HUMAN FACTORS INFLUENCING THE OCCURRENCE OF GOPHER TORTOISES (*GOPHERUS POLYPHEMUS*) ON PRIVATE LANDS IN MISSISSIPPI

By

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To the Lord for always watching over me. To everyone who has ever planted a flower in my garden of life. A special dedication to my grandmothers for always seeing the beauty in me and being there with glasses of lemonade on sunny days and umbrellas in the rain. You taught me to value myself and to hold firmly to my dreams. These people are the stones that have constructed my path. They soften the impact as I walk along my journey, and I will carry them in my heart for the rest of my days.

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Co-chair: Debbie Miller
Major: Wildlife Ecology and Conservation

Private landowners own a substantial portion of the land in the United States, so conservation of habitats and species may be hindered without their cooperation. Our study examined how certain human factors of private landowners may be affecting gopher tortoise occurrences on private lands. We measured these factors using a mail survey, personal interviews, gopher tortoise burrow surveys, and vegetation sampling. Then, we used a millet bioassay to examine a specific human-influenced action (the use of the imazapyr herbicide near burrows) to determine if tortoise eggs might be affected by the decision to use imazapyr close to burrows.

Results of the study showed that 38% of respondents had never seen a gopher tortoise on their properties and 38% of respondents had been aware of gopher tortoises on their properties for 10^{+} years. Respondents were largely unsure of gopher tortoise population trends (45%). Gopher tortoises were rated as higher concern than other wildlife by 45% of respondents. The main reason for respondents not being enrolled in wildlife incentive programs was being unaware of their existence (69%). These results

indicate that an outreach and education program is essential to the conservation of tortoises in Mississippi.

Most tortoises occurred in longleaf pine on properties where the highest priority for landowners was maintaining a natural setting. Less than a fourth of respondents conducted prescribed burns, but nearly half of respondents reported adopting some type of land management practice due to learning about tortoises. Potential threats to tortoises on respondents' properties were fire ants, armadillos, and herbicides. However, our imazapyr study showed that imazapyr persists in negligible amounts in the apron soil and is well below lethal levels (determined by similar herbicides).

CHAPTER 1
GENERAL INTRODUCTION

Range and Conservation Status

Gopher tortoise populations are distributed throughout the Coastal Plain of the southeastern United States in upland habitats. Gopher tortoises prefer longleaf pine sandhill, xeric oak, scrub, pine flatwoood, dry prairie, and coastal dune habitats with well-drained sandy soil for burrow construction and open understory with herbaceous ground vegetation on which they feed (Mushinsky et al. 2003). The majority of the populations are found in north-central Florida and southern Georgia. The species has been severely reduced in southern Alabama and Mississippi, southeastern Louisiana, and southeastern South Carolina. The species has also been depleted along Florida's southeast coast and throughout much of the Florida Panhandle (Puckett & Franz 2006).

The gopher tortoise became federally listed as threatened in its range west of Mobile and Tombigbee Rivers in Alabama, Mississippi, and Louisiana on July 7, 1987 (USFWS 2009). It is currently state listed as endangered in Mississippi and South Carolina, indicating that gopher tortoises have become so rare that there is real danger of them becoming extinct in these regions (Puckett & Franz 2006; Environmental Protection Agency 2006). The tortoise is also state listed as threatened in Georgia and Florida. In Louisiana, the tortoise is not state listed, but is federally listed as threatened. In Alabama, the tortoise is protected at the state level as a non-game species (Puckett & Franz 2006).

Tortoise Habitat Needs

Gopher tortoises (*Gopherus polyphemus*) eat a wide variety of plants (over 300 species). Studies have shown that they eat plants such as *Panicum spp.*, *Rubus spp.*,

Piriqueta spp., and *Stylosanthes spp.* (Birkhead et al. 2005). Tortoises also eat scrub palmetto (*Sabal etonia*), red mulberry (*Morus rubra*), late purple aster (*Aster patens*), and sundrops (*Oenothera fruiticosa*) in addition to numerous other low growing plants (Ashton & Ashton 2008). These types of plants are found in forests with a relatively open canopy that allows large amounts of sunlight to reach the ground.

Gopher tortoise females reach reproductive age around 10 to 15 years old (when their shells reach a length of approximately nine inches). A mature female will normally lay one clutch of eggs annually between May and June with 3-15 eggs per clutch. Gopher tortoises are slow growing and growth varies by geographic region. It is believed that gopher tortoises may live in excess of 60 years (Puckett & Franz 2006).

A tunnel-like burrow excavated by the tortoise's shovel-like front feet serves as its home. These burrows have been documented to be up to 40 ft in length and can be as deep as 10 ft. Burrows have a half-moon shape opening with the cross section width approximately equal to the tortoise's length. The burrow can generally be distinguished in the landscape by the mound of sandy soil around the entrance (Puckett & Franz 2006). Preferred gopher tortoise soil for good burrow construction is humus-poor, extremely well-drained, relatively deep to deep, with fine to coarse sand, and often has high quartz sand content. Preferred tortoise burrow soil does not consist of loamy or clayey subsurface horizons, fragipans, well-developed argillic horizons with clay, or plinthite that would interfere with drainage, gopher tortoise egg or hatchling success, and burrowing (McDearman 2005).

Burrows are vital to gopher tortoise survival as they keep temperature and humidity levels relatively stable throughout the year, which is important for an animal

that must use its environment to thermoregulate its body temperature. The burrow also provides protection from drought, fires, and temperature extremes. In addition to benefiting tortoises, the burrows are vital as a refuge for over 360 other animal species, such as the pine snake (*Pituophis melanoleucus*), gopher frog (*Rana capito*), rattlesnakes (*Crotalus* or *Sistrurus spp.*) and the Florida mouse (*Podomys floridanus*) who utilize tortoise burrows (Jackson & Milstrey 1989).

Historic Southeastern Mississippi Gopher Tortoise Habitat

Historically, longleaf pine (*Pinus palustris*) forests of the southeastern United States burned frequently at one- to three-year intervals, usually in the summer months. Southern pines have a thick, insulating bark that withstands low intensity fires (Stewart 2009). This burning produced widely spaced overstories, sparse midstories of scattered hardwoods, and a very diverse herbaceous groundcover dominated by plants like bluestem (*Andropogon* or *Schizachyrium spp.*). These conditions provided the herbaceous groundcover for foraging and the open-canopy conditions for thermoregulation and nesting required by the gopher tortoise (Frost 1993; Yager et al. 2007).

Before European settlement, longleaf pine forests covered 25–35 million hectares of the southeastern landscape. Native Americans used fire to aid in farming, managing game, and improving hunting conditions (Stewart 2009). European settlers changed the fire regime by clearing and burning small patches of forest for settlement instead of burning larger areas. In addition, extensive commercial logging in the 1800s impacted fire regimes and removed most of the pine forests through timber harvesting. By the 1900s, fewer than 10% of the original stands where left intact (Frost 1993). Most forest land had been cleared by the 1920s. By the 1930s, these lands had been

reforested for timber harvests and protected from wildfires. In the early 1980s, people began to realize the ecological importance of fire and prescribed burning increased in popularity, so agencies and citizens started burning liberally again in pine forests. However, now it is becoming increasingly difficult to conduct prescribed burns (especially on smaller tracts of land), due to increased concerns about the effects of smoke and property damage (Stewart 2009).

Present-Day Southeastern Mississippi Gopher Tortoise Habitat

Over time, much of the longleaf pine (*Pinus palustris*) forests in the southeastern Mississippi Coastal Plain that are preferred by gopher tortoises have been lost, due to the suppression of prescribed burning and conversion to different land uses. Prescribed burning is necessary to create the widely spaced overstories, diverse herbaceous groundcover like bluestem (*Schizachrium scoparium*) needed for tortoise foraging, and limited shade from hardwood midstories that is required for tortoise nesting and thermoregulation. As a result of widespread fire suppression, gopher tortoises have been forced to occupy less suitable human-created open habitats like pastures and food plots.

Today only two million hectares of pre-settlement forests exist (Quicke et al. 1994). The loss and degradation of longleaf pine forests is mainly due to land-use change, timber harvest, and fire suppression (Haywood & Gilliam 2002). Pine habitats no longer receiving frequent burns often have shrub and hardwood succession, which causes a closed canopy and reduction in forage availability to wildlife that feed on herbaceous plant material (Auffenberg & Franz 1982). The exclusion of fire and new forest management practices have shifted certain areas of forest toward loblolly or slash pine mixed with hardwood species like white oak (*Quercus alba*), southern red oak (*Q.*

falcata), and mockernut hickory (*Carya tomentosa*). Simultaneously, a dense midstory of shrubs dominated by hollies (*Ilex spp.*) and blueberries (*Vaccinium spp.*) has crowded out herbaceous groundcover (Leonard et al. 2000).

Approximately 310,000 private landowners own a total of 13 million acres of Mississippi forestland (Mississippi Forestry Association 2009). These private lands serve a multitude of purposes like recreation and resource extraction. Areas planted with dense pine plantations currently cover extensive acreages and may act as barriers to gopher tortoise movement. Tortoises in dense pine plantations often relocate to roadsides to forage and may become vulnerable to vehicle strikes, predation, and illegal harvest (Diemer & Moler 1982).

Forest loss and modification have been major contributors to the 80% decline of gopher tortoise populations seen in the last 100 years (Auffenberg & Franz 1982). As predicted by some researchers (Auffenberg & Franz 1982), fire exclusion has drastically reduced tortoise numbers. Densely planted pine plantations and lack of intermediate stand management allow overstory canopy closure that can result in burrow abandonment due to degradation of nesting and foraging conditions (Guyer & Hermann 1997; Aresco & Guyer 1999). Tortoise population densities have been found to be low in areas where leaf litter and shading has suppressed herbaceous groundcover (Landers & Speake 1980).

Today, fragmented gopher tortoise populations are found in the southeastern Coastal Plain (Auffenberg & Franz 1982). Degradation and fragmentation of habitat can cause gopher tortoises to disperse to find better habitats and result in genetic isolation as well as mortality (Mushinsky & McCoy 1994). The remaining suitable or potentially

suitable habitat needs to be managed to promote an increase in gopher tortoise populations. Private landowners will need to play an important role in this process if it is to be successful.

Habitat loss, due to land development, presents the most serious threat to the survival of the gopher tortoise (McCoy & Mushinsky 1992). Tortoises inhabiting proposed development sites may be relocated to another location, which might result in further problems like the spread of Upper Respiratory Tract Disease (URTD) or the disruption of resident tortoise populations. Many relocated tortoises may also be killed crossing roads in an attempt to navigate back to their original location. Road mortality is a growing problem for tortoises. Roads may also act as barriers to tortoise dispersal and cause isolation of certain populations (Puckett & Franz 2006). Illegal hunting for consumption of gopher tortoise meat is another problem that may contribute to their decline, since they reproduce at a rate that cannot withstand harvest. Gopher tortoises may face other problems as well that factor into their overall reduction in population size (Puckett & Franz 2006).

Role of the Private Landowner in Gopher Tortoise Conservation

Private landowners are the key element in the long-term conservation of gopher tortoises. Most public land is managed effectively for conservation, but some public upland habitats are being destroyed by lack of management or changing natural areas into dense silviculture. Numerous biologists feel that there is a need for more than just large state forests and parks to insure that upland species survive. Many smaller privately owned lands scattered across various regions of different states in the gopher tortoises' range may aid in the attempt to conserve gopher tortoises (Ashton 2009).

The small clusters of tortoises on private lands may provide important habitat that could maintain the genetic diversity required for the long-term preservation of gopher tortoises. However, private lands can be affected by urban sprawl, construction of human dwellings, oil and mineral mining, silviculture, and agriculture. Modifications of certain management practices like avoiding use of any heavy equipment around burrows when nesting is occurring could prove helpful in reducing the negative impacts that these practices can have on tortoises. Conservation-minded private landowners or those landowners that want to receive tandem benefits to wildlife, such as quail and turkeys, may be open to practicing more tortoise-friendly land management practices.

Private landowners must be willing to collectively put into place environmental actions like habitat conservation or rehabilitation in order to have a successful recovery of gopher tortoise populations. In order for any recovery plan to be successful in the conservation of this threatened species, the variables that act as predictors for the levels of support for tortoise conservation must first be understood. Landowners must understand that the tortoise is in decline and what factors have led to its decline. Then, landowners must be educated on what role they can play in the tortoises' recovery.

Gopher Tortoise Research

Comprehensive burrow surveys of public lands in Mississippi like Camp Shelby National Guard training facility, DeSoto National Forest, and several state wildlife management areas have already been conducted, but research on private lands is scarce (Hermanna et al. 2002). However, knowledge about the status and location of gopher tortoises on privately owned properties is vital to the formation and implementation of any restoration plan. Currently, there is a gap in knowledge about these two factors and as a result, effective planning has been precluded. No

comprehensive surveys for gopher tortoises in Mississippi have been completed and existing records for occurrences are out-dated.

The effects of some forest management activities currently used near gopher tortoises may be having undesirable effects on tortoises. Imazapyr use is widespread in pine culture to control weeds. It might be affecting tortoises and their eggs. Studies have not been conducted to assess this possibility. It would be useful to evaluate the persistence of imazapyr in soils commonly used by tortoises to evaluate the risk herbicide application may pose to tortoise eggs.

We took a three-pronged approach with our research. Our research consisted of an anonymous mail survey to gather information to help construct an effective education and outreach campaign to help with gopher tortoise conservation on private lands in southeast Mississippi. Our research also involved thirty interviews of private landowners in southeast Mississippi to help understand the factors that inspire landowners to want to conserve tortoises on their properties. In addition, we explored the land management practice of spraying imazapyr in areas that have gopher tortoise burrows to determine whether the imazapyr persists in apron soils where eggs are often laid.

Our Research Objectives

- Examine the ecological aspects of gopher tortoise conservation on private lands.
- Examine the sociological aspects of gopher tortoise conservation on private lands.
- Determine if a herbicide could persist in the apron soils of burrows long enough to have the potential to affect tortoise eggs.

Study Sites for Our Research

Three counties in southeastern Mississippi were the focus of the mail survey and

the case studies. Based on information given by the respondents in the mail surveys and the interviews, we were able to construct a picture of how these respondents viewed these three counties in economic and residential terms. Jackson County is viewed as a mix of metropolitan and rural. It is located on the coast of Mississippi. It is a county that is largely reliant on fishing and coastal activities, including tourism. Wayne County is inland and more rural. It is largely reliant on timber harvesting, commercial chicken houses, livestock, and oil drilling. Marion County is inland and slightly more metropolitan than Wayne County. Timber harvesting and oil drilling are two of the more common sources or supplements of income in this county.

The Wildlife Management Area (WMA) where we conducted the field portion of our study to estimate imazapyr concentrations in gopher tortoise burrow apron soils is managed by the Florida Fish and Wildlife Conservation Commission. It is an area where a variety of native Florida wildlife and plants are managed and where people may come to view wildlife and hunt during designated hunting seasons. The WMA has longleaf pine forests where gopher tortoises construct burrows. Our study utilized one of these longleaf pine forests.

CHAPTER 2
THE MAIL SURVEY USED AS A TOOL IN CONSERVATION ISSUES RELATING TO GOPHER TORTOISES (*GOPHERUS* POLYPHEMUS)

Introduction

Tortoises are declining because of numerous threats. Therefore, comprehensive conservation efforts must be undertaken immediately to help tortoises recover. The actions of private landowners are key to tortoise recovery, because private lands comprise a large proportion of land in the United States and suitable tortoise habitat is fragmented between public and private lands. Recovery requires cooperation between public land managers, private landowners, and government policy-makers at the local, state, and federal level. However, research about private landowners must be conducted to allow agencies to develop a deeper understanding of private landowners and develop tortoise conservation programs that will effectively provide landowners with the knowledge and skills they need to play a beneficial role in tortoise conservation.

Literature Review

Humans both influence and are impacted by natural resource management issues. Wildlife management problems almost always develop into people problems: people are involved at all levels of each management issue. Conservation is human driven and human values toward the management of land or natural resources underlie any conservation actions taken. Preserving biodiversity requires people's commitment to any protective actions employed (Jacobson 1998).

Social aspects of conservation biology must be employed when dealing with these human-wildlife issues, especially since human dependence on natural resources like timber are increasing as human population numbers increase. Behavioral research that investigates conservation motives assumes people will take actions that are in their

greatest economic interest. Using this approach will require employing positive reinforcement strategies, because punishment and negative reinforcement usually result in noncompliance by landowners (Jacobson et al. 2003).

Wildlife management from a human dimensions' perspective views people as a vital part of any management that is to be effective in its goal. The focus is on gaining a scientifically-based interpretation of human motivation and behavior (Decker & Chase 1997). Decision-making processes that utilize scientific measurements of private landowners' perceptions of different wildlife, their preferred wildlife management practices, and both how they are affected by and how they may affect wildlife are more effective than those that do not (Decker et al. 2001; Miller & McGee 2001). People-wildlife problems are mostly process-driven. They necessitate the participation of private landowners throughout the whole process in order to effectively solve people-wildlife conflicts.

