A Species Action Plan for the Sherman's Fox Squirrel
Sciurus niger shermani

Final Draft
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DEDICATION

This Species Action Plan is dedicated to the memory of

Courtney Hooker Tye

(1983-2014)

In addition to being a bright and gifted wildlife biologist studying the ecology and conservation of the Florida's fox squirrels, Courtney had an amazing affect on all those she came in contact with. She was generous and her curiosity was insatiable. She loved the natural world and all the critters she encountered in her exploration. We were fortunate that Courtney brought her energy and enthusiasm to the development of this plan. Her contributions were as big as her heart. It is to her spirit and memory that we dedicate this work.

The Sherman's Fox Squirrel Team

Cover photograph by David Jones

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EXECUTIVE SUMMARY

This plan provides the framework for the conservation and management of the Sherman's fox squirrel. The Sherman's fox squirrel is a large tree squirrel, 1 of 4 subspecies in Florida, known for its varying pelage colorations and distinct relationship to the longleaf pine community. The conservation needs of the Big Cypress fox squirrel are addressed in a separate plan in order to clarify each subspecies' conservation objectives and management needs.

Once considered a game species in Florida, the major threats to the Sherman's fox squirrel today include the loss, degradation, and fragmentation of habitat within its range in peninsular Florida. The primary habitat of the Sherman's fox squirrel—the fire-dependent longleaf pine community—has declined due to land use changes, logging, and fire suppression. These threats have resulted in the isolation of the subspecies in patchy areas across the state. Isolated populations are vulnerable to local extinction from disease outbreaks, hurricanes, land use changes, and other causes. Urbanized habitats, such as golf courses and city parks, may provide suitable habitat if the understory is open and there is abundant food supply; however, their ability to support persisting populations over long-term is not well understood. In addition, mortality can be high in urbanized areas due to vehicle collisions and predators. The result is that some urban populations may be unsustainable without regular immigration of individuals from other populations.

Based on the biological assessment, the biological review group (BRG) concluded that the subspecies did not meet any listing criteria. However, the lack of data necessary for an adequate evaluation of the subspecies was of great concern. Therefore the subspecies was recommended to remain as a Species of Special Concern until sufficient data have been collected. The goal of this plan is to determine the conservation status of the Sherman's fox squirrel. The BRG also noted the importance of proper land conservation and management on a landscape scale. A primary objective is to clarify genetic relationships with other fox squirrel subspecies to better evaluate the distribution (extent of occurrence) and listing status of the Sherman's fox squirrel. Another objective is to determine the extent of occurrence and area of occupancy of the subspecies. The final objective is increasing survival and productivity of this squirrel on private and public conservation lands.

To achieve these objectives, the Sherman's fox squirrel and its habitat must be protected through science-based management, regulation, public education, and law enforcement. Successful conservation of the subspecies will require effective coordination among local, state, and federal agencies; non-governmental organizations; private landowners; university researchers; and the public. Through its programs, the FWC can provide technical and logistical support for private landowners and other groups. Additionally, the FWC can be directly involved by implementing or influencing actions necessary to achieve the conservation goal for this state-listed subspecies.

A summary of this plan will be included in the Imperiled Species Management Plan (ISMP), in satisfaction of the management plan requirements in Chapter 68A-27, Florida Administrative Code, Rules Relating to Endangered or Threatened Species. The ISMP will address comprehensive management needs for 60 of Florida's imperiled species and will include an implementation plan; rule recommendations; permitting standards and exempt activities;

anticipated economic, ecological, and social impacts; projected costs of implementation and identification of funding sources; and a revision schedule. The imperiled species management planning process relies heavily on stakeholder input and partner support. This level of involvement and support is also critical to the successful implementation of the ISMP. Any significant changes to this plan will be made with the continued involvement of stakeholders.

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GLOSSARY OF TERMS AND ACRONYMS

Agouti: A pattern of pigmentation in which individual hairs have several bands of light and dark pigment with black tips.

Area of Occupancy: The area within its extent of occurrence (see Extent of Occurrence), which is occupied by a taxon, excluding cases of vagrancy. This reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may contain unsuitable or unoccupied habitats (as defined by International Union for Conservation of Nature [IUCN]).

BCFS: Big Cypress fox squirrel

BRG: Biological review group, a group of taxa experts convened to assess the biological status of taxa using criteria specified in Rule 68A-27.001, Florida Administrative Code, and following the protocols in the Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0) and Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1).

BSR: Biological status review report, the summary of the biological review group's findings. Includes a Florida Fish and Wildlife Conservation Commission (FWC) staff recommendation on whether or not the species status meets the listing criteria in Rule 68A-27-001, Florida Administrative Code. These criteria, based on the IUCN criteria and IUCN guidelines, are used to help decide if a species should be added or removed from the Florida Endangered or Threatened Species List. In addition, FWC staff may provide within the report a biologically justified opinion that differs from the criteria-based finding.

DEP: Florida Department of Environmental Protection

Ecotone: The transitional zone between 2 distinct ecological communities.

Extent of Occurrence: The geographic area encompassing all observations of individuals of a species, including intervening areas of unoccupied habitat. Synonymous with range. See Also Area of Occupancy (as defined by IUCN).

F.A.C.: Florida Administrative Code. The Department of State's Administrative Code, Register and Laws Section is the filing point for rules promulgated by state regulatory agencies. Agency rulemaking is governed by Chapter 120, Florida Statutes, the Administrative Procedures Act. Rules are published in the Florida Administrative Code.

FFS: Florida Forest Service, formerly the Florida Division of Forestry

FNAI: Florida Natural Areas Inventory, a non-profit organization administered by Florida State University and dedicated to gathering, interpreting, and disseminating information critical to the conservation of Florida's biological diversity.

F.S.: Florida Statutes

FWC: The Florida Fish and Wildlife Conservation Commission, the state agency constitutionally mandated to protect and manage Florida's native fish and wildlife species.

FWCG: The Florida Wildlife Conservation Guide

GIS: Geographic Information System

ISMP: Imperiled Species Management Plan

IUCN: International Union for Conservation of Nature, a professional global conservation network.

IUCN Red List: An objective, global approach for evaluating the conservation status of plant and animal species, the goals of which are to: Identify and document those species most in need of conservation attention if global extinction rates are to be reduced; and provide a global index of the state of change of biodiversity.

Mast: The hard seeds and nuts (hard mast) or fruits and berries (soft mast) of trees and shrubs.

NPS: National Park Service

PVA: Population Viability Analysis

SDM: Species Distribution Models

Take: As defined in Rule 68A-1.004, F.A.C. (General Prohibitions). "Taking, attempting to take, pursuing, hunting, molesting, capturing, or killing any wildlife or freshwater fish, or their nests or eggs by any means whether or not such actions result in obtaining possession of such wildlife or freshwater fish or their nests or eggs."

UF: University of Florida

USFS: United States Forest Service

USFWS: United States Fish and Wildlife Service, the federal agency mandated to protect and manage the nation's native freshwater fish and wildlife resources.

WCPR: Wildlife Conservation, Prioritization, and Recovery. A program administered by the FWC on FWC-managed areas to ensure that protected lands are managed for the highest benefit of wildlife.

WOCC: White Oak Conservation Center

INTRODUCTION

Biological Background

This plan is for the Sherman's fox squirrel (*Sciurus niger shermani)*, a subspecies of eastern fox squirrel (*Sciurus niger*).

Taxonomy

Ten subspecies of eastern fox squirrel have been identified in the United States; the Sherman's fox squirrel is 1 of 4 subspecies inhabiting Florida and is the largest in size (Hall 1981). The geographic range of this squirrel in Florida varies depending on the source and has been loosely based on several unreliable determinations, such as morphological measurements and pelage coloration, instead of genetic analyses (Kantola 1992, Figure 1). In addition to the Sherman's fox squirrel, other fox squirrels in Florida include the Big Cypress fox squirrel (*S.n. avicennia*), occurring in south Florida; the southeastern fox squirrel (*S.n. niger*), occurring in the panhandle; and the Bachman's fox squirrel *(S.n. bachmani)*, which is thought to occur in the extreme western portion of the Panhandle (Hall 1981). According to Turner and Laerm (1993), the Bachman's fox squirrel may represent a clinal variation to *S. n. niger*, and the recognition of this subspecies warrants additional studies.

Life History

Ideal habitat for the Sherman's fox squirrel is mature, open, fire-maintained longleaf pine (*Pinus palustris*) and turkey oak (*Quercus laevis*) sandhills and pine flatwoods (Moore 1957, Kantola and Humphrey 1990, Kantola 1992, Florida Natural Areas Inventory [FNAI] 2001). To accommodate large home ranges and seasonally fluctuating food resources, suitable habitat should also include more productive lower slopes of sandhills (Kantola 1992). This subspecies also inhabits mixed hardwood pine, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats with pines and oaks (Endries et al. 2009).

The Sherman's fox squirrel is frequently found on agricultural lands and urbanized areas such as parks and golf courses, which often mimic the structure of sandhills and pine flatwoods (scattered overstory pines and oaks and low groundcover). It is unclear if the individuals that use these habitats require immigration to persist. A better understanding of Sherman's fox squirrel habitat preferences and needs is required for land use planners and land managers to make decisions compatible with their long-term conservation.

The Sherman's fox squirrel typically has 2 breeding seasons each year. The winter breeding season runs from October to February and the summer breeding season runs from April to August (Wooding 1997). Males expand their home ranges during the breeding season, and several males will cluster around a single female while she is in estrus (Wooding 1997; also see Koprowski 1994 for a summary of breeding behavior in *Sciurus niger*). Females average 1 litter per year with a mean of 2.3 offspring per litter (Moore 1957, Wooding 1997), compared with 2.5 to 3.2 young for the midwestern fox squirrel (Kantola 1992). Young are weaned at 90 days and sexual maturity is reached at about 9 months.

