

Assessing Tennessee Landowners' Attitudes toward Wild Hogs and Support for Control Options

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Carlotta Anne Caplenor
December 2016

Copyright © 2016 by Carlotta Anne Caplenor
All rights reserved.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my advisor, Dr. Neelam Poudyal, for the guidance and support he extended to me throughout my graduate study and research work. I would also like to thank my other committee members, Dr. Lisa Muller and Chuck Yoest, for their constructive comments regarding this thesis project. Special thanks must also go to Cristina Maldonado for the help and encouragement she provided during survey implementation and data entry. My parents have also given me their unequivocal support, as always, throughout this graduate study process for which I am extremely grateful. I would also like to thank all of the private landowners in Tennessee who participated in this survey. Their responses were extremely valuable for the success of this project. Finally, I would like to express my thanks to Dr. Mark Fly, Dr. Wayne Clatterbuck, and Dr. John Zobel for their help and support, and for believing in me early on in this graduate school adventure.

ABSTRACT

Wild hogs (*Sus scrofa*) are an invasive species with destructive habits, particularly rooting and wallowing, which can directly impact agricultural crops, pasture land, and water quality. Considering wild hogs are widely dispersed across the landscape, it is extremely difficult to control them. Moreover, disagreements can arise among different stakeholders over whether and how their population should be managed. The purpose of this study was to examine Tennessee landowners' attitudes toward wild hogs, to compare acceptability of control methods, and to evaluate the factors significantly influencing public support for wild hog control regulations. Logistic regression was used to analyze data collected from a statewide survey in Tennessee in the fall of 2015. Tennessee landowners had overwhelmingly negative attitudes towards wild hogs, and were concerned about the impact on the natural environment and rural economy. While landowners show support for controlling the wild hog population, levels of acceptability for options vary. Respondents favor active management and support education and incentive-based control programs to control wild hogs. Consistent with the Norm-Activation Theory, results showed social and personal norms, awareness of consequences, and other demographic characteristics significantly predicted landowners support for state regulations to control wild hogs in Tennessee. Findings increase our understanding of the human dimensions of wild hog management and that of other similarly invasive animals, and may guide resource managers in designing effective and socially acceptable management strategies to control wild hog populations in Tennessee and elsewhere.

TABLE OF CONTENTS

Chapter One Introduction	1
Background	1
Wild hogs	2
Origins	2
Recent status of population and damage	3
Wild hogs in Tennessee	5
Human dimensions of wildlife management	6
Statement of the problem and justification	7
Objectives	8
Chapter Two Literature Review	10
Social considerations of invasive species management	10
Human dimensions of wildlife management	12
Conceptual background	14
Previous studies on wild hogs and damage	18
Chapter Three Materials and Methods	21
Research design and survey instrument	21
Data processing & analysis	23
Examining the acceptability of wild hog management options	23
Principal Component Analysis	23
Potential for Conflict Index	24
Kruskal-Wallis Test	25
Factors influencing support for state regulations to control wild hogs	26
Dependent variable	27
Independent variables	27
Chapter Four Results and Discussion	34
Survey response	34
Descriptive analysis	34
Sample characteristics	35
Knowledge of and attitudes towards wild hogs	35
Landowners' efforts to control wild hogs on private land	39
Support for wild hog control options and regulations	40
Principal component analysis	42
Potential for Conflict	44
Kruskal-Wallis Test	45
Factors influencing support for state regulations to control wild hogs	46
Chapter Five Conclusions and Implications	51
References	55
Appendix	64
Appendix 1. Questionnaire survey	65
Appendix 2. Follow-up reminder post card	76
Vita	77

LIST OF TABLES

Table 3.1 Summary of independent variables included in ordered logistic regression model	33
Table 4.1 Demographic characteristics of respondents	36
Table 4.2 Respondents' opinions about wild hog management and support for regulations in Tennessee	38
Table 4.3 Factors derived from the acceptability of wild hog control options	43
Table 4.4 Results from ordered logistic regression explaining factors influencing landowner support for state regulations to control wild hogs	47

LIST OF FIGURES

Figure 2.1 The Cognitive Hierarchy Model of Human Behavior	15
Figure 2.2 Schwartz's original Norm Activation Model	17
Figure 4.1 Respondents' perceived reason for wild hogs being present in their area	37
Figure 4.2 Percentage of respondents with perceived effectiveness of various methods to control wild hogs	40
Figure 4.3 Mean relative acceptability of various management actions to control wild hogs.....	42
Figure 4.4 Mean response differences in acceptability of wild hog management actions	45

CHAPTER ONE

INTRODUCTION

Background

Non-native invasive species can have a significant influence on landscapes by impacting native biodiversity, environmental and human health, and the economy (Bardsley & Edwards-Jones, 2006; Bremner & Park, 2007; Sharp, Larson, & Green, 2011). While not all of these impacts are negative, many are seen as an increasing environmental threat around the world (Bardsley & Edwards-Jones, 2006; Pimentel, Lach, Zuniga, & Morrison, 2000). Exotic species can easily invade a new area where they may not have many natural predators, especially if they are highly adaptable to a variety of habitat conditions (Pimentel et al., 2000). Around 50,000 non-native species have been introduced into the United States, including plants, mammals, birds, fish, and mollusks (Pimentel et al., 2000). Whether species are intentionally or accidentally introduced into new ecosystems, economic and environmental costs can occur when native species are displaced, wildlife or human health is threatened, or ecosystem functions are inhibited (Bardsley & Edwards-Jones, 2006). Wild hogs are one such invasive species, and land managers are struggling to control them in Tennessee and surrounding states.

Researchers and natural resource managers recognize the threat of invasive species is as much a social issue as it is an ecological one. In addition to the investment of substantial public funding, controlling invasive species requires cooperation from thousands of landowners across the landscape. The non-landowner segment of the public may also have opinions on whether and how their tax contributions should be directed towards control programs. In addition, heterogeneity in the public worldview (e.g. economy vs. environment, protection vs. use) makes it difficult to predict concerns and apprehensions regarding the growth and management of invasive species in their surroundings. Thus, the success of a project can be highly dependent on public support, particularly when eradication is the goal (Bremner & Park, 2007). Unsuccessful invasive

species management projects are often linked to a lack of public knowledge and support, and an agency's failure to consider public opinion into account (Sharp et al., 2011). Therefore, the importance of public perceptions when making management decisions cannot be overstated.

Wild hogs

Wild hogs (*Sus Scrofa*) are a non-native species that were introduced to the United States by early Spanish explorers in the 16th century (Mengak, 2012). Species occur in the United States in three forms – as domestic pigs, Eurasian wild boar, and hybrids between the two. Despite their popularity as a big game species, they are considered invasive because of their destructive rooting and wallowing behaviors (Mayer & Brisbin, 2009).

Origins

Wild hogs originated in Southeast Asia, dispersed into the Indian subcontinent, and then proceeded to spread across Eurasia into Western Europe (Mayer & Brisbin, 2009). Today populations can be found on all continents except for Antarctica, making them one of the more widely dispersed mammals in the world (Barrios-Garcia & Ballari, 2012; Centner & Shuman, 2014). Hernando de Soto is credited with introducing domestic pigs to the United States in the early 1500s (Mayer & Brisbin, 2009). Many of these pigs, and those brought by subsequent explorers and colonists, either escaped or were released as free-roaming and became feral over time.

Eurasian wild boar were introduced centuries later due to their popularity as a big game species for sportsmen. In 1912, a game preserve was established for them on Hooper Bald in Graham County, North Carolina. Wild boar began escaping the fenced enclosures, and subsequently bred with the already established populations of feral and domestic pigs in the area. The range of the hogs continued to grow, and crossbreeding accounts for the genetic variations and diverse appearances in the hogs we see today (Mayer & Brisbin, 2009).

Recent status of population and damage

The U.S. Department of Agriculture reported over five million wild hogs (Centner & Shuman, 2014), while another study determined numbers have reached over six million (Mayer, 2014). Wild hogs existed in 17 states in the 1980s, but have now been observed in 47 states (Mayer, 2014; USDA-APHIS, 2013). The first established populations were mostly located in the southern states and California, but since 1988 they have expanded to the central states of Colorado, Kansas, and Indiana (Gipson, Hlavachick, & Berger, 1998).

Wild hogs cause a variety of damages including row crop destruction, livestock injury, decreased water quality and forest regeneration, and infrastructure damage. Nationwide, wild hog damage is conservatively estimated at \$1.5 billion per year, which includes agricultural and environmental disturbances (Wild Pig Info, 2013; Pimentel, 2007). Several damage estimates have also been done at the state-level, particularly in the South. In Texas in 2004, wild hog damage was estimated at \$52 million annually, not including damages incurred to urban and suburban areas (Higginbotham, 2013). In Alabama, crop damage was estimated to be around \$75 million in 2009 (Shi, Zhang, Zheng, & Ditchkoff, 2009). In 2013, Louisiana estimated the total economic impact to their agricultural sector to also be \$75 million (Tanger, Guidry, & Niu, 2015). In 2011, Georgia found wild hogs caused \$81 million in damages to agricultural and property, and the South Carolina Wild Hog Task Force reported wild hogs in every county of the state with damage and control estimates reaching the tens of millions (Mengak, 2012; South Carolina Wild Hog Task Force, 2015).

Wild hogs prey on young mammals and ground-nesting birds, destroy nests of marine turtles, and compete with native wildlife such as white-tailed deer (*Odocoileus virginianus*) and wild turkeys (*Meleagris gallopavo*) for forage (Jerrolds, 2013; Miller, 2014). In the Fall, diet overlap of wild hogs with white-tailed deer is as high as 50% (Wild Pig Info, 2013). Rooting and wallowing behaviors are also believed to seriously jeopardize efforts to protect threatened and endangered species in protected habitats (Bevins, Pedersen, Lutman, Gidlewski, & Deliberto, 2014).

Wild hogs can carry parasites and diseases, including pseudorabies, influenza, hepatitis E, and multiple strains of brucellosis, which can be transmitted to wildlife, livestock, pets, and although rare, even humans (Bevins, Pedersen, Lutman, Gidlewski, & Deliberto, 2014). They are also known carriers of several waterborne pathogens including *Escherichia coli* (E. coli) and *Salmonella* (Kaller, Collier, Achberger, & Barry, 2000). A study in 2015 sampled 40 water bodies on private lands between Natchitoches and Alexandria, Louisiana. Results showed all tested sites contained some level of pathogens, and based on one or more criteria, were likely unsafe for human or wildlife contact. They also found a strong link between the pathogens and fecal samples from wild hogs using DNA fingerprinting (Kaller et al., 2000).

Once established, wild hog populations are often difficult to eradicate due to high reproductive capacity and early maturation. Wild hogs can begin reproducing as early as at six months of age, and can breed year-round with about 80% of sows breeding each year. They typically have 1-2 litters a year with an average of five or six pigs a litter (Higginbotham, 2013; Wild Pig Info, 2013). They are highly intelligent and adaptable, and humans are the only effective predators. Additionally, wild hogs are classified as opportunistic omnivores, meaning they are scavengers in addition to being able to eat a variety of plants and animals across many different geographical areas and seasons (Barrios-Garcia & Ballari, 2012). Therefore, populations can double in as little as a year, and 90% must be removed to see any serious decline in numbers (Wild Pig Info, 2013; Woody, 2015).

Management options for controlling wild hogs include capture with snares or traps, aerial sharpshooting, or hunting with dogs. Campbell and Long (2009) reviewed many control techniques and compared advantages and disadvantages. Electric fencing has been used to exclude or inhibit the movement of wild hogs in California, Hawaii, and Australia. However, construction and maintenance can be costly. Snares may not be very expensive, but only one animal can be captured at a time. Management efforts also include educating the public or offering technical help to landowners. Public hunting alone is usually not effective at reducing population numbers because only a few at a time can be removed this way. Hunting as a recreational activity has also encouraged the

illegal transport of wild hogs in order to bolster populations, which negates any population control (Bevins et al., 2014; Gipson et al., 1998; Mayer & Brisbin, 2009). Trapping is more effective than some of the other techniques as it enables a large group to be caught at once with relatively inexpensive and safe equipment (Campbell & Long, 2009; Jerrolds, 2013).

Wild hogs in Tennessee

In the 1920s some wild hogs escaped from farms and the Hooper Bald hunting preserve in North Carolina, resulting in feral populations that eventually spread into Tennessee. Before the 1950s, Tennessee's initial wild hog populations consisted of isolated pockets in the vicinity of the Great Smoky Mountains and along the Cumberland Plateau. However, in addition to natural reproduction and expansion, offspring of the Hooper Bald wild hogs were intentionally transported into other areas of both North Carolina and Tennessee for hunting purposes. Private individuals as well as state wildlife agencies have contributed to purposeful reintroductions throughout the Southeast in order to either augment existing populations or to establish new ones (Bevins et al., 2014; Gipson et al., 1998; Mayer & Brisbin, 2009). For example, wild hogs were brought to the Catoosa Wildlife Management Area on the Cumberland Plateau in the early 1960s, and the Anderson Tully Wildlife Management Area north of Memphis, TN in 1979 (Jerrolds, Pelren, Darroch, & Anderson, 2014).

In response to growing numbers, Tennessee implemented a statewide year-round hog hunting season in 1999. However, this unintentionally compounded the problem by continuing to encourage the illegal transport of wild hogs to previously uninhabited areas. Over the last two decades, the range of wild hogs in Tennessee has expanded from 15 counties to almost 80 out of 95, and hunting has proven to be an ineffective means of control (TWRA & WHEAT, 2012; Wild Hog Regulations). A report submitted to the Tennessee Wildlife Resources Agency in the spring of 2016 indicated that while wild hogs and the damages they incur are limited to certain parts of the state, the total impact is substantial, with an estimated value of damage at approximately \$26 million in 2015 (Poudyal, Caplenor, Maldonado, & Muller, 2016). Additionally, landowners also spent

nearly \$2 million in control costs on their property, resulting in a total of \$28.31 million in damage and control costs. This estimate is conservative since the monetary value of environmental damage was not included, and there are probably other kinds of damage the survey was unable to capture. Nevertheless, the estimate of total damage is comparable with the damage statistics reported in several neighboring states discussed previously.

The estimated loss of crops and other property due to wild hog damage, and costs incurred in controlling were further analyzed to characterize the total economic impact in terms of lost output, jobs, and income. The expenditures involved in controlling wild hogs and managing damage have created some positive economic activities, but the net total economic impacts attributable to wild hog damage has resulted in a loss of \$32.8 million in industrial output, along with \$4.59 million in lost labor income and 332 jobs affected in Tennessee (Poudyal et al., 2016).

A more recent approach to wild hog management in Tennessee has been the formation of the Wild Hog Eradication Action Team (WHEAT). WHEAT is a unique partnership comprised of 25 stakeholders from government and non-governmental sectors including hunting, conservation, agriculture, and human health organizations. Established in 2011, WHEAT strives to eliminate incentives for illegal stocking, establish effective means of control for landowners, and provide technical and educational support to landowners. WHEAT has also become a model for hog management in nearby states (TWRA & WHEAT, 2012; Woody, 2015).

Human dimensions of wildlife management

Over the past few decades, wildlife managers have become increasingly interested in understanding and predicting the public's attitudes and behavior toward wildlife-related issues. In response, a cognitive approach that examines concepts such as values, attitudes, and norms has become popular, as they can help explain how thoughts lead to actions. The concept of norms in particular has played a big part in research pertaining to how people make decisions or behave regarding natural resource issues (Manfredo, 2008).

Christine Horne postulated that, “No concept is invoked more often by social scientists in the explanation of human behavior than the ‘norm’” (2001). *Norms* involve a sense of internal obligation, and can refer to what most people are doing (a descriptive norm), or to what people “should” or “ought” to do (an injunctive norm) in a particular circumstance (Vaske & Manfredo, 2012). Additionally, *social norms* are shared by a group whose members all agree on what is acceptable behavior or conduct (Vaske, 2008). Therefore, the interaction of the group members is a crucial component, as group approval tends to motivate adherence to the norm. These characteristics make norms an especially useful cognitive construct for identifying public acceptability, pinpointing and mitigating any potential conflict among stakeholders, and predicting support for wildlife management. Thus, applying the concept of behavioral norms can offer insights on landowners’ knowledge and perceptions of wild hogs. In addition, landowners’ knowledge and attitudes toward wild hogs may be influenced by other factors. For example, landowners of different ages and with varying levels of income and education may have contrasting views on wild hogs, and may show different levels of support for regulations designed to control them.