Continuous reexamination and adjustment are necessary to assess any changes in landowner interests in conservation or willingness to practice conservation-minded land management. Research has shown that attitudes like those that underlie interest in conservation can change with exposure to situations or new knowledge (Decker & Chase 1997). Agencies must be sensitive to these changes in interest in conservation and be prepared to deal with them. Agency goals must respect landowners' preferences or risk losing landowners' trust and cooperation (Slovic 1993).

Baseline information is necessary to measure the success of education and outreach programs. Pinpointing target audiences, knowledge gaps, conservation interest level, and the most effective informational sources will increase the chances

that education and outreach programs will be effective in increasing support and actions for wildlife conservation. Understanding the specific predictive variables that generate positive or negative attitudes about wildlife conservation is crucial. Also, groups or population subsets that will most likely be uneasy about certain management actions should be identified. Channels of communication can be opened and the involvement of the necessary audiences in conservation management practices can be more effectively achieved once landowner interests and attitudes are better understood.

The recovery efforts for wildlife may be perceived differently by each landowner and involve personally held beliefs about government, external influences, people's personal relationship with wildlife, and the involvement of special interest groups. Landowners' actions may not even be an accurate reflection of how they view the actual species needing recovery. Front-end research on the human dimensions of conservation can improve communication and landowner participation in creating successful environmental policy. Maintenance of biodiversity is dependent on better integration of disparate approaches and views. Human dimensions involves understanding the beliefs, attitudes, values, behaviors, and demographic characteristics of the landowners involved in the specific conservation issues (Jacobson 1998).

Predicting Support for Gopher Tortoise Conservation

Wildlife managers will be better able to design programs that will encourage people to practice management that is beneficial to wildlife if they know the interacting variables that help form people's interest in conservation of wildlife. If managers learn how to target the variables that form interest in landowners for a certain species like tortoises, they can potentially increase the number of landowners that have positive

views of tortoises and are willing to participate in programs directed toward tortoise conservation.

Each person's interest levels are affected by factors such as values regarding animals and nature, knowledge about a species, personal interactions with a species, and the specific characteristics of the species that allow people to develop attachments to them (Kellert et al. 1996). Landowners that see wildlife and nature as valuable will most likely be more positive towards any recovery efforts for gopher tortoises than those landowners who place little value on wildlife and nature. The greater the interest that landowners have in a behavior like conservation the more likely landowners' intentions will be to engage in that specific behavior (Ajzen & Fishbein 1980). Socioeconomic and demographic characteristics might affect environmental behaviors as well. Landowners' degree of support or opposition to land management practices that benefit gopher tortoises is important to recovery efforts. By considering these variables, mistakes such as overestimating landowner support or underestimating opposition can be avoided.

Theoretical Framework

The occurrence of gopher tortoises on a particular piece of property will be influenced by the ecological characteristics of that property, which will in turn be affected by land management practices. Land management practices can be influenced by landowner demographics, knowledge, willingness to use prescribed burning, and interest in government assistance programs. The habitat type that covers most of the property will depend on whether the land is managed for livestock, agriculture, timber harvesting, or wildlife viewing. Total number of acres owned may also affect what a land's primary

use is and whether gopher tortoises occur on that land.

We made predictions regarding factors we expected to influence the occurrence of gopher tortoises on private properties (Table 2-1).

In our context of longleaf pine forest and gopher tortoise habitat, prescribed burning is the key activity that maintains gopher tortoise habitat quality. Therefore, we examined willingness to apply this management activity to benefit tortoises. Demographic characteristics like age, education, and income may influence willingness to use prescribed burning to benefit non-game species (Jacobson 2009). Similarly, knowledge about the gopher tortoise's ecology/ecological role and required land management practices as well as valuation of the importance of managing for game species versus non-game species may also influence willingness to use prescribed burning. We made predictions regarding willingness to use prescribed burning to benefit non-game species and these variables (Table 2-2).

Older people have had more opportunities to be educated about and experience the benefits of prescribed burning. These older respondents may feel more comfortable using prescribed burning in order to get government assistance to supplement their income, especially given the current economy. Better educated respondents may have had more opportunities to learn about prescribed burning and its benefits through classes, reading, etc. Since the United States is experiencing economic hardship, lower income respondents may be willing to conduct prescribed burns to supplement and increase their incomes.

Landowners' knowledge about a species' ecology and ecological role can influence willingness to use prescribed burning to benefit non-game species and

interest in government assistance programs. Studies have shown that people in the United States tend to have more knowledge about animals that can cause problems for humans than the animals that do not cause any problems (Kellert & Berry 1980). Therefore, respondents may be more knowledgeable about raccoons (*Procyon lotor*) or other nuisance animals than gopher tortoises if the tortoises have not caused the respondents serious problems. We made predictions regarding knowledge of gopher tortoises and factors that may affect the landowners' amount of knowledge of gopher tortoises (Table 2-3).

Landowners may be unaware of the basic ecology of a species on their land and therefore be unable to make management decisions that do not harm a particular species. For example, landowners may be unaware that gopher tortoises do not thrive in dense forests or be unaware of the specific plants that tortoises require for food. They may also think that they have gopher tortoises when they really have box turtles or river turtles if they do not have any knowledge about what a gopher tortoise looks like.

Providing landowners with opportunities for education about a species and assistance with management may offer the best prospects for achieving ecosystem management objectives across diverse landowners with different demographic characteristics (Creighton et al. 2002). Some landowners may also be willing to implement management practices that promote game species, but be unwilling to take special efforts to manage in ways to benefit non-game species like gopher tortoises. Government assistance programs are available to provide private landowners with technical and financial help with practices that benefit wildlife such as gopher tortoises. We predicted that the same factors that influenced landowner's willingness to burn

would also influence their interest in government assistance programs (Table 2-4).

Study Description and Research Questions

One social research method being used increasingly as a tool in wildlife management issues is the mail survey. It has been recognized as an effective tool for information gathering. According to Colorado State University (2009), one of the benefits to self administered surveys is that they are a relatively inexpensive method for gathering information. For reasons of cost as well as ease of implementation, mail surveys are used more for social research than more costly telephone or face-to-face interviews. In addition, mail surveys in general present few special sampling error concerns and can measure characteristics of larger populations. The ability of questionnaire surveys to gather information about populations by surveying only limited samples makes them appealing to use in research (Dillman 1991). Another benefit of surveys with multiple choice questions is that their standardized questions provide precise measurements, because the number of potential responses is limited (Colorado State University 2009).

One problem with survey use is that questions must be general enough to be appropriate for all respondents. Multiple choice questions might not include the most appropriate response for some respondents. Survey use also requires that a minimum number of people respond (Colorado State University 2009). If the survey has a low response rate, the chances of having non-response bias increases.

This study proposes that occurrences of tortoises on private lands are influenced by the ecological characteristics of these private lands, land management practices of the private landowners, the private landowner's willingness to manage for wildlife and

interest in government assistance programs, and the landowners' knowledge of gopher tortoises (Figure 2-1).

This study examines and explores relationships between variables that influence occurrences of gopher tortoises on private lands in Mississippi by answering the following research questions:

1. Gopher tortoise occurrence:
    A. Which ecological characteristics of the properties serve as good predictors of gopher tortoise occurrence?
    B. Is there a difference in the occurrence of gopher tortoises among counties?
2. Willingness to use prescribed burning:
    A. Is there a relationship between willingness to use prescribed burning and age, income, or education of landowners?
    B. Is there a relationship between willingness to use prescribed burning and knowledge of gopher tortoise ecology?
3. Knowledge of gopher tortoise ecology:
    A. Is there a relationship between knowledge of gopher tortoises and age, income, or education of landowners?
    B. Is there a relationship between landowners' knowledge of gopher tortoises and occurrences of gopher tortoises?
4. Interest in government assistance programs:
    A. Is there a relationship between interest in government assistance programs and age, income, or education of landowners?
    B. Is there a relationship between interest in government assistance programs and knowledge of gopher tortoise ecology?

Methods

Survey Instrument

A descriptive (observational), cross-sectional survey instrument designed to

quantify and analyze discrete determinants that are conducive to the degree of support for or opposition to gopher tortoise conservation was created to distribute as a mail survey (Fink 2003). The survey instrument contained 29 components that measured five main subjects: respondent's interest in managing for wildlife, respondent's knowledge of gopher tortoises, ecological characteristics of landowner's property, the occurrence of gopher tortoises on the respondent's property, and demographics of the respondent (see Appendix A for survey instrument).

At the beginning of the survey instrument, a brief letter of introduction was placed to tell the respondents why the survey was being conducted, how they were selected, why it was important for them to respond, and the method for returning the survey (Babbie 2007; Appendix B). The survey questionnaire included an anonymity statement in the letter of introduction to let the respondents know that their answers were anonymous. An anonymous survey design was chosen to try to increase the likelihood of eliciting more responses to the questionnaire (Miller 2001). The questionnaires were color-coded to distinguish among counties. Jackson County was given a pastel yellow color, Marion County was given a pastel blue color, and Wayne County was given a pastel green color.

The survey instrument began with the most interesting set of questions in order to increase the likelihood of being completed. Requests for demographic data were placed at the end of the survey instrument to prevent the appearance of being a routine form (Babbie 2007). The survey was divided into three sections to help it flow well, with similar questions grouped together to help make answering questions easier. Each section had an introduction with a brief statement about the section content and

purpose as well as instructions for completing that section. Sensitive questions were asked last within each section and the questions went from more general to more specific. This funnel or reversed-pyramid procedure started with broad, factual, and simple questions and proceeded to more complicated, indirect, attitudinal, and private questions (Lin 1976; Jacobson 1999; Babbie 2007). Boxes were used in the last two sections for respondents to place an x mark inside. Nearly all questions were closed-ended so that the survey instrument was less time consuming for the respondent to fill out and so that ease of coding answers for analysis was increased. A statement thanking respondents for their time appeared at the end of the survey instrument (Babbie 2007).

Section 1, the opinion section of the survey instrument, was designed to determine the respondent's level of interest in wildlife management or conservation. We utilized a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree) that contained a central neutral category. The use of a five point scale with a central neutral category is known to prevent confusion in respondents and reduce measurement error. The two implicit assumptions of Likert scales are that the sum of the response category ranks is linear with the relevant trait of the person and that the expected response category used by a person is the same for every item (Massof 2005). The opinion scale incorporated 6 questions where a higher mean indicated more positive opinions or attitudes towards wildlife management in general and gopher tortoises in particular. The scale measured interest in management of game species, interest in management of non-game species like the gopher tortoise, interest in financial incentive programs, and interest in receiving technical assistance in managing habitat to promote gopher

tortoises. There was also one value-based question which assessed opinions regarding the relative importance of managing for game species versus non-game species.

The knowledge index in section 2 of the survey instrument had 19 questions about the respondent's knowledge of gopher tortoises and about the landowner's property. It was designed to measure the ecological characteristics of the landowner's property, the respondent's confidence in their ability to identify gopher tortoises and their burrows, and the respondent's knowledge of tortoise population trends and land management activities that benefit gopher tortoises. It also measured the respondent's knowledge of the importance of gopher tortoises to other wildlife, awareness of conservation programs like Safe Harbor, Healthy Forest Reserve Program (HFRP), and Wildlife Habitat Incentive Program (WHIP), and the respondent's primary reason for not enrolling in wildlife incentive programs. Gopher tortoise occurrence on the respondent's property and neighboring properties was asked about as well.

The one contingency question in the survey instrument was located in section 2. This question had an arrow pointing from one particular response to a bolded statement saying, "If yes, please answer the next question." The follow-up question included a bolded statement that said, 'Please answer only if you placed an x mark by "currently" on the previous question' (Babbie 2007). This method was employed to make it easier for respondents to know whether or not to answer the second question. The answer to this particular question was only relevant to the respondents that had given one particular response to the previous question.

The demographic section of the survey instrument was composed of 4 items that queried the respondent's age, education, and household income for the previous year.

It contained a statement prior to answering questions that stated that the researcher wanted to know about how different types of people feel about the issues being studied. This type of statement was used to put people at ease, make them feel that their responses were valuable, and increase the likelihood that the respondents would answer such personal questions. Length of residence in Mississippi and type of residence (rural, city, etc.) were demographic measures placed in section 2, since they pertained to the respondent's property. A 4-point bipolar scale that ranged from rural (country) to large city (50,000+ people) was used to determine the respondent's type of residence.

A stamped postcard with a return address was included within the survey packet (Appendix C). We requested that the postcard be returned separately from the questionnaire to maintain the anonymity of the survey instrument. The postcard was designed to allow the landowner to fill in his or her name and contact information if he or she was interested in receiving information on habitat management for gopher tortoises or in receiving translocated tortoises. The postcard also asked the respondents to mark a box if they consented to a visit to survey their land for burrows and to examine habitat characteristics. The complete survey packet consisted of a letter of introduction; the survey instrument; a self-addressed, stamped envelope; and a self-addressed, stamped postcard.

Sampling Strategy and Survey Administration

The survey instrument and postcard were examined by survey experts at the University of Florida to make sure that the questions and format followed standard survey procedures. Then, the survey instrument and the postcard were submitted to the University of Florida's Institutional Review Board (IRB) to ensure that they did not

contain any items that might cause harm to the respondents. Before being sent out to respondents, the questionnaire was pretested on five private landowners who had agreed to pretest the questionnaire. Their names and contact information were provided by Tom Mann, a herpetologist at the Mississippi Museum of Natural Science. This pretesting was conducted to help eliminate questions that were confusing, offensive, or irrelevant, and to identify pertinent questions that needed to be added (Jacobson 1999).

Nineteen counties in southeast Mississippi lie within the geographic range of the gopher tortoise and were therefore originally considered as potential counties to which the survey instrument could be distributed. Counties on the extreme northern and western fringe of the gopher tortoises' range, such as Clarke, Jasper, and Covington were excluded because the number of tortoises in these counties was expected to be very low. According to GIS maps created by Mississippi's United States Fish and Wildlife Service office, large portions of these counties have clay soils that the gopher tortoises would find unsuitable to inhabit. The populations of gopher tortoises in these counties would be very sparse for this reason regardless of the individual land management practices of private landowners that this study is focusing on. Of the remaining thirteen counties, it was decided that three counties was a reasonable number with the time and money available for this part of the study. The remaining counties were arranged alphabetically and assigned a number. A random number generator was then used to choose the three counties for distribution of the survey instrument: Jackson County, Marion County, and Wayne County were selected.

The landowner names and contact information were pulled from a property tax

database administered by Dr. Ian Munn of Mississippi State University. A biologically-based threshold of 25 acres was set as a minimum patch size able to support a viable population of gopher tortoises. Dr. Munn randomly chose 900 addresses from each county to send to us for survey distribution. These lists were sent to the University of Florida's Document and Mail Service to be cleaned and any duplicate addresses purged before distribution.

The questionnaire was self-administered, and it was the responsibility of the respondent to fill it out and send it back in the mail. A total of 2,584 survey packets were mailed in February 2009. Of these, 259 were returned to sender by the United States Post Office as undeliverable for reasons ranging from death of the respondent to the respondent having moved without updating his or her address in the tax database.

A reminder postcard was sent one week after the first survey packet was mailed (Appendix C). Response rates have been shown to increase after reminder postcards are sent (Jacobson 1999). Two weeks after the reminder postcard was mailed, a second mailing of the survey packet was sent after removing the undeliverable addresses discovered during the first mailing. The second mailing was done to try to remind people that may have lost or forgotten about the first survey packet, but that had intended to respond. The second mailing was an attempt to decrease nonresponse bias.

Potential Sources of Bias Resulting from Mail Surveys

Nonresponse bias is the bias of most concern in mail survey studies. There are four common sources of nonresponse that can occur: people may be away from their home for some reason (i.e. vacation or work), people may refuse to answer,

people may be unable to answer the survey, and people may not be found because they moved, etc. (Israel et al. 1992). Refusals can result from apathy, fear of privacy invasion, or for various other reasons. Researchers often compare characteristics of early respondents with late respondents (i.e. responses to the first and third waves of the survey instrument), because the presence of differences in these responses suggests that non-respondents are likely to be different as well. Early respondents have been found to be more likely to adopt practices of change than both later respondents and non-respondents (Israel et al. 1992).

In this study, we dated the survey instrument on the day that it was received by the researcher so that responses from survey instruments returned early could be compared to survey instruments returned later and conclusions could be drawn about the responses of those people that had not returned the survey instrument. As each questionnaire was received, it was opened and assigned a serial identification number for easy tracking. Extrapolation over successive waves of returned surveys should reflect the characteristics of non-respondents (Filion 2001).

Another potential source of bias characteristic of mail surveys involves respondents that have a well-formed opinion about the topic addressed by the survey. The respondent sample in this study may be biased by a predominance of those people most interested and most opposed to gopher tortoise conservation. The people that are pro-conservation and anti-conservation may be better represented than the people that fall in the middle of this continuum. These people with extreme opinions may already have a more rehearsed opinion than people that do not have a prior interest in the issue. Researchers believe that respondents that have a prior interest in a subject have

had more time to think about questions and to carefully weigh their answers. These respondents are more likely to have pre-formed answers that may be impacted by social pressures to adopt one belief over another belief. If the respondent has no prior interest or knowledge of an issue, he or she must decide what they feel or think at the moment of answering and are less likely to have answers influenced by social pressure (Hippler & Schwarz 1987).

