Impact of White-Tailed Deer (*Odocoileus virginianus* Zimmerman) on Ornamental Plants in Alabama Green Industries and Home Landscapes[1]

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Abstract

Nursery and landscape professionals as well as homeowners throughout Alabama continue to experience deer damage to ornamental plants due to the increasing populations of white-tailed deer (*Odocoileus virginianus* Zimmerman). To understand the extent of damage, surveys were created for green industry professionals and homeowners. The industry survey was sent to members of the Alabama Nursery and Landscape Association (ALNLA) (N = 223). The homeowner survey was sent to nine Master Gardener associations and administered through one day of onsite surveys at Huntsville Botanic Garden (N = 668). Questions inquired if respondents encountered injury to plants from whitetail deer, what types of preventive methods they were using, plants typically browsed, and extent of plant loss annually as a result of deer activity. Fifty-five percent of green industry professionals and 37% of homeowners answered 'yes' to damage problems, and of those, more homeowners (61%) than industry (41%) employed preventive methods to reduce deer browse. High fencing, electric fencing, Liquid Fence® repellent, and motion irrigation were the most effective of eleven preventive measures listed. Indian hawthorn (*Rhaphiolepis indica* L.) and hosta (*Hosta* spp.) were the most commonly damaged plants according to industry and homeowners, respectively. The majority of homeowners experienced damage during the spring, while industry participants reported most damage during the winter and fall months.

Index words: wildlife management, plant damage, deer browse, deer repellent.

Significance to the Nursery Industry

White-tailed deer are the most numerous large mammals in North America. With the continuing population increase of white-tailed deer, a significant number of nursery and landscape professionals as well as homeowners have experienced damage to ornamental plantings. As white-tailed deer populations in non-rural areas of Alabama increase, mainly due to growth of exurban environments of the 21st century, residential landscapes sustain more feeding damage. This research shows that the amount of damage correlates to the Alabama Department of Conservation and Natural Resources (2000) map of deer populations. Large amounts of damage were seen in east and west central Alabama and the northeast part of the state. While the majority of businesses and individuals that sustain deer damage are familiar with repellents, not all of them use repellents and the majority do not feel that they are cost effective. Exclusion methods such as fencing and scare tactics such as motion lighting and irrigation are among the most commonly used and thought to be the most effective at controlling deer damage. Alternative plantings that include plants that deer do not want to eat could reduce costs to homeowners, however many favorites would need to be left out of plantings. Further scientific research to compare effectiveness of various repellents is needed, as well as trials of plant material considered to be less attractive to deer.

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Introduction

An estimated fifteen to twenty million white-tailed deer (*Odocoileus virginianus* Zimmerman) live in the United States, and 1.8 million live in Alabama alone (1, 4). White-tailed deer damage is becoming more prevalent as the green industry in Alabama develops. The economic impact of the green industry in Alabama has drastically increased from $1.9 billion in 2003 to $2.9 billion in 2007 providing jobs for more than 43,000 Alabamians (10). Increasing urbanization of rural landscapes continues to drive white-tailed deer out of their native habitats creating new challenges in suburban wildlife management due to direct human contact and interactions (5). Increased deer numbers in suburban areas are due to the exurban environments of the 21st century. These environments provide a patchwork of suburban areas separated by portions of wooded areas that provide suitable habitats for white-tailed deer (17). In comparison to deer living in forests and rural areas, these deer do face greater threats from vehicular accidents as adults and predation from coyotes and domestic animals as neonatal deer; however, their food sources are more predictable in these exurban environments (17). These ideal environments combined with overpopulation and a keen adaptability of white-tailed deer has led to the current problems experienced by homeowners and the green industry (3). Therefore, there is a need for more effective and cost efficient methods to manage white-tailed deer to reduce browse damage in suburban/exurban areas of Alabama.