Statement of the problem and justification

Given their growing population and the costly damages they inflict, wild hogs are now forefront on the minds of many concerned natural resource managers and rural property owners. However, landowners in Tennessee may disagree over the best ways to manage wild hogs. Among recreation groups such as hunters, some might view potential hunting opportunity positively, while others might be concerned about wild hogs’ invasion of wildlife habitats or disease risk to livestock. Identifying socially acceptable approaches is key to the success of any control programs. Knowledge of the public’s acceptability of various management actions can be used to adjust policies accordingly and balance what is best for the resource and public expectations. For example, even if people are overwhelmingly in favor of controlling wild hogs, they may differ in how that goal should be achieved. Dandy et al. (2011) examined public preferences for wildlife

management in peri-urban Scotland, and active management was widely accepted by the respondents compared to a do-nothing approach. However, lethal management was deemed unacceptable, and almost all respondents preferred other management options. Understanding public perceptions can be essential to mitigating potential conflicts, in addition to predicting behavior toward wildlife (Vaske & Manfredi, 2012).

Most of the studies on wild hogs have focused on biological and economic research, with little attention on their social impacts (Adams et al., 2005). More recently, Tanger, Vlosky, and Kaller (2016) pointed out the only known published research since then on human perceptions of wild hogs was a study comparing the attitudes of Georgia and Illinois farmers toward wild hogs (Harper, Miller, Vaske, Mengak, & Bruno, 2016). However, results from elsewhere may not necessarily be applicable to Tennessee, as social and cultural contexts could vary by state. This is particularly true because many of the surveys regarding wild hog damage in neighboring states have relied on convenience or purposive sampling (Tanger et al., 2015; Mengak, 2012). The level of damage could also vary, affecting perceptions of consequences for no control. Finally, few researchers have studied private landowners' general views of wild hogs and whether and levels of support for alternative management actions. It could also be helpful to employ theoretically grounded methods to a random sample of landowners so the results could be more generalizable in predicting public support for wild hog management.

Objectives

The overall goals of this study are to increase our understanding of landowners' knowledge of and opinions towards wild hogs, and to investigate the factors determining the level of support for the management of wild hogs in Tennessee.

The specific objectives of this study are:

1. to assess landowners' knowledge of and attitudes toward wild hogs.
2. to compare landowners' acceptability of alternative management approaches to control wild hogs.

3. to determine the factors influencing landowners' support for regulations to control wild hogs in Tennessee.

CHAPTER TWO

LITERATURE REVIEW

Social considerations of invasive species management

Invasive species are considered to be major drivers of ecosystem change and one of the major environmental concerns today (Bremner & Park, 2007; García-Llorente, Martín-López, González, Alcorlo, & Montes, 2008; Sharp et al., 2011). While research has primarily concentrated on the ecological effects of invasive species on biodiversity, literature has emerged over the past ten years with more of a social focus on attitudes, risk perceptions, environmental values, human-wildlife conflicts, and other cognitive factors (Estevez, Anderson, Pizarro, & Burgman, 2014). After all, humans are involved in almost every step of the invasive process from contributing to their purposeful and accidental introduction, to suffering the consequences (e.g., damage) and dealing with their management and control (García-Llorente et al., 2008). Therefore, social concerns should be merged with ecological ones when researching solutions to the ever increasing problems from invasive species.

Knowledge of the species, attitudes, and socio-demographic factors such as age and gender can serve as predictors of public support for the eradication of invasive species. For instance, Akiba, Miller, and Matsuda (2012) looked at public preferences for the eradication of raccoons (*Procyon lotor*) in Japan and pinpointed factors affecting levels of support. They found that attitudes toward raccoons, attitudes toward damage, knowledge, age, and gender were all predictors of public support for eradication. Respondents with negative attitudes toward damage were also more likely to support eradication. However, actual support for raccoon eradication was low (31% in favor), possibly due to a lack of knowledge.

Bremner and Park (2007) explored socio-demographic factors influencing attitudes towards the management of non-native invasive species, and how support for management varied by species. Most respondents (73-84%) supported the control or eradication of species that cause economic damage or threaten native species. They

found gender was a significant factor, with men showing a higher level of support for control or eradication programs than women. Respondents were less likely to back control programs involving birds or rhododendron (*Rhododendron ferrugineum*), and were more likely to support projects pertaining to Japanese knotweed (*Fallopia japonica*) or giant hogweed (*Heracleum mantegazzianum*). The level of support for controlling rhododendron may have been lower because of its pleasant appearance.

Attitudes and perceptions toward invasive species can also vary among stakeholder groups. García-Llorente, Martín-López, González, Alcorlo, and Montes (2008) examined the perceptions and attitudes of different stakeholder groups affected by non-native invasive species on the southwestern coast of Spain. They employed hierarchical cluster and principal component analyses to survey responses, and identified five different stakeholder groups that varied in their degree of knowledge, perceptions, attitudes, and willingness to pay for eradication. These results highlight the importance of considering different stakeholder views when implementing control programs for invasive species in order to increase the overall level of support and minimize potential conflicts.

Kalnicky, Brunson, and Beard (2014) acknowledge there is still much to learn about people's attitudes toward non-native species and their support for management. They used a social-ecological systems framework to examine the relationship between coqui frog (*Eleutherodactylus coqui*) abundance on private property and attitudes toward the coqui. They found people with more frogs had less negative attitudes toward them, possibly due to habituation. They also found that attitudes toward the frogs did not correlate with control strategies, and suggested that lack of knowledge about control options could be a factor.

In a sample survey of 1,166 visitors to Cumberland Island National Seashore, Sharp, Larson, & Green (2011) examined how the general worldview, or the individual's core values regarding the environment and economy, related to support for invasive species management. They found environmental attitudes were the best predictors of backing for the management of invasive species. For example, *absolute ecocentric* visitors (i.e., believe in the persistence of all species) are more likely to support a do-

nothing management approach, while *adaptive ecocentric* visitors (i.e., agree human intervention is sometimes necessary) tend to favor more of a hands-on management approach. These subcategories of ecocentric orientation, based on the anthropocentric-ecocentric continuum, serve as useful indicators of people's changing ethical perceptions regarding invasive species. Adaptive ecocentric attitudes significantly correlated with both support of on-site management as well as complete eradication; therefore, on-site adaptive management was found to be the most acceptable management strategy.

Human dimensions of wildlife management

A species does not have to be non-native to induce human-wildlife conflict and potential controversy among stakeholders. Therefore, gaining an understanding of public knowledge and what management strategies they find acceptable is still highly relevant for all wildlife. There has been an extensive amount of research on the human dimensions of wildlife management, particularly in North America. Many studies have identified differences between stakeholder perceptions and support for management. For example, Crawford, Poudyal, and Maerz (2014) surveyed stakeholder groups (i.e., island visitors, tourists, tourism industry employees) to assess their attitudes and value orientations as they relate to terrapin (*Malaclemys terrapin*) management at Jekyll Island, one of the barrier islands along the Atlantic coast of Georgia. Respondents generally held *biocentric* value orientations, which would indicate their tendency to view nature as something with inherent worth that should be preserved even if human benefit from its resources was reduced (Vaske, Donnelly, Williams & Jonker, 2001). Accordingly, they found the general on-site terrapin management option to be the most accepted when compared with a do-nothing or total eradication approach. Support varied by stakeholder group with visitors and residents being twice as likely to support general terrapin management than employees. Improved communication or education among groups with conflicting views may result from a lack of knowledge about the species or effectiveness of the management options.

Wald, Jacobson, and Levy (2013) also found significant differences among stakeholders' perceptions and support for the management of outdoor cats (*Felis catus*) has. Their research was the first to analyze attitudes and beliefs about outdoor cats among three influential stakeholder groups – Trap-Neuter-Return (TNR) supporters, Audubon Society members, and the public. They found TNR supporters had more positive attitudes toward outdoor cats than Audubon Society members or the public. Public perceptions were generally the most neutral. They also revealed support for non-lethal management over lethal management (83% compared to 13%).

Strong differences between male and female support for lethal control and/or hunting have been found (Jackman & Rutberg, 2015; Kellert & Berry, 1987; Lauber, Anthony, & Knuth, 2001). Dougherty, Fulton, and Anderson (2003) found wildlife value orientations, attitudes, and gender may influence the acceptability of lethal deer (*Odocoileus virginianus*) management. However, gender acted as a moderator between values, beliefs, and attitudes rather than as a predictor variable. Gender influenced the strength of correlation and predictability between these factors, with women exhibiting a stronger relationship. Women's attitudes toward lethal wildlife control may be more affected by underlying beliefs and values than those of males. However, men were found to be more supportive overall of lethal deer control than women.

Lethal wildlife control may be more acceptable after more supported methods have been tried and failed. Dandy et al. (2011) examined public preferences for wildlife management in relation to age, gender, and familiarity with wildlife in peri-urban Scotland. Fencing was the preferred method of control, with little variation seen across age, gender, or familiarity. Active management was widely accepted by the respondents compared to a do-nothing approach. However, lethal management was unacceptable, with almost all respondents preferring other control options. As a third option, lethal management received some support across demographic groups. The hypothesis that attitudes toward wildlife management options would differ across age, gender, and familiarity was not supported, and could be due to social and cultural differences between regions. Support for lethal control was also relatively lower than what has been

previously reported in other deer studies (Green, Askins, & West, 1997; Kilpatrick, Labonte, & Barclay, 2007).

Lamb and Cline (2000) investigated public knowledge of black-tailed prairie dog (*Cynomys ludovicianus*) and preferences for their management in an 11-state short-grass prairie region of the United States. Respondents reported a mostly negative view of the prairie dogs despite their status as a keystone species and the consideration of their being listed as “threatened” under the Endangered Species Act. Results also indicated a rather low public understanding of the scientific management of prairie dogs, which could potentially hinder public participation in policy decisions.

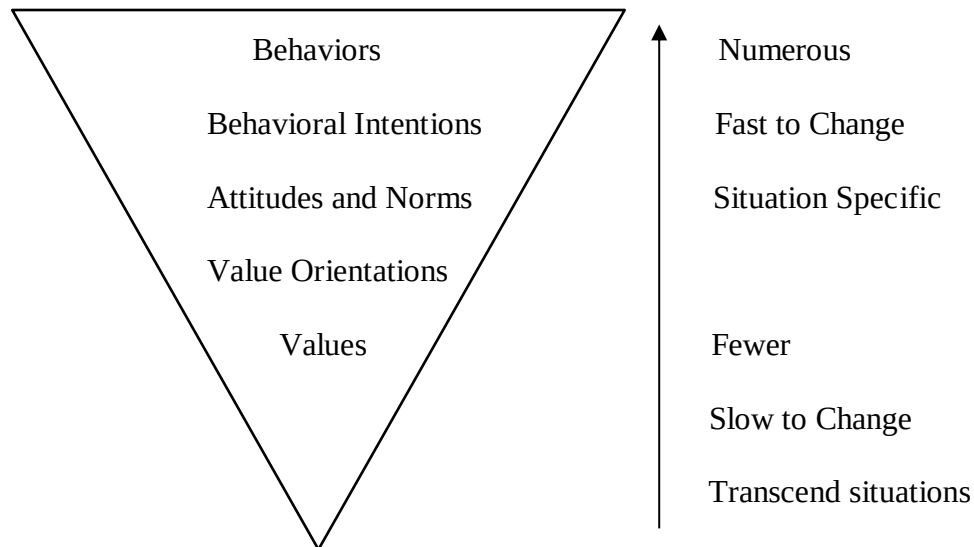
Human dimensions research can also contribute to wildlife recovery or reintroduction in areas where a species may not have lived for several decades. Morzillo, Mertig, Garner, and Liu (2007) surveyed residents in East Texas to examine attitudes toward black bears (*Ursus americanus*) and a possible bear population recovery. Positive attitudes toward black bears and their increasing populations were associated with younger male respondents who had a higher knowledge of bears and had seen them in the wild. Many respondents felt uncertain about their attitudes regarding black bears due to limited knowledge and experience, which suggests changing attitudes toward bears should be further evaluated in the future. Knowledge of a species as well as their potential impact to humans may be important predictors of attitudes towards species.

Conceptual background

Over the past several decades, research pertaining to the human dimensions of wildlife management has been continually expanding on social psychology theories. Understanding psychological models of human thoughts and behavior can help researchers explain why people think and behave the way do, and can assist natural resource managers as they work with diverse individuals and communities by allowing them to predict behaviors and attitudes toward future management strategies. Theory provides groundwork for investigating new questions and adding to previous research.

Among many others, the Cognitive Hierarchy Theory is a behavioral model based on the idea that human thought processes can be arranged into a hierarchy of cognitions.

Each build upon one another in what can visually be observed as an inverted pyramid, and often include values, value orientations, norms, attitudes, and behavior (Figure 2.1). Values tend to be few in number, not specific to objects or situations, and slow to change. Elements higher up the hierarchy are more numerous and subject to change, such as attitudes and norms. These are more dynamic, and therefore, more likely to account for variability in a given population. Natural resource managers often strive to measure them to predict concepts at the top of the pyramid, such as behavior. For example, if one can present a correlation, or even causation, between norms and behavior, they then have vital information that can help them predict people's acceptance of various management strategies (Vaske, 2008).



(Source: Vaske, 2008, pg. 24)

Figure 2.1 The Cognitive Hierarchy Model of Human Behavior

Researchers tend to define and measure norms differently (see Vaske & Whittaker, 2004). For example, Jackson (1965) described a structural approach for evaluating behavior along a continuum, and this use of the norm concept is favored when determining standards for acceptable human or wildlife impacts. Whittmann, Vaske,

Manfredo, and Zinn (1998) used this approach to develop standards for an agency's use of lethal control for urban wildlife. Their study examined how three structural characteristics of norms (range of acceptable conditions, norm intensity, and norm agreement) vary across similar situations for three different wildlife species (beavers (*Castor Canadensis*), coyotes (*Canis latrans*) and mountain lions (*Puma concolor*)). Participants were not as supportive of lethal management when the human-wildlife interaction was low, and acceptability of lethal management varied across the species in identical situations. For example, in most of the settings involving beaver and coyotes, killing a coyote was found to be more acceptable than killing a beaver.

Jonker, Organ, Muth, Zwick, and Siemer (2009) also found people more accepting of lethal wildlife management when there is an increase in perceived damage severity. They used a mail survey to compare beaver management preferences across three regions in Massachusetts and to determine the strength and direction of social norms in relation to participants' level of beaver encounters, lethal vs. non-lethal management actions, and their perceptions of beaver damage. Norms were influenced by the type of beaver interactions as well as fluctuations in the amount of damage.

The norm concept has also been used to examine social pressure (norms) on behavior. This Theory of Planned Behavior, which was originally the Theory of Reasoned Action (Ajzen & Fishbein, 1980), includes attitudes, subjective norms, and perceived behavioral control as explanatory components used to predict behavioral intention. Willcox, Giuliano, & Monroe (2012) used this theory to predict cattle ranchers' intentions to include wildlife management in their routine ranch operations in Alabama, Florida, Georgia, and Mississippi. They found attitude and subjective norms important in predicting behavioral intent, while perceived behavioral control was not essential. This is consistent with findings from other studies that have applied the theory to wildlife recreational activities such as hunting (Hrubes, Ajzen, & Daigle, 2001) and backpackers' use of bear-resistant food canisters (Martin & McCurdy, 2009). The theory of planned behavior has also been successfully used to explain a wide range of human health behaviors such as smoking (Shi, Ehlers & Warner, 2014) and underage alcohol use (Lac, Crano, Berger & Alvaro, 2013).

Some researchers focus on the variables focusing or activating the norm, which in turn can influence behavior. Schwartz (1977) first developed the norm activation theory in the context of altruistic behavior using three key components (Figure 2.2). He described the *personal norm* (PN) as a feeling of moral obligation to behave a certain way. However, norms by themselves are not always enough to guide behavior. Instead, they are often activated by situational factors such as one's *awareness of consequences* (AC), or an individual's recognition of the negative effects that their behavior or lack thereof may cause, and *ascription of responsibility* (AR), which refers to the idea of accepting responsibility for the consequences of these actions (Vaske, 2008). This theory has been successfully used to explain a variety of general pro-environmental behaviors such as recycling (Bratt, 1999), carbon footprint mitigation (Vaske, Jacobs, & Espinosa, 2015), and electricity saving behavior (Zhang, Wang, & Zhou, 2013).

