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Chinese Tallowtree Biology and Management in Southeastern U.S. Forests

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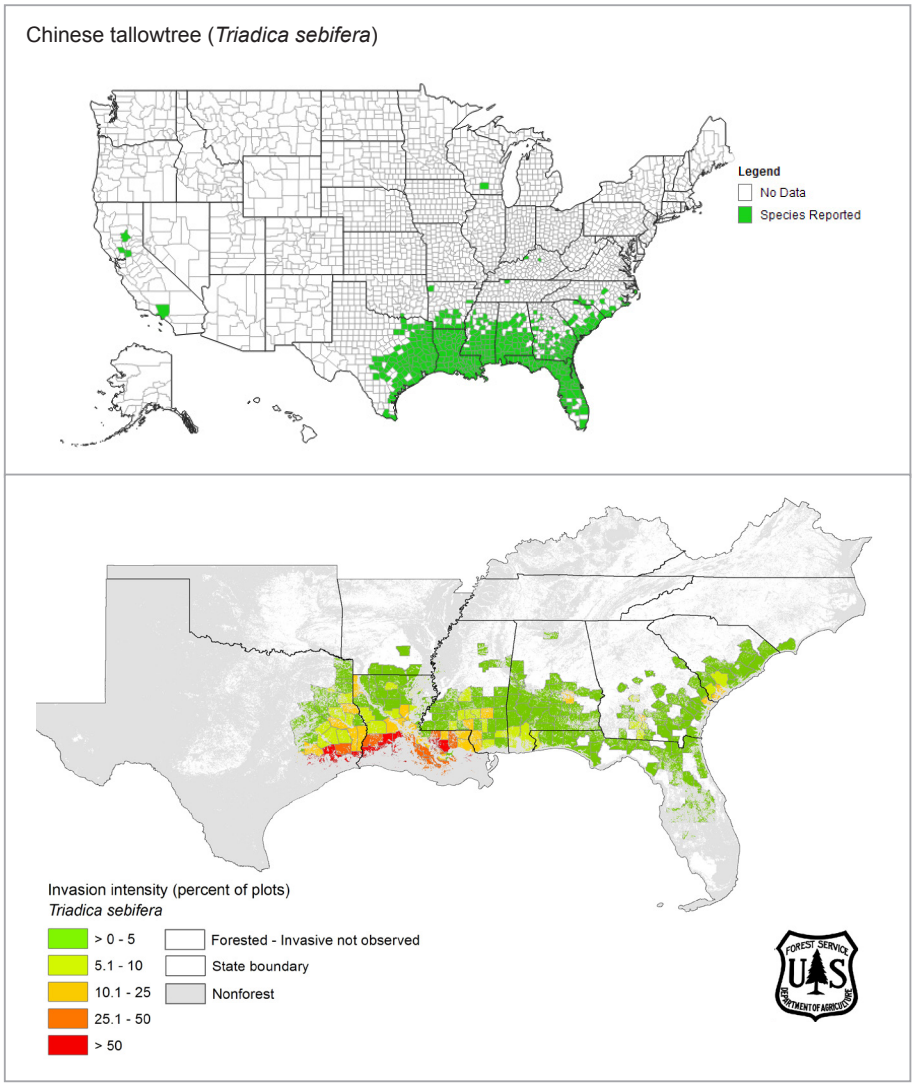

Figure 1. Observed presence of Chinese tallowtree throughout the U.S. (A) and percent of USDA FIA plots having Chinese tallowtree in the southeastern U.S. (B). Note that Chinese tallowtree is prevalent across most of the coastal Southeast, even though it may not occur in FIA plots, which are in forested areas. It is especially common in the Western Gulf Region.

Chinese tallowtree [*Triadica sebifera* (L.) Small] is the most pervasive and stand replacing exotic tree species in southeastern U.S. forests[4]. Originally introduced to the U.S. in 1776, Chinese tallowtree was documented in South Carolina in the late 1700s and in Texas by 1910. It is now present throughout much of the southeastern U.S., especially in coastal areas and the Western Gulf Region (Fig. 1). Several factors have contributed to its spread. An unfortunate decision in hindsight, the U.S. Department of Agriculture established the Office of Foreign Seed and Plant Introduction in the early 1800s to promote non-native species for agricultural products. Chinese tallowtree was subsequently promoted in the Gulf States to establish a local soap and candle industry based on the high concentration of tallow in the seeds. It has also been planted as a source of pollen for bees and honey production. Bright red fall foliage and seeds that resemble popcorn (Chinese tallowtree is also called popcorn tree) also contributed to its spread through use in the horticultural industry, as did its easy establishment and rapid early growth. Chinese tallowtree's rapid growth, high seed production, and ability to outcompete native vegetation across many habitat types make this invasive plant a great threat to native ecosystems.

