FERAL PIG (*Sus scrofa*) SURVIVAL, HOME RANGE, AND HABITAT USE AT

LOWNDES COUNTY WILDLIFE MANAGEMENT AREA, ALABAMA

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FERAL PIG *(Sus scrofa)* SURVIVAL, HOME RANGE, AND HABITAT USE AT LOWNDES COUNTY WILDLIFE MANAGEMENT AREA, ALABAMA

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Wesson Dalton Gaston, son of James Monroe and Nancy (Wesson) Gaston, Jr., was born December 5, 1980 in Americus, Georgia. He graduated from Southland Academy in 1999. He attended Bob Jones University in1999 and received a Bachelor of Science degree in Biology with a minor in Business Administration in May, 2003. He entered the Graduate School of Auburn University in January, 2004.

THESIS ABSTRACT

FERAL PIG *(Sus scrofa)* SURVIVAL, HOME RANGE, AND HABITAT USE AT LOWNDES COUNTY WILDLIFE MANAGEMENT AREA, ALABAMA

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Survival, home range, and habitat use are key components of feral pig ecology that can help wildlife biologists and land managers develop control methods for this species. Feral pigs were captured and released with transmitters attached to them. We conducted telemetry on them for one full year consisting of high hunting pressure and low hunting pressure seasons. From telemetry data, we were able to ascertain the survival rate, home ranges and habitat use from the pigs that were monitored.

Females had a higher survival rate than males cumulatively and seasonally regardless of age. The pigs had higher survival estimates during the low pressure hunting season. The type of season had a significant effect on home range size and habitat use of the feral pigs.

This study provides pertinent data and implications not only for the Alabama Department of Conservation and Natural Resources, but also for other state agencies with public lands. This research project showed how pig movements and survival rates are related to the amount of hunting/control pressure applied to them.

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Style manual or journal used Journal of Wildlife Management

Computer software used Microsoft Office Word 2003, SAS 9.1, MICROMORT, LOCATE, CALHOME, ArcView GIS 3.2 (ESRI), ArcGis 8.3

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I. INTRODUCTION

Feral hogs (*Sus scrofa*) are wild-living descendants of domestic swine and are in the family Suidae. Two other types of wild hogs, Eurasian wild boar and wild boar x feral pig hybrids, have also been established in the United States. Non-domesticated wild boars were introduced in the United States in the late 1800s as game animals; their behavioral and morphological characteristics made them ideal trophy animals. To date, no pure populations of Eurasian wild boar have been documented in the South (Wood and Barrett 1979, Mayer and Brisbin 1991).

History

Christopher Columbus introduced hogs in 1493 to the West Indies when he brought them over on ships for sustenance. They were first introduced into the United States by Hernando de Soto as early as 1539 for domestication (Wood and Barrett 1979, Mayer and Brisbin 1991). Wild populations were first established through the escape of domestic swine and intentional releases to establish wild populations (Mayer and Brisbin 1991). Settlers and explorers encouraged the spread of this ungulate through open range practices to increase the population. With this population increase, settlers were able to harvest pigs for food and sport without incurring any feeding costs. The first established populations of feral pigs in Alabama are the result of free-range livestock practices dating back to the late 1770s (Mayer and Brisbin 1991). Feral hogs were seen as a valuable food source for the explorers and settlers; however, their populations now are considered a pest in most parts of the United States.

Reproduction

Feral pigs are the most abundant, non-native ungulates in the United States (Singer et al. 1984). They have the highest reproductive potential of all native or introduced big game species in North America (Dickson et al. 2001). Adult hogs can breed year-round with an average gestation period of 115 days and can become sexually mature at 5-7 months of age (Sweeney et al. 1979). The length of the sows' estrous cycle is 21-23 days with the heat period lasting approximately 48 hours (Henry 1968). Litter size ranges from 4-8 piglets, and sows can have 2 litters per year when adequate food and habitat is available (Matschke 1964, Wood and Barrett 1979, Kammermeyer et al. 2003). Depending on location, there are usually two major farrowing periods: mid-winter and early summer (Henry 1966, Taylor et al. 1998)

Diet

Feral pigs are omnivorous and will eat a variety of foods ranging from roots to carrion, but the majority of their diet consists of plant material (Asashi 1995, Dickson et al. 2001). Since pigs are opportunists or generalists, their diet depends on foods being available at the exact time of foraging (Belden and Frankenberger 1990, Warren and Ford 1997). They feed mostly at night and during the twilight hours, but will feed during the day (Singer et al. 1981, Taylor 2004). Pigs will root up the landscape while searching for food. Because of their foraging habits, feral hogs can cause large amounts of damage to the environment.

Since feral pigs are opportunistic feeders, they are often viewed as a threat to native wildlife species. Pigs can impact native wildlife through competition for resources, predation on eggs, and by being a nuisance relative to wildlife management (Rollins 1999). The major negative impact that hogs have on native wildlife in hardwood forests is competition for the mast crop (Wood and Barrett 1979). The results can be devastating when competition between these animals occurs during a year with low mast production.

Diseases

Feral pigs are known to be reservoirs for parasites and diseases. Since they are very susceptible to diseases and parasites, natural resource managers and agricultural specialists are concerned about the increasing hog populations because of the disease potential. Once a disease occurs in a population, diffusion can easily take place through contact or transmission of fluids. This not only affects the feral hog population, but it can also affect native wildlife, domestic livestock, pets, and humans (Pavlov 1988, Sweitzer and Gardner 1996). Swine brucellosis (*Brucella suis*) and pseudorabies are diseases that are of particular concern because they threaten the domestic swine industry.

Swine brucellosis can spread to domestic swine causing abortions in sows and infertility in boars. Once this disease becomes established in a domestic operation, it is almost impossible to control and may have a large economic impact. Humans can contract swine brucellosis through the handling of contaminated carcasses or eating undercooked meat (Kammermeyer et al. 2003). Pseudorabies is not a risk to humans; however, wildlife, domestic animals, and pets are susceptible to this sometimes fatal disease (Witmer et al. 2003).

Damage

Wood and Barrett (1979) noted that the introduction and support of feral pigs, an exotic species, was not ecologically beneficial due to the adverse effects they have on native species of plants and wildlife. Once an exotic species becomes established, it might be impossible to remove them (Conover and Conover 2001). Agricultural and environmental agencies view feral pigs as undesirable "economic pests" due to their potential to damage agricultural crops and the environment. A list of important crops that swine can destroy includes: corn (*Zea mays*), milo (*Sorghum bicolor*), rice (*Oryza sativa*), watermelons (*Citrullus lanatus*), peanuts (*Arachis hypogaea*), hay, turf, wheat (*Triticum aestivum*), and other grains (Dickson et al. 2001). Through their rooting and wallowing activities which maintain their core temperature, pigs can damage large amounts of crops, equipment, and livestock feeding and watering facilities (Onida et al. 1995, Taylor 1999, 2004). They can destroy young pine plantations by uprooting seedlings and consuming the roots. Also, they will feed on the grass stage of longleaf pines (*Pinus palustris*) and can damage larger pines by chewing and rubbing the lateral roots (Dickson et al. 2001).

Home Range and Habitat Use

A home range is defined as the area an individual normally traverses during its activities of food gathering, mating, and caring for young (Truve 2004). Feral pig movements are usually influenced by food availability, weather, breeding, and hunting pressure (Matschke and Hardister 1966). In free-ranging feral hogs, the females will travel in family groups called sounders. These groups are made up of several sows along with their young. Upon maturation, females can settle into their home ranges relatively quickly because of the lack of competition. On the other hand, competition and territoriality may cause boars to travel great distances to establish their home ranges (Morini et al. 1995). Adult boars are often solitary and join other pigs only when breeding opportunities arise (Boitani et al. 1994, Nakatani and Ono 1995, Kammermeyer et al. 2003).

Wild boars in Europe were reported to have home ranges of 40-150 km^2. In Europe, home ranges of Eurasian boars increase due to the animals migrating in search of available food during harsh weather. Pure wild boars often have larger home ranges than the feral pigs in North America (Boitani et al. 1994). Home ranges for feral pigs in North America range from an average of 1.1-5.32 km^2 (Kurz and Marchinton 1972, Singer et al. 1981, Baber and Coblentz 1986, Boitani et al. 1994). Knowledge of habitat use by a species of animal is necessary for understanding land-cover preference and to help biologists draw inferences about which habitat is occupied with regards to availability (Bond et al. 2002). These inferences then lead to wildlife management decisions regarding that species of animal.

Feral pigs use a wide variety of habitat conditions (Hanson and Karstad 1959, Dickson et al. 2001). The habitat used by wild pigs depends on type of cover and cover density (Barrett 1978). Thick cover provides protection from humans and other predators, while providing the pigs with preferred bedding sites. In the Southeast, pigs typically use riparian forests associated with a steady water source, but they will inhabit areas from bottomland swamps to mountainous forests (Kurz and Marchinton 1972, Wood and Brenneman 1980, Dickson et al. 2001).

Human presence can alter the movements of wild pigs (Singer et al. 1981), and hunting and control efforts often increase the area traveled by pursued hogs. This pressure may cause dispersal into new areas and alter home ranges (Sodeikat and Pohlmeyer 2003). Continuous pressure may cause pigs to disperse and leave their normal home range (Maillard and Fournier 1995).

Control

Once an exotic species, such as a feral pig population, has become established, it is very difficult to control (Conover and Conover 2001, Dickson et al. 2001). Numerous efforts have been made by biologists and land managers to control the ever growing feral pig populations. Many options for pig control exist. Shooting, live trapping, hunting with dogs, fencing, feeding away from crops, and snaring are some of the methods used to suppress pig populations and the damage they cause (Choquenot et al. 1996, Dickson et al. 2001, Geisser and Reyer 2004).

