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A Survey of Key Arthropod Pests on Common Southeastern Street Trees

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Abstract. Cities contain dozens of street tree species each with multiple arthropod pests. Developing and implementing integrated pest management (IPM) tactics, such as scouting protocols and thresholds, for all of them is untenable. A survey of university research and extension personnel and tree care professionals was conducted as a first step in identifying key pests of common street tree genera in the Southern United States. The survey allowed respondents to rate seven pest groups from 0 (not pests) to 3 (very important or damaging) for each of ten tree genera. The categories were sucking insects on bark, sucking insects on leaves, defoliators and leafminers, leaf and stem gall forming arthropods, trunk and twig borers and bark beetles, and mites. Respondents could also identify important pest species within categories. Some tree genera, like *Quercus* and *Acer*, have many important pests in multiple categories. Other genera like *Liriodendron, Platanus,* and *Lagerstroemia* have only one or two key pests. Bark sucking insects were the highest ranked pests of *Acer* spp. Defoliators, primarily caterpillars, were ranked highest on *Quercus* spp. followed closely by leaf and stem gallers, leaf suckers, and bark suckers. All pest groups were rated below '1' on *Zelkova* spp. Identifying key pests on key tree genera could help researchers prioritize IPM development and help tree care professionals prioritize their training and IPM implementation. Recommendations for future surveys include having more respondents and tree taxa represented and identifying trees to species within large genera, such as *Acer* and *Quercus*.

Key Words. *Acer*; Integrated Pest Management; *Quercus*; Scale Insects.

INTRODUCTION

Integrated pest management (IPM) for urban trees has been studied for decades (Olkowski et al. 1974). Yet key IPM components developed for agricultural systems, such as standard scouting and monitoring practices, decision making criteria, and cultural management tactics, are not well developed for urban trees (Raupp et al. 1992; Fettig et al. 2005; Raupp et al. 2010; Frank et al. 2013). A major difference between IPM for urban trees compared to agricultural crops is the diversity of plant and pest species and the complexities of the landscape. For example, cities may have dozens of street tree genera and hundreds of species (Raupp et al. 2006). Each tree species hosts many specialist and generalist herbivorous arthropod species (Nielsen et al. 1985; Frank et al. 2013). Even if each species has just one to three key pests (Raupp et al. 1985), the number of pests for which monitoring (e.g., degree day models, traps) and decision-making tools (e.g., economic injury or action thresholds) are needed is immense.

The diversity of urban tree species and their arthropod pests necessitates development of clear IPM priorities to help researchers focus limited resources on the most common or damaging pests or those that require the most pesticide applications. A first step toward developing research priorities is identifying the key pests associated with common urban tree taxa. Key pests are those that frequently or persistently cause severe damage and account for a disproportionate amount of control effort or expense (Smith and Van den Bosch 1967). Focusing on the key pests of common, key plants—those that sustain disproportionately more pests or damage—can increase the efficiency of developing and implementing IPM programs (Raupp et al. 1985; Raupp et al. 2001).

University research and extension personnel, and others in the tree care industry, were surveyed to identify key arthropod pests of the most common genera of street trees in the Southeastern U.S.A. There have been several attempts to rank the importance of arthropod pest species of urban trees based on prevalence, economic cost, and pesticide use (Kielbaso and Kennedy 1983; Neely et al. 1984; Nielsen et al. 1985; Wu et al. 1991). However, none have been conducted in the past 30 years, during which time new exotic pests have arrived, preference for tree species has changed, and atmospheric temperature has increased. For example, the USDA updated the Plant Hardiness zones to reflect higher average winter temperatures across the U.S.A. (USDA 2012). Thus, the geographic range within which some tree species may be suitable has changed along with the distribution of some pests.

Review of Previous Pest and IPM Assessments

One of the first assessments of pest status on urban trees is from Kielbaso and Kennedy (1983). In 1980, they surveyed 1534 municipal tree care professionals, then ranked the pests by region in the Northeast, North Central, South, West, and Nationally. In 1991, Wu et al. (1991) reported a comparison between the 1980 survey and a new, similar survey in 1986 of 1062 municipalities. Respondents were asked to list the tree pests they considered most important. Rankings varied by region as in the previous assessment by Kielbaso and Kennedy (1983). In the South, borers, bagworms, and aphids were the top three pests, followed by webworms and scales. Pine bark beetle is reported on the Southern list, which was not reported in other regions. Nielsen et al. (1985) conducted a survey of 44 communities in the North Central region about the common street tree species and pest problems.

These surveys provide the relative importance of pests in each region, but their interpretation is limited by two factors. Respondents were free to list taxa based on their experience or expertise rather than selecting from a list of choices. Respondents listed 81 arthropod taxa, an indication of the diversity of tree pests, but the taxonomic specificity varied, and not all taxa were reported to species (Wu et al. 1991). For example, in Wu et al. (1991), many lepidopterans are listed, some of which are species (e.g., gypsy moth), while others are colloquial designations (e.g., webworms, tent caterpillars) in addition to just "caterpillar." Lepidopteran larvae are large, cause noticeable damage and frass, and are easy to identify, so a list of "top ten" pests may be populated with several types of caterpillar. However, cryptic taxa show up in the surveys as just "scales" or "borers" and may be ranked lower as a result. In addition, previous surveys did not ask respondents to match important pests to the tree taxa on which they occurred. Thus, rankings are driven in part by particularly abundant or pest-prone tree species. Although this provides an important picture of what managers were dealing with on a city-wide basis, it does not help identify which tree taxa are most pest-prone and which taxa with fewer pests may be alternatives.

METHODS

Street tree genera and pests differ throughout the country (Wu et al. 1991). A particularly important factor affecting tree selection and pest abundance is climate, which varies with latitude. Therefore, this survey focused on arthropod pests of street trees in the Southern U.S.A., since the goal was to identify current key pests in one region and compare to past assessments, rather than compare among regions. The region included Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia, following the definition of the "Southern Region" used by the USDA Southern IPM Center.

The survey was distributed via national email listservs that include university research and extension faculty and professionals involved in the tree care industry, such as those who work for municipalities, tree care companies, industry organizations, and agrochemical companies. The initial request for participation was sent on March 3, 2017 and described the focus and goals of the survey. Those who were willing to participate then received the survey, along with specific individuals who were invited to increase participation and industry representation.

Twelve tree genera were included in the survey that are commonly planted as street trees in the Southeastern U.S.A.: *Acer, Fraxinus, Lagerstroemia, Liquidambar, Liriodendron, Pinus, Platanus, Prunus, Pyrus, Quercus, Ulmus*, and *Zelkova*. These genera were selected because they were represented by the most individual trees listed in tree inventories from five Southeastern cities: Atlanta, GA; Savannah, GA; Charleston, SC; Charlotte, NC; and Raleigh, NC (Just et al. 2018).