Data Analysis

Several analyses were used to draw conclusions about the population as a whole, compare knowledge and opinions, and see how strongly variables were related. The survey instrument was precoded with spreadsheet codes. Data was placed into an Excel spreadsheet and imported into SPSS 17.0 (SPSS, Englewood Cliffs, New Jersey 2009) to conduct all statistical analyses. We treated the 5-point Likert scale questions as interval level data in our analyses. Nonresponse bias was checked using a t-test to compare the demographics between early and late respondents. We used Pearson's correlation coefficient to examine relationships between continuous variables of interest. More specifically, we tested the following relationships:

- Interest in government assistance programs vs. age
- Interest in government assistance programs vs. income
- Interest in government assistance programs vs. valuation of importance of managing for game or non-game species
- Tortoise occurrence vs. valuation of importance of managing for game or non-game species

We used ANOVA to test for difference between means of groups. More specifically, we tested the following relationships:

- Interest in government assistance programs vs. level of education

- Willingness to use prescribed burning vs. level of education
- Willingness to use prescribed burning vs. top priority land use
- Knowledge of gopher tortoise ecology vs. level of education
- Knowledge of gopher tortoise ecology vs. tortoise occurrence

We used the common practice of combining answers to related questions into a composite scale (Babbie 2007). We grouped the questions that asked about interest in government assistance into one scale and questions about knowledge of tortoises into another. The reliability of these scales was checked using Cronbach's alpha.

Results

Response Rate

We mailed a total of 2,584 survey packets and 259 were returned as undeliverable. Respondents completed and returned a total of 534 survey instruments, giving us a response rate of 23%. There was no difference in mean age (t_{250} = - 0.756; p = 0.450) or mean income (t_{250} = - 0.109; p = 0.913) between early versus late respondents. This result indicates there was little difference in the demographics of early versus late responders, which suggests little need to weight the data to adjust for nonresponse bias.

Study Population Demographics

We compared U.S. Census demographic data for the three counties with demographic data from our study sample to assess the differences between our sample and the true population of interest (Table 2-5).

Gopher Tortoise Occurrence

Occurrences of gopher tortoises on landowners' properties increased by a factor of 3.28 when longleaf pine habitat covered most of the private property (p = 0.001). Occurrences increased by a factor of 2.66 when recreation was rated as the highest priority for land use (p = 0.001). Occurrences increased by a factor of 2.23 when a

natural setting was rated as the highest priority for land use ($p = 0.002$). Other ecological characteristics were not statistically significant at $p \leq 0.05$.

Tortoises occurred in a variety of habitat types and most respondents reported having tortoises in multiple habitat types on the same property. Respondents reported tortoises in mixed pine habitat (42%), longleaf pine (15%), pasture (23%), loblolly pine (27%), slash pine (11%), row crops (0.03%), and other habitat types (0.09%). Respondents used a variety of land management practices in areas where tortoises occurred. Respondents reported using prescribed burning (13%), food plots (12%), mowing (6%), disking (6%), herbicides (5%), grazing (5%), fire ant control (4%), and bedding (0.37%). No landowners used thinning.

There was no correlation between the respondent's valuation of importance of managing for game species versus non-game species and tortoise occurrence ($R^2 = -0.081$; $p = 0.065$). There was no significant difference in occurrences of gopher tortoises between the three counties ($F_{2, 519} = 0.718$; $p = 0.488$).

Willingness to Use Prescribed Burning to Benefit Non-game Species

We tested demographic data, knowledge about the importance of gopher tortoises to other wildlife, and valuation of importance of managing for game species versus non-game species with willingness to use prescribed burning to benefit non-game species (Table 2-6).

Landowners' Knowledge of Gopher Tortoises

We constructed a knowledge scale, but the test for reliability showed low internal consistency (alpha = 0.508), indicating that knowledge of one aspect of gopher tortoise biology was not highly correlated with knowledge of other aspects. No relationships were apparent between either age or income and knowledge of any of the six topics

asked about gopher tortoise biology (questions 2.1-2.6). We tested knowledge questions with education (Table 2-7), other knowledge questions (Table 2-8), and tortoise occurrence (Table 2-9).

Tukey post-hoc comparisons indicated respondents who graduated high school ($p = 0.041$) gave significantly higher ratings on confidence in being able to distinguish burrow types than respondents who had completed graduate degrees. Respondents who completed vocational/technical school had better knowledge of which foods gopher tortoises eat than respondents who had graduated college ($p = 0.011$), and those respondents who had completed a graduate degree ($p = 0.012$). Respondents who completed some college had better knowledge of which foods gopher tortoises eat than respondents who had graduated college ($p = 0.024$), and those respondents who had completed a graduate degree ($p = 0.029$).

Tukey post-hoc comparisons indicated that respondents who thought tortoises were important to other wildlife gave significantly higher ratings of tortoise occurrence than respondents who responded they did not think tortoises were important to other wildlife ($p = 0.001$) or who were unsure if tortoises were important to other wildlife ($p = 0.001$). Respondents who thought tortoise numbers were increasing were significantly more likely to currently have tortoises on their property than respondents who thought tortoise numbers were decreasing ($p = 0.001$). Respondents who thought tortoise numbers were decreasing were significantly more likely to currently have tortoises on their property than respondents who thought tortoise numbers were staying the same ($p = 0.001$).

Respondents who were confident in their ability to identify tortoises gave

significantly higher ratings for tortoise occurrence than respondents who were not confident in their ability to identify gopher tortoises (p = 0.001) and respondents who were unsure of their ability to identify tortoises (p = 0.001). Respondents who were confident in their ability to distinguish between burrow types gave significantly higher ratings for tortoise occurrences than respondents who were not confident in their ability to distinguish between burrow types (p = 0.001) and respondents who were unsure of their ability to distinguish between burrow types (p = 0.001).

Respondents who were not confident in their ability to distinguish between burrow types gave significantly higher ratings for tortoise occurrence than respondents who were unsure of their ability to distinguish between a gopher tortoise burrow and an armadillo burrow (p = 0.018). Respondents who thought tortoises ate blueberry gave significantly higher ratings for tortoise occurrences than respondents who thought tortoises ate gopher apple (p = 0.001) and respondents who thought tortoises ate bluestem (p = 0.045).

Interest in Government Assistance

Cronbach's coefficient alpha was calculated to test the reliability of the government assistance scale. The scale had an alpha of 0.713, indicating a high level of internal consistency. We tested demographic data and valuation of importance of managing for game species versus non-game species with interest in government assistance (Table 2-10).

Tukey post-hoc comparisons indicated that of the seven education categories, respondents who only had a high school degree (p = 0.001) had significantly higher interest ratings than respondents in the other groups.

There was a relationship between interest in government assistance and county of

residence ($F_{2, 531} = 67.494$; $p = 0.001$). Tukey post-hoc comparisons of the three counties indicated that respondents who lived in Jackson County (mean = 2.1709) gave significantly higher interest ratings than respondents who lived in Wayne County (mean = 1.7394) and Marion County (mean = 1.3194). Respondents from Wayne County gave significantly higher interest ratings than respondents who resided in Marion County.

Discussion

Gopher Tortoise Occurrence

While longleaf pine stands and properties managed to provide a natural setting had the majority of tortoises, properties managed to provide opportunities for recreation also had several tortoise occurrences. Landowners would benefit from assistance by wildlife managers in creating more natural areas or enhancing currently used tortoise habitat within recreational areas. Landowners must be reassured that they will still be able to use their land for recreation, but at the same time they can provide increased areas of suitable habitat for tortoises. These landowners would possibly be more accepting of tortoise management practices if they are educated about how tortoises and certain land uses like hunting are not mutually exclusive.

Many respondents reported they were currently practicing fire ant control and prescribed burning, but both management practices could be increased to give tortoises more favorable habitat. Workshops on fire ant control and prescribed burning would be helpful to landowners and might encourage use of these management practices. Wildlife managers might also visit landowners' properties to assess the actual threat of fire ants to tortoises and recommend the best method for control. In addition, managers might help landowners conduct the first burn or two on their lands in order to teach them proper techniques and safety.

Willingness to Use Prescribed Burning to Benefit Non-game Species

The positive correlation between age and willingness to use prescribed burning suggests that older respondents should be targeted with education programs about prescribed burning. Individuals who have been exposed to education programs about the benefits of fire are much more likely to support the use of prescribed fire as a tool for resource management (Jacobson et al. 2001; Loomis et al. 2001). Older individuals would also benefit from demonstrations of proper prescribed burning procedures.

Education programs about prescribed burning should also target younger age groups by reinforcing positive views of prescribed burning. A good method of educating local landowners involves utilizing the diffusion theory whereby pertinent information is given to recognized opinion leaders in the local community. Information will then diffuse from the opinion leaders to the informed landowners in a community until it finally reaches the uninformed landowners (Jacobson 2009). The opinion leaders may be the respondents who think that tortoises are important to other wildlife, because there is a positive correlation between this factor and willingness to use prescribed burning to benefit non-game species.

Mississippi may also want to model Florida's creation of three Prescribed Fire Councils, which consists of agency, industry, and landowner alliances. The Wildland Fire Education Working Team of the National Wildfire Coordinating Group has developed key messages that land management agencies are encouraged to use in outreach programs (Jacobson 2009). These messages may be adapted to use with private landowners. Focus groups may also be conducted to identify the needs for different age groups concerning the use of prescribed burning. Younger age groups

may have different needs and interests that will encourage them to use prescribed burning than older landowners.

Landowners' Knowledge of Gopher Tortoises

Programs teaching gopher tortoise facts need to target individuals with higher education. Education programs should utilize facts and theories about tortoises and management in combination with hands-on demonstrations and outdoor workshops. Landowners would also benefit from activities that take them in the field to increase their personal experiences with and observations of tortoises. In addition, education about the types of plants that tortoises eat and their identification might help landowners to better manage for tortoises.

Programs should be developed to educate landowners to increase their knowledge about the tortoises' ecology/ecological role to help them see the valuation of importance of managing for non-game species as well as game species and to demonstrate that management practices that benefit tortoises can benefit game species as well. These landowners may be hunters who value game species more than non-game species and may think that tortoises are not important to game species.

Interest in Government Assistance

Knowing the type of people who are most interested in government assistance will help agencies focus their efforts on that section of the population which most likely to want to participate in programs. The positive correlation between age and interest in government assistance indicates that programs should target older individuals for participation in government assistance programs. Individuals with only a high school education should also be targeted with campaigns that introduce them to the available government assistance programs.

Individuals who believe that game species were more important to manage than non-game species should be targeted with campaigns that educate them about and encourage them to participate in government assistance programs. Programs can place emphasis on the fact that gopher tortoise management practices can increase the number of game species like turkeys and deer on their properties. Programs should reassure hunters that having tortoises on their properties will not interfere with using their lands for hunting. Hunting is an important part of southeast Mississippi's culture, and hunters may be afraid that hunting and tortoise management are contradictory to each other.

Final Recommendations

Landowners are most likely to be interested in programs that help them achieve their goals of being able to hunt, use recreational vehicles, etc. on their lands, while incorporating ways to provide habitat for tortoises. It is important that recommendations on providing tortoise habitat do not cause problems with their highest priority land use. Programs should make landowners feel like they are doing something important and that they are a crucial part. If respondents are made to feel important and valued, they will be more likely to cooperate.

An informational campaign about government assistance programs should target older and less educated landowners. These demographics will need to be considered when designing education programs and outreach efforts. Locations where these landowners might be commonly found could be determined and material about government assistance programs could be placed in these areas (if permitted). The key will be to make learning about these programs as easy as possible for the landowners in these demographic categories.

Jackson County's older individuals should be targeted with education programs and outreach about government assistance programs. Jackson County is closer to the coast than the other two counties and may have been impacted more by the devastation caused by Hurricane Katrina. Programs to assist with clean-up and restoration of tortoise habitat might benefit landowners and encourage them to adopt tortoise management practices.

The other two counties would still benefit from assessments to see the type of help landowners need to restore their properties to create suitable tortoise habitat (if they are interested in receiving government assistance). Wildlife managers should visit properties that request help and assist with the creation of action plans. These action plans would give a guide for the steps needed to restore properties to provide tortoise habitat.

Table 2-1. Predictions regarding gopher tortoise occurrence.

Variable assessed	Prediction
Education	Occurrence of tortoises should increase with education
County	Occurrence of tortoises should vary by county

Table 2-2. Predictions regarding willingness to use prescribed burning to benefit non-game species.

Variable assessed	Prediction
Age	Willingness to burn should increase with age
Education	Willingness to burn should increase with education
Income	Willingness to burn should decrease with income
Knowledge about the gopher tortoise's ecology and required land management practices	Willingness to burn should increase with knowledge of tortoise ecology
Valuation of the importance of managing for game species versus non-game species	Willingness to burn should increase with equal valuation of the importance of managing for both game and non-game species

Table 2-3. Predictions regarding knowledge of gopher tortoise ecology.

Variable assessed	Prediction
Education	Knowledge of gopher tortoises should increase with age
Valuation of the importance of managing for non-game and game species	Knowledge of gopher tortoises should increase with more valuation of non-game species relative to game species

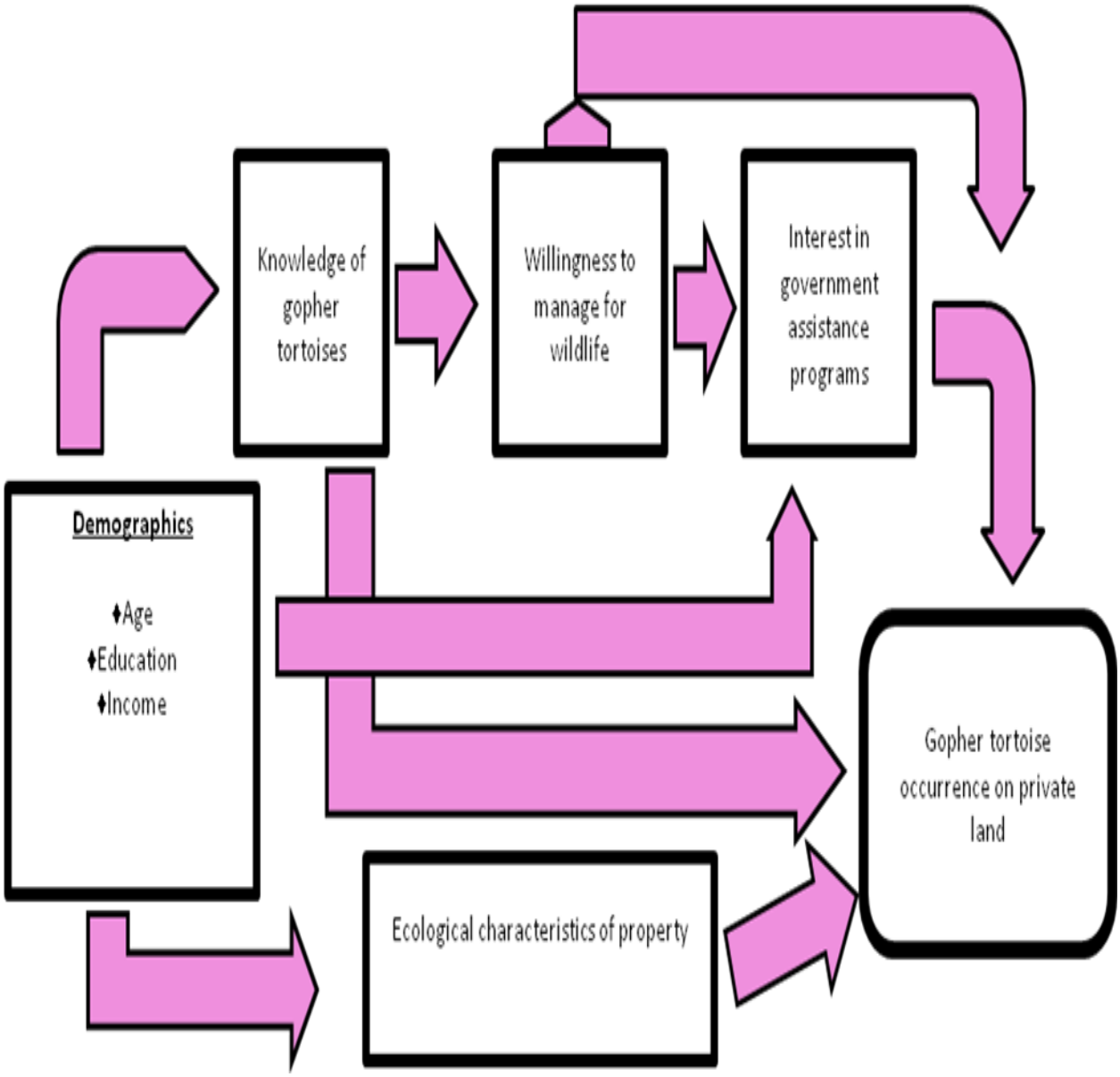

Figure 2-1. Conceptual diagram of factors influencing gopher tortoise occurrence on private lands.

Table 2-4. Predictions regarding interest in government assistance programs.