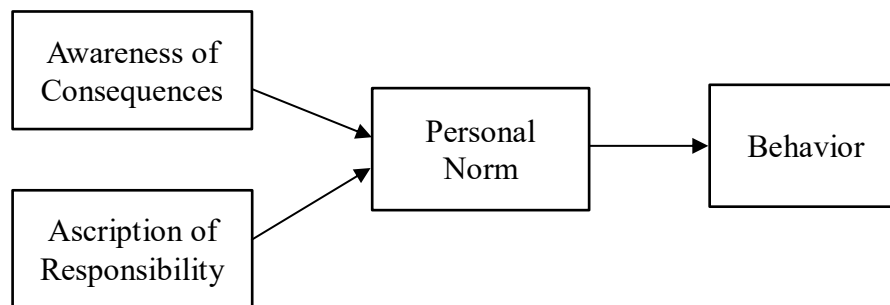


Figure 2.2 Schwartz's original Norm Activation Model

It is common for Schwartz's model to be adapted to include only a portion of the original variables or to measure them in a different way (Vaske, 2008). For example, Bratt (1999) did not measure AR in his study on recycling behavior, and social norms were instead used as an activator of personal norms. He hypothesized that the experienced social norm of recycling would influence behavior indirectly through a personal norm. His study confirmed the indirect impact of the social norm and was consistent with results from previous work. However, he also hypothesized the capability of a personal norm to predict recycling behavior would be higher with increasing

awareness of negative consequences for not supporting recycling, but this assertion was not supported by the study. However, results may have been affected by the question format.

Previous studies on wild hogs and damage

Wild hogs' effects on ecosystems (Barrios-Garcia & Ballari, 2012; Campbell & Long, 2009; Krull, Choquenot, Burns, & Stanley, 2013; Siemann, Carrillo, Gabler, Zipp, & Rogers, 2009), spread of disease (Clavijo et al., 2013), reproductive biology (Sweeney, Sweeney, & Provost, 1979), range expansion (Gipson et al., 1998), and management (Adams et al., 2005; Campbell & Long, 2009; Centner & Shuman, 2014) have been extensively studied. Adams et al. (2005) noted the need for more studies to address landowner/manager knowledge of and attitudes toward wild hogs. Since then, there have been few published studies that examine public perceptions (Harper et al., 2016; Tanger, Vlosky, & Kaller, 2016), although recently studies in some southern states have produced technical reports with the dual purpose of assessing statewide damage impacts (Mengak, 2012; Miller, 2014).

Adams et al. (2005) used purposive sampling to assess the observations, experiences, and actions of landowners and managers in Texas concerning wild hogs on their property. The study was not designed to represent all rural landowners in Texas, and instead respondents were selected based on their ecological region. Less than half of the respondents were able to correctly answer questions regarding wild hog biology and their impacts, and authors emphasized expanding information and education programs. Landowners participating in the study also viewed wild hogs as a nuisance instead of as a recreational opportunity or something of economic value.

A mail survey of 1200 individuals in Southwest Georgia that attended education programs provided by the Southwest Cooperative Extension Service found that most respondents believed wild hogs were a nuisance and agreed they should be eliminated whenever possible (Mengak, 2012). This same survey was revised and mailed out again in 2015, to 3,000 rural landowners as well as farmers who were registered with the USDA Natural Resources Conservation Service or other government farm assistance

programs. Results were similar to the initial study, with mostly negative attitudes and respondents feeling state and federal agencies did not provide enough needed assistance for wild hog control (Mentak, 2016).

Miller (2014) conducted a mail survey of randomly sampled landowners in 45 counties in Illinois with reported hog populations or counties adjoining them. Results were similar to those in Georgia, as most landowners expressed negative attitudes toward wild hogs. Harper, Miller, Vaske, Mentak, and Bruno (2016) took the results from the Georgia and Illinois studies and explored whether farmers differed in their attitudes toward and beliefs about wild hogs by state. Although respondents from both states exhibited a general dislike for wild hogs, those from Georgia had the least consensus for statements measuring beliefs toward wild hogs. They also felt negatively toward wild hogs as a game species, suggesting that time did not change tolerance, unlike in other studies where acceptance went up over time (Organ & Ellingwood, 2000).

Most studies on wild hogs used purposive or convenient sampling. Jerrolds (2013) estimated the economic impact of wild hog damage in Tennessee by conducting an online survey of extension agents, Natural Resource Conservation Service (NRCS) employees, and Farm Bureau officials. The study provided useful insights on the extent of wild hog damage, but did not address attitudes toward wild hogs or their management options. A more comprehensive evaluation of damage collected directly from the property owners, and extrapolation of the sample to the entire state is important. A random sample of landowners is more likely to represent the overall population's perceptions, attitudes and support. There is also a need to employ theoretically grounded methods to a random sample of landowners to predict public support for wild hog management.

Few researchers have studied how private landowners in general view wild hogs and whether and how they show different levels of support for alternative management actions. This study intends to fill this research gap by applying a norm approach to study the factors influencing Tennessee landowners' support for wild hog management. Based on results from similar studies, it is expected that landowners will view wild hogs as a nuisance and perceive their spread as damaging to the environment and harmful to the

rural economy. It is also hypothesized that landowners' level of support for tighter regulations to control wild hogs will be significantly influenced by their norm strength, awareness of consequences, experience of damage, level of income, and other demographic factors.

CHAPTER THREE

MATERIALS AND METHODS

Research design and survey instrument

An eight-page questionnaire was developed in the summer of 2015 to collect data from private landowners in Tennessee regarding their knowledge of and attitudes toward wild hogs, as well as their experience of damage from them. A number of questions recently tested and used for similar surveys in nearby states were used to develop a preliminary instrument (Mengak, 2012; Miller, 2014; Tanger et al., 2015). Feedback on the questionnaire was collected from survey experts, economists, and wildlife biologists. Input from the Tennessee Wildlife Resources Agency's Wild Hog Coordinator, Chuck Yoest, provided additional insight for relevant questions to ask in Tennessee. The funding partners of the Wild Hog Eradication Action Team committee were also provided a draft to review, and their input was considered during the revision.

Mail surveys were used to collect data during the fall of 2015. To ensure a sufficient number of responses for analysis purposes, a random sample of 5,000 landowners was selected. The sample was drawn from 68 counties reported to have established populations of wild hogs (TWRA & WHEAT, 2012; USDA, 2014). Contact information including name and address was purchased from Survey Sampling, Inc., a company that sells mailing lists of property owners. Landowners, farmers, and homeowners in rural areas were chosen because they tend to have first-hand knowledge of and experience with wild hogs.

Following a method modified from Dillman (2006), a packet including a personalized cover letter, 8-page questionnaire (Appendix 1), and pre-paid business reply envelope was mailed in the first week of October 2015. The cover letter was designed to invite respondents to complete the survey and explain the purpose of the study. It also assured that participation was voluntary, and that contact information and responses would remain anonymous and confidential. A follow up reminder postcard (Appendix 2) was mailed to all non-respondents two weeks later to thank those who had already

responded to the survey and encourage participation from those who had not. No additional mailing was sent out to accommodate the request of one of the study's funding partners and because we had already received a response comparable with other recent surveys conducted in nearby states regarding wild hog damage. The University of Tennessee's Office Institutional Review Board (IRB Approval #UTK IRB-15-02450-XP) approved the final survey instrument and protocols.

The questions on the survey were organized into four sections - Section A: Knowledge and experience with wild hog damage, Section B: Opinions about wildlife and wild hogs, Section C: Efforts to control wild hogs, and Section D: Demographic information (Appendix 1). Section A requested landowners to provide information on when they first noticed signs of wild hogs on their property, whether the population had changed since then, and if the hogs had caused any damage to their land or property. Finally, they also responded to questions about whether they have taken action to reduce or prevent damage from wild hogs on their property, the nature of measures taken, and whether they were effective at mitigating damage. A five-point Likert scale was used to indicate the severity of damages (1-not a problem, 5-severe problem). A Likert scale is a widely used fixed choice response format in survey design, and is well known for measuring attitudes and other cognitive constructs (Vaske, 2008). Responses can also easily be entered and coded for data analysis. Other questions of a dichotomous nature (Yes or No) were also included throughout the survey where applicable (e.g. whether they have seen wild hogs or signs of them on their land).

Section B included questions regarding landowners' opinions about wild hogs. A five-point Likert scale was used to let respondents indicate their level of agreement with a given statement (1-strongly disagree, 5-strongly agree). Section C asked questions pertaining to wild control efforts in Tennessee in general as well as on landowners' own property. A five-point Likert scale was used to let respondents indicate the acceptability of control methods (1-completely unacceptable, 5-completely acceptable). In the demographics portion (Section D), respondents reported their age, sex, employment, farm operations, annual income, and whether they hunt for game in Tennessee or elsewhere.

Data processing & analysis

Responses for the 1,620 returned surveys were entered into an Excel spreadsheet, and analysis was conducted using IBM SPSS® 22 statistical software.

Examining the acceptability of wild hog management options

Principal Component Analysis

A Principal Component Analysis (PCA) with a varimax rotation was performed on the multi-item scale of wild hog management actions in order to identify any common themes in acceptability. A PCA is a widely used statistical tool in the social sciences that reduces a large set of variables into a smaller subset of underlying constructs while still retaining most of the variation in the dataset (Jolliffe, 2002). This is done by identifying new variables, the principal components, where variation in the data is maximized (Ringnér, 2008), and by essentially stripping away unnecessary data. In this way, two or more correlating items can then be expressed by a single factor.

The more the items are correlated, the higher their internal consistency will be. Tests of reliability examine the internal consistency among the variables and show whether the multiple items measure the same construct (Vaske, 2008). Cronbach's alpha was used to test the reliability of the three factors that emerged from performing the PCA on the wild hog management scale. An alpha coefficient ≥ 0.7 is generally the accepted internal consistency for variables to be considered reliable for measuring, although an alpha of 0.65 to 0.70 is often thought of as adequate in human dimensions research (Larson et al., 2016; Vaske, 2008). Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy was also used to confirm that the factor analysis was suitable to adequately summarize the information provided by the initial items.

A varimax rotation option was selected while running the PCA because it maximizes the variance of loadings on each factor, while simultaneously minimizing the variance around the new variable. It is a commonly used orthogonal rotation method, and

is recommended by Kim and Mueller (1978). Orthogonal methods assume that the factors in the analysis are uncorrelated. For this reason, Tabachnick & Fidell (2007) suggest initially running an oblique instead of an orthogonal rotation to look at the correlations before deciding which rotation method to use. Therefore, a preliminary PCA was run using a direct oblimin (oblique) rotation. Correlations exceeding 0.32 indicate that there is a 10% or more overlap in variance among the factors (Tabachnick & Fidell, 2007, p. 646). None of the correlations were above this threshold upon observing the factor correlation matrix. Therefore, the factors were assumed to be uncorrelated, and a varimax rotation was used for the primary PCA. Three factors emerged based on Kaiser Criteria, which suggests that components with eigenvalues greater than one indicate dimensions worthy of interpretation (Kaiser, 1960). Components with eigenvalues less than one contain less information than one of the original variables, and so are not worth retaining (Jolliffe, 2002).

Potential for Conflict Index

The acceptability of wild hog management actions was further examined using the second generation Potential for Conflict Index (PCI₂). The PCI was developed to aid understanding and apply human dimensions findings to managerial concerns (Harper et al., 2016; Vaske, 2008). It is particularly useful for the analysis of surveys that use response scales with an even number of options on either side of a neutral center point (e.g., -2, -1, 0, 1, 2, where -2 is completely unacceptable, 0 is neutral, and 2 is completely acceptable). Responses framed in this manner enable one to evaluate the consensus of a given management action. PCI values range from 0 to 1, and measure the distribution of response frequency on either side of the scale's center point. A PCI₂ value of 0 indicates the maximum consensus possible in management acceptability, whereas a 1 suggests the greatest potential for conflict (e.g., half of the respondents agree while the other half disagrees). Computation of the variables also provides basic summary statistics such as central tendency, dispersion, and shape, and results can be visually displayed as bubble graphs. The y axis of the graph is equal the neutral point on the response scale. Therefore, bubbles situated above the axis indicate an item's greater average

acceptability, while those below the axis show less. The center of the bubble is plotted on the y axis in accordance to the mean response of the measured variable. The size of the bubble shows the PCI value and statistically corresponds to the degree of dispersion. The larger (smaller) the bubble, the greater the potential for conflict (consensus) regarding a statement of interest (Crawford, Poudyal, & Maerz, 2015; Harper et al., 2016; Sharp et al., 2011; Vaske, 2008; Wald, Jacobson, & Levy, 2013).

Kruskal-Wallis Test

The Kruskal-Wallis test was used to identify differences in acceptability for the wild hog management actions. The Kruskal-Wallis test is a nonparametric test, and is used when the assumptions of Analysis of Variance (ANOVA) are not met, such as normally distributed groups and equal variance on the scores. They both assess for significant differences on a dependent variable by a grouping independent variable (with three or more groups), but the Kruskal-Wallis allows for an ordinal dependent variable. ANOVA tests for mean differences, while non-parametric tests hypothesize about the median. However, the median is not as sensitive to outliers. Therefore, like all non-parametric tests, the Kruskal-Wallis Test is not as powerful as the ANOVA. The null hypothesis is that the medians are identical, while the alternative is they are different. To perform the Kruskal-Wallis test, responses are ranked and summed for each group. One way ANOVA is then applied to the ranks rather than to the original observations. The Kruskal-Wallis test statistic is approximately a chi-square distribution. If the calculated value of the Kruskal-Wallis test is less than the critical chi-square value, then the null hypothesis cannot be rejected. If the calculated value of Kruskal-Wallis test is greater than the critical chi-square value, then the null hypothesis is rejected, and it can be said that at least two of the groups have different medians (Mehotcheva, 2008; Statistics Solutions, 2013). Since a significant interaction was revealed, a Mann-Whitney test for between-groups comparisons with Bonferroni correction was conducted to pinpoint which items were statistically significant from each other.

Factors influencing support for state regulations to control wild hogs

To understand factors associated with private landowners' support for tighter regulations to control wild hogs, a multivariate ordered logistic regression model was used. Ordered regression is a statistical technique that uses one or more independent variables to predict the behavior of an ordinal dependent variable. The dependent variable (measured on a 5-point Likert scale) is the ordered response category variable, and the independent variables may be categorical, ordinal, or continuous. For categorical independent variables, the odds that one group has a higher or lower value on the dependent variable are compared to the second group. For continuous independent variables (e.g., age), a single unit increase or decrease in that variable (e.g., a one year increase or decrease in age), is associated with the odds of the dependent variable having a higher or lower value. How well the overall ordinal regression model predicts the dependent variable can also be determined, and presented with an X^2 (Chi-square) coefficient. The McFadden pseudo R^2 was used to assess the variability accounted for on the dependent variable by the independent predictor variable, while individual predictors were assessed by the ordered log-odds (logit) regression coefficients.

In the ordered logistic regression model, also known as proportional odds model, there is an observed ordinal variable Y , which is a function of another unmeasured continuous latent variable Y^* . The value of Y^* , based on various cut-off points, determine what the observed ordinal variable means. For example, if the responses are measured on the five-point Likert scale, then,

$$Y_i = 1 \text{ if } Y^*_i \leq \kappa_1$$

$$Y_i = 2 \text{ if } \kappa_1 \leq Y^*_i \leq \kappa_2$$

$$Y_i = 3 \text{ if } \kappa_2 \leq Y^*_i \leq \kappa_3$$

$$Y_i = 4 \text{ if } \kappa_3 \leq Y^*_i \leq \kappa_4$$

$$Y_i = 5 \text{ if } Y^*_i \geq \kappa_4$$

where κ_1 , κ_2 , κ_3 , and κ_4 are cut-off points.

Logistic regressions, by design, overcome many of the restrictive assumptions of linear regressions. For example, linearity, normality and equal variances are not

assumed, nor is it assumed that the error term variance is normally distributed. The assumptions of ordinal regression include that only one dependent variable can be used, and it is measured at the ordinal level (e.g., a 5-point Likert scale). There is also one regression equation for each category of the ordinal dependent variable except the last (i.e. reference) category, and adequate cell count (80% of cells must have more than 5 counts, and no cell should have zero count) (Statistics Solutions, 2013).

Dependent variable

Since the objective of regression modeling was to assess what factors influence landowners' support for regulations controlling wild hogs in Tennessee, the survey asked respondents to indicate their level of agreement (1-strongly disagree, 5-strongly agree) with the statement, "I support tighter regulations to control wild hogs in Tennessee." This ordinal response variable was the dependent variable in the ordered logistic regression model. It was hypothesized to be a function of independent variables as shown below:

$$\text{Support for wild hog control regulations} = f(\text{awareness of consequences, social norms, personal norms, demographics, familiarity with wild hogs})$$

Independent variables

As previously discussed, human dimensions literature suggests that cognitive variables (e.g. norms, awareness of consequences) and demographic variables are related to an individual's support for wildlife management. Several cognitive concepts were included as items in Section B of the questionnaire that assessed opinions toward wild hogs, and were also included as independent variables in the logistic model.

