favors tallow at the expense of the white oak group, evidenced by the higher densities of white oak seedlings in the untreated area. Anfang and others (2020) found that the removal of invasive European buckthorn (*Rhamnus cathartica* L.) via mowing facilitated the growth and survival of its regeneration by increasing light availability. The growth rate of Chinese tallow has also been shown to increase with increased light levels (Siemann and Rogers 2003). Due to their carbon allocation patterns, oak seedlings are initially more slow growing than many of their competitors (Hodges and Gardiner 1993). Thus, if conditions become favorable for prolific Chinese tallow regeneration, it is likely that the white oak group will be outcompeted by this fast growing invasive species. Additionally, herbicide applications against exotic plants can negatively impact non-target native species (Peterson and others 2020, Rinella and others 2009). It is also

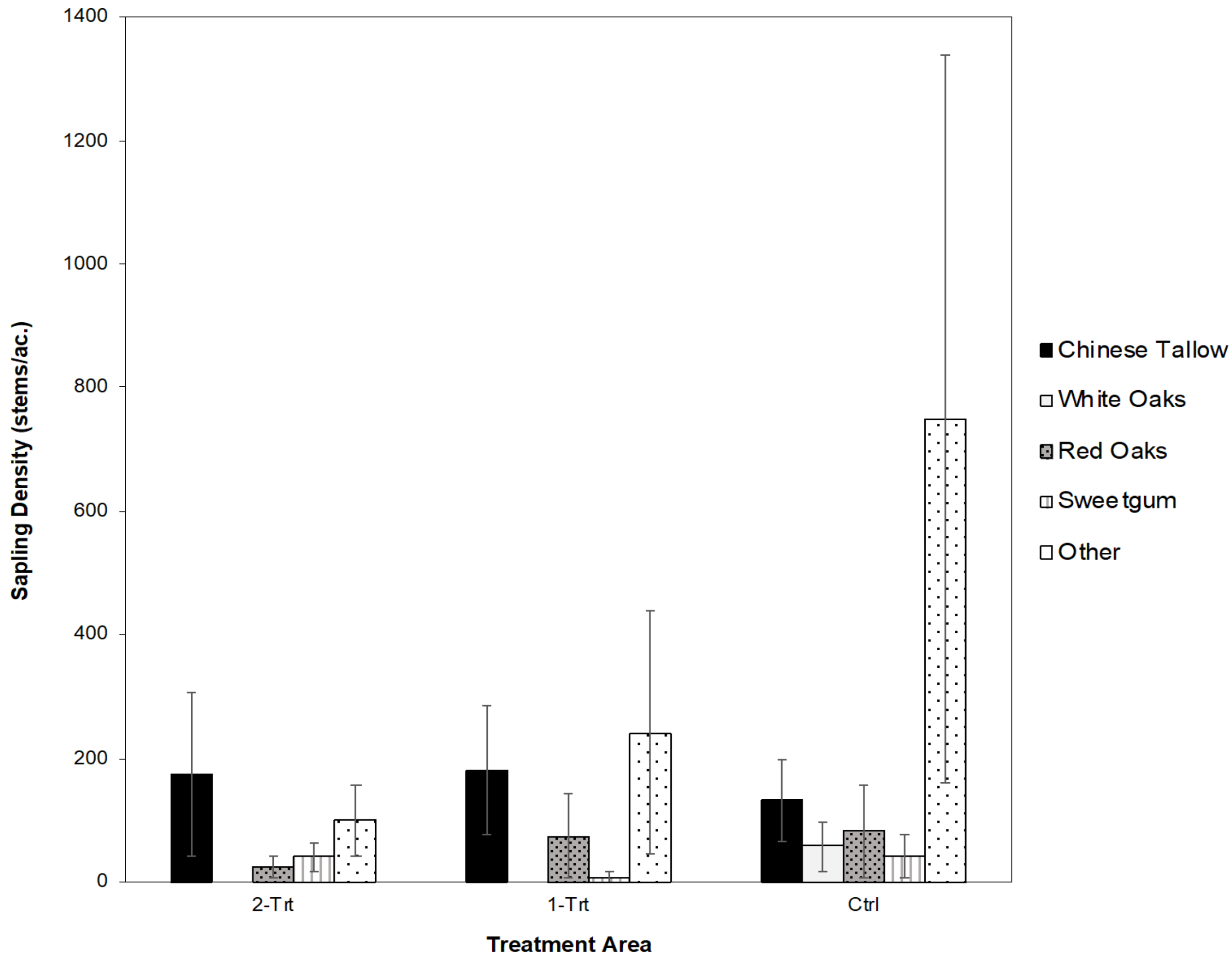

Figure 2—Mean density (stems per acre) for saplings for native and non-native species groups among two areas treated for Chinese tallow and an untreated control area at Boggy Slough Conservation Area. Error bars represent standard error.

possible, then, that some of the regeneration in the white oak group was unintentionally damaged and/or killed through the broadcast spraying of Chinese tallow, contributing to its greater density in the control area.