Variable assessed	Prediction
Age	Interest in government assistance should increase with age
Education	Interest in government assistance should increase with education
Income	Interest in government assistances should decrease with income
Knowledge about the gopher tortoise's ecology/ecological role and required land management practice	Interest in government assistance programs should increase with knowledge of tortoise ecology
Valuation of the importance of managing for game species versus non-game species	Interest in government assistance should increase with equal valuation of the importance of managing for both game and non-game species

Table 2-5. Comparisons between census/NCDC demographics and study sample demographics from Jackson County, Marion County, and Wayne County, Mississippi (U.S Census Bureau 2009; North Carolina Department of Commerce 2009).

Demographic Category	Jackson County		Marion County		Wayne County	
	U.S. Census/ NCDC	Study Sample	U.S. Census/ NCDC	Study Sample	U.S. Census/ NCDC	Study Sample
No. of people	130, 694	166	25, 830	194	20, 755	174
Median age	37	65	39	55	36	45
% with only h.s. degree	81%	14%	67%	20%	65%	17%
% with B.S. or higher degree	17%	48%	12%	44%	10%	50%
Median household income	$43, 411	$90,500	$30, 948	$45,500	$32, 078	$90,500
Urban : rural	68% : 32%	7% : 93%	31% : 69%	1% : 99%	23% : 77%	6% : 94%

Table 2-6. Statistical relationships between willingness to use prescribed burning to benefit non-game species and other variables of interest.

Test variable	Relationship	F value	R^2 value	P-value
Age	Positive correlation	N/A	0.031	0.001
Income	None	N/A	- 0.001	0. 976
Knowledge about the importance of gopher tortoises to other wildlife	Negative correlation	N/A	- 0.377	0.001
Valuation of importance of managing for game species versus non-game species	Positive correlation	N/A	0.569	0.001
Education	None	1.116	N/A	0.352

Table 2-7. Statistical relationships between landowners' knowledge of gopher tortoises and landowners' education.

Test variable	Relationship	F value	R^2 value	P-value
Confidence in identifying gopher tortoise burrows	N/A	$F_{6, 515} = 2.569$	N/A	0.018
Foods eaten	N/A	$F_{6, 515} = 4.362$	N/A	0.001

Table 2-8. Statistical relationships between landowners' valuation of the importance of managing for game species versus non-game species and landowners' knowledge of gopher tortoises.

Test variable	Relationship	F value	R^2 value	P-value
What respondents thought about gopher tortoise population trends	Negative correlation	N/A	- 0.089	0.043
Respondents' confidence in their ability to identify gopher tortoises	None	N/A	0.034	0.439
Respondents' confidence in their ability to distinguish between burrow types	None	N/A	- 0.049	0.267
What food respondents thought tortoises ate	None	N/A	-0.085	0.051
Which management statements respondents believed to be correct	Negative correlation	N/A	- 0.207	0.001

Table 2-9. Statistical relationships between landowners' knowledge of gopher tortoises and tortoise occurrence.

Test variable	Relationship	F value	R^2 value	P-value
Valuation of importance of managing for game species versus non-game species	Negative correlation	N/A	-0.523	0.001
What respondents thought about tortoises' importance to other wildlife on their lands	Negative correlation	N/A	-0.523	0.001
What respondents thought about tortoises importance to other wildlife on their lands	N/A	$F_{2, 519}$ = 23.68	N/A	0.001
Gopher tortoise population trends	N/A	$F_{2, 519}$ = 58.91	N/A	0.001
Confidence in identifying gopher tortoises	N/A	$F_{2, 519}$ = 106.574	N/A	0.001
Confidence in ability to distinguish between burrow types	N/A	$F_{2, 519}$ = 86.889	N/A	0.001
Foods gopher tortoises eat	N/A	$F_{2, 519}$ = 28.102	N/A	0.001
Which management statements respondents believed to be correct	None	$F_{2, 519}$ = 1.085	N/A	0.339

Table 2-10. Statistical relationships between interest in government assistance programs and other variables of interest

Test variable	Relationship	F value	R^2 value	P-value
Income	None	N/A	-0.052	0.267
Age	Positive correlation	N/A	0.039	0.001
Education	N/A	3.412	N/A	0.003
Valuation of importance of managing for game species versus non-game species	Negative correlation	N/A	-0.581	0.001

CHAPTER 3
CASE STUDIES OF PRIVATE LANDOWNERS INTERVIEWED IN JACKSON, MARION, AND WAYNE COUNTIES

Introduction

Research has progressed from studying behaviors and attitudes toward wildlife to acquiring a more basic understanding of key belief patterns that influence these attitudes and behaviors toward wildlife. Understanding underlying beliefs about wildlife can help determine societal-level changes in wildlife perception over time and allow managers to predict the level of public support about certain wildlife issues.

Values are the most central component of a belief system and the foundation of a person's view toward the environment. Basic beliefs strengthen and give meaning to fundamental values (Vaske & Donnelly 1999). Patterns of basic beliefs create value orientations (Fulton et al. 1996). Such values tend to be widely shared by the same culture (Fulton et al.1996; Vaske & Donnelly1999). Personal experiences with wildlife can also determine value orientations toward wildlife (Tarrant et al. 1997).

Manfredo et al. (2003) and Teel et al. (2007) have proposed that there needs to be a societal level shift in wildlife value orientations from a materialistic orientation to a more mutualistic view of wildlife to achieve long-term conservation of rare species. A materialistic orientation looks at wildlife as a resource that provides benefits to humans. Mutualism sees wildlife as having rights like humans, deserving of care and compassion (Katcher & Wilkins 1993; Serpell 2003; Vining 2003). Some people believe that accepting wildlife's right to their habitat is a step towards mutual respect and some people believe it is a human obligation (Raadik & Cottrell 2007).

The current rate of loss of biodiversity necessitates a better understanding of how humans value wildlife so that policy-makers can tailor their efforts to encourage

behaviors that promote biodiversity. As people become more urbanized, they are more removed from the natural world and wildlife. Urbanized populations may have some exposure to and concern for certain species, but daily contact with nature and wildlife has declined as a result of urbanization (Kellert 1996). A species that is not valued by humans is more likely to receive little concern, have their habitat requirements ignored, and is more likely to decline to rarity or extinction than a species that humans value (Fulton et al. 1996; Vaske & Donnelly 1999).

The human value placed on a species may be one of the most important determinants behind that species' survival (Fulton et al. 1996; Vaske & Donnelly 1999). Qualitative research methods provide an effective approach to discovering the determinants of wildlife value orientations. Interviews help illuminate influences on the value that people give to different wildlife in their own words. The use of interviews can help increase understanding of the whole picture that illustrates people's values toward wildlife (DeRuiter & Donnelly 2002).

Interpretive research involves use of qualitative data such as interviews, discussions, and participant observations. Qualitative data can provide the researcher with a variety of viewpoints to help facilitate an understanding of the factors of interest more fully (Henderson 1991). This approach uses qualitative data to build a complex, more holistic word picture that explains detailed views of the participants obtained in a setting more natural to the participant (Creswell 1994). Participant selection for interpretive research is not intended to give a representative sample of the larger population being studied, but rather to gain an in-depth understanding of a specific subsample of subjects (Davenport & Anderson 2005). Qualitative sampling seeks

information richness and selects the cases more purposefully rather than trying to get a representative sample (Crabtree & Miller 1992). A qualitative, interpretive approach preserves contextually relevant details as it documents differing accounts of reality (Davenport & Anderson 2005). Researchers argue that certain information can be difficult or even impossible to obtain by using means other than qualitative approaches like the case study (Sykes 1990).

Case studies are now a common research strategy. Their contextual nature and strength in addressing contemporary phenomena in real-life contexts make them a useful research tool (Meyer 2001). Case studies are intensely focused on a small sample of cases so that they explore new processes and behaviors or ones that are not well understood in more detail than a study with a larger sample is capable of exploring (Hartley 1949). Since the researcher has more time to focus on each case, this approach is useful for exploring the more complex how and why questions instead of just the who, what, and where questions (Leonard-Barton 1990). The detailed observations that are possible in the case study method allow the researcher to provide a closer examination of each case, examine cases in relation to each other, and view the process being researched within its total environment whereas a larger study might not have the time, manpower, or funding for such close examination of large samples (Gummesson 1988).

The biggest strength of personal research is that it allows flexible and responsive interaction between the interviewer and the respondents (Sykes 1990). With this type of research, meaning can be probed, topics covered more easily, and questions made clearer for respondents. Another great strength of personal interviews is the validity of

data obtained because individuals are questioned in greater detail than other means of investigation allow. The respondent's opinions and understandings can be more thoroughly explored in an interview (Hakim 1987).

Theoretical Framework

In this study, face-to-face interviews were used in an effort to supplement the mail survey data, but were analyzed separately from the survey data. Interviews offer further insight into the thinking processes and values of individuals. More specific questions can be asked in interviews than is possible with mail surveys.

With regards to the population of interest in this study, the additional information gathered from the interviews can help construct the education and outreach program in a way that will most effectively reach private landowners. The addition of the interview approach to gopher tortoise conservation efforts may increase the likelihood of their continued persistence and recovery by aiding in further understanding private landowners and their views of gopher tortoises. However, researcher bias must be identified and minimized by using a standardized list of questions for every interview and by writing the interviewee's response verbatim.

Study Description and Research Questions

This study examines the relationships between landowners' opinions about gopher tortoises and their willingness to conserve gopher tortoises by answering the following research questions:

1. What are the trends in gopher tortoise occurrence on private lands?
2. What threats to gopher tortoises are present on private lands?
3. What are the ecological conditions on properties where gopher tortoises persist?

4. What sources of information about gopher tortoises are landowners being exposed to?
5. What is the nature of the information landowners know about gopher tortoises?
6. How are opinions about gopher tortoise conservation characterized?
7. Are landowners willing to make compromises to better protect gopher tortoises?
8. What is the relative importance of gopher tortoises to landowners compared to other concerns?
9. What are the preferred means of information transfer?
10. What is the interest level in financial incentive programs?

Methods

Sample Strategy and Interview Procedure

Mail surveys were sent to 2,584 randomly selected landowners in three randomly selected counties who own >25 acres of land in Southeast Mississippi. The interview sample population consisted of a small subset of 135 private landowners who received mail surveys and returned the enclosed postcards, indicating that they would be willing to allow a visit and an interview. Ten postcards from each county were randomly chosen from all of the postcards returned. Thirty landowners total were visited; ten people per county.

During June 2009, we conducted the thirty face-to-face interviews. Standardized interview questions (Appendix E) approved by the University of Florida's Institutional Review Board were asked of interviewees. Phone calls or e-mail contact was then made by the researcher to schedule a time for the interviews. When relying on interviews for data collection, the issue of building trust between the researcher and the interviewees is extremely important. Trust can be built by contacting potential interviewees before the interviews (King 1994). Phone calls that were made to

landowners followed a prepared script (Appendix D) approved by the University of Florida's Institutional Review Board to help with standardization.

The interviews were sit-down-interviews. They occurred on the landowners' properties. To place them at ease, the interviewees were read a short paragraph stating that they did not have to answer any questions that they were uncomfortable with and that their identity would be kept confidential. The interview was informal and casual to make it appear more like a regular discussion than a structured interrogation. The goal of the interview was to see the research topic from the perspective of each interviewee and to understand why he or she came to have the particular perspective that he or she held. As recommended, the interviews had a preponderance of open questions to encourage free thinking (King 1994).

Potential Sources of Bias from Postcard Sample

The sample may be biased towards people that have more interest in the issue and that have more favorable opinions about gopher tortoise conservation and government assistance programs. Landowners with more negative views towards these issues may have been less likely to agree to the request for an interview. It was also a very small subset (0.01%) of the mail survey population and may not be representative of the larger population that responded to the mail survey. However, the desire for depth and different perspectives implies that the number of cases must be relatively small. Using a small number of cases allows for more comparison and contrast between the cases and a deeper and richer look at each individual case.

Landowner Introduction to Government Conservation Assistance Programs

After each interview, the researchers introduced the interviewees to government assistance programs available to aid with gopher tortoise conservation. Handouts with

pictures of animals covered under the programs and the type of habitat suitable for these animals were given to interested landowners. Contact information for the various agencies involved in administering these programs was placed at the bottom of the handout. Landowners were encouraged to explore the programs for themselves and see if they would be willing to participate.

The programs available to private landowners in Mississippi include the Safe Harbor Agreement (SHA), the Candidate Conservation Agreement with Assurances (CCAA), and the Healthy Forests Reserve Program (HFRP). These handouts introduced landowners to these assistance programs in a manner that was both visually appealing and informative. This method proved effective in conveying the message and as an education tool. It provided brief, but important information that landowners had previously been unaware of.

Gopher Tortoise Assessment and Vegetation Sampling of Interviewee's Property

After discussing incentive programs, each landowner was asked to show the researcher the general area(s) where he or she had most recently seen gopher tortoise burrows. Areas that were sandhills, flatwoods, scrub, pasture, planted pines, mixed pine-hardwood, old fields, and right-of-ways were examined. We began our surveying in the spots were gopher tortoises had been recently seen by the landowner.

The navigator began by carrying a GPS unit and walking a straight line while pointing a compass direction that bisected the forest stand. The navigator identified any burrows that were within 8 m on either side of the transect as he/she walked. A flag was placed every 10 m to mark the line surveyed. We walked 250 m or to the far edge of the stand if it was less than 250 m, with each individual observing a swath 16 m wide. A 32 m strip was covered using this process. Then, we moved over 20 m and repeated

the process in the other direction, adding 180˚ to the original compass bearing. We walked as many transects as were required to cover an acre.

Once more than two burrows were found on a single 250 m transect that had been walked by two observers, the survey was discontinued and the area was labeled as a “High” tortoise density area. If < 2 burrows were observed in the first acre surveyed, we walked at least one more transect in the stand, depending on the stand size, before categorizing its density. The following list was used to categorize density (low-high) of gopher tortoises in a stand:

- Low: < 0.5 tortoise per acre (≤ 1 burrow per acre)
- Medium: 0.5-1 tortoise per acre (1-2 burrows per acre)
- High: > 1 tortoise per acre (≥ 2 burrows per acre)

Only burrows with half-moon shaped openings, flat bottoms and arched roofs, width twice the height, and sandy mounds in front were counted as gopher tortoise burrows. Burrows with debris occluding the opening were counted, but burrows with a collapsed roof or vegetation growing at the base of the opening that would prevent a tortoise from entering the burrow were excluded from the count (FWC 2007).

To obtain a better understanding of the habitat conditions in areas where gopher tortoises were found, we measured a variety of biotic factors, including percent cover of trees, shrubs, and herbaceous groundcover at numerous locations on the six properties where tortoises currently occurred. Within these six properties, a total of seven stands and 19 plots were measured.

We used methods from the United States Fish and Wildlife Service (2009) to conduct our vegetation sampling. This method was designed to allow researchers to conduct a quick assessment of the number of tortoise burrows in the area being

surveyed. The location at which vegetation estimates were taken was obtained by selecting a random UTM coordinate from a random number table. At this location we used a convex densitometer to obtain estimates of canopy cover by averaging readings taken while facing north, south, east, and west. Shrub cover was determined by putting flags at a 4 m radius in each direction from the plot center. The percentage cover of shrubs inside this area was ocularly estimated, using the following categories:

- < 1%
- 1-5%
- 6-25%
- 25-50%
- 51-75%
- 76-100%

Next, groundcover was determined by measuring 3 m in each direction from the plot center. A 1 m x 1 m PVC square was placed on the ground at each location and an ocular estimate was made, using the above categories to estimate the percentage of areal coverage of herbaceous groundcover. Basal area of trees was estimated using a prism.

A new random UTM coordinate was determined in the same manner as the first coordinate and the process repeated. Five points per stand were done when possible not to overlap. The presence of threats like cogongrass, fire ants, and vehicular traffic were also visually assessed and documented.

Data Analysis

For analysis, responses to interview questions were grouped into five categories:

- ecological characteristics of properties (Questions 12, 13, 15, 23, and 24)
- trends in gopher tortoise occurrence (1, 2, 3, 4, and 16)
- sources of information about gopher tortoises (4, 5, 6, 7, and 19)
- interest in financial incentives (20, 21, and 22)
- interest in wildlife conservation (8, 9, 10, 11, 17, and 18)

Similar answers to each question were grouped. A count of these similar answers was conducted for each question and the counts were transformed into percentages (Sanders et al. 2009).

For the vegetation survey, average values for each vegetative characteristic measured were calculated for each property. These averages were then used to calculate an average of all of the sites to determine the typical vegetation characteristics of the areas on private lands where gopher tortoises are persisting. The basal area per acre of trees was calculated by counting number of trees in a circle when looking through 10 BAF prism and multiplying the count by 10 (Martin 1996). This result gives the estimate of basal area per acre (ft^2/acre).

Results

Sample Population Demographics

Demographic information on the sample was collected at the time of the interview. The majority of landowners (99.97%) were greater than 50 years of age. The majority of landowners (99.97%) were born in Mississippi. Nearly every landowner (99.97%) hunted or had family who hunted. Most landowners (99.94%) lived in a rural area close to a larger city.

Professions of interviewees included farmers, foresters, and educators. A fairly small proportion of all jobs (8.5%) in Mississippi involve forestry (Mississippi Forestry Association 2009), but the case study sample population had a large percentage of landowners that conducted timber harvesting. The majority of landowners interviewed owned large tracts of land for timber or hunting that they did not regularly live on, which is typical of Mississippi (Sun et al. 2008).