Previous pest assessment surveys have used many different taxonomic groups and ranking systems. This survey focused on broad pest categories but also sought information on specific pest species that are most prevalent or problematic within those categories. Seven broad pest categories were created based on feeding guild and damage caused. Pest categories were sucking insects on bark, sucking insects on leaves, defoliators and leafminers, leaf and stem gall forming arthropods, trunk and twig borers and bark beetles, and mites.

Respondents completed two tables in the survey. The first had a row for each of the twelve tree genera and a column for each pest category. Respondents recorded a value of 3 (very common/damaging), 2 (moderate), 1 (rare/not very damaging), or 0 (not a pest) in each cell of the first table based on their expertise and experience with trees in the Southeastern U.S.A. Values were presented as "very common/damaging" and "rare/not very damaging," since it is possible for pests to be common in the environment but cause minor or infrequent damage, and for pests to be relatively rare but very damaging when they do occur. Each respondent could balance their perception of commonness and severity to select a score. A mean was calculated for each tree/pest combination recorded (Table 1).

In the second table, respondents listed the most important pest species for each tree genus from the pest category they considered to be most important from the first table. For example, if a respondent considered "leaf suckers" to be the most important category of pests on *Acer* spp. in the first table, they would list the species of "leaf suckers" they thought were important in the second table. Since the same pest category was not always selected by all respondents, these data are presented in Table 2 as the pest category with the highest mean in the first table followed by the pest species listed by respondents as important in that category. In addition, the survey presents the pest species listed by respondents who considered other pest categories most important (Table 2).

RESULTS AND DISCUSSION

15 completed surveys were received from people residing in the following eight Southeastern states: Alabama (1), Florida (2), Kentucky (2), North Carolina (4), Oklahoma (1), South Carolina (1), Tennessee (3), and Virginia (1). Respondents included 12 university research or extension faculty, two technical specialists at tree care firms, and one city forester.

Sucking Insects on Bark

This category primarily includes scale insect species, in particular armored scales. Pests in this category feed on fluid in phloem, parenchyma, cambium, or other vascular tissues, and damage trees by reducing the energy available for growth and storage. Infested

Table 1. Common tree genera and ranking of pest guilds or damage types in the Southeastern U.S.A. 3 = very common/damaging, 2 = moderate, 1 = rare/ not very damaging, 0 = non-issue. Values are means of responses followed by the number of times the category was ranked by respondents as 3.

Genus	Bark suckers (scales)	Leaf suckers (aphids, lacebugs, scales)	Defoliators (Lepidopterans, Coleopterans, sawflies)	Leaf and stem gallers	Borers and bark beetles	Mites	Overall tree genera means
Acer (*n* = 15)	2.67 (11)	1.67 (1)	1.38 (1)	0.73 (1)	1.33 (1)	1.31 (0)	1.52
Fraxinus (*n* = 14)	0.50 (0)	0.71 (0)	0.57 (0)	0.86 (1)	2.57 (12)	0.69 (0)	0.98
Lagerstroemia (*n* = 15)	1.47 (4)	1.87 (3)	0.73 (1)	0.07 (0)	0.67 (1)	0.15 (0)	0.83
Liquidambar (*n* = 15)	0.33 (0)	0.53 (0)	0.73 (1)	0.20 (0)	0.60 (0)	0.31 (0)	0.45
Liriodendron (*n* = 15)	1.33 (2)	2.07 (6)	0.87 (0)	0.27 (0)	0.73 (1)	0.31 (0)	0.93
Pinus (*n* = 15)	0.87 (0)	1.20 (0)	1.40 (2)	0.27 (0)	2.13 (7)	0.67 (0)	1.09
Platanus (*n* = 15)	0.13 (0)	1.73 (4)	0.73 (0)	0.13 (0)	0.47 (0)	0.77 (0)	0.66
Prunus (*n* = 15)	1.07 (3)	1.13 (1)	2.27 (6)	0.33 (0)	1.87 (6)	0.62 (0)	1.22
Pyrus (*n* = 15)	0.40 (0)	0.53 (0)	0.73 (0)	0.27 (0)	0.67 (0)	0.46 (0)	0.51
Quercus (*n* = 15)	1.73 (5)	1.93 (5)	2.07 (5)	2.06 (4)	1.53 (2)	1.23 (1)	1.76
Ulmus (*n* = 15)	0.87 (1)	1.13 (1)	1.40 (1)	0.67 (0)	1.20 (2)	0.58 (0)	0.98
Zelkova (*n* = 15)	0.53 (0)	0.33 (0)	0.40 (0)	0.13 (0)	0.53 (0)	0.07 (0)	0.33
Overall pest category means	0.99	1.24	1.11	0.50	1.19	0.60	

Table 2. Top pest categories for each genus and key pest species within those categories. Top pest category reflects the category with the highest value in Table 1. If equal values appeared in Table 1, both pest categories and associated species are presented. The most commonly identified pest species appears first followed by the number of times it was listed in parentheses. Important pests listed by respondents who selected a different top category are listed in the final column.