Nursery professionals and homeowners have several options for managing deer damage including fences, repellents, and considering deer feeding preferences (19). One way to determine the effectiveness of these methods in reducing

white-tailed deer damage is to use surveys. Surveys have been used to identify the amount of deer damage endured annually by nurseries and homeowners, as well as to assess potentially effective deer deterrents. In 1997, Lemieux et al. (13) surveyed nursery and orchard operators throughout nine northeast states and reported that 65% of respondents (n = 341) had deer damage issues. Respondents reported losses in crops totaling $1,727,156 during 1997, with a median loss of $3,700. The majority of damage was due to browsing, although rubbing and trampling were also reported. To control these problems, respondents were spending up to $528,348 with a median expenditure of $1,000. In a previous study in 1987, Purdy et al. (16) conducted a survey to gauge crop damage concerns of orchardists in New York. New York is the second leading state in apple production for the United States, and 90% of surveyed orchardists reported deer damage to their crops. Through surveying, Sayre et al. (18) reported that damage to nurseries and suburban landscapes was becoming rampant in areas of the Northeast, and 62% of respondents specified that information on damage prevention and additional research to improve deterrent methods was necessary. Forty-nine percent of homeowners reported that they had seen some evidence of deer damage to plants on their property. They also indicated that most damage to their landscape occurred during the winter and spring seasons.

Connelly et al. (7) conducted a survey of property owners in 1987 to examine public tolerance of deer in suburban environments. The majority of respondents (66%) indicated that they had seen evidence of deer feeding on their property during the past year. Residents also expressed concern for other deer related issues including the risk of Lyme disease and vehicular accidents. Another survey conducted by Connelly et al. (6) in 2008 was used to assess deer impacts and management options on a landscape scale. This survey evaluated landowner perceptions of deer impacts and management policies, in particular hunting, and provided an estimate of deer harvested on their properties annually. Results showed that approximately one-third of respondents would like to see a decline in the population of deer in their area. The majority of respondents believe that hunting is necessary to control deer populations in their area and reduce crop damage.

Common methods to control unwanted deer damage for homeowners can be divided into six categories: exclusion, scare or frightening tactics, habitat modification, population reduction through culling, commercial repellents, and alternative plantings (14). Landscaping based on deer feeding preferences may provide an alternative to chemical repellents and unsightly physical barriers for homeowners (9). A survey of community attitudes toward contraception of suburban deer as a management technique was conducted in 1997 and 1998 by Lauber and Knuth (12). The study was designed to communicate ideas and techniques about contraception to the public in hopes of determining perspectives and attitudes toward contraception as a management strategy in place of hunting. Immunocontraceptive drugs have been shown to be effective in stimulating immune systems of captive deer to produce antibodies that prevent pregnancy (15). Lauber and Knuth (12) concluded that particular concerns for homeowners were more likely to influence their attitudes about contraception methods as control options as opposed to traditional control methods.

Increasing information and better education for green industry professionals and homeowners on preventive measures to reduce damage, could in turn help minimize damage through proper planning and determination of feasible management strategies. Therefore, surveys may help determine deer pressure statewide, effects on the green industry, and effective means of deterring deer feeding damage on ornamental plants.

Since little research has been compiled on white-tailed deer damage to nurseries and commercial and residential landscapes throughout Alabama, surveys were developed to determine the following information: how much deer damage is experienced, areas of the state most prone to damage, what types of preventive methods are utilized and their effectiveness, plants most vulnerable to injury, and timing of the majority of damage. By determining the significance of deer damage throughout Alabama and discovering the most effective preventive methods currently used, more research can be done to educate professionals and homeowners on effective management strategies, as well as improve damage control.

Materials and Methods

Industry professionals. The population surveyed in this questionnaire included current nursery and landscape professional members of the Alabama Nursery and Landscape Association (ALNLA) that were located in Alabama (N = 223). The survey was designed to determine the amount of deer damage that they experience, the types of deterrent techniques that professionals were currently employing and their effectiveness, and familiarity of respondents with commercially available products on the market, plants that are most commonly targeted, and the time of year most browse damage occurs. The target population was asked a variety of questions to determine their perspectives on deer damage in their business and throughout the green industry. Questions were primarily closed-ended questions that were either multiple choice, categorical, likert-scale, ordinal, or numerical. However, there were a small number of open-ended questions that allowed respondents to provide a written response.

There was one set of questions for all professionals as well as a divided section for nursery and landscape professionals to be answered based upon their business type. Nursery professionals were asked information about their businesses' deer damage, and landscape professionals were asked about the damage and control for their clients' landscapes.

The surveys were mailed to recipients in ALNLA envelopes along with a pre-paid envelope for return. Two cover letters were also included, one of which affirmed support from the ALNLA and requesting timely responses. The second letter explained the purpose of the survey and described the research. Participants were given one month to complete and return the survey. Respondents were also given the option to take the survey online through surveymonkey.com. Consistent with Dillman's principles, both the industry and homeowner surveys were designed with clear and easy to comprehend questions, a detailed cover letter explaining why it is important to respond, included pre-paid return envelopes, and the instrument kept as short as possible (8).