Ecological Characteristics of Properties

We assessed through observation and interviews a variety of threats to tortoises on properties visited (Table 3-1).

Some landowners (10%) used Arsenal (trademark of BASF; contains imazapyr) while nearly four times as many landowners (38%) used Roundup (trademark of Monsanto; contains glyphosate). Some landowners used both Arsenal and Roundup on their properties and some landowners (21%) currently used other brands of herbicide. A small portion of landowners (10%) applied herbicides near tortoise burrows. However, most landowners either had not applied herbicides near burrows (21%) or did not have burrows (69%).

We found gopher tortoises persisting in a variety of human-altered habitats (on six properties ranging from 100-1300 acres). They were able to dig burrows where pipelines (1 out of 6 properties), timber harvesting (3 out of 6), crops (2 out of 6), and hunting (5 out of 6) occurred. Some sites had more than one type of human-altered landscape.

Trends in Gopher Tortoise Occurrence

Trends in gopher tortoise occurrences included the length of landowner's awareness of tortoises on his/her property (Table 3-2), when the landowner last saw tortoises on his/her property (Table 3-3), the landowner's view of tortoise population trends (Table 3-4), when the landowner saw young tortoises or small burrows on his/her property (Table 3-5), and landowners with neighbors with tortoises on their properties (Table 3-6).

Gopher tortoises face a number of threats from other animals. Fire ant (*Solenopsis invicta*) presence on properties was widespread, but gopher ticks

(*Amblyomma tuberculatum*) had not been observed by most landowners who had tortoises. Gopher tortoises also face potential threats from herbicide usage near burrows.

Sources of Information about Gopher Tortoises

A small percentage of landowners (10%) had learned about gopher tortoises through personal observation. Nearly a fourth of landowners (21%) had learned about tortoises from friends or family. Over a fourth of landowners (38%) had learned about tortoises from other people. Over a fourth of landowners (31%) had learned about tortoises from agencies, companies, and universities. A small percentage of landowners had learned about tortoises from the Internet (7%) and nearly a fourth of landowners had learned about tortoises from books (21%). A small percentage of landowners (3%) reported they had never received information before our survey. Most landowners had learned about gopher tortoises from at least two different sources.

Over half of the landowners (62%) said that the sources of information that they had encountered about gopher tortoises had presented information that gave a positive impression towards tortoises. Approximately a fourth of landowners (24%) stated that sources that they had learned from had presented information that gave a negative impression. Less than a fourth of landowners (14%) had learned from sources that they categorized as neutral and less than a fourth of landowners (14%) had no answer. Again, landowners often gave more than one answer about different types of information sources that they had encountered.

Landowners listed public sources (28%), agencies and universities (14%), the Internet (7%), books (10%), and family and friends (10%) as giving information that presented positive impressions towards tortoises. Other people as sources (17%) and

the Internet (3%) were rated as giving information that presented negative impressions towards tortoises. Other sources (14%) were rated as neutral in impression. Nearly three-fourths of the landowners (72%) said that these sources had instilled in them a positive opinion about gopher tortoises. A small percentage of landowners (3%) said that the sources had instilled in them a negative opinion and a small percentage of landowners (3%) had no answer. Nearly a fourth of landowners (21%) felt that the sources had created a neutral opinion.

Landowners (21%) mentioned that magazines would be a good medium to use in attempts to foster positive attitudes towards gopher tortoises in landowners. A few landowners (17%) mentioned television or other types of mediums. A small percentage of landowners (10%) answered newspapers and unsure. A very small percentage of landowners (3%) mentioned public education programs, pamphlets, posters, and billboards. Landowners (7%) also said personal letters to landowners, mailings, and other types of publications would be effective. Over a fourth of landowners (31%) mentioned that just getting any type of information out would be helpful to landowners and cited a huge lack in available information. Most landowners learned about gopher tortoises from at least two different sources and often gave more than one answer about different types of sources they had encountered.

Interest in Financial Incentives

Over half of the landowners (62%) said that a financial incentive would encourage them to adopt land management practices that benefit gopher tortoises. Possible constraints made some landowners (28%) hesitant, but they were open to exploring the available programs. Most landowners (55%) were not able to provide an answer when asked how much money per year would be sufficient to encourage them

to conduct one prescribed burn every three years. A few landowners (24%) said that any amount would encourage them. The primary reason that landowners (69%) were not currently enrolled in a wildlife incentive program was that they were not aware of the programs. A small group of landowners (21%) were concerned about committing to particular types of land management.

Interest in Wildlife Conservation

Nearly half of the landowners (45%) had tried land management practices like prescribed burning, due to what they had learned about gopher tortoises. Over one-third of landowners' reported that their management practices (39%) were not affected by their knowledge of gopher tortoises. Less than a fourth of landowners (16%) reported other reasons, such as inability to do prescribed burning, for not engaging in land management activities that would benefit tortoises. Of the ten landowners who currently burned, less than a fourth of landowners (17%) burned because of the presence of gopher tortoises on their lands.

Most landowners (90%) considered gopher tortoises and other wildlife when they planned for future land use. Over half of the landowners (79%) gave wildlife high priority relative to other land uses. A small percentage of landowners gave medium priority (10%), neutral priority (7%), and low priority (3%) to wildlife relative to other land uses. Timber (34%), farming (17%), and livestock (14%) were listed by landowners as a higher priority than wildlife.

Nearly half of landowners (45%) said that they rated gopher tortoises as high a concern to them compared to other wildlife. A small percentage of landowners (7%) rated them as a moderate concern. Less than a fourth of landowners (14%) considered tortoises to be of neutral concern to them and more than a fourth of landowners (34%)

have little concern for gopher tortoises compared to other wildlife. Landowners had different perceptions about the overall attitude of other people who live in their counties towards gopher tortoises. More than a fourth of landowners (34%) seemed unsure, while other landowners believed the attitude is positive (24%), neutral (28%), or negative (1%).

The majority of landowners (86%) stated that they were able to make land management decisions that allowed them to achieve their goals and benefit gopher tortoises. Although nearly half of landowners (45%) thought that their neighbors were willing to manage their lands for gopher tortoises, most landowners (52%) were unsure if their neighbors were willing to manage for gopher tortoises.

Tortoise Burrow and Vegetation Sampling Survey Findings

Only six of the 30 properties visited currently had tortoise burrows. Most tortoise burrows on the six properties occurred in mixed hardwood-pine stands. We assessed the tree species present, land use, and tortoise density at sites that had burrows. Oaks were present at 83% of sites with tortoise burrows, loblolly pines at 67%, and longleaf pines at 50%. The land use was natural forests at 67% of sites, timber harvesting at 50%, hunting at 33%, power lines at 17%, and pipelines at 17%. The density of tortoises (in tree stands) was high at 72% of sites and low at 28%.

The stands with higher densities of tortoise burrows had less tree canopy coverage, more herbaceous groundcover, and sandier soils than the stands with fewer densities of tortoise burrows. The higher density stands were also located in more natural areas with less human-impact. We assessed the average vegetation measurements at the sites with burrows (Table 3-7).

The common soil types found in areas where gopher tortoises most often

occurred were Bassfield sandy loam (coarse-loamy, siliceous, semiactive, thermic Typic Hapludults) and Latonia sandy loam (coarse-loamy, siliceous, semiactive, thermic Typic Hapludults). We determined the soil characteristics at the sites with burrows (Table 3-6).

Discussion

Ecological Characteristics of Properties

Landowners could benefit from information about fire ant and armadillo control. The landowners should be taught that tortoises are preyed upon by red imported fire ants (*Solenopsis invicta*) and that armadillos can also cause problems for tortoises. Education programs should address that many predators, including armadillos and fire ants, will attack gopher tortoise nests (Douglass & Winegarner 1977; Diemer1992); fire ant predation accounts for 27% of posthatching mortality of gopher tortoise hatchlings (Epperson & Heise 2003); mammalian predators like raccoons are responsible for destroying most gopher tortoise nests (87% within the first few weeks after laying) and the surviving hatchlings are often attacked and killed by the red imported fire ant (Landers et al. 1980).

Use of glyphosate more than imazapyr should be discouraged, because imazapyr appears to be less toxic and persistent than glyphosate, even though imazapyr's effect on gopher tortoises has not been extensively studied. Landowners should be told that based on active ingredient concentrations required for herbicide efficacy and inherent toxicity, the use of glyphosate reduces the margin of safety relative to potential environmental exposure concentrations by up to three orders of magnitude (Murphy et al. 2003). The landowner education programs should encourage

the substitution of imazapyr for glyphosate in areas that have tortoises and reinforce that areas around burrows should not be sprayed.

Trends in Gopher Tortoise Occurrence

Efforts to simply increase awareness of gopher tortoises among private landowners might engender greater appreciation for the species and greater willingness to adopt practices that benefit them. The landowners (~ 25%) who had consistently been aware of gopher tortoises on their lands for long periods, but that had not been practicing beneficial management techniques should be targeted with education programs. These landowners need to be made aware of necessary management practices and have their fears of trying to conduct prescribed burning without assistance from professionals addressed. Education programs and pamphlets with pictures of gopher tortoises would reduce the misidentification of tortoises. Landowners should also be encouraged to attend regularly updated workshops on how to place conservation-minded land management practices into action on their lands (Uliczka et al. 2004). In addition, landowners should be offered workshops on regulations and laws concerning tortoises to reduce landowner fear of the government.

Sources of Information about Gopher Tortoises

Landowners' suggestions for mediums that could be used to increase the exchange of information about gopher tortoises, such as magazines that private landowners read should be considered as information pathways to reach landowners. Landowners should be encouraged to form cooperative community groups to share information about tortoises and to aid each other with tortoise management.

Since landowners who reported encountering sources with positive orientations toward tortoises were willing to allow visits to their properties, these landowners may

have a more positive view of tortoises. This positive view may have created a bias towards seeking out or better remembering the positive sources of tortoise information in these landowners. Overall, landowners cited a huge lack of available information about tortoises.

An education program needs to be launched to address the significant lack of information available to landowners about gopher tortoises from federal, state, and local government sources. Positive messages and information about tortoise management should be used to target and encourage landowners to participate in tortoise conservation. The ecological importance of tortoises should be emphasized to landowners.

Efforts to educate landowners about the status of gopher tortoises as well as their ecological and intrinsic importance might increase landowners' knowledge and help them understand the urgent need to act quickly to conserve gopher tortoises. New knowledge about biodiversity conservation must continuously be spread and accepted among the majority of landowners to prevent further decline of rare species. Landowners who attend educational programs will have more knowledge of biodiversity conservation and may also have a stronger tendency to have a more positive attitude towards conservation (Uliczka et al. 2004).

Interest in Financial Incentives and Wildlife Conservation

Support in the form of financial aid and physical help with management, especially prescribed burning, would be beneficial to landowners as well. Landowners would also benefit from being made aware of a localized source from which they could get information about gopher tortoises and conservation. Some type of program that encourages neighbors with gopher tortoises to work together to conserve the tortoises

left in the area might help with facilitating conversation about gopher tortoises among people in a community and cooperation among landowners with contiguous lands that have gopher tortoises on them.

Landowners should be taught about and encouraged to use land management activities that help gopher tortoises persist, like prescribed burning. Landowners should be encouraged to consider the impact that their management practices and land use will have on wildlife. If landowners understand the connectedness of all of these factors, they might be more effective with wildlife conservation efforts.

It should be emphasized that wildlife conservation does not have to conflict with landowners' land use goals. Landowners in areas that have potentially suitable tortoise habitat should receive handouts and other literature about incentive programs that allow tortoise conservation, while allowing other land use goals to be accomplished. Whole communities with potential tortoise habitat should be targeted with information about available programs to try to conserve multiple pieces of land for conservation in a single area.

Effectively designed education programs about gopher tortoises and the management practices like prescribed burning that the tortoises require should have a high success rate if they take the landowners interests and concerns into account. Channels of communication between agencies and landowners need to be open and cooperation fostered through respect and honest communication. Landowners need to feel like part of the solution and an adversarial relationship should be avoided.

Tortoise Burrow and Vegetation Sampling Survey Findings

If landowners are interested in tortoise conservation, but still want to supplement their income with pipelines, small areas of row crops, and areas for timber production,

they could be taught to construct natural areas adjacent to these areas that support small tortoise populations. If landowners want to hunt, areas adjacent to hunting areas could also be utilized as areas to incorporate natural tortoise areas. Since turkeys and deer tend to thrive in the same open-canopy habitats that are beneficial to gopher tortoises, hunters might be encouraged to add natural areas that benefit tortoises and encourage increases in game populations as well. Landowners should be reassured that they do not need to devote their entire land to natural areas to conserve tortoises.

Landowners should be taught how to practice tortoise conservation while still growing trees for harvesting. Landowners would also benefit from practicing thinning of trees. Several of the forest stands visited had been allowed to become too dense for tortoises, due to the landowners' reported inability to clean-up their land after Hurricane Katrina. Landowners could use help cleaning up and restoring their lands.

Management Recommendations

In order to bring gopher tortoise conservation to the next level in Mississippi, local sources like county extension agents available to answer landowners' questions should be knowledgeable about beneficial management practices for gopher tortoises. There is a vital need for a local person who will interact with landowners face-to-face to establish rapport and to determine the best way to accommodate the landowners' needs while still focusing on tortoise conservation as the long-term goal. Providing training on gopher tortoise management for extension agents and other agency personnel who regularly contact landowners could be an efficient means of reaching large numbers of landowners with appropriate information.

Landowners would benefit from the establishment of a program to oversee and conduct the actual prescribed burns. Every landowner interviewed was concerned

about conducting their own burn without the presence of experts. Money given to the landowners as an incentive to burn could include the cost of hiring a professional or maybe money can be given to local communities with larger gopher tortoise populations to establish a team of experts that would aid landowners with burns. Cost-benefit analyses would determine the best method for aiding landowners with burns.

The largest obstacle to gopher tortoise conservation would appear to be lack of education and distribution of information about gopher tortoises and the types of land management that they require. A pamphlet or bulletin with this type of information could be mailed to landowners. The smaller size of pamphlets and bulletins might allow landowners to take them onto the land with them and use them as a guide when planning potential land uses for an area of his/her property. A local newsletter about gopher tortoises and other local threatened, endangered, or invasive species could be made available for a small subscription rate. Workshops, classes, seminars, etc. at the local level might effectively disseminate the necessary information as well. Methods employed to aid in gopher tortoise conservation should consider ease of use and ease of participation for the landowner.

Negative sources of gopher tortoise information should be dealt with in a sensitive and direct manner. The best way to address this type of information is to mention in education programs and literature that some information about gopher tortoises and their needed management practices are inaccurate and this inaccuracy may lead to negative views towards tortoises. Mention sources of information that have accurate information and positive views about tortoises as alternatives to inaccurate and negative sources.

When designing an education program, age-appropriate factors should be considered. Older landowners may not use modern technology (such as Twitter, Facebook, or the internet) as much as landowners less than fifty years old. This demographic age group might use newspapers, magazines, TV, radio, etc. as their usual mediums for learning information, but it would be prudent to verify that this suggestion is the case.

Forest management magazines should be utilized as a medium to distribute beneficial management practices. Hunting magazines should stress that game species like wild turkeys and deer thrive in the same type of habitat that tortoises need. Hunting magazines should also mention that game species' population numbers might increase when using beneficial tortoise management practices.

Programs to address tortoise threats found on private properties should be developed. Landowners would benefit from workshops or literature on the most effective methods for fire ant control in areas that have tortoises. Workshops and literature on armadillo control would also benefit the landowners in their efforts to conserve tortoises. Interviewees might also benefit from a fund included in available programs to assist in fighting these threats.

Table 3-1. Presence of threats to tortoises on properties visited.

Threats to tortoises	Present on Property	Absent on property	Unsure
Fire ants	97%	3%	0%
Gopher ticks	7%	38%	55%
Armadillos	86%	10%	3%
Herbicides (recently used)	52%	48%	N/A

Table 3-2. Length of landowner's awareness of tortoises on property.

Length of time	% of responses
≥ 10 years	38%
≤ 10 years	17%
Turtles (unknown species) for ≥ I year	3%
Never	38%

Table 3-3. When landowner last saw tortoises on property.

Length of time	% of responses
> 1 year	28%
1 year	24%
Unsure	7%
Never	41%

Table 3-4. Landowner's perception of tortoise abundance trends on their properties.

Abundance trend	% of responses
Same	24%
Increased	3%
Decreased	28%
Unsure	45%

Table 3-5. When landowner saw young tortoises or small burrows on property.

Time	% of responses
Recently	14%
Past	7%
Never	76%
Unsure	3%

Table 3-6. Neighbors with tortoises on their properties.

Tortoises	% of responses
Yes	24%
No	55%
Unsure	21%

Table 3-7. Vegetation measurements at tortoise sites.

Vegetation measurements	Mean values
canopy cover	29%
shrub cover	25-50%
groundcover	25-50%
groundcover type	63% patchy
	24% uniform
basal area	18.33 ft^2/acre

Table 3-8. Soil characteristics at tortoise sites (NRCS 2009).