Genus	Top pest group	Species in top category	Species listed as important from other categories
Acer	Bark suckers	Gloomy scale, *Melanaspis tenebricosa* (7); Japanese maple scale, *Lopholeucaspis japonica*; obscure scale, *Melanaspis obscura;* white peach scale, *Pseudaulacaspis pentagon*; oyster shell scale, *Lepidosaphes ulmi*; cottony maple scale, *Pulvinaria innumerabilis*; cottony maple leaf scale, *Pulvinaria acericola;* terrapin scale, *Lecanium nigrofasciatum*; calico scale, *Eulecanium cerasorum; Lecanium* spp.	Flatheaded appletree borer, *Chrysobothris femorata*; Japanese beetles, *Popillia japonica*; green-striped mapleworm, *Anisota rubicunda*; spring cankerworm, *Paleacrata vernata*; fall cankerworm, *Alsophila pometaria*; ambrosia beetles.
Fraxinus	Borers	Emerald ash borer, *Agrilus planipennis* (9); clearwing borers, *Podosesia* spp.	
Lagerstroemia	Leaf suckers	Crape myrtle aphid, *Tinocallis kahawaluokalani* (8).	Crape myrtle bark scale, *Acanthococcus lagerstroemiae*; Japanese beetle, *Popillia japonica*; ambrosia beetles; Sri Lanka weevil, *Myllocerus undecimpustulatus undatus*.
Liquidambar	Defoliators	Fall webworms, *Hyphantria cunea* (3).	Camphor shot borer, *Cnestus mutilatus*; ambrosia beetles.
Liriodendron	Leaf suckers	Tulip tree aphid, *Illinoia liriodendri* (9).	Tulip tree scale, *Toumeyella liriodendri*; yellow poplar weevil, *Odontopus calceatus*; root collar borer, *Euzophera ostricolorella*; American plum borer, *Euzophera semifuneralis*.
Pinus	Borers	Bark beetles (8); Southern pine beetle, *Dendroctonus frontalis*; black turpentine beetle, *Dendroctonus terebrans*; *Ips* spp.	Pine needle scale, *Chionaspis pinifoliae*; Nantucket pine tip moth, *Rhyacionia frustrana*; redheaded pine sawfly, *Neodiprion lecontei*; pine bark adelgid, *Pineus strobi*; pine sawyer, *Monochamus scutellatus*; longhorned beetles.
Platanus	Leaf suckers	Sycamore lace bug, *Corythucha ciliata* (11).	
Prunus	Defoliators	Eastern tent caterpillar, *Malacosoma americanum* (5); Japanese beetle, *Popillia japonica*; spring cankerworm, *Paleacrata vernata*; fall cankerworm, *Alsophila pometaria*.	Flatheaded appletree borer, *Chrysobothris femorata*; peachtree borer, *Synanthedon exitiosa*; lesser peachtree borer, *Synanthedon pictipes*; white peach scale, *Pseudaulacaspis pentagon*; oyster shell scale, *Lepidosaphes ulmi*; San Jose scale, *Quadraspidiotus perniciosus*; ambrosia beetles.
Pyrus	Defoliators and borers	Defoliators: cankerworms (2); spring cankerworm, *Paleacrata vernata*; fall cankerworm, *Alsophila pometaria*. Borers: ambrosia beetles (3); flatheaded appletree borer, *Chrysobothris femorata*; clearwing borers.	Spider mites; psyllids, aphids; pearleaf blister mite, *Phytoptus pyri*.

Table 2. (continued)

Genus	Top pest group	Species in top category	Species listed as important from other categories
Quercus	Defoliators and stem/ leaf gallers	Defoliators: orangestriped oakworm, *Anisota senatoria* (3); pink-striped oakworm, *Anisota virginiensis*; spring cankerworm, *Paleacrata vernata*; fall cankerworm, *Alsophila pometaria*; yellownecked caterpillar, *Datana ministra* Stem/Leaf gallers: horned oak gall, *Callirhytis cornigera* (3); gouty oak gall, *Callirhytis quercuspunctata* (3); jumping oak gall, *Neuroterus saltatorius*; oak apple gall.	Lecanium scale, *Parthenolecanium* spp. (5); oak lecanium scale, *Parthenolecanium quercifex*; obscure scale, *Melanaspis obscura*; oak erriococcid, *Eriococcus quercus*; Kermes scale, *Allokermes kingii*; twig girdler, *Oncideres cingulata*; oak leaf itch mite, *Pyemotes herfsi*; flatheaded appletree borer, *Chrysobothris femorata*; two-lined chestnut borer, *Agrilus bilineatus*.
Ulmus	Defoliators	Elm leaf beetle, *Xanthogaleruca luteola* (4).	Native elm bark beetle, *Hylurgopinus rupes*; smaller European elm bark beetle, *Scolytus multistriatus*; banded elm bark beetle, *S. schevyrewi*; Japanese maple scale, *Lopholeucaspis japonica*; calico scale, *Eulecanium cerasorum*; *Parthenolecanium* spp.; elm cocks comb gall, *Colopha ulmicola;* elm sack gall, *Tetraneura ulmi*; plant hoppers.
Zelkova	Bark suckers & Borers	Bark suckers: Japanese maple scale, *Lopholeucaspis japonica* (2); calico scale, *Eulecanium cerasorum* (2). Borers: native elm bark beetle, *Hylurgopinus rupes* (1); smaller European elm bark beetle, *Scolytus multistriatus* (1); ambrosia beetles (1).	

trees may have slowed growth, sparse canopies, and dead branches. Over 100 years ago, Metcalf identified gloomy scale (*Melanaspis tenebricosa*) as the most important shade tree pest in North Carolina (Metcalf 1912; Metcalf 1922). Scale insects (family not specified) remained important pests in 1980, ranked third in importance in the Southern U.S.A. and 2nd nationally (Kielbaso and Kennedy 1983). A survey in 1986 found scales ranked fifth in the South behind two caterpillar species, aphids, and borers. Scales were also among the top pests in two surveys of urban landscapes (not only trees) (Holmes and Davidson 1984; Raupp and Noland 1984) and trees in the North Central U.S.A. (Nielsen et al. 1985; Kielbaso and Kennedy 1983).

In most assessments, scales have ranked in the top five pests of trees. Currently, bark feeding scales are especially important pests of *Acer* spp. Gloomy scale was the most frequently listed species. Eight other armored and soft scale species were also identified as important. Bark sucker scales ranked second on *Liriodendron* spp. and included just one species: Tuliptree scale (*Toumeyella liriodendri*). This is in contrast with *Quercus* spp. on which bark suckers ranked fourth behind defoliators, gallers, and leaf suckers, but with a higher mean rating (1.73) than *Liriodendron* spp., and with five scale taxa listed as important by respondents. Comparing results for *Quercus* spp. and *Liriodendron* spp. highlights that a pest, like scales, can rank highly on a tree taxa with few pests, like *Liriodendron* spp., whereas scales rank lower on *Quercus* spp. but are more diverse and considered more important.

This survey captured a new pest, crape myrtle bark scale (*Acanthococcus lagerstroemiae*), which is in the process of spreading across the South. Respondents from areas already invaded by crape myrtle bark scale identified bark suckers as most important, but respondents in uninvaded areas identified leaf suckers, of which crape myrtle aphid (*Tinocallis kahawaluokalani*) is the only species, as most important. Crape myrtle bark scale is a more damaging pest than crape myrtle aphid and more difficult to manage. A survey conducted several years from now would likely document crape myrtle bark scale to be most important throughout the region.

Sucking Insects on Leaves

Primary pests in this category include phloem-feeding scales, aphids, and whiteflies. Phloem feeders damage trees by removing carbon and nutrients needed for growth and storage and can reduce photosynthesis and other leaf processes. In addition, phloem feeders excrete a sticky sugar-based solution called honeydew that coats leaves, cars, sidewalks, and other surfaces. This creates a nuisance and is often the subject of citizen complaints. For this reason, previous pest assessments often have ranked soft scales and aphids, such as elm aphids and oak aphids, in the top five pests of every region in the United States (Kielbaso and Kennedy 1983; Nielsen et al. 1985; Wu et al. 1991).