Chinese tallow was the only species group to significantly vary in size among the three treatment areas, which is likely a result of incorporated treatments that directly targeted tallow (i.e., hack-n-squirt). Tallow saplings were taller in the control (19.1 feet) compared to the 2-Trt (8.0 feet) area ($p=0.09$). Conversely, non-ephemeral tallow seedling basal diameter was greater in in the 2-Trt (0.29 inches) area versus the control (0.10 inches) area ($p=0.04$). The two treatments may have successfully eliminated most of the older, larger tallow saplings. However, this elimination of intraspecific competition may also have created an environment with more light and growing space for the younger or newly-established tallow stems to grow. Thus, it appears that even areas that were treated twice still have tallow that may be capable of outcompeting other species.

CONCLUSIONS

The protection of riparian forests is critical, and invasive species like Chinese tallow continue to be a prominent threat. This study did not evaluate the efficacy of herbicide treatments, due to a lack of pre-treatment data, but assessed regeneration dynamics in the post-treatment environment. Tallow and the white oak groups showed some differences in density and/or size among the treatment areas. These effects were variable and did not always favor the native, desired species. Based on these results, it seems that management beyond herbicide treatments of tallow will be necessary to facilitate recruitment of the native species that have historically made up the overstory of these forests.

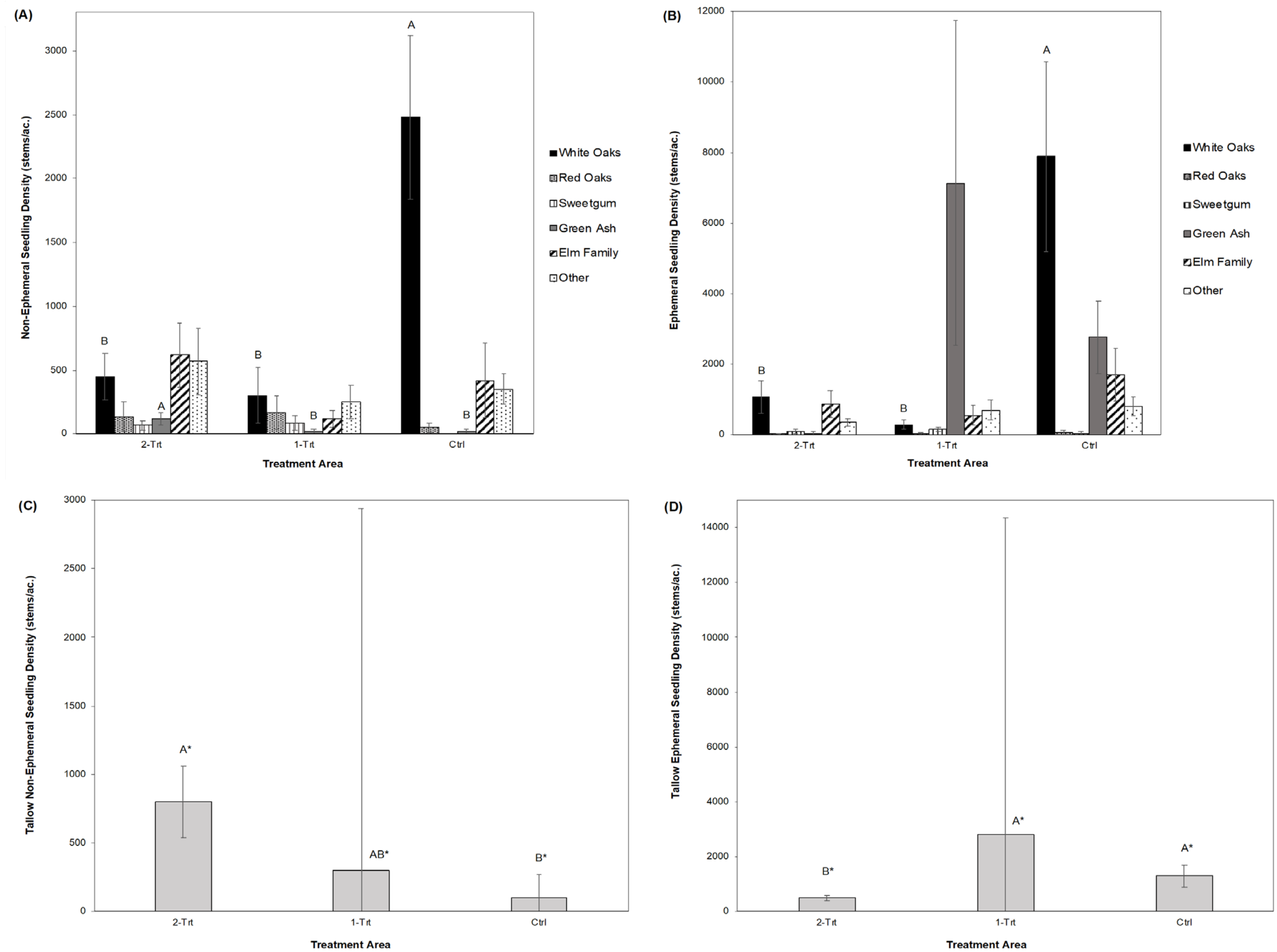

Figure 3—Mean density (stems per acre) for (A) non-ephemeral and (B) ephemeral seedlings for native species groups and median density (stems per acre) for (C) non-ephemeral and (D) ephemeral Chinese tallow seedlings among two areas treated for Chinese tallow and an untreated control area at Boggy Slough Conservation Area. Different letters above each species group indicate that means (native groups) or medians (tallow) are significantly different from other areas at α = 0.10 based on ANOVA and post-hoc Tukey's HSD analyses or Kruskal-Wallis and post-hoc Wilcoxon analyses (marked with an asterisk). Species groups without letters did not show significant differences among treatment areas. Error bars represent standard error.