1. Cognitive variables:

The cognitive variables included in the regression model were awareness of consequences, personal norms, and social norms.

I. AWARENESS OF CONSEQUENCES:

Awareness of consequences (AC) is one of the activators in Schwartz's norm activation theory (1977), and can be thought of as an individual's recognition of the

negative effects that their behavior or lack thereof may cause. AC is represented in the model with the statements, “Wild hogs are a nuisance,” “The spread of wild hogs will damage the natural environment,” and “Crops and livestock damage from wild hogs will harm the rural economy.” Responses in each statements ranged from one (strongly disagree) to five (strongly agree). Each item was entered into the model as separate variables, NUISANCE, SPREAD, ECON_DAMAGE.

Landowners who are more aware of the consequences that result from a presence of wild hogs were hypothesized to be more supportive of wild hog regulations.

Therefore, a positive relationship was predicted for each of the variables.

II. SOCIAL NORMS:

Norms can help collectively explain people’s behavior (Vaske, 2008). Social norms refer to standards widely held by members of the same social group, and were explored with the statement, “My neighbors would like me to support wild hog eradication programs.” Responses ranged from one (Strongly disagree) to five (Strongly agree), and were represented with the variable NEIGHBORS. A positive relationship was expected with support for wild hog regulations.

III. PERSONAL NORMS:

Schwartz (1977) described the personal norm as a feeling of moral obligation to behave a certain way. Personal norms were examined with the statement “I feel morally obligated to do my part to eradicate wild hogs.” Responses ranged from one (Strongly disagree) to five (Strongly agree), and it was represented by the variable OBLIGATED. A positive relationship was expected between those who exhibited a greater sense of obligation to eradicate wild hogs and their support for wild hog regulations.

IV. REG_ADEQUACY

Respondents were asked to indicate their level of agreement with the statement, “The laws to control wild hogs on private land in Tennessee are adequate.”

Responses ranged from one (Strongly disagree) to five (Strongly agree), and were

part of the same section as the other cognitive variables that assessed opinions toward wild hogs. This item was represented with the variable REG_ADEQUACY, and a negative relationship was expected between it and support for wild hog control. If landowners already believe wild hog regulations are adequate, they may be unlikely to support additional ones.

2. Demographic variables

I. AGE

Landowners' age ranged from 19-105 with an average of 64.33 years. Studies have shown age to be a factor of support for the eradication of non-native species. Some suggest that middle-aged people are more supportive of eradication programs, while others show younger people have a higher awareness of invasive species concerns and are more willing to pay for eradication (Bremner & Park, 2007; García-Llorente et al., 2008). Due to these mixed results, the model outcome was uncertain.

II. GENDER

A dummy was created as GENDER = 1 if respondents indicated being a female, and 0 otherwise. The role of gender is often examined in wildlife research, and many studies have revealed strong differences between male and female respondents' support for lethal control and/or hunting (Jackman & Rutberg, 2015; Kellert & Berry, 1987; Lauber et al., 2001). Bremner and Park (2007) also found that gender influenced attitudes toward conservation management, with men showing a higher level of support for control or eradication programs. Therefore, a positive relationship was hypothesized.

III. INCOME

Considering the sensitive nature of personal information, landowners' annual household income was measured in categorical terms, which ranged from one (less than \$25,000) to eleven (more than \$250,000) in increments of \$25,000. Although there are few, if any, studies where income has played a significant factor in the

support for eradication of a non-native species, it was included in the model in case there was an effect on the support for regulations to control wild hogs.

IV. FULLTIMEFARMER

Respondents were asked to indicate a farming occupation that best describes them. A dummy was created as FULLTIMEFARMER = 1 if they indicated being a full-time farmer/rancher and landowner, and 0 otherwise. Those who returned the survey but did not respond to this question were also assumed to be 0. It was hypothesized that full-time farmers and landowners would be more likely to have first-hand knowledge of wild hogs, as well as be more likely to have noticed if their land or property had been damaged by them. Therefore, a positive relation between these full-time farmers/landowners and support for wild hog regulations was expected.

V. GOVTAKEOVER

Respondents were asked if they would consider allowing government officials on their property to control wild hogs if they experienced, or continued to experience, damage from them. As a follow-up question, those who indicated “no” were asked to choose a reason that best described why from a set of six options: I am concerned for my privacy, I am concerned for the safety of my family and neighbors, I am concerned about liability due to possibly injury to officials, I am concerned about possible government takeover of my property, My neighbors do not allow this, and Other (please specify). A dummy was created as GOVTAKEOVER = 1 if they indicated concern about government takeover of their property, and 0 otherwise. Those who returned the survey but did not respond to this question were also assumed to be 0. Respondents who expressed concern about government takeover may be less likely to support wild hog regulations due to skepticism of any regulations that may include land use or property rights restrictions. Thus, a negative relationship was expected.

VI. DEER_HUNTER

Respondents were asked to indicate the game species, if any, they hunt from a list of nine options (check all that apply): Bear, Deer, Ducks, Elk, Geese, Turkey, Rabbit, Squirrel, Wild Hogs. A dummy was created as DEER_HUNTER = 1 if they indicated “yes” to hunting deer, and 0 otherwise. Those who returned the survey but did not respond to this question were also assumed to be 0. Deer hunters may like the opportunity to take a wild hog if they were to come across one while hunting deer. Therefore, they were expected to have negative support for regulations to control wild hogs.

VII. DOMESTIC_PIGS

Respondents were asked to indicate which of the following, if any, were major operations on their farm (check all that apply): Row crops, Fruits or vegetables, Timber, Cattle and calves (beef), Dairy cows, Domestic pigs, Sheep/goats, Poultry, Tree nursery, Orchards, Aquaculture, Other (please specify). A dummy was created as DOMESTIC_PIGS = 1 if they indicated “yes” to domestic pigs, and 0 otherwise. Those who returned the survey but did not respond to this question were also assumed to be 0. Landowners who raise domestic pigs may support wild hog regulations due to interbreeding and other concerns. Thus, a positive relationship was expected.

3. Landowner familiarity with wild hogs

I. SEEN_WILDHOG

Respondents were asked to indicate whether they have seen wild hogs, or signs of them, on their land. A dummy was created as SEENWILDHOGS = 1 if they indicated yes, and 0 otherwise. Those who returned the survey but did not respond to this question, or who indicated that they were unsure, were also assumed to be 0. Respondents who have seen wild hogs on their property may be more likely to have experienced damage and to view them as negative. Therefore, a positive relation between those who have seen them on their land and their support for tighter wild hog regulations was expected.

II. HOG_HUNTER

Using the same hunting question as described above for HOG_HUNTER, a dummy was created as HOG_HUNTER = 1 if respondents indicated “yes” to hunting wild hogs, and 0 otherwise. Those who returned the survey but did not respond to this question were also assumed to be 0. Those who hunt wild hogs may enjoy having them on their land or in surrounding areas for recreational purposes. Therefore, a negative relation between those who hunt wild hogs and their support for tighter regulations to control them was expected. Table 3.1 shows the summary of variables included.

Table 3.1 *Summary of independent variables included in ordered logistic regression model*

Variables	<i>n</i>	Description	<i>M(SD)</i>
<i>Cognitive variables</i>		Agreement with the statement (1-strongly disagree to 5-strongly agree)	
NUISANCE	1534	Wild hogs are a nuisance	4.56 (.88)
SPREAD	1520	The spread of wild hogs will damage the natural environment	4.56 (.86)
ECON_DAMAGE	1528	Crops & livestock damage from wild hogs will harm the rural economy	4.55 (.88)
NEIGHBORS	1472	My neighbors want me to support wild hog eradication	3.68 (1.08)
OBLIGATED	1507	I feel morally obligated to eradicate wild hogs	3.84 (1.16)
REG_ADEQUACY	1424	Laws to control wild hogs on private land in TN are adequate	2.94 (1.12)
<i>Demographic variables</i>			
AGE	1518	Age	19 - 105 64.33 (12.85)
GENDER	1531	Gender	0 – male 1 – female 0.23 (.42)
INCOME	1291	Income	1 (< \$25,000) – 11 (\$250,000 +) 3.53 (2.33)
FULLTIME FARMER	1620	Full-time farmer, Landowner	1 if full-time farmer, 0 otherwise 0.24 (.43)
GOVTAKEOVER	1620	Concerned about gov't takeover	1 if concerned, 0 otherwise 0.22 (.42)
DEER_HUNTER	1620	Hunts deer	1 if hunts deer, 0 otherwise 0.30 (.46)
DOMESTIC_PIGS	1620	Has pigs as a major farm operation	1 if has pigs, 0 otherwise 0.01 (.12)
<i>Landowner familiarity with wild hogs</i>			
SEEN_WILDHOG	1620	Has seen wild hogs on property	1 if seen, 0 otherwise .12 (.33)
HOG_HUNTER	1622	Hunts wild hogs	1 if hunts hogs, 0 otherwise .06 (.24)

CHAPTER FOUR

RESULTS AND DISCUSSION

Survey response

Out of 5,000 questionnaire packets sent to landowners, 17 came back as undeliverable, and eight were returned because the person was deceased or otherwise unable to respond. As a result, the effective target sample was reduced to 4,975. A total of 1,620 surveys were returned for an adjusted response rate of 32.56%. This response rate is consistent with other recent surveys of landowners that have been implemented in the region regarding wild hog damage; 30.5% in Louisiana (Tanger et al., 2015), 37.7% in Georgia (Mengak, 2016), and 16% in Mississippi (Neal, Tegt, & Strickland, 2016). A non-response bias check was not conducted due to time and resource limitations. However, similarities in several key demographic characteristics were found between the sample and the general population of farmers in Tennessee. For example, according to the 2012 USDA Census of Agriculture, 71% of the farming operators in Tennessee were male, whereas 29% were female. In the study sample, 77% respondents were male and 23% were female. Similarly, 71% of both the study sample, as well as the general population of farming operators in Tennessee, were between the ages of 45 and 74.

Descriptive analysis

Analysis of the data began by visually examining most of the survey responses. Looking at frequency tables gave an idea of the response, counts, and percentages of each variable, while visually examining them using bar and pie charts gave an additional tool to check for outliers and errors. Any inconsistent numbers (eg., 6 entered for a 1-5 scale) were flagged to look up later for verification/correction. Descriptive statistics were also analyzed to give an idea of the central tendency, dispersion, and shape of the responses. This allowed for a quick determination of the range and average age, gender, and annual income of the respondents. While there was quite a bit of missing data from incomplete survey responses, the questions pertaining to the research interests had high response

rates compared to some of the other sections, such as those regarding economic damage resulting from wild hogs.

Sample characteristics

Table 4.1 summarizes demographic characteristics of the sample. The age of respondents ranged from 19 to 105, with the majority of them (83%) between 45 and 80 years of age. The average age was 64 years old. This is consistent with Georgia's recent survey of landowners, where the average age was also 64 (Mengak, 2016). Out of 1,531 that indicated their gender, 77% respondents were male and 23% were female. Similarly, Tanger, Vlosky, & Kaller (2016) reported that their sample of Louisiana commodity farmers was 79% male and 21% female. Of the 1,291 who answered the question pertaining to income, 75% reported an annual household income less than \$100,000 before taxes. Just over 1500 participants responded to whether or not they hunt, and 37% identified themselves as hunters. Most (84%) of those who self-identified as a hunter indicated they hunt for deer, followed by squirrel (63%), turkey (60%), and rabbit (47%). About 17% hunt wild hogs, but it was unclear whether they were counting the occasional shooting on their property to control wild hogs.

When asked about major operations at their farm, about half of the respondents raised cattle and calf (i.e. beef), whereas row crops and timber production each made up about one-third. About 10% of respondents reported poultry, fruits and vegetables, hay, and others as major farming operations. Horses, honeybees, hunting, and turf grass were frequently mentioned in the "others" category.

Knowledge of and attitudes towards wild hogs

When asked if they have seen wild hogs or signs of them on their land, 200 (13%) out of 1,581 confirmed the presence of wild hogs, whereas another 2% were unsure. Therefore, about 4% of the original target sample (4,975) confirmed the presence of wild hogs, which is similar to a recent survey in Mississippi where 6.5% of the statewide sample saw wild hogs or damage inflicted by them (Neal, Tegt, & Strickland, 2016). Most those reporting wild hogs on their land first saw wild hogs after 2001. Very few

Table 4.1 *Demographic characteristics of respondents*

Demographics	Descriptive Statistics		
	<i>n</i>	<i>M</i> (SD)	% of Respondents
Average Age (years)	1518	64.33 (12.85)	
< 45 years	118		8
45 – 60	412		27
61 – 70	493		32
71 – 80	362		24
> 80 years	133		9
Gender (female)	358		23
Annual Household Income			
< \$50,000	519		40
\$50,000 to \$99,999	455		35
\$100,000 to \$149,999	190		15
\$150,000 to \$199,999	57		4
\$200,000 to \$249,999	13		2
\$250,000 +	47		4
Hunts game in TN	594		37

Individuals noticed wild hogs on their Tennessee property before 1980. When asked how the wild hog population in their area has changed since they first noticed them, nearly half (44%) indicated it has increased, while the other 17% indicated no change. About one-fifth (21%) indicated the wild hog population in their area declined. The remaining 18% did not know about the wild hog population trend in their area.

Landowners indicated a number of reasons behind the presence of wild hogs in their area. As shown in Figure 4.1, “Illegal release/transfer” was indicated by slightly more than half (54%) of the 196 respondents who answered the question. The other commonly mentioned reasons included “Lack of hunting pressure” (42%), “Natural causes” (30%), “state prohibits transport of wild hogs” (27%), and “Hunting clubs are releasing them” (23%). Reasons related to regulations such as “inadequate stock laws” and “state regulations prohibiting transport of wild hogs” were mentioned relatively less frequently (<4%). However, reasons related to land management practices including “more absentee landowners” and “neighbor’s agricultural practices” were perceived as possible causes of wild hog presence on their property. The top three perceived reasons for the presence of wild hogs were the same top three reported by Tanger, Vlosky, &

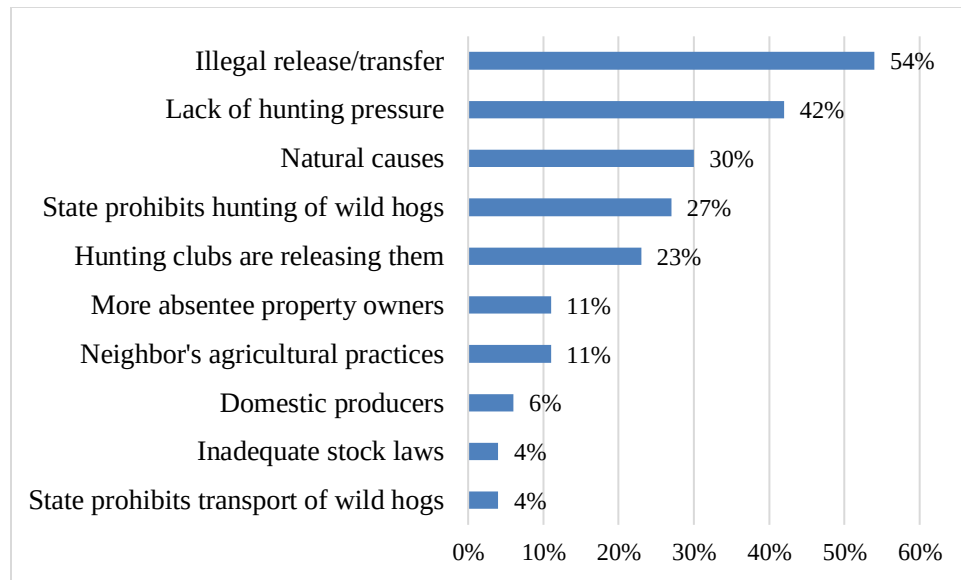


Figure 4.1 Respondents' perceived reason for wild hogs being present in their area (n = 196)

Kaller (2016) for their survey of Louisiana commodity farmers – “Illegal release/transfer,” “Lacking of hunting pressure,” and ‘Natural Causes.” However, the order differed by percent agreement. For example, 45% of their respondents believed that natural causes were the top reason for increasing wild hog populations, whereas 54% in our sample reported illegal release/transfer as the top perceived reason.

As expected, respondents in general seemed to have an unfavorable view of wild hogs. For example, when asked to indicate their level of agreement (1-strongly disagree, 5-strongly agree), as many as 89% of respondents agreed on some level with the statement “Wild hogs are a nuisance” (Table 4.2). A similar proportion (90%) strongly or somewhat agreed with “The spread of wild hogs will damage the natural environment” and “Crop and livestock damage from wild hogs will harm the rural economy.” On the other hand, 58% somewhat or strongly disagreed with “Problems related to wild hogs are exaggerated.” About half (49%) of the respondents neither agreed nor disagreed about the adequacy of laws to control wild hogs in Tennessee.