Leaf suckers were the top ranked pest for *Liriodendron* spp., *Lagerstroemia* spp., and *Platanus* spp. in this survey. Tuliptree aphids (*Illinoia liriodendri*) can become very abundant on tulip trees where they produce copious honeydew and cause leaves to become discolored or die (Dreistadt and Dahlsten 1988). The density of honeydew drops landing below a tree can be used to monitor tuliptree aphid density as part of an IPM program (Dreistadt 1987). The most important pest of *Platanus* spp. is sycamore lace bug (*Corythucha ciliata*) a leaf sucker that causes extensive stippling on leaves which then become discolored or die. This was the only arthropod pest identified as important on *Platanus* spp. in this survey, though *Platanus* spp. are susceptible to other arthropod pests and leaf pathogens, such as leaf scorch (*Xylella fastidiosa*) and plane anthracnose (*Apiognomonia veneta*)(Filer 1977).

Leaf suckers were ranked third for *Quercus* spp. yet rated highly in importance (1.93). Several leaf sucking insects occur on *Quercus* spp., including oak lace bugs (*Corythucha arcuata*) and aphids (Johnson and Lyon 1976). The most prominent in the South and identified most in the survey are *Parthenolecanium* spp. Scales, including oak lecanium scale (*P. quercifex*), and European fruit lecanium scale (*P. corni*). These scales can become very abundant on willow oaks and other *Quercus* spp., especially under urban conditions (Meineke et al. 2013; Meineke and Frank 2018). They are univoltine throughout the South, and their life cycle includes leaf feeding and bark feeding stages (Camacho et al. 2017). This identifies a weakness in the pest categories used for the survey, because some respondents listed *Parthenolecanium* spp. as bark suckers and others listed them as leaf suckers. Since *Parthenolecanium* spp. scales were the primary pest listed in both categories, scales likely would rank higher as pests of *Quercus* spp. if responses were combined in a more specific category.

Defoliators and Leafminers

Caterpillars are important pests of some tree species. They can defoliate susceptible species, and repeated defoliation can reduce tree growth and survival (Kulman 1971; Coffelt et al. 1993). Even partial defoliation can reduce tree growth and beauty and provoke citizen complaints (Coffelt and Schultz 1990). Caterpillar frass can be a nuisance accumulating on sidewalks, decks, cars, and other surfaces, causing citizen complaints (Coffelt and Schultz 1990). Previous pest assessments have listed lepidopteran defoliators as a top pest during outbreaks of exotic pests like gypsy moth and native pests like orange-stripped oakworms and cankerworms (Nielsen et al. 1985; Wu et al. 1991; Kielbaso and Kennedy 1983). Since lepidopteran species often have outbreak cycles of many years, they may not be important pests every year.

In this survey, lepidopteran defoliators were most important on *Prunus* spp. (2.27) due primarily to *Prunus* spp. susceptibility to eastern tent caterpillar (*Malacosoma americanum*), which prefer *Prunus* spp. such as black cherry (*Prunus serotina*) and can defoliate trees. Spring cankerworm (*Paleacrata vernata*) and fall cankerworm (*Alsophila pometaria*) are generalist caterpillars that feed heavily on many tree taxa including *Prunus* spp. Defoliators including cankerworms and more specialized caterpillars, such as orange-striped oakworm (*Anisota senatoria*), were the highest rated pests on *Quercus* spp. Orange-striped oakworms and cankerworms can defoliate large expanses of urban areas garnering citizen complaints, harming trees, and often leading to expensive management practices (Coffelt et al. 1993; Chanthammavong et al. 2014; Asaro and Chamberlin 2015).

Beetles eat tree leaves as larvae, adults, or both depending on species. Coleopteran defoliators, like Japanese beetles (*Popillia japonica*), imported willow leaf beetles (*Plagiodera versicolora*), and elm leaf beetles (*Xanthogaleruca luteola*), can be severe pests on certain tree species. In the 1980s, elm leaf beetle was among the highest ranked tree pest nationally but was ranked lower in the South (Wu et al. 1991). Elms are less common now due to Dutch elm disease, but new resistant American elm genotypes and Asian species such as Siberian elm (*U. pumila*) and lacebark elms (*U. parvifolia*) are becoming more common in urban plantings. Although elm leaf beetle was identified as an important elm pest in this survey, recent research suggests European elm flea weevil (*Orchestes alni*) is the most frequent beetle to damage elm leaves in many regions (Condra et al. 2010; Griffin and Jacobi 2016). European elm flea weevil was first discovered in North America in 2007 and has since become widespread (Anderson et al. 2007). European elm flea weevil larvae mine leaves, whereas elm leaf beetle larvae skeletonize leaves. Determination of which pest species is present will inform the best course of management.

Sawflies can be important defoliators, primarily of evergreen tree species, that reduce tree growth and survival (Kulman 1971). Only one sawfly species, Redheaded pine sawfly (*Neodiprion lecontei*), was identified as a pest in this survey.

Leaf and Stem Gallers

Galls, such as horned oak gall (*Callirhytis cornigera*), become important pests in some situations (Johnson and Lyon 1976). Galls have not been ranked highly or even appeared in previous pest assessments. However, their consequences for plant vigor and management can be severe (Eliason and Potter 2000a; 2000b; 2001). *Quercus* spp. appear to have the most consequential gall pests of the tree genera in this survey. Gallers were essentially tied with defoliators as the most important pest category of *Quercus* spp., with horned oak gall and gouty oak gall (*Callirhytis quercuspunctata*) mentioned most frequently.

Trunk and Twig Borers

Important trunk boring insects are primarily coleopteran and lepidopteran species. Borers are often difficult to control, and the consequences of borer attacks can be rapid and severe. Thus, borers have ranked highly in previous pest assessments. For example, "borers"' ranked as the first and third most important street tree pest in the Southern and North Central U.S.A. and fourth nationally (Kielbaso and Kennedy 1983; Wu et al. 1991). Several exotic borers that are devastating pests have arrived since these surveys were conducted, including emerald ash borer (*Agrilus planipennis*), Asian longhorned borer (*Anoplophora glabripennis*), and walnut twig beetle (*Pityophthorus juglandis*).

Borers were the most important pest category of *Fraxinus* spp. due to emerald ash borer, which is spreading through the South. Borers of *Pinus* spp. are primarily Scolytine beetles. The most serious pest of *Pinus* spp. is southern pine beetle (*Dendroctonus frontalis*), which attack trees en masse, especially when trees are stressed by drought or injury. Southern pine beetle is an example of how the importance of pests can change due to higher temperatures, as it has spread north as far as Massachusetts where it did not occur before the last decade (Dodds et al. 2018). In the south, flat-headed apple tree borer (*Chrysobothris femorata*) and ambrosia beetles, such as *Xylosandrus crassiusculus*, are pests of some tree species especially when stressed by drought, flooding, winter damage, or injury (Frank and Ranger 2016; Ranger et al. 2016; Frank et al. 2017).