Identification and Biology

Chinese tallowtree is a small to medium sized deciduous tree with a broadly pyramidal, open crown. Maximum height is typically 50 ft., although some reach 70 ft. (Fig.

Figure 2. Mature Chinese tallowtree can reach heights of up to 70', though stem form is rarely straight.

2). Chinese tallowtree leaves are alternate, with long petioles and smooth edges. Leaf shape varies from broadly diamond shaped to ovate, with a rounded to wide-angled base and tapering tip (Fig. 3). Leaves turn yellow, orange, purple, and red in the fall (Fig. 4), and are considered attractive by some landowners. Sap is milky white and can be irritating to the skin. In younger trees, bark color is reddish-brown to grey-brown, and the texture is smooth with vertical fissures. Bark in older trees is usually whitish-grey, and has flat-topped ridges and appears somewhat platy. It is relatively short lived (100 years) and can reach reproductive maturity in three years. Chinese tallowtree flowers in the late spring to early summer on slender 2-8 inch yellow-green catkins (Fig. 3). Terminal clusters of 3-lobed capsules approximately ½ inch diameter in size mature in the fall, splitting open to reveal three white, waxy seeds (Fig. 5).

Figure 3. Chinese tallowtree catkins & foliage.

Biology and Ecology

A mature Chinese tallowtree tree can produce up to 100,000 seeds each year. Seeds are consumed and spread by birds or are dispersed by water (e.g., falling into a stream or flood water and being deposited downstream). Chinese tallowtree seeds readily sprout throughout the growing season in any open or disturbed habitat, but can also germinate under closed, undisturbed canopies (Fig. 6). New trees can also arise from root suckers up to 15 ft. from the main tree (Fig. 7).

Chinese tallowtree has an unusual combination of fast growth and high tolerance to stress. It grows well on soils that are poorly drained, intermittently flooded, or saline and can grow rapidly in full sun or shade[5,11]. Chinese tallowtree is most likely to be found in low, flat areas adjacent to water and roadways and is more likely to occupy younger, highly disturbed forest stands[4,9]. It also occurs in upland sites and is becoming more common along fence lines and in untended pastures. The Chinese tallowtree population across the Southeast has increased dramatically over the past two decades. As of 2008, Chinese tallowtree occupied 457,000 acres of southern forests. In East Texas the population increased 174% between 1991 and 2005, and in Louisiana where the population increased 500% over the same time period, Chinese tallowtree is now the fifth most common tree[8].

Chinese Tallowtree Impacts

Chinese tallowtree can quickly take over a site, forming dense monocultures and outcompeting native vegetation and more desirable tree species (Fig. 8). Chinese tallowtree can disrupt important ecological processes in southern ecosystems. In fire dependent communities, Chinese tallowtree invasion can suppress the ability to carry fire through reduction in

Figure 4. Chinese tallowtree foliage turns bright colors during fall; unfortunately, this may contribute to its presence as an ornamental tree.

the horizontal continuity of surface fuels due in part to rapid leaf decomposition. Decomposing leaf litter also causes high levels of mortality in the early life stages of amphibians[10]. Conversion of coastal tallgrass and marsh communities into woodland thickets of Chinese tallowtree can displace federally endangered grassland bird species[13], and reduce arthropod diversity. Increasing impacts to production forestry are also of concern.

Chinese tallowtree has very few qualities that make it valuable as a conventional timber resource. Mature trees generally have poor form, and the wood has low density and is relatively weak and brittle, especially when dry. However, in some mixed-hardwood stands Chinese tallowtree can be collected and utilized for certain timber products. For instance, when combined with wood of other tree species, Chinese tallowtree will likely not affect the product quality of mixed hardwood structural flakeboard, or other applications such as composite panel production, furniture, and medium density fiber board.

Figure 5. Chinese tallowtree seeds begin green and turn a dark color just before they mature. Once mature, they open and resemble popcorn.

