Evaluation of White-Tailed Deer (*Odocoileus virginianus* Raf.) Browse Preferences and Commercially Available Deer Repellents in Southern Landscapes

by

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Abstract

Variation exists among landscape plant species browsed by white-tailed deer

(*Odocoileus virginianus* Raf.) herds. Two experiments were conducted during February,

2011 and 2012 where browse damage was evaluated for *Rhaphiolepis indica* L.*,*

Rhododendron indicum L. 'Judge Solomon'*, Ilex cornuta* Lindl. 'Burfordii Nana',

Ophiopogon japonicus L. f.*,* and *Thuja occidentalis* L. Tests were conducted inside a

430-acre high fence compound where approximately 100 adult free-ranging white-tailed

deer were located, equating to approximately 150 deer per square mile.   Twelve days

after placement (DAP) in a mock landscape using container grown plants, *Rhaphiolepis*

indica had the entire canopy removed both years. *Rhododendron indicum* 'Judge

Solomon' had between ⅓ and ½ of its canopy removed during 2011, but less than ⅓ of

the canopy removed in 2012 12 DAP. *Ilex cornuta* 'Burfordii Nana' was only slightly

browsed during 2011 with no damage in 2012. *Ophiopogon japonicus* in 2011 and *Thuja*

occidentalis in 2012 had no browse damage.

Rhododendron indicum* L. 'Judge Solomon' and *Rhaphiolepis indica* L. are two

woody species found palatable to *Odocoileus virginianus* Raf. Both were recipients of

chemical deer repellent applications during experiments conducted in February, 2011

and March, 2012. In Experiment 1, the repellents tested were PredaScent™, Deer Out™, Deer Stopper®, Plantskydd™, and Buck Off!. The control treatment was water. Thirty one days after treatment (DAT), there was no difference among the treatments, including the control, for browse damage rating or growth index (GI) for either species, with the plant species remaining mostly unbrowsed. During Experiment 2, Gold'n Gro® Guardian, Deer Out™, Deer Stopper®, and Buck Off! were tested. The control treatment again was water. At study termination 31 DAT, treatments were similar for browse damage rating and GI including the control for *Rhododendron indicum* 'Judge Solomon', with the plant species remaining unbrowsed throughout the study. Browse damage for controls was greater than all other treatments except the Gold'n Gro® Guardian for *Rhaphiolepis indica.* Although not severe, both treatments received browse damage while plants treated with Buck Off!, Deer Out™, and Deer Stopper® received no browse damage. There were no differences in treatment GI at 31 DAT.

Begonia semperflorens L*., Impatiens x hybrid* L*., and Catharanthus roseus* L. G. Don were herbaceous species used in two similar repellent experiments during the spring/summer of 2011. Experiment 1 was initiated April 11th and the included treatments were PredaScent™, Deer Out™, Deer Stopper®, and Gold'n Gro® Guardian. The control treatment was water. Experiment 2 was initiated on June 3rd with the PredaScent™ treatment being omitted. Both experiments yielded no differences due to treatment for all species including the control for browse damage rating. Mean damage ratings for all treatments and species remained at zero during the first test except

control treatments on *Impatiens x hybrid* which had a 0.125 rating 14 DAT. Mean

browse damage ratings of all treatments and species remained at zero for the duration

of the study in Experiment 2. Experiment 1 had no treatment differences for GI 31 DAT,

although in Experiment 2, the Gold'n Gro® Guardian treatment on *Begonia*

semperflorens was different from all other treatments 31 DAT, having a lower mean GI

than the other treatments.

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CHAPTER I
INTRODUCTION AND LITERATURE REVIEW

White-tailed deer (*Odocoileus virginianus* Raf.) are one of the most abundant

mammals in North America (16). Their name is derived from their tails, which are broad

and solid white underneath. The coat color of a white-tailed deer ranges from reddish

brown in summer to grayish brown in the winter. The bellies of these mammals are

generally white. Male deer, or bucks, have headgear known as antlers that grow

between March and September and are covered in a layer of tissue known as velvet.

This velvet dries before the breeding season (October-January) and the deer will remove

it by rubbing the antlers on trees, fence posts, low shrubs, or whatever else they

suitable. Females, or does, are usually smaller in stature than the bucks, but both sexes

typically weigh between 100-200 lbs (16). In Alabama, breeding occurs in January, with

birthing the first week in August.   One to two offspring is typical.

The white-tailed deer population in the United States is estimated to be in excess

of 26 million animals (27, 29), with an estimated 1.6 million in Alabama alone (10), in

vast contrast to the approximately 350,000 (United States) (27, 29) and 5,000 (Alabama)

(10) existing around 1900. The heavy presence of white-tailed deer often leaves

evidence as proof of passage through the environment. Jagged or torn edges of twigs or

stems are evidence of deer browse. Deer lack upper incisors, so a smooth, clean cut is

not achieved (11, 24). Most browsing occurs below the height of six feet. As mentioned

before, rubbing of trees or other suitable objects by males is quite visually evident

during the appropriate time of the year. Deer leave footprints or hoof prints that have

been described as cloven or heart-shaped (16). Fecal droppings of the white-tailed deer

are very distinct, described as groups of droppings (pellets) measuring 3/4" long with

pinched-off ends (16).

Deer are able to live in a variety of settings and can readily adapt to human

altered landscapes (31). For example, installing a dusk to dawn light right in the middle

of a deer's preferred feeding area may deter it during the short term (because it is new

and unfamiliar), but long term, the deer will realize that the light poses no threat and

will feed directly under the light. VerCauteren et al. (31) tested a motion activated light

and sound emitting frightening device on a group of urban mule deer (*Odocoileus*

hemionus Raf.) and elk (*Cervus elaphus* L.), and found that the devices were not

effective. As the animals became accustomed to the device, they ignored it altogether.

As human population of the United States increases, the need for products and

housing will exponentially increase as well. Naturally, the spread of the population

outward from city centers will increasingly occur due to the development of new

business, and thus new subdivisions and communities for people to dwell will appear.

With the fringes of cities and nearby rural properties experiencing high rates of

development, human-wildlife interactions will rise. These newly developed

relationships between humans and wildlife often changes the wildlife member's status from resource to pest (9).

More than 60 million people are calling exurbia home (25), and an estimated 10 million people were added to exurban areas in the United States between 2000 and 2010 (12). Over the years, defining exurbia has been a challenge. Nelson (25) presents four factors that explain exurbanization: Continued availability of jobs located outside of city centers; Continued yearning for a rural lifestyle among United States households; Continued advances in technology that make rural living easier; And continued support by policy makers to develop exurban areas instead of continued compaction in city centers. Manufacturing firms make up the largest group of employers that show evidence of shifting their facilities to exurbia. More land volume available for firms to acquire, along with lower land cost and development expense are contributing factors. Nelson (25) explains several reasons for the shift. The lay-out of the manufacturing facilities has changed over time due to technological advances. With more machines doing work, the layout of plant design has gone from vertical to horizontal which requires much more land. An exurban location also taps into a more rural labor force that is skilled in machinery and has greater willingness to work with the absence of labor unionization.

Exurbanites have a greater appreciation for quality of life than city dwellers. They have a greater desire to escape the noise, congestion, haze, and crime that comes along with living the city life, and are also more willing to commute to jobs. Many

exurban dwellers believe their lifestyle offers more leisure opportunities and some that

commute into the city even consider the drive itself a form of leisure. Exurbanites value

the accessibility to outdoor recreational activities and are subject to take better

advantage of them.   Also, land use restrictions in the exurban landscape are much

more relaxed as compared to urban areas giving dwellers more choices as to activities

that can be conducted on their property (25).

Technological advances as described by Nelson (25) also have a role in explaining

exurbanization. Increased services extended to exurban areas including garbage pick-up,

water, sewage treatment and disposal, and shopping all contribute to the increase in

exurban dwelling. Communication devices and their advancements (cell phones,

computers, and TV advancements) also have made it easy for exurban dwellers to feel

connected.

Interstate and state highways are maintained to levels that are very effective in

moving people to multiple locations very quickly. Housing is made affordable through

mortgage programs and tax subsidies. The urban policy of the United States favors new

construction over remodeling of existing structures and developing available land to

expand urbanization. These are all policies described by Nelson (25) that contribute to

exurbanization.

As the expansion of exurbia continues, human-wildlife (specifically human-deer)

interactions are on the rise. As stated by Messmer (23), wildlife damage has been

typically considered a rural or agricultural problem, but in recent times, wildlife causes a

much broader spectrum of problems. Some of the problems at the forefront are deer-vehicle collisions, disease, the negative effect on agricultural/timber production, and deer damage to households.

Conover (6) calculated that the amount of damage to automobiles involving collisions with deer in the United States exceeds $1 billion annually. He also estimated that 29,000 people are injured and 211 people die in collisions yearly. Only about 50% of deer-automobile incidents are thought to be reported, so we can assume that damage amounts actually exceed what is reported. The collisions are of significant concern especially in areas with high traffic volumes along with high numbers of deer (16).

Deer can transmit diseases to humans and other wildlife (16). *Salmonella*, *Giardia*, and *E. coli* are some of the diseases that are carried by white-tailed deer. Deer are also an important vehicle in the distribution of ticks that carry bacteria causing Lyme disease. Although Chronic Wasting Disease (CWD), an infection involving chronic weight loss which leads to death of white-tailed deer and other cervids, cannot be contracted by humans, deer are a carrier, thus adding attention to problems associated with deer.

Wildlife damage to agricultural crops is estimated to exceed $4.5 billion annually (7). Most wildlife damage to agricultural crops is caused by deer (35).   It is reasonable that deer damage $750 million worth of timber in the United States as well (6). As these animals continue to have a monetary impact on human lives, humans will strive to find ways to lessen the amount of money lost as a direct result of white-tailed deer.

Consumers or households fall into a large category of people who have problems with wildlife damage. Both Messmer (23) and Conover (6) agree that over 60% of suburban or exurban households experience problems with wildlife in the United States on an annual basis. These households reported an average loss of $63 per household while spending over 260 million hours trying to eliminate or solve the damage problem, equating to a total loss of $1.9 billion because of wildlife damage annually. A survey conducted by Storm et al. (30) found that damage to landscape plantings was a common concern among the participants. These consumers have tried and used many methods to help solve their problems with deer specifically. Not all methods are a cure-all, and some have proven to not work at all.

Deer and horticulture have an important relationship not always viewed as positive. White-tailed deer damage to nurseries, orchards, and private landscapes is a leading problem within the industry (21). Efforts to protect these facets of the industry have included exclusion, using deer resistant plants, culling, scare tactics, and repellents. According to Lemieux et al. (21), an inherent risk to the nursery industry is that homeowners will reduce their use (purchases) of valuable landscape trees and shrubs because of the fear of deer damage. A 2000 mail survey conducted on Hilton Head Island, S.C. concluded that residents there wanted to see fewer deer in their yards in the future and did not report a decrease in the amount of money required to replace plant material damaged by deer over a one year period (15).