When asked about whether and how wild hogs should be managed in Tennessee, 72% somewhat or strongly agreed with the statement that wild hogs should be completely eradicated wherever possible. In a related question, 85% somewhat or strongly agreed

Table 4.2 *Respondents' opinions about wild hog management and support for regulations in Tennessee*

Statement	<i>n</i>	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Wild hogs are a nuisance	1534	2.5%	1.2%	7.6%	14.9%	73.7%
The spread of wild hogs will damage the natural environment	1520	2.4%	1.3%	6.4%	18.4%	71.6%
Crops & livestock damage from wild hogs will harm the rural economy	1528	2.4%	1.7%	6.3%	18.1%	71.5%
Problems related to wild hogs are exaggerated	1510	41.8%	16.4%	21.5%	12.3%	8.1%
Wild hogs should be eradicated wherever possible	1530	6.6%	7.9%	13.6%	18.2%	53.7%
Laws to control wild hogs on private land in TN are adequate	1424	14.9%	11.2%	48.7%	15.4%	9.8%
Wild hogs should be managed to the level they do not damage property/environment	1523	6.7%	2.4%	5.6%	19%	66.3%
Wild hog eradication should be funded through increased hunting license fees	1523	27.5%	12%	32.4%	13.4%	14.7%
I feel morally obligated to eradicate wild hogs	1507	6%	4.7%	26.5%	24.6%	38.3%
My neighbors would like me to support wild hog eradication	1472	4.3%	2.6%	46.1%	14.3%	32.5%
I support tighter regulations to control wild hogs in TN	1523	6%	3%	22%	20%	49%

wild hogs should be managed to the level they do not damage property or the environment. The difference between these two figures suggests a segment of the respondents would be satisfied if wild hogs are managed to a “no-harm” level. Just less than one-third (28%) somewhat or strongly agreed with the idea of funding wild hog eradication programs through increased hunting license fees. The majority of the respondents (63%) somewhat or strongly agreed they feel morally obligated to do their part to eradicate wild hogs. This suggests a high level of personal norm among respondents in combating wild hog problems. Nearly half (47%) agreed their neighbors want them to support wild hog eradication programs, indicating the landowner may have social support and acceptance from their neighbors should they choose to control wild hogs.

Finally, an overwhelming majority (69%) somewhat or strongly agreed they support tighter regulations to control wild hogs in the state. These results are again consistent with recent landowner surveys completed in both Illinois and Georgia. For example, Mengak (2016) also found respondents overwhelmingly agreed with negative statements about wild hogs, with 75.2% agreeing on some level they were a nuisance (compared to 74% strongly agreeing in our sample). Similarly, Miller (2012) reported 78.6% of respondents in Illinois agreed on some level that wild hogs should be eliminated whenever possible (compared to our 72%).

Landowners' efforts to control wild hogs on private land

Landowners who reported to have wild hogs present on their land were asked about their actions to reduce or prevent damage. Of 151 who responded to this question, 72% have taken some action. In terms of the type of action taken, the highest number of people (97) reported shoot on sight. The other frequently mentioned actions were trapping (58), hunting without dogs (40), and baiting and shooting (32). Relatively less frequently mentioned actions included hunting with dogs (26), electric fencing (19), harassments (17), aerial hunting by government agencies (14), non-electric fencing (14), and repellents (10).

When asked about their perception of the effectiveness of the actions taken to control wild hogs, respondents revealed some differences. As shown in Figure 4.2, an overwhelming majority of those who acted indicated that it was effective. Actions considered somewhat or very effective by over two-thirds (of those responding to the respective question) were shoot on sight, hunting with or without dogs, trapping, and baiting and shooting. While hunting with dogs was perceived to be effective by the majority, only 25 people reported they have taken such action. On the other hand, actions reported to be ineffective by most respondents were harassment (with dogs, donkeys, lights), aerial hunting, and non-electric fencing. There is probably a need for analyzing the landowners' perception of the effectiveness of various methods relative to the science-based appropriateness of methods in controlling populations, and designing effective outreach and education programs.

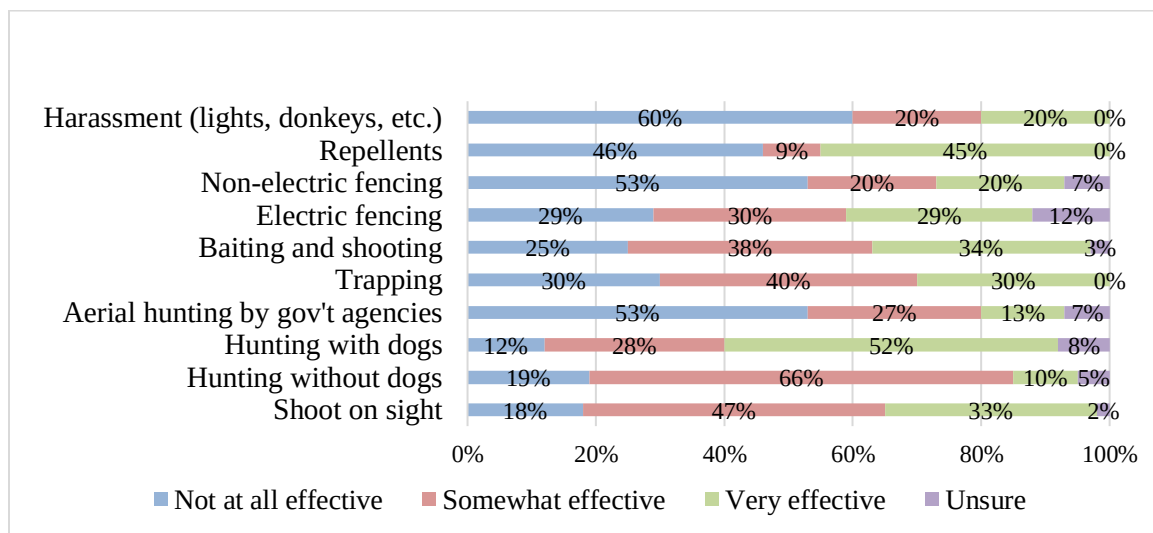


Figure 4.2 Percentage of respondents with perceived effectiveness of various methods to control wild hogs

Support for wild hog control options and regulations

Since wild hogs are present on private as well as public lands, any sort of statewide effort by agencies to eradicate wild hogs will require cooperation from

landowners. When asked whether they would consider allowing government officials on their property to control wild hogs (in case they were to experience damage in the future or the level of damage continues to grow), about half (49%) indicated “Yes.” Only one-fifth (21%) were against the idea, while one-third (31%) were not sure. Of those who were unsure or against the idea of allowing government officials on their property, slightly less than half (45%) cited concern for privacy, and possible government takeover of property as reason for their response. Concern for the safety of family, neighbors, and liability due to possible injury to officials were two other reasons, each cited by about one third (33%). Very few (4%) indicated their neighbors do not allow such actions.

When asked about their acceptability of different approaches to deal with wild hog populations, the majority of landowners supported most control methods (Figure 4.3). Management approaches with the majority of respondents showing somewhat or complete acceptance were providing technical assistance to landowners/farmers (85%), capturing and killing (80%), educating people on how to prevent damage (78%), targeted sharpshooting on the ground over bait sites (71%), offering financial reward to landowners for killing wild hogs (68%), and helping landowners with subsidy for damage insurance (63%). Approaches considered somewhat or strongly unacceptable by the majority included leaving the wild hogs alone (82%) and capturing and relocating (57%). About half (50%) thought allowing the sale of wild hogs was somewhat or completely unacceptable.

As Figure 4.3 shows, the mean level of acceptability (in a scale of 1-completely unacceptable to 5-completely acceptable) was the lowest (1.63) for leaving the wild hogs alone (i.e., doing nothing), and highest (4.41) for providing technical assistance to landowners/farmers. Overall, the figure indicates respondents’ mean level of acceptability was higher for management approaches emphasizing technical and educational assistance, financial incentives, and subsidy to landowners in controlling the population or dealing with the damage, rather than approaches such as aerial control, allowing the sale of wild hogs, relocating them, or doing nothing.

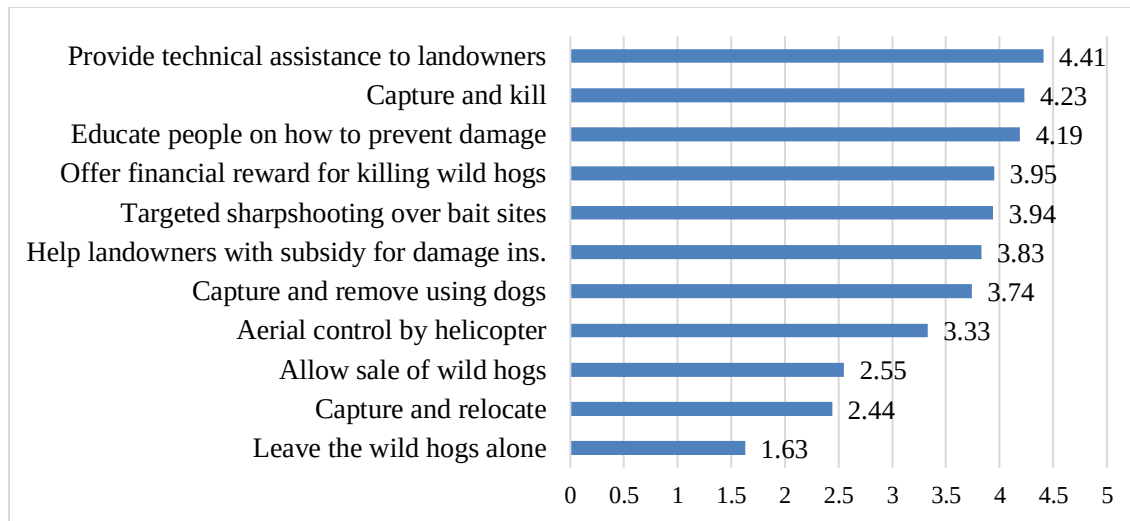


Figure 4.3 Mean relative acceptability of various management actions to control wild hogs ($n = 1,422$); statistically significant at $H(10) = 4552.18$, $p < .01$

Principal component analysis

As discussed in the methods section, a PCA was performed on the scale of wild hog management actions in order to identify any common underlying themes in acceptability (see Table 4.3). Four statements representing more aggressive management actions, such as targeted sharpshooting and aerial control by helicopter, loaded in the first component, which was therefore called “Lethal.” Similarly, four statements representing more passive management actions, such as providing technical assistance and educating people on preventing damage, loaded in the second component, and was named “Education-based.” Finally, a third factor emerged containing three items of less aggressive, non-lethal wild hog management actions including “Leave the wild hogs alone” and “Capture and relocate.” However, it had a low Cronbach’s Alpha of only 0.488, so caution should be used in interpreting this factor if it were to be used in any further analysis. The lethal factor had an acceptable alpha of 0.767, while the education-based factor had an adequate alpha of 0.676.

Factor loadings are the correlation coefficients, and range from -1 to 1. The closer the loading is to -1 or 1, the more strongly the factor affects the variable. Stevens (1992) suggested using a factor loading cut-off of 0.4. All three factors included loadings

Table 4.3 *Factors derived from the acceptability of wild hog control options*

Factors	Management Action	<i>M</i>	Factor Loadings	Eigenvalues	Cronbach's Alpha
Lethal				3.46	0.767
	Targeted sharpshooting on the ground over bait sites	3.99	0.798		
	Capture & kill	4.25	0.787		
	Capture & remove using dogs	3.75	0.773		
	Aerial control by helicopter	3.35	0.620		
Education-based				1.75	0.676
	Provide technical assistance to landowners/farmers	4.39	0.805		
	Educate people on how to prevent damage	4.20	0.726		
	Help landowners or farmers with subsidy for damage insurance	3.84	0.689		
	Offer financial reward for killing	3.97	0.558		
Non-lethal				1.12	0.488
	Capture & relocate	2.39	0.762		
	Allow sale of wild hogs	2.56	0.750		
	Leave the wild hogs alone	1.62	0.454		

Analysis n = 1,272

of 0.454 or higher, and had eigenvalues greater than 1. Over half of the items loaded at 0.726 or above, but ranged from 0.805 (Provide technical assistance) to 0.454 (Leave the wild hogs alone). The eigenvalues showed most of the variance was explained by the Lethal component (31.49%), but the three factors together explained 58% of the variance in the data. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.785, above the recommended value of 0.6, and Bartlett's Test of Sphericity was significant at $X^2(55) = 3590.89$, $p < .001$. Overall, these analyses indicated three distinct factors underlying landowner acceptability of wild hog management actions, particularly when comparing the Lethal and Education-based factors. The items loading together to make up the Non-lethal factor had the least amount of respondent acceptability, possibly because they had the potential to simply shift the wild hog problem elsewhere. "Leave the wild hogs alone" received the least support, explaining why it loaded poorly compared to the other items. Despite that the education-based items could also be considered "non-lethal," there was an obvious theme of support underlying them, which can be seen in the action verbs within the statements such as "Educate," "Provide," and "Help." This level of landowner outreach was not found in the non-lethal factor.

Potential for Conflict

Landowner acceptability of the wild hog management actions was further examined using the Potential for Conflict Index (PCI₂) to evaluate the consensus of each item and to determine whether groups would emerge similar to those that resulted from the PCA analysis. Figure 4.4 illustrates the mean response differences in the acceptability of the wild hog management options. Bubbles are centered on the mean response, while the potential for conflict index is indicated by the size of the labeled bubbles and ranges from 0 (minimum conflict) to 1 (maximum conflict). Potential for conflict index values show a do-nothing approach to wild hog management to be the least acceptable option with higher consensus. Aerial control by helicopter is relatively acceptable but more controversial. Capture and relocate and allowing the sale of wild hogs are also unacceptable. Providing technical assistance, educating people on

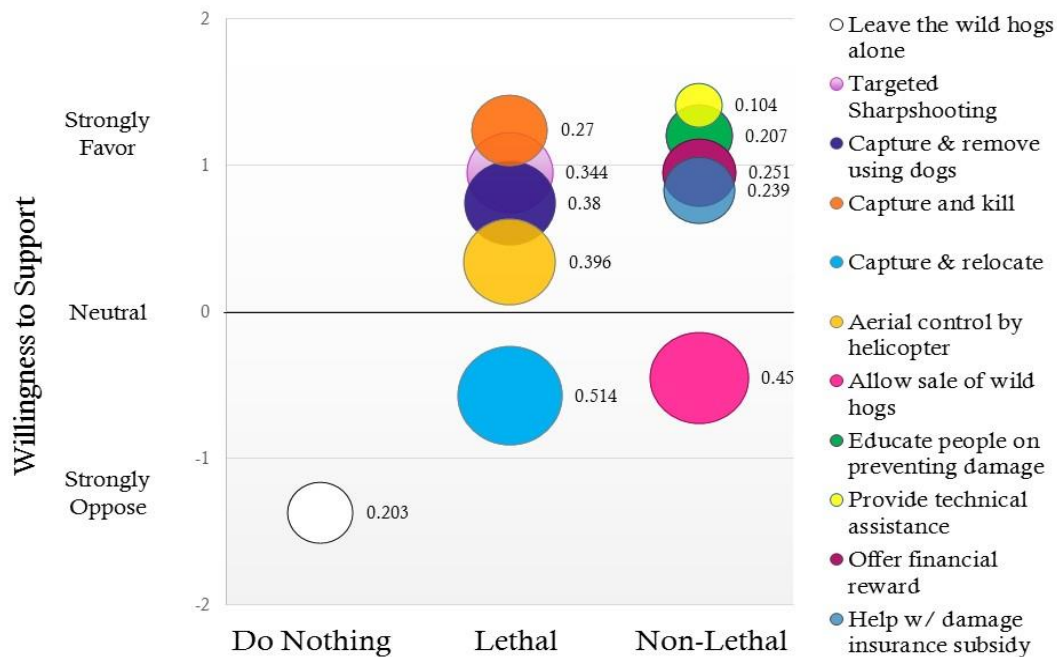


Figure 4.4 Mean response differences in acceptability of wild hog management actions

preventing damage, offering financial reward, and helping landowners with damage insurance subsidies all received the highest support with the least conflict (higher consensus), are grouped together in the top right of Figure 4.4, and were also all included in the education-based factor that was identified from the PCA analysis. The items from the lethal factor, such as targeted sharpshooting and capture and remove using dogs, have a similar level of support as the education-based items, but the potential for conflict is higher. For example, targeted sharpshooting and offering financial reward are situated in similar positions horizontally on the graph because they have close to the same mean acceptability. However, the PCI₂ value for targeted sharpshooting is 0.344 compared to offering financial reward's PCI₂ value of 0.251, indicating targeted sharpshooting is potentially a more controversial management option.