The most effective method of controlling a pig population is to employ an integrated pest management approach which combines continuous live trapping, shooting, and hunting with dogs to subdue pig populations (Kammermeyer et al. 2003). However, pressuring pigs may cause them to disperse into new areas or increase their home ranges, thus dispersing the population (Maillard and Fournier 1995). Hunting pressure can influence the movements and habitat preference of animals (Root et al. 1988). This is an area of study where information is deficient. Home range sizes and the types of habitat used may be altered depending on the amount of pressure applied to a species of animal; however, few studies deal with home range and habitat use along varying degrees of hunting pressure. Home range and habitat use data from this study will allow state officials to better implement feral pig control plans by having a more in depth knowledge of a pig's range and habitat preference through different hunting pressure seasons.

Our objectives for this study were to ascertain annual and seasonal home ranges and habitat preferences along with survival rates and cause-specific mortality of feral pigs on Lowndes County WMA, Alabama during low and high pressure hunting scenarios. This information will allow biologists and land managers to see what effect pig control has on movements, habitat used, and survival of feral species.

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CHAPTER II. HOME RANGE AND HABITAT USE OF FERAL PIGS (*Sus scrofa*) ON LOWNDES COUNTY WMA, ALABAMA

Abstract

This study was conducted on Lowndes County Wildlife Management Area (WMA), Alabama to assess the survival, home ranges, and habitat preferences of feral pigs during high and low hunting pressure seasons. For the study, two six-month seasons were defined (high pressure hunting or low pressure hunting) based on the number of hunters that entered the woods on the WMA. We collared twenty-four pigs to determine home range and habitat use from 1 February 2005-31 January 2006 on Lowndes County WMA. Seventeen collared pigs had an average home range of 403.6 $\pm$ 65.6 ha in the low pressure season, and 11 pigs had an average home range of 278.6 $\pm$ 64.5 ha during the high pressure season. Season had a significant effect on home range size ($P = 0.039$) and core range size ($P = 0.018$). The test for group effect randomization indicated that the pigs did not choose their habitats (home range or core range) randomly ($P < 0.0001$). The type of season had a significant effect on habitat use ($P = 0.027$). Sex ($P = 0.062$) and age ($P = 0.84$) did not have any significant effects on pig habitat preference. During the low pressure season, the collared pigs preferred wetland and shrub/scrub habitats;

whereas, they preferred pine forests and shrub/scrub habitats during the high pressure season.

Key words: feral pig, home range, habitat use, humans, hunting pressure

Introduction

Feral pigs (*Sus scrofa*) are a controversial wildlife species, and their numbers and ranges are increasing due to their high fecundity and translocation by humans. While they remain a popular game species, they have the potential to root up and ruin crop fields and native vegetation, which raises concern amongst farmers, landowners, and land managers (Wood and Barrett 1979, Dickson et al. 2001). The popularity of feral pigs is on the rise with legends of "Hogzilla" and "Monster Pig" sparking hunters' interest in this species (Caudell 2007). Feral pigs offer hunters extra opportunities to hunt when other game species seasons are closed. Wildlife biologists are faced with the dilemma of trying to provide hunting opportunities while, at the same time, minimizing the deleterious impacts on the environment such as erosion, spreading exotic plants, food plot and crop damage.

A home range is defined as the area an individual normally traverses during its activities of food gathering, mating, and caring for young (Truve 2004). In the case of feral pigs, home ranges are usually influenced by food availability, weather, breeding, and hunting pressure (Matschke and Hardister 1966). In free-ranging feral hogs, the females will travel in family groups called sounders. These groups are made up of several sows along with their young. Upon maturing, females can settle into their home ranges relatively quickly because of the lack of competition. On the other hand, competition and territoriality may cause boars to travel great distances to establish their home ranges (Morini et al. 1995). Adult boars are often solitary and join other pigs only when breeding opportunities arise (Boitani et al. 1994, Nakatani and Ono 1995, Kammermeyer et al. 2003).

Human presence can alter the movements of wild pigs (Singer et al. 1981), and hunting and control efforts often increase the area traveled by pursued hogs. This pressure may cause dispersal into new areas and alter home ranges (Sodeikat and Pohlmeyer 2003). In Europe, home ranges of Eurasian boars increase due to the animals migrating in search of available food during harsh weather (Maillard and Fournier 1995). Continuous pressure may cause pigs to disperse and leave their normal home range (Maillard and Fournier 1995). This will expand the pig population into new areas, which will increase damage.

Wild boars in Europe were reported to have home ranges of 40-150 km^2. Pure wild boars often have larger home ranges than the feral pigs in North America (Boitani et al. 1994). This is due to the Eurasian boars migrating to warmer areas that contain more food sources. Home ranges for feral pigs in North America range from an average of 1.1-5.32 km^2 (Kurz and Marchinton 1972, Singer et al. 1981, Baber and Coblentz 1986, Boitani et al. 1994). The smaller home ranges of feral pigs in North America are due to the milder climates and plentiful food sources year round in the environments they inhabit. While knowledge of feral pig home ranges is beneficial, feral pig habitat preference will help managers and biologists develop more effective control regimens.

Knowledge of habitat use by a species of animal is necessary for understanding land-cover preference and helps biologists to draw inferences about which habitat is occupied with regards to availability (Bond et al. 2002). These inferences then lead to wildlife management decisions regarding that species of animal. Feral pigs use a wide variety of habitat conditions (Hanson and Karstad 1959, Dickson et al. 2001). Wild pigs choice of habitat use depends on type of cover and cover density (Barrett 1978). Thick cover provides protection from humans and other predators, while providing the pigs with preferred bedding sites. In the Southeast, pigs typically use riparian forests associated with a steady water source, but they will inhabit areas from bottomland swamps to mountainous forests (Kurz and Marchinton 1972, Wood and Brenneman 1980, Dickson et al. 2001)).

Hunting pressure can influence the movements and habitat preference of pressured animals (Root et al. 1988). Home range sizes and the types of habitat used may be altered depending on the amount of pressure applied to feral hogs; however, few studies deal with home range and habitat use along different hunting pressures. Home range and habitat use data from this study will allow state officials to better implement feral pig control plans by having a more in depth knowledge of a pig's range and habitat preference along different hunting pressure situations. Our objectives for this study were to understand feral pig movements and habitat use under varying harvest pressures by ascertaining cumulative and seasonal home ranges and habitat preferences of feral pigs on Lowndes County WMA, Alabama.

Methods

Study Area

We conducted this study from February 2005 through March 2006 in and around Lowndes County Wildlife Management Area (WMA), in Lowndes County, Alabama. The 4,218 ha WMA is located near the town of White Hall between Montgomery and Selma, Alabama and is managed by the Division of Wildlife and Freshwater Fisheries of the Alabama Department of Conservation and Natural Resources. The Lowndes County WMA and the surrounding land consist of planted hardwoods (red oak, *Quercus rubra*;

white oaks, *Quercus alba*; water oak, *Quercus nigra*; willow oak, *Quercus prinus*; swamp chestnut oak, *Quercus michauxii*; red hickory, *Carya ovalis*) agricultural fields, pine stands, clearcuts, swamps, and bottomland hardwoods; which are habitats conducive to fostering the population of feral pigs. Lands adjacent to the Lowndes County WMA are managed for farming, beef cattle, gravel mining, and game hunting. Feral hogs may be harvested on the WMA with appropriate weapons during the big and small game seasons, along with a specified three-week hog hunt during the months of August and September. The Lowndes County WMA biologists and surrounding landowners use opportunistic feral pig hunting throughout the year to help manage the population. Signs explaining my project were posted at Lowndes County WMA entrances and parking lots and gas stations in the area. Adjacent landowners were notified about the project. The study was conducted under permit number 2003-0608 of the Institutional Animal Care and Use Committee of Auburn University.

Capture and Monitoring

The study was conducted from February 2005 through March 2006; however, data were analyzed from February 2005 through January 2006. This allowed for one complete year of data where the hunting seasons could be equally divided.

Beginning in February 2005, we captured feral pigs via cage traps baited with shelled corn, corn mash, and molasses, wrangling, and a drop net on Lowndes County WMA and adjacent land. Since pigs do not contain sweat glands and are susceptible to overheating when exposed to extreme sunlight (Baber and Coblentz 1986, Dickson et al. 2001), traps were placed in well shaded areas to ensure the pigs' safety. Traps were set before dusk and checked every morning. Pre-baiting was carried out for a week or two to maximize trapping efforts.

Upon capture, pigs were injected intramuscularly with Telazol (Tiletamine HCL and Zolazepam HCL) via a three foot pole syringe at a rate of 1.5cc/45.4 kg (Jolley and Hanson 2005 pers. commun.). Once immobilized, ophthalmic ointment was administered to the animals' eyes to prevent them from drying out. A blindfold was placed around the head to cover the eyes and to keep the animal from being startled by movements. Pigs were sexed and a livestock ear tag was attached for identification purposes. Morphological measurements were taken to the nearest centimeter. These measurements included chest and neck girth, total length, back of head to snout, top of shoulder blade to toe, and tusk length. Alertness, respiration rate, and heart rate were monitored throughout anesthetization. Cool water was available in case a pig started to overheat. All animals were monitored until fully alert and then released at the trap site.

Since pigs are considered to be in the "growing" stage up until they reach 45.4 kg (Callis et al. 1971), the captured pigs were divided into two groups, adults ($\geq$ 45.4 kg) and juveniles ($\leq$ 44.9 kg). This differentiation was done to prevent animals from becoming too large for the transmitter harness over the course of the study.

The use of telemetry provided continuous information regarding the movement of animals and made it easier to decipher the home ranges of animals and whether or not they had dispersed from an area (Truve 2004). Gathering this movement data provided basic information regarding a species and is valuable to control programs and wildlife managers (Sanderson 1966).

Adults were fitted with transmitter harnesses that contained mortality-sensor VHF transmitters (Advanced Telemetry Systems, Inc., Isanti, MN, USA). Harnesses were secured to allow for future growth during the study period. Mortality-sensor VHF ear tag transmitters (Advanced Telemetry Systems, Inc., Isanti, MN, USA) were attached to the ears of juvenile pigs. The choice to use ear tag transmitters instead of receiver harnesses on juveniles was based on the rapid growth rate of young pigs.