Excluding selected areas of property from deer browse is usually accomplished by fencing. Fencing can be costly requiring 8-10 ft in height and being constructed of woven wire. The cost of fencing requires up to about $4 to $6 per foot, excluding labor (16). Life expectancy of a fence of this type should be 20+ years.   Fences are an actual physical barrier and are more often than not, quite expensive. Other fences involve using a single strand of electrified wire and an enticement measure (such as coating the wire with peanut butter) to actually get the deer to touch the fence and receive a low voltage shock (24). These type fences are a psychological barrier in that they "train" the deer to avoid traveling near or beyond the bounds of the fence. Seamans and Helon (28) evaluated another exclusion approach. They studied the use of electrified mats at fence gates as a possible exclusion remedy for deer. As with fences, there was some success, but eventually some adaptable deer figured out a way to outwit the purpose of these devices.

The use of deer resistant plants has some value in reducing browse.   Selecting plants with spines or thick bark may limit deer browse in some situations (16). Many homesites in exurban areas provide luscious evergreen foliage with high nutrient content. Use of these homesites by exurban deer as browse sites is more likely to occur during the winter and winter-spring transition seasons when food may be limited in deciduous forest areas (18). This fact has driven homeowners to find and use deer resistant plantings when deer populations are high enough to cause significant damage. The Internet Center for Wildlife Damage Management (ICWDM) provides a list of

ornamental plants and their susceptibility to deer browse (8). Baker (1) included a

compiled list from several states of susceptible and resistant plant species to white-

tailed deer damage. Incorporating some of these plants that are resistant to deer

browse into the landscape could be a good management tool since many landscapes are

made up of broadleaf herbaceous plants, woody plants with leaves and tender twigs,

and grasses, -three major plant groups that white-tailed deer use as food (34).

Examination of these lists finds that deer resistant plant species sometimes varies by

state. Personal experience with deer browse damage to *Ophiopogon japonicus* L. f., for

example, is contrary to the stated resistance found in state lists.

Culling deer (removal of deer through hunting) is another effective control

method for white-tailed deer. Kilpatrick and LaBonte (19) conducted three surveys over

a 7 year period of an exurban community where 90 to 98% of the residents returned

their surveys. The study was based on an intensive shotgun-archery hunt for the

purpose of herd reduction. The results included a reduction of the herd by 92%, less

damage to landscape plantings, and 83% fewer cases of Lyme disease. This survey

backed up the results of an experimental archery hunt that reduced the deer population

by 50% and many residents subsequently reported reduced deer damage to landscape

plantings (17). Although culling is indeed a proven way to control a deer herd, hunter

access to hunting areas in exurban areas is not always easy. With subdivisions being

incorporated into larger tracts of lands, the number of people owning land has

increased, forcing hunters to gain permission to hunt from more individuals. With more

landowners come more personal opinions about deer and hunting. All persons living in an exurban area will not grant a hunter permission to hunt, creating exclusion zones (30). These exclusion zones and areas adjacent to them in many cases will become refugia for deer during the hunting season, reducing the effectiveness of the cull.

Scare tactics used to control deer can be motion sensors that will trigger noise makers, lights, and/or irrigation. However, marketed motion detection frightening devices emitting light and sound were ineffective on the control of urban elk and mule deer, both closely related to the white-tailed deer (31). Gilsdorf et al. (14) found that a bio-acoustic frightening device failed to reduce deer damage in cornfields. Additionally, noisy devices and devices using bright lights could annoy neighbors in an exurban environment. Short term successes of most of these devices are due to the adaptive nature of the white-tailed deer (13, 31).

The emerging method of choice for controlling deer browse in residential landscapes is the use of repellents (2). Basically, repellents reduce the palatability of a desirable plant and reduce herbivory by deer by exploiting their fear of unfamiliar olfactory, visual, or taste cues (20). Some commercially available repellents are Deer-Away Big Game Repellent®, Miller's Hot Sauce Animal Repellent®, Hinder®, Deer Out®, Plantskydd®, and Tree Guard®. Active ingredients contained in these repellents vary but may include putrescent egg solids, capsaicin, and ammonium soaps. The putrescent egg solids are waste products derived primarily from egg processing plants (broken or cracked eggs, etc.), capsaicin is an ingredient that comes from the plant genera

Capsicum, which includes the chili pepper, and ammonium soaps are basically just cleaning soaps or ingredients contained in them. Most of these products are more effective when applied as a topical (directly onto the plant) than when applied as an area repellent (as a perimeter treatment or treating just one plant among many) (33). Studies have also shown that repellents emitting sulfurous odors generally have the greatest success in repelling deer (5, 26, 33). Deer Away® and Havahart®, products emitting sulfurous odors via putrescent egg solids, were found effective in deterring white-tailed deer browse when applied to herbaceous plant species (5).

Milorganite®, a slow release organic fertilizer produced from human sewage, was tested by Stephens et al. (29) and was found to be a very effective method of control overall in some locations, but a high degree of variation in effectiveness was found among multiple locations. A problem with product durability in the field was reported from a test of hot sauce (capsaicin) (32). Many repellents are labor intensive in that they are not rain proof and must be re-applied soon after a rain event or irrigation for continued efficacy (16).

Some commercially available repellents have proven very effective even when applied to highly palatable landscape plant species. Liquid Fence® and Deer Stopper® ranked high in testing when applied to 'G.G. Gerbing' azalea (*Rhododendron indicum* L. 'G.G. Gerbing'), 'Gumpo White' azalea (*Rhodendron eriocarpum* L. 'Gumpo White'), and indian hawthorn (*Rhaphiolepis indica* L.) (1).

Many other factors play a part in the efficacy of a product including deer density, learned behaviors of deer, available resources, and seasonal variation in plant palatability. Byers et al. (4) even concluded that repellents were basically ineffective for browse reduction to highly desirable food under very high deer pressure.

Opportunities for studying deer resistant plant species and chemical repellents are plentiful. Affirmation of proven and new product efficacy on certain landscape plants under varying conditions is an important step to browse damage management. Potential work exists in eliminating variability among lists of resistant plant species to browse damage. With a highly adaptable creature, like the white-tailed deer, exurban expansion will continue to create conflict between deer and humans (3). As studies continue it will be important to keep two things in mind. First, that the measure of a successful repellent will be in the reduction of damage and not total elimination of damage (29), and second, that alternating among products may strengthen the individual qualities that a single repellent offers (22).

Literature Cited

1. Baker, L.A. 2010. State Survey of White-Tailed Deer (*Odocoileus virginianus* Zimmerman) Impacts on Residential Landscapes and the Green Industry of Alabama and an Evaluation of Commercial Deer Repellents. MS Thesis, Auburn Univ., Auburn.

2. Baker, L.A., D.J. Eakes, G.B. Fain, S.S. Ditchkoff, and C.E. Coker. 2010. An Overview and Cost Analysis of Deer Repellents for Homeowners and Landowners. Circular ANR-1370. Alabama Cooperative Extension Service. Auburn University, AL.

3. Bowker, J.M., D.H. Newman, R.J. Warren, and D.W. Henderson. 2003. Estimating the economic value of lethal versus nonlethal deer control in suburban communities. Soc. and Natural Res. 16:143-158.

4. Byers, R.E., D.H. Carbaugh, and C.N. Presley. 1989. Screening of odor and taste repellents for control of white-tailed deer browse to apples or apple shoots. J. Environ. Hort. 8:185-189.

5. Coker, C.E.H. 2001. Evaluation of White-Tailed Deer (*Odocoileus virginianus* Raf.) Feeding Preferences and Deterrent Stratagies for Horticultural Commodities. PhD Dissertation, Auburn Univ., Auburn.

6. Conover, M.R. 1997. Monetary and intangible valuation of deer in the United States. Wildlife Soc. Bul. 25:298-305.

7. Conover, M.R. 2002. Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management. Lewis Publishers, Boca Raton, FL.

8. Craven, S.R. and S.E. Hygnstrom. 1994. Prevention and Control of Wildlife Damage. D25-D40. Retrieved from http://icwdm.org/handbook/ mammals/mam_d25.pdf.

9. DeStefano, S. and R.M. DeGraaf. 2003. Exploring the ecology of suburban wildlife. Frontiers in Ecol. and the Environ. 1:95-101.

10. DeWitt, R. 2009. Hunting in Alabama. Tuscaloosa News. Retrieved from http://www.encyclopediaofalabama.org/face/Article.jsp?id=h-1893.

11. Ditchkoff, S.S. 2011. Anatomy and Physiology. In D.G. Hewitt (Ed.), Biology and Management of White-tailed Deer. CRC Press, Taylor and Francis Group, Boca Raton, FL.

12. Gardner, T. and Marlay, M.C. 2012. Population growth in the exurbs before and since the great recession. Retrieved from http://metrotrends.org/commentary/ExurbanPopulationGrowth.cfm.

13. Gilsdorf, J.M., S.E. Hygnstrom, and K.C. VerCauteren. 2003. Use of frightening devices in wildlife damage management. Integrated Pest Management Reviews 7:29-45.

14. Gilsdorf, J.M., S.E. Hygnstrom, K.C. VerCauteren, G.M. Clements, E.E. Blakenship, and R.M. Engeman. 2004. Evaluation of a deer-activated bio-acoustic frightening device for reducing deer damage in cornfields. Wildlife Soc. Bul. 32:515-523.

15. Henderson, D.W., R.J. Warren, and D.H. Newman. 2000. Human perceptions before and after a 50% reduction in an urban deer herd's density. Wildlife Soc. Bul. 28:911-918.

16. Hygnstrom, S.E., B.D. Trindle, S.M. VanTassel, and K.C. VerCauteren. 2008. Managing Deer Damage in Nebraska. USDA Natl. Wildlife Res. Ctr.-Staff Publ. Univ. Nebraska-Lincoln, NE.

17. Kilpatrick, H.J. and W.D. Walter. 1999. A controlled archery deer hunt in a residential community: cost, effectiveness, and deer recovery rates. Wildlife Soc. Bul. 27:115-123.

18. Kilpatrick, H.J. and S.M. Spohr. 2000. Spatial and temporal use of a suburban landscape by female white-tailed deer. Wildlife Soc. Bul. 28:1023-1029.

19. Kilpatrick, H.J. and A.M. LaBonte. 2003. Deer hunting in a residential community: the community's perspective. Wildlife Soc. Bul. 31:340-348.