Kruskal-Wallis Test

A Kruskal-Wallis test was employed to further compare the acceptability of the wild hog management options. While the means and PCI₂ values demonstrated a

difference among the items, results from the Kruskal-Wallis confirmed this difference is statistically significant [$H(10) = 4552.18, p < .01$]. Therefore, the null hypothesis “there is no difference among the groups” was rejected. Post hoc comparisons using the Mann-Whitney test with Bonferroni correction were used to determine which specific items differed. Most of the items were statistically significant from each other. “Leave the wild hogs alone” was the one do-nothing approach on the scale, and was statistically significantly different from every other management option presented in Figure 4.3 ($p < .01$). Two other options significant from each of the others at $p < .01$ was “Aerial control by helicopter” and “Provide technical assistance to landowners/farmers.” The other eight management actions were not significantly different from at least one, and at most three, other items. For example, “Targeted sharpshooting on the ground over bait sites” was not statistically different from “Offer financial reward to landowners for killing wild hogs,” while “Capture and remove using dogs” was not different from “Help landowners or farmers with subsidy for damage insurance,” as far as median level of acceptability.

Factors influencing support for state regulations to control wild hogs

Results from a multivariate ordered logistic regression model used to explain factors associated with private landowners’ support for regulations to control wild hogs are presented in Table 4.4. The chi-square test on the log-likelihood ratio was significant at $X^2(df = 15) = 618.49, p < 0.01$, indicating the model was an overall good fit for the data and supported a relationship between the outcome and predictor variables. Twelve of 15 variables used in the model were significant predictors influencing support for wild hog regulations (McFadden pseudo $R^2 = 0.214$). GENDER, INCOME, and SEEN_WILDHOG were the only variables not significant in the model.

As expected, the coefficients for the variables representing *awareness of consequences* (NUISANCE, SPREAD, & ECON_DAMAGE) appeared positive and significant ($p < 0.05$), suggesting landowner support for wild hog regulations increases with their awareness of the harm that can result from the spread of wild hogs. In addition, the variables representing personal and social norms (NEIGHBORS &

Table 4.4 Results from ordered logistic regression explaining factors influencing landowner support for state regulations to control wild hogs

Dependent Variable: Support for state regulations to control wild hogs in TN			
Variables	Description	Coefficient	Std. Error
NUISANCE	Wild hogs are a nuisance	0.287**	0.130
SPREAD	The spread of wild hogs will damage the natural environment	0.346**	0.142
ECON_DAMAGE	Damage from wild hogs will harm the rural economy	0.245**	0.125
NEIGHBORS	My neighbors would like me to support wild hog eradication	0.690***	0.075
OBLIGATED	I feel morally obligated to eradicate wild hogs	0.431***	0.069
REG_ADEQUACY	Laws to control wild hogs on private land in TN are adequate	-0.192***	0.060
AGE	Age	0.013***	0.005
GENDER	Gender	0.133	0.155
INCOME	Income	-0.028	0.029
FULLTIMEFARMER	Full-time farmer, Landowner	0.298*	0.158
GOVTAKEOVER	Concerned about gov't takeover on land	-0.516***	0.148
DEER_HUNTER	Hunts deer	-0.313**	0.144
DOMESTIC_PIGS	Has pigs as a major farm operation	1.28**	0.612
SEEN_WILDHOG	Has seen wild hogs on property	0.026	0.203
HOG_HUNTER	Hunts wild hogs	-0.486*	0.272
Chi-Square		618.49***	
McFadden pseudo R ²		0.214	
n		1,131	

*** $p \leq 0.01$, ** $p \leq 0.05$, * $p \leq 0.10$

OBLIGATED) were also positive and significant ($p < 0.01$), which may indicate feelings of personal moral obligation to eradicate wild hogs, as well as community support, strongly foster support for wild hog regulations. These results are consistent with previous studies, which found normative beliefs largely influence public support for wildlife management actions (Jonker, Organ, Muth, Zwick, & Siemer, 2009; Zinn, Manfredo, Vaske, & Wittmann, 1998). Although REG_ADEQUACY was part of the same scale as the above variables assessing opinions towards wild hogs, this item cast a more positive light on the current wild hog situation in Tennessee (“The laws to control wild hogs on private land in Tennessee are adequate”). As predicted, its relationship was negative, confirming landowners are less likely to support regulations to control wild hogs if they believe the laws are already adequate.

Common demographic factors included in the model were age, gender, and income. However, age was the only significant variable ($p < 0.05$) positively related with support for regulation. Several studies have revealed strong differences between male and female respondents when it comes to support for lethal control and/or hunting (Jackman & Rutberg, 2015; Kellert & Berry, 1987; Lauber et al., 2001). However, Jackson & Rutberg (2015) also point out a lack of agreement exists on the amount of influence gender has on attitudes toward wildlife despite its importance as a demographic variable. This is due to an often disproportionate number of females in studies involving hunting and agricultural stakeholders. They claim it is common to have survey samples with 70% or more male respondents, and cite several examples (Jackman & Rutberg, 2015). In the general population there may be an equal proportion of males and females, but not necessarily in a list of property owners or heads of household contacted for survey purposes. In our study, 77% of respondents were male and 23% female. In studies citing significant differences (Jackman & Rutberg, 2015; Kellert & Berry, 1987; Lauber et al., 2001), the male to female ratio was more equal (e.g., 57% female vs. 43% male in Jackson & Rutberg’s study and 52.4% female vs. 52.4% male in Kellert & Berry’s).

The predicted outcome for income was uncertain due to lack of significance in human dimensions literature. Perhaps if a higher percentage of household income was

derived from farming, it may have had a bigger influence on support for regulations to control wild hogs. Over half of the sample (69%) derived 0 – 25% of their income from farming, while only 12% derived 76 – 100%. Landowners perceived support for control almost equally regardless of their income. Results have been mixed in studies showing age as a significant factor of support for the eradication of non-native species (Bremner & Park, 2007; García-Llorente et al., 2008). Therefore, the outcome of this variable was uncertain, particularly with a rather older sample (83% between 45 and 80 years of age; $M = 64$). However, older landowners may have more experience and knowledge of wild hogs and the damage they inflict, which explains the relationship between age and support in the model.

As expected, the coefficient of the variable FULLTIMEFARMER appeared positive and significant ($p < 0.10$). This may indicate full-time farmers and landowners who spend more time more on their land are more likely to have first-hand knowledge of wild hogs, as well as be more likely to have noticed if their land or property has been damaged by them. GOVTAKEOVER was confirmed to have a significant negative relationship with support for regulations to control wild hogs. Conceptually, it makes sense that those who are concerned about possible government takeover of their property would be less likely to support state regulations to control wild hogs for fear of restrictions on their property rights. They may fear officials would have too prominent of a presence on their property, or they could believe landowners are responsible for what happens on their land without the help of outside agencies.

DEER_HUNTER was both negative and significant in the model ($p < 0.05$). Perhaps social norms contribute to hunters in general being less likely to support state regulations for wild hog control regardless of their preferred species to hunt.

DOMESTIC_PIGS was positive and significant in the model ($p < 0.05$), as expected. This may indicate landowners who raise domestic pigs as a major farm operation have concerns about their pigs interbreeding with wild hogs. Additionally, they may fear wild hogs could spread disease to their livestock. Regardless, having domestic pigs did have a significant influence on support for regulations to control wild hogs.

SEENWILDHOGS had a positive, but insignificant influence on the dependent variable. HOG_HUNTER was both negative and significant in the model ($p < 0.10$). This may indicate those who hunt hogs are less likely to support regulations to control their populations. Hog hunters have an incentive to keep wild hogs present, and may resist programs calling for their eradication.

CHAPTER FIVE

CONCLUSIONS AND IMPLICATIONS

The purpose of this study was to examine Tennessee landowners' attitudes towards wild hogs, compare the acceptability of alternative management approaches to control them, and evaluate the factors significantly influencing landowners' support for wild hog control regulations. The findings increase our understanding of the human dimensions of wild hog management and that of other similarly invasive animals, and may guide resource managers in designing effective and socially acceptable management strategies to control wild hog populations in Tennessee and elsewhere.

Results indicate Tennessee landowners have overwhelmingly negative attitudes towards wild hogs, and are concerned about their impact on the natural environment and rural economy. They agreed wild hogs should be completely eradicated wherever possible, or at least managed to the level they do not cause damage. While they indicated overall strong support for wild hog control in Tennessee, levels of acceptability vary across different management options, and three common themes in levels of support were observed. There was support for more aggressive management actions, such as targeted sharpshooting and capture and kill, as well as more education-based methods, such as providing technical support to landowners and educating people. However, the overall consensus was greater for the education-based options. Findings also showed a do-nothing approach to wild hog management was the least acceptable option with the highest consensus. Therefore, from a management standpoint, any other option would be preferable to simply leaving the wild hogs alone. Wildlife management agencies and institutional partnerships like WHEAT may benefit from these findings of high public interest to legislators when discussing the issue of wild hog control.

In addition to informing management, this study contributes to supporting and advancing literature in human dimensions of natural resources. Findings also suggest landowner support for regulations to control wild hogs could depend on social and personal norms, awareness of consequences, and other demographic characteristics. This finding further supports the existing notion in human dimensions literature that normative

influences can be important precursors to human behavior. Measuring norms is a valuable tool for wildlife managers, as they can help predict, and therefore affect, stakeholder responses to management decisions. Landowners are more likely to support regulations to control wild hogs if their neighbors or peers support them. Management implications are that a peer-to-peer type effort might be helpful in public awareness campaigns.

Results follow Schwartz's Norm Activation Theory, which suggests one's awareness of consequences is another important cognitive variable indirectly influencing behavior. Increasing public awareness of the potential consequences from having wild hogs in their area could be beneficial in garnering more support for regulations, particularly considering many people have not experienced damage on their property yet.

Other landowner characteristics, such as being a full-time landowner/farmer or raising domestic pigs can also increase the probability of support for wild hog regulations. This implies agencies could approach various landowner associations, such as the Tennessee Pork Producers' Association, to communicate about control programs. This could also be an outreach opportunity to inform the public on the increasing threat of wild hogs for those who feel regulations currently in place in Tennessee are already adequate.

Some landowners believe the prohibition of wild hog hunting is a possible reason behind wild hog spread, so it could be helpful to work with landowners on the relative effectiveness of hunting and other methods in controlling wild hog populations. While some may view hunting as a means to control wild hog numbers, the population growth occurring after the implementation of a statewide hog hunting season in Tennessee has shown otherwise. Respondents' support was found to be influenced by social norms, so peer education programs could be established to inform the public on the long-term feasibility and effectiveness of hunting in controlling wild hog population. Again, landowners are more likely to support regulations if their neighbors and peers do, and communication could help breach this gap between what managing agencies think is an effective means of wild hog control, and what the public thinks. States such as Texas have seen some outreach success through maintaining a strong online presence with

readily available wild hog fact sheets, publications, instructional videos, and social media pages dedicated to providing information on recognizing signs of wild hogs, setting traps, and trouble-shooting.

Other perceived reasons landowners gave as possible causes of wild hog presence on their property related to land management practices including “more absentee property landowners” and “neighbors’ agricultural practices.” Again, this creates an opportunity for agencies to reach out to absentee landowners and farmers and understand how their land management practices are contributing to wild hog growth. They are not a homogeneous group, so it may require additional research to determine what impacts their management decisions. However, with absentee landowners on the rise in the United States, it could be worthwhile to explore what influences their decision-making (e.g., recreation, income, conservation) and where they seek information in terms of land management (e.g., influential individuals, agricultural organizations, wildlife agencies). Filling this knowledge gap could make it easier to develop and tailor outreach to absentee landowners (Petrzelka & Armstrong, 2015). For example, regional offices could engage interest through direct targeting with phone calls. They could also send mail with informational pamphlets and invitations to outreach and agricultural extension events aimed at helping landowners with control techniques. However, this would require accurate landowner contact information, and providing this level of time and resources could be challenging.

Landowners may hesitate to support wild hog control due to concerns over government intervention on their property or property rights. However, effective implementation of wild hog management will depend on cooperation from thousands of landowners across the state. Our findings indicate public skepticism toward government involvement in controlling wild hogs on private land may hinder the progress. Communication could ease the fears of those concerned about government takeover of their property. A conflict may exist between those who would support receiving technical help (e.g., being shown how to correctly set up and manage a trapping mechanism), but who also have this fear of restricted property rights. More information can alleviate concerns of government involvement and help landowners feel more

included in the process. Considering wild hogs are invading landscapes across county and state boundaries, developing and maintaining trust will be key to collectively controlling wild hogs throughout the state.

Finally, a few caveats of this study should be noted. The sample did not include landowners with smaller tracts of land (below 5 acres). If those small-scale landowners also experience different levels of interaction with or damage from wild hogs, findings may look slightly different. Interaction and a greater familiarity with wild hogs could affect attitudes, which could influence support for regulations. Similarly, this survey focused on rural landowners, and was not distributed to urban populations, partly because wild hogs are predominantly in rural areas. However, urban and rural residents may vary in their demographics, experiences, and perceptions of wildlife and wildlife-related recreation. For example, urban residents may be less likely to support wild hog regulations if they are not familiar with their invasive status and the damage they inflict. However, they may show more support if they are better educated or less likely to enjoy their presence for recreational purposes (i.e., hunting). Including and comparing both types of residents could be a direction for future research.

While this study showed clear evidence of overwhelming public support for controlling wild hogs through various types of programs, funding statewide control programs will be expensive and will require a great deal of public funding. Future research could explore how much a publicly managed eradication program is worth to the public and how much landowners are willing to pay to fund such programs.

REFERENCES

- Akiba, H., Miller, C. A., & Matsuda, H. (2012). Factor influencing public preference for raccoon eradication plan in Kanagawa, Japan. *Human Dimensions of Wildlife*, 17(3), 207–219.
- Adams, C. E., Higginbotham, B. J., Rollins, D., Taylor, R. B., Skiles, R., Mapston, M., & Turnman, S. (2005). Regional perspectives and opportunities for feral hog management in Texas. *Wildlife Society Bulletin*, 33(4), 1312–1320.
- Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Bardsley, D., & Edwards-Jones, G. (2006). Stakeholders' perceptions of the impacts of invasive exotic plant species in the Mediterranean region. *GeoJournal*, 65(3), 199–210.
- Barrios-Garcia, M. N., & Ballari, S. A. (2012). Impact of wild boar (*Sus scrofa*) in its introduced and native range: a review. *Biological Invasions*, 14, 2283–2300.
- Bevins, S. N., Pedersen, K., Lutman, M. W., Gidlewski, T., & Deliberto, T. J. (2014). Consequences associated with the recent range expansion of nonnative feral swine. *BioScience*, 64(4), 291–299.
- Bratt, C. (1999). The impact of norms and assumed consequences on recycling behavior. *Environment and Behavior*, 31(5), 630–656.
- Bremner, A., & Park, K. (2007). Public attitudes to the management of invasive non-native species in Scotland. *Biological Conservation*, 139, 306–314.
- Campbell, T. A., & Long, D. B. (2009). Feral swine damage and damage management in forested ecosystems. *Forest Ecology and Management*, 257(12), 2319–2326.
- Centner, T. J., & Shuman, R. M. (2014). Governmental provisions to manage and eradicate feral swine in areas of the United States. *Ambio*, 44, 121–130.
- Clavijo, A., Nikooienejad, A., Esfahani, M. S., Metz, R. P., & Schwartz, S. (2013). Identification and Analysis of the First 2009 Pandemic H1N1 Influenza Virus from U. S. Feral Swine, 327–335.
- Crawford, B. a., Poudyal, N. C., & Maerz, J. C. (2015). When drivers and terrapins collide: Assessing stakeholder attitudes toward wildlife management on the Jekyll Island Causeway. *Human Dimensions of Wildlife*, 20(1), 1–14.