Feral pigs deployed with transmitters were not tracked for a period of 48 hours following capture and transmitter attachment. This allowed them time to adjust to wearing the harnesses and ear tags. I located feral pigs using ATS VHF receivers and three-element, hand-held Yagi antennas. Locations gathered from each pig had at least 2 hours between them to prevent bias. Locations were taken 2-5 times per week with an attempt to obtain > 30 locations per season: low hunting pressure and high hunting pressure. We divided the study into 2 seasons (low pressure: February-July; high pressure: August-January) based on the hunting data presented by the 2005-2006 State of Alabama Wildlife Management Area Harvest Report (McCutcheon 2006) (Table 2.1). Man-days hunted and the number of animals harvested from Lowndes County WMA were analyzed to assess the amount of human pressure applied to wildlife during certain times of the year. The time period of February-July (2005; low pressure) contained 260 man-days hunted, while the time period of August 2005-January 2006 (high pressure) had 4985 man-days hunted. In the low pressure season, fewer people hunted turkeys and small game, and the gates were closed to the public for several months during this time frame. In the high pressure season, a higher number of hunters entered the woods in pursuit of deer and hogs, and there was a special 3-week early hog season during this time period.

Telemetry sessions were carried out throughout the day and night to account for all movement periods. Locations of pigs were established by taking ≥ 2 bearings ≤ 15 minutes of each other from preset stations to reduce movement error. The bearings were between 20^0 and 160^0 of each other to ensure that appropriate bearing angles were obtained (Gese et al. 1988). Stations were established throughout the study area based on land terrain and accessibility. Locations with an error of 0.1 km^2 or more were discarded and not used in the home range calculations.

Test collars were utilized to quantify user error associated with telemetry in the study area. Approximately 100 locations were used from two VHF test collars (four stations) to calculate error. This error (SD = 4.24) was then incorporated into the computer program LOCATE (Pacer, Truro, Nova Scotia) to estimate locations.

Home Range and Habitat Use

Seasonal and cumulative home ranges were estimated using the adaptive kernel method (Worton 1989) in the computer program CALHOME. Home ranges were areas defined as 95% of the maximum probability of the study area, while core areas were defined as 62% of the maximum probability of the home range (Shivik et al. 1996). A three-way ANOVA was carried out to test whether or not sex, age, type of season, and their interactions significantly impacted home range size.

Habitat analysis was carried out in ArcView GIS 3.2 (ESRI) and ArcGIS 8.3. The source data set (National Land Cover Database 2001 data set) was reclassified to provide more statistical power (Vogelmann et al. 2001). Aebischer's method of compositional analysis was carried out to calculate use versus availability based on the type of season (high or low pressure), sex, and age of the collared pigs (Aebischer et al. 1993). Habitat proportions were measured as the proportion of each land-cover type located within the defined study area. The study area, or available habitat types, was calculated by drawing a 100 % MCP around all pig home ranges buffered by the radius (3543 meters) of the largest pig home range. Habitat availability was measured to encompass the potential habitats that a collared pig could traverse. We defined home range use based on the proportion of each land-cover type within the home ranges compared to study area availability (Johnson's second order selection 1980). Habitat use at the core area was compared to availability within the pigs' home ranges (Johnson's third order selection 1980). Ranking matrices were calculated by t-tests for the low and high pressure seasons to determine which habitats were preferred by order.

We collected blood samples during trapping and shooting efforts from pigs that were not used in the study to test for disease prevalence within the study population. Also, we drew blood from the pigs with transmitters after the study was finished. The serum was tested for the presence of swine brucellosis, pseudorabies, and classical swine fever.

Results

Forty-seven pigs were captured during the study period at Lowndes County WMA and adjacent lands. Thirty-one pigs were fitted with transmitters, and livestock ear tags only were attached to 16 pigs with no transmitters. One of the transmittered pigs wedged himself underneath a vehicle, and subsequently died. Of the thirty-one pigs fitted with transmitters, 24 (13 adults, 11 juveniles; 14 boars, 10 sows) were used in the home range and habitat analyses.

We drew blood from 25 pigs throughout the study. Their serum was sent to the state diagnostic lab in Auburn, Alabama to be tested for swine brucellosis, pseudorabies, and classical swine fever. All results came back negative. These 25 samples were made up from the pigs that were trapped and not used for the study, and also from ones that were used in the study.

Neither the harnesses nor ear tag transmitters worked as well in the field as anticipated. This was due to the pigs' wallowing and rooting which led to the malfunction of several transmitters. Six pigs with transmitters disappeared during the course of the study. Despite numerous attempts to locate them (including telemetry flights), they were never found.

Three pigs had their transmitters fall off. One harness broke and slipped off the pig's body, while the other two pigs just slipped out of their harnesses. We inadvertently fitted the harnesses too loosely around the animals' body upon capture, and their data were censored based on the day the harness fell off.

A boar severely damaged his ear tag transmitter and disappeared for several weeks. He was subsequently captured again, and we were able to replace the ear tag transmitter with a harness transmitter due to his growth since the first capture. Another pig ripped his ear tag transmitter out, but was later killed by an adjacent landowner. Several transmitters were damaged and emitted the mortality sensor instead of the normal pulse. The pigs were thought to be dead, but when we walked in to retrieve the carcasses and transmitters, we frightened the pigs from their bedding areas. Because this occurred on several occasions, we waited several days after obtaining an initial mortality signal from the transmitters to ensure that the pigs did not move before retrieval efforts.

Home Range

Eleven males (5 juveniles and 6 adults) and 6 females (3 juveniles and 3 adults) were monitored during the low pressure season (Table 2.2 and Table 2.3). A total of 432 radio locations were obtained on 11 boars, and 240 locations were obtained from 6 sows during the low pressure season. A total of 334 radio locations were collected from 8 juveniles, and 338 locations were obtained from 9 adults during the low pressure season. Six boars (2 juveniles and 4 adults) and 5 sows (2 juveniles and 3 adults) were monitored during the high pressure season. A total of 311 radio locations were collected from the boars, and 298 locations were obtained from the sows during the high pressure season. We collected 188 radio locations for juveniles and 421 locations for adults during the high pressure season. Hunting mortality and transmitter malfunction curtailed our efforts for a larger amount of radio locations. More locations were collected for each collared pig, but were not used due to their error of 0.1 or greater in LOCATE.

The type of season significantly affected the home range size of collared pigs (P = 0.039). Sex (P = 0.69) and age (P = 0.35) did not significantly impact home range size. The type of season significantly impacted the core range of the pigs (P = 0.01), while sex (P = 0.26) and age (P = 0.28) did not significantly influence the size of the pigs' core range. The average sizes of the core ranges decreased from low pressure to high pressure seasons.

The mean home range of the 17 pigs monitored during the low pressure season was 403.6 $\pm$ 65.6 ha with a core range of 90.1 $\pm$ 13.7 ha. Boars had an average home range of 403.1 ± 68.7 ha and sows had an average home range of 404.4 ± 147.4 ha during the low pressure season. During the high pressure season, boars had an average home range size of 283.8 ± 75.2 ha, while sows had an average home range size of 272.5 ± 119.9 ha. The pigs tightened up or decreased their home range size during the time when human pressure was the highest.

Although insignificant, juvenile pigs had unexpected larger home ranges than adults. The average juvenile and adult home ranges during the low pressure season were 499.8 ± 111.7 and 318.1 ± 67.9 ha respectively; while the average juvenile and adult home ranges during the high pressure season were 354 ± 158.9 and 235.6 ± 53.2 ha.

Habitat Use

We focused on the second and third orders of habitat usage as defined by Johnson (1980). The second order of habitat use deals with the habitat use comprised of an animal's home range within the study area that was available. The third order of usage was used to describe the core areas or patches within an animal's home range (Johnson 1980). From these orders, we were able to decipher which habitat types feral pigs chose to use within our given study area along with the core areas within their home ranges.

Habitat proportions available for the study area in 2005-2006 were water: 4.9%, developed: 4.3%, deciduous/mixed: 11.9%, evergreen: 3.5%, shrub/scrub: 12.1%, grassland/pasture/cultivated crops: 30.1%, wetlands: 33.3%. The test for group effect randomization indicated that the pigs did not choose their habitats randomly (Wilks' Lambda=0.615, d.f 6, $P < 0.001$), but rather chose the habitats that specifically met their needs. The type of season had a significant impact on which habitat types the pigs preferred ($P = 0.02$). The sex of the pigs proved to impact habitat preference but was not statistically significant (*P* = 0.06); whereas, the age of the pigs did not affect habitat use (*P* = 0.84). The low pressure ranking matrix ordered the habitats in sequence as wetlands > shrub/scrub > developed > deciduous/mixed > evergreen > grassland/pasture/cultivated crops > H_2O (Table 2.4). The high pressure ranking matrix ordered the habitat types as evergreen > shrub/scrub > wetlands > H_2O > deciduous/mixed > grassland/pasture/cultivated crops = developed (Table 2.5).

The type of season (*P* = 0.25), sex of the pigs (*P* = 0.96), and age (*P* = 0.82) did not significantly impact which habitats the pigs used for their core areas. The test for group effect proved that the pigs chose specific habitats to use for their core ranges (*P* = 0.002). The core range vs. home range availability ranking matrix ordered the habitats from most preferred to least preferred: deciduous/mixed > shrub/scrub = wetlands > grassland/pasture/cultivated crops > developed > evergreen > water.

Discussion

Home ranges should be smaller if the pig's living requirements are provided in a smaller area (Sanderson 1966), and when food was scarce during the winter, home range size increased (Kurz and Marchinton 1972, Singer et al. 1981). Maillard and Fournier (1995) showed that with pig home ranges and movements increased with the onset of hunting pressure in the winter, then decreased when hunting pressure subsided. Our high pressure season (fall and winter) showed the opposite results. The average home range size decreased by 125 hectares when food supply was shorter in the high pressure season than compared to the low pressure season in our study. This could be attributed to high hunter pressure causing the pigs to decrease their home range in an attempt to avoid the hunters. The pigs would stay in impenetrable thickets to avoid detection by hunters during the day and would venture out to nearby food plots at night to feed before returning to the thickets.