Figure 6. Chinese tallowtree seeds sprouting in an open area of the forest understory.

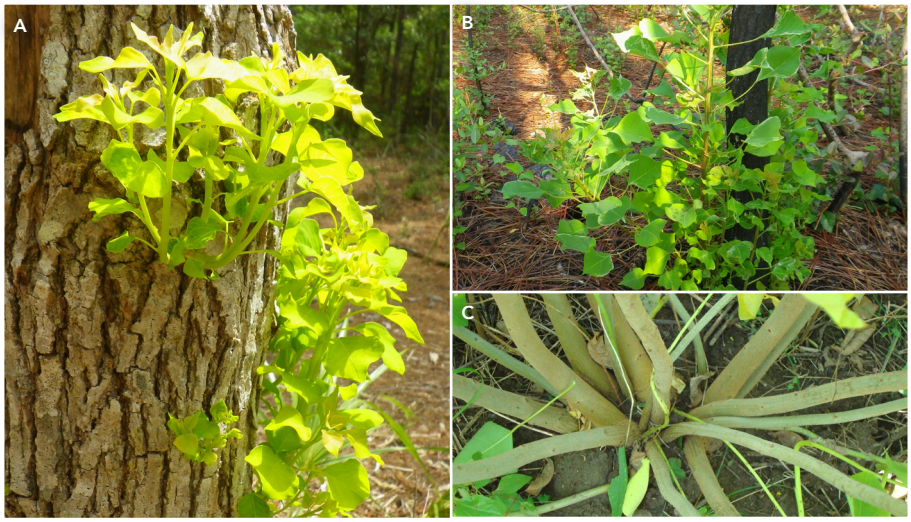

Figure 7. Chinese tallowtree will vigorously resprout on damaged stems (A), or at the base of heavily burned (B) or broken stems (C).

Management

SILVICULTURE

Forestry operations can increase the chance of Chinese tallowtree invasion. Any activities that expose mineral soil, create openings in the canopy, and reduce competition from dominant tree species can do so, especially when Chinese tallowtree is already established in the area. To reduce Chinese tallowtree establishment after harvesting, remove or kill as many seed-bearing trees and as much advance reproduction as possible from the area prior to the harvest. Site preparation (e.g., clearing, burning slash, disking, and herbicide treatment) may also help to reduce the likelihood of Chinese tallowtree seed germination and establishment[12]. Mowing or shredding alone is not recommended, as this will result in a large number of resprouts. However, herbicide treatment of resprouts or cut stumps after mowing or shredding is an effective management tool.

HERBICIDES

Several herbicides are effective for controlling Chinese tallowtree[6,7]. Control can be challenging, though, as prolific sprouting from the root collar and from lateral roots is common following some treatments. Many herbicides will require multiple applications for complete control. Control options can be further complicated by the fact that Chinese tallowtree often grows near water, dictating the use of an herbicide labeled for aquatic use.

Figure 8. Dense Chinese tallowtree monoculture.

Historically, triclopyr ester formulations (Garlon® 4 Ultra) have been prescribed for basal bark or foliar treatments, triclopyr amine formulations for cut stump or foliar treatments, and imazapyr (Arsenal®) for cut stump, injection or foliar treatments. Triclopyr ester may be a better option for foliar spray due to Chinese tallowtree's waxy leaves; however, triclopyr ester may exhibit increased volatility during warm weather and possibly injure non-target plants. Consequently, triclopyr amine may be a better option during this time. Several newer herbicides also show promise for Chinese tallowtree control.

Imazamox (Clearcast®), which has full aquatic labeling by the EPA, has good broadcast control of Chinese tallowtree with minimal impacts on native species including live oak (*Quercus virginiana*), bald cypress (*Taxodium distichum*), blackgum (*Nyssa sylvatica*), loblolly pine (*Pinus taeda*), and sweetgum (*Liquidambar*

Table 1. Herbicide treatments recommended for Chinese tallowtree control in the southeastern U.S.
Reprinted from 'Management Options for Chinese Tallowtree', ANR-2232[6], modified slightly, and used with permission of the Alabama Cooperative Extension System (Alabama A&M University and Auburn University).