Mites

Spider mites can be important pests of some urban tree species. Spider mite abundance can erupt in response to environmental conditions such as impervious surface cover, heat, drought, or dust (Ehler and Frankie 1979; Rigamonti and Lozzia 1997; Sperry et al. 2001; Kropczynska et al. 2002; Meineke et al. 2016), or in response to anthropogenic inputs such as insecticides (Szczepaniec et al. 2011), fertilizer (Prado et al. 2015), or road salts (Fostad and Pedersen 1997). Thus, they are often innocuous until some environmental conditions or disturbance occur. Due to their sporadic outbreaks, mites are not always ranked highly in urban tree pest assessments (Kielbaso and Kennedy 1983; Wu et al. 1991). However, spider mites were among the most common and problematic pests in urban landscapes and among the pests for which the most pesticide applications were made (Holmes and Davidson 1984; Raupp and Noland 1984; Braman et al. 1998). Mites were not the highest ranked pests of any tree genera in this survey. Mites ranked highest on *Acer* spp. and *Quercus* spp., which can be infested with maple spider mites (*Oligonychus aceris*) and oak spider mites (*O. bicolor*). These can become abundant after insecticide applications that kill natural enemies and due to excess nitrogen that improves leaf quality (Frank and Sadof 2011; Prado et al. 2015).

DISCUSSION

Overall, *Quercus* spp. has the highest total pest rating, which is the mean of all seven pest categories, and *Acer* spp. has the second highest. This does not mean that *Quercus* spp. or *Acer* spp. are necessarily more pest prone or poorer choices for planting along streets or in landscapes. Considering trees at the genus level means some genera, such as *Quercus* and *Acer*, are each represented by dozens of species, but genera such as *Liriodendron*, *Platanus*, and *Zelkova* are each represented by one. Thus, when respondents consider all the species in a large genus, it is likely they can think of a species on which bark sucking insects are important, a species on which leaf sucking insects are important, and another on which defoliators are important. A genus with one or two species could seem relatively pest free by comparison.

The provenance of trees is another important consideration when interpreting the total pest score for each genus. *Zelkova* spp. is represented primarily by a single species, *Z. serrata*, imported from Asia. Exotic trees often host fewer herbivore species, at least initially, than native trees (Southwood 1961; Burghardt and Tallamy 2013). *Quercus* and *Acer*, for example, are represented primarily by native species that may host hundreds of herbivore species (Southwood 1961; Tallamy and Shropshire 2009). A few of these herbivores, such as scales or caterpillars, may become pests under urban conditions (Coffelt et al. 1993; Meineke et al. 2013; Dale and Frank 2014; Dale and Frank 2018). *Quercus* and *Acer* also contain exotic species with few pests, such as sawtooth oak (*Quercus acutissima*), trident maple (*Acer buergerianum*), and Norway maple (*Acer platanoides*).

Key plants in an IPM program are those that have a disproportionate amount of pests or damage or those that are particularly valuable (Raupp et al. 1985). In this sense, some native *Quercus* spp. and *Acer* spp. may constitute key plants that are more pest prone than other species. Consumers and municipalities often have goals of increasing the number of native species planted as a conservation measure to preserve arthropod and bird populations. Greater use of native species combined with their higher herbivore abundance suggests that researchers and practitioners should prioritize developing IPM tactics for the most common and pest prone native trees. From the inventories used in the survey, these include species such as *Q. phellos*, *Q. palustris*, *Q. falcata,* and *A. rubrum*. A more detailed survey of species within these genera would be required to ascertain key plants on which to focus research and management. A future survey should also include susceptibility to abiotic conditions and pathogens.

Key pests are those that frequently or persistently cause severe damage and account for a disproportionate amount of control effort or expense (Smith and Van den Bosch 1967). Galling arthropods and mites appear to be the least important pest categories among the tree genera in this survey. Pests in both of these categories can be very destructive on some tree species under certain conditions and can be more difficult to manage due to concealed or cryptic life stages and fewer available pesticides (Kropczynska et al. 1988; Eliason and Potter 2000b; Eliason and Potter 2001; Szczepaniec et al. 2011). Thus, galling insects or mites may constitute key pests for some arborists. The other four pest categories have similar ratings, though leaf sucking insects is highest. Most tree genera had leaf feeding scales, aphids, or lace bugs identified as important in the survey. These and bark sucking insects qualify as key pests on susceptible species due to their persistence and density. Phloem feeding insects in this group have the added problem of producing honeydew (Dreistadt and Dahlsten 1988).

Defoliators were also important overall. As key pests, they are often sporadic rather than persistent, but are very damaging to their hosts and adjacent plants with damage and frass that is apparent to the public (Schultz and Sivyer 2006; Eirich 2008; Frank 2014). This leads to high demand for expensive management practices when defoliator outbreaks occur (Coffelt and Schultz 1990; Eirich 2008). Similarly, borers may occur sporadically but with severe consequences, such as rapid tree death. The importance of this will depend largely on the number of susceptible trees (Raupp et al. 2006). For example, emerald ash borer is a key pest that is devastating municipalities in Northern and Central states that have a high proportion of ash trees. In Southern regions, where ash trees are less common, the effect of emerald ash borer on individual trees is still severe, but consequences for municipalities are less. The prominence of *Pinus* spp. increases the risk from southern pine beetles.

The diversity of plants and pests in urban landscapes makes IPM education and implementation difficult. This survey provides an overview of the most important pest categories on the most common tree genera in the Southern U.S.A. Assessing pest risk by plant genera has proven valuable in previous research (Raupp and Noland 1984; Raupp et al. 1985; Raupp et al. 2006). This survey provides insight into the trees and pests on which research, extension, and industry personnel could focus IPM development and implementation efforts. It also provides information to improve future surveys, for example, by focusing on species of prominent genera such as *Quercus* and *Acer* and by not including genera with few species or few pests such as *Zelkova*, *Lagerstroemia*, and *Liriodendron*. Some respondents suggested adding genera including *Magnolia*, *Cornus*, *Cercis*, and *Cupressus* to future surveys. A future survey would also benefit from including tree pathogens and by including more respondents, especially more respondents employed as arborists and municipal foresters. A direct benefit of this research for arborists and municipal foresters is helping to focus formal and individual education efforts. Identifying important pest categories and species will help extension educators focus their teaching and practitioners focus their learning on pests likely to be key in their situations.

LITERATURE CITED

Anderson, R.S., C.W. O Brien, G.A. Salsbury, and S.J. Krauth. 2007. Orchestes alni (L.) newly discovered in North America (Coleoptera: Curculionidae). JOURNAL-KANSAS ENTOMOLOGICAL SOCIETY 80: 78.