The amount of pressure in each season proved to be a significant influence on the sizes of the feral pigs' home ranges. Their home ranges were larger during the low pressure season when compared to the high pressure season. The pigs seemed to tighten up their movements and seek out areas of refuge away from human presence; however, human-induced mortality was the highest source of pig mortality. While most of the hunters probably focused their efforts around wetlands or swamps during the high pressure season, the pigs changed from using wetlands (most preferred in low pressure) to using evergreen forests where there might be less human traffic.

Although males are mostly solitary, they seemed to be somewhat tolerant of each other; in that, their home ranges often overlapped with each other. Visually, the home ranges of boars and sows overlapped each other regardless of sex or age (Figure 2.1 and 2.2). Boars and sows had roughly the same home range size regardless of the type of season which coincides with findings in coastal South Carolina (Wood and Brenneman 1980). The boars probably did not have to travel great distances to find food or a receptive sow based on the types of favorable habitats and the large number of pigs on Lowndes WMA.

Juveniles had larger average home ranges than adult pigs. Several pigs were collared as juveniles but survived to adulthood during the study. The larger juvenile home range could be due to their exploration of new areas to establish their own territory as they grew into adulthood. A juvenile female had the largest home range (1085 hectares) in the low pressure season. This same pig also had the largest home range

(734.6 hectares) during the high pressure season and likely influenced the average juvenile home ranges. Several juveniles dispersed to completely new areas and established new home ranges.

While the average number of radio locations per pig was relatively low, we feel that they are an adequate portrayal of the habitat traversed by the pigs. Each radio location is a depiction of a "picture" in a photo album. While not every pig movement was recorded, we were able to acquire an adequate representation of the pigs' home range by looking at their "photo album." The difference in spatial habitats appears to be the reason for differing home range sizes in the different studies (Wood and Brenneman 1980). This is why each study produces different results and is only specific to the animals located on the area that is being studied.

The low pressure season mainly consisted of the hot months (spring/summer) when rainfall was not as plentiful as during the winter months. This season covered the time during the low pressure turkey season and the summer months when the gates were closed to the public. There were a few turkey hunters in the area and very little pressure when the gates were closed. With less human pressure in the woods, the pigs explored more and increased their home range size.

The pigs preferred wetlands over all the other habitat types during the low hunting pressure season. They used the wetlands for thermoregulation, drinking, and for the array of edible aquatic plants (Dickson et al. 2001). The pigs utilized these habitats for bedding, farrowing, and food resources. During the early spring, we noticed numerous farrowing beds along with an increase of piglet sightings in close proximity of wetlands and shrub/scrub habitats. Surprisingly, developed areas were the third most preferred habitat. Developed areas included those areas that were around houses, other structures, and roads/roadsides. This could be due to pigs occasionally rooting up road sides in search of tubers or grubs. During low pressure situations, they may become more adventurous or curious of these developed areas. They have often been known to raid gardens near houses.

The high pressure season consisted of the early pig season and deer season (fall/winter). Human pressure was high during this season with more hunters present than during the low pressure season. Most of the hunters probably focused on the wetland areas during this time when searching for pigs. Many of the hunter's vehicles were parked near wetland areas. Thus, with more pressure applied to the wetlands, the pigs chose to utilize pine forests more than the other habitat types because of the lack of human presence. The second choice (shrub/scrub) was probably chosen for its thick cover providing refuge and nesting areas.

Conclusions and Management Implications

Feral pig movements and habitat use were different than expected. Juveniles had larger home ranges than adults, and instead of the hunting pressure dispersing the pigs, the pressure seemed to make the pigs decrease their home ranges. The pigs did not use the wetlands habitat predominately for both seasons as previously thought. This project provided more insight into the ecology of pigs in different pressure settings.

Future pig researchers should take into careful consideration the mode of transmitter attachment. This study used ear tags and harnesses to attach transmitters to specimens. The ear tag transmitters were minimally invasive and were simple to attach; however, their signal had a limited distance due to the small antennae that pointed at the ground. Because of the pigs' rooting characteristics, the 289-day lifespan transmitter did not last the entirety of the battery life.

The harness transmitters had a 372-day lifespan. Their signal had excellent range (almost 3.22 km) under ideal circumstances, but the harnesses did not work as well as anticipated. Harnesses were difficult to properly fit on the specimen. Some of the harnesses broke and several slipped off of the animals. Several pigs that were tracked down after the study to retrieve the transmitter showed signs of the harness cutting into their bodies. Future studies should consider using a different mode of attachment than the harnesses.

The low pressure ranking matrix ordered the habitats in sequence as wetlands > shrub/scrub > developed > deciduous/mixed > evergreen > grassland/pasture/cultivated crops > H_2O. For better control efforts by managers, traps should be placed near wetlands and shrub/scrub habitats when the pigs have been minimally disturbed. These wetland and thick areas will attract pigs during the hot times of the year. While stalking or hunting the pigs, these areas should be traversed by hunters to increase their chances of harvesting pigs.

The high pressure ranking matrix ordered the habitat types as evergreen > shrub/scrub > wetlands > H_2O > deciduous/mixed > grassland/pasture/cultivated crops = developed. Since the high pressure consisted of the cooler parts of the year, the pigs did not focus on thermoregulation from the wetlands. During high hunting pressure, managers should focus on the pine forests and shrub/scrub habitats to better their chances of harvesting pigs. If hunters choose to hunt habitats that are not as heavily hunted (i.e. evergreen forests), then their chances of taking a pig may increase.

Managers and biologists often come up with new methods to control animals. They developed a technique to reduce numbers of an unwanted species through the use of telemetry. The 'Judas' pig technique was based on the 'Judas' goat method (Pech et al. 1992, Conover 2002) of radio-collaring one member of a group and then allowing them to rejoin the group. After a sufficient time period has passed to allow the goats to join others, they were tracked down, and the other goats with them were removed. Since sows are more sociable than boars, most of these techniques have been implemented by collaring adult sows (McIlroy and Gifford 1997). After the study was finished, we used the Yagi antennae and receiver to track down the remaining pigs to collect the transmitters. This proved to be an effective mode of removing pigs. In 7 days of tracking, we removed approximately 20 pigs (including 6 fetuses) in March 2006. We tracked down a collared sow and dispatched her, while her collared juvenile daughter escaped. On subsequent days, we followed this juvenile female, harvesting pigs with whom she was associating. Tracking a collared juvenile female that was motherless proved to be an effective 'Judas' pig system. Sows are independent of other pigs and may or may not join up with other pigs. Since we harvested the adult sow (mother), the juvenile female (daughter) quickly found other pigs with whom to associate, because she was probably dependent on other pigs for company and leadership. So, collaring a motherless, juvenile female proved to be an effective method in population control for this study.

While hunting pigs to retrieve the transmitters, we flushed many pigs that were bedded up in blown down trees. The trees were blown down from a hurricane the previous year. This provided the pigs with extra shade and concealment while providing a structure for protection to their back. The pigs were protected from predators on one side by having the log at their back while maintaining a visible field to their front. A blown down tree provided the pigs with an optimal bedding site. If a piece of property contains a large amount of blown down trees, it would be beneficial for managers to focus removal efforts around these trees.

On this study, several pigs showed the capacity for quick learning. One collared adult boar was trapped a total of 7 times. After being trapped on the third occasion, the boar appeared to be calm and collected in the trap while we worked on setting him free. We deduced that he was satisfied with receiving a meal of corn and molasses while being confined in the trap for several hours before being set free. Another collared adult boar showed a learning curve with regard to a heavily hunted area of the WMA. While tracking him at night, we found that he traversed food plots and surrounding areas, but when day came, he bedded up in the same impenetrable thicket many times during the hunting season. When the hunters walked through the woods during the day, he became a creature of habit by resting in a thicket where hunters did not go.

The collared pigs were mostly nocturnal and crepuscular. Also, we noticed an increase in pig sightings (movements) after a rain. When the ground is moist, animals that rely heavily on smell can pick up scents more easily (Lemel and Soderberg 2003). Also, pigs can root up ground more easily when the ground is soft and moist. To optimize their control efforts, managers and biologists can focus control efforts during dawn and dusk periods and after rain showers.

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Table 2.1: Wildlife management area harvest report 2005-2006 summary for Lowndes County WMA, Alabama (McCutcheon 2006).

Season	Man-days hunted	Number of animals harvested
High Pressure		
(Aug. 1, 2005-Jan. 31, 2006)		
Deer (gun)	2010	155
Deer (archery)	875	91
Feral swine	2100	300
Totals	4985	546
Low Pressure		
(Feb. 1, 2005-July 31, 2005)		
Turkey	250	15
Turkey (youth)	10	0
Totals	260	15

Table 2.2: Feral pigs monitored during the low pressure hunting season (February 1, 2005-July 31, 2005) on Lowndes County WMA, Alabama.

Pig ID	Pressure	Sex	Age	Home Range *	Core Range *
300	Low	M	Adult	100.4	34.2
399	Low	M	Juvenile	324.9	78.1
418	Low	F	Juvenile	198	39.9
439-1	Low	M	Juvenile	459.8	132.4
457-2	Low	M	Juvenile	888.3	173.1
479	Low	M	Juvenile	383.5	139.6
500-861	Low	M	Juvenile	400	135.6
539-2	Low	F	Juvenile	1085	170.2
560	Low	F	Juvenile	258.9	54.4
578	Low	F	Adult	104.2	31.3
658	Low	M	Adult	228.9	38.7
679	Low	F	Adult	520.4	99.8
701	Low	M	Adult	554	195.1
779	Low	M	Adult	639.1	71.7
800	Low	M	Adult	305	67.2
880	Low	M	Adult	150.6	28.1
921	Low	F	Adult	260	42.9

*measurement in hectares

Table 2.3: Feral pigs monitored during the high pressure hunting season (August 1, 2005-January 31, 2006) on Lowndes County WMA, Alabama.