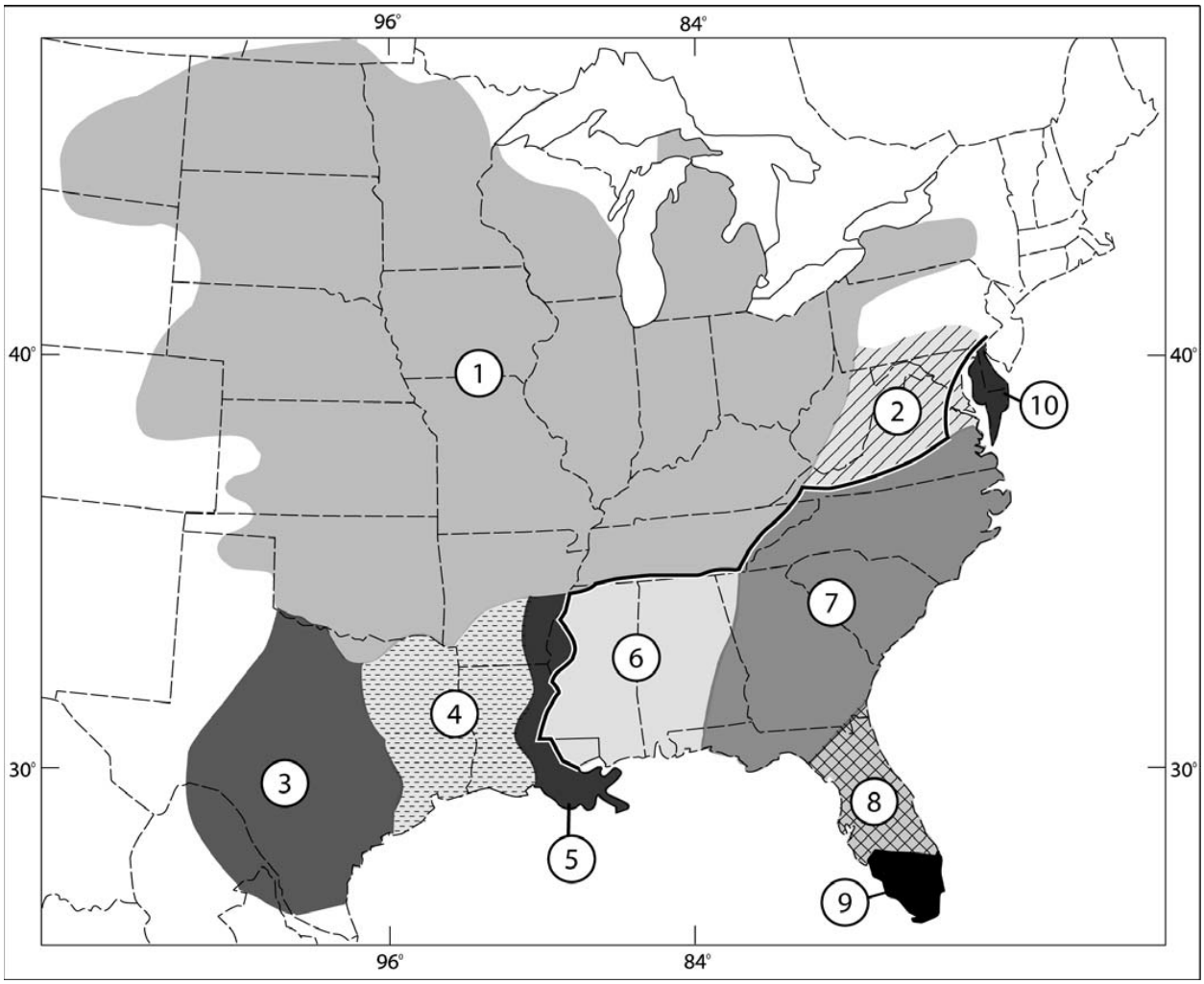

Figure 1. Geographic distribution of subspecies of eastern fox squirrel (*Sciurus niger*-Hall 1981,Koprowski 1994): 1) *S. n. rufiventer,* 2) *S. n. vulpinus,* 3) *S. n. limitis,* 4) *S. n. ludovicianus,* 5) *S. n. subauratus,* 6) S. *n. bachmani,* 7) *S. n. niger,* 8) *S. n. shermani,* 9) *S. n. avicennia,* and 10) *S. n. cinereus* (from Moncrief et al. 2010).

Figure 2. Sherman's fox squirrel juvenile captured in a kestrel box on Camp Blanding Joint Training Center. Photographs by University of Florida (UF) Fox Squirrel Research Team.

Captive fox squirrels have lived more than 10 years (Moore 1957); however, based on an annual mortality rate of 30% for radio-collared adult squirrels and field observations, average longevity in the wild is likely considerably shorter (Wooding 1997).

Longleaf pine seeds and turkey oak acorns appear to be some of the main food items consumed by Sherman's fox squirrels in the sandhill community (Moore 1957). Squirrels have been observed to move their home ranges into live oak (*Q. virginiana*) forests if turkey oaks fail to produce mast (Kantola and Humphrey 1990). The highest-quality habitat for the Sherman's fox squirrel may therefore be habitat that includes both longleaf pine savanna and live oak forest (Kantola and Humphrey 1990). Additional food items include other acorns, fungi, bulbs, vegetative buds, insects, nuts, and staminate pine cones (Kantola 1992).

Figure 3. Sherman's fox squirrel nest in longleaf pine on Bell Ridge Longleaf Wildlife and Environmental Area. Photograph by Terry Doonan, FWC.

Sherman's fox squirrels use several different nests in their home ranges (Kantola and Humphrey 1990). Most nests are leaf nests made of Spanish moss, pine needles, twigs, and leaves, while a few nests are within tree cavities (Kantola and Humphrey 1990). In the Ordway-Swisher Biological Station, nests of this squirrel were found in 6 tree species: longleaf pine, slash pine (*P. elliottii*), post oak (*Q. stellata*), laurel oak (*Q. laurifolia*), live oak, and turkey oak (Kantola and Humphrey 1990). Turkey oak was used most frequently (68.6%), followed by longleaf pine (17.7%), live oak

(4.9%), post oak (3.9%), laurel oak (3.9%) and slash pine (1%) (Kantola and Humphrey 1990). Sherman's fox squirrels in Florida occur at lower densities and have larger home ranges than estimates obtained for *Sciurus niger* elsewhere in its range (Wooding 1997).

A population of approximately 100 to 200 animals was estimated to inhabit the 37 km^2 (14 mi^2) area occupied by the Ordway-Swisher Biological Station, Putnam County, Florida (Kantola and Humphrey 1990). Other density estimates in Florida range from 7 to 38 individuals per km^2 (Wooding 1997, Humphrey et al.1985, Kantola 1986, Moore 1957). Average home range size for the Sherman's fox squirrel is 16.7 ha (41.2 ac) for females and 42.8 ha (105.7 ac) for males (Kantola and Humphrey 1990). Kantola (1992) reports midwestern fox squirrel home ranges average 0.8 to 7.0 ha (2.0 to 17.3 ac). Sherman's fox squirrel adults defend mutually exclusive core areas (Kantola and Humphrey 1990). Males have home ranges that overlap with those of females and other males, but there is very little overlap in home ranges of adult females (Wooding 1997). The relatively large home ranges of this subspecies may result from a food supply that varies in time and space (Kantola and Humphrey 1990). The low carrying capacity in Florida may be explained by a lack of high-quality, storable seeds, coupled with periodic failures of seed crops (Wooding 1997). Habitat that is low in productivity leads to low population densities, large home range sizes, and the low production of young per unit area (Wooding 1997).

Description

The Sherman's fox squirrel is a large tree squirrel typically measuring 600 to 700 mm (23 to 28 in) in length. Fox squirrels of the southeastern coastal plain are highly variable in color, varying in dorsal coloration from gray to tan agouti to completely non-agouti black, with buff or black on the ventrum (Moore 1956, Kiltie 1989). They almost always have a variable amount of white on the rostrum and ears (Kiltie 1989).

Preliminary results from a University of Florida (UF) pelage study indicate that color morphs of the Sherman's fox squirrel can be classified into 6 categories (Figure 4, (Moore 1956, C. Tye, UF, unpublished data):

1. Gray—primary dorsal pelage coloration is silver to gray and ventral is white or whitish in color
2. Buff/tan—primary dorsal and side coloration is agouti and ventral is cream to tan in color
3. Agouti with partial dorsal melanism—primary dorsal coloration is agouti with areas of black toward the head extending past the neck
4. Black-bellied—most of the ventral areas are black with varying dorsal coloration
5. Dorsal melanism—most of the dorsum is black with a non-black venter, typically cream, off-white, or orange in color
6. Melanistic—dorsal and ventral areas are almost entirely black except for the nose, ears, and, possibly, the toes

Figure 4. Six color morphs of the Sherman's fox squirrel. In numerical order as described in text; photographs by 1) Robert Green at Three Rivers State Park, 2) Carrol Betts near Chiefland, 3) David Jones near Kissimmee, 4) Alexandra Lundahl in Pinellas County, 5) Jodi Orens near Morriston, and 6) UF Fox Squirrel Research Team at Ordway-Swisher Biological Station.

Geographic Range and Distribution

Four surveys have assessed the distribution of fox squirrels in Florida (Brady 1977, Williams and Humphrey 1979, Wooding 1997, Eisenberg et al. 2011). While the exact geographic boundaries of each subspecies are unclear, based on morphological characteristics, it is generally accepted that the range of *Sciurus niger shermani* includes most of peninsular Florida (Figure 5), extending northward into southern Georgia, westward into Gilchrist and Levy counties, southward on the west coast probably to the vicinity of the Caloosahatchee River (at least to Highlands and Hillsborough counties), and southward on the east coast to Jupiter in Palm Beach County (Moore 1956, Wooding 1997). Humphrey and Jodice (1992) considered the specimens south of Palm Beach County as intergrades between the Sherman's fox squirrel and the Big Cypress fox squirrel.

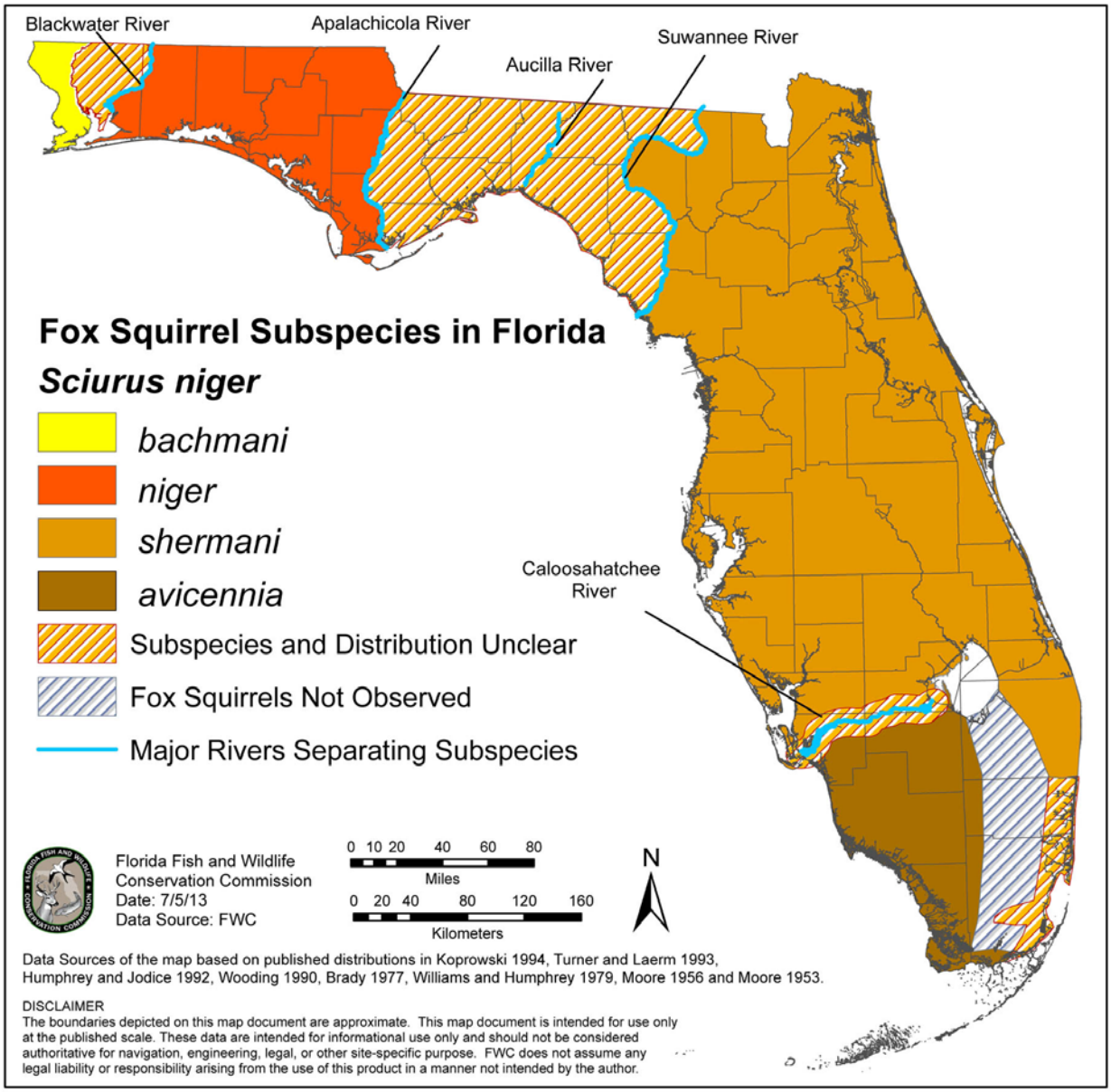

Figure 5. Range of the Sherman's fox squirrel in Florida, compared to that of other fox squirrel subspecies.

Conservation History

Fox squirrels were formerly a game animal in Florida and were hunted legally statewide. The season was closed within the range of Big Cypress fox squirrel in 1972. In 1991, the season was closed on all wildlife management areas. A final closure ended the legal harvest of fox squirrels in Florida in 1995.

Sherman's fox squirrels were listed as Threatened from 1975 to 1978 and as a Species of Special Concern from 1980 to the present. The International Union for Conservation of Nature (IUCN) Rodent Specialist Group currently lists the subspecies as Lower Risk, Near Threatened because

of “extensive loss of the habitat of S. n. shermani, which could be mitigated by establishment of preserves of adequate size” (Hafner et al.1998).