Asaro, C., and L. A. Chamberlin. 2015. Outbreak History (1953-2014) of Spring Defoliators Impacting Oak-Dominated Forests in Virginia, with Emphasis on Gypsy Moth (Lymantria dispar L.) and Fall Cankerworm (Alsophila pometaria Harris). American Entomologist 61:174–185.

Braman, S., J. Latimer, and C. Robacker. 1998. Factors influencing pesticide use and integrated pest management implementation in urban landscapes: a case study in Atlanta. HortTechnology 8:145–149.

Burghardt, K.T., and D.W. Tallamy. 2013. Plant origin asymmetrically impacts feeding guilds and life stages driving community structure of herbivorous arthropods. Diversity and Distributions 19:1553–1565.

Camacho, E.R., J.H. Chong, S.K. Braman, S.D. Frank, and P.B. Schultz. 2017. Life History of Parthenolecanium spp. (Hemiptera: Coccidae) in Urban Landscapes of the Southeastern United States. Journal of Economic Entomology 110:1668–1675.

Chanthammavong, N., G. Bryant, and S.D. Frank. 2014. The effect of sticky bands on cankerworm abundance and defoliation in urban trees. Arboriculture & Urban Forestry 40:135–142.

Coffelt, M.A., and P.B. Schultz. 1990. Development of an aesthetic injury level to decrease pesticide use against orangestriped oakworm (Lepidoptera: Saturniidae) in an urban pest management project. Journal of Economic Entomology 83:2044–2049.

Coffelt, M.A., P.B. Schultz, and D.D. Wolf. 1993. Impact of late-season orangestriped oakworm (Lepidoptera: Saturniidae) defoliation on oak growth and vigor. Environmental Entomology 22:1318–1324.

Condra, J.M., C.M. Brady, and D.A. Potter. 2010. Resistance of landscape-suitable elms to Japanese beetle, gall aphids, and leaf miners, with notes on life history of Orchestes alni and Agromyza aristata in Kentucky. Arboriculture & Urban Forestry 36:101–109.

Dale, A.G., and S.D. Frank. 2014. The effects of urban warming on herbivore abundance and street tree condition. PlosOne 9.

Dale, A.G., and S.D. Frank. 2018. Urban plants and climate drive unique arthropod interactions with unpredictable consequences. Current Opinion in Insect Science 29:27–33.

Dodds, K.J., C.F. Aoki, A. Arango-Velez, J. Cancelliere, A.W. D'Amato, M.F. DiGirolomo, and R.J. Rabaglia. 2018. Expansion of Southern Pine Beetle into Northeastern Forests: Management and Impact of a Primary Bark Beetle in a New Region. Journal of Forestry 116:178–191.

Dreistadt, S., and D. Dahlsten. 1988. Tuliptree aphid honeydew management. Journal of Arboriculture 14:209–214.

Dreistadt, S.H. 1987. Monitoring of Honeydew Excretion in the Field as a Method of Sampling Illinoia liriodendri (Homoptera: Aphididae) Infesting Liriodendron tulipifera. Journal of Economic Entomology 80:380–383.

Ehler, L.E., and G.W. Frankie. 1979. Arthropod Fauna of Live Oak in Urban and Natural Stands in Texas. II. Characteristics of the Mite Fauna (Acari). Journal of the Kansas Entomological Society 52:86–92.

Eirich, R. 2008. Establishing Action Threshholds for Control of Cankerworms in Regina, Saskatchewan, Canada. Arboriculture & Urban Forestry 34:66.

Eliason, E.A., and D.A. Potter. 2000a. Budburst phenology, plant vigor, and host genotype effects on the leaf-galling generation of Callirhytis cornigera (Hymenoptera: Cynipidae) on pin oak. Environmental Entomology 29:1199–1207.

Eliason, E.A., and D.A. Potter. 2000b. Impact of whole-canopy and systemic insecticidal treatments on Callirhytis cornigera (Hymenoptera: Cynipidae) and associated parasitoids on pin oak. Journal of Economic Entomology 93:165–171.

Eliason, E.A., and D.A. Potter. 2001. Biology and management of the horned oak gall wasp on pin oak. Journal of Arboriculture 27:92–101.

Fettig, C.J., J.G. Fidgen, and S.M. Salom. 2005. A review of sampling procedures available for IPM decision-making of forest and shade tree insects in North America. Journal of Arboriculture 31:38–47.

Filer, T. 1977. Sycamore pests: a guide to major insects, diseases, and air pollution, Dept. of Agriculture, Forest Service, Southeastern Area, State and Private Forestry.

Fostad, O., and P. Pedersen. 1997. Vitality, variation, and causes of decline of trees in Oslo center (Norway). Journal of Arboriculture 23:155–165.

Frank, S.D. 2014. Bad neighbors: urban habitats increase cankerworm damage to non-host understory plants. Urban Ecosystems 17:1135–1145.

Frank, S.D., and C.S. Sadof. 2011. Reducing Insecticide Volume and Nontarget Effects of Ambrosia Beetle Management in Nurseries. Journal of Economic Entomology 104:1960–1968.

Frank, S.D., and C.M. Ranger. 2016. Developing a media moisture threshold for nurseries to reduce tree stress and ambrosia beetle attacks. Environmental Entomology 45:1040–1048.

Frank, S.D., A.L. Anderson, and C.M. Ranger. 2017. Interaction of Insecticide and Media Moisture on Ambrosia Beetle (Coleoptera: Curculionidae) Attacks on Selected Ornamental Trees. Environmental Entomology 46:1390–1396.

Frank, S.D., W.E. Klingeman, S.A. White, and A. Fulcher. 2013. Biology, Injury, and Management of Maple Tree Pests in Nurseries and Urban Landscapes. Journal of Integrated Pest Management 4:1–14.

Griffin, J.J., and W. Jacobi. 2016. Ten-year performance of elms in the National Elm Trial, pp. 31-36. *In*, III International Symposium on Woody Ornamentals of the Temperate Zone 1191, 2016.

Holmes, J.J., and J.A. Davidson. 1984. Integrated pest management for arborists: implementation of a pilot program. Journal of Arboriculture 10(3):65–70.

Johnson, W.T., and H.H. Lyon. 1976. Insects that feed on trees and shrubs. An illustrated practical guide, Cornell University Press.

Just, M.G., S.D. Frank, and A.G. Dale. 2018. Impervious surface thresholds for urban tree site selection. Urban Forestry and Urban Greening 34:141–146.

Kielbaso, J.J., and K.K. Kennedy. 1983. Urban forestry and entomology: A current appraisal, pp. 423-440. In G. W. Frankie and C. S. Koehler (eds.), Urban Entomology: Interdisciplinary Perspectives. Praeger Publishers, New York, NY.