20. Kimball, B.A., J. Taylor, K.R. Perry, and C. Capelli. 2009. Deer responses to repellent stimuli. J. Chem. Ecol. 35:1461-1470.

21. Lemieux, N.C., B.K. Maynard, and W.A. Johnson. 2000. Evaluation of commercial deer repellents on ornamentals in nurseries. J. Environ. Hort. 18:5-8.

22. MacGo-wan, B., L. Severeid, and F. Skemp, Jr. 2004. Control of deer damage with chemical repellents in regenerating hardwood stands. Proc. 6th Walnut Council Res. Symp. Walnut Pest Management 127-133.

23. Messmer, T.A. 2000. The emergence of human-wildlife conflict

    management: turning challenges into opportunities. Intl.

    Biodeterioration & Biodegradation 45:97-102.

24. Miller, B.K., G.L. O'Malley, and R.K. Myers. 2001. Electric Fences for

    Preventing Browse Damage by White-tailed Deer. Circular FNR-136.

    Purdue University Cooperative Extension Service. West Lafayette, IN.

25. Nelson, A.C. 1992. Characterizing exurbia. J. of Planning Lit. 6:350-368.

26. Santilli, F., L. Mori, and L. Galardi. 2004. Evaluation of three repellents for

    the prevention of damage to olive seedlings by deer. J. Wildlife Res.

    50:85-89.

27. Seamans, T.W., B.F. Blackwell, and J.D. Cepek. 2002. Coyote hair as an area

    repellent for white-tailed deer. Intl. J. of Pest Mgt. 48:301-306.

28. Seamans, T.W. and D.A. Helon. 2008. Evaluation of an electrified mat as a

    white-tailed deer (*Odocoileus virginianus)* barrier. Intl. J. of Pest Mgt.

    54:89-94.

29. Stephens, O., M. Mengak, G. Gallagher, D. Osborn, and K. Miller. 2005. Effectiveness of milorganite as a repellent to protect ornamental and agronomic plants from deer over-browsing. Proc. Wildlife Damage Mgt. Conf. Internet Ctr. for Wildlife Damage Mgt. 163-170.

30. Storm, D.J., C.K. Nielsen, E.M., Schauber, and A. Woolf. 2007. Deer-human conflict and hunter access in an exurban landscape. Human-Wildlife Conflicts 1:53-59.

31. VerCauteren, K.C., J.A. Shivik, and M. J. Lavelle. 2005. Efficacy of an animal-activated frightening device on urban elk and mule deer. Wildlife Soc. Bul. 33:1282-1287.

32. Wagner, K.K. and D.L. Nolte. 2000. Evaluation of hot sauce (R) as a repellent for forest mammals. Wildlife Soc. Bul. 28:76-83.

33. Wagner, K.K. and D.L. Nolte. 2001. Comparison of active ingredients and delivery systems in deer repellents. Wildlife Soc. Bul. 29:322-330.

34. Wright, B.D., R.K. Lyons, J.C. Cathey, and S. Cooper. 2002. White-tailed Deer Browse Preferences for South Texas and the Edwards Plateau. Circular B-6130. Texas A&M AgriLife Extension System. Texas A&M University, TX.

35. Wywialowski, A.P. 1994. Agricultural producers' perceptions of wildlife-

    caused losses. Wildlife Soc. Bul. 22:370-382.

CHAPTER II

IMPACT OF PLANT SPECIES ON WHITE-TAILED DEER BROWSE

Abstract

Variation exists among landscape plant species browsed by white-tailed deer (*Odocoileus virginianus* Raf.) herds. Two experiments were conducted during February, 2011 and 2012 where browse damage was evaluated for *Rhaphiolepis indica* L.*,* *Rhododendron indicum* L. 'Judge Solomon'*, Ilex cornuta* Lindl. 'Burfordii Nana', *Ophiopogon japonicus* L. f.*,* and *Thuja occidentalis* L. Tests were conducted inside a 430-acre high fence compound where approximately 100 adult free-ranging white-tailed deer were located, equating to approximately 150 deer per square mile.   Twelve days after placement (DAP) in a mock landscape using container grown plants, *Rhaphiolepis indica* had the entire canopy removed both years. *Rhododendron indicum* 'Judge Solomon' had between ⅓ and ½ of its canopy removed during 2011, but less than ⅓ of the canopy removed in 2012 by 12 DAP. *Ilex cornuta* 'Burfordii Nana' was only slightly browsed during 2011 with no damage in 2012. *Ophiopogon japonicus* in 2011 and *Thuja occidentalis* in 2012 had no browse damage.

Index words: *Odocoileus virginianus* Raf.*,* browse damage, susceptible landscape plants

Species used in this study: *Rhaphiolepis indica* L*., Rhododendron indicum* L. 'Judge Solomon'*, Ilex cornuta* Lindl. 'Burfordii Nana', *Ophiopogon japonicus* L. f*.,* and *Thuja occidentalis* L.

Significance to the Industry

State research and extension reports in the United States vary in which landscape plant species are susceptible to browse by white-tailed deer. Deer herd dynamics play a large role in arguments about listed plant species' susceptibility to browse damage. This study demonstrated browse preference of a deer herd located in east central Alabama among five landscape plant species identified as susceptible to deer browse damage. Although *Ophiopogon japonicus* is listed as rarely damaged, it was included in the study due to personal observation of the species receiving browse damage. This study provides insight for growers and consumers about plant selection and protection when deer browse pressure exists.

Introduction

White-tailed deer *(Odocoileus virginianus* Raf.) browse damage to landscape plants is problematic, especially in suburban areas. The white-tailed deer population in the United States is believed to be in excess of 26 million animals (11, 13), with an estimated 1.6 million in Alabama alone (4). More than 60 million people are calling exurbia home (9), and an estimated 10 million people were added to exurban areas in the United States between 2000 and 2010 (6). Development of areas located outside of city centers (exurbia) continues as job availability increases, Americans yearn for rural

lifestyles, technology advances, and policy makers support outer-city growth as an alternative to continued inner-city compaction (9). As the expansion of both exurbia and deer populations continue, human-wildlife (specifically human-deer) interactions continue to rise. Recent times have introduced a wider spectrum of problems with deer, one of the foremost being browse damage to agricultural/horticultural crops. Wildlife damage to agricultural crops is estimated to exceed $4.5 billion annually (3). Most wildlife damage to agricultural crops is caused by deer (16). White-tailed deer damage to nurseries, orchards, and private landscapes is a leading problem within the green industry (8).   Extension articles among states in the United States vary in which plant species are susceptible to browse and those not palatable to white-tailed deer (1). Previous work has shown variability among deer herds and has also exposed their adaptive nature (15). These factors expressed the need for examination of the browse preference of deer in the southeastern United States.

Materials and Methods

   Experiment 1: One gallon *Rhaphiolepis indica* L*., Rhododendron indicum* L. 'Judge Solomon'*, Ophiopogon japonicus* L. f.*,* and *Ilex cornuta* Lindl. 'Burfordii Nana' were randomly staked using galvanized nursery hooks with six plant replicates per species per block on a 5,000 square foot simulated landscape plot located at the Auburn University Deer Lab (Piedmont Research Substation), Camp Hill, AL 36850 on February 1, 2011 (Figure 1). The plant material was obtained from Moore and Davis Nursery in Shorter, AL 36075 where it was cultivated under standard nursery practices.   Species

selected were either identified in previous work as susceptible to deer browse damage

as landscape plants, listed as susceptible in extension articles, or identified as

susceptible from personal observation (Table 1). Approximately 100 adult free-ranging

white-tailed deer were located within the 430 acre high fence compound equating to

approximately 150 deer per square mile. Reasonable deer density per square mile for

most areas in the Southeast is around 25 (7). Supplemental feed was available ad

libitum. Resource availability during late winter for white-tailed deer is low and

movement to areas with greater resources, such as food plots, was expected (12). The

test plot was irrigated via an overhead system, covered with landscape fabric, and

mulched with pine bark to a depth of 1.5 inches (3.81cm). Feeding damage was taken

every other day between February 1st and February 14th, starting on February 3rd.   Each

plant was assigned a damage rating based on a numbered scale from 0 to 3 where 0=no

browse damage, 1=⅓ of the plant canopy browsed or removed, 2=½ of the plant canopy

browsed or removed, and 3=plant canopy completely browsed or removed (Figure 2). A

Realtree Pro-series^{TM} game camera was placed to document deer activity in the plot.

Data were subjected to ANOVA and mean separations determined using Tukey's

Studentized Range Test (p ≤ 0.05) in a statistical software package (SAS® Institute

version 9.1.3, Cary, NC).

     Experiment 2: Initiated on February 8, 2012, feeding damage was taken every

other day between February 8th and February 24th starting on February 10th. Materials

used were the same as in Exp. 1 except that *Thuja occidentalis* L. was used instead of

Ophiopogon japonicus. Methods used in this experiment were the same as described in Exp. 1.

Results and Discussion

Experiment 1: All species in the test experienced browse damage at some point during the study except *Ophiopogon japonicus* (Table 2). At 6 days after placement (DAP), there was a difference in browse damage to *Rhaphiolepis indica* compared to the other species with a mean damage rating of 1.71. By 8 DAP, all canopies of *Rhaphiolepis indica* plants had been removed (Figure 3). *Rhododendron indicum* 'Judge Solomon' browse damage increased over time beginning 2 DAP and by 12 DAP the mean rating was 1.54. *Ilex cornuta* 'Burfordii Nana' damage also increased slightly over time, and by 10 DAP the mean rating was 0.38, but was similar to *Ophiopogon japonicus* at 0.00. *Rhaphiolepis indica* and *Rhododendron indicum* 'Judge Solomon' plants received the most browse damage (3.00 and 1.54 by 12 DAP, respectively). Personal observation with *Ophiopogon japonicus* being heavily browsed in Birmingham, AL was in conflict with the findings in this study. Previous work done at the lab had similar results where 'G.G. Gerbing' azalea (*Rhododendron indicum* L. 'G.G. Gerbing'), 'Gumpo White' azalea (*Rhododendron eriocarpum* L. 'Gumpo White'), and indian hawthorn (*Rhaphiolepis indica* L.) were the top three most browsed species by white-tailed deer (1).