The U.S. Fish and Wildlife Service (USFWS) identified the Sherman’s fox squirrel as a C2 candidate taxon for listing in 1994 (USFWS 1994) but did not list the taxon (C2 refers to a species that may warrant listing but which does not have sufficient data to determine status designation). The Florida Committee on Rare and Endangered Plants and Animals has designated the Sherman’s fox squirrel as Threatened (Kantola 1992), and FNAI ranked the Sherman’s fox squirrel G5T3/S3 (G5 refers to the entire species = demonstrably secure globally; T3 refers to the specific subgroup, roughly equivalent to the S3 rank except that “throughout its range” is substituted for “in Florida”; S3 = either very rare and local in Florida or found locally in a restricted range or vulnerable to extinction from other factors) (FNAI 2001).

Although there has been extensive loss of habitat for fox squirrels, land acquisition programs such as Preservation 2000 and Florida Forever have allowed for the purchase of some potential habitat. However, loss and fragmentation of unprotected habitat is ongoing. Those losses underscore the importance of proper management conservation lands as critical to ensuring that they are suitable for the Sherman’s fox squirrel. The Florida Fish and Wildlife Conservation Commission (FWC) initiated the Wildlife Conservation, Prioritization, and Recovery (WCPR) program in 2008 to provide assessment, recovery, and planning support for the Wildlife Management Area and Wildlife and Environmental Area system to enhance management of focal species and recovery of listed species. This program helps assess species needs and opportunities, prioritize what FWC does for imperiled and focal species on system lands, prescribe management to aid in species recovery, prescribe monitoring to allow evaluation of the species’ response to management, and ensure the information is shared. The Sherman’s fox squirrel is a WCPR focal species. As species conservation strategies are developed for FWC-managed lands, recommendations for management and monitoring of the species are provided for lands that have a role in its conservation. FWC regional biologists in the Wildlife and Habitat Management Section are responsible for coordination of the WCPR program and providing technical assistance to other public agencies’ land mangers regarding the Sherman’s fox squirrel as well as other focal species. FWC has identified closing data gaps for fox squirrels as a priority, and a State Wildlife Grant is funding a UF-led research effort to address questions regarding taxonomy, habitat selection, and monitoring methods for fox squirrels in Florida.

Threats and Recommended Listing Status

In 2010, the FWC directed staff to evaluate the status of all species listed as Threatened or Species of Special Concern that had not undergone a status review in the past decade. To address this charge, staff conducted a literature review and solicited information from the public on the status of the Sherman’s fox squirrel. The FWC convened a biological review group (BRG) of experts on the Sherman’s fox squirrel to assess the biological status of the subspecies using criteria in Rule 68A-27.001, Florida Administrative Code (F.A.C.). This rule includes a requirement for BRGs to follow the Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 3.0) and Guidelines for Using the IUCN Red List Categories and Criteria (Version 8.1). FWC staff developed a draft Biological Status Review Report (BSR) that included the BRG’s findings and preliminary listing recommendation from staff. FWC distributed the draft for peer review, and the reviewers’ input was incorporated in a final report.

The Sherman's fox squirrel BRG concluded from the biological assessment that the subspecies did not meet any criteria to warrant listing as a state Threatened subspecies, although they did identify a continued decline due to continuing habitat loss. However, the BRG expressed concerns about the adequacy of the data currently available for evaluating the status of the Sherman's fox squirrel. The BRG concluded that research evaluating current status, range, and occupancy of the Sherman's fox squirrel is critical and that, as new data become available, it is crucial that the subspecies be re-evaluated prior to removal from the Florida Endangered and Threatened Species List. Therefore, FWC staff recommended that the Sherman's fox squirrel be maintained as a Species of Special Concern until information gaps are addressed. Findings from the BRG are included in a BSR information findings table.

Threats

The biggest threat to the Sherman's fox squirrel is destruction of habitat due to encroaching development (Kantola and Humphrey 1990, FWC 2005). Such habitat loss has already been significant; it is estimated that only 10 to 20% of the Sherman's fox squirrel's historic habitat is still intact (Bechtold and Knight 1982 as cited in Kantola 1992). Most of its habitat has been logged; converted to pasture; degraded by lack of fire; or used for agriculture, commercial development, and residential development (Bechtold and Knight 1982 as cited in Kantola 1992). Florida's longleaf pine forests in particular were reduced by 88% between 1936 and 1986, to the extent that by 1987 only 380,000 ha (939,000 ac) remained (Wooding 1997). Many of the other habitat types in which Sherman's fox squirrels occur are declining. Mixed pine-hardwood forest is declining, and natural pineland, sandhill, and scrub are in poor condition and declining. The condition of other important habitat types such as the 13 transitional habitats is unknown (FWC 2008). Further habitat destruction is expected to continue as Florida's human population continues to expand (FWC 2005, Zwick and Carr 2006, FWC 2008).

In addition to habitat loss, the quality of remaining habitat is also a concern. Kantola and Humphrey (1990) suggested that most remaining tracts of longleaf pine savanna in Florida were not of good quality. Logging and the suppression of fire have led to the replacement of pine trees by turkey oak over much of the Sherman's fox squirrel's range (Kantola and Humphrey 1990). Some improvements have been made through restoration projects on public conservation lands and incentive programs for private landowners, but the current condition of natural pinelands is still poor throughout much of its historic extent (FWC 2005). Management of upland longleaf pine savannas for other specialist species, such as gopher tortoises (*Gopherus polyphemus*), red-cockaded woodpeckers (*Picoides borealis*), northern bobwhite (*Colinus virginianus*), and grassland bird species, can be compatible with the needs of the Sherman's fox squirrel (Perkins et al. 2008) if due consideration is given to retention of mast-producing trees. Managers restoring degraded longleaf pine savannas should retain a component of site-appropriate mature oaks to provide mast and nest sites for Sherman's fox squirrels (Perkins et al. 2008). Greenberg and Simons (1999) described land managers as being "misguided" if they removed all mature oaks when attempting to restore or maintain longleaf pine and sandhill ecosystems. Prescribed fire is necessary to prevent encroachment of excessive hardwoods and to maintain the open structure preferred by the Sherman's fox squirrel in upland longleaf pine savanna and mixed pine–hardwood forests (Weigl et al. 1989, Kantola and Humphrey 1990, Perkins and Conner 2004, Lee et al. 2009).

Fragmentation of habitat poses another risk to the Sherman's fox squirrel. Due to their slow, lumbering gait, fox squirrels are vulnerable to road mortality (Figure 5). Mortality from vehicle collisions is likely to increase as Florida's human population increases. Better understanding of Sherman's fox squirrel populations, habitat preference, and habitat use may help in planning land use and road-construction projects to avoid creating additional hazards.

Figure 6. Sherman's fox squirrel killed by a vehicle near Reddick. Road mortality can have a significant impact on Sherman's fox squirrel populations. Photograph by Jeff Gore, FWC.

Fragmentation of suitable habitat further isolates local populations, increasing vulnerability to local extinction events. Hunting of the Sherman's fox squirrel may have been detrimental to local populations in the past, particularly those small, isolated populations that had low potential for recolonization (Kantola 1992). Presumably, this threat has decreased as hunting of this squirrel is no longer permitted.

Diseases may pose a significant threat to population stability and viability. White Oak Conservation Center (WOCC) in Nassau County recorded several Sherman's fox squirrel die-offs due to a fibromatosis outbreak throughout the property. The population at WOCC has yet to recover from the most recent die-off in 2002 to 2003 (S. Citino, WOCC, personal communication). Although squirrel poxvirus, a skin fungus that can cause high rates of mortality (Terrell et al. 2002), has been detected in Big Cypress fox squirrels (Kellam 2010), its impact to the entire species population is unknown (USFWS 2002; see Appendix 2 for additional details).

CONSERVATION GOAL AND OBJECTIVES

Goal

Determine the conservation status for the Sherman's fox squirrel in Florida.

Objectives

I. Determine the level of genetic variation between the different subspecies of fox squirrels potentially occurring in Florida (*Sciurus niger shermani, S. n. niger, S. n. avicennia, S. n. bachmani*) within 5 years of plan implementation.

Rationale

The Sherman's fox squirrel is one of 4 subspecies of eastern fox squirrel occurring in Florida. However, the ranges of those subspecies and their relationships to each other are not fully understood. A clear delineation of the range of the Sherman's fox squirrel and the other subspecies is needed in part because of declining populations and the precarious status of several subspecies (Turner and Laerm 1993). Subspecies delineations have been based on unreliable morphological features instead of genetic analyses. To best evaluate the validity of current fox squirrel subspecies designations, genetic studies based on mitochondrial deoxyribonucleic acid (DNA) and microsatellite loci developed for fox squirrels (Fike and Rhodes 2009) should be conducted. However, in doing this it needs to be recognized that Moncrief et al. (2010) found *S. niger* lacks key information to delineate subspecies or patterns within subspecies (it is missing phylogeographic structure in the cytochrome-b sequences of mitochondrial DNA). Therefore, future genetic studies could be based on the results of mitochondrial DNA analyses (e.g., Moncrief et al. 2010) but should examine segments of DNA that evolve more rapidly to reveal patterns of divergence and phylogeographic structure, such as microsatellites, amplified fragment length polymorphisms, and single nucleotide polymorphisms (Manel et al. 2003, Moncrief et al. 2010). For example, Fike and Rhodes (2009) have developed 26 polymorphic microsatellite markers for the fox squirrel. Further, select statistical procedures that can be employed to analyze genetic data spatially across a landscape may offer opportunities for robust analyses to better identify patterns or structure (Manel et al. 2003).

II. Determine the extent of occurrence and area of occupancy within 5 years of plan implementation.

Rationale

Prior to the BSR, the last statewide survey to assess the distribution of fox squirrels in Florida was conducted in the early 1990s (Wooding 1997). Uncertainty of the current extent of occurrence and area of occupancy was listed by the BRG as a reason that the Sherman's fox squirrel should maintain the status of Species of Special Concern. Current data on area of occurrence and occupancy was cited as critical to the BRG and outside reviewers. Since the completion of the BSR, a UF-FWC web-based survey was conducted to gather fox squirrel sightings from the public as well as from natural-resource professionals. The results of this survey provide a useful tool and an important first step in meeting this objective. Methods to measure occupancy based on the survey data are currently being tested by graduate students at UF.

III. Maintain or improve habitat management efforts on public and private conservation lands in order to maximize population size and productivity rates for the Sherman's fox squirrel while determining its conservation status.

Rationale

While the goal is to determine the conservation status of the Sherman's fox squirrel, it is essential to ensure that its status does not decline in the interim. Habitat loss and degradation are the biggest threats to this squirrel. Large tracts of high-quality, well-managed habitat, particularly on conservation lands, may be the key to long-term conservation of the subspecies. On smaller tracts, conservation of the Sherman's fox squirrel will require coordination with adjacent land managers to ensure the long-term security of the species. Habitat management will be an ongoing emphasis for effective conservation, and efforts to improve those activities can begin now, while other actions are being implemented to more directly address the goal for the Sherman's fox squirrel.

Conservation lands that currently support Sherman's fox squirrel populations are important to maintaining the population, but lands in less than optimal condition with high potential to support the subspecies should be a priority for land managers. Managers of smaller public tracts should make every effort to engage owners of neighboring private lands in cooperative efforts to improve habitat quantity and quality. Maintaining and improving habitat should provide a direct link to increasing survival and productivity, while research is conducted to identify the demographic parameters needed for fox squirrel conservation. Publicly owned conservation lands are uniquely suited to provide core areas of habitat to enhance the security of the species. However, habitat quality for the Sherman's fox squirrel on many of these conservation lands is currently less than optimal and can be improved. Prioritizing areas with high potential to support fox squirrel populations for restoration will help achieve this objective.

Research is currently underway at UF to quantify the preferred structure and habitat characteristics of the Sherman's fox squirrel. Providing land mangers with the best possible science on its habitat needs will help to ensure the highest possible survival and productivity on the lands they manage.

CONSERVATION ACTIONS

The following sections describe the conservation actions that will make the greatest contribution toward achieving the conservation objectives. Actions are grouped by category (e.g., Habitat Conservation and Management, Population Management). The Conservation Action Table (Table 1) provides information on action priority, urgency, potential funding sources, likely effectiveness, identified partners, and leads for implementation.