Homeowners. The homeowner population surveyed consisted of Master Gardeners throughout the state of Alabama. Presidents of Master Gardener Associations were contacted via email and asked to participate in the study. Willing participants returned the email and provided addresses for

sending surveys by mail. The homeowner survey was a paper only survey. A total of nine associations were represented by participation in the homeowner survey including the Capital City, Central Alabama, Blount County, Baldwin County, Barbour County, Chilton County, Jefferson County, Calhoun County, and Coffee County associations. Surveys were also given to homeowners visiting the Huntsville Botanical Garden on Saturday, October 10, 2009. The combined number of homeowners surveyed was 207.

The main objective of this survey was to determine the amount of deer browse damage that homeowners experience throughout the state of Alabama, what plants receive most damage, when they experience the most damage, and common types of preventive methods used by homeowners and their success. The majority of questions on the survey were closed-ended questions, but there were several open-ended questions that allowed participants to provide a written response. Closed-ended questions consisted of multiple choice and likert-scale question types. For several questions respondents were able to select more than one answer, so percentages did not always add up to 100.

The data were input into Microsoft Excel and then imported to SPSS. Descriptive statistics were run to describe the groups including mean and median. Both parametric and non-parametric statistics were used depending on the type of data collected. Chi-square tests for independence were run in order to determine if there were relationships between those questions that included nominal and ordinal data. Spearman's rho correlations were run on those questions that reported scale or ratio data.

Results and Discussion

Industry professionals. At the conclusion of the survey of green industry professionals, 78 mailed and three internet surveys had been completed, for a total of 81 respondents, yielding a response rate of 36.3%. The breakdown of survey respondents included 47 nursery professionals (67%), 14 landscape professionals (20%), 8 professionals that had both nursery and landscape operations (11%), and the remaining professionals did not specify their business type (2%). The nursery and nursery/landscape operations (N = 55) were located in east central (27%), southwest (27%), northeast (18%), west central (11%), southeast (11%), and northwest Alabama (6%). The landscape only operations (N = 14) were located in east central (50%), west central (21%), northwest (14%), and southwest Alabama (14%).

The majority of industry respondents (55%) indicated that they currently have deer damage or have experienced deer damage in the past. The top three areas of the state indicating 'yes' to damage problems by industry professionals were east central (69%), southwest (67%), and west central Alabama (56%). According to a chi-square test for independence, the percentage of businesses that experienced deer damage did not differ by location across the state, $\chi 2(5, N = 77) = 8.098$, $p = 0.151$. These results of this test may be invalid however, as more than 20% of the categories had counts less than five. The survey respondents were concentrated in two areas of the state (east central and southwest) and smaller numbers were evenly distributed across the rest of the state.

In order to make potential inferences, nursery professionals were asked what type of land surrounded their nursery. The nurseries were surrounded by wooded areas (52.6%), open fields (28.2%), suburban areas (11.5%), and 3.8% by waterfront. Forty-eight percent of the growers considered their property to be a deer habitat. A chi-square test was performed on each of the types of surrounding land. The businesses that experienced damage and were located near wooded areas did differ greatly from those that did not experience damage, $\chi 2(1, N = 78) = 4.019$, $p = 0.45$. More businesses near wooded areas experienced damage than did not. Wooded areas give cover for deer to approach the businesses. The businesses that were in suburban areas also differed; however, in this case it was reported that more suburban businesses do not experience damage than those that do, $\chi 2(1, N = 78) = 4.017$, $p = 0.045$. The chi-square tests on both open fields and waterfront did not differ between those experiencing damage or not.