Soil type	Organic matter	Clay content	Silt content	Sand content
Bassfield	0.28%	8.4%	18.4%	73.3%
Latonia	0.25%	9.7%	10%	80.2%

CHAPTER 4
ESTIMATING IMAZAPYR CONCENTRATIONS IN GOPHER TORTOISE APRON SOILS USING A BIOASSAY TECHNIQUE

Introduction

Cogongrass as an Invasive Weed

Cogongrass (*Imperata cylindrical*) is an invasive perennial grass from Asia that has spread on a global scale, causing numerous problems for native plants and wildlife. It is currently viewed as a weed in approximately 73 countries. It is also listed as the seventh worst weed in the world (Burnell et al. 2004). The United States Department of Agriculture (USDA) has listed cogongrass on the Federal Noxious Weed List (MacDonald 2004). In the United States, there are several thousand hectares of the grass. Cogongrass threatens the emerging pine seedling forests in the southeastern United States by reducing growth of pine seedlings and causing significantly less nitrogen content in the pine foliage and fewer roots (Daneshgar & Jose 2009). Thousands of hectares in Alabama and Mississippi are invaded by cogongrass (Bryson and Carter 1993; Matlack 2002).

Cogongrass has been shown to affect pine productivity, pine survival, wildlife habitat, native plant diversity, growth, and survival, and fire behavior (it contains flammable oils in the blades). Before being invaded, natural longleaf pine ecosystems have pine canopies and understories with graminoids, shrubs, and legumes. After being invaded by cogongrass, the understory is more monotypic (Lippincott 2000) and the remaining pines will struggle to survive as they are outcompeted by the cogongrass (Daneshgar et al. 2008). Cogongrass also spreads readily on sites that have been disturbed through human activities. Cogongrass usually invades areas after mining, clear cutting, highway construction, and natural fire or flood (MacDonald 2004).

Cogongrass and its Impacts on Gopher Tortoises

Cogongrass affects gopher tortoises in a variety of ways. Cogongrass is an invasive species that is capable of outcompeting nearly all native vegetation (MacDonald 2004), which reduces food availability for gopher tortoises. Cogongrass competes for nutrients, light, water, and space and can cause physical injury to other plants (Jagoe 1938; Eussen & Wirjahardja 1973). It extracts available soil moisture from shallow soil layers, making it difficult for native perennial grasses to grow (Dozier et al. 1998). Cogongrass can reduce the growth of coexisting species, as has been demonstrated with teak. The height of teak (*Tectona* sp.) plants found in cogongrass-infested areas was about 10 cm while those plants found in areas with no cogongrass were over 100 cm in height one year after planting (Dickens & Buchanan 1975).

Another important part of gopher tortoise habitat management is prescribed burning to maintain the open-canopy forest structure that tortoises require for persistence. Cogongrass alters normal fire cycles of the southeastern United States. Natural gopher tortoise ecosystems like sandhill communities are impacted by this alteration. Cogongrass burns readily, but has fire resistant roots and tubers and quickly recovers after fire. Fires where cogongrass is abundant have a higher maximum temperature. Therefore, there is increased fire mortality of long-leaf pines that are normally fire-tolerant (Lippincott 2000). Prescribed burning is not recommended as a management practice in areas with cogongrass, because the fire would be too intense and ineffective in controlling this fire-tolerant grass.

Use of Herbicides for Cogongrass Management

Cogongrass can be managed with labor, machinery, and herbicides (Cox & Johnson 1993). Herbicides are often used to reduce cogongrass and the reduction of

cogongrass helps make an area more hospitable for gopher tortoises. Over the last thirty years, the ability of numerous herbicides has been evaluated to control cogongrass, but few have been successful (Dickens & Buchanan 1975; Sandanam & Jayasinghe 1977). The two herbicides most commonly used in cogongrass management are glyphosate (ex. Roundup; trademark of Monsanto) and imazapyr (ex. Arsenal; trademark of BASF). The efficacy of imazapyr on cogongrass has been shown to be better than that of glyphosate, so it may be used for management of cogongrass more often than glyphosate (Udensi et al. 1999).

Imazapyr is a broad-spectrum herbicide that is commonly sprayed in forest settings. It provides good control of cogongrass for approximately one year after application (Miller 2000). Applications of imazapyr in the fall have resulted in the greatest efficacy (Johnson et al. 1999). It is more effective at this time of year, because this is when the basipetal flow of photosynthates is occurring (Tanner et al. 1992; Gaffney 1996). Imazapyr is thought to be safe for humans and wildlife. However, off-target effects, particularly to angiosperms, require limits to its use in certain places (MacDonald 2004). The direct or indirect impacts on gopher tortoises have yet to be studied.

Potential Effects of Pesticides on Gopher Tortoises

Current herbicides used in forest settings are often considered non-toxic, biodegradable, and are said to be harmless to gopher tortoises. However, upon closer examination, it is apparent that the methods presently used to test herbicide safety fail to prove that tortoises are not negatively impacted by herbicides. The herbicides used in forests may be unknowingly causing harm to gopher tortoises through direct or indirect effects of the chemicals on these animals (Ashton 2008). An example of an

indirect effect is the herbicide killing important forage plants like blackberry and legumes that gopher tortoises rely on for food (BASF 2008). Prior research looking at direct effects of pesticides on closely related species has found smaller body size in various reptile hatchlings (Burger & Gibbons 1998; Pepper et al. 2004; Sparling et al. 2006). This suggests that it is feasible that herbicides may be causing some of the same types of problems for gopher tortoises.

Researchers have documented effects of pesticides in numerous reptiles and amphibians. Some of the problems that have been seen in reptile eggs exposed to pesticides are egg mortality (Willemsen & Hailey 2001; Dabrowska et al. 2006) and developmental problems (Willingham et al. 2000; Dabrowska et al. 2006). Snapping turtle (*Chelydra serpentina*) eggs have experienced developmental abnormalities, increased egg mortality, and reduced hatchling survivorship when exposed to pesticides (de Solla et al. 2001). Loggerhead sea turtles (*Caretta caretta*) have been shown to have decreased hatching of eggs, greater incidence of deformities of hatchlings, and unhealthy turtles when exposed to pesticides (Storelli & Marcotrigiano 2000). Some studies have shown that embryos and adults of salamanders, frogs, and turtles experienced sublethal effects from such chemicals and some areas experienced population declines from environmental pollution exposure (Bishop & Gendron 1998). Pesticides also affect reptiles' secondary sex characteristics and nest numbers (Norris & Carr 2006). A study discovered significant negative effects on total white blood cell counts of loggerhead sea turtles (*Caretta caretta*) when chlordane was found in their blood (Gardner & Oberdorster 2006). Chlordane is a wood preservative that is introduced into the environment by spillage and runoff where it may cause problems like

reduced hatchling growth (Simpson et al. 1995).

There are many opportunities for tortoises to be exposed to herbicides that have been sprayed around burrows. Through direct intake or surface exposure, herbicides could be affecting reproduction, health, and other important factors not realized at the present time. Because eggs are often laid in the apron soils and tortoises cross the apron to both enter and leave their burrows, surface exposure could occur regularly if herbicides are sprayed in this area.

Gopher tortoises are a threatened species and face numerous challenges to their continued persistence. Little research has been conducted to assess the direct effects this herbicide could have on gopher tortoises. Forested areas that gopher tortoises inhabit are commonly sprayed and these herbicides may be having a bigger impact than thought, adding to the challenges already faced by these threatened tortoises.

Use of Bioassays in Herbicide Research

A bioassay is a technique that uses a plant species sensitive to a particular herbicide to study the movement, activity, and persistence of that herbicide in soils. Bioassays are less specific than chemical tests, but are useful in detecting phytotoxic metabolites often missed by chemical methods. Bioassays are also of relative low cost compared to chemical tests (Brinton et al. 2006). The increased use of herbicides could pose both health and environmental problems through leaching and surface migration (Radian & Mishael 2008). Bioassays are an effective tool to help answer questions about the severity of such problems around gopher tortoise burrows.

Theoretical Framework

Gopher tortoises often make their nests in the aprons of their burrows. Their eggs incubate for approximately 80-100 days in the apron soil. A threatened species'

reproduction and fertility as well as its offspring must be guarded from harm if it is to replenish its population numbers and not slide into extinction. If imazapyr persists for long periods after having been administered, it is possible that the eggs may spend much of their incubation time in soil that has herbicide in it. Some of the more critical developmental time of the embryos may be affected by imazapyr.

If imazapyr is unknowingly affecting the health and successful hatching of gopher tortoise eggs, managers and private landowners that spray imazapyr as part of their land management practices need to be made aware of this fact. They can then change to another herbicide less harmful to gopher tortoise eggs, adjust the timing of their spraying to avoid the critical egg laying and incubating period, or avoid spraying near burrows. They may also choose to practice other cogongrass management techniques that do not involve chemicals.

The bioassay technique can indicate whether there is enough imazapyr staying in the apron soil to warrant more extensive and more costly studies. If high concentrations of imazapyr are found to persist over time, the actual effects on eggs and the gopher tortoises themselves should be examined more closely. This research determined if there is a cause for concern and if further research is warranted. It also determined whether herbicides are one more problem that needs to be addressed in the overall plan for conservation of gopher tortoises.

Study Description and Research Questions

Our research investigated whether imazapyr persisted in the apron soil of gopher tortoise burrows. It determined the length of time that imazapyr remained in the apron soil layers, which provides a rough estimate of the time that eggs may be exposed to this herbicide. It discussed the implications of the time that imazapyr is present in the

apron soils and the possibility that it may be affecting the gopher tortoise eggs laid in the apron, using literature on the effects of contaminants on other turtles' eggs, alligators' eggs, and lizards' eggs to support a possible relationship.

This study examined and explored a relationship between the amount of time imazapyr persists in the apron soil of gopher tortoise burrows and the amount of time that gopher tortoise eggs develop in imazapyr-exposed soil by answering the following questions:

1) How long did imazapyr persist in the apron soils where applied at a rate of 0.5 lbs. per acre and 1 lb. per acre?

2) Is there enough evidence that imazapyr persists long enough in apron soils to produce possible exposure problems for gopher tortoises and their eggs that would justify longer and more costly studies?

Methods

Study Site Description

The Joe Budd Wildlife Management Area (WMA) where we conducted our study was an 11,039 acre piece of property along the north shore of Lake Talquin near Tallahassee, Florida (latitude: 30.4793642˚; longitude: - 84.5207422˚). The WMA had an annual mean temperature of 67˚F and an annual precipitation rate of 56.7 in (NRCS 2009). The section of the WMA where we conducted our research was composed of mesic (moist) flatwoods with old-growth longleaf and oaks. Shrubs and herbs present included wiregrass (*Aristida stricta*), saw palmetto (*Serenoa repens*), and wax myrtle (*Myrica cerifera*).

Our study site was located in one of the WMA's longleaf pine forests and had two soil types. The Hurricane-Chipley complex comprised 70% of the site. The Hurricane soil's taxonomic class was sandy, siliceous, thermic Oxyaquic Alorthods. The Chipley

soil's taxonomic class was thermic, coated Aquic Quartzipsamments. The Foxworth-Lakeland complex comprised 30% of the site. The Foxworth and the Lakeland soil's taxonomic class was thermic, coated Typic Quartzipsamments. The two soil types had approximately 94% sand, 3% silt, and 2% clay content. The Hurricane-Chipley complex had 0.3% and the Foxworth-Lakeland complex had 0.3% of organic matter (NRCS 2009). The WMA provided habitat for a variety of wildlife indigenous to the flatwoods and sandy upland areas of panhandle Florida, such as alligators (*Alligator mississippiensis*), gopher tortoises (*Gopherus polyphemus*), white-tailed deer (*Odocoileus virginianus*), and wild turkey (*Meleagris gallopavo*) [FWC 2007].

Soil Collection Procedure

We located twelve abandoned gopher tortoise burrows that still had well-defined aprons. We flagged a 1-meter-by-1-meter square around each burrow, with one edge of the square in line with the rear of the burrow mouth and extending out into the apron. We used a 1-meter-by-1-meter test area as a tradeoff between two competing needs: large enough that the entire apron soil was subjected to the treatment, but small enough that we minimized the impact on current animals and plants living around the burrows. We designated four burrows to serve as controls, four to receive lower concentration treatments, and four to receive higher concentration treatments, using a random number generator to assign the burrows to a treatment group.

We sprayed Arsenal (a trademark of BASF) with a CO_2 pressurized backpack research sprayer at a ground speed of 2 mph (0.9 m/s) using a 4-nozzle boom fitted with 8002vs nozzles that had a 6-foot- (2 m) effective swath. We sprayed imazapyr, the active ingredient, at a rate of 0.5 lbs. acid equivalent (ae.) per acre (187 g/4,047 m^2) on the four burrows that received the lower concentration of Arsenal and 1 lb. ae. per acre

(373 g/4,047 m^2) on the four burrows that received the higher concentration of Arsenal. The use of an intermediate rate, (0.75 lb. ae. per acre) is common in operational practice for cogongrass management. We used two concentrations so that we could assess the effect of concentration on persistence. We collected soil samples at three points in time. Our first samples were taken within thirty minutes of the herbicide spraying, the second were taken 6 weeks after spraying, and the third 12 weeks after spraying.

We used a handheld soil auger to collect eight soil samples from each burrow apron. We inserted the auger to a depth of 15 cm, because gopher tortoises dig their nests in the apron soil to an average depth of approximately 15 cm (Butler & Hull 1996). We combined the eight soil samples collected at each burrow in a plastic bowl. We broke up hard clumps of soil, removed organic debris, and placed the material into soil sampling bags labeled with the researcher's name, date of collection, burrow number, and treatment.

We immediately placed the bags in a plastic container and put them in a cooler with ice to protect them from heat and light. We sanitized the auger and bowl with a solution of 70% alcohol after completing soil collection at each burrow and changed gloves to keep from contaminating samples. We took the soil bags back to the lab after all soil collections were completed and immediately placed them in a freezer to stop microbial activity.

Bioassay Development

We conducted two standard dose-response curve laboratory experiments with a test plant species. This curve allowed us to estimate the amount of imazapyr in the supernatant created from soil samples collected around gopher tortoise burrows at

three different collection times. It was expected that although the test species may still grow in the presence of low levels of imazapyr, the test species should begin to show signs of injury when exposed to higher levels of imazapyr (Lavy & Santelmann 1971).

Standard Curve Experiments

We used 250 ml Pyrex glass jars with lids to create our stock solutions. We started with 100% Arsenal AC. We filled a graduated cylinder with 100 ml of distilled water. We used a 1 ml pipette to remove 1 ml of distilled water from the graduated cylinder, leaving us with 99 ml of distilled water in the graduated cylinder. We poured the distilled water into one of the Pyrex jars. We added 1 ml of Arsenal AC formulated product with a second pipette to this jar to make a 1% solution.

We added 90 ml of distilled water to the other six Pyrex jars. We placed 10 ml of the 1% solution into the second Pyrex jar with a third pipette to make treatment 1 with a 0.1% concentration of Arsenal. We repeated this process with a new pipette to create treatment 2 with a 0.01% concentration, treatment 3 at 0.001%, treatment 4 at 0.0001%, treatment 5 at 0.00001%, and treatment 6 at 0.000001%. We placed the lids on the jars and gently shook them for 30 seconds to mix them.

We replicated the experiments twice (referred to as experiments A and B) to develop a standard curve for quantitative determination of imazapyr concentration in soil extracts from apron soils. We conducted experiment A for three reasons: to determine the range of concentrations of Arsenal best suited for creating a standard curve to relate imazapyr concentration to plant response in the bioassay procedure, to determine which of two plant species exhibited more consistent herbicide rate responses to herbicide, and to determine the most appropriate plant response metric to use as an index of plant susceptibility to the herbicide. We used radish (*Raphanus sativus*) and brown top millet

(*Brachiaria ramosa*) as our two test species. We labeled plastic Petri dishes (with dimensions of 60 x 15 mm) to indicate treatment received and replicate number, creating four replications of each treatment plus a control for each species. We prepared 56 Petri dishes total.

We lined each Petri dish with two 55mm circular filter papers. We placed either 10 millet or 10 radish seeds in each Petri dish and added 2 ml of the appropriate stock solution for various serial dilutions. We added 2 ml of distilled water to the controls. We randomized the Petri dishes on the tray to ensure a completely randomized design. We placed the tray on the middle rack of a growth chamber maintained at 27˚C to provide a plant response to Arsenal similar in magnitude and symptoms to that which would occur in a natural field setting that was planted with the same sensitive test species used in the lab (Lavy & Santelmann 1971).

We checked the Petri dishes daily. We measured three response factors during experiment A. First, we counted the number of seeds germinated daily. Second, we weighed the plant biomass at day 4 to obtain a fresh weight. Third, we took another fresh weight at day 7. We determined that number of seeds germinated and day 7 fresh weights were not effective indicators of injury. We also found that there was a problem with drying-out of the filter papers. The filter-paper bioassay is often limited by volatilization problems where filter papers can dry out (Cutulle et al. 2009).

We started experiment B with the same set-up as experiment A with two adjustments. We decreased the amount of stock solution originally added to each Petri dish to1 ml and then added 1 ml of distilled water daily to each Petri dish to try to prevent desiccation problems. We elected fresh weight at day 4 as our only response

variable for this experiment.