The Florida Game and Fresh Water Fish Commission (predecessor to the FWC) added the Sherman's fox squirrel to the Florida Endangered and Threatened Species List in 1975. In the last 37 years, some of the threats to this species have been mitigated through acquisition of public conservation lands and increased emphasis on prescribed fire in land management. However, there is a need to evaluate the validity of the available information and to take action to enhance our knowledge of the geographic distribution, basic demographic information, habitat associations, and taxonomic validity of the subspecies.

Habitat Conservation and Management

Throughout its range, the Sherman's fox squirrel inhabits natural, agricultural, and urbanized habitats. Important natural communities for the species are characterized by open, mature, upland pine–oak communities, most often dominated by longleaf pine and turkey oaks (Figure 7). Other natural communities utilized by this squirrel include pine flatwoods and upland hardwood forests. Both mature pine and mixed pine–hardwood habitats are preferred by fox squirrels (Perkins and Conner 2004). Within stands of mature, open-canopy pines it is important to retain patches of mast-producing hardwood, especially mature oaks, for nesting and food production (Perkins et al. 2008). Representative photos (Figures 7 through 11) show fox squirrel habitat characterized by frequent fire, diverse ground cover, and the presence of mature oaks.

Sherman's fox squirrels are regularly observed on some urban and agricultural lands, and these populations often persist for many years. These patches of habitat often have an open understory maintained by mowing or other mechanical manipulation, and contain mature mast-producing trees. These patches of habitat will require careful planning and management to sustain inhabiting fox squirrels in the future.

Figure 7. Sandhill habitat in Withlacoochee State Forest, Citrus County, with longleaf pine and scattered turkey oaks present. Photograph by Terry Doonan, FWC.

The following actions are identified based on known habitat needs of the Sherman's fox squirrel, and they address the threats of habitat loss and degradation. Implementing these actions, while collecting additional data to further our understanding of its status, is important to maintaining the Sherman's fox squirrel population.

Habitat Conservation

Action 1 Identify priority areas throughout the range of the Sherman's fox squirrel (on both private and public lands) to ensure that habitats with the greatest potential to benefit the species are protected, connected, and improved.

Action 2 Maintain, enhance, and encourage the creation of habitat corridors on private and public lands through incentives programs and existing habitat conservation programs.

Figure 8. Sandhill habitat, Twin Rivers State Forest, Madison County. Photograph by Terry Doonan, FWC.

Fragmentation and loss of habitat were identified in the BSR as the primary threat to the Sherman's fox squirrel. To counteract this threat, high priority areas should be designated as Sherman's fox squirrel core conservation areas to clearly identify sites necessary for effective species conservation (Action 1). Identification of sites as core conservation areas should be completed in cooperation with landowners and land managers. Within core conservation areas and other priority conservation areas, habitat management plans should account for resource requirements of the Sherman's fox squirrel and include strategies to maximize habitat quality for the squirrel in appropriate locations and to minimize known threats (e.g., road mortality). The identification of priority areas is necessary to ensure that limited resources are used where the greatest potential for success exists on the landscape. Identifying these landscape priorities will create core areas that can be expanded as the number of Sherman's fox squirrels inhabiting these areas stabilize and additional resources become available. This action addresses habitat loss and degradation at a landscape level by identifying areas most important to species conservation. Considerations for designating core conservation areas for the Sherman's fox squirrel may include proximity to other conservation land, importance as a corridor, presence of existing populations, and presence of suitable habitat. Road mortality rates should be considered when planning corridors. Incentives to use existing roads, and the minimization of new road development, should be included to reduce mortality. An updated Geographic Information System (GIS) model is being developed as part of Action 15 and will become a useful tool in targeting areas for corridors.

In both urban and natural areas, suitable fox squirrel habitat can become fragmented and isolated from other patches of suitable habitat. To increase the quality of natural and urbanized sites for the Sherman's fox squirrel, there is a need to increase the relative size and connectivity of occupied habitat through the formation of corridors. Corridors connect isolated habitat patches, allowing squirrels to move among sites, thus increasing the effective size of available habitat

(Action 2). Effective corridors will provide a linkage between core areas and support movement between sub-populations. These corridors are also critical to dispersal of fox squirrels into unoccupied potential habitat. Increased habitat availability allows both urban and natural sites to support larger, more viable populations. On private land, the planting of native mast-producing trees along fencerows may increase use of those areas as corridors between habitat patches. Corridor development can be encouraged with cost reimbursements for private landowners and for public lands facilitated with targeted purchases or less-than-fee-simple acquisitions for conservation purposes. Identifying potential Sherman's fox squirrel corridors that are utilized by other species will increase the conservation value of these corridors. Habitat acquisition and enhancement efforts will be encouraged through incentives covered in the Influencing and Incentives section (Action 1, Action 2, Action 18).

Figure 9. Upland pine habitat with multiple oak species present. Photograph by Dan Greene, UF Fox Squirrel Research Team.

Habitat Management

Action 3 Develop habitat management guidelines and monitoring recommendations for public land managers and private landowners.

Figure 10. Upland pine habitat with multiple hardwood tree species present. Photograph by Terry Doonan, FWC.

A firm understanding of necessary habitat management is essential to ensure that land managers are properly informed and able to plan effectively for conservation of fox squirrels while meeting their other management objectives. Providing monitoring recommendations will allow managers to ensure that management actions are having the intended benefit for fox squirrels. Current monitoring recommended by the WCPR program for the Sherman's fox squirrel has recorded observations of adults and juveniles in areas where they have not been observed previously. A need has been identified for a standardized protocol for monitoring the species, but that protocol has not yet been developed. Developing a

monitoring program is addressed in Action 10, and the results of this research need to be incorporated into the land manager recommendations for fox squirrel habitat management. Habitat quality is a prime factor in Sherman's fox squirrel population density and the size of home ranges. Improved habitat quality will allow for more individuals to inhabit an area and for females to have greater success rearing young. By improving habitat, individuals may meet their foraging needs without traveling as far, reducing road mortality and exposure to predation.

Figure 11. Mesic flatwoods habitat on Big Bend Wildlife Management Area, Taylor County. Photograph by Scotland Talley, FWC.

The habitat requirements of the Sherman's fox squirrel are unclear, but some general principles are accepted as beneficial. While Florida-specific research is ongoing, existing information from southern Georgia and other areas within the Sherman's fox squirrel's range should be incorporated into management actions.

Factors expected to increase overall habitat quality for the Sherman's fox squirrel, at multiple scales, include the following:

- Preserve and reclaim large areas (at least 25 km^2 [9.65 mi^2]) of Sherman's fox squirrel habitat (Kantola 1992).
- Mature oak trees are important as daytime refuge sites (Connor and Godbois 2003), nesting sites (Edwards and Guynn 1995), and for mast production (Humphrey and Kantola 1990).
- A variety of oak species is ideal because mast production by different species may vary seasonally and year to year (Kantola and Humphrey 1990, Lee et al 2009).
- Sites with ecotones between pine uplands and oak forests are priorities for conservation because of their importance to fox squirrels (Kantola and Humphrey 1990).
- Maintaining single large hardwood trees and small patches of oaks within pine uplands creates the highest-quality fox squirrel habitat. One study recommends 6 hardwood patches with a basal hardwood area of 0.5 m (1.6 ft) squared for every hectare (2.47 ac) of pine savanna (Perkins et al. 2008).
- Varying the season, intensity, frequency, and spatial coverage of fire creates and maintains mature oak coverage, and mimics natural and historical fire regimes in Florida (Greenberg and Simons 1999).
- Uneven-aged stand management and single-tree selection is recommended for harvesting practices to better maintain mature oaks and patchy areas within pine uplands (Connor and Godbois 2003, Connor et al. 2008).
- Prescribed fire is an effective and efficient tool for managing habitat. Recommended fire frequency for optimizing Sherman's fox squirrel habitat varies from 2 to 3 years (Perkins

et al. 2008) to 5 years (Kantola and Humphrey 1990), but the actual frequency implemented on individual stands should be determined with consideration of the aforementioned factors.

Figure 12. Fire as a management tool. Low-intensity fire in the longleaf pine and turkey oak-dominated sandhill community will allow the growth of scattered oaks and can maintain a diverse groundcover. Photographs by Courtney Tye and Chris Tucker, FWC.

Figure 13. While aesthetically pleasing and beneficial to many longleaf pine-dependent species, the homogeneous landscapes above do not represent ideal fox squirrel habitat due to the lack of oak trees. Photographs by Courtney Tye FWC.

Figure 14. Habitat restoration using selective removal of oaks. Removal of excess small oaks while leaving some mature oaks will allow herbaceous ground cover to recover and improve the habitat for the Sherman's fox squirrel. Photograph by Scotland Talley, FWC.

Population Management

No specific population management actions are currently proposed for the Sherman's fox squirrel. Nest boxes for fox squirrels have been used as a population management tool in other areas of the fox squirrel range such North Carolina (Weigl et al.1989). Although they have been recorded nesting and rearing young in kestrel boxes throughout peninsular Florida, the importance of nest boxes to fox squirrels in Florida is largely unknown. In areas with little cover, such as agricultural fields, use of nest boxes may be beneficial in that the boxes provide a habitat structure for nesting and rearing young or for escape from predators.

There are concerns that squirrel poxvirus will negatively impact survivorship and productivity in Sherman's fox squirrel populations. To reduce the possibility of disease outbreaks occurring, activities should be avoided that concentrate fox squirrels together and therefore may increase the spread of the disease. If outbreaks of squirrel poxvirus or other diseases occur, outreach to local communities should be conducted with recommendations to limit use of bird feeders until outbreaks have run their course (Action 20).

Predation is not believed to limit population size or density for the species, so predator control is not currently recommended. Anecdotal information indicates that road-based mortality could be a population concern (D. Greene, UF, personal communication). If research indicates that road-based mortality is an issue, additional actions may be proposed to address it in future. Poisoning from pesticides or other sources has not been documented as a significant source of mortality. Hurricanes or other unexpected environmental events can have catastrophic impacts on local populations; however, the range of the Sherman's fox squirrel is believed to be large enough to

keep catastrophic events of that type from causing range-wide population collapses. Studies of such impacts are extremely difficult to execute given the random nature of those events.

Translocation is not currently recommended for Sherman's fox squirrels. Translocation has been used as a management tool for some fox squirrel subspecies with varying levels of success (Dawson et al. 2009), but anticipated problems outweigh the benefits in using translocation as a population management tool for the Sherman's fox squirrel. Wooding (1997) translocated 3 Sherman's fox squirrels from a golf course in Marion County and 3 fox squirrels from a cattle ranch in Alachua County to reintroduce them into San Felasco Hammock State Preserve in Alachua County. Radio telemetry of the translocated squirrels indicated that all 6 emigrated to areas outside of the preserve and 1 was killed by a vehicle. Our incomplete understanding of how fox squirrels will behave when translocated and the optimal conditions necessary for a successful translocation limits the usefulness of translocations as a management tool. If future research addresses these concerns, translocation may be considered.

Under current rules regulating wildlife rehabilitation, a rehabilitated Sherman's fox squirrel should be released "at or near the point of capture, or onto habitat where such wildlife naturally occur, and which will biologically support the species" (Rule 68A-9.006, F.A.C.). The release of a rehabilitated squirrel into habitats beyond the point of capture could be problematic and should be treated like a translocation and with similar concerns, particularly if the origin of an animal is not known. The appropriate release of rehabilitated squirrels is further discussed in Action 16.

Monitoring and Research

The BSR concluded that data on subspecies delineation, habitat requirements, and population demographics are not adequate to make inferences pertaining to the current status of the Sherman's fox squirrel. Insufficient data concerning the animal exist partly because of the extensive effort required to trap and monitor this species. To address these concerns and the data gaps identified by the BRG and peer reviewers, and to achieve the conservation goal and objectives, several actions have been identified. Monitoring and Research actions focus on answering basic questions about the population status, trends, and distribution of the Sherman's fox squirrel, and confirming the taxonomic status of the subspecies. The following are the most critical pieces of information needed to assess the Sherman's fox squirrel population status and trends for the management and conservation of the species. In the next 5 to10 years, the focus is to make progress on these research needs.

Action 4 Develop a GIS-based habitat model to identify areas to survey for Sherman's fox squirrel presence and absence.

Action 5 Develop an occupancy-based survey protocol to determine presence and absence of Sherman's fox squirrels in potential habitat.