Respondents were asked to state the time of year that they experienced the majority of deer damage. Seasons in Alabama were divided into winter (December–February), spring (March–May), summer (June–August), and fall (September–November). Most professional respondents reported damage to occur in winter, with 45.5% of participants experiencing damage during this season. Damage could be highest in winter because deer are continually looking for nutrient rich vegetation during the winter months, and most nursery and landscape professionals have a well managed fertilization program throughout the entire year to ensure consistent nutrient levels within the plant (11). Because fertilizers are applied continually, these plants are more likely to exhibit flushes of growth during the winter months that native vegetation and home landscape plants would be less likely to provide. Thirty-four percent of respondents stated that they experienced the majority of their damage in the fall. According to respondents, the smallest amount of damage occurred in spring and summer, with 9.1% and 11.4%, respectively. Damage also corresponds to the white-tailed deer lifecycle. Respondents reported a significant amount of damage to occur in the fall, and this is the time that female deer have the largest nutritional demands. Breeding season occurs in January, and there is a 200-day gestation length. Females give birth to fawns in the early fall and then begin the lactation process. During the lactation process female deer have the highest nutritional demands because they must provide for their young (8), so it is not surprising that nursery and landscape professionals reported high amounts of deer damage in the fall.

Respondents were asked to list plants that deer typically browse at their place of business by common or scientific name. Over sixty plants were listed as susceptible to deer feeding damage; however, seven genera were identified as having the most damage throughout the survey. For industry professionals, the seven most commonly listed selections were:

Indian hawthorn (*Rhaphiolepis indica* L.) — 21%
Holly (*Ilex* spp.) — 10%
Pansy (Viola × wittrockiana) — 8%
Azalea (*Rhododendron* spp.) — 7%
Rose (*Rosa* spp.) — 6%
Hosta (*Hosta* spp.) — 5%
Hydrangea (*Hydrangea* spp.) — 3%.

After assessing if damage occurs, when and where it occurs and the types of plants deer typically browse, questioning then turned to if and how companies try to limit

deer browse problems. Of the 55% that answered 'yes' to damage, only 41% were using or had used preventive measures to control or eliminate damage in their business. The differences in percentages between those using preventive methods to those not using preventives could be due to the lack of familiarity with common methods of controlling deer damage, budget restrictions, or cost comparisons of loss to gain. The data were then split into two categories for comparison: 1) nursery and nursery/landscape businesses and 2) landscape only businesses. While neither of these groups showed significant correlations on using preventive methods and damage or loss, the comparison between the two groups are notable. In the nursery and nursery/landscape category, 52% of the businesses reported having damage to plant material; however only 55% of those experiencing damage use any type of preventive method to control the damage. Percent of plants damaged ranged from 1 to 20%. In this same category, 38% of businesses experience loss of plant material. Only 52% of nursery and nursery/landscape companies that reported losses use any type of preventive method. Percent of plants lost ranged from 1 to10 %. In the landscape only category, 71% of the businesses reported damage to plant material and of those, 70% used some type of preventive method. Percent of plants damaged ranged from 5 to 80%. Seventy-one percent of the landscape companies reported loss of plant material and again, 70% used some type of preventive method. Percent of plants lost ranged from 1 to 50%.

Respondents were asked to identify any preventive measures that they were currently using or have used in the past. They were able to select more than one preventive measure on a chart provided having 11 preventive measures (Table 1). Of the nursery and landscape professionals reporting damage, they have used 'other methods' (56%), chemical repellents (44%), fencing (34%), and mechanical methods (19%) in order to reduce deer damage. The 'other methods' category was an open ended question with an extreme variation on replies. The only answers listed multiple times were dogs (9%) and netting (6%). On a separate question, the nursery and nursery/landscape participants were asked if they had animals on site and what type. Sixty-eight percnt of the businesses indicated that they had animals on site, and the animals listed most often were dogs (39%), cats (29%), cattle (13%) and horses (13%). A chi-square test was performed to determine if those businesses that experience damage or not differs based on whether or not they have animals on site.

Table 1. The following list of preventative methods was included on both the nursery/landscape professionals' and homeowners' surveys. Participants were asked if they used each product or not and if they have used it, how effective it was.

High fence
Electric fence
Buck Off®
Deer Away®
Deer Off®
Deer Stopper®
Liquid Fence®
Plantskydd®
Other (repellent)
Motion lighting
Motion irrigation
Frightening sounds
Other (general)

The test failed to indicate a difference, $\chi 2(1, N = 56) = 2.353$, $p = 0.125$. This suggests that deer are not generally inhibited by the presence of other animals on site or that they get used to the other animals.