Kropczynska, D., M. Van de Vrie, and A. Tomczyk. 1988. Bionomics of Eotetranychus tiliarium and its phytoseiid predators. Experimental & Applied Acarology 5:65–81.

Kropczynska, D., B. Czajkowska, A. Tomczyk, and M. Kielkiewicz. 2002. Mite communities on linden trees (Tilia sp.) in an urban environment, pp. 303-313. In F. Bernini, R. Nannelli, G. Nuzzaci and E. de Lillo (eds.), Acarid Phylogeny and Evolution: Adaptation in Mites and Ticks: Proceedings of the IV Symposium of the European Association of Acarologists. Springer Netherlands, Dordrecht.

Kulman, H. 1971. Effects of insect defoliation on growth and mortality of trees. Annual Review of Entomology 16:289–324.

Meineke, E., E. Youngsteadt, R.R. Dunn, and S.D. Frank. 2016. Urban warming reduces aboveground carbon storage, p. 20161574. *In*, Proc. R. Soc. B, 2016. The Royal Society.

Meineke, E.K., and S.D. Frank. 2018. Water availability drives urban tree growth responses to herbivory and warming. Journal of Applied Ecology 55:1701–1713.

Meineke, E.K., R.R. Dunn, J.O. Sexton, and S.D. Frank. 2013. Urban warming drives insect pest abundance on street trees. PlosOne 8.

Metcalf, Z.P. 1912. The gloomy scale, an important enemy of shade trees in North Carolina. Journal of the Elisha Mitchell Scientific Society 28:88–91.

Metcalf, Z.P. 1922. The gloomy scale. N.C. Agriculture Experiment Station Technical Bulletin 21:1–23.

Neely, D., E. Himelick, and S. Cline. 1984. Assessment of pesticide usages by commercial and municipal arborists. Journal of Arboriculture 10(5):143–147.

Nielsen, D., E. Hart, M. Dix, M. Linit, J. Appleby, M. Ascerno, D. Mahr, D. Potter, and J. Jones. 1985. Common street trees and their pest problems in the North Central United States. Journal of Arboriculture 11:225–232.

Olkowski, W., C. Pinnock, W. Toney, G. Mosher, W. Neasbitt, R. Bosch, and H. Olkowski. 1974. An integrated insect control program for street trees. California Agriculture 28:3–4.

Prado, J., C. Quesada, M. Gosney, M.V. Mickelbart, and C. Sadof. 2015. Effects of Nitrogen Fertilization on Potato Leafhopper (Hemiptera: Cicadellidae) and Maple Spider Mite (Acari: Tetranychidae) on Nursery-Grown Maples. Journal of Economic Entomology 108(3):1221–7

Ranger, C.M., M.E. Reding, P.B. Schultz, J.B. Oliver, S.D. Frank, K.M. Addesso, J. Hong Chong, B. Sampson, C. Werle, S. Gill, and C. Krause. 2016. Biology, Ecology, and Management of Nonnative Ambrosia Beetles (Coleoptera: Curculionidae: Scolytinae) in Ornamental Plant Nurseries. Journal of Integrated Pest Management 7(1):9;1–23.

Raupp, M., and R. Noland. 1984. Implementing landscape plant management programs in institutional and residential settings [Integrated pest management]. Journal of Arboriculture 10(6):161–169.

Raupp, M.J., J.A. Davidson, J.J. Homes, and J.L. Hellman. 1985. The concept of key plants in integrated pest management for landscapes. Journal of Arboriculture 11:317–322.

Raupp, M., C. Koehler, and J. Davidson. 1992. Advances in implementing integrated pest management for woody landscape plants. Annual Review of Entomology 37:561–585.

Raupp, M.J., P.M. Shrewsbury, J.J. Holmes, and J.A. Davidson. 2001. Plant species diversity and abundance affects the number of arthropod pests in residential landscapes. Journal of Arboriculture 27:222–229.

Raupp, M.J., A.B. Cumming, and E.C. Raupp. 2006. Street tree diversity in eastern North America and its potential for tree loss to exotic borers. Arboriculture & Urban Forestry 32:297–304.

Raupp, M.J., P.M. Shrewsbury, and D.A. Herms. 2010. Ecology of herbivorous arthropods in urban landscapes. Annu Rev Entomol 55:19–38.

Rigamonti, I., and G. Lozzia. 1997. Injurious and beneficial mites on urban trees in Northern Italy, pp. 177-182. *In*, International Symposium on Urban Tree Health 496, 1997.

Schultz, P.B., and D.B. Sivyer. 2006. An Integrated Pest Management Success Story: Orangestriped Oakworm Control in Norfolk, Virginia, US. Arboriculture & Urban Forestry 32:286.

Smith, R., and R. Van den Bosch. 1967. Integrated control, pp. 295–340, *Pest control-biological, physical and selected chemical Methods*. Eds WW Kilgore and RL Doutt. Acadamic Press, New York. 206pp. Academic Press, New York, NY.

Southwood, T. 1961. The number of species of insect associated with various trees. The Journal of Animal Ecology: 1–8.

Sperry, C.E., W.R. Chaney, G. Shao, and C. Sadof. 2001. Effects of Tree Density, Tree Species Diversity and Percentage of Hardscape on Three Insect Pests of Honeylocust. Journal of Arboriculture 27:263–271.

Szczepaniec, A., S.F. Creary, K.L. Laskowski, J.P. Nyrop, and M.J. Raupp. 2011. Neonicotinoid Insecticide Imidacloprid Causes Outbreaks of Spider Mites on Elm Trees in Urban Landscapes. PloS one 6: e20018.

Tallamy, D.W., and K.J. Shropshire. 2009. Ranking lepidopteran use of native versus introduced plants. Conservation biology : the Journal of the Society for Conservation Biology 23:941–947.

USDA. 2012. USDA Plant hardiness zone map, Agricultural Research Service, U.S. Department of Agriculture. Accessed from <http://planthardiness.ars.usda.gov>.

Wu, Z., S. Jamieson, and J. Kielbaso. 1991. Urban forest pest management. Journal of Arboriculture 17:150–158.