Soil Samples Experiment

We oven-dried the 36 samples of soil collected from tortoise burrow aprons at the WMA in individually labeled paper bags at 100˚F for 48 hours. We chose oven-drying at this relatively low temperature to get a constant sample weight because we needed to use a drying method that would not drive off the volatiles of the imazapyr.

We prepared the soil samples for extraction. First, we mixed the soil samples thoroughly. Next, we placed 200 g of soil and 200 ml of distilled water (1:1 w/v) into 36 Pyrex jars. We mixed the jars vigorously by hand for five minutes. We selected distilled water as our extraction agent rather than alcohol, because Arsenal is soluble in water and alcohol may have affected plant growth. Then, we poured 50 ml of each mixture into centrifuge tubes. We used four tubes for each sample to get supernatant for each of our four replicates. We ran the centrifuge at 2500 rpm for ten minutes to settle out the soil on the bottom as the precipitant.

We used the same procedure that we used in experiment B of the standard curve experiments to set up the soil sample experiment, except we chose to use only brown top millet as a test species. We determined from the standard curve experiments that radishes were not a good test species for imazapyr bioassays, because they showed no influence from treatment. We had 144 Petri dishes for this experiment that we placed on three trays that were rotated daily when we watered the Petri dishes to prevent position bias.

Data Analysis

We determined the equation for the line of best fit that demonstrated the

relationship between fresh weight of millet and the concentration of imazapyr to develop our standard curve by using simple linear regression. First, we determined that all four assumptions for using simple linear regression were met. Next, we natural log transformed both variables (concentration and fresh weight at day 4) to get a line of best fit with points that were more closely spaced around the line. We ran the simple linear regression in SPSS. Then, we created a graph to show the relationship.

We compared the fresh weight of the millet grown in the presence of imazapyr extracted from the soil of burrows exposed to three different application rates of imazapyr (0, 0.5 pound per acre, and 1 pound per acre) using an ANOVA. We first made sure that all four of the assumptions for analysis of variance were met. Then, we performed the ANOVA in SAS (v.9.1) to determine if the means differed from one another, accounting for the fact that each Petri dish was subsampled (replicated). These comparisons were repeated for the three different time periods that soil samples were collected (0, 6 weeks, and 12 weeks after herbicide application).

Finally, using the mean fresh weight of millet for each sampling date and treatment in the soil samples experiment, we estimated the concentrations of imazapyr present in each soil sample. We used the equation for the line that we obtained in step 1 to estimate the dose for each of these 9 possibilities (three time periods and three application rates of herbicide).

Results

Standard Curve Experiment

We used the four highest concentrations of imazapyr (0.1-0.0001 % Arsenal AC product; manufactured by BASF) to create our standard curve, because these were the concentrations that showed a linear relationship. Simple linear regression determined

the equation for the line of best fit as Y= -0.032x + -1.946 (R^2 = 0.140; p = 0.153). We then developed a graph (Figure 4-1) that displayed the line of best fit and the 95% upper and lower confidence intervals.

Soil Sample Experiment

We compared the results of the three collection times. There was no difference in the mean fresh weight of millet grown in soil exposed to imazapyr from the tortoise burrow apron soils at time zero ($F_{2, 45}$ = 0.503, p = 0.608) or at 6 weeks ($F_{2, 45}$ = 1.231, p = 0.302). There was a significant difference ($F_{2, 45}$ = 3.488, p = 0.040) in the mean fresh weight of millet grown in soil exposed to imazapyr from the tortoise burrow apron soils at 12 weeks. Tukey post-hoc comparisons of the treatment and control groups for the 12 week collection time indicated that the mean fresh weight of millet in the control group was significantly higher than the mean fresh weight of millet in the high concentration treatment group (p = 0.0356). We finished by calculating the estimate of the concentrations of imazapyr (ppm) remaining in the soil for each of the three treatments at each of the three time periods soil was collected from the aprons of tortoise burrows (Figure 4-2 and Table 4-1).

Discussion

Potential Explanations for Imazapyr Concentrations Discovered

The primary mechanism of imazapyr degradation in soils is microbial degradation and aqueous photolysis (WSSA 1994). The key parameters affecting the soil degradation rate of imazapyr in the field include temperature and soil texture size. Depending on environmental conditions, imazapyr has an average half-life in soils of many months (Vizantinopoulos & Lolos 1994; El Azzouzi et al. 1998). One study reported that the half-life of imazapyr in soils ranges from one to seven months,

depending on soil type, temperature, and soil moisture (Mangels 1991) and is shorter at cooler soil temperatures and in sandier soils (American Cyanamid 1986). Another study demonstrated that half-life rates were an average of 87 days (with a range from 68.6 to 155.4 days), depending on temperature and other factors.

Microbial degradation of the technical grade imazapyr through microbial activity increases with warmer temperatures, the presence of sandier soils, increasing soil moisture, and lower organic matter soil (Murphy et al. 2003). Studies have also found that adsorption decreases with increasing soil temperature (Vizantinopoulos & Lolos 1994). In studies of the related compound imazaquin, microbial degradation rates also increased when soil moisture content increased (Mangels 1991).

We found very low concentrations of imazapyr in all treatments and all time periods after treatment, except for the anomaly at 6 weeks in the dose 1 treatment. We predicted that the estimated concentrations of imazapyr would be highest at time zero and would decrease as time progressed with the lowest estimated concentrations expected to be at 12 weeks. Estimated concentrations of imazapyr were lower at time zero than expected and had increased by 6 weeks (suggesting a possible phytotoxic effect other than imazapyr). The concentrations then decreased by 12 weeks to a lower concentration than the 6 week collection time. The controls at 6 and 12 weeks showed anomalies by having concentrations of imazapyr present in the soil when there should have been no imazapyr present.

The adsorption of imazapyr to soil particles is normally weak, but can vary with soil properties (Mangels 1991). Under most field conditions imazapyr will not bind strongly to soils and will be highly available in the environment. However, adsorption is

reversible and desorption can readily occur (WSSA 1994). Factors like soil moisture, runoff, and soil temperature may affect adsorption and desorption of imazapyr in soil. Soil moisture and runoff may have caused imazapyr levels to rise at 6 weeks and to contaminate the control burrows at 6 and 12 weeks. One study reported an increase of imazapyr residues due to runoff of the herbicide (Lee et al. 1991). However, the burrows in our study were on average 103 meters apart (SD = 227), with the range in distance between burrows from 15.6 to 236 meters, so movement from one burrow to another seems unlikely.

Heavy rainfall can cause significant adsorption of imazapyr to soil particles (McDowell et al. 1997). Imazapyr residues in soil following postemergent application have been known to increase eight days after initial application and continue to increase until a peak of 0.23 ppm at day 231 post-treatment. This phenomenon is attributed to runoff of residues from plant surfaces following rainfall and to the release of residues from decaying plant matter (Lee et al. 1991).

Tropical Storm Faye occurred during August of 2008. Over 12 inches of rainfall occurred at the study site during a four day period (Aug 22-25). We sprayed on Aug 19. The rain that occurred between time zero and 6 weeks may have increased the absorption of imazapyr in the apron soils and the rain may have caused runoff of imazapyr that reached the control burrow apron soils.

Other potential explanations for the unexpected results involve issues in the laboratory. For example, millet may not have been the most appropriate test species for imazapyr. One study found that cabbage (*Brassica oleracea*) and sorghum (*Sorghum bicolor*) are more sensitive to imazapyr than other plant species (Liao et al. 2006). We

would recommend that this study be repeated with one or both of these plant species as the test species. If these species are more sensitive to imazapyr, it may be easier to clearly distinguish between injury response and concentrations of imazapyr present. The reoccurring desiccation issue in Petri dishes may have affected the growth and fresh weight of some of the plants differentially. The controls seemed to dry out more quickly than the treatments, possibly due to more plant mass present in the controls. In addition, imazapyr could potentially have been distributed unevenly over the filter paper, due to evaporation and condensation on the Petri dish roof (Cutulle et al. 2009).

Likely Effects of Imazapyr Concentrations Discovered on Tortoises

We are unaware of any published studies that have investigated the effect of imazapyr on any species of reptile, but studies have been conducted with another herbicide, glyphosate. Glyphosate is an herbicide that has properties similar to imazapyr. Glyphosate concentrations as low as 68 ppm have been shown to have negative effects on hatching success of red-eared sliders (*Trachemys scripta elegans*). Concentrations as low as 0.25 ppm of atrazine affect tiger salamander (*Ambystoma tigrinum*) eggs and cause a smaller size and lower weight in larvae. Concentrations of 0.504 ppm of atrazine affects quail (*Coturnix japonica*) eggs, causing more defective eggs, decreased embryo viability, and decreased14-day hatchling weight by 13.1% (Burger & Gibbons 1998; Larson et al. 1998; Wilhelms et al. 2006).

For most weed control situations, 10 to 15 gallons of diluted glyphosate spray solution per acre has been shown to allow for effective coverage of weeds. For atrazine, the typical application rate is 1.5 pounds per acre or less (Hartzler 2009). Normal application rates of imazapyr for cogongrass range from 0.5 to 1 pound per acre (Hartzler 2001). According to our results, imazapyr persists in apron soils at negligible

amounts, except at the times and doses already discussed (6 weeks/dose 0, 6weeks/ dose 1, and 12 weeks/dose 0). Imazapyr does not appear in significant concentrations in apron soils at the majority of the times and doses, even after direct spraying. Imazapyr certainly appears in concentrations well below a lethal level in most of the times and doses. No tests of the direct effect of imazapyr on gopher tortoise eggs has been conducted, so additional investigation may still be warranted. It might be worth directly investigating the egg, because the egg can be sensitive to and a potential route of exposure to toxicants (Wilhelms et al. 2006).

Management Implications

According to our findings, imazapyr may be one of the safer herbicides to use in areas that have tortoise burrows. Land managers can now use imazapyr with a relatively high degree of confidence that they are not negatively impacting gopher tortoises on their lands. However, further studies controlling for the potential problems described with our study should be conducted to determine if the same trends are evident, especially for the three time and dose combinations mentioned previously. If the patterns are repeated, land managers will have stronger evidence that imazapyr is relatively safe for use around tortoise burrows.

However, until the egg can be studied to determine if imazapyr directly affects eggs (even at low doses), we recommend adjusting the timing of the application of imazapyr. Gopher tortoises tend to lay their eggs between late April and mid-June. The eggs lay in the apron soil for approximately three months. As a precaution, apron soils should not be sprayed during this three month period. Land managers should wait for all viable eggs to hatch before applying imazapyr.

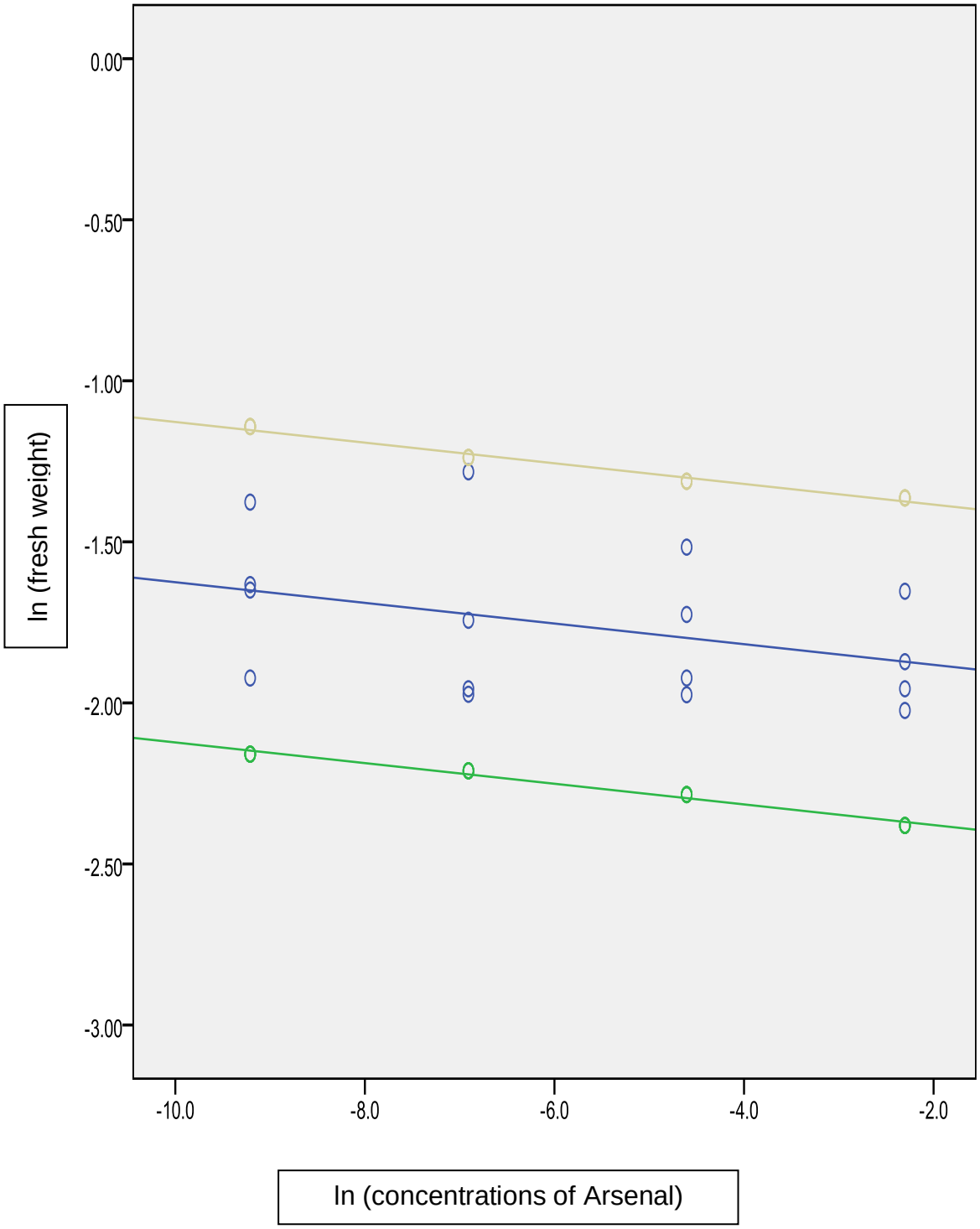

Figure 4-1. Dose response of millet seeds exposed to different concentrations of imazapyr. Used as a standard curve to assess imazapyr concentrations of soil samples. Line of best fit and 95% confidence intervals.

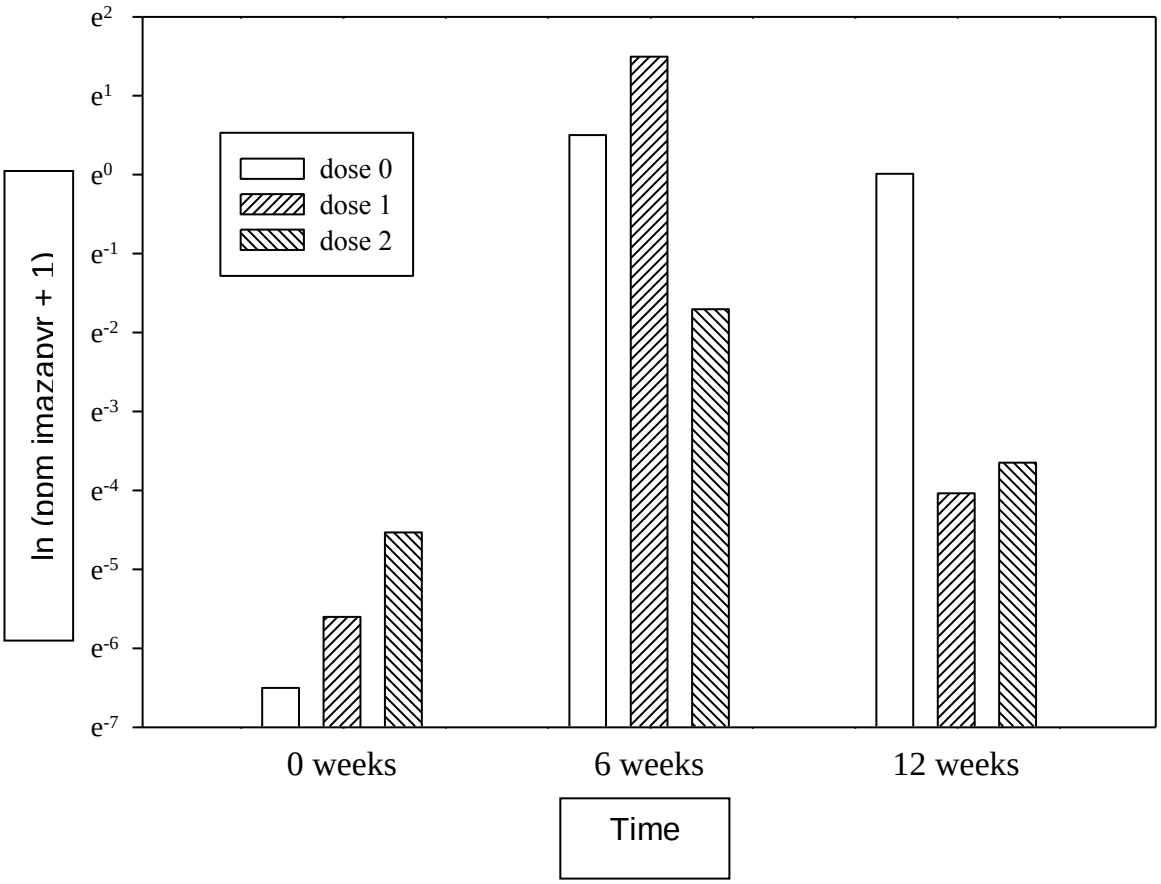

Figure 4-2. Estimated imazapyr concentration assessed by millet seed bioassay for soil samples from gopher tortoise burrow aprons treated with different concentrations of imazapyr and collected 0, 6, and 12 weeks after treatment.