Industry participants were asked to estimate the amount of money they spent annually on management techniques. For all businesses those that reported expenditures for deer management (N = 20) the figures ranged from $30 to $5,000 annually. The total spent was $21,580 with an average of $1,079 and a mode of $1,000. The majority spent $100–$300 (35%) with large percentages having spent $601–$1,000 (25%), $1,001–$2,500 (15%), and $3,000 or more (10%). A Spearman's rho correlation was performed to determine if there were any relationships between location of the business within the state and money spent annually on deer management. There were no correlations.

Several chemical repellents were represented on the survey including Buck Off!® (Cleary Chemical Corp., Dayton, NJ), Deer Away® (Woodstream Corp., Lititz, PA), Deer Off® (Woodstream Corp., Lititz, PA), Deer Stopper® (Messina Wildlife, Washington, NJ), Liquid Fence® (The Liquid Fence Company, Inc., Brodheadsville, PA), and Plantskydd® (APC, Inc., Ankeny, IA). The repellent utilized most by professionals was Deer Away® (30%). Deer Off® and Deer Stopper® were two other repellents that were reported to be widely applied by professionals both with 23% use of the products. Liquid Fence® was ranked next according to usage by professionals (20%) who employed preventive methods. Three percent use of Buck Off! as a preventive method was reported, and 0% reported using Plantskydd®. Buck Off!® is a fairly new product to the market which might explain its lack of use, and Plantskydd® is a blood-based repellent which might discourage some professionals from using this product as it does cause staining on the plant.

A chi-square test was performed to determine if familiarity with repellents was distributed differently over the three types of businesses (nursery, nursery/landscape, and landscape only). The test indicates a difference between the three groups, $\chi 2(2, N = 65) = 8.028$, $p = 0.018$. Only 39% of nursery owners were familiar with repellents in comparison to the nursery/landscape group (75%), and landscape only group (77%). This difference is likely explained by the different plant management techniques of the groups. Nurseries tend to use preventive methods that are not affected by overhead irrigation. The number of irrigation events and the volume of water applied tends to be less in a landscape setting, and would therefore not dilute or remove repellents from the plants as quickly. Nursery settings would require repeated reapplication that would increase cost dramatically. When determining if repellents were cost effective, 61% percent were unsure if deer repellents were cost effective, while 33% of respondents claimed that deer repellents were not cost effective. Only 6% of industry participants believed that deer repellents were cost effective.

Other preventive methods included in the survey were motion lighting, motion irrigation, and frightening sounds. Of these mechanical methods, motion lighting and irrigation were most frequently used by professionals (13%), followed by frightening sounds (3%). Motion lighting could have high usage because many professionals and homeowners could already utilize this technology for security/crime prevention.

Participants were asked to rank each of the preventive methods listed according to effectiveness. Effectiveness

ratings were determined on a Likert-scale, including not effective, fairly effective, moderately effective, effective, and highly effective. The numbers 0–4 represented these categories respectively. The top three ratings of preventive methods by professionals were electric fences (M = 2.71), Liquid Fence® (M = 2.50), and high fence (M = 2.33) (Fig. 1). Those nursery and landscape professionals who use electric fencing seem to consider it to be a fairly effective resource in diminishing deer injury to their crops; however, none of the rating averages approached the highly effective rating.

To determine familiarity with commercial deer repellents, industry professionals were asked if they were familiar with any chemical repellents on the market, what brands they were familiar with, and if scent played a role in purchasing the product. The most recognized brands were Deer Stopper® (40%), Liquid Fence® (36%), Deer Away® (16%), and Deer Off® (16%). The four most recognized were also the four most used chemical repellents by industry professionals. All four of these repellents contain putrescent egg solids. When asked if scent at application played a role in purchasing a deer repellent, 69% of industry respondents said 'no'. Some repellents can smell offensive to the applicator, so it is important to note that most respondents were more concerned with effectiveness rather than application scent.

Landscape professionals reported that 72% of their clients complain of deer browse problems. Of the clients that experienced damage, the majority (33.3%) reported 10% damage. Over the past five years, it was reported that deer damage complaints from landscape clients have increased (32%) along with 36% of clients expressing that deer populations in their area have increased. A chi square test was performed to determine if the use of preventive methods increased as the amount of client complaints changed. The test indicates a significant difference, $\chi 2(2, N = 25) = 10.210$, $p = 0.006$. For those businesses whose complaints have increased, 88% have used or are using preventive methods. For those businesses who complaints have remained the same, only 31% have used or are using preventive methods. No businesses reported a decrease in complaints and 16% reported being not sure if complaints have changed. Of the 16% who were unsure, 100% of them were not employing any preventive methods.