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Résumé. On dénombre dans les villes des douzaines d'espèces d'arbres d'alignement hébergeant chacune de multiples insectes arthropodes nuisibles. Le développement et l'implantation de stratégies de gestion intégrée des ravageurs, tels des protocoles de reconnaissance et des seuils d'intervention pour tous ces ravageurs est insoutenable. Une étude regroupant du personnel de recherche et de vulgarisation universitaire et des professionnels arboricoles fut effectuée à titre de première étape avec l'identification des principaux ravageurs de genres d'arbres communément plantés en alignement dans le sud des États-Unis. L'enquête demandait aux répondants de classifier sept groupes de ravageurs entre 0 (pas vraiment nuisible) à 3 (ravageur important ou causant des dommages) pour chacun des 10 genres d'arbres. Les catégories de ravageurs étaient les insectes suceurs sur l'écorce, les insectes suceurs des feuilles, les défoliateurs et les mineuses, les galligènes sur les feuilles et les tiges, les perceurs du tronc et des tiges, les scolytes et les tétranyques. Les répondants pouvaient également identifier nommément certains ravageurs importants parmi ces catégories. Quelques genres d'arbres comme *Quercus* et *Acer*, sont concernés par des ravageurs significatifs dans plusieurs catégories. D'autres genres comme *Liriodendron*, *Platanus* et *Lagerstroemia* ne sont affectés que par un ou deux ravageurs importants. Les insectes suceurs sur l'écorce étaient les ravageurs les plus dommageables chez les espèces d'*Acer*. Les défoliateurs, particulièrement les livrées, étaient les ravageurs les plus dommageables chez les espèces de *Quercus*, suivis de près par les galligènes et les insectes suceurs du feuillage et de l'écorce. Toutes les catégories de ravageurs étaient classées sous le niveau 1 chez les espèces de *Zelkova*. Identifier les ravageurs importants chez les principaux genres plantés permet aux chercheurs de prioriser le développement de la gestion intégrée des ravageurs et aide les professionnels de l'arboriculture à prioriser leur formation et l'implantation de la gestion intégrée des ravageurs. Les recommandations pour les recherches futures visent à accroître le nombre de répondants et la variété des espèces représentées ainsi que la caractérisation des espèces concernées parmi les genres étendus tels *Acer* et *Quercus*.

Zusammenfassung. Städte haben Dutzende verschiedene Baumarten, jede mit vielfältigen Schädlingen aus dem reiche der Gliederfüßler. Die Entwicklung und Implementierung von Techniken des Integrierten Pflanzenschutzes, so wie Aufklärungsprotokolle und Schwellenwerte für alle von ihnen ist nicht durchführbar. Als erster Schritt zur Identifizierung von Schädlingen an häufig vorkommenden Straßenbäumen in den südlichen Vereinigten Staaten wurde eine Bestandsaufnahme bzw. Umfrage unter den Verantwortlichen aus Wissenschaft und Forschung und Praktikern aus de Baumpflege durchgeführt. Die Umfrage gab den Teilnehmern die Gelegenheit, sieben verschiede Schädlingsgruppen von 0 (kein Schädling) bis 3 (sehr wichtig oder schädlich) für jeweils einen aus zehn Baumgattungen zu bewerten. Die Kategorien waren saugende Insekten an der Rinde, Sauginsekten an Blättern, Blattfresser und Blattminier-Insekten, an Blättern und Stängeln Gallen formende Gliederfüßler, Stamm- und Zweigbohrer, Borkenkäfer und Milben. Die Teilnehmer konnten innerhalb der Kategorien auch wichtige Schädlinge identifizieren. Einige Baumgattungen, wie *Quercus* und *Acer* haben viele wichtige Schädlinge in multiplen Kategorien. Andere Gattungen, wie *Liriodendron*, *Platanus* und *Lagerstroemia* haben nur ein oder zwei Hauptschädlinge. An der Borke saugende Insekten wurden bei *Acer* spp. als höchstschädlich eingestuft. Blattfresser, überwiegend Raupen, wurden bei *Quercus* als Hauptschädlingsgruppe bewertet, dicht gefolgt von Gallen bildenden Insekten, Blattsaugern und Borkensaugern. Bei *Zelkova* spp wurden alle Schädlingsgruppen unter 1 bewertet. Die Identifizierung von Hauptschädlingen an Hauptbaumarten könnte den Forschern helfen, die Entwicklung Integrierter Pflanzenschutz-Programme zu priorisieren und es könnte den Baumpflegern helfen, ihr Training und die Implementierung von IPM zu verstärken. Empfehlungen für künftige Forschung und Umfragen beinhalten, mehr Teilnehmer zu befragen, mehr Baumarten zu integrieren und einzelne Baumarten innerhalb von großen Gattungen wie *Acer* und *Quercus* zu identifizieren.

Resumen. Las ciudades contienen docenas de especies de árboles, cada una con múltiples plagas de artrópodos. Desarrollar e implementar tácticas de manejo integrado de plagas (MIP), así como los protocolos de exploración y los umbrales para todos ellos es insostenible. Se realizó una encuesta entre el personal de investigación y extensión de la universidad y los profesionales

del cuidado de árboles como primer paso para identificar las plagas clave de los géneros de árboles comunes de la calle en el sur de los Estados Unidos. La encuesta permitió calificar siete grupos de plagas de 0 (no plagas) a 3 (muy importante o perjudicial) para cada uno de los diez géneros de árboles. Las categorías fueron insectos chupadores de corteza, insectos chupadores en hojas, defoliadores y minadores, artrópodos formadores de agallas en hojas y tallos, barrenadores de troncos y ramitas, escarabajos de la corteza y ácaros. Los encuestados también podrían identificar especies de plagas importantes dentro de las categorías. Algunos géneros de árboles, como *Quercus* y *Acer*, tienen muchas plagas importantes en múltiples categorías. Otros géneros como *Liriodendron*, *Platanus* y *Lagerstroemia* tienen solo una o dos plagas clave. Los insectos chupadores de la corteza fueron las plagas de mayor rango en *Acer* spp. Los defoliadores, principalmente las orugas, se clasificaron mejor en *Quercus* spp. seguidos de cerca por los formadores de agallas de la hoja y el tallo, los chupadores de hojas y corteza. Todos los grupos de plagas se clasificaron por debajo de "1" en *Zelkova* spp. La identificación de plagas clave en los géneros de árboles clave podría ayudar a los investigadores a priorizar el desarrollo de MIP y ayudar a los profesionales del cuidado de árboles a priorizar su capacitación e implementación de MIP. Las recomendaciones para futuras encuestas incluyen tener más encuestados y taxones de árboles representados e identificar árboles para especies dentro de géneros grandes, como *Acer* y *Quercus*.

Arboriculture & Urban Forestry Quiz Questions

To complete this quiz, go to the ISA website, log into your MyISA account, and make your way to the page for Arboriculture & Forestry CEU Quizzes (www.isa-arbor.com/store/ceuquizzes/113).

Add the quiz to your cart, proceed through checkout, and look for the content to appear on your personal dashboard under the header, "My Quizzes." If you need a username and password, send us an e-mail (isa@isa-arbor.com).

A passing score for this quiz requires sixteen correct answers. Quiz results will display immediately upon quiz completion. CEU(s) are processed immediately. You may take the quiz as often as is necessary to pass.

CEU quiz by Richard Rathjens, The Davey Tree Institute, Kent, OH, U.S.A.