Pig ID	Pressure	Sex	Age	Home Range *	Core Range *
375	High	F	Juvenile	148.4	42.1
439-2	High	M	Juvenile	42.1	13.5
500-861	High	M	Juvenile	490.9	110.4
539-2	High	F	Juvenile	734.6	120.4
658	High	M	Adult	192.7	46.6
701	High	M	Adult	459.7	54.7
880	High	M	Adult	140.9	33.5
900	High	F	Adult	198.7	39.4
921	High	F	Adult	44.2	13.1
940-737	High	M	Adult	376.2	114.5
960	High	F	Adult	236.7	49.6

*measurement in hectares

Table 2.4: Low pressure habitat preference ranking matrix of home range vs. study area from February 1, 2005-July 31, 2005 on Lowndes County WMA.

	H20	DEV	DM	GREEN	SS	GRASS	WET	RANK
H20		- - -	- - -	- - -	- - -	- - -	- - -	0
DEV	+ + +		+	+	-	+	-	4
DM	+ + +	-		+	-	+	-	3
GREEN	+ + +	-	-		-	+	-	2
SS	+ + +	+	+	+		+ + +	-	5
GRASS	+ + +	-	-	-	- - -		- - -	1
WET	+ + +	+	+	+	+	+ + +		6

*H2O = water; DEV = developed; DM = deciduous/mixed; GREEN = evergreen; SS = shrub/scrub; GRASS = grassland/pasture/cultivated crops; WET = wetlands

Table 2.5: High pressure habitat preference ranking matrix for home range vs. study area from August 1, 2005-January 31, 2006 on Lowndes County WMA.

	H20	DEV	DM	GREEN	SS	GRASS	WET	RANK
H20		+	+	- - -	-	+	-	2
DEV	-		-	-	-	-	-	0
DM	-	+		- - -	-	+	-	1
GREEN	+ + +	+	+ + +		+	+	+	5
SS	+	+	+	-		+ + +	+	4
GRASS	-	+	-	-	- - -		-	0
WET	+	+	+	-	-	+		3

*H2O = water; DEV = developed; DM = deciduous/mixed; GREEN = evergreen; SS = shrub/scrub; GRASS = grassland/pasture/cultivated crops; WET = wetlands

Table 2.6: Habitat preference ranking matrix for core range vs. home range for Lowndes County WMA 2005-2006.

	H20	DEV	DM	GREEN	SS	GRASS	WET	RANK
H20		-	- - -	-	- - -	- - -	- - -	0
DEV	+		- - -	+	- - -	- - -	- - -	2
DM	+ + +	+ + +		+ + +	+ + +	+ + +	+	5
GREEN	+	-	- - -		- - -	- - -	- - -	1
SS	+ + +	+ + +	- - -	+ + +		+	+	4
GRASS	+ + +	+ + +	- - -	+ + +	-		-	3
WET	+ + +	+ + +	-	+ + +	-	+		4

*H2O = water; DEV = developed; DM = deciduous/mixed; GREEN = evergreen; SS = shrub/scrub; GRASS = grassland/pasture/cultivated crops; WET = wetlands

Figure 2.1: Adult core areas during the low pressure hunting season (February 1, 2005-July 31, 2005) on Lowndes County WMA, Alabama.

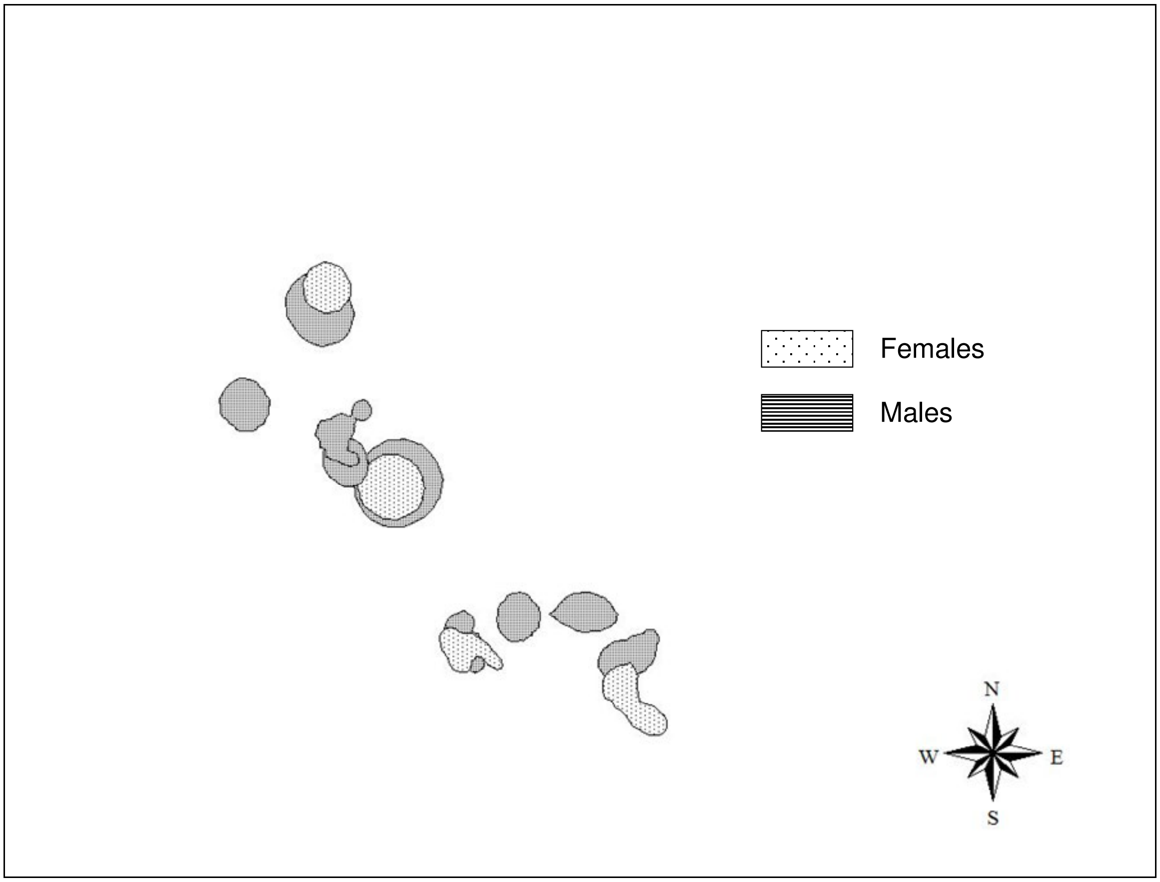
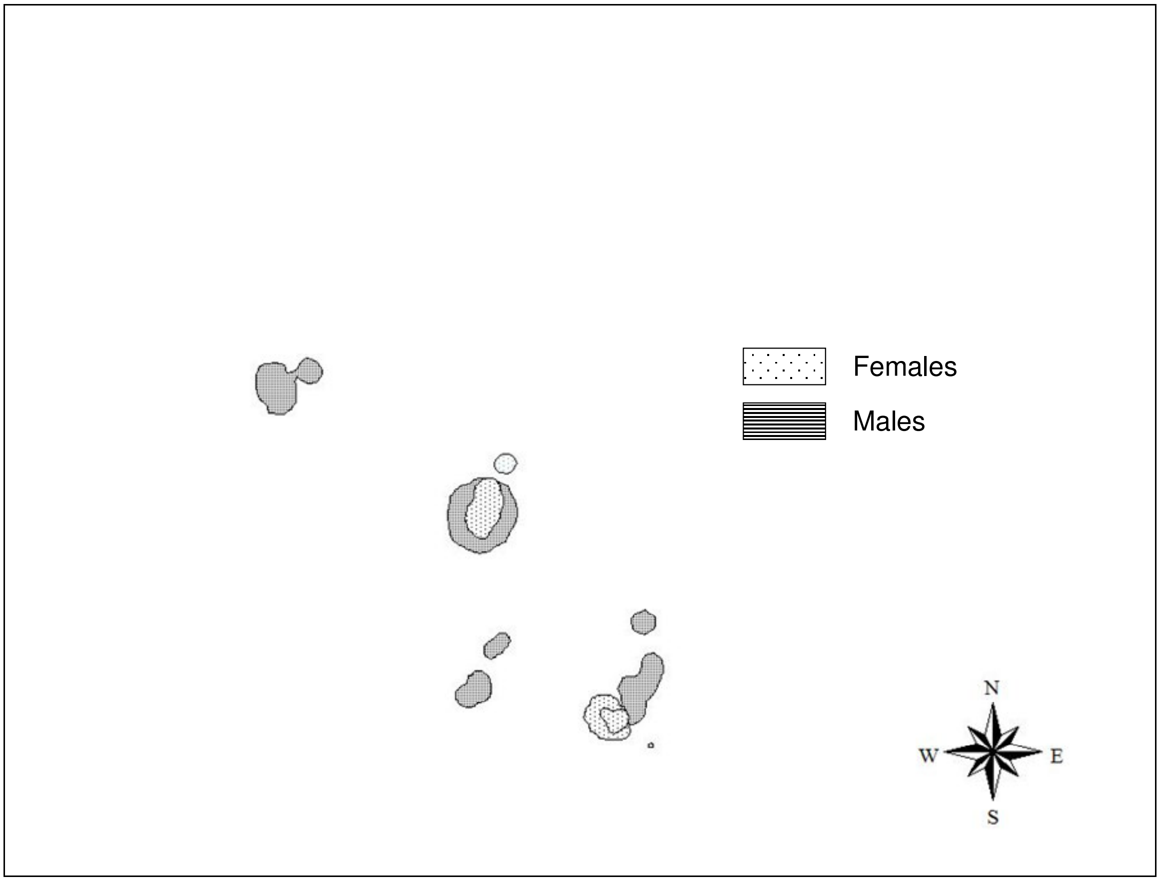


Figure 2.2: Adult core areas during the high pressure hunting season (August 1, 2005-January 31, 2006) on Lowndes County WMA, Alabama.