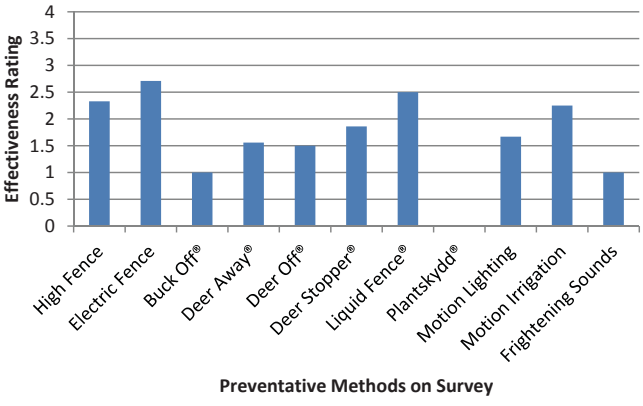

Fig. 1. Mean effectiveness ratings of deer preventative methods by Alabama nursery and landscape professionals where: 0 = not effective, 1 = fairly effective, 2 = moderately effective, 3 = effective, and 4 = highly effective. Those with no rating were not used by green industry professionals that participated in the survey.

Because of the increased amount of clients' complaints about deer damage, 38% of landscape professionals offered deer repellent application to their clients as an add-on maintenance cost. A chi-square test was preformed and indicated that the businesses that charged clients did not differ on complaints than those that did not charge, $\chi 2(1, N = 23) = 0.727$, $p = 0.394$. Regardless of complaints, the majority (70%) did not charge extra for deer repellents.

Homeowners. The homeowner survey was distributed to 668 individuals and 206 responses were returned for a response rate of 31%. The majority of homeowners (93%) answered the survey based on experiences at their primary residence. Of those answering the survey for second homes, the answers included lake homes (29%), beach homes (14%), and cabins in wooded areas (14%). The residences in question were located in east central (50%), west central (17%), northeast (15%), southeast (13%), northwest (3%), and southwest (1%) Alabama.

Homeowners were asked both the size of their property and the age of the development in which they lived in order to gain a sense of plant development on and around their property. The majority of property size was greater than one acre (43%), while 23% lived on ½ to one acre, 23% lived on ¼ to ½ acre, and 11% lived on less than ¼ acre. The largest group of the sample lived in developments that were 5–20 years old (35%), followed by 20–40 years (30%), 40–60 years (16%), greater than 60 years (15%), and less than five years (4%).

When homeowners were asked if they had encountered any deer damage problems in their landscape, 37% responded they had experienced browse damage, while 63% of respondents had not experienced damage issues. The majority of homeowners who encountered damage issues were located in the east central section of the state (56%). Other areas of the state that frequently reported seeing damage are west central sections of the state (15% of respondents), northeast (13%), and southeast (9%). According to the white-tailed deer density map of the state from the Alabama Department of Conservation and Natural Resources, the southern half of the state of Alabama has the highest deer density within the state — 30 or more deer per square mile (2). The northeast corner of Alabama also has 30 or more deer per square mile (2). These areas directly correspond to those areas with the highest reported incidence of deer damage to landscape plants as parts of both east and west central Alabama fall in the southern half of the state.

Chi-square tests for independence were performed on location, size, and age of the properties with regard to frequency of deer damage. The percent of participants in the various locations of the state did not differ on experiencing deer damage, $\chi 2(5, N = 201) = 6.709$, $p = 0.243$. The age of the property also indicated no differences in experiencing deer damage, $\chi 2(4, N = 199) = 3.943$, $p = 0.414$. The percent of participants and the sizes of property did differ on experiencing damage, $\chi 2(3, N = 197) = 32.431$, $p = 0.000$. On properties one acre and smaller, the majority of participants (81%) experienced no deer damage; however, on properties over one acre, the majority of participants (59%) did experience deer damage. Larger properties would allow for more cover and movement areas for deer that are farther away from people.

