A Species Action Plan for the Southern Fox Squirrel *Sciurus niger niger*

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EXECUTIVE SUMMARY

This plan provides the framework for the conservation and management of the Southern fox squirrel (*Sciurus niger niger*), a large tree squirrel known for its variable pelage and distinct relationship with mature, open, mixed pine-hardwood communities maintained by regular fires. This plan was originally developed for the Sherman's fox squirrel (*S. n. shermani)* but is revised to reflect that Sherman's fox squirrel is no longer believed to be genetically distinct from the Southern fox squirrel.

The Florida Fish and Wildlife Conservation Commission (FWC) developed this plan as a component of