Experiment 2: *Ophiopogon japonicus* was substituted by *Thuja occidentalis* in this experiment since no browse damage was observed to *Ophiopogon japonicus* in Exp. 1. *Thuja occidentalis* is a species seen heavily browsed (author, personal observation, 5,

10) and is also listed as frequently damaged in some states (Table 1).   In 2012, only two species received browse damage, *Rhododendron indicum* 'Judge Solomon' and *Rhapiolepis indica* (Table 3). These same species were the most heavily browsed in 2011. *Thuja occidentalis* and *Ilex cornuta* 'Burfordii Nana' experienced no browse damage for the duration of the study in 2012. By 8 DAP, all canopies of *Rhaphiolepis indica* plants were removed. It was 8 DAP before any damage was observed on *Rhododendron indicum* 'Judge Solomon' (0.08). By 12 DAP, the mean damage rating had reached 0.13 and was worse than damage on *Ilex cornuta* 'Burfordii Nana' or *Thuja occidentalis*. Again, *Rhaphiolepis indica* and *Rhododendron indicum* 'Judge Solomon' plants received the most browse damage in 2012 (3.0 and 0.13 respectively).

A general comparison of the two experiments yielded a few interesting points. In 2011, all species that were browsed had some damage by 2 DAP. In contrast during 2012, damage occurred by 4 DAP, but only to *Rhaphiolepis indica.* Interestingly, all browsed species' damage ratings increased over time during 2011, and no other species experienced browse damage in 2012 until all canopies of *Rhaphiolepis indica* were completely removed, and then only *Rhododendron indicum* 'Judge Solomon' received browse damage. Finally, *Ilex cornuta* 'Burfordii Nana' was browsed in 2011, but was not in 2012. Although browse damage was expected, both *Ophiopogon japonicus* and *Thuja occidentalis* were resistant in this work. Greater browse pressure was observed in 2011 than in 2012. A snow event occurred during the overnight hours of February 9, 2011 where the test plot received 1 to 2 inches of snow (14). Browsing of forbes and grasses

during this period was hindered and could have rendered the plants on the plot more susceptible. A 2001 study showed that higher precipitation improved habitat while drier conditions caused low food availability for white-tailed deer (2). Climate data shows that 2011 was cooler and drier than 2012 (Table 4), a possible cause for more browse pressure during 2011.

Conclusion

This study confirmed that deer located at the Auburn University Deer Lab preferred *Rhaphiolepis indica* compared to other species tested. *Rhaphiolepis indica*, along with *Rhododendron indicum* 'Judge Solomon', require protection from deer browse. *Ophiopogon japonicus* and *Thuja occidentalis* were resistant in this study. There was variability between the two studies for browse damage on *Ilex cornuta* 'Burfordii Nana', a species that received damage in 2011 and showed resistance in 2012. Greater browse pressure was observed in 2011 than in 2012, possibly caused by cooler, drier weather in 2011 coupled with a snow event at the test plot during the study. This study provided insight into why extension articles among states in the U.S. vary in which plant species are susceptible versus not palatable by deer, and also supports variability among deer herds further exposing their adaptive nature (15). This variability and possession of adaptive qualities by white-tailed deer will necessitate examination of the palate of herds among different locations in order to make sound plant selections and provide adequate protection from browse damage.

Literature Cited

1. Baker, L.A. 2010. State Survey of White-Tailed Deer (*Odocoileus virginianus Zimmerman*) Impacts on Residential Landscapes and the Green Industry of Alabama and an Evaluation of Commercial Deer Repellents. MS Thesis, Auburn Univ., Auburn.

2. Bello, J., S. Gallina, and M. Equihua. 2001. Characterization and habitat preferences by white-tailed deer in Mexico. J. of Range Mgt. 54:537-545.

3. Conover, M.R. 2002. Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management. Lewis Publishers, Boca Raton, FL.

4. DeWitt, R. 2009. Hunting in Alabama. Tuscaloosa News. Retrieved from http://www.encyclopediaofalabama.org/face/Article.jsp?id=h-1893.

5. Forester, J.D., D.P. Anderson, and M.G. Turner. 2008. Landscape and local factors affecting northern white cedar (*Thuja occidentalis*) recruitment in the Chequamegon-Nicolet National Forest, Wisconson (USA). American Midland Naturalist 160:438-453.

6. Gardner, T. and M.C. Marlay. 2012. Population growth in the exurbs before

    and since the great recession. Retrieved from http://metrotrends.org/

    commentary/ExurbanPopulationGrowth.cfm

7. Killmaster, C. 2010. Realistic QDM goals vital for hunting satisfaction. Georgia

    Outdoor News, July 2010. Retrieved from http://www.gon.com/article.php?id=

    2421&cid=87.

8. Lemieux, N.C., B.K. Maynard, and W.A. Johnson. 2000. Evaluation of commercial

    deer repellents on ornamentals in nurseries. J. Environ. Hort. 18:5-8.

9. Nelson, A.C. 1992. Characterizing exurbia. J. of Planning Lit. 6:350-368.

10. Rooney, T.P., S.L. Solheim, and D.M. Waller. 2009. Factors affecting the

    regeneration   of northern white cedar in lowland forests of the Upper Great

    Lakes Region, USA. Forest Ecol. and Mgt. 163:119-130.

11. Seamans, T.W., B.F. Blackwell, and J.D. Cepek. 2002. Coyote hair as an area

    repellent for white-tailed deer. Intl. J. of Pest Mgt. 48:301-306.

12. Smith, J.R., R.A. Sweitzer, and W.F. Jensen. 2007. Diets, movements, and consequences of providing wildlife food plots for white-tailed deer in central north dakota. J. of Wildlife Mgt. 71:2719-2726.

13. Stephens, O., M. Mengak, G. Gallagher, D. Osborn, and K. Miller. 2005. Effectiveness of milorganite as a repellent to protect ornamental and agronomic plants from deer over-browsing. Proc. Wildlife Damage Mgt. Conf. Internet Ctr. for Wildlife Damage Mgt. 163-170.

14. Unger, S. 2011. Snow Event of February 9, 2011. Retrieved from http://www.srh.noaa.gov/bmx/?n=winter_02092011.

15. VerCauteren, K.C., J.A. Shivik, and M.J. Lavelle. 2005. Efficacy of an animal-activated frightening device on urban elk and mule deer. Wildlife Soc. Bul. 33:1282-1287.

16. Wywialowski, A.P. 1994. Agricultural producers' perceptions of wildlife-caused losses. Wildlife Soc. Bul. 22:370-382.

Figure 1. Simulated landscape plot located at the Auburn University Deer Lab.

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Figure 2. Landscape plant species representing respective damage ratings 0 to 3.
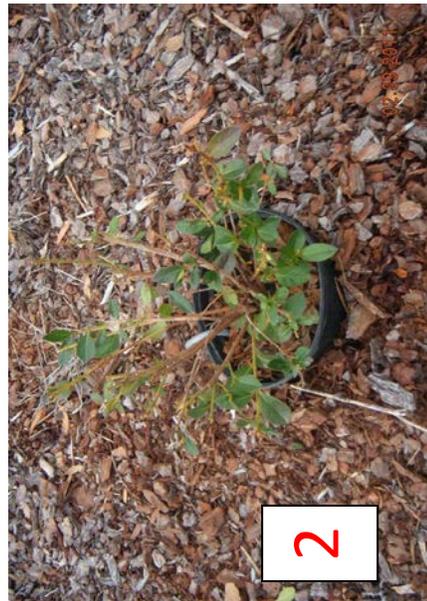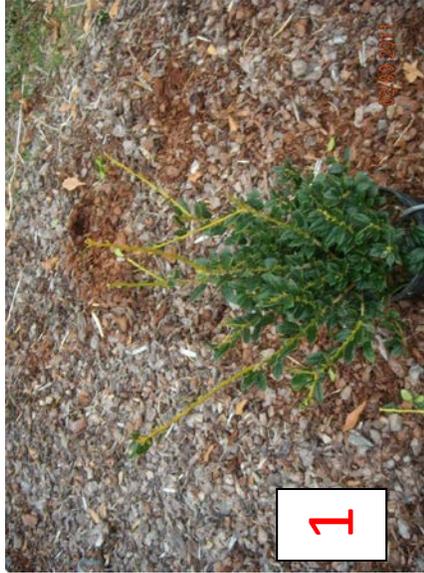
Figure 3. Female white-tailed deer browsing *Rhaphiolepis indica*.

Table 1. Tested landscape plant species susceptibility listing by state for deer browse.[z]

Botanical Name	Common Name	State	Susceptibility
Ilex cornuta 'Burfordii Nana'	Dwarf Burford Holly	AK	Resistant
Ilex cornuta 'Burfordii Nana'	Dwarf Burford Holly	MI	Occasionally Damaged
Ilex cornuta 'Burfordii Nana'	Dwarf Burford Holly	AL	Attracting
Ophiopogon japonicus	Mondo grass	FL	Rarely Damaged
Ophiopogon japonicus	Mondo grass	TN	Resistant
Ophiopogon japonicus	Mondo grass	AK	Resistant
Rhaphiolepis indica	Indian hawthorn	GA	Frequently Damaged
Rhododendron indicum 'Judge Solomon'	Judge Solomon indica azalea	FL	Severly Damaged
Rhododendron indicum 'Judge Solomon'	Judge Solomon indica azalea	SC	Severly Damaged
Rhododendron indicum 'Judge Solomon'	Judge Solomon indica azalea	MI	Frequently Damaged
Thuja occidentalis	arborvitae	SC	Frequently Damaged
Thuja occidentalis	arborvitae	MI	Frequently Damaged

[z]Baker, L.A. 2010. State Survey of White-Tailed Deer (*Odocoileus virginianus* Zimmerman) Impacts on Residential Landscapes and the Green Industry of Alabama and an evaluation of Commercial Deer Repellents. MS Thesis, Auburn Univ., Auburn.

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Table 2. White-tailed deer browse preference[z] on four landscape plant species during February, 2011.

Species	DAP[y]					
	2	**4**	**6**	**8**	**10**	**12**
Rhododendron indicum 'Judge Solomon'	$0.17^{x,ns}$	0.33^{ns}	0.54b	1.00b	1.25b	1.54b
Rhaphiolepis indica	0.17	0.17	1.71a	3.00a	3.00a	3.00a
Ophiopogon japonicus	0.00	0.00	0.00b	0.00c	0.00c	0.00c
Ilex cornuta 'Burfordii Nana'	0.04	0.13	0.17b	0.29c	0.38c	0.38c

[z] Ratings based on a numbered scale from 0 to 3 where 0=no browse damage, 1=⅓ of the plant canopy eaten, 2=½ of the plant canopy eaten, and 3=plant canopy completely damaged or removed.

[y] DAP=days after placement.

[x] Means within same column followed by the same letter are similar based on Tukey's Studentized Range Test at α=0.05 (n=24).

[ns] Means not significantly different.

Table 3. White-tailed deer browse preference[z] on four landscape plant species during February, 2012.