Herbicide[a]	Example Trade Name(s)	Application Method	Rate	Site type
Aminopyralid	Milestone®	Cut stump	10%	Noncrop, natural areas
Aminocyclopyrachlor + metsulfuron	Streamline®	Broadcast IPT foliar[b]	11.5 oz./acre 11.5 oz./100 gal.	Noncrop, natural areas
Imazamox	Clearcast®	Broadcast IPT foliar Cut stump Hack and squirt	64 oz./acre 2% 50% 50%	Noncrop, aquatic, natural areas
Imazapyr	Arsenal®, Habitat®	Broadcast IPT foliar Cut stump Hack and squirt	2 to 4 pt./acre 2% 6 to 9% 50%	Noncrop, aquatic, forestry, natural areas
Picloram + fluroxypyr	Surmount®	Broadcast	3 to 6 pt./acre	Grass pastures
Picloram + 2,4-D	Grazon® P+D	Broadcast IPT foliar	4 qt./acre 1%	Grass pastures
Triclopyr amine	Garlon® 3A, Renovate®	IPT foliar	2%	Noncrop, aquatic, natural areas, forestry
Triclopyr ester	Garlon® 4, Pathfinder® II	Basal bark Cut stump	20 to 30% 25%	Noncrop, forestry, natural areas

[a]The addition of a nonionic surfactant at 0.25% v/v for almost all foliar herbicide treatments or methylated seed oil at 1% v/v for imazamox is highly recommended.

[b]IPT = individual plant treatment. This term is used to distinguish herbicide rate recommendations on a percentage basis rather than on a per acre basis.

[c]Concentrated imazapyr herbicide will kill any hardwood tree that has roots in the treated area if the spray to the cut stump or target tree stem reaches the ground. Extreme caution should be exercised to avoid collateral damage.

[d]Pathfinder II is a ready-to-use product that can be used full-strength for basal bark and cut stump treatments.

Additional notes on chemical control: Foliar treatments after leaves begin changing color in the fall are ineffective. Cut-stump treatments are easiest and most effective when applied in the late fall and can be used on any diameter stump. For water-based cut-stump treatments, such as aminopyralid, imazamox, or triclopyr amine, always apply the herbicide immediately after cutting. Basal bark treatments (using low spray volume on the lower 18" of trunk with an oil or diesel carrier) are effective on trees less than 6 inches in diameter at the base. Hack and squirt treatments are effective on any size trees, and are most effective when applied in the fall. For all application methods except basal bark that can be applied any time of year as long as the bark is dry, avoid treatment in the spring when sap flow is upward and new leaves are forming. Any use of pasture formulation of herbicides containing picloram or dicamba can damage non-target trees when applied at the tree line margins of pastures or when non-target desirable trees are in the pasture. Always follow label directions and specific laws pertaining to the state in which you are applying herbicide.

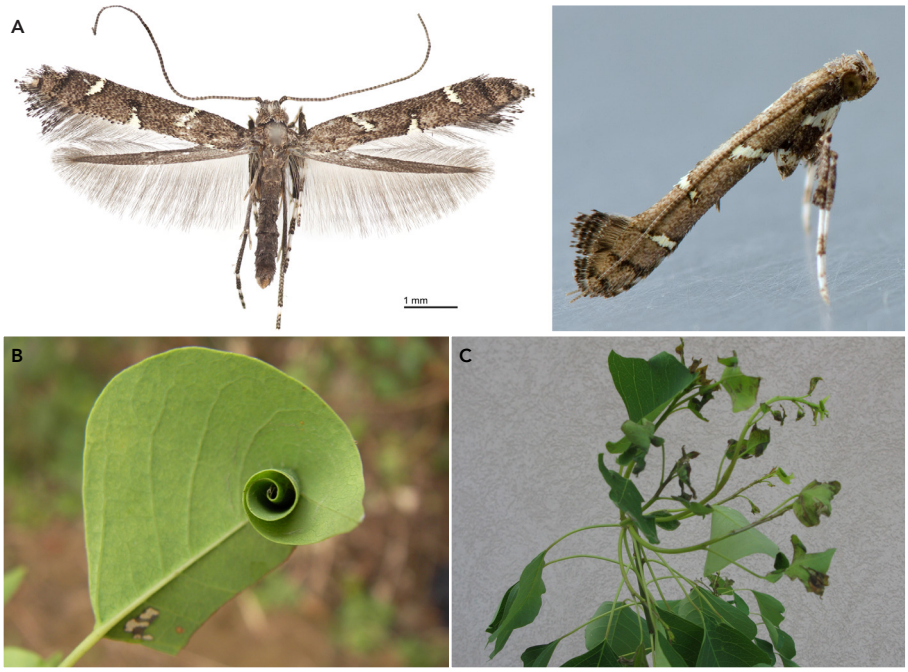

Figure 9. Adult Caloptilia triadicae *(Lepidoptera: Gracillariidae) (A), a moth now found commonly feeding on Chinese tallowtree in the southeastern U.S. Feeding damage by the larvae results in individual leaf rolls (B) and a tattered appearance on branches (C).*