- Dandy, N., Ballantyne, S., Moseley, D., Gill, R., Peace, A., & Quine, C. (2011). Preferences for wildlife management methods among the peri-urban public in Scotland. *European Journal of Wildlife Research*, 57(6), 1213–1221.
- Dillman, D.A. 2006. *Mail and internet surveys: The tailored design method*, 2nd ed. John Wiley & Sons, Hoboken, NJ. p. 523.
- Dougherty, E. M., Fulton, D. C., & Anderson, D. H. (2003). The influence of gender on the relationship between wildlife value orientations, beliefs and the acceptability of lethal deer control in Cuyahoga Valley National Park. *Society and Natural Resources*, 16, 603–623.
- Estèvez, R. A., Anderson, C. B., Pizarro, J. C., & Burgman, M. A. (2014). Clarifying values, risk perceptions, and attitudes to resolve or avoid social conflicts in invasive species management. *Conservation Biology*, 29(1), 19–30.
- García-Llorente, M., Martín-López, B., González, J. A., Alcorlo, P., & Montes, C. (2008). Social perceptions of the impacts and benefits of invasive alien species: Implications for management. *Biological Conservation*, 141, 2969–2983.
- Gipson, P. S., Hlavachick, B., & Berger, T. (1998). Range Expansion by Wild Hogs across the Central United States. *Wildlife Society Bulletin*, 26(2), 279–286.
- Green, D., Askins, G. R., & West, P. D. (1997). Public opinion: obstacle or aid to sound deer management? *Wildlife Society Bulletin*, 25(2), 367–370.
- Harper, E., Miller, C. A., Vaske, J. J., Mengak, M. T., & Bruno, S. (2016). Stakeholder Attitudes and Beliefs Toward Wild Pigs in Georgia and Illinois. *Wildlife Society Bulletin*, 40(2), 269–273. <http://doi.org/10.1002/wsb.653>
- Higginbotham, B. J. (2013). *Wild Pig Damage Abatement Education and Applied Research Activities*. Texas A&M AgriLife Research and Extension Center: Overton. Retrieved from <http://feralhogs.tamu.edu/files/2013/06/WildPigDamageAbatementEducationAppliedResearchActivities.pdf>
- Horne, C. (2001). Sociological perspectives on the emergence of norms. In M. Hechter & K.D. Opp (Eds.), *Social Norms* (pp. 3–34). New York: Russell Sage Foundation.

- Hrubes, D., Ajzen, I., & Daigle, J. (2001). Predicting hunting intentions and behavior: An application of the Theory of Planned Behavior. *Leisure Sciences*, 23(September), 165–178.
- Jackman, J. L., & Rutberg, A. T. (2015). Shifts in attitudes toward coyotes on the urbanized East coast: The Cape Cod experience, 2005–2012. *Human Dimensions of Wildlife*, 20(4), 333–348.
- Jackson, J.M. (1965). Structural characteristics of norms. In I.D. Steiner & M.F. Fishbein (Eds.), *Current Studies in Social Psychology* (pp. 301-309). New York: Holt, Rinehart, and Winston, Inc.
- Jerrolds, W. R. (2013). *A survey to estimate population distribution and economic impact of feral swine in Tennessee*. University of Tennessee, Martin.
- Jerrolds, W. R., Pelren, E. C., Darroch, B. A., & Anderson, R. G. (2014). A survey to estimate population distribution of and damage caused by feral swine in Tennessee, 1, 167–174.
- Jolliffe, I.T. *Principal Component Analysis* (Springer, New York, 2002).
- Jonker, S. A., Organ, J. F., Muth, R. M., Zwick, R. R., & Siemer, W. F. (2009). Stakeholder norms toward beaver management in Massachusetts. *Journal of Wildlife Management*, 73(7), 1158–1165.
- Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, 20, 141-151.
- Kaller, M., Collier, B., Achberger, E., & Barry, O. (2000). *Detection of Feral Hog Impacts to Water Quality and Wildlife Final Report*. Baton Rouge: LSU Agricultural Center.
- Kalnicky, E. A., Brunson, M. W., & Beard, K. H. (2014). A social-ecological systems approach to non-native species: Habituation and its effect on management of coqui frogs in Hawaii. *Biological Conservation*, 180, 187–195.
- Kellert, S. R., & Berry, J. K. (1987). Attitudes, knowledge, and behaviors toward wildlife as affected by gender. *Wildlife Society Bulletin*, 15(3), 363–371.

- Kilpatrick, H. J., Labonte, A. M., & Barclay, J. S. (2007). Acceptance of deer management strategies by suburban homeowners and bowhunters. *Journal of Wildlife Management*, 71(6), 2095–2101.
- Kim, J. O., & Mueller, C. W. (1978). Introduction to factor analysis: What it is and how to do it. Beverly Hills, CA: Sage.
- Krull, C. R., Choquenot, D., Burns, B. R., & Stanley, M. C. (2013). Feral pigs in a temperate rainforest ecosystem: Disturbance and ecological impacts. *Biological Invasions*, 15(10), 2193–2204.
- Lac, A., Crano, W. D., Berger, D. E., & Alvaro, E. M. (2013). Attachment Theory and Theory of Planned Behavior: An Integrative Model Predicting Underage Drinking. *Developmental Psychology*, 49(8), 1579-1590.
- Lamb, B. L., & Cline, K. (2003). Public knowledge and perceptions of black-tailed prairie dogs. *Human Dimensions of Wildlife*, 8(2), 127–143.
- Larson, K. L., Nelson, K. C., Samples, S. R., Hall, S. J., Bettez, N., Cavender-Bares, J., Groffman, P. M., Grove, M., Heffernan, J. B., Hobbie, S. E., Learned, J., Morse, J. L., Neill, C., Ogden, L. A., O’Neil-Dunne, J., Pataki, D.E., Polsky, C., Chowdhury, R. Roy, Steele, M., Trammell, T. L. E. (2016). Ecosystem services in managing residential landscapes: priorities, value dimensions, and cross-regional patterns. *Urban Ecosystems*, 19(1), 95–113.
- Lauber, T. B., Anthony, M. L., & Knuth, B. A. (2001). Gender and ethical judgements about suburban deer management. *Society & Natural Resources*, 14(7), 571–583.
- Manfredo, M. J. (2008). Norms: Social Influences on Human Thoughts about Wildlife. In *Who Cares About Wildlife?: Social Science Concepts for Exploring Human-Wildlife Relationships and Conservation Issues* (pp. 111–139). Fort Collins: Springer.
- Martin, S. R., & McCurdy, K. (2009). Wilderness food storage in Yosemite: Using the Theory of Planned Behavior to understand backpacker canister use. *Human Dimensions of Wildlife*, 14(July 2015), 206–218.

- Mayer, J. J. (2014). *Estimation of the Number of Wild Pigs Found in the United States* (SRNL-STI-2014-00292). Savannah River National Laboratory: Aiken, South Carolina.
- Mayer, J. J., & Brisbin Jr., I. L. (2009). *Wild Pigs: Biology, Damage, Control Techniques and Management* (SRNL-RP-2009-00869). Savannah River National Laboratory: Aiken, South Carolina.
- Mehotcheva, T. H. (2008, April 23). The Kruskal-Wallis test. Retrieved from <http://www.let.rug.nl/nerbonne/teach/rema-stats-meth-seminar/presentations/Mehotcheva-2008-Kruskal-Wallis.pdf>
- Mengak, M.T. (2012). *2012 Georgia wild pig survey final report*. Warnell School of Forestry and Natural Resources, University of Georgia. Athens, GA.
- Mengak, M. T. (2016). *2015 Georgia wild pig survey final report*. Warnell School of Forestry and Natural Resources, University of Georgia. Athens, GA.
- Miller, C.A. (2014). *Landowner attitudes and perceived risks toward wild pigs on private lands in Illinois* (Federal Aid Project Number W-112-R-22). University of Illinois at Urbana-Champaign: Prairie Research Institute.
- Morzillo, A. T., Mertig, A. G., Garner, N., & Liu, J. (2007). Resident attitudes toward black bears and population recovery in East Texas. *Human Dimensions of Wildlife*, 12(6), 417–428.
- Neal, D. M. J. Tegt, and B. Strickland. Assessment of wild hog damage to Mississippi agriculture productivity. A paper presented at the 2016 International Wild Pig Conference, April 17-20, 2016. Myrtle Beach, South Carolina. Abstract last retrieved on April 14, 2016 at <http://www.wildpigconference.com/docs/2016program.pdf>
- Organ, J. F., & Ellingwood, M. R. (2000). Wildlife stakeholder acceptance capacity for black bears, beavers, and other beasts in the east. *Human Dimensions of Wildlife*, 5(3), 63–75.
- Petrzelka, P., & Armstrong, A. (2015). Absentee landowners of agricultural land: Influences upon land management decision making and information usage. *Journal of Soil and Water Conservation*, 70(5), 303–312.

- Pimentel, D., Lach, L., Zuniga, R., & Morrison, D. (2000). Environmental and economic costs of nonindigenous species in the United States. *BioScience*, 50(1), 53 – 65.
- Pimentel, D. (2007). Environmental and economic costs of vertebrate species invasions into the United States. *Managing Vertebrate Invasive Species*, 2-8.
- Poudyal, N. C., Caplenor, C., Maldonado, C., & Muller, L. (2016). *Results from a statewide survey of Tennessee landowners regarding wild hogs and their damage*. Knoxville, TN.
- Ringnér, M. (2008). What is principal component analysis? *Nature Biotechnology*, 26, 303–304.
- Selected Operator Characteristics. (2012). In *USDA Census of Agriculture - State Data*. Retrieved October 11, 2016, from https://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_1_State_Level/Tennessee/
- Schwartz, S.H. (1977). Normative influences on altruism. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 10, pp. 221-279). New York, NY: Academic Press.
- Sharp, R. L., Larson, L. R., & Green, G. T. (2011). Factors influencing public preferences for invasive alien species management. *Biological Conservation*, 144, 2097–2104.
- Shi, Y., Ehlers, S., & Warner, D. O. (2014). The theory of planned behavior as applied to preoperative smoking abstinence. *PLoS ONE*, 9(7): e103064.
- Shi, W., Zhang, Y., Zheng, B., & Ditchkoff, S. S. (2009). Economic estimate of wild pig damage to agriculture in Alabama. Proceedings of the 2010 international wild pig symposium. 11-13 April 2010, Pensacola, FL.
- Siemann, E., Carrillo, J. A., Gabler, C. A., Zipp, R., & Rogers, W. E. (2009). Experimental test of the impacts of feral hogs on forest dynamics and processes in the southeastern US. *Forest Ecology and Management*, 258(5), 546–553.
- South Carolina Wild Hog Task Force. (2015). *Clemson Cooperative Extension*. Retrieved from http://www.clemson.edu/extension/natural_resources/wildlife/wildhogs/
- Statistics Solutions. (2013). Data analysis plan: Kruskal-Wallis Test [WWW Document]. Retrieved from <http://www.statisticssolutions.com/kruskal-wallis-test/>

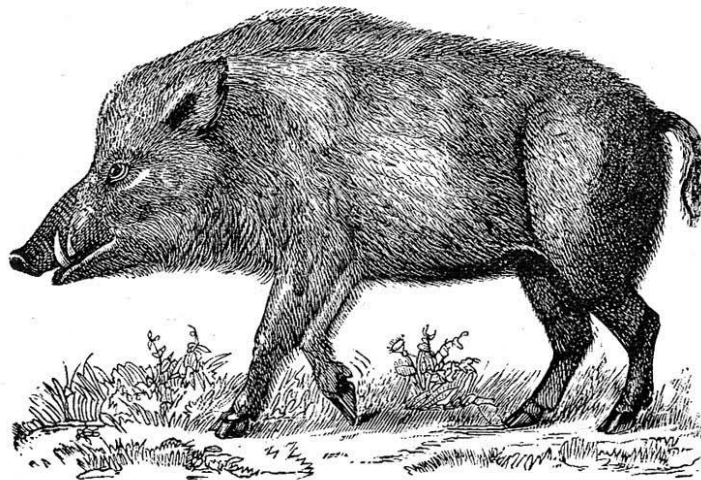
- Statistics Solutions. (2013). Data analysis plan: Ordinal Regression [WWW Document]. Retrieved from <http://www.statisticssolutions.com/academic-solutions/member-resources/member-profile/data-analysis-plan-templates/data-analysis-plan-ordinal-regression/>
- Stevens, J.P. (1992). *Applied multivariate statistics for the social sciences* (2nd edition). Hillsdale, NJ: Erlbaum.
- Sweeney, J. M., Sweeney, J. R., & Provost, E. E. (1979). Reproductive biology of a feral hog. *The Journal of Wildlife Management*, 43(2), 555–559.
- Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Upper Saddle River, NJ: Pearson Allyn & Bacon.
- Tanger, S.M., Guidry, K.M., & Nui, H. (2015). Monetary estimates of feral hog damage to agricultural producers in Louisiana. *Journal of the NACAA*. 8(2).
- Tanger, S., Vlosky, R., & Kaller, M. (2016). *The Fear Factor: Psychological and Social Impacts of Feral Hogs on Farmers in Louisiana*.
- TWRA, WHEAT (Producers). Yoest, C. (Narrator). (2012). *Tennessee's Wild Hog Eradication Action Team* [Online video].
- USDA Animal Plant Health Inspection Service [USDA-APHIS]. 2013. Feral swine: damage and disease threats. Retrieved from https://www.aphis.usda.gov/publications/wildlife_damage/content/printable_version/feral_swine.pdf. Retrieved August 24, 2016.
- USDA Feral Swine Distribution Map. (2014). In *SE Cooperative Wildlife Disease Study*. Retrieved from <http://swine.vet.uga.edu/nfsms/information/map2014.htm>
- Vaske, J. J. (2008). *Survey Research and Analysis: Applications in Parks, Recreation and Human Dimensions*. State College: Venture Publishing, Inc.
- Vaske, J. J., Donnelly, M. P., Williams, D. R., & Jonker, S. (2001). Demographic influences on environmental value orientations and normative beliefs about National Forest management. *Society & Natural Resources*, 14, 761–776.
- Vaske, J. J., Jacobs, M. H., & Espinosa, T. K. (2015). Carbon footprint mitigation on vacation: A norm activation model. *Journal of Outdoor Recreation and Tourism*, 11, 80–86.

- Vaske, J. J., & Manfredo, M. J. (2012). *Social psychological considerations in wildlife management*. (W. F. Decker, Daniel J., Riley, Shawn J., Siemer, Ed.) *Human dimensions and wildlife management* (2nd ed.). Baltimore: JHU Press.
- Vaske, J.J., & Whittaker, D. (2004). Normative approaches to natural resources. In M.J. Manfredo, J.J. Vaske, B.L Bruyere, D. R. Field, and P. Brown (Eds.), *Society and natural resources: A summary of knowledge* (pp. 283-294). Jefferson, MO: Modern Litho.
- Wald, D. M., Jacobson, S. K., & Levy, J. K. (2013). Outdoor cats: Identifying differences between stakeholder beliefs, perceived impacts, risk and management. *Biological Conservation*, 167, 414–424.
- Wild Hog Regulations. (n.d.). *Tennessee Wildlife Resources Agency*. Retrieved from <https://www.tn.gov/twra/article/wild-hog-regulations>
- Wild Pig Info. (2013, June 27). *Mississippi State University Extension*. Retrieved from <http://wildpiginfo.msstate.edu/>
- Willcox, A. S., Giuliano, W. M., & Monroe, M. C. (2012). Predicting cattle rancher wildlife management activities: An application of the Theory of Planned Behavior. *Human Dimensions of Wildlife*, 17(March 2014), 159–173.
- Wittmann, K., Vaske, J. J., Manfredo, M. J., & Zinn, H. C. (1998). Standards for lethal response to problem urban wildlife. *Human Dimensions of Wildlife*, 3(4), 29–48.
- Woody, L. (Fall 2015). Grunt Work. *Tennessee Wildlife*, 39(2), 6-9.
- Zhang, Y., Wang, Z., & Zhou, G. (2013). Antecedents of employee electricity saving behavior in organizations: An empirical study based on norm activation model. *Energy Policy*, 62, 1120-1127.

APPENDIX

Wild Hogs on Private Lands in Tennessee

(A statewide survey of landowners)



THE UNIVERSITY of
TENNESSEE **UT**

Department of Forestry, Wildlife, & Fisheries

2015

You are one of the few randomly selected landowners in Tennessee to participate in this survey. Your help is critical for determining the type and extent of damage caused by wild hogs in Tennessee. Regardless of wild hog presence or damage on your property, the answers you provide will help agencies develop more effective programs to eliminate wild hogs. If you are less than 18 years old, please do not fill out the survey.

This study is sponsored by the following partners of the Tennessee Wild Hog Eradication Action Team (WHEAT)



Section A. Knowledge and experience with wild hog damage: In this section, please tell us about your knowledge and experience with wild hogs on your land in Tennessee, if any. Please answer every question as completely as possible.

1. Have you seen wild hogs or signs of them on your land?

- ☐ Yes, please continue below
☐ No, please skip to page 5, Section B.
☐ Unsure, please skip to page 5, Section B.