Research on fox squirrel distribution statewide began with a mail survey by Brady (1977) to wildlife experts to determine known and historic locations. The distribution of fox squirrels throughout Florida was also investigated by Wooding (1997) through field surveys, interviews, and mail surveys. Both Brady (1977) and Wooding (1997) arrived at similar conclusions, that fox squirrels are widespread but distribution is sparse. A potential habitat model for the

Sherman's fox squirrel was developed by FWC and is included in the Fish and Wildlife Research Institute's Technical Report TR-15 Wildlife Conservation Habitat Needs in Florida: Updated Recommendations for Strategic Habitat Conservation Areas (Endries et al. 2009). This basic model identified potential habitat based on the 2004 land cover data, but did not include data regarding habitat use or quality or occupancy. The model's usefulness was questioned during the BSR process. The BRG felt that it is crucial that an updated potential habitat model is developed with consideration of habitat use and quality. This model needs to be updated using recently acquired data on fox squirrel locations and refined using the best available information on habitat quality to make it more useful. This improved potential habitat map will be an important tool for implementing Actions 2 and 3. This model will be dynamic and will be updated and refined as research and monitoring actions are completed and better data are available.

To develop an up-to-date, GIS-based habitat model, occurrence records from the recent web survey will be paired with appropriate GIS layers to delineate potential habitat throughout the Sherman's fox squirrel range (Action 4). Then, Species Distribution Models (SDM) will combine occurrence locations and environmental parameters such as land cover to determine habitat associations based on presence data. The Sherman's fox squirrel SDM can form the basis to develop a map depicting the probability of occurrence across the Sherman's fox squirrel range. Sites with a high probability of occurrence should provide sufficient areas to survey for presence/absence to further validate the resulting GIS habitat model. Further analyses of the model will provide insight regarding specific habitat parameters utilized by the Sherman's fox squirrel (Action 14).

To effectively manage Sherman's fox squirrel populations, it is imperative that reliable occupancy survey techniques are developed for natural and urban habitats throughout its range (Action 5). Survey methods such as live trapping, line transects, nest counts, point counts, and remote camera surveys should be evaluated to determine the most effective technique for detecting occurrence. Preliminary results from the UF Study indicate that camera traps are the most effective technique for detection (D. Greene, personal communication). Live capture of fox squirrels is extremely time consuming, yielding a low success rate (Weigl et al.1989). The presence of cored pine cones and leaf nests has been suggested as an indicator of Sherman's fox squirrel occurrence but, due to the difficulty of distinguishing the Sherman's fox squirrel from gray squirrel (*Sciurus carolininsis*) signs, it is currently not a reliable method without a viable nest-distinguishing protocol (Wood 2001). Presence can also be determined by driving field transects, but this method requires a keen eye due to fox squirrel fleeing response. The effectiveness of walking transects requires further research and may only be viable in an extremely open area.

Action 6 Develop a protocol for collecting and handling tissue samples for genetic analysis.

Action 7 Solicit collection of tissue from road kills throughout the state by agency biological and law enforcement staff, biological staff from other agencies, university researchers, and the general public.

Action 8 Trap to collect tissue samples by using sites identified from reported locations and based on gaps in data from road-killed specimens.

Action 9 Conduct genetic analyses to determine the current extent of occurrence and area of occupancy for the Sherman's fox squirrel.

Current subspecies delineations are based on unreliable morphological data, which have led to statewide range discrepancies. A re-examination of the systematic affinities of populations of fox squirrels in Florida and a clearer delineation of subspecies' ranges are necessary for further conservation and management. Population genetics and phylogeographic techniques are powerful tools to address the relationship of Sherman's fox squirrels to other fox squirrel subspecies. Standard genetic techniques based on mitochondrial DNA and 26 microsatellite loci developed for fox squirrels (Fike and Rhodes 2009) are appropriate (Actions 6 and 9).

UF is currently (2012 through 2015) conducting research to determine subspecies designations using traditional phylogenetic methods and model-based clustering approaches. UF and FWC have developed a protocol to facilitate tissue collection in order to ensure appropriate collection procedures and to ensure specimens are legally obtained (Appendix 3; Actions 6 and 7). The collection of tissue will continue through various avenues, including road mortality and current and future research efforts. The tissue collection protocol has been disseminated to federal and state biologists and land managers (FWC, Department of Environmental Protection [DEP], Florida Forest Service [FFS], U.S. Forest Service, National Park Service, USFWS, water management districts) as well as the general public to ensure adequate statewide coverage and sample size is achieved (Action 7).

To ensure sufficient samples are obtained, UF will also conduct selective trapping near the currently perceived subspecies divisions and in underrepresented areas of Florida (Action 8). Fox squirrel location data from the UF-FWC web-based sighting survey, along with current UF research and historical records, will be used to select trapping locations (Action 5). The trapping method will be based on the results of current research to determine the most efficient method (Action 5). UF recently completed and is in the process of analyzing data from a trapping study at Ordway-Swisher Biological Station (Putnam County) and Camp Blanding Joint Training Center (Clay County). The study used wooden box traps placed on the ground and Tomahawk live traps placed horizontally on a platform several feet above the ground; analysis of results should indicate whether one method more reliably captures Sherman's fox squirrels. Once genetic analyses are complete (Actions 8 and 9), a detailed range map as well as description of the extent of occupancy for all subspecies of fox squirrels in Florida can be developed to assist in their management and conservation (Action 9).

Action 10 Develop a scientifically sound monitoring protocol for the Sherman's fox squirrel.

Action 11 Develop a protocol to estimate density and abundance of Sherman's fox squirrels in different habitat types.

Action 12 Implement a monitoring program to track Sherman's fox squirrel populations in 5-year intervals.

In the southeastern United States, fox squirrels have a low capture success and occur in low densities, a combination that results in uncertainty in the status of the population. There is

currently no effective protocol for quantifying and monitoring the subspecies (Weigl et al. 1989, Kantola and Humphrey 1990). Previous efforts to estimate density and abundance include research by Kantola and Humphrey (1990) and Wooding (1997). Although Kantola and Humphrey (1990) provided valuable insight into fox squirrel biology, their study suffered from small sample size. Wooding (1997) was able to capture a higher number of squirrels; however, the overall capture rate of fox squirrels using live traps is low (Weigl et al.1989) and handling adds risk of injury.

As part of a State Wildlife Grant, Dr. Robert McCleery and 3 graduate students at UF are conducting research on fox squirrels in Florida to develop a monitoring protocol by evaluating 4 survey methods based on feasibility of time, effort, cost, and logistics (Actions 5 and 10; McCleery et al. 2011). These methods include 2 mark–recapture surveys using live-trapping (wooden box traps and Tomahawk live traps) and camera surveys, distance sampling, time–area counts, and fixed-width strip transects (McCleery et al. 2011). Past survey techniques such as transects and trapping have had low success and low capture rate due to the shyness of Sherman's fox squirrels in natural habitat; thus, they are an unreliable measure of detection. The results of this study will be used to finalize the monitoring protocol that will allow detection of true absence as opposed to a failure of the survey methodology in detecting animals.

Passive digital photography has been an effective technique to identify individuals and generate population estimates for a variety of mammal species (Sarmento et al. 2009, Negrões et al. 2010). Additionally, individual recognition techniques based on "camera traps" can be used to implement a mark–recapture program and gather population information concerning productivity, survival, and even movement patterns (Gilkinson et al. 2007). The camera-based mark–recapture method uses patterns and markings to identify unique individuals (Baumgartner 1943, Weigl et al. 1998). Color patterns of fox squirrels in Florida are unique among individuals (Kiltie 1992). Researchers at UF have been developing a camera-based individual Sherman's fox squirrel recognition technique (using color patterns and physical anomalies). Preliminary data from UF suggest that the camera surveys are the most feasible of the 4 survey techniques that researchers have been evaluating to determine occupancy and for long-term monitoring.

Although camera surveys likely provide the most effective way to determine occupancy rates and long-term monitoring of population trends, other research may require trapping of individuals. For example, to increase the precision in estimating density and abundance, mark–recapture through live trapping may be required (Action 11). Successful trapping and monitoring methods will also be essential for research, such as fecundity and survivorship studies, requiring use of telemetry (Action 13). Telemetry studies will also make it possible to more accurately assess subspecies' habitat use and to more accurately measure optimal habitat composition and structure characteristics (Action 14 and Action 1). Trapping also provides an opportunity to collect tissue samples for genetic studies (Action 8 and Action 9).

When the details (e.g., method, season, bait, duration of survey needed) of the monitoring protocol (Actions 5 and 10) are established and the necessary sample size is determined (Action 11), a standardized, the statewide monitoring program can begin (Action 12). The monitoring program will be established at multiple locations throughout the state, based on subspecies ranges (Action 9), web-based occupancy model results, GIS-habitat model (Action 4), and

discussion with experts. Future land use plans for each survey area should also be considered, with the goal of uninterrupted surveys in the future (i.e., properties that are in a long-term protection plan should be prioritized over private lands where land-use or ownership can change). It should be feasible to conduct surveys at 5-year intervals at the selected sites. A subset of the sites should include lands that are degraded or fragmented or that are undergoing land management activities that may negatively affect fox squirrels. Habitat management (e.g., prescribed fire, mechanical treatments, and timber management) and land use changes should be documented whenever possible to increase our understanding of population responses to management actions (Action 3). Over time, data obtained from monitoring, combined with the supplemental habitat data, can provide guidance on several habitat management actions (Actions 1 through 3).

Action 13 Initiate research to estimate demographic parameters (e.g., fecundity, juvenile survival, population density, population growth, recruitment, immigration and emigration rates, etc.) needed for robust population models and population viability analyses (PVA).

PVA is used to estimate the likelihood of a population's extinction, compare proposed management options, and assess species recovery efforts. PVA was carried out on the Sherman's fox squirrel by using demographic information from fox squirrel species as a whole (Root and Barnes 2006, Endries et al. 2009). Although the Sherman's fox squirrel BRG concluded from the biological assessment that the subspecies did not meet any criteria to warrant listing as a Threatened species, the BRG expressed concerns about the adequacy of the data currently available. In particular, there were concerns over the results of the PVA, due to the lack of Florida-specific demographic data to build the PVA model. For a robust population model and accurate PVA, demographic data such as fecundity, adult and juvenile survival, dispersal, and density estimates are critical. These data will also help identify the primary population limiting factors (e.g., mortality from road kills, predation, and food availability) and will aid in developing effective management strategies.

Obtaining data on demographic parameters such as age-specific fecundity and survival rates, dispersal rates and distances necessitates use of radio telemetry studies. Ideally, telemetry studies would be conducted in a subset of study areas that are used for long-term monitoring (Action 12). Data from camera-based surveys (Actions 5 and 11) could be used to locate optimal capture sites for radio-collaring. Any trapping efforts initiated can also assist with the collection of tissue samples for DNA analyses (Actions 5, 6, and 10).

Action 14 Determine habitat associations and identify preferred habitat types.

Action 15 Develop GIS-based potential habitat maps stratified by habitat quality.

The Sherman's fox squirrel has been documented utilizing a variety of land cover types, including sandhill, mixed pine-hardwood, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats with pines and oaks (Kantola 1992, FNAI 2001, summarized in Endries et al. 2009). Past distribution surveys coupled with a 2011 to 2012 UF-FWC web-based survey, indicate that across the landscape, fox squirrels occur in a multitude of vegetative communities, along ecotones, adjacent to

development, and near roadways (Brady 1977, Williams and Humphrey 1979, Wooding 1997). However, habitat requirements on a landscape scale are not well understood, making isolated populations vulnerable to local extinction if essential habitat needs are not addressed due to the lack of information. Obtaining and providing information about the squirrels' preferred habitat and critical habitat needs to land managers is essential to their conservation. While occurrence locations can provide useful information concerning habitat use, the presence of Sherman's fox squirrels does not necessarily indicate preferred habitat. Identifying habitat preferences requires assessing the density and productivity of squirrels using the habitat.

Habitat models built upon occurrence data (Action 4) and habitat-related variables will allow further investigation of habitat associations and preferred habitat types. Highly ranked locations based on the model can be field verified through the monitoring methods associated with Actions 5, 10 and 11 to further validate fox squirrel habitat (Action 14).