styraciflua). However, black willow (*Salix nigra*) was susceptible to imazamox in broadcast field trials in the Alabama Mobile-Tensaw Delta. Imazamox can also be used for cut stump and hack and squirt applications. In a recent study, aminopyralid (Milestone®), aminocyclopyrachlor (in Streamline® and other products), fluroxypyr (Vista®) and imazamox provided better control than triclopyr amine and triclopyr ester for cut stump, basal bark, and individual plant foliar treatments[3].

Table 1 lists herbicides and application techniques that have been shown to be effective for various application methods including broadcast, foliar individual plant treatment (IPT), basal bark, cut stump, and hack and squirt. **Always read and follow the herbicide label for specific information concerning applications near water and in grazed areas, non-target injury, specific rates, and application guidance. Keep in mind that it is illegal to use herbicides in a manner that is inconsistent with the label. It is highly recommended to contact a professional when working with herbicides.**

FIRE

Chinese tallowtree is considered a fire suppressor and prescribed fire used alone is typically not effective for Chinese tallowtree control. Chinese tallowtree litter degrades rapidly, and there is also often little growing in the understory, resulting in very little fine fuel accumulation to carry a fire. However, if sufficient fuels are present, there is some evidence that prescribed fire might be an effective management tool for Chinese tallowtree. In mixed stands where Chinese tallowtree is not dominant, fire can reduce germination probability, and growing season burns may be hot enough to top-kill even larger trees. Growing season burns may also provide some suppression of Chinese tallowtree in prairies and grasslands. However, Chinese tallowtree will generally sprout following fire, and follow-up herbicide treatment will be needed. Effects of frequent fire on establishment and persistence of Chinese tallowtree have not been studied.

BIOLOGICAL CONTROL

One significant factor in the success of Chinese tallowtree in its invaded range is the historical lack of specialized herbivores that exert population-level regulation[1]. The only herbivore with a narrow host range found feeding on tallowtree in its invaded range is the moth *Caloptilia triadicae* (Lepidoptera: Gracillariidae) (Fig. 9). The young caterpillars of this species mine the leaves, whereas older caterpillars cut out a leaf section and create a distinctive helical retreat where pupation occurs[2]. *Caloptilia triadicae* is thought to be of Chinese origin and was first discovered in the invaded range in 2004. This moth has now been reported at nearly all the tallowtree-infested areas of the southeastern USA. It is unknown if feeding by this caterpillar impacts tree health or vigor.

Research on classical biological control of Chinese tallowtree began in 2007 and identified a number of promising candidates from the weed's native range[14]. These candidates include the defoliating/root-feeding flea beetle *Bikasha collaris* (Coleoptera: Chrysomelidae) (Fig. 10). The Bikasha flea beetle damages Chinese tallowtree through foliar feeding as adults and burrows into the roots as larvae, hollowing out internal tissues, causing significant damage that effectively reduces both above- and below-ground biomass. This insect has been shown to be safe in quarantine testing, and a petition for field release was submitted to USDA/APHIS in April 2016. A second agent presently undergoing quarantine testing is the defoliating moth *Gadirtha triadicae* (Lepidoptera: Nolidae). Finally, a complex of

three gall midges (*Schizomyia* n. spp.; Diptera: Cecidomyiidae) that attack stems and flowers of Chinese tallowtree are also being studied in China.

INTEGRATED PEST MANAGEMENT

Recent studies of slash pine/maritime forests suggest that combining a spring application of mastication (brush mulcher), followed by a fall application of foliar herbicide targeting residual and new growth, together with establishment of a frequent growing season prescribed fire regime may be highly effective at reducing Chinese tallowtree density and establishment opportunities for the long-term while also increasing native species diversity[9]. Fire can be effective as part of a larger management plan, especially after herbicide treatment. In this case, fire will further damage weakened plants and kill any exposed seeds. Even cool season fires can be effective if there is an abundance of fine fuel in response to herbicide treatment.