2. In what year did you first notice signs of wild hogs on your property? _____

3. Based on your experience, how has the wild hog population in your area changed since you first noticed them?

- ☐ Increased ☐ Decreased ☐ Stayed the same ☐ Don't know

4. What do you think are the reasons for wild hogs being present in your area? (check all that apply)

- | | |
|--|---|
| ☐ Illegal release/transfer | ☐ Inadequate stock laws |
| ☐ Lack of hunting pressure | ☐ State regulations prohibiting transport of wild hogs |
| ☐ Domestic producers | ☐ State regulations prohibiting wild hog hunting |
| ☐ Neighbor's agricultural practices | ☐ Natural causes |
| ☐ Hunting clubs are releasing them | ☐ Other (please specify) _____ |
| ☐ More absentee property owners | |

5. Have wild hogs ever caused any noticeable damage to your land or property?

- ☐ Yes, please continue below
☐ No, please skip ahead to page 5, Section B.

6. How much land did you own, lease, or rent in Tennessee this past year (last 12 months)?

Own: _____ acres
Lease or rent: _____ acres

7. How many of those acres do you estimate to have been damaged by wild hogs?

_____ acres

8. During the past year, which of the following were damaged by wild hogs on your property? (Check all that apply).

- | | |
|--|---------------------------------------|
| ☐ Cash crops (non-timber) | ☐ Vegetables |
| ☐ Pastures | ☐ Tree nursery |

☐ Stream or ponds
 ☐ Fruit Orchards
☐ Fences
 ☐ Equipment
☐ Landscape (e.g., garden, yard)
 ☐ Timber
☐ Food plots
 ☐ Stored commodities

9. Which of the crops you grow or produce were damaged by wild hogs, if any?

Crop	Acres	Crop	Acres	Crop	Acres
Corn		Soybean		Rice	
Cotton		Peanuts		Watermelon	
Barley		Sunflower		Tobacco	
Oats		Potatoes		Pasture	
Wheat		Sweet Potatoes		Other	
Sorghum		Tomatoes		Other	

10. During the past year, what type of damage did you have? (check all that apply)

☐ Rooting or grubbing
 ☐ Injury to pets
☐ Wallows
 ☐ Injury to livestock
☐ Damage to fences
 ☐ Loss of lease value
☐ Damage to irrigation equipment/pipe
 ☐ Loss of timber value
☐ Consumption of grain or hay
 ☐ Loss of land value
☐ Disease transfer to pets/livestock
 ☐ Other (please specify)

11. Please estimate the value of your losses to crops from wild hogs during the past year (last 12 months) \$

12. Because of damage you expected to receive from wild hogs, did you avoid planting a high dollar value crop (which would receive high damage) and planted a crop of lower value instead?

☐ Yes
 ☐ No, go to Q. 14

13. How much money do you estimate that you have LOST because wild hogs caused you to plant a lower value crop? \$

14. Do you raise livestock?

☐ Yes
 ☐ No, please skip to Q. 20

15. Please indicate the type(s) of livestock you have raised in recent years.

☐ Cattle and calves
 ☐ Sheep/goats
 ☐ Aquaculture
 (beef)

Dairy cows Poultry Other
 (specify)

Domestic pigs Horses Other
 (specify)

16. This past year, did you see any evidence of wild hogs entering or gaining access to
Housing for livestock (e.g., barns, pens) _____Yes _____No
Stored animal feed (e.g., hay, grain) _____Yes _____No

17. Have you lost any livestock because of wild hogs?
 _____Yes _____No, please skip to Q. 20

18. Fill out the following table to tell us about loss of your livestock to a wild hog-related cause.

Livestock type	Number lost to wild hogs	Wild hog related cause (circle all that apply)		
Beef cattle/calves		Disease	Attack	Other_____
Dairy cows		Disease	Attack	Other_____
Domestic pigs		Disease	Attack	Other_____
Sheep/goats		Disease	Attack	Other_____
Poultry		Disease	Attack	Other_____
Horses		Disease	Attack	Other_____

19. Considering the last three years, what is your estimated average annual loss to livestock due to wild hogs? \$_____ average per year

20. During the past year, what types of damage (other than crop damage you reported in Q. 11) have you had due to wild hogs, and what were the estimated costs you incurred for each?

Damage incurred in the past year	Estimated cost incurred
Replanting costs	\$.....
Re-disking costs	\$.....
Damage to residential property	\$.....
Loss of timber	\$.....
Damage to wildlife food plots	\$.....
Damage or consumed livestock feed or grain	\$.....
Damage to pastures	\$.....
Loss of stored commodities	\$.....
Damage to equipment	\$.....
Damage to fences	\$.....
Damage to stock ponds or tanks	\$.....

Landscape damage (e.g. personal garden, yard)	\$.....
Damage to natural waters	\$.....
Damage to drains or levees	\$.....
Loss of income from hunting leases	\$.....
Other (please specify)_____	\$.....
Other (please specify)_____	\$.....
Other (please specify)_____	\$.....

21. Based on your knowledge of wild hog damage on your land, please rate the severity of the damage to the following.

Damage type	Rate the severity of the damages Circle one number for each				
	Not a problem	Small problem	Moderate problem	Severe problem	Unsure
Loss of wildlife habitat	1	2	3	4	5
Damage to forest vegetation	1	2	3	4	5
Soil erosion	1	2	3	4	5
Loss of trees	1	2	3	4	5
Reduced water quality	1	2	3	4	5
Damage type	Not a problem	Small problem	Moderate problem	Severe problem	Unsure
Damage to stream banks, ponds	1	2	3	4	5
Loss of natural beauty of the area	1	2	3	4	5
Decline in wildlife (turkey, deer, etc.)	1	2	3	4	5
Disease transmission to livestock	1	2	3	4	5

22. Have you or others working on your land ever taken actions to reduce or prevent damage from wild hogs on your property?

_____ Yes _____ No, please skip to Q. 25

23. If yes, please indicate which actions you took and then circle how effective each action was.

Actions taken		Not at all effective	Somewhat effective	Very effective	Unsure
_____	Shoot on sight	1	2	3	4
_____	Hunting without dogs	1	2	3	4
_____	Hunting with dogs	1	2	3	4
_____	Aerial hunting by government agencies	1	2	3	4
_____	Trapping	1	2	3	4
_____	Baiting and shooting	1	2	3	4

___	Electric fencing	1	2	3	4
___	Non-electric fencing	1	2	3	4
___	Repellents	1	2	3	4
___	Harassment (lights, dogs, donkeys, noisemakers etc.)	1	2	3	4

24. During the past year, about how much (including labor) did it cost you to control wild hogs on your property? \$_____

25. If you have experienced damage from wild hogs, did you seek help from a county, state, or federal agency?

___ Yes ___ No, please skip to Q. 28

26. Please indicate which agencies you sought help from? (Please check all that apply).

___ County Extension	___ Private hog control company
___ Tennessee Wildlife Resource Agency (TWRA)	___ USDA Wildlife Services
___ University Extension	___ Tennessee Division of Forestry
___ Tennessee Farm Bureau	___ Other (please specify) _____
___ Tennessee Department of Agriculture	

27. Did this outside help reduce the damage?

___ Yes ___ No

28. Do you or anyone in your family hunt wild hogs on your property?

___ Yes ___ No

29. Do you currently allow wild hog hunters on your property?

___ Yes ___ No

30. Have you taken advantage of Tennessee's wild hog exemption program (i.e. hunting wild hog without a license)?

___ Yes ___ No ___ Not familiar with the program

Section B. Opinions about wildlife and wild hogs: In this section, tell us about your opinions of wildlife in general, and wild hogs in particular. Please answer even if wild hogs are not present on your property.

31. Please indicate how much you disagree or agree with the following statements about wild hogs by circling the number that matches your response.

	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
Wild hogs are a nuisance	1	2	3	4	5

The spread of wild hogs will damage the natural environment	1	2	3	4	5
Crops and livestock damage from wild hogs will harm the rural economy	1	2	3	4	5
Problems related to wild hogs are exaggerated	1	2	3	4	5
Wild hogs should be completely eradicated wherever possible	1	2	3	4	5
The laws to control wild hogs on private land in Tennessee are adequate	1	2	3	4	5
Wild hogs should be managed to the level that they do not damage property or the environment	1	2	3	4	5
Wild hog eradication programs should be funded through increased hunting license fees	1	2	3	4	5
I feel morally obligated to do my part to eradicate wild hogs	1	2	3	4	5
My neighbors would like me to support wild hog eradication programs	1	2	3	4	5
I support tighter regulations to control wild hogs in Tennessee	1	2	3	4	5

Section C. Efforts to control wild hogs: Please answer the following questions regarding wild hog control efforts in Tennessee in general and on your property specifically.

32. If you experience damage from wild hogs in the future OR if the level of damage you currently experience continues, would you consider allowing government officials to control wild hogs on your property?

_____ Yes _____ No _____ Not sure

33. If you said NO or UNSURE, which of the following best describes why you would not allow officials to control wild hogs on your property?

_____ I am concerned for my privacy.

_____ I am concerned for the safety of my family and neighbors.

- _____ I am concerned about liability due to possibly injury to officials.
- _____ I am concerned about possible government takeover of my property.
- _____ My neighbors do not allow this.
- _____ Other (please specify)
-

34. Currently, the illegal transportation of wild hogs in Tennessee is a Class A misdemeanor. The penalty for this offense is a fine up to \$2,500 and jail time up to 11 months and 29 days for each wild hog illegally moved. Do you think this penalty should be changed? (please check one)

- _____ Yes, both the fine and jail should be increased.
- _____ No, this is about right.
- _____ No, both the fine and jail term should be reduced.

35. Controlling wild hogs in Tennessee may require a combination of different management actions and regulations. Please give your level of acceptance for the following management actions to control wild hogs on and around your property.

Management action	Completely unacceptable	Somewhat unacceptable	Neutral	Somewhat acceptable	Completely acceptable
Leave the wild hogs alone	1	2	3	4	5
Targeted sharpshooting on the ground over bait sites	1	2	3	4	5
Capture and remove using dogs	1	2	3	4	5
Capture and kill	1	2	3	4	5
Capture and relocate	1	2	3	4	5
Aerial control by helicopter	1	2	3	4	5
Allow sale of wild hogs	1	2	3	4	5
Educate people on how to prevent damage	1	2	3	4	5
Provide technical assistance to landowners/farmers	1	2	3	4	5

Offer financial reward to landowners for killing wild hogs	1	2	3	4	5
Help landowners or farmers with subsidy for damage insurance	1	2	3	4	5

36. Currently, wild hogs are present in most of Tennessee's counties. Consider a statewide program that would use a combination of lethal and non-lethal techniques to eradicate wild hogs from Tennessee within the next five years. The program would be spearheaded by a collaborative body of government and non-governmental organizations in the state, but the cost will be funded through increased sales or property taxes. If the eradication costs will be spread across all households in the state, would you be willing to pay \$**BID** /acre per year for the next five years to implement this program?

_____ Yes, Skip to Section D (Q. 38)

_____ No

37. If you said NO above, which of the following describes your opinion? (please check all that apply)

_____ I don't think it is worth paying that much to control wild hogs.

_____ I don't think the program to eradicate wild hogs would be successful.

_____ I believe the hunters, NOT the landowners, should pay for the eradication.

_____ I live in an area unlikely to ever be damaged by wild hogs.

_____ I think we should leave the wild hogs alone.

_____ I would rather pay a private company to control hogs on my own property.

Section D: Demographic information: The following questions will help us ensure that people we are surveying are representative of all landowners and farmers across Tennessee. **All answers will be kept confidential.**

38. What is your age? _____ years

39. What is your gender?

_____ Male

_____ Female

40. Which of the following best describes you? (check one)

_____ Full-time farmer/rancher, landowner

_____ Full-time farmer/rancher, Non-landowner

_____ Part-time farmer/rancher, landowner

☐ Part-time farmer/rancher, Non-landowner
☐ Farm/ranch manager
☐ Landowner living ON farm and NO agriculture production occurs on land
☐ Landowner living ON farm but LEASING to someone else who farms/ranches
☐ Landowner living OFF farm and NO agricultural production occurs on land
☐ Landowner living OFF the farm but LEASING to someone else who farms/ranches
☐ I do not farm/ranch

41. Which of the following are the major operations at your farm or ranch? (check all that apply)

☐ Row crops	☐ Dairy cows	☐ Tree nursery
☐ Fruits vegetables	or ☐ Domestic pigs	☐ Orchards
☐ Timber	☐ Sheep/goats	☐ Aquaculture
☐ Cattle and calves (beef)	☐ Poultry	☐ Other(please specify)_____

42. Approximately what percent of your household's income is derived from farming and ranching?

☐ 0%	☐ 26-50%	☐ 76-100%
☐ 1-25%	☐ 51-75%	

43. Do you hunt for big or small game in Tennessee or elsewhere?

☐ No, go to Q.45
☐ Yes

44. Which of the following do you hunt?

☐ Bear	☐ Elk	☐ Rabbit
☐ Deer	☐ Geese	☐ Squirrel
☐ Ducks	☐ Turkey	☐ Wild hogs

45. In 2014, what is your approximate annual household income before taxes? (please check one)

☐ Less than \$25,000	☐ \$150,000 to \$174,999
☐ \$25,000 to \$49,999	☐ \$175,000 to \$199,999
☐ \$50,000 to \$74,999	☐ \$200,000 to \$224,999
☐ \$75,000 to \$99,999	☐ \$225,000 to \$249,999
☐ \$100,000 to \$124,999	☐ \$250,000 and higher
☐ \$125,000 to \$149,999	

Thank you for completing this survey

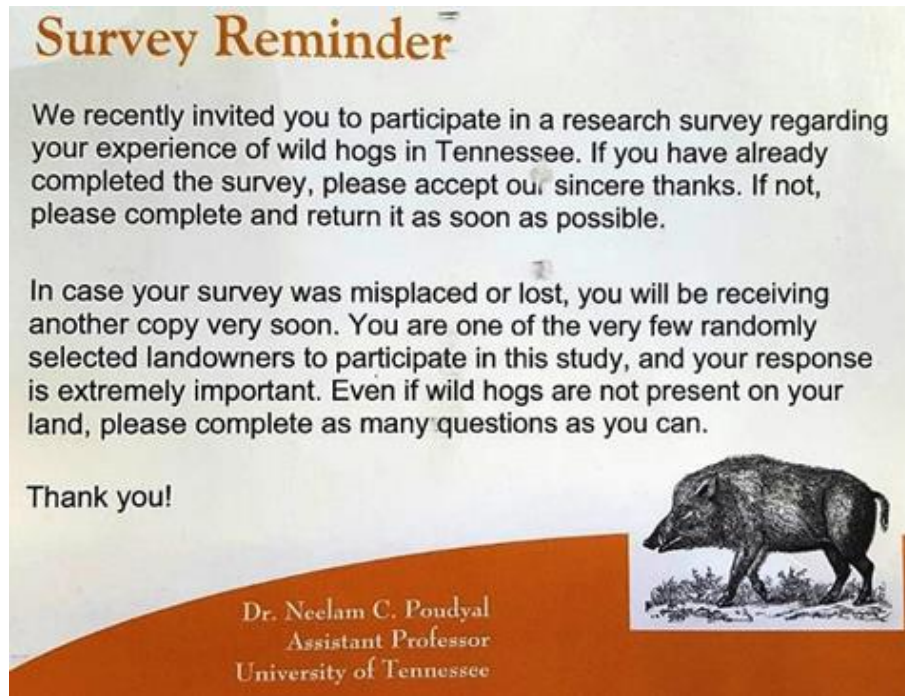
Please use the space provided below for any additional comments.

Please return this survey in the enclosed postage-paid envelope. If you have misplaced the envelope, send the completed survey to:

Professor Neelam Poudyal
Department of Forestry, Wildlife, & Fisheries
University of Tennessee
274 Ellington Plant Science Bldg.
Knoxville, TN 37996

ID

Appendix 2. Follow-up reminder post card



VITA

Carlotta is an M.S. student in the Department of Forestry, Wildlife, & Fisheries at the University of Tennessee, Knoxville (UT). She earned a B.A. in English from UT in 2004, and went on to work for the Knoxville Municipal Court for ten years. Her research and professional interests lie in social science aspects of natural resource conservation and management. Her M.S. thesis project investigates public attitudes and support for invasive species management with a particular focus on Tennessee landowners' attitudes toward wild hogs and support for eradication programs. She volunteers at Great Smoky Mountains National Park giving natural resource information and education, and more recently at the Obed Wild and Scenic River as a visitor assistant. Carlotta is an active member of several academic and professional organizations including Gamma Beta Phi, the Association of National Park Rangers, and the National Association for Interpretation. After graduating in December of 2016, she hopes to pursue a career as a Park Ranger.