Table 4-1. Collection time (weeks), dose, and ppms of imazapyr assessed by millet seed bioassay for soil samples from gopher tortoise burrow aprons treated with different concentrations of imazapyr and collected 0, 6, and 12 weeks after treatment.

Time (weeks)	Dose	Ppms (imazapyr)
0	0	0.0015
0	1	0.0037
0	2	0.0108
6	0	4.22
6	1	85.29
6	2	0.1997
12	0	1.75
12	1	0.0178
12	2	0.0264

APPENDIX A
MAIL SURVEY INSTRUMENT

<u>SECTION 1</u>: WHAT ARE YOUR OPINIONS?
CIRCLE THE ONE RESPONSE THAT BEST SHOWS HOW YOU FEEL. We are interested in your opinions about gopher tortoises and other wildlife, financial incentive programs for managing wildlife, and about private landowners taking conservation actions to help gopher tortoises. Please indicate the extent to which you agree or disagree with each of the following statements. There are no right or wrong answers, just your valuable opinion.

Strongly Disagree	Disagree	Neutral/ No Opinion	Agree	Strongly Agree
1	**2**	**3**	**4**	**5**

1. I would be willing to implement or allow controlled burning on my property to benefit white-tailed deer, wild turkey, or other game species…

1 2 3 4 5

2. I would be willing to implement or allow controlled burning on my property to benefit gopher tortoises and other non-game species…

1 2 3 4 5

3. I would be interested in government programs that provide financial help with land management that benefits white-tailed deer and other game species…

1 2 3 4 5

4. I would be interested in government programs that provide financial help with land management that benefits gopher tortoises and other non-game species…

1 2 3 4 5

5. It is just as important to manage for non-game species like the gopher tortoise as it is to manage for game species…

1 2 3 4 5

6. I would be interested in receiving advice from a wildlife manager to help me conserve gopher tortoises in a manner compatible with my plans for my property…

1 2 3 4 5

<u>SECTION 2</u>: QUESTIONS ABOUT GOPHER TORTOISES AND YOUR LAND
This section asks you about your familiarity with gopher tortoises and about the types of lands currently or previously used by gopher tortoises. Please place an x mark [x] in the box by your response on the questions with boxes by their answer

1. Do you think gopher tortoises are important to other wildlife on your land?

[ ] Yes
[ ] No
[ ] Unsure

2. Do you think gopher tortoise numbers are increasing, decreasing, or staying the same?

[ ] Increasing
[ ] Decreasing
[ ] Staying the same
[ ] Unsure

3. Do you know what gopher tortoises look like?

[ ] Yes
[ ] No
[ ] Unsure

4. Do you think you could distinguish between a gopher tortoise burrow and an armadillo burrow?

[ ] Yes
[ ] No
[ ] Unsure

5. Which of the following do you think gopher tortoises eat? (Please check all that apply).

[ ] blueberry
[ ] gopher apple
[ ] bluestem
[ ] cogon grass
[ ] beetles
[ ] unsure

6. Which of the following do you believe to be correct? (Please check all that apply).

[ ] Prescribed burning harms gopher tortoises.
[ ] Gopher tortoises like dense forests.
[ ] Fire ants harm gopher tortoises.
[ ] None of the above.

7. When have you seen gopher tortoises on your property?

[ ] Currently → **If yes, please answer the next question (# 8).**
[ ] Past, but not now
[ ] Never
[ ] Don't know

8. Approximately how many gopher tortoise burrows do you think are currently present on your property? **(Please answer only if you placed an x mark by "currently" on question # 7).**

[ ] none
[ ] 1-10
[ ] 11-50
[ ] more than 50

9. Have you noticed other gopher tortoises within half a mile of your property in the last 5 years?

[ ] Yes
[ ] No
[ ] Unsure

10. Have you heard of any of the following programs? (Please check all that apply).

[ ] the Safe Harbor Program
[ ] the Healthy Forests Reserve Program
[ ] the Wildlife Habitat Incentives Program (WHIP)

11. If you are currently not enrolled in any wildlife incentive programs, what is the primary reason for this?

[ ] I don't know about these programs.
[ ] I don't want to commit to managing my property in a particular manner.
[ ] These programs don't pay enough to compensate for my efforts.
[ ] The time commitment required by these programs is too long.
[ ] Other: (i.e., already enrolled)

_____

12. How many total acres do you own in Mississippi?

_____

13. For how many years have you owned land in Mississippi?

[ ] less than 5 years
[ ] 5-10 years
[ ] 11-20 years
[ ] greater than 20 years

14. Would you categorize your private property to be in a …?

[ ] rural area (country)
[ ] small town (< 10,000 people)
[ ] small city (10–50,000 people)
[ ] large city (50,000+ people)

15. Which of the following habitat types cover most of your private property? (Please check one or two).

[ ] longleaf pine forest
[ ] loblolly pine plantation
[ ] slash pine plantation
[ ] pasture
[ ] unmanaged mixed pine/hardwoods
[ ] row crops
[ ] other: _____ (please specify)

16. In what habitat type do the tortoises occur on your property?
_____

17. Which of the following do you rate as the highest priority for your land?

[ ] recreation
[ ] livestock
[ ] a natural setting
[ ] timber
[ ] agriculture
[ ] other: _____ (please describe)

18. Do you lease any of this land to other people for agricultural production, livestock, or hunting?

[ ] Yes
[ ] No

19. Which of the following land use management practices do you use in areas where tortoises occur? (Please check all that apply).

[ ] thinning
[ ] prescribed burning
[ ] bedding
[ ] mowing
[ ] disking
[ ] grazing
[ ] herbicides
[ ] food plots
[ ] fire ant control
[ ] none of the above

<u>SECTION 3</u>: WHAT IS YOUR BACKGROUND?
This section asks about your background so that we may know how different types of people feel about the issues in this survey. You may skip any question that you do not feel comfortable answering, but <u>please do remember that this survey is anonymous</u>.

1. What formal schooling have you completed? (Please check one).

[ ] some high school
[ ] graduated high school

[ ] vocational/technical school
[ ] some college
[ ] college graduate
[ ] some graduate school
[ ] graduate degree

2. In what decade were you born?

[ ] 1920-1929
[ ] 1930-1939
[ ] 1940-1949
[ ] 1950-1959
[ ] 1960-1969
[ ] 1970-1979
[ ] 1980-1989

3. Your occupation is best described as: (Please check one).

[ ] Professional/managerial
[ ] Technical/sales
[ ] Human services
[ ] Farming/forestry/fisheries
[ ] Trades/crafts
[ ] Student
[ ] Homemaker
[ ] Retired
[ ] Unemployed
[ ] Other: _____
(please specify)

4. Which of the following categories best describes your total household income last year?

[ ] $30,000 or less
[ ] $31,000-$60,000
[ ] $61,000-$80,000
[ ] $81,000-$100,000
[ ] greater than $100,000

Thank you for the time you have spent to help us better understand gopher tortoises.

APPENDIX B
SURVEY COVER LETTER

Vicki Underwood, Graduate Research Assistant
110 Newins-Ziegler Hall, P.O. Box 110430
Gainesville, FL 32611-0430
352-231-0135 (work cell phone), 352-392-6984 (fax)
anurians@ufl.edu

Date

Dear Southeastern Mississippi Landowner,

Hello. My name is Vicki Underwood. I am a graduate student at the University of Florida. In collaboration with the Mississippi Museum of Natural Science and Mississippi State University, I am collecting information on the status of gopher tortoises on private lands in Mississippi.

You have been selected to participate in this survey because you are a private landowner in Southeastern Mississippi that could have gopher tortoises on your land. Your opinions and knowledge are vital to learning about Mississippi's gopher tortoise populations. Even if you have never seen gopher tortoises on your property, your input will still be valuable.

Enclosed is a questionnaire for you to complete at your leisure. **Please do not throw this survey away.** This survey is a university study and there are no commercial agencies involved with this research. This survey is your opportunity to be heard about issues involving gopher tortoises and their conservation. Your participation, though voluntary, is crucial to the success of our research. You do not have to answer any question that you do not wish to answer. We would appreciate if you would take about 10 minutes to respond to the enclosed questionnaire.

The survey is anonymous, so we will not be able to determine your identity from the questionnaire you return. Also, your name and address will not appear in any public materials or publications related to this study and will not be provided to any outside sources. Your identity as a participant will be confidential to the full extent of the law. There is no compensation for your participation and there are no direct benefits or risks to you for participating in this study.

When you are finished with this survey, please fold the survey and place it in the enclosed envelope with the pre-paid postage on it. Then, please place it in a mailbox **by [Date]** or as soon after as possible. Please place an x on the postcard if you want to receive information in the mail about habitat management for gopher tortoises and programs that provide technical and/or funding assistance for land management beneficial to gopher tortoises, wish to be considered as a candidate to receive gopher tortoises on your land, or would be willing to allow me to visit your property to collect

some biological information on the areas where you have tortoises. Please mail this postcard **separately** from the survey to maintain your confidentiality.

If you are interested in the results of our study, I would be happy to share them with you. For questions about this study, please contact me at 352-231-0135 (work cell phone) or at anurians@ufl.edu. Thank you very much for your valuable time and opinion.

Sincerely yours,

Vicki Underwood
Advisors: Dr. Holly Ober and Dr. Debbie Miller

If you have any questions about your rights as a participant or the confidentiality of the information that you provide, you can contact the UF Institutional Review Board (UFIRB), University of Florida, Box 112250, Gainesville, FL 32611; ph (352)392-0433.

APPENDIX C
SURVEY POSTCARDS

FRONT OF CONTACT POSTCARD:

Prepaid Postage Here

Vicki Underwood
University of Florida
Department of Wildlife Ecology and Conservation
110 Newins-Ziegler Hall, P.O. Box 110430
Gainesville, FL 32611-0430

BACK OF CONTACT POSTCARD:

Please place an X in each of the following boxes that you agree with:

[ ] Yes, I would like to receive information in the mail about managing habitat for gopher tortoises.
[ ] Yes, I would like to receive information in the mail about the possibility of having gopher tortoises that were removed from other sites relocated to my property.
[ ] Yes, I would be willing to have a one-time visit to my property by the graduate student doing this study to collect additional information on gopher tortoises. The visit will be arranged at a time convenient to me. To arrange a time and date for this visit, it would be best to **contact me by phone or e-mail at the following phone number (include area code) or e-mail address**:
_____

***Please place your name and address below.**

Name:
Address:

FRONT OF REMINDER POSTCARD:

Postage Here

Vicki Underwood
University of Florida
Department of Wildlife Ecology and Conservation
110 Newins-Ziegler Hall, P.O. Box 110430
Gainesville, FL 32611-0430

Private Landowner's Name
Street Address/P.O. Box Number
City, MS (zip code)

BACK OF REMINDER POSTCARD:

Dear Southeastern Mississippi Landowner,

Two weeks ago, you received an anonymous mail survey, asking research questions about possible occurrences of gopher tortoises on your land and your interest in their conservation and financial assistance programs that aid with efforts to conserve gopher tortoises on private properties. If you have **not** already filled out the survey and returned it to me, I am sending you this postcard to remind you to please fill it out and place it in the envelope provided with the survey that has prepaid postage on it. Then, please drop it at your earliest convenience in the mail if you wish to participate in my research study. If you have already filled out and mailed the survey, I want to personally thank you for your valuable time and ask you to disregard this postcard.

Sincerely,

Vicki Underwood

APPENDIX D
SCRIPT FOR PHONE CALLS TO ARRANGE INTERVIEW VISIT

"Hello, my name is Vicki Underwood. I am the graduate research assistant from the University of Florida that is conducting gopher tortoise research. I mailed you the anonymous survey about gopher tortoises. I received your contact postcard, indicating that you would be willing to schedule a visit for me to conduct a short interview with you and examine the areas where you have or had gopher tortoise burrows.

I want to get a rough estimate on the number of burrows you have, see the type of vegetation that is in the area(s), measure elevation, and evaluate the presence of threats like cogongrass, fire ants, and vehicular traffic.

Your participation is voluntary. You do not have to allow me to do any of the actions just mentioned. You do not have to allow me to perform any action on your property that you are uncomfortable with.

The information that I gather will be anonymous and your name will not appear in any public materials or publications and will not be provided to any outside sources. This research is a university study and there are no commercial agencies involved with this research. Your identity as a participant will be confidential to the full extent of the law. There is no compensation for your participation and there are no direct benefits or risks to you for participating in this study.

Would you still like to schedule a time for me to visit your property?"

If **YES**, ask,

"When would be a convenient day and time for you?"

If **NO**, say,

"I appreciate your time. Thank you for allowing me to contact you."

END CALL: "Have a nice day!" (If **YES**, say, "I look forward to meeting you.")

APPENDIX E
SCRIPT FOR INTERVIEW QUESTIONS

"This interview is part of a university study. There are no commercial agencies involved with this research. This interview is your opportunity to be heard about issues involving gopher tortoises and their conservation. Your participation is voluntary, but will be crucial to the success of our research. You do not have to answer any question that you do not wish to answer. Your name and address will not appear in any public materials or publications related to this study and will not be provided to any outside sources. Your identity as a participant will be confidential to the full extent of the law. There is no compensation for your participation and there are no direct benefits or risks to you for participating in this study. There are no right or wrong answers, just facts about you, your property and its gopher tortoises, and your opinions."

1) When did you first become aware of gopher tortoises on your property?

2) Have you noticed changes in the number of gopher tortoises over time?

3) When was the last time that you saw gopher tortoises on your property?

4) Which sources have you learned about gopher tortoises from?

5) How much of the information that you have seen or heard about gopher tortoises has shown them in a positive light and how much in a negative light?

6) Which of the above sources of information portrayed a positive impression and which ones a negative impression?

7) Would you say that the information that you have heard about gopher tortoises has instilled in you a generally positive or negative outlook towards gopher tortoises?

8) A. Would you say that the knowledge that you have learned about gopher tortoises has made you try to practice land management practices like prescribed burning that benefit gopher tortoises?

B. **If you are regularly using prescribed burning**, did the presence of gopher tortoises influence your decision to burn or are you burning for a different reason?

9) A. When you think of future goals for land use, do you consider how gopher tortoises and other wildlife will be impacted by your decisions?

B**. If so**, how high a priority is wildlife relative to other land uses?

C. What other land uses are higher priority to you?

10) When considering different types of wildlife, are gopher tortoises of fairly low or high concern to you?

11) Do you feel like you are able to make land management decisions that will both allow you to achieve your goals and benefit gopher tortoises or do you feel like both objectives are not realistically achievable together?

12) Have you noticed fire ants in the areas where you have gopher tortoises?

13) Have you seen any large ticks on any of the gopher tortoises on your land?

14) Have you seen any baby gopher tortoises or noticed any small burrows that could belong to baby gopher tortoises?

15) Have you noticed armadillos in the areas where you have gopher tortoises?

16) Do your neighbors talk about having gopher tortoises on their properties?

17) Do you think that they are willing to manage their land in ways that would benefit gopher tortoises?

18) Do you think that people in this county have a generally positive attitude towards gopher tortoises or a more negative attitude?

19) How do you think information about gopher tortoises could be better presented to help people develop more positive attitudes?

20) Would you be more likely to adopt land management practices that will benefit wildlife if you were given a financial award for doing so or do you prefer to not have any 'constraints' on how you manage your land?

21) How much money per year would be sufficient to encourage you to do a prescribed burn once every three years?

22) If you are currently not enrolled in a wildlife incentive program, what is the primary reason that you are not enrolled?

a) Not aware of programs.
b) Not want to commit to particular type of property management.
c) Not enough compensation for my efforts.
d) Time commitment is too long.

23) Do you currently use herbicides on your property?

24) **If use herbicides:** What type(s) of herbicide do you use?
Do you spray in the portion of the property where the burrows are located?

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BIOGRAPHICAL SKETCH

Vicki Janene Underwood was born in Knoxville, Tennessee. She has had a love for animals and science since childhood. Vicki attended undergraduate school at the University of Tennessee, Knoxville. She received her Bachelor of Arts in psychology, receiving the honor of Top Graduate in the College of Arts and Sciences. She decided to pursue her interest in wildlife and entered graduate school at the University of Florida in the Department of Wildlife Ecology and Conservation as a master's student. This thesis is a product of her two and a half years of graduate research. Vicki hopes to combine her background in psychology and wildlife to enter a competitive Ph.D. program and obtain her Ph.D. in microbiology and immunology with an emphasis on interactions between disease and the human immune system (possibly using animal models). She wants to research HIV and AIDS and autoimmune diseases.