Figure 10. Adult (A) and feeding damage (B) of Bikasha collaris, *the first biological control agent of Chinese tallowtree in the U.S. The larvae feed on the roots and the adults feed on the leaves.*

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Resources

For the location and phone numbers of state agencies in the southeastern U.S. providing forestry assistance and information, see the following websites:

Alabama Forestry Commission: http://www.forestry.alabama.gov/

Arkansas Forestry Commission:
http://forestry.arkansas.gov/Pages/default.aspx

Florida Forest Service: http://www.floridaforestservice.com/

Georgia Forestry Commission: http://www.gatrees.org/

Kentucky Division of Forestry:
http://forestry.ky.gov/Pages/default.aspx

Louisiana Department of Agriculture and Forestry:
http://www.ldaf.state.la.us/

Mississippi Forestry Commission: http://www.mfc.ms.gov/

North Carolina Forest Service: http://www.ncforestservice.gov/

Oklahoma Forestry Services: http://www.forestry.ok.gov/

South Carolina Forestry Commission:
http://www.state.sc.us/forest/

Tennessee Division of Forestry:
https://www.tn.gov/agriculture/section/forests

Texas A&M Forest Service: http://texasforestservice.tamu.edu/

Virginia Department of Forestry: http://www.dof.virginia.gov/

For the location and phone numbers of University Extension personnel in the southeastern U.S. providing forestry assistance and information, see the following websites:

Alabama Cooperative Extension System:
http://www.aces.edu/main/

University of Arkansas Cooperative Extension Service:
http://www.uaex.edu/

University of Florida's Institute of Food and Agricultural Sciences (UF/IFAS):
http://solutionsforyourlife.ufl.edu/

University of Georgia Extension: http://extension.uga.edu/

Kentucky Cooperative Extension Service:
https://extension.ca.uky.edu/

Louisiana Cooperative Extension Service:
http://www.lsuagcenter.com/

Mississippi State University Extension Service:
http://extension.msstate.edu/

North Carolina Cooperative Extension:
https://www.ces.ncsu.edu/

Oklahoma Cooperative Extension Service:
http://www.oces.okstate.edu/

Clemson Cooperative Extension (South Carolina):
http://www.clemson.edu/extension/

University of Tennessee Extension:
https://extension.tennessee.edu/

Texas A&M AgriLife Extension: http://agrilifeextension.tamu.edu/

Virginia Cooperative Extension: http://www.ext.vt.edu/

To locate a consulting forester:

Association of Consulting Foresters:
http://www.acf-foresters.org/acfweb.

Click on "Find a Forester", then select your state in the "People Search – Public" search page.

For more information on how to select a consulting forester, go to:

http://msucares.com/pubs/publications/p2718.pdf

http://texashelp.tamu.edu/011-disaster-by-stage/pdfs/recovery/ER-038-Selecting-a-Consulting-Forester.pdf

http://www.uaex.edu/environment-nature/forestry/FSA-5019.pdf

Additional information on the Chinese tallowtree is available at:

http://southernforesthealth.net/

http://wiki.bugwood.org/Archive:SEEPPC/Chinese_Tallowtree_-_Triadica_sebifera_L.

Photo Credits

Figure 1: EDDMapS, 2016, Early Detection & Distribution Mapping System, The University of Georgia - Center for Invasive Species and Ecosystem Health, Available online at http://www.eddmaps.org/; last accessed November 7, 2016 (A). USDA Forest Service, 2016, created by Christopher M. Oswalt, USDA FS Southern Research Station, Forest Inventory & Analysis, 25 July 2016 (B).

Figure 2: Lauren S. Pile, Clemson University; Nancy Loewenstein, Auburn University

Figure 3: Lauren S. Pile, Clemson University (A); Nancy Loewenstein, Auburn University (B)

Figure 4: Nancy Loewenstein, Auburn University

Figure 5: Nancy Loewenstein, Auburn University

Figure 6: Lauren S. Pile, Clemson University

Figure 7: Lauren S. Pile, Clemson University (A and B) and Nancy Loewenstein, Auburn University (C)

Figure 8: Nancy Loewenstein, Auburn University

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