Species	DAP[y]					
	2	**4**	**6**	**8**	**10**	**12**
Rhododendron indicum 'Judge Solomon'	0.00[x,ns]	0.00[ns]	0.00[NS]	0.08b	0.08b	0.13b
Rhaphiolepis indica	0.00	0.13	0.13	3.00a	3.00a	3.00a
Thuja occidentalis	0.00	0.00	0.00	0.00b	0.00b	0.00c
Ilex cornuta 'Burfordii Nana'	0.00	0.00	0.00	0.00b	0.00b	0.00c

[z] Ratings based on a numbered scale from 0 to 3 where 0=no browse damage, 1=⅓ of the plant canopy eaten, and 3=plant canopy completely damaged or removed.

[y]DAP=days after placement.

[x]Means within same column followed by the same letter are similar based on Tukey's Studentized Range Test at α=0.05 (n=24).

[ns]Means not significantly different.

Table 4. 2011 and 2012 climatological summary[z] for Camp Hill, AL 36850[y].

Parameter	2011[x]	2012[w]
Mean Temperature	40.0° F, 4.4° C	47.9° F, 8.8° C
Total Precipitation	5.01 in., 12.7 cm	6.64 in., 16.9 cm
Total Snow	0.3 in., 0.8 cm	0.0 in., 0.0 cm

[z]U.S. Department of Commerce, National Oceanic & Atmospheric Administration, National Environmental Satellite, Data, and Information Service, National Climatic Data Center, Federal Building, 151 Patton Avenue, Asheville, NC 28801, www.ncdc.noaa.gov.

[y]Station: CAMP HILL 2 NW, AL US.

[x]Data range: 12/01/2010 to 02/28/2011.

[w]Data range: 12/01/2011 to 02/29/2012.

CHAPTER III

IMPACT OF COMMERCIALLY AVAILABLE CHEMICAL REPELLENTS ON WHITE-TAILED

DEER BROWSE TO SELECTED LANDSCAPE SPECIES

Abstract

Rhododendron indicum L. 'Judge Solomon' and *Rhaphiolepis indica* L. are two

woody species palatable to *Odocoileus virginianus* Raf. Both were recipients of chemical

deer repellent applications during experiments conducted in February, 2011 and March,

2012. In Experiment 1, the repellents tested were PredaScent™, Deer Out™, Deer

Stopper®, Plantskydd™, and Buck Off!. The control treatment was water. Thirty one

days after treatment (DAT), there was no difference among the treatments, including

the control, for browse damage rating or growth index (GI) for either species, with the

plant species remaining mostly unbrowsed. During Experiment 2, Gold'n Gro®

Guardian, Deer Out™, Deer Stopper®, and Buck Off! were tested. The control treatment

was water. At study termination 31 DAT, treatments were similar for browse damage

rating and GI including the control for *Rhododendron indicum* 'Judge Solomon', with the

plant species remaining unbrowsed throughout the study. Browse damage for controls

was greater than all other treatments except the Gold'n Gro® Guardian on *Rhaphiolepis*

indica. Although not severe, both treatments received browse damage while plants

treated with Buck Off!, Deer Out™, and Deer Stopper® received no browse damage. There were no differences among treatments for GI at 31 DAT.

Begonia semperflorens L*., Impatiens x hybrid* L*., and Catharanthus roseus* L. G. Don were herbaceous species used in two similar repellent experiments during the spring/summer of 2011. Experiment 1 was initiated April 11th and included the treatments PredaScent™, Deer Out™, Deer Stopper®, and Gold'n Gro® Guardian. The control treatment was water. Experiment 2 was initiated on June 3rd with the PredaScent™ treatment being omitted. Both experiments yielded no differences due to treatment for all species including the control for browse damage rating. Mean damage ratings for all treatments and species remained at zero during Experiment 1 except control treatments of *Impatiens x hybrid* which had a 0.125 rating 14 DAT. Mean browse damage ratings of all treatments and species remained at zero for the duration of Experiment 2. Experiment 1 had no treatment differences for GI 31 DAT, although in Experiment 2, the Gold'n Gro® Guardian treatment on *Begonia semperflorens* was different from all other treatments 31 DAT, having a lower mean GI than the other treatments.

Index words: browse damage, *Odocoileus virginianus* Raf., woody plants, herbaceous plants

Species used in this study: *Rhaphiolepis indica* L*.; Rhododendron indicum* L. 'Judge Solomon'; *Begonia semperflorens* L.; *Impatiens x hybrid* L.; *Catharanthus roseus* L. G. Don

Chemicals used in this study: Buck Off! (Cleary Chemical Corporation), Deer Out™ (Deer Out, LLC), Deer Stopper® (Messina Wildlife Management), Gold'n Gro® Guardian (Itronics Metallurgical, Inc.), Plantskydd™ (Tree World Plant Care Products, Inc.), and PredaScent™ (PredaScent Eight Seconds, LLC)

Significance to the Industry

People ranging from homeowners to professional horticulturists living or operating businesses in suburban areas where white-tailed deer herds are present have encountered situations necessitating landscape plant protection from browse damage. Many methods to control this problem exist, but chemical repellents have an upperhand in the market place due to low cost and ease of application. Many chemical products exist to control browse damage, some containing dried swine and /or cattle blood, putrescent whole egg solids, and capsaicin. Many of these ingredients are by-products of other processes providing adequate inputs for companies that manufacture horticultural products.   As suburban America expands, so does the market for these companies producing products aimed to mitigate the problem at hand. With new products hitting the shelves every year, it becomes important to know which ones are effective for suppressing deer browse damage and which ones have limitations. This work confirmed efficacy of three previously tested and marketed commercial deer repellents. Efficacy of three newer commercially available deer repellents was found as well, along with some results that need further testing.

Introduction

Wildlife damage to agricultural crops is estimated to exceed $4.5 billion annually (8). Most wildlife damage to agricultural crops is caused by deer (27). It is reasonable to estimate that deer damage $750 million worth of timber in the United States as well (7). Deer and horticulture have an important relationship not always viewed as positive. White-tailed deer damage to nurseries, orchards, and private landscapes is a leading problem within the industry (16). According to Lemieux et al. (16), an inherent risk to the nursery industry is that homeowners will reduce their use (purchases) of valuable landscape trees and shrubs because of the fear of deer damage.

Consumers or households fall into a large category of people who have problems with wildlife damage. Both Messmer (17) and Conover (7) agree that over 60% of suburban or exurban households experience problems with wildlife in the United States on an annual basis. These households reported an average loss of $63 per household while spending over 260 million hours trying to eliminate or solve damage problems, equating to a total loss of $1.9 billion because of wildlife damage annually. A survey conducted by Storm et al. (23) found that damage to landscape plantings was a significant concern among participants near Carbondale, Illinois. As these animals continue to have a monetary impact on human lives, humans will strive to find ways to lessen the amount of money lost as a direct result of white-tailed deer.

Jagged or torn edges of twigs or stems are evidence of deer browse (9, 18). Deer lack upper incisors, so a smooth, clean cut is not achieved. Most browsing occurs below

the height of six feet. Rubbing of trees or other suitable objects by males attempting to

remove dried velvet (a layer of tissue covering the antlers during growth) is visually

evident before the breeding season (October-January). Deer leave footprints or hoof

prints that have been described as cloven or heart-shaped (13). Fecal droppings of the

white-tailed deer are very distinct, described as groups of droppings (pellets) measuring

3/4" long with pinched-off ends (13).

Nurserymen, landscape professionals, and homeowners alike have labored to no

avail in many cases trying to prevent deer damage to property. Exclusion, use of

resistant plant species, culling, scare tactics, and repellents are some of the commonly

used methods to control damage by white-tailed deer.

Repellents

The emerging method of choice for controlling white-tailed deer browse in

residential landscapes is the use of repellents (2). Basically, repellents reduce the

palatability of desirable plants and reduce herbivory by deer by exploiting their fear of

unfamiliar olfactory, visual, or taste cues (15). Some commercially available repellents

are Deer-Away Big Game Repellent®, Miller's Hot Sauce Animal Repellent®, Hinder®,

Deer Out®, Plantskydd®, and Tree Guard®. Active ingredients contained in these

repellents vary, but may include putrescent egg solids, capsaicin, and/or ammonium

soaps. Putrescent egg solids are waste products derived primarily from egg processing

plants (broken or cracked eggs, etc.), capsaicin is an ingredient that comes from the

plant genera *Capsicum*, which includes the chili pepper, and ammonium soaps are

basically just cleaning soaps or ingredients contained in them. Most of these products

are more effective when applied as a topical (directly onto the plant) than when applied

as an area repellent (as a perimeter treatment or treating just one plant among many)

(26). Studies have also shown that repellents emitting sulfurous odors generally have

the greatest success in repelling deer (6, 20, 26). Deer Away® and Havahart®, products

emitting sulfurous odors via putrescent egg solids, were found effective in deterring

white-tailed deer browse when applied to selected herbaceous plant species (6).

Milorganite®, a slow release organic fertilizer produced from human sewage,

was tested by Stephens et al. (22). Although found to be a very effective method of

control overall, in some situations there was a high degree of variation in effectiveness

found among multiple locations. A problem with product durability in the field was

found in a test of hot sauce (capsaicin) (25). Many repellents are labor intensive in that

they are not rain proof and must be re-applied soon after a rain event or irrigation for

continued efficacy (13). Many other factors play a part in the efficacy of a product

including deer density, learned behaviors of deer, available resources, and seasonal

variation in plant palatability.   Byers et al. (5) even concluded that repellents were

basically ineffective for browse reduction to highly desirable food under high deer

pressure.

This study evaluates three newer commercially available deer repellents and

attempts to affirm the performance of three that have been previously tested and

marketed for some time. The findings will assist homeowners and professional land

managers in the equipping of their toolboxes for fixes involving white-tailed deer

browse damage.

Materials and Methods

Woody Species

Two experiments were conducted during February, 2011 and March, 2012 to

evaluate the effectiveness of select commercially available deer repellents (Table 1).

Several new products, as well as previously tested products, were used. Both

experiments were conducted at the Auburn University Deer Lab, located within the

Piedmont Research Substation in Camp Hill, AL 36850. Approximately 100 adult free-

ranging white-tailed deer were located within the 430-acre high fence compound

equating to approximately 150 deer per square mile. Reasonable deer density for most

areas in the Southeast is about 25 per square mile (14). Supplemental feed was

available ad libitum. Resource availability during late winter for white-tailed deer is low

and movement to areas with greater resources, such as food plots, was expected (21).

The simulated landscape plot (located inside the high fence) covered 5,000 square feet

and was irrigated via an overhead system. The area was covered with landscape fabric

topped with approximately 1.5 inches (3.81 cm) of pine bark mulch. A Realtree Pro-

series[TM] game camera was placed to document deer activity on the plot.