CHAPTER III. SURVIVAL RATES AND CAUSE-SPECIFIC MORTALITY OF FERAL PIGS (*Sus scrofa*) ON LOWNDES COUNTY WMA, ALABAMA

Abstract

Juvenile and adult feral pigs were trapped and equipped with radio transmitters and/or livestock ear tags in an attempt to estimate survival rates and cause-specific mortality on and around Lowndes County Wildlife Management Area (WMA), Alabama. For the study, two six-month seasons were defined (high pressure hunting or low pressure hunting) based on the number of hunters that entered the woods on the WMA. Of the 35 marked pigs, 25 died or were considered dead during the study (1 February 2005-31 January 2006). Causes of known deaths included humans (n = 14) and unknown (n = 2). An animal was also considered to be dead if the animal disappeared from the area and was not located again during the remainder of the study (n = 6) or the transmitter fell off (n = 3), in order to provide minimum estimates of survival. Survival estimates were based on cumulative (high and low pressure), high, and low pressure hunting seasons. Females had a higher survival rate than males cumulatively and seasonally (cumulative: sows 27.7%, boars 17.5%; low pressure: sows 71%, boars 50.3%; high pressure: sows 40.7%, boars 34.4%). Males and females showed no significant difference in annual survival (P = 0.25). There was no significant difference between male and female

survival during the low pressure (P = 0.16) or high pressure seasons (P = 0.37). Pigs had higher survival estimates during the low pressure hunting season.

Key words: feral pig, survival rates, cause-specific mortality, humans, pressure

Introduction

Telemetry studies have made it possible to advance our knowledge of the activities and mortality of marked animals (Mech 1967, Hessler et al. 1970). Survival rates are an important source of information that affects population trends. Temporal and gender-specific variation in mortality rates is a vital cornerstone that determines population processes. This information provides insight into population growth and reproductive rates which affect conservation and management practices (Bond et al. 2001, Gehrt 2005).

Ever since their first introduction into North America by Hernando de Soto in 1539, feral pigs have continued to spread throughout the land causing immeasurable amounts of damage to property and the environment (Wood and Barrett 1979, Mayer and Brisbin 1991). Ecologically, feral pigs are a keystone species, because various wildlife species and environments are negatively influenced through pig foraging. To help control populations, the biology, behavior, and population trends of the culprit species must be known. While many aspects of the life history of feral pigs have been studied, little information is available in the literature regarding survival rates and cause-specific mortality of this species.

Proper wildlife management requires the manager to possess knowledge regarding the rates of population growth and decline (Choquenot et al. 1996). Survival estimates and cause-specific mortality allow wildlife managers to make informed decisions on when to apply control pressure if necessary for a certain species.

Radiotelemetry studies allow researchers to ascertain the cause of mortality and the time at which the study animal died; this information may be used for the estimation of survival rates and cause-specific mortality (Heisey and Fuller 1985). Annual and seasonal survival rates and cause of mortality along the age and gender gradient are beneficial pieces of information that can help wildlife managers set up wildlife control programs (Gehrt 2005). Knowing this information is very advantageous when dealing with a species prolific as the feral pig.

Feral pigs are established in at least 52 of the 67 counties in Alabama. Pigs were intentionally released for hunting purposed in 38 counties. The heaviest concentration of feral pigs appears to be in southwest Alabama. Overall, feral swine seem to be established throughout most of the state (Armstrong and Causey 2004) which poses disease threats to domestic swine production and damage threats to the environment.

In the case of this study, survival rates based primarily on hunting pressure will allow state wildlife officials to gain insight regarding the rate of survival for feral pigs on public lands. Our objectives were to ascertain estimates of cumulative and seasonal survival rates and cause-specific mortality for feral pigs on Lowndes County WMA, Alabama.

Methods

Study Area

This study was conducted February 2005 through March 2006 at and around Lowndes County Wildlife Management Area (WMA), in Lowndes County, Alabama. The 4,218 hectare WMA is located near the town of White Hall between Montgomery and Selma, Alabama and is managed by the Division of Wildlife and Freshwater Fisheries of the Alabama Department of Conservation and Natural Resources. The WMA and the surrounding land consist of planted hardwoods, agricultural fields, pine stands, clearcuts, swamps, and bottomland hardwoods, and these diverse habitats are conducive to fostering the hog population. Lands adjacent to the WMA are managed for farming, beef cattle, gravel mining, and game hunting. Feral hogs may be harvested on the WMA with appropriate weapons during the big and small game seasons, along with a specified three-week hog hunt during the months of August and September. The WMA biologists and surrounding landowners use opportunistic feral pig shooting throughout the year to help reduce the population. Signs explaining the project were posted at WMA entrances and parking lots and gas stations in the area. Adjacent landowners were notified about the project.

Data Collection

Beginning in February 2005, a total of 47 pigs were captured and fitted with radio-transmitters and/or livestock ear tags. All of the pigs fitted with radio transmitters (n=30) were used along with 5 ear-tagged pigs harvested by hunters/landowners were used in survival analysis. All age classes and sexes were contained in the sample. Pigs were captured by wrangling, a drop net, and cage traps baited with shelled corn, corn mash, and molasses.

Upon capture, pigs were immobilized with Telazol (Tiletamine HCL and Zolazepam HCL), which was injected intramuscularly via a three-foot pole syringe at a rate of 1-1.5cc/45 kg. A blindfold was placed over their eyes to help calm the animal while morphological measurements were taken and the transmitter was attached. Adults were fitted with receiver harnesses that contained mortality-sensor VHF transmitters (Advanced Telemetry Systems, Inc., Isanti, MN, USA). Harnesses were secured to allow for future growth during the study period. Mortality-sensor VHF ear tag transmitters

(Advanced Telemetry Systems, Inc., Isanti, MN, USA) were attached to the ears of juvenile pigs. The choice to use ear tag transmitters instead of receiver harnesses on juveniles was based on the rapid growth rate of young pigs. Livestock ear tags were attached to both ears of the pigs that were not used for the movement study but would be part of the survival study. All animals were monitored until fully alert and then released at the capture site.

Feral pigs deployed with transmitters were not tracked for a period of 48 hours following capture and transmitter attachment. This allowed them time to adjust to wearing the harnesses and ear tags and return to normal activity patterns. Locations were taken 2-5 times per week with no less than 30 locations per season. I defined pressure based on the number of hunters that entered the woods in search of game (McCutcheon 2006). As hunters enter the woods, their presence, scent, and gunshots can cause pigs to increase their movement rates in an attempt to avert danger, thus making them more susceptible to being harvested (Sparrowe and Springer 1970, Pilcher and Wampler 1982). The low pressure season started February 1, 2005 and ended July 31, 2005 (181 radio days) and coincided with minimal human presence during turkey season (260 man-days hunted) and the summer months in which the gates were closed to the public. The high pressure season began August 1, 2005 and ended January 31, 2006 (184 radio days). This season corresponded to the special hog season in August and September and deer season (4985 man-days hunted) in which a larger number of hunters entered the woods than the low pressure season (Table 3.1).

Cause-specific mortality factors for pigs with transmitters were ascertained through use of radiotelemetry to locate carcasses shortly after death. Ear-tagged pigs without transmitters were noted when harvested by hunters and landowners. A pig was considered to be “dead” if the transmitter fell off and the animal was never recaptured, the pig disappeared completely with the transmitter and was not located during the remainder of the study, and through visual confirmation of a death occurrence. From this protocol, the survival rates would be minimum estimates of survival. Survival estimates of pigs equipped with transmitters were assumed to be the same as pigs that were not marked (Burger et al. 1995).

We used the computer program MICROMORT (Heisey and Fuller 1985) to calculate survival estimates based on marked pigs with the bias adjusted survival estimates to account for a small sample size. This program allows for staggered entry; in that, pigs could be captured throughout the study period, and their survival data still be used in the study. Cumulative and seasonal survival rates for each class of pigs were calculated based on the number of transmitter days for the specified time interval (Heisey and Fuller 1985).

Survival and cause-specific mortality rates were computed for two seasons: low hunting pressure and high hunting pressure. After the radio days were calculated, “humans” and “other” were used as the causes of mortality. The “other” category included the pigs that died of unknown causes, disappeared, and transmitters fell off. The pigs that died due to unknown causes were thought to be from predation based on the state of their bodies after death, but conclusive evidence could not be produced that predation had occurred.

Analysis

All feral pigs that had available capture and death data were used in the survival analysis. From the survival estimates and variances calculated in MICROMORT, z-tests were conducted to determine significance between gender and age by season. Statistical tests were considered significant when P-values ≤ 0.05.

Results

Forty-seven pigs were captured during the study period at Lowndes County WMA and adjacent lands. Thirty-one pigs were fitted with transmitters, and livestock ear tags were attached to 16 pigs. One of the transmittered pigs died due to capture myopathy. He wedged himself underneath a vehicle and died shortly thereafter from stress. This is the only pig fatality on this project due to capture myopathy. Thirty pigs with transmitters along with 5 ear-tagged pigs harvested by hunters (2 were killed after January 31, 2006, but were still alive during the study) were used in the analysis (Table 3.2).

Neither the harnesses nor ear tag transmitters worked as well in the field as anticipated. This was due to the pigs' wallowing and rooting which led to the malfunction of several transmitters. Six pigs with transmitters disappeared during the course of the study. Numerous attempts were made to locate these pigs including telemetry flights, but they were never found. Transmitter damage was attributed to their disappearance. The pig's rooting and wallowing damaged the transmitters to an extent that a signal could not be produced. For minimum survival estimates, these 6 pigs were censored as dead on the last available tracking location.