Although Kantola and Humphrey (1990) suggest that edges of longleaf pine savanna and live oak forest provide the highest-quality habitat for the Sherman's fox squirrel, the optimal composition and structure of priority fox squirrel habitat throughout the range is unknown. In addition, Kantola (1992) advised that tracks of land suitable for fox squirrels should be at least 25 km^2 (9.65 mi^2). However, further research is needed to evaluate the appropriate spatial scale in variety of habitats throughout their range.

To answer these questions, UF is currently conducting a study investigating the composition and structure and presence and absence of the Sherman's fox squirrel for multiple landcover types, including sandhill and upland pine. Sampling units will be placed randomly in mature forests stratified by fire frequency to determine the pine and oak distribution, canopy density, shrub cover and ground cover. A multi-scaled approach will be applied to the landcover types across a 5 km^2 (2 mi^2) area with 5 grids per landcover type. Land management records will be reviewed to note any habitat manipulation activities (e.g., hardwood removal, thinning, roller-chopping). Mark–recapture methods employing cameras will be used to estimate Sherman's fox squirrel population density on each sampling unit, (Action 11).

Data on Sherman's fox squirrel density in habitats with varying levels of management obtained through camera surveys form an important component of the optimal-habitat evaluation. However, to fully understand the influence of habitat on fox squirrel population growth and potential, data on demographic parameters such as survival and fecundity (Action 13) must be obtained from variety of habitat types and configurations. Future research on the relationship between habitat and population growth will be key to identification of optimal Sherman's fox squirrel habitat.

Once the subspecies' optimal habitat conditions (Action 14) have been identified through research, GIS-based potential habitat maps stratified by habitat quality can be created (Action 15).

Rule and Permitting Intent
This section identifies the current regulations addressing conservation of the Sherman's fox squirrel and discusses some of the potential issues with protections and the development of appropriate permitting guidelines.

Action 16 Determine level of protection needed to achieve conservation goals for the Sherman's fox squirrel.

Current Protections and Regulations
Based on the BSR findings, the FWC proposes to maintain the listing status as a Species of Special Concern under Rule 68A-27.005, F.A.C., until the actions identified in Monitoring and Research provide the data necessary to accurately evaluate the status of the Sherman's fox squirrel. The protection provided in this rule is that: "No person shall take, possess, transport, or sell any species of special concern included in this subsection, or parts thereof or their nests or eggs except as authorized by permit from the executive director, permits being issued upon reasonable conclusion that the permitted activity will not be detrimental to the survival potential of the species."

Although this rule provides the basis for protection of the Sherman's fox squirrel, interpretation of activities that lead to take is difficult without a better understanding of the life history of this squirrel. Issuance of any permits for take is in accordance with Rule 68A-27.005, F.A.C., and should not be detrimental to the survival potential of the species. Incidental take of Sherman's fox squirrels during normal land management activities (i.e., prescribed burning) are exempted in accordance with Rule 68A-27.007, F.A.C., which states: "Land management activities that benefit wildlife and that are not inconsistent with Management Plans for species as defined in this rule chapter are authorized and do not require a permit authorizing incidental take despite any other provision of this section." However, information collected from future monitoring and research is needed to identify any specific protection requirements (Action 16). If it is determined that some activities may lead to take (as defined in Rule 68A-27.001, F.A.C.), or it is determined that the rule language is not adequate to provide protections and enforcement, the rule may be amended to ensure adequate protection for the Sherman's fox squirrel (Action 16).

Two other rules may impact Sherman's fox squirrel conservation. First, take for possession through taxidermy is an area of concern. Taxidermy is addressed in rule Rule 68A-12.004, F.A.C., which specifies: "Possession or Sale of Birds or Mammals; Taxidermy Operations and Mounting Requirements." This rule prohibits the taxidermy of listed species without a permit, but includes a provision for taxidermy of road-killed fox squirrels. Wooding (1990) interviewed landowners and hunt clubs that discouraged or prohibited guests from taking Sherman's fox squirrels, although they were legal game at the time. Some of these clubs or landowners kept road-killed fox squirrels to offer guests as "trophy" squirrels for mounting in lieu of harvesting a squirrel. Maintaining the ability to legally obtain trophy fox squirrels may have built support for removing fox squirrels as a game species in Florida. Visually distinguishing the 4 subspecies of fox squirrel occurring in Florida is not always possible. Until genetic work is completed, the ranges of each of these subspecies is unclear, although the Caloosahatchee River has been provided in past literature (Kantola 1992) as a potential southern range limit for the Sherman's fox squirrel, and the Apalachicola River as a western limit. Current interpretation of Rule 68A-

12.004, F.A.C., allows for the Sherman's fox squirrel, along with the Big Cypress fox squirrel (listed as Threatened), to be taxidermied without a permit. It is unclear if this has an impact on Sherman's fox squirrel populations; however, to prevent illegal harvest and possession, the taxidermy rule should be clarified. Clarifications may need to address the similarity of appearance of all fox squirrel subspecies and the uncertainty of each subspecies range (Figure 5).

The release of rehabilitated fox squirrels is another area of concern. As previously discussed, Rule 68A-9.006, F.A.C., "Wildlife Rehabilitation Permit" specifies that the release of rehabilitated animals occur "at or near the point of capture, or onto habitat where such wildlife naturally occur, and which will biologically support the species." Release of animals near the point of capture should not create any unintended consequences. In situations where animal origin is unknown, release can be problematic if it is allowed to occur on any suitable habitat where the species occurs; similarity of appearance between the Sherman's fox squirrel and Big Cypress fox squirrels, and lack of information on the range limits for these 2 subspecies could lead to impacts to Big Cypress fox squirrels. Squirrel poxvirus, recently detected in the Big Cypress fox squirrel (Kellam 2010), can produce high rates of mortality in infected populations. A further complication is that squirrel poxvirus has an incubation period of 7 to 14 days before tumors become visible (Kilham 1955, Hirth et al.1969). Depending on the length of rehabilitation, infected squirrels could be unknowingly released into healthy populations. Uncertainty in range of fox squirrel subspecies could also lead to release of individuals into genetically distinct populations. To prevent unintended impacts to Big Cypress fox squirrel populations, permitting for rehabilitation facilities that care for fox squirrels should include conditions to prevent release of fox squirrels of unknown origin into any wild populations and to limit release of fox squirrels of known origin at the point of capture.

Protections and Permitting Considerations

No specific guidelines for permitting are provided in rule for Species of Special Concern, and Rule 68A-27.005, F.A.C., does not distinguish between intentional and incidental take. Intentional take is usually for scientific or conservation purposes, and these permits are called scientific collecting permits. Scientific collecting permits should be issued for projects that will advance the goals of this species action plan or other conservation plans for the Sherman's fox squirrel.

Incidental take is take that occurs during otherwise lawful activities. Permits for the incidental take of Sherman's fox squirrels would be authorized if "there is a reasonable conclusion that the permitted activity will not be detrimental to the survival of the species." Few permits for incidental take are currently issued under the existing rule and permitting system. Currently, technical assistance information is available at the Florida Wildlife Conservation Guide. Limited surveying guidelines and recommendations for avoiding active nests by limiting activity within a buffer of 38.1 m (125 ft) are provided. These recommendations apply only to land development activities or significant changes in land use and do not apply to land management activities that benefit wildlife in accordance with Rule 68A-27.007, F.A.C. It is unknown if these recommendations are sufficient to provide protections for the Sherman's fox squirrel. Research and monitoring actions identified in this plan will provide data to develop effective avoidance and minimization measures. However, as a Species of Special Concern, avoidance of impacts to the Sherman's fox squirrel is preferred to developing permitting measures.

Figure 15. A pile of stripped longleaf pine cones from a Sherman's fox squirrel. Photographs by Kris Cathey, FWC.

The following considerations need to be included in developing adequate technical assistance and guidelines for avoidance:

- Identifying sites with Sherman's fox squirrels may be difficult, but is necessary prior to development (including road widening, transmission line installation, and other infrastructure improvements) to avoid impacts and maintain conservation status.
    - Detection may depend on use of squirrel signs (stripped green pine cones, nests, tracks, etc) and not upon seeing a Sherman's fox squirrel.
    - Current survey methods for detecting fox squirrels encourage the use of walking transects, which probably under-represent presence (Eisenberg et al 2011).
    - Survey techniques for the Sherman's fox squirrel need to reliably detect Sherman's fox squirrels when they are present. Methods for detecting Sherman's fox squirrels in urban, agricultural, and natural areas have not been tested.
- The current guidelines to avoid active nest trees may not provide adequate protection and may lead to unintended mortality or disturbance.
    - Sherman's fox squirrels are secretive, and determining active nests may be difficult. Understanding the importance of nests across the landscape may be more important than determining if young are present in a nest.
    - A definition for an *active* nest needs to be developed using the best science available.
- Habitat protections for the Sherman's fox squirrel need to be incorporated into avoidance recommendations.
    - Maintaining daytime refugia (in the form of large hardwood trees) should be considered in developing buffer distances around nests or active fox squirrel foraging areas (Conner and Godbois 2003).
    - Ground cover containing wiregrass has historically been associated with high-quality fox squirrel habitat; however, large mast producing oaks are an important component of fox squirrel habitat (Conner and Godbois 2003).

  - Understanding connections between populations of fox squirrels using urban and agricultural areas and those in more natural habitats are important components of addressing issues of fragmentation. Data from Actions 14 and 15 can guide the development of technical assistance to minimize fragmentation.
- Life history requirements of the Sherman's fox squirrel need to be incorporated into avoidance recommendations to maintain the population until the conservation status can be assessed.
  - Disturbance impacts are not well understood for the Sherman's fox squirrel. When disturbed, Sherman's fox squirrels will sometimes go up the closest tree or to point of refuge (nest or large trees). Going to the top of a tree may make a disturbed individual vulnerable to avian predators.
  - Buffer distances should be based on susceptibility to disturbance and foraging needs. These distances may need to vary based on activity and habitat type. No data currently exist to quantify disturbance of Sherman's fox squirrels
- Differing needs of squirrels inhabiting urban, agricultural, and natural areas need to be considered when developing avoidance and minimization guidelines.
  - Disturbance and toleranceof human activity may differ for squirrels inhabiting urban, agricultural, or natural areas.
  - Additional research actions may be needed to identify characteristics of squirrels inhabiting these habitat types.

Law Enforcement

Action 17 Use materials from education and outreach to train law enforcement to identify fox squirrels, their nests, evidence of presence, and habitat so they can identify potential take situations.

To enforce rules and protections developed under Action 16, law enforcement personnel will need training in identification of fox squirrels, their nests, and situations in which take may occur. Training materials should be developed to create awareness of current rules and permitting guidelines, and to explain the biological background for those protections (Action 17). In addition to training, law enforcement input may be needed to improve awareness and compliance with changes to Rule 68A-12.004, F.A.C. (taxidermy rule).

Incentives and Influencing

While large tracts of conservation lands in public ownership are critical to fox squirrel conservation, over half of Florida is privately owned. Any effort to conserve Sherman's fox squirrels on public lands still depends upon an effort to encourage private landowners to implement management actions that maintain or improve existing and future fox squirrel habitat. Habitat on private land is essential for expanding the potential habitat on public lands, especially smaller tracts. Private lands are also essential for creating corridors between populations (Action 2). Knowledge of Sherman's fox squirrel locations gained through the UF-FWC online survey should be used when planning corridors to ensure movement between local populations.

County growth management plans and land development regulations provide an avenue by which FWC can inform and influence land use changes that are relevant to the conservation of

the Sherman's fox squirrel and its associated community types. Road mortality rates and locations should be analyzed to determine if a pattern exists that can be utilized in conjunction with known Sherman's fox squirrel locations from the web survey when planning road development. This will assist in placement of new roads or corridors to minimize road mortality.

Action 18 Develop new incentive programs (or enhance existing ones) to encourage implementation of habitat management practices that are consistent with habitat management guidelines that benefit the Sherman's fox squirrel.

The use of incentive programs that offer technical and financial assistance to private landowners to restore and manage habitat should be encouraged. Current incentive programs include the Florida Forest Stewardship Program, Wildlife Habitat Incentives Program, Environmental Quality Incentives Program, Landowner Assistance Program, and Partners for Fish and Wildlife Program. These programs are voluntary for landowners and some may provide financial incentives, depending on annual appropriation, for wildlife conservation and habitat management on private lands. In addition to these incentive programs, property tax exemptions are available for conservation easements.