Experiment 1: One gallon *Rhododendron indicum* L. 'Judge Solomon' and

Rhaphiolepis indica L. were obtained from Moore and Davis Nursery in Shorter, AL

36075 on February 22, 2011, where they were cultivated under standard nursery

practices. Before placement on the plot, treatments were applied separately and in

isolation.   The included repellent treatments were: PredaScent™ (PredaScent Eight

Seconds, LLC, 111 Freeport Road, Pittsburgh, PA 15215), Deer Out™ (Deer Out LLC, P.O.

Box 290, South Plainfield, NJ 07080), Deer Stopper® (Messina Wildlife Management,

P.O. Box 122, Chester, NJ 07930), Plantskydd™ (Tree World® Plant Care Products Inc.,

1421 South 11th Street, St. Joseph, MO 64503), and Buck Off! (Cleary Chemical

Corporation, 178 Ridge Rd., Suite A, Dayton, NJ 08810). The control treatment was

water. The two new repellents tested were PredaScent™ and Deer Out™. The other

repellent treatments used had been found effective in previous work (1). Each

treatment was applied to 12 plants per species. The experimental design was a

randomized complete block design with 4 blocks for a total of 12 plants per treatment.

All repellent treatments except PredaScent™ were applied foliarly according to label

directions via pressurized garden sprayers (separate sprayers used for each treatment).

The PredaScent™ treatment was a single capsule placed at the substrate surface in the

one gallon container. PredaScent™ directions call for a capsule placed every 3 feet (0.91

m) in a perimeter formation. Four randomized blocks of the 6 treatments with 3

subsamples of each plant species were placed on the simulated landscape plot and

secured with galvanized nursery hooks. Each plant occupied approximately 20.25 ft^2

(1.88 m^2) of space (4.5 ft, 1.37 m spacing). Previous tests at the plot found that the deer

often entered the plot at a similar location, thus necessitating blocking.

Plants were evaluated for damage 7, 14, 21, and 31 days after treatment (DAT). Most repellent labels recommend reapplication after 30 days for continued efficacy. Plants were given a damage rating based on a 0 to 3 scale (0=no browse damage, 1=⅓ of the plant canopy browsed or removed, 2=½ of the plant canopy browsed or removed, and 3=plant canopy completely removed). Growth indices (GI) [(height + width 1 + width 2)÷ 3] were recorded at the conclusion of the experiment or 31 DAT. Data were subjected to ANOVA and mean separations determined using Tukey's Studentized Range Test ($p \leq 0.05$) in a statistical software package (SAS® Institute version 9.1.3, Cary, NC).

Experiment 2: Initiated on March 12, 2012, this experiment was conducted similar to Experiment 1 except that the Plantskydd™ and PredaScent™ treatments were removed and Gold'n Gro® Guardian (Itronics Metallurgical, Inc., P.O. Box 60089, Reno, NV 89506), a new product, added. Each plant occupied approximately 30.25 ft^2 (2.81 m^2) of space (5.5 ft, 1.68 m spacing).

Data were collected as in Experiment 1, subjected to ANOVA, and mean separations determined using Tukey's Studentized Range Test ($p \leq 0.05$) in a statistical software package (SAS® Institute version 9.1.3, Cary, NC).

Herbaceous Species

Two experiments were conducted during the spring/summer of 2011 to evaluate the effectiveness of selected commercially available deer repellents when applied to the herbaceous species *Begonia semperflorens* L*., Impatiens x hybrid* L*.,* and *Catharanthus*

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roseus L. G. Don. The tests were conducted at the same location and under the same

conditions as the afore mentioned woody species. *Begonia semperflorens* and

Impatiens x hybrid were indicated as susceptible to browse damage by the providing

grower as well as in state extension lists (1). Although not consumed in previous work,

Catharanthus roseus plants were damaged when plant canopies were clipped and

dropped by deer (6).

 Experiment 1: Catharanthus roseus was obtained on March 12, 2011 from

Young's Plant Farm in Auburn, AL 36830, potted from its original 36 cell pack size into

one gallon nursery containers, and grown at the Paterson Greenhouse Facility located

on the campus of Auburn University, AL 36849 for approximately four weeks prior to

test initiation on April 11, 2011. *Begonia semperflorens* and *Impatiens x hybrid* were

sourced the same and kept in their original 8" (20.32cm) pots. Before placement on the

plot, treatments were applied separately and in isolation via pressurized garden

sprayers (separate sprayers used for each treatment). The included repellent

treatments were: PredaScent™ (PredaScent Eight Seconds, LLC, 111 Freeport Road,

Pittsburgh, PA 15215), Deer Out™ (Deer Out LLC, P.O. Box 290, South Plainfield, NJ

07080), Deer Stopper® (Messina Wildlife Management, P.O. Box 122, Chester, NJ

07930), and Gold'n Gro® Guardian (Itronics Metallurgical, Inc., P.O. Box 60089, Reno, NV

89506). The control treatment was water. PredaScent™, Deer Out™, and Gold'n Gro®

Guardian were all newer products that were included in the study. Deer Stopper® was

found effective in previous work (1). Each treatment was applied foliarly to each plant

species according to label directions. The PredaScent™ treatment was a single capsule placed at the substrate surface of the container as previously stated. The experimental design was a randomized complete block design with 4 blocks for a total of 8 plants per treatment. Plant species were placed on the simulated landscape plot and secured with galvanized nursery hooks. Each plant occupied approximately 30.25 ft^2 (2.81 m^2) of space (5.5 ft, 1.68 m spacing).

Data were collected as described in the woody species test, subjected to ANOVA, and mean separations determined using Tukey's Studentized Range Test ($p \leq 0.05$) in a statistical software package (SAS® Institute version 9.1.3, Cary, NC).

Experiment 2: Catharanthus roseus was obtained on May 2, 2011 from Young's Plant Farm in Auburn, AL 36830, potted from the original 36 cell pack size into one gallon nursery containers, and grown in at the Paterson Greenhouse Facility located on the campus of Auburn University, AL 36849 for approximately four weeks prior to test initiation on June 3, 2011. *Begonia semperflorens* and *Impatiens x hybrid* were sourced the same and kept in their original 8" (20.32 cm) pots. The methodology was similar to Experiment 1 except that the PredaScent™ treatment was removed. The experimental design was a randomized complete block design with 4 blocks for a total of 12 plants per treatment. Data were collected and analyzed as in Experiment 1.

Results and Discussion

Woody Species

    Experiment 1: There were no treatment differences for either *Rhododendron indicum* 'Judge Solomon' or *Rhaphiolepis indica* 31 DAT for growth indices (GI) (Table 2). There were no differences for damage ratings among the treatments, including the control, for *Rhododendron indicum* 'Judge Solomon' at 7, 14, 21, or 31 DAT (Table 3). Means were less than 1 for all treatments. Although not different, control treatments had received some browse damage by 14 DAT. There were no differences in browse damage among treatments, including the control for *Rhaphiolepis indica* at 7, 14, and 31 DAT. Means for browse damage ratings remained less than 1 for all treatments for the duration of the study. The PredaScent™ treatment was different from all other treatments 21 DAT with a mean browse damage rating of 0.250. All other treatments had a 0.00 mean damage rating the same day. Although not significant, PredaScent™ treatments also received browse damage at 7 and 14 DAT (Table 3). By 31 DAT, the Deer Out™ treatment had a mean browse damage rating of 0.083 while the PredaScent™ browse damage rating remained at 0.250. Although effective, PredaScent™ (encapsulated coyote urine), an area/perimeter repellent, was the weakest performing treatment on *Rhaphiolepis indica* supporting previous findings of topical treatments being more effective than area treatments (26). A previous study found coyote urine reduced winter browsing by white-tailed deer on woody plants (24). In contrast, wolf urine was found ineffective in reducing browse damage to agricultural

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and forestry resources by red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*) (12). It was also documented that urine from coyotes consuming large amounts of meat had a more sulfurous odor and increased repellency of potential prey (19). More testing of PredaScent™ is needed.

Experiment 2: There were no treatment differences for GI for either species at 31 DAT (Table 4). There were no differences for browse damage rating between treatments, including the control, for *Rhododendron indicum* 'Judge Solomon' at 7, 14, 21, or 31 DAT. Browse damage means were 0 for all treatments for the duration of the study (Table 5). There were no treatment differences for browse damage rating, including the control, for *Rhaphiolepis indica* at 7 and 14 DAT, although browse damage was seen on control treatments at 14 DAT (Table 5). By 21 DAT, browse damage to control treatments was different from all other treatments, with a mean browse damage rating of 0.583. Although different from the control, browse damage also occurred on the Gold'n Gro® Guardian treatment with a mean damage rating of 0.083. By 31 DAT, Gold'n Gro® Guardian and control treatments had similar browse damage ratings with means of 0.417 and 0.750, respectively. The Gold'n Gro® Guardian treatment was also similar to all the other treatments despite mean browse damage ratings of 0 for all other treatments. Mean browse damage ratings for all treatments were below 1 (less than 1/3 of the plant canopy browsed or removed). *Rhododendron indicum* 'Judge Solomon' and *Rhaphiolepis indica* plants were highly marketable 31 DAT when the study was terminated.

Herbaceous Species

Experiment 1: Growth indices 31 DAT for *Begonia semperflorens, Impatiens x hybrid,* and *Catharanthus roseus* were similar regardless of treatment (Table 6). There were also no differences due to treatment for browse damage rating on all three species for the duration of the study. Means for browse damage ratings were 0 for all treatments and species except the *Impatiens x hybrid* control treatment which had a rating of 0.125 14 DAT, but then remained unchanged until study termination.

Experiment 2: Thirty one DAT, there were no GI differences between treatments for *Impatiens x hybrid* or *Catharanthus roseus. Begonia semperflorens* plants treated with Gold'n Gro® Guardian had the lowest GI compared to other treatments 31 DAT with a mean value of 12.69 in (32.23cm) (Table 6). Plants were stunted and lesions were present on the leaves. Browse damage ratings were similar among the treatments for all three species during the study. Mean browse damage ratings were 0 for all treatments on all species for the duration of the study.

Conclusion

Woody Species

All tested chemical repellents in both experiments provided protection from deer browse, producing marketable plants 31 DAT for both species. Although effective as applied in Experiment 1 to *Rhododendron indicum* 'Judge Solomon' plants, browse damage increased over time for *Rhaphiolepis indica* plants treated with PredaScent™ until 21 DAT. It is possible that highly palatable species, especially when the capsule is

placed under dense canopies, could experience some browse damage until the PredaScent™ product has fully released and activated. We recommend that the product be watered in if this condition exists, although product labeling lacks this direction. Removal of the PredaScent™ treatment in Experiment 2 provided no conclusive data that the product alone was deterring browse in Experiment 1.