Three pigs had their transmitters fall off. One harness broke and slipped off the pig's body, while the other two pigs just slipped out of their harnesses. We inadvertently fitted the harnesses too loosely around the animals' body upon capture, and their data were censored based on the day the harness fell off to provide minimum survival estimates (Pollack et al. 1989).

A boar had completely damaged an ear tag transmitter and disappeared for several weeks during the low pressure season. He was subsequently captured again, and the ear tag transmitter was replaced with a harness transmitter due to his growth since the first capture. Another pig ripped his ear tag transmitter out, but was later killed by an adjacent landowner. Several transmitters were damaged and emitted the mortality sensor instead of the normal pulse. The pigs were thought to be dead, but when we walked in to retrieve the carcasses and transmitters, the pigs jumped up from their beds and ran away. Since this occurred on several occasions, we waited several days to see if the transmitter moved to a different location before walking in to retrieve it.

During the study period for Lowndes County WMA and adjacent lands, the primary cause of mortality was due to humans (14 of the 25 deaths, 56%). The other 11 deaths included: disappearance (24%); loss of transmitter (12%); and undecided (8%). Ten pigs were still alive after January 31, 2006, but were killed, died, or the transmitter fell off from February 1, 2006 through March 2006 (Table 3.3).

Females tended to have a higher survival rate than males both cumulatively and seasonally: cumulative, females 27.7%, males 17.5%; low pressure, females 71%, males 50.3%; and high pressure, females 40.7%, males 34.4%. Humans accounted for a higher percentage of deaths than the "other" category in the cumulative and high pressure seasons. This is due to the high number of pigs being harvested by hunters during the high pressure season.

Gender and age comparisons were made within and across the cumulative and pressure categories (Table 3.4). There were no significant differences between pig survival rates regardless of gender, age, or season. The survival rates showed that there were differences between gender, age, and season but not significant differences based on the p-values. The z-test between low pressure-juvenile female survival (74%) and high pressure-juvenile female survival (32%) revealed the greatest difference ($P = 0.06$).

Discussion

Lowndes County WMA is considered to be one of best public lands for hunting feral pigs, and many pig hunters made numerous trips to this WMA. Some hunters opted to solely pursue hogs even when other hunting seasons were open. Hunters also harvested pigs on an opportunistic basis when a pig presented itself before the primary targeted species.

Since hunters actively pursue feral pigs on Lowndes county WMA, it is no surprise that the main cause of pig mortality is related to humans. The rate of human-caused mortality might be a little larger than the data indicated. Signs explaining the project were posted at the main entrance and at heavily hunted areas. Hunters might have killed a pig with a transmitter and/or ear tags and not reported it thinking they might face disciplinary action. If this was the case, then not all marked hunter-killed pigs may have been reported. For example, a hunter killed a pig then cut off the transmitter and threw it in a pond; while another hunter just cut off the transmitter and left it in the woods. Also, an ear with the ear tag transmitter still attached was found in a cotton field. The cut marks on the ear were made by a knife.

Females consistently had a higher survival rate than males regardless of age. Some possible explanations for this could be that males have larger home ranges and traverse the environment at a greater rate in search of breeding opportunities and to express dominance. Also, hunters often shoot boars before sows because of their trophy value. With sows having a higher survival rate, many will survive to have one or more litters, thus increasing the population. To reduce the pig population, hunters and managers should target the adult sow first out of a group of pigs. This will take out an older breeding female from the population.

Piglets are the most vulnerable of the age classes, because of their small size and inability to fend for themselves (Fruzinski 1995, Lozan 1995, Mattioli et al. 1995). Two piglets that were tagged showed possible signs of predation, but the evidence was inconclusive on whether or not predation had occurred. None of the adult pigs in the study died due to predation. Thus, predation is not prevalent in older pigs. While on telemetry expeditions, several piles of coyote scat were noticed to contain feral pig hair, but the consumption of pigs could have been due to scavenging rather than predation. Peak mortality during the year coincides with hunting seasons. Therefore, hunting mortality appeared to be compensatory rather than additive, because it did not increase total mortality (Henry and Conley 1978).

A sow and 6 piglets were trapped at one time. The sow and a female piglet were attached with transmitters, while the other 5 piglets were attached with livestock ear tags. While conducting telemetry several months later, the marked sow was spotted with only two of her piglets; however, nothing could be verified as to what had happened to the missing piglets. During the high pressure season, the juveniles had a lower survival rate than did the adults.

Data show that intensive hunting pressure can cause deer to move greater distances, increase movements, and alter home ranges, which in turn influences their vulnerability to harvest (Root et al. 1988). Feral pig gender and age survival rates decreased across the board from low pressure to high pressure. It is possible that the hunting pressure administered on the WMA could have caused the pigs to alter their behavior making them more susceptible to hunters.

Henry and Conley (1978) showed that annual pig survival was 49 % and did not vary by age on Tellico WMA, Tennessee from 1956 through 1971 with an estimated pig population of 200-797. The study at Lowndes County WMA, Alabama showed a much lower survival rate than the previous study along with juvenile females having a higher survival rate than adult males.

Conclusions and Management Implications

Feral pig management objectives for Lowndes county WMA need to be established, because of the damage they caused on the environment. If the goal is to offer hunters more pigs to hunt throughout the hunting seasons, then the current management practices should remain intact. By not allowing hunting during the summer months, the population of pigs can recover through the birthing and maturation processes.

If the feral pig management goal is to further reduce the number of pigs on the WMA, then new management options need to be evaluated. Since survival rates were higher during the summer months (low pressure), a feral pig season could be opened during the summer to facilitate a decrease in the population even further and push survival rates down. This would not allow the pig population any chance to rebound from the regular hunting seasons. After the hunting seasons expire each year, the pigs have roughly 5-6 months to recuperate and rebuild their population levels. Henry and Conley (1978) also showed that pig survival was at its highest during the spring and summer seasons on Tellico WMA, Tennessee. Constant hunting pressure should be applied year round to decrease the population or at least keep it from increasing.

While retrieving the transmitters in March 2006 after the study was completed, we noticed large numbers of fresh farrowing nests along with an influx of piglet sightings. During this time, many sows were either pregnant or suckling. We removed one sow that was pregnant with 6 piglets, and another sow that had one new-born piglet in her nest. It is during this time of parturition, heavy hunting could damage the productivity of the pig population (Henry 1966).

An extra feral pig season would allow the hunters additional opportunities to harvest a sought after species on the WMA. Since there is more daylight during the summer, more hunters may be able hunt after work without having to take any time off. This lets the hunters deal with the problem animals and manage the pig population without much cost incurred to the state. If a summer season is not feasible, then strictly managed weekend hunts could be applied. Feral pig permits could be issued during the summer for a small amount of money. This would allow more hunters to enjoy the outdoors while producing extra revenue for the state wildlife program.

If a future pig project is conducted on Lowndes county WMA, additional efforts need to be implemented in publicizing and describing the project. This way, hunters may be more willing to cooperate and report all harvests of marked individuals without the fear of repercussions. This would enable the project to report even more accurate findings.

Future pig researchers should take into careful consideration the mode of transmitter attachment. This study used ear tag and harness transmitters on specimens. The ear tag transmitters were minimally invasive and were simple to attach; however, their signal had a limited distance due to the small antennae that pointed at the ground. Because of the pigs' rooting characteristics, the 289 day life span transmitter did not last the entirety of the battery life.

The harness transmitters had a 372 day life span. Their signal had excellent range (almost 3.2 km) under ideal circumstances, but the harnesses did not work as anticipated. Harnesses were difficult to properly fit on the specimen. Some of the harnesses broke and several slipped off of the animals. Several pigs that were tracked down after the study to retrieve the transmitter showed signs of the harness cutting into their bodies. Future studies should consider using a different mode of attachment than the harnesses.

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Table 3.1: Wildlife management area harvest report 2005-2006 summary for Lowndes County WMA, Alabama (McCutcheon 2006).

Season	Man-days hunted	Number of animals harvested
High Pressure		
(Aug. 1, 2005-Jan. 31, 2006)		
Deer (gun)	2010	155
Deer (archery)	875	91
Feral swine	2100	300
Totals	4985	546
Low Pressure		
(Feb. 1, 2005-July 31, 2005)		
Turkey	250	15
Turkey (youth)	10	0
Totals	260	15

Table 3.2: Survival summary of captured pigs on Lowndes County WMA 2005-2006.

ID	Sex	Age when collared	Capture date	Death date	Days in low pressure	Days in high pressure	Death reason
300	M	A	3/6/2005	11/7/2005	148	99	Human (car)
375	F	J	9/24/2005	3/21/2006	0	130	
399	M	J	2/8/2005	1/28/2006	174	181	Human
418	F	J	2/11/2005	8/23/2005	171	23	Disappeared
439-1	M	J	2/11/2005	10/10/2005	171	71	Human
439-2	M	J	7/29/2005	12/5/2005	3	127	Human
439-3	M	J	12/15/2005	2/24/2006	0	48	
457-1	F	J	3/6/2005	3/24/2005	19	0	Undecided
457-2	M	J	4/3/2005	9/7/2005	120	38	Disappeared
479	M	J	2/8/2005	7/15/2005	158	0	Disappeared
500	M	J	2/11/2005	12/26/2005	171	148	Human
518	M	A	2/26/2005	4/17/2005	51	0	Disappeared
539-1	M	J	3/6/2005	4/5/2005	31	0	Undecided
539-2	F	J	4/7/2005	10/19/2005	116	80	Human
560	F	J	2/9/2005	1/28/2006	173	181	Human
578	F	A	2/4/2005	6/27/2005	144	0	Disappeared
599	M	A	6/9/2005	7/5/2005	27	0	Fell off
620	F	A	12/15/2005	3/1/2006	0	48	
658	M	A	4/7/2005	3/21/2006	116	184	
679	F	A	2/22/2005	9/14/2005	160	45	Fell off
701	M	A	3/11/2005	2/22/2006	143	184	
779	M	A	2/23/2005	2/3/2006	159	184	
800	M	A	4/9/2005	10/28/2005	114	89	Human
840	M	A	2/3/2005	2/22/2005	20	0	Fell off
880	M	A	2/9/2005	12/19/2005	173	141	Disappeared
900	F	A	9/24/2005	3/7/2006	0	130	
921	F	A	3/6/2005	3/13/2006	148	184	
940	M	A	6/28/2005	11/13/2005	34	105	Human
960	F	A	7/26/2005	1/28/2006	6	181	Human
979	M	A	6/9/2005	7/8/2005	30	0	Human
#25	F	J	3/6/2005	12/10/2005	148	132	Human
#28	M	J	7/29/2005	10/15/2005	3	76	Human
#33	M	J	3/23/2005	6/8/2005	78	0	Human
#52	M	J	9/24/2005	3/20/2006	0	145	
#88	F	J	6/9/2005	3/14/2006	53	184	

Table 3.3: Feral pig radio days and survival for seasonal categories on Lowndes County WMA, Alabama from February 1, 2005-January 31, 2006.