Homeowners were also asked what type of land surrounded their residence. Multiple answers were chosen so

percentages will not total to 100%. The homes were surrounded by wooded areas (61%), suburban areas (37%), open fields (15%), and waterfront (9%). Thirty-three percent of the homeowners considered their property to be deer habitat. A chi-square test was performed on each of the types of surrounding land. The homeowners that experienced damage and were located near wooded areas did differ greatly from those that did not experience damage, $\chi 2(1, N = 204) = 39.352$, $p = 0.000$. More homeowners near wooded areas (89%) experienced damage than did not. Wooded areas give cover for deer to approach the landscapes. The homes that were in suburban areas also differed; however, in this case it was reported that more suburban homes do not experience damage than those that do, $\chi 2(1, N = 204) = 25.888$, $p = 0.000$. The chi-square tests on both open fields and waterfront did not differ between those that experienced damage and those that did not. After discovering that both wooded properties and those larger than one acre both showed differences in deer damage, a chi-square test was performed to determine if the size of the lot differed in being wooded or not. The percent of homes that were wooded did differ by size, $\chi 2(3, N = 199) = 56.539$, $p = 0.000$. As the properties increase in size, the percent wooded property increased. Those properties over one acre were 91% wooded.

Respondents were asked to state the time of year that they experienced the majority of deer damage. Seasons in Alabama were divided into winter (December–February), spring (March–May), summer (June–August), and fall (September–November). There was no reported difference among the seasons. Damage by season ranged from fifteen to eighteen percent.

Respondents were asked to list plants that deer typically browse their personal landscaped areas by common or scientific name. Over sixty plants were listed as susceptible to deer feeding damage; however, seven genera were identified as having the most damage throughout the survey. The most frequently browsed plants according to homeowners were:

Hosta (*Hosta* spp.) — 10%
Hydrangea (*Hydrangea* spp.) — 7%
Pansy (Viola × wittrockiana) — 6%
Rose (*Rosa* spp.) — 4%
Pea (Pisum sativum) — 3%
Daylily (*Hemerocallis* spp.) — 3%
Azalea (*Rhododendron* spp.) — 3%.

After assessing if damage occurred, when and where it occurred and the types of plants deer typically browse, questioning then turned to if and how homeowners try to limit deer browse problems. Of the 37% of participants that reported they experienced deer browsing, 61% used some type of preventive method to reduce deer damage to their landscape and of those not experiencing damage, 4% were using preventive methods. Homeowners were also asked about the typical amount of deer damage experienced annually to landscapes along with the percentage of plants that were lost annually. Of the homeowners that experienced damage, the majority (37%) reported 1 to 10% of their plants were damaged. This was followed by 29% of homeowners receiving 26 to 50% damage, 24% of homeowners receiving 11 to 25%, and 13% of homeowners receiving greater than 50% damage. Percent of plants damaged ranged from 1 to 100%. Of those participants losing plants, 62% of participants lost 1 to 10% of their plant material annually to deer damage, followed by 18% who had 11 to 25% loss, 10% who had 26 to 50% loss, and 10% had greater than 50% loss of their plants annually due to deer injury. Percent of plants lost ranged from 1 to 90%.

Respondents were asked to identify any preventive measures that they were currently using or have used in the past. They were able to select more than one preventive measure on a chart provided having 11 preventive measures (Table 1). The majority of homeowners who were using preventive methods stated they were using high fencing (27%), followed by 'other methods' (25%), chemical repellents (24%), and mechanical methods (5%). Fencing might be ranked highly among respondents because many homeowners use fencing for privacy, separation from neighboring properties, or theft prevention. The 'other methods' category was an open ended question with an extreme variation on replies. The only answers listed multiple times were dogs (11%) and human hair (11%). A chi-square test was performed to determine if those homeowners that experience damage or not differs based on whether or not they have dogs or cats outside. Both tests failed to indicate a difference, for dogs $\chi 2(1, N = 204) = 0.328$, $p = 0.567$ or for cats $\chi 2(1, N = 204) = 2.104$, $p = 0.147$. This again suggests that deer are not generally inhibited by the presence of other animals on site.

Several repellents were also represented on the survey including Buck Off!® (Cleary Chemical Corp., Dayton, NJ), Deer Away® (Woodstream Corp., Lititz, PA), Deer Off® (Woodstream Corp., Lititz, PA), Deer Stopper® (Messina Wildlife, Washington, NJ), Liquid Fence® (The Liquid Fence Company, Inc., Brodheadsville, PA), and Plantskydd® (APC, Inc., Ankeny, IA). Deer Away® and Liquid Fence® were the most frequently used liquid repellents, with 7% of homeowners using each of the products. Homeowners used these products as well, however at much lower frequency: Deer Stopper® (4%) and Deer Off® (3%). No homeowners reported using Buck Off!® or Plantskydd®. Buck Off!® is a fairly new product to the market which might explain its lack of use, and Plantskydd® is a blood-based repellent which might discourage some professionals from using this product as it does cause staining on the plant.