Prescribed fire is a habitat management tool that can be difficult for private landowners to use. Throughout the state, multiple agencies and organizations (e.g., The Nature Conservancy, FFS, FWC, DEP) have worked cooperatively to create prescribed fire strike teams (for example, the Northeast Florida Resource Management Support Team, Lake Wales Ridge Prescribed Fire Strike Team, etc) to increase support to land managers implementing prescribed burning. While successful at this endeavor, these teams function primarily on public lands; current strike teams cannot meet the prescribed fire needs of private landowners, and there has been little emphasis in applying this approach to private lands. Efforts should be made to create or support the implementation of methods to meet requests from private landowners for assistance in applying prescribed fire. Support for prescribed fire on private lands improves the potential to increase available fox squirrel habitat.

Once the preferred habitat structure and composition of the fox squirrel is understood, further encouragement of specific practices and management regimes within the incentive programs should be utilized to promote Sherman's fox squirrel habitat where permissible. Efforts should be made to update the FWCG.

Preliminary results associated with the survey in Action 4 reveal fox squirrel presence on agricultural land and urban areas such as golf courses and parks. Agricultural entities should be targeted to participate in incentive programs, particularly the Environmental Quality Incentives Program, to enhance existing habitat and provide for future needs. To provide corridors across agricultural land, the installation of hedgerows across fields lacking a canopy can be implemented to provide cover. Hedgerows created with native, mast-producing trees such as hardwoods and pines provide both cover and food. Developing guidance for urban areas such as golf courses and parks will help to maintain Sherman's fox squirrel population.

Education and Outreach

Action 19 Disseminate habitat management guidelines and monitoring protocols to private landowners and public land managers.

Action 20 Develop comprehensive outreach program (including brochures, kiosks, Project Wild, Land Use Planning, etc) that target a variety of audiences.

Action 21 Develop strategy to ensure our partners, stakeholders, and the public are aware of rule changes and protections for the Sherman's fox squirrel.

Education and outreach are important components of effective management strategies for imperiled wildlife species. Citizens who are well informed regarding needs of and potential benefits to imperiled species and their habitats are more likely to support these efforts. Outreach efforts should be applied broadly to encompass multiple scenarios and media.

Important themes for education programs and materials include:

- Robust Sherman's fox squirrel populations indicate high-quality habitat conditions well suited for many species of Florida's wildlife, including rare or imperiled species.
- Making the public aware of the life history of the Sherman's fox squirrel, especially the fact that they are relatively long lived and slow to reproduce, making them especially vulnerable to rapid changes in habitat.
- Fragmentation of Sherman's fox squirrel habitat increases the threat of road kill.
- While feeding of Sherman's fox squirrels is discouraged, squirrels will visit bird feeders regularly, which can lead to disease problems. Bird feeders should be disinfected regularly, especially if fox squirrels become regular guests.

The FWCG, WCPR, and the Office of Conservation Planning Services of FWC are each vehicles for disseminating the recommendations and guidelines produced in Action 3.

Communicating changes to rules and permitting guidelines to the appropriate audiences and providing a forum for answering questions will be important to ensure compliance of protective measures for the Sherman's fox squirrel. A strategy for communicating this information to target audiences will be developed, implemented, and adapted as needed.

Many Floridians believe there is value in conserving the Sherman's fox squirrel and other native species. People gain a sense of reassurance from the knowledge that imperiled species are protected, whether or not they have any plans to view the species or its supporting habitat. As such, just knowing management for imperiled species is occurring on conservation lands will enhance the quality of life for some Floridians.

Coordination with Other Entities

No specific actions have been identified; however, Actions 4 through 15 in Monitoring and Research will require coordination between FWC and researchers. Avoidance and minimization

guidelines (Action 16) and interpretation should be provided to the Office of Conservation Planning Services and permitting staff.

Several initiatives and working groups have formed over the last several decades to address the loss of Florida's uplands, and these groups should be made aware of and encouraged to include the Sherman's fox squirrel and its habitat needs in their operations. Existing working groups include North Florida Sandhills working group and the West Central Florida Uplands working group. These groups have been established to improve coordination among agencies and researchers to conserve and restore upland habitat. The Upland Ecosystem Restoration Project is multiagency effort to increase populations of northern bobwhites and other fire-dependent wildlife on public lands.

Implementation of recommended habitat conservation measures (Actions 1 and 2) will require effective partnerships and coordination among land managers, species experts, and stakeholders. Successful management for the Sherman's fox squirrel on state and federal conservation lands is essential for conservation of this species. State conservation lands must continue to play a major role in the conservation and recovery of the Sherman's fox squirrel and other imperiled species.

Many public conservation lands are required to have a management plan approved by the Acquisition and Restoration Council or the agency's governing board. Specifically, s. 253.034(5), Florida Statutes (F.S.), says in part that all land management plans shall include an analysis of the property to determine if significant natural resources, including listed species, occur on the property. If significant natural resources occur, the plan shall contain management strategies to protect the resources. The Florida Forever Act (s. 259.105, F.S.) adds that all state lands that have imperiled species habitat shall include, as a consideration in the management plan, restoration, enhancement, management, and repopulation of such habitats. For lands that support, or have the potential to support Sherman's fox squirrels, the FWC should be consulted (as statutorily required) and the lead management agency is encouraged to include FWC as part of the management plan advisory group.

As documented above, Floridians have ecological, legal, economic, and ethical reasons to manage imperiled species on State conservation lands. Imperiled species face increasing threats due to the continued increase in the human population, the land alterations that accompany this growth, and the potential for negative impacts due to climate change. Considering this, imperiled species management and restoration should be, and can be, a higher priority on all State conservation lands.

Table 1. Sherman's Fox Squirrel *(Sciurus niger shermani)* Conservation Action Table

NOTE: An explanation of acronyms used is below the table.

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
3	2	1	Identify priority areas throughout the range of the SFS (on both private and public lands) to ensure that habitats with the greatest potential to benefit the species are protected, connected, and improved.	Habitat Conservation & Mgmt	EXPANDED	YES	YES	$25-50k	Existing budget	WHM	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Effective at achieving desired outcome.	Feasible and already under way.	Yes, habitat conservation necessary for long term survival.
3	3	2	Maintain, enhance, and encourage the creation of habitat corridors on private and public lands through incentives programs and existing habitat conservation programs.	Habitat Conservation & Mgmt	NEW	YES	YES	$50-100k	SWG, Existing, Grant and other	CPS	DOACS, NRCS, Land Trusts or NGOs, DEP, FFS, USFS, USFWS, County Environmental Land Programs	Effective at achieving desired outcome.	Feasible and already under way.	No, however corridors will reduce isolation of small populations.
3	3	3	Develop habitat management guidelines and monitoring recommendations for public land managers and private landowners	Habitat Conservation & Mgmt	NEW	YES	YES	$0-25k	Existing budget	HSC	NRCS, FFS, USFWS, NPS,	Effective at achieving desired outcome.	Feasible and already under way.	No, however without guidance many land managers and owners will not be aware of the habitat needs required by SFS.
2	1	4	Develop a GIS-based habitat model to identify areas to survey for SFS presence and absence.	Monitoring & Research	EXPANDED	YES	YES	$25-50k	SWG , Existing, and other	HSC, FWRI	UF	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is critical to assessing the status of this species.
2	2	5	Develop an occupancy-based survey protocol to determine presence and absence of SFS in potential habitat.	Monitoring & Research	EXPANDED	YES	NO	$25-50k	SWG , Existing, and other	HSC, FWRI	UF	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is important for assessing the current status and persistence of this species in existing habitat.
1	1	6	Develop protocol for collecting and handling tissue samples for genetic analysis.	Monitoring & Research	ONGOING	YES	YES	$0-25k	SWG , Existing, and other	HSC, FWRI	UF, FNAI, NPS, Camp Blanding JTC, FPS, WMD, USFWS, DEP,FFS,USFS, Pepperdine University	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is critical to assessing the status of this species.
1	1	7	Solicit collection of tissue from road kills throughout the state by agency biological and law enforcement staff, biological staff from other agencies, university researchers and the general public.	Monitoring & Research	EXPANDED	YES	YES	$0-25k	SWG , Existing, and other	HSC, FWRI, LE	UF, FNAI, NPS, Camp Blanding JTC, FPS, WMD, USFWS, DEP,FFS,USFS, Pepperdine University	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is critical to assessing the status of this species.
1	1	8	Trap to collect tissue samples by using sites identified from reported locations and based on gaps in data from road-killed specimens.	Monitoring & Research	ONGOING	YES	YES	$0-25k	SWG , Existing, and other	HSC, FWRI	UF, FNAI, NPS, Camp Blanding JTC, FPS, WMD, USFWS, DEP,FFS,USFS, Pepperdine University	Effective at achieving desired outcome, dependent on sample size acquired.	Feasible and already under way.	Yes, this data is critical to assessing the status of this species.
1	1	9	Conduct genetic analyses to determine the current extent of occurrence and area of occupancy for SFS.	Monitoring & Research	EXPANDED	YES	NO	$50-100k	SWG , Existing, and other	HSC	UF, FNAI, NPS, Camp Blanding JTC, FPS, WMD, USFWS, DEP,FFS,USFS, Pepperdine University	Effective at achieving desired outcome	Feasible, expansion of existing project	Yes, expansion of existing effort, will improve quality of data.

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Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
3	2	10	Develop a scientifically sound monitoring protocol for SFS.	Monitoring & Research	ONGOING	YES	NO	$25-50k	SWG , Existing, and other	HSC, FWRI	UF	Effective at achieving desired outcome	Feasible and already under way.	Yes, population levels unknown and necessary for assessing the status of this species.
3	3	11	Develop a protocol to estimate density and abundance of SFS in different habitat types.	Monitoring & Research	ONGOING	YES	NO	$0-25k	SWG , Existing, and other	HSC, FWRI	UF	Effective at achieving desired outcome	Feasible and already under way.	No. However, to achieve the goal of the SAP this is a critical action. The lower priority reflects the need to accomplish other actions first.
3	4	12	Implement a monitoring program to track SFS populations on a 5-year interval.	Monitoring & Research	NEW	YES	NO	$25-50k	Existing Budget	HSC	UF, FFS, FPS, USFWS, DEP	Effective at achieving desired outcome	Not clear about the demand needed to accomplish across the range of this species.	No. However, to achieve the goal of the SAP this is a critical action. The lower priority reflects the need to accomplish other actions first.
3	1	13	Initiate research to estimate demographic parameters (e.g., fecundity, juvenile survival, population density, population growth, recruitment, immigration and emigration rates, etc.) needed for robust population models and population viability analyses (PVA).	Monitoring & Research	NEW	YES	NO	$50-100k	SWG , Existing, and other	FWLI, FWRI	UF, other universities	Effective at achieving desired outcome.	Not clear about the demand needed to accomplish across the range of this species.	Yes, this data is critical due to the lack of information concerning local and statewide population parameters.
2	1	14	Determine habitat associations and identify preferred habitat types.	Monitoring & Research	ONGOING	YES	YES	$25-50k	SWG , Existing, and other	HSC, FWRI	UF	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is critical to assessing the status of this species.
3	2	15	Develop GIS-based potential habitat maps stratified by habitat quality.	Monitoring & Research	EXPANDED	YES	NO	$0-25k	SWG , Existing, and other	HSC	UF	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is critical to understanding occurrence.
3	1	16	Determine level of protection needed to achieve conservation goals for the SFS.	Protections & Permitting	NEW	YES	YES	$0-25k	Existing budget	HSC, Legal	FFS, DEP	Effective at achieving desired outcome.	Feasible.	Yes, important to understand level of protection needed and address potential take.
3	3	17	Use materials from education and outreach to train law enforcement to identify fox squirrels, their nests, evidence of presence, and habitat so they can identify potential take situations.	Law Enforcement	NEW	YES	YES	$0-25k	Unknown	HSC, LE	UF	Effective at achieving desired outcome.	Feasible.	Yes, critical to prevent take, enforce regulations, and prevent the need for future relisting.
3	4	18	Develop new incentive programs (or enhance existing ones) to encourage implementation of habitat management practices that are consistent with habitat management guidelines that benefit the Sherman's fox squirrel.	Incentives & Influencing	NEW	YES	YES	$0-25k	Existing budget	CPS	DOACS NRCS, USFWS, FFS,	Highly Effective at achieving desired outcome.	Feasible, relationships already exist, just require more information desired habitat parameters.	No, programs promote habitat management and restoration which generally benefits the fox squirrel through the use of prescribed fire and longleaf pine establishment.
3	3	19	Disseminate habitat management guidelines and monitoring protocols to private landowners and public land managers.	Education & Outreach	NEW	YES	YES	$0-25k	Existing budget	HSC, CPS	NRCS, FFS, USFWS, NPS,	Effective at achieving desired outcome.	Feasible.	No, however without guidance many land managers and owners will not be aware of the habitat needs required by SFS.