Interval	No. Radio Days	Human Mortality	Other Mortality	Survival Rate *	95 % Confidence Limits
Cumulative	6200	14	11	N/A	N/A
Male	3744	10	7	0.17	0.086-0.418
Female	2456	4	4	0.28	0.133-0.693
Adults	3047	5	6	0.25	0.122-0.582
Adult male	2001	4	4	0.20	0.084-0.637
Adult female	1046	1	2	0.29	0.107-1.000
Juveniles	3153	9	5	0.18	0.084-0.461
Juvenile male	1743	6	3	0.12	0.044-0.518
Juvenile female	1410	3	2	0.23	0.088-0.851
Low pressure	3062	2	7	N/A	N/A
Male	1924	2	5	0.50	0.319-0.843
Female	1138	0	2	0.71	0.469-1.000
Adults	1473	1	4	0.52	0.315-0.926
Adult male	1015	1	3	0.46	0.243-0.984
Adult female	458	0	1	0.62	0.309-1.000
Juveniles	1589	1	3	0.62	0.405-0.990
Juvenile male	909	1	2	0.52	0.279-1.000
Juvenile female	680	0	1	0.74	0.454-1.000
High pressure	3138	12	4	N/A	N/A
Male	1820	8	2	0.34	0.193-0.679
Female	1318	4	2	0.41	0.220-0.845
Adults	1574	4	2	0.47	0.282-0.868
Adult male	986	3	1	0.44	0.227-0.984
Adult female	588	1	1	0.48	0.224-1.000
Juveniles	1564	8	2	0.29	0.148-0.638
Juvenile male	834	5	1	0.23	0.091-0.764
Juvenile female	730	3	1	0.32	0.135-0.977

*Survival rates based on bias adjusted estimate

Table 3.4: Feral pig survival comparisons for Lowndes County WMA, Alabama from February 1, 2005-January 31, 2006.

Survival Intervals	Comparison	Z-stat	P-value
Cumulative Survival			
	juvenile male vs. juvenile female	-0.5802	0.281
	adult male vs adult female	-0.3499	0.363
	male vs. female	-0.6944	0.245
Low P survival			
	juvenile male vs. juvenile female	-0.7948	0.214
	adult male vs adult female	-0.5103	0.305
	male vs. female	-0.9868	0.161
High P Survival			
	juvenile male vs. juvenile female	-0.3922	0.348
	adult male vs adult female	-0.1423	0.444
	male vs. female	-0.332	0.37
Other survival comparisons			
	low-juvenile-male vs high-juvenile-male	1.2188	0.111
	low-juvenile-female vs high-juvenile-female	1.5271	0.063
	low-adult-male vs high-adult-male	0.0722	0.472
	low-adult-female vs high-adult-female	0.39	0.348
	low-male vs high-male	0.903	0.184
	low-female vs high-female	1.3688	0.085

CHAPTER IV. CONCLUSIONS

This study was designed to investigate the home ranges, habitat use, survival, and cause-specific mortality of feral pigs along a high and low hunting pressure at Lowndes County Wildlife Management Area. For the study, two six-month seasons were defined: low hunting pressure (February 2005 to July 2005) and high hunting pressure (August 2005 to January 2006). The low pressure season started February 1, 2005 and ended July 31, 2005 (181 radio days) and coincided with minimal human presence during turkey season (260 man-days hunted) and the summer months in which the gates were closed to the public. The high pressure season began August 1, 2005 and ended January 31, 2006 (184 radio days). This season corresponded to the special hog season in August and September and deer season (4985 man-days hunted) in which a larger number of hunters entered the woods than the low pressure season. We captured feral pigs beginning in February 2005 and monitored them via mortality sensor VHF transmitters through January 2006. Through telemetry, we were able to calculate home ranges, habitat use, survival, and cause-specific mortality for a full year.

Survival

We marked 35 pigs, of which 25 died or were considered dead during the study. Humans (or hunting) accounted for 88% of the known pig deaths (mortality). I also considered animals to be dead if the animal disappeared from the area and was not located again during the remainder of the study (n = 6) or the transmitter fell off (n = 3), in order to provide minimum estimates of survival. Survival estimates were based on cumulative (high and low pressure seasons combined), high, and low pressure seasons. Males and females showed no significant difference in annual survival (P = 0.25). There was no significant difference between males and females in the low pressure (P = 0.16) or high pressure seasons (P = 0.37); however, sows had a higher survival rate than boars cumulatively and seasonally (cumulative: sows 27.7%, boars 17.5%; low pressure: sows 71%, boars 50.3%; high pressure: sows 40.7%, boars 34.4%). All pigs had higher survival estimates during the low pressure hunting season.

Females consistently had higher survival rates than males regardless of age. Some possible explanations for this could be that males have larger home ranges and traverse the environment at a greater rate in search of breeding opportunities and to express dominance. Also, hunters often shoot boars before sows because of their trophy value. With sows having a higher survival rate, many will survive to have one or more litters, thus increasing the population. Managers may therefore want to consider targeting the adult sow first out of a group of pigs for better population control. This will remove older breeding females out of the population, reducing piglet production.

Feral pig gender and age survival rates decreased across the board from low pressure to high pressure. It is possible that the hunting pressure administered on the WMA could have caused the pigs to alter their behavior making them more susceptible to hunters.

Feral pig management objectives for Lowndes county WMA need to be established, because of the damage they cause to the environment. The pig population now root up roads, food plots, wetlands (which causes erosion), neighboring pastures and crop land, and possibly may spread cogon grass (*Imperata cylindrica*). They also compete with the native wildlife for the mast crop and other foods. If the goal is to offer hunters more pigs to hunt throughout the hunting seasons including the three week pig season in August/September, then the current management practices should remain intact. By not allowing hunting during the summer months, the population of pigs can recover through the parturition and maturation processes. For example, a piglet that is born at the end of the high pressure season (January 31) would be about 7 months old and capable of reproduction by the time the next high pressure season came around.

If the feral pig management goal is to further reduce the number of pigs on the WMA, then new management options need to be evaluated. Since survival rates were higher during the summer months (low pressure), a feral pig season could be opened during the summer to facilitate population control and decrease sow survival rates. This would not allow the pig population a chance to rebound from the regular hunting seasons. After the highly hunted deer season expires each year, the pigs have roughly 5-6 months to recuperate and rebuild their population levels. Constant hunting pressure should be applied year round to decrease the population or at least keep it stable.

Home Range and Habitat Use

We collared twenty-four pigs to determine home range and habitat use from 1 February 2005-31 January 2006 on Lowndes County WMA. Seventeen collared pigs had an average home range of 403.6 $\pm$ 65.6 ha in the low pressure season, and 11 pigs had an average home range of 278.6 $\pm$ 64.5 ha during the high pressure season. Season had a significant effect on home range size (P = 0.03) and core range size (P = 0.01).

The amount of pressure in each season proved to be a significant influence on the sizes of the feral pigs' home ranges. Their home ranges were larger during the low pressure season when compared to the high pressure season. The pigs seemed to tighten up their movements and stay near areas of refuge away from human presence; however, human-induced mortality was still the highest source of pig mortality.

Juveniles had larger average home ranges than adult pigs. Several pigs were collared as juveniles but survived to adulthood during the study. The larger juvenile home range could be due to their exploration of new areas to establish their own territory as they grew into adulthood. A juvenile female had the largest home range of 1085 hectares in the low pressure season. This same pig also had the largest home range of 734.6 hectares during the high pressure season. Several juveniles dispersed to completely new areas and established new home ranges.

The test for group effect randomization indicated that the pigs did not choose their habitats (home range or core range) randomly ($P < 0.0001$). The type of hunting pressure season had a significant effect on habitat use ($P = 0.02$). Sex ($P = 0.06$) and age ($P = 0.84$) did not have any significant effects on pig habitat preference. During the low pressure season, the collared pigs preferred wetland and shrub/scrub habitats; whereas, they preferred pine forests and shrub/scrub habitats during the high pressure season.

The pigs preferred wetlands over all the other habitat types during the low hunting pressure season. They used the wetlands to help regulate their body temperature, provide access to water, and for the array of edible aquatic plants that were available. The high pressure season consisted of the early pig season and deer season (fall/winter). Human pressure was high during this season with more hunters present than during the low pressure season. Most of the hunters probably focused on the wetland areas during this time when searching for pigs. Thus, the pigs chose to utilize pine forests more than the other habitat types because of the lack of human presence. During high hunting pressure, managers should focus on the pine forests and shrub/scrub habitats to increase their chances of harvesting pigs. If hunters choose to hunt habitats that are not as heavily hunted (i.e. evergreen forests), then their chances of taking a pig may increase.

This study provides pertinent data and implications not only for the Alabama Department of Conservation and Natural Resources, but also for other state agencies with public lands. This research project showed how pig movements and survival rates are related to the amount of hunting/control pressure applied to them. Managers can use this information to implement more effective control methods as they continue their plight against feral pigs.