Other preventive methods included in the survey were motion lighting, motion irrigation, and frightening sounds. Mechanical methods employed by homeowners included motion lighting (7%), frightening sounds (4%), and motion irrigation (1%). Motion lighting could have high usage because many homeowners might already utilize this technology for security/crime prevention.

Participants were asked to rank each of the preventive methods listed according to effectiveness. Effectiveness ratings were determined on a Likert-scale, including not effective, fairly effective, moderately effective, effective, and highly effective. The numbers 0–4 represented these categories respectively. The top three ratings of preventive methods by homeowners were Liquid Fence® ($M = 2.40$), high fence ($M = 2.31$) followed by Deer Off®, Deer Stopper®, and Frightening sounds all receiving 2.00 (Fig. 2). Motion irrigation was not included in this list because only one person rated its effectiveness. Seventy-two percent of homeowners did not consider deer repellents to be a cost effective means of deterring deer.

To determine their familiarity with commercial deer repellents, homeowners were asked if they were familiar with

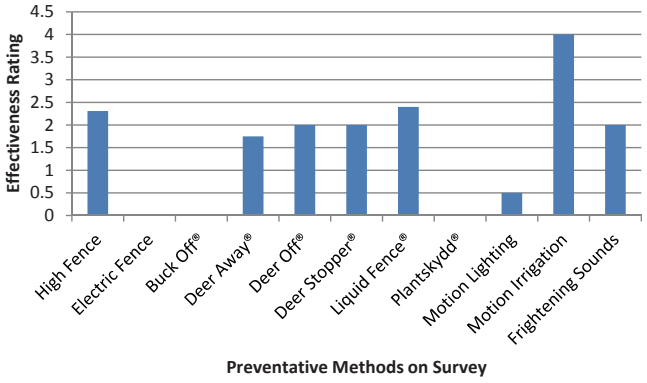

Fig. 2. Mean effectiveness ratings of deer preventative methods by Alabama homeowners where: 0 = not effective, 1 = fairly effective, 2 = moderately effective, 3 = effective, and 4 = highly effective. Those with no rating were not used by homeowners that participated in the survey.

any repellents on the market, what brands they were familiar with, and if scent played a role in purchasing the product. For homeowners the most recognized brands were Deer Off® (22%), Liquid Fence® (19%), and Deer Away® (19%). When asked if scent at application played a role in purchasing a deer repellent, 75% of homeowner respondents said 'no'. Some repellents can smell offensive to the applicator, so it is important to note that most respondents were more concerned with effectiveness rather than application scent.

Participants were asked if they have a garden or not and if so, flower, vegetable, or both. Ninety-five percent of all participants had some type of garden. Chi-square tests were performed and showed no difference if there was a garden present or not and if the participant experienced deer damage, $\chi 2(1, N = 199) = 0.001$, $p = 0.982$. There was also no difference on the type of garden, $\chi 2(1, N = 184) = 4.311$, $p = 0.116$. According to responses on this survey, gardens do not predict a higher likelihood of deer damage, nor are they partial to one type of garden over another.

Results of this study show that many nursery and landscape professionals along with homeowners throughout Alabama have experienced some type of deer browse damage, although many are not using any type of preventive method to eliminate or reduce damage. Of the industry professionals experiencing damage, there was quite a distinction between the nursery and nursery/landscape and landscape only companies that used preventive methods. The landscape only companies were much more likely to employ a preventive method for damage or loss. According to responses, the majority of both professionals and homeowners concurred that they were familiar with some types of repellents on the market, that most commercial products were not considered cost effective, and that scent did not restrict their decision to purchase and use commercial products. It is clear that several sections of the state are more prone to deer damage, which correlates to the white-tailed deer density map provided through the Alabama Department of Wildlife and Conservation. Further research is needed in the area of alternative plantings and scientific experiments should be performed with repellent products on the market. By understanding the extent of white-tailed deer damage in Alabama, more effective ways to control deer damage can be explored. Dissemination of information collected from this survey could educate homeowners and professionals about improved and reliable damage prevention.

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