ACKNOWLEDGMENTS

This work was supported by the USDA National Institute of Food and Agriculture McIntire-Stennis Cooperative Forestry Research Program project [Accession No: 1012158]. The management initiatives at BSCA are funded by the T.L.L. Temple Foundation. Additional support for this research was provided by the Arthur Temple College of Forestry and Agriculture at Stephen F. Austin State University, Nacogdoches, TX. Field assistance was provided by Sally Shroyer and Tyler Jones.

LITERATURE CITED

Anfang, C.; Schuster, M.J.; Wragg, P.D.; Reich, P.B. 2020. Increased light availability due to forestry mowing of invasive European buckthorn promotes its regeneration. Restoration Ecology. 28(2): 475–482.

Boyce, R.L. 2015. Recovery of native plant communities in southwest Ohio after *Lonicera maackii* removal. The Journal of the Torrey Botanical Society. 142(3): 193–204.

Diggs, G.M.; Lipscomb, B.L.; Reed, M.D.; O'Kennon, R.J. 2006. Illustrated flora of east Texas, Volume 1. Botanical Research Institute of Texas & Austin College. 26: 1–1594.

Dybala, K.; Matzek, V.; Gardali, T.; Seavy, N.E. 2019. Carbon sequestration in riparian forests: A global synthesis and meta-analysis. Global Change Biology. 25: 57–67.

Greene, B.T.; Blossey, B. 2012. Lost in the Weeds: *Ligustrum sinense* reduces native plant growth and survival. Biological Invasions. 14: 139–150.

Hodges, J.; Gardiner, E. 1993. Ecology and physiology of oak regeneration. In: Loftis, D.; McGee, C.E., eds. 1993. Oak regeneration: serious problems, practical recommendations. Symposium Proceedings; 1992 September 8-10; Knoxville, Tennessee. Presented by the Center for Oak Studies. Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture Forest Service, Southeastern Forest Experiment Station. 319 p.

Kellison, R.C.; Young, M.J. 1997. The bottomland hardwood forest of the Southern United States. Forest Ecology and Management. 90: 101–115.

Kozlowski, T.T. 2002. Physiological-ecological impacts of flooding on riparian forest ecosystems. Wetlands. 22: 550–561.

Kroschel, W.A.; King, S.L.; Keim, R.F. 2016. Tree regeneration by seed in bottomland hardwood forests. Southeastern Naturalist. 15(9): 42–60.

Lowrance, R.; Todd, R.; Fail, J. [and others]. 1984. Riparian forests and nutrient filters in agricultural watersheds. BioScience. 34(6): 374–377.

Nilsson, C.; Berggren, K. 2000. Alterations of riparian ecosystems caused by river regulation. BioScience. 50(9): 783–792.

Oliver, C.; Burkhardt, E.; Skojac, D. 2005. The increasing scarcity of red oaks in Mississippi river floodplain forests: influence of the residual overstory. Forest Ecology and Management. 210: 393–414.

Peterson, P.G.; Merrett, M.F.; Fowler, S.V. [and others]. 2020. Comparing biocontrol and herbicide for managing an invasive non-native plant species: efficacy, non-target effects and secondary invasion. Journal of Applied Ecology. 57: 1876–1884.

Predick, K.I.; Turner, M.G. 2008. Landscape configuration and flood frequency influence invasive shrubs in floodplain forests of the Wisconsin River (USA). Journal of Ecology. 96: 91–102.

Repka, R.; Sebesta, J.; Madera, P.; Vahalik, P. 2015. Comparison of the floodplain forest floristic composition of two riparian corridors: species richness, alien species, and the effect of water regime changes. Biologia. 70(2): 208–217.

Rinella, M.J.; Maxwell, B.D.; Fay, P.K. [and others]. 2009. Control effort exacerbates invasive-species problem. Ecological Applications. 19(1): 155–162.

Romano, S.P. 2010. Our current understanding of the upper Mississippi river system floodplain forest. Hydrobiologia. 640: 115–124.

Schindler, S.; Sebesvari, Z.; Damm, C. [and others]. 2014. Multifunctionality of floodplain landscapes: relating management options to ecosystem services. Landscape Ecology. 29: 229–244.

Siemann, E.; Rogers, W.E. 2003. Changes in light and nitrogen availability under pioneer trees may indirectly facilitate tree invasions of grasslands. Journal of Ecology. 91: 923–931.