Rhaphiolepis indica plants treated with Gold'n Gro® Guardian repellent in Experiment 2 experienced browse damage by 21 DAT and browse damage increased until study termination 31 DAT. Although not different from other treatments other than the control 21 DAT, and similar to the control and all other treatments 31 DAT, it was the only chemical treatment that experienced browse damage in the study. The product could have been experiencing wear as has been found with other repellents (25) or the fertilizer carrier for the Gold'n Gro® Guardian repellent was impacting nitrogen content in the leaves of *Rhaphiolepis indica*, rendering the plants more desirable (3, 10). Buck Off!, Deer Out™, and Deer Stopper® performed well as expected, all containing putrescent whole egg solids (6, 20, 26). This work supported efficacy of Plantskydd™ found by Baker in 2010 (1).

Herbaceous Species

Both experiments, conducted during spring/early summer 2011 yielded no differences due to treatment for browse damage rating on *Begonia semperflorens, Impatiens x hybrid,* and *Catharanthus roseus.* Although efficacy of repellents is likely seen in both tests, the fact that the plot is surrounded by natural areas providing other

browse choices at this time of year can't be ignored. Deer pressure on the plot was

documented (Figure 1), but new vegetation growth has resumed in the forests, resulting

in higher quality forage availability (11).

During Experiment 2, GI data and visual signs indicated possible phytotoxicity to

Begonia semperflorens by the Gold'n Gro® Guardian treatment (Figure 2). Increased air

temperatures later in the season along with the repellent being carried via liquid

fertilizer are possible causes. Previous fertilizer work with foliar urea applications to

soybeans, and the associated leaf burn, was caused by the accumulation of toxic

amounts of urea in the leaves (4). Baker (1) tested phytotoxicity of several deer

repellents on two herbaceous plant species and found no effect on leaf greenness,

although some leaf staining was present on plants treated with Plantskydd™. Further

phytotoxicity testing is needed on Gold'n Gro® Guardian.

Table 6 provides cost information for the tested repellents on a per 1000 ft²

basis. This information will vary based on actual coverage and reapplication timing (i.e.

application to mature plant material vs. newly planted material; repellent wear due to

excessive rainfall or irrigation causing the need for shorter reapplication intervals). Cost

ranges per year were between $11.00 (Deer Out™) and $143.28 (Buck Off!). At the time

of this writing Itronics Metallurgical, Inc. lacked Environmental Protection Agency

registration for the Gold'n Gro® Guardian repellent, so it was unavailable for sale. The

label lacked clear information on coverage and reapplication timing.

Literature Cited

1. Baker, L.A. 2010. State Survey of White-Tailed Deer (*Odocoileus virginianus* Zimmerman) Impacts on Residential Landscapes and the Green Industry of Alabama and an Evaluation of Commercial Deer Repellents. MS Thesis, Auburn Univ., Auburn.

2. Baker, L.A., D.J. Eakes, G.B. Fain, S.S. Ditchkoff, and C.E. Coker. 2010. An Overview and Cost Analysis of Deer Repellents for Homeowners and Landowners. Circular ANR-1370. Alabama Cooperative Extension Service. Auburn University, AL.

3. Ball, J.P., K. Danell, and P. Sunesson. 2000. Response of a herbivore community to increased food quality and quantity: an experiment with nitrogen fertilizer in a boreal forest. J. Applied Ecol. 37:247-255.

4. Bremnen, J.M. 1995. Recent research on problems in the use of urea as a nitrogen fertilizer. Fert. Res. 42:321-329.

5. Byers, R.E., D.H. Carbaugh, and C.N. Presley. 1989. Screening of odor and taste repellents for control of white-tailed deer browse to apples or apple shoots. J. Environ. Hort. 8:185-189.

6. Coker, C.E.H. 2001. Evaluation of White-Tailed Deer (*Odocoileus virginianus* Raf.) Feeding Preferences and Deterrent Stratagies for Horticultural Commodities. PhD Dissertation, Auburn Univ., Auburn.

7. Conover, M.R. 1997. Monetary and intangible valuation of deer in the United States. Wildlife Soc. Bul. 25:298-305.

8. Conover, M.R. 2002. Resolving Human-Wildlife Conflicts: The Science of Wildlife Damage Management. Lewis Publishers, Boca Raton, FL.

9. Ditchkoff, S.S. 2011. Anatomy and Physiology. In D.G. Hewitt (Ed.), Biology and Management of White-tailed Deer. CRC Press, Taylor and Francis Group, Boca Raton, FL.

10. Dostaler, S., J.P. Ouellet, J.F. Therrien, and S.D. Côté. 2011. Are feeding preferences of white-tailed deer related to plant constituents? J. Wildlife Mgt. 75:913-917.

11. Edenius, L. 1991. The effect of resource depletion on the feeding behavior of a browser-winter foraging by moose on Scots pine. J. of Applied Ecol. 28:318-328.

12. Elmeros, M., J.K. Winbladh, P.N. Anderson, A.B. Madsen, and J.T. Christensen. 2011. Effectiveness of odour repellents on red deer (*Cervus elaphus*) and roe deer (*Capreolus capreolus*): a field test. European J. of Wildlife Res. 57:1223-1226.

13. Hygnstrom, S.E., B.D. Trindle, S.M. VanTassel, and K.C. VerCauteren. 2008. Managing Deer Damage in Nebraska. USDA Natl. Wildlife Res. Ctr.-Staff Publ. Univ. Nebraska-Lincoln, NE.

14. Killmaster, C. 2010. Realistic QDM goals vital for hunting satisfaction. Georgia Outdoor News, July 2010. Retrieved from http://www.gon.com/article.php?id= 2421&cid=87.

15. Kimball, B.A., J. Taylor, K.R. Perry, and C. Capelli. 2009. Deer responses to repellent stimuli. J. Chem. Ecol. 35:1461-1470.

16. Lemieux, N.C., B.K. Maynard, and W.A. Johnson. 2000. Evaluation of commercial deer repellents on ornamentals in nurseries. J. Eviron. Hort. 18:5-8.

17. Messmer, T.A. 2000. The emergence of human-wildlife conflict management: turning challenges into opportunities. Intl. Biodeterioration & Biodegradation 45:97-102.

18. Miller, B.K., G.L. O'Malley, and R.K. Myers. 2001. Electric Fences for Preventing Browse Damage by White-tailed Deer. Circular FNR-136. Purdue University Cooperative Extension Service. West Lafayette, IN

19. Nolte, D.L., J.R. Mason, G. Epple, E. Aronov, and D. L. Campbell. 1994. Why are predator urines aversive to prey? J. of Chem. Ecol. 20:1505-1516.

20. Santilli, F., L. Mori, and L. Galardi. 2004. Evaluation of three repellents for the prevention of damage to olive seedlings by deer. J. Wildlife Res. 50:85-89.

21. Smith, J.R., R.A. Sweitzer, and W.F. Jensen. 2007. Diets, movements, and consequences of providing wildlife food plots for white-tailed deer in central north dakota. J. of Wildlife Mgt. 71:2719-2726.

22. Stephens, O., M. Mengak, G. Gallagher, D. Osborn, and K. Miller. 2005. Effectiveness of milorganite as a repellent to protect ornamental and agronomic plants from deer over-browsing. Proc. Wildlife Damage Mgt. Conf. Internet Ctr. for Wildlife Damage Mgt. 163-170.

23. Storm, D.J., C.K. Nielsen, E.M., Schauber, and A. Woolf. 2007. Deer-human conflict and hunter access in an exurban landscape. Human-Wildlife Conflicts 1:53-59.

24. Swihart, R.K., J.J. Pignatello, and M.J.I. Mattina. 1991. Aversive responses of white-tailed deer, *Odocoileus virginianus*, to predator urines. J. of Chem. Ecol. 17:767-777.

25. Wagner, K.K. and D.L. Nolte. 2000. Evaluation of hot sauce (R) as a repellent for forest mammals. Wildlife Soc. Bul. 28:76-83.

26. Wagner, K.K. and D.L. Nolte. 2001. Comparison of active ingredients and delivery systems in deer repellents. Wildlife Soc. Bul. 29:322-330.

27. Wywialowski, A.P. 1994. Agricultural producers' perceptions of wildlife-caused losses. Wildlife Soc. Bul. 22:370-382.

Figure 1. Deer pressure on the plot during May, 2011.

Figure 2. Leaf damage on *Begonia semperflorens* treated with Gold'n Gro® Guardian repellent during June, 2011.

Table 1. Analyses of tested commercially available deer repellents.

Product	Rate	Active Ingredients	Cost
Buck Off!	16oz/gallon H2O	Putrescent whole egg solids	$95.50/gallon
Deer Out™	14.25oz/gallon H2O	Putrescent whole egg solids, peppermint and garlic oil, white pepper	$109.95/gallon
Deer Stopper®	14.25oz/gallon H2O	Putrescent whole egg solids, rosemary and mint oil	$124.99/gallon
Gold'n Gro® Guardian	Mix 8-8-8 + 4%S with enough H2O to make 3 quarts solution and then add 1 quart of repellent to complete 1 gallon spray solution	Denatonium bonzoate (a bittering agent undrinkable at 30-100ppm)	N/A[z]
Plantskydd™	1 pound/gallon H2O	Dried swine and/or cattle blood	$27.95/pound
PredaScent™	1 pegg (capsule)/3.5 linear feet	Dehydrated coyote urine	$39.97/150 peggs

[z]Gold'n Gro Guardian lacks EPA registration and is currently unavailable for sale.

Table 2. Effect of 5 deer repellents on growth indices^z of 2 woody landscape plant species, February, 2011.

Repellent	Species	
	Rhododendron indicum 'Judge Solomon' 31 DAT^w GI	Rhaphiolepis indica 31 DAT GI
Buck Off!	16.83^{ns}	16.50^{ns}
Deer Out™	17.50	15.33
Deer Stopper®	17.33	16.50
Plantskydd™	17.14	16.56
PredaScent™	17.28	15.53
Control^y	17.64	16.33

^{z}Growth index (GI) = [(height + width1 + width2) / 3] in inches.
^{y}Treated with water.
^{w}DAT=Days After Treatment
^{ns}Means not different based on Tukey's Studentized Range test at α=0.05 (n=12).

Table 3. Effect of 5 commercial deer repellents on browse damage rating[z] of 2 woody landscape plant species, February, 2011.