Table 1. Sherman's Fox Squirrel *(Sciurus niger shermani)* Conservation Action Table

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Ongoing, Expanded or New Effort?	Authority	Man Power	Estimated Cost To Implement	Funding Source(s)	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgent?
3	4	20	Develop comprehensive outreach program (including brochures, kiosks, Project Wild, Land Use Planning, etc) that target a variety of audiences.	Education & Outreach	NEW	YES	YES	$0-25k	Existing, Grant, and other	CPS, OCR, Project Wild	NGOs, UF, IFAS, DEP, local governments	Effective at achieving desired outcome.	Feasible.	No, however without the support of an educated public accomplishing the objectives of the SAP will be difficult.
3	3	21	Develop strategy to ensure our partners, stakeholders, and the public are aware of rule changes and protections for SFS.	Education & Outreach	NEW	YES	YES	$0-25k	Existing budget	OPA, HSC, OCR	FFS, DEP, local governments	Effective at achieving desired outcome.	Feasible.	No. However, making the public aware of the status and regulations regarding SFS is critical to the successful implementation of the SAP.

Acronyms used in this table:

CPS:	Conservation Planning Services, an Office of the Florida Fish and Wildlife Conservation Commission's Division of Habitat and Species Conservation
DEP:	Florida Department of Environmental Protection
DOACS:	Florida Department of Agricultural and Consumer Services
FFS:	Florida Forest Service
FNAI:	Florida Natural Areas Inventory
FWC:	Florida Fish and Wildlife Conservation Commission
FWLI:	Florida's Wildlife Legacy Initiative
FWRI:	Fish and Wildlife Research Institute, the research branch of the Florida Fish and Wildlife Conservation Commission
GIS:	Geographic information system
HSC:	Habitat and Species Conservation, a Division of the Florida Fish and Wildlife Conservation Commission
JTC:	Joint Training Center
LE:	Law enforcement
NGO:	Non-governmental organization(s)
NPS:	National Park Service
NRCS:	National Resource Conservation Service
OCR:	Office of Community Relations, Florida Fish and Wildlife Conservation Commission
OPA:	Office of Policy and Accountability, Florida Fish and Wildlife Conservation Commission
PVA:	Population viability analysis
SAP:	Species Action Plan
SFS:	Sherman's fox squirrel
SWG:	State wildlife grant
UF:	University of Florida
USFS:	United States Forest Service
USFWS:	United States Fish and Wildlife Service
WHM:	Wildlife and Habitat Management, a Section of the Florida Fish and Wildlife Conservation Commis Division of Habitat and Species Conservation
WMD:	Water Management District(s)

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APPENDICES

Appendix 1. University of Florida and Florida Fish and Wildlife Conservation Commission Fox Squirrel Web Survey.

To build a species distribution model of fox squirrels in Florida, fox squirrel sightings were collected from 20 August, 2011 to 1 April, 2012. A web-based tool was created to allow both natural resource professionals and the general public to submit fox squirrel sighting locations throughout Florida. Participants were encouraged to provide pictures of fox squirrels through email to further verify the validity of sightings received from the public. The Google map application recorded geo-referenced locations (latitude and longitude in decimal degrees) submitted by survey participants. Along with the geo-referenced fox squirrel locations, each participant was encouraged to submit the following information: date of the sighting, name, organization (if applicable), and email address. Participants were asked to choose their affiliation from the following 2 choices: general public or natural resource professional (biologist, extension, forester, land manager, etc.). A comments box allowed participants to enter further sighting information such as surrounding land use, behavior, individual description, etc. The survey was announced to state, federal, county, and private professionals as well as to the general public through email list serves, various newsletter articles, flyers, social media, and word of mouth at public and governmental events.

The survey produced 4,221 sighting locations from 2,673 individuals. Of the participants, 74% were from the general public and the remaining 26% were submitted by natural resource professionals.

Along the southern extent of the Sherman's fox squirrel range, the Caloosahatchee River, fox squirrels were reported occurring north and south of the river (i.e., within the range of the Sherman's fox squirrel and the Big Cypress fox squirrel). A few sightings that occurred on each side of the river were less than 1.6 km (less than 1 mi) from one another. Where both species occur along the river, the width of the river is only 0.16 km (0.1 mi) wide and near a bridge. This observation, along with the lack of an occurrence break between the range of the Sherman's fox squirrel and Big Cypress fox squirrels, indicates that a discrete separation between the subspecies does not occur as previously thought. Along perceived subspecies divisions for the Bachman's, southeastern, and Sherman's fox squirrels, a similar pattern is noted regarding the lack of a break in occurrence of fox squirrels along the major rivers (Aucilla, Apalachicola, Choctawhatchee, Yellow, Blackwater, and Suwannee rivers) in the Panhandle. The following map displays all sightings from the survey.

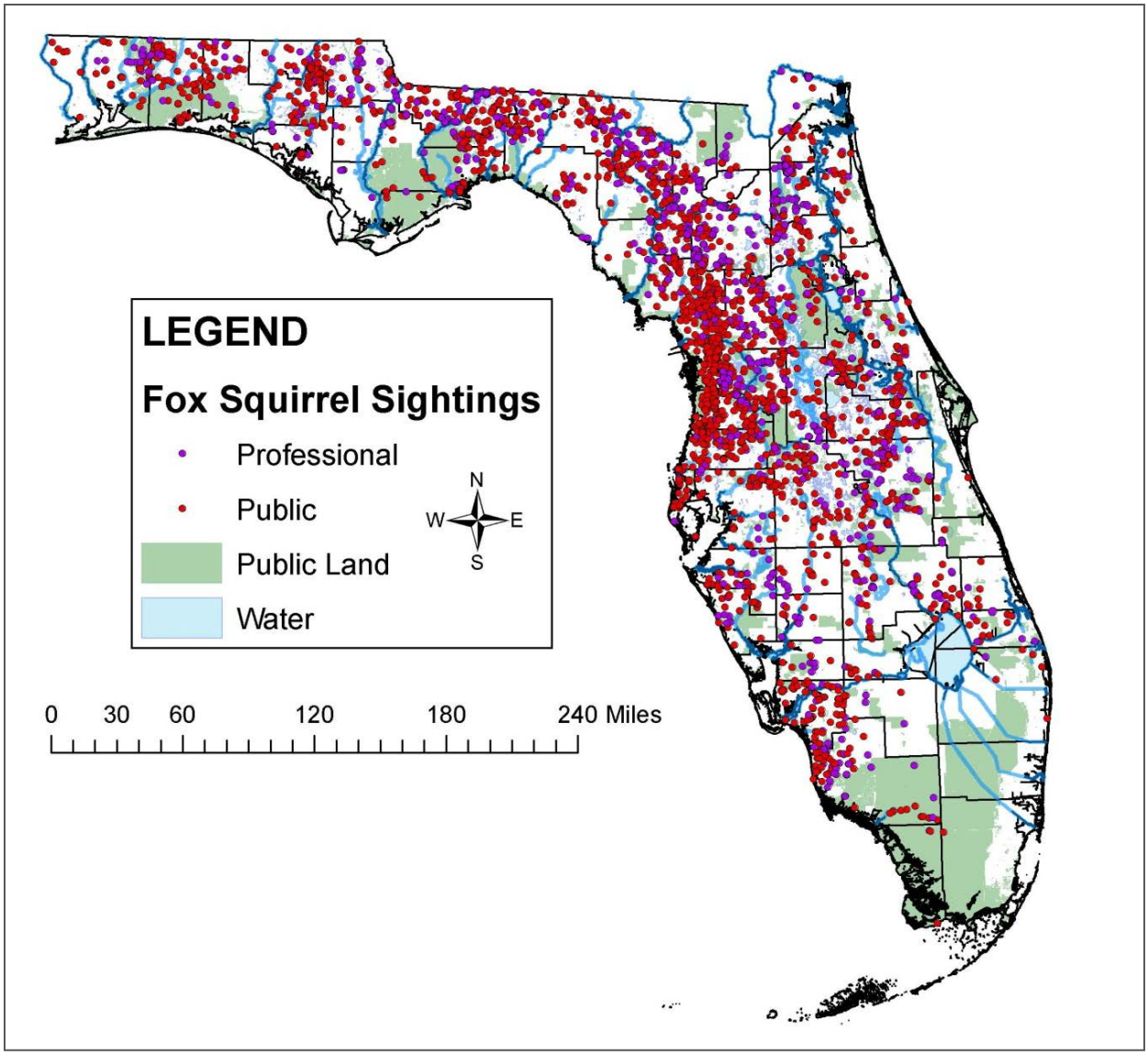

Figure 1. Fox squirrel (*Sciurus niger*) sightings, survey dates: 20 August 2011 to 1 April 2012.

Appendix 2. Additional information on squirrel poxvirus, a potential threat to the viability of Big Cypress fox squirrel populations.

Squirrel poxvirus is an infectious disease that typically results in a condition sometimes called fibromatosis (Robinson and Kerr 2001). *Fibromatosis* refers to the presence of benign, cutaneous, tumors (fibromas) formed by the disease. In infected squirrels, fibromas often form on multiple parts of the body at the same time (Terrell et al. 2002). Squirrel poxvirus has a reported incubation period of 7 to 14 days before visible tumors appear (Kilham 1955, Hirth et al. 1969,). High rates of morbidity and mortality in infected squirrels have been reported (Terrell et al. 2002). Squirrel poxvirus typically either goes into remission or leads to mortality in <2 months (Kilham 1955). A widespread outbreak of squirrel poxvirus in Florida infected >200 squirrels, across 7 counties, with high rates of mortality (Terrell et al. 2002). In 2010, a squirrel poxvirus-infected Big Cypress fox squirrels was documented within Big Cypress (Kellam 2010). As a result, the National Park Service is consistently monitoring Big Cypress fox squirrels in the Big Cypress National Preserve for signs of squirrel poxvirus outbreak, with ongoing outreach efforts to inform the public how to identify and report squirrels showing symptoms of the disease (Kellam 2010 J. Kellam, National Park Service, personal communication).

Appendix 2, Literature Cited

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Appendix 3. Tissue Collection Protocol developed by the University of Florida and Florida Fish and Wildlife Conservation Commission.

Four subspecies of fox squirrels (southeastern, Sherman's, Bachman's, and Big Cypress) are recognized as occurring in Florida. There are presently no clear methods to differentiate between subspecies, and the geographic distribution of each is not well known. To investigate the distribution and to determine the evolutionary distinction among the 4 subspecies, I am requesting genetic samples from fox squirrels throughout Florida.

Whole Specimen Collection

If possible, please collect the whole specimen. Whole specimens should be double bagged and frozen with a label stored inside the outer bag.

Tissue Collection

If collecting a sample, cut off an ear with scissors or a knife (sterile if possible) and place tissue in a labeled plastic bag, or in a labeled vial of 95% denatured ethanol. Store all samples in a standard freezer, including the vials to prolong the life of the sample.

Record the following information on a label and store with the sample:

- Collection date (month, date, year)
- Locality information, including lat/longs or UTM's if possible (these can be obtained from Google Earth if you do not have a GPS unit)
- Name, affiliation, and contact information for the collectors
- If submitting an ear sample (and not whole carcass) please include the following:
    - Gender of squirrel, if identifiable.
    - If possible, take pictures of the head, back and belly of the squirrel and email the photos to greenda@ufl.edu

Please contact me after collecting a sample/specimen to arrange for shipment.
If you have any questions, please call or email me.

Thank you!

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