Repellent	Species							
	Rhododenron indicum 'Judge Solomon'[ ]				*Rhaphiolepis indica*			
	7 DAT[x]	14 DAT	21 DAT	31 DAT	7 DAT	14 DAT	21 DAT	31 DAT
Buck Off!	0.000[w,ns]	0.000[ns]	0.000[ns]	0.000[ns]	0.000[ns]	0.000[ns]	0.000b	0.000[ns]
Deer Out™	0.000	0.000	0.000	0.000	0.000	0.000	0.000b	0.083
Deer Stopper®	0.000	0.000	0.000	0.000	0.000	0.000	0.000b	0.000
PlantSkydd™	0.000	0.000	0.000	0.000	0.000	0.000	0.000b	0.000
PredaScent™	0.000	0.000	0.000	0.000	0.083	0.167	0.250a	0.250
Control[y]	0.000	0.083	0.083	0.083	0.000	0.000	0.000b	0.000

[z]Browse damage ratings based on a 0 to 3 scale (0=no browse damage, 1=⅓ of the plant canopy browsed or removed, 2=½ of the plant canopy browsed or removed, and 3=plant canopy completely removed).

[y]Treated with water.

[x]DAT=Days after treatment.

[w]Means within same column followed by the same letter are not different based on Tukey's Studentized Range Test, α=0.05.

[ns]Means not significantly different.

Table 4. Effect of 4 deer repellents on growth indices[z] of 2 woody landscape plant species, March, 2012.

Repellent	Species	
	Rhododenron indicum 'Judge Solomon'	*Rhaphiolepis indica*
	31 DAT[w] GI	31 DAT GI
	30.25[ns]	13.94[ns]
Buck Off!	30.25	13.94
Deer Out™	30.33	13.86
Deer Stopper®	29.08	13.67
Gold'n Gro® Guardian	29.17	14.00
Control[y]	28.03	13.06

[z]Growth index (GI) = [(height + width1 + width2) / 3] in inches.
[y]Treated with water.
[w]DAT=Days After Treatment.
[ns]Means not significantly different based on Tukey's Studentized Range test at α=0.05 (n=12).

Table 5. Effect of 4 commercial deer repellents on browse damage rating[z] of 2 woody landscape plant species during March, 2012.

Repellent	Species							
	Rhododendron indicum 'Judge Solomon'				*Rhaphiolepis indica*			
	7 DAT[x]	14 DAT	21 DAT	31 DAT	7 DAT	14 DAT	21 DAT	31 DAT
Buck Off!	0.000[w,ns]	0.000[ns]	0.000[ns]	0.000[ns]	0.000[ns]	0.000[ns]	0.000b	0.000b
Deer Out™	0.000	0.000	0.000	0.000	0.000	0.000	0.000b	0.000b
Deer Stopper®	0.000	0.000	0.000	0.000	0.000	0.000	0.000b	0.000b
Gold'n Gro® Guardian	0.000	0.000	0.000	0.000	0.000	0.000	0.083b	0.417ab
Control[y]	0.000	0.000	0.000	0.000	0.000	0.083	0.583a	0.750a

[z]Browse damage ratings based on a 0 to 3 scale (0=no browse damage, 1=⅓ of the plant canopy is browsed or removed, 2=½ of the plant canopy is browsed or removed, and 3=plant canopy completely removed).

[y]Treated with water.

[x]DAT=Days After Treatment.

[w]Means within same column followed by the same letter are not different based on Tukey's Studentized Range Test, α=0.05.

[ns]Means not significantly different.

Table 6. Effect of 3 deer repellents 31DAT[w] on growth indices[z] of 3 herbaceous plant species, June, 2011.

Repellent	Species		
	Begonia semperflorens	Impatiens x hybrid	Catharanthus roseus
Deer Out™	13.72a[x]	16.19[NS]	17.72[NS]
Deer Stopper®	13.94a	16.53	17.56
Gold'n Gro® Guardian	12.69b	16.06	17.92
Control[y]	14.33a	15.94	18.64

[z]Growth index (GI)= [(height + width1 + width2) / 3] in inches.
[y]Treated with water.
[w]DAT=Days After Treatment.
[x]Means within same column followed by the same letter are not different based on Tukey's Studentized Range Test, α=0.05.
[ns]Means not significantly different.

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Table 7. Cost analyses of tested chemical repellents.

Product	Cost[z]	Coverage[y]	cost/1000ft^2	Reapplication timing[x]	Cost/year/1000ft^2
[v]Buck Off!	$95.50/gallon	8000ft^2	$11.94	1 month	$143.28
[u]Deer Out™	$109.95/gallon	40000ft^2	$2.75	3 months	$11.00
[t]Deer Stopper®	$124.99/gallon	40000ft^2	$3.12	1 month	$37.44
[s]Gold'n Gro® Guardian	N/A[w]	Variable	N/A[w]	Variable	N/A[w]
[r]Plantskydd™	$27.95/pound	7200ft^2	$3.88	3 months	$46.56
[q]PredaScent™	$39.97/150 peggs	5500ft^2	$7.27	4 weeks	$94.51

[z]Current as of the time of this writing.

[y]Minimum coverages of each product.

[x]Minimum reapplication interval of each product.

[w]Gold'n Gro® Guardian lacks EPA registration and is currently unavailable for sale.

[v]Cleary Chemical Corporation, 178 Ridge Rd., Suite A, Dayton, NJ 08810.

[u]Deer Out LLC, P.O. Box 290, South Plainfield, NJ 07080.

[t]Messina Wildlife Management, P.O. Box 122, Chester, NJ 07930.

[s]Itronics Metallurgical, Inc., P.O. Box 60089, Reno, NV 89506.

[r]Tree World® Plant Care Products Inc., 1421 South 11th Street, St. Joseph, MO 64503.

[q]PredaScent Eight Seconds, LLC, 111 Freeport Road, Pittsburgh, PA 15215.

CHAPTER IV

FINAL DISCUSSION

Browse Preference

Although many studies and professional observations support information reported in state extension publications as to ornamental plant species' susceptibility to deer browse, it is important to realize that variability exists among those state lists. Findings in Chapter 2 confirm that *Rhaphiolepis indica* and *Rhododendron indicum* 'Judge Solomon' are susceptible to deer browse damage, which aligns with most state information. Use of these species in a landscape with a nearby deer herd will require protection. *Ilex cornuta* 'Burfordii Nana' was found to be only slightly browsed in 2011 and was resistant in 2012, and both *Ophiopogon japonicus* and *Thuja occidentalis* were resistant. Findings with *Ilex cornuta* 'Burfordii Nana' in this study varied, as do extension lists on this species' susceptibility to deer browse. Personal experience in the green industry around Birmingham, AL (approximately 100 miles NW of the test plot) is that both *Ophiopogon japonicus* and *Thuja occidentalis* are highly susceptible to deer browse damage. Variability among deer herds exists with respect to browse preference. This variability and possession of adaptive qualities by white-tailed deer will necessitate

examination of the palate of herds among different locations in order to make sound

plant selections and provide adequate protection from browse damage.

Chemical Repellents

Continued expansion of exurban communities will undoubtedly usher

opportunity for new chemical deer repellents to be marketed. Efficacy of new products

(Deer Out™, Gold'n Gro® Guardian, and PredaScent™) was observed in both woody and

herbaceous species during this study. Confirmation of efficacy on previously tested

products at the Auburn University Deer Lab (Buck Off!, Deer Stopper®, and

Plantskydd™) was also achieved. Experiment 1 on woody landscape species

(*Rhaphiolepis indica, Rhododendron indicum* 'Judge Solomon') only yielded a difference

among the treatments for damage rating 21 DAT on *Rhaphiolepis indica*, where the

PredaScent™ treatment had received more browse damage than all other treatments.

By 31 DAT there were no differences among the treatments and mean damage rating

for the PredaScent™ treatment on *Rhaphiolepis indica* was unchanged. Label directions

on PredaScent™ state that irrigation or rainfall will enhance product efficacy (both

methods being relied upon in this experiment), but lack instructions for watering in the

product. Although effective as applied, it is possible that dense plant canopies of

Rhaphiolepis indica could have slowed product release (up to 21 DAT), and product

activation may be enhanced with watering in (water directly contacting the capsule),

especially under circumstances where dense foliage exists. Control treatments to

Rhaphiolepis indica received the most browse damage during Experiment 2, followed by Gold'n Gro® Guardian treatments 31 DAT. Although damage to *Rhaphiolepis indica* plants treated with Gold'n Gro® was not seen until 21 DAT, damage increased until study termination 31 DAT. Future work is needed to evaluate product durability and the consequences of transporting the repellent with a liquid fertilizer. Questions about repellent product wear or increased nitrogen content (both possible drivers for browse damage) in the leaves (or both) with this product need to be answered.

Two experiments with repellent applications to herbaceous species during spring/summer 2011 yielded no differences among the treatments for browse damage rating on *Begonia semperflorens, Impatiens x hybrid,* and *Catharanthus roseus.* During this time of year, vegetative feeding choices in adjacent wooded areas to the plot are plentiful. Although efficacy of repellents is likely seen in both tests, the fact that the plot is surrounded by natural areas providing other browse choices can't be ignored. During Experiment 2, growth index data and visual signs indicated possible phytotoxicity to *Begonia semperflorens* by the Gold'n Gro® Guardian treatment. Increased air temperatures later in the season along with the repellent being carried via liquid fertilizer are possible culprits.

All tested repellent products provided protection from deer browse damage both years to woody and herbaceous plant material. Marketability of the tested plant species at the conclusion of both tests was high with the exception of Gold'n Gro®

Guardian treatments to *Begonia semperflorens* during June, 2011. As expected from examination of previous work, products containing putrescent whole egg solids (Buck Off!, Deer Out™, and Deer Stopper®) were highly effective in this study. Cost ranges per year per 1000ft^2 fell between $11.00 (Deer Out™) and $143.28 (Buck Off!).

Facilities and Future Work

This study examined the efficacy of multiple repellents on a single experimental plot at the Auburn University Deer Lab. Although limited by space and monetary inputs in this study, future work at the lab could benefit with construction and use of multiple plots. This would allow for separation of products being tested (eliminating potential cross over effects of repellents on the same plot), while still allowing for testing of multiple products during optimal times of the year. Testing multiple products separately with the current set up would be lengthy.

Potential future work from this study includes continued efficacy testing with new products on other browsed plant species and testing of future products as they hit the market. More work in the areas of efficacy, durability, and safety (phytotoxicity, food crops) is needed for the Environmental Protection Agency to register Gold'n Gro® Guardian, an Itronics Metallurgical, Inc. product. Initiation of a plan to expand the testing facility at the Auburn University Deer Lab to include multiple test plots has the potential to benefit research efforts on chemical repellents. Finally, when charged with deer browse management, it is important to realize that deer herd density, adaptability

of the white-tailed deer, available resources, and seasonal variation in plant palatability

will all be factors affecting browse preference and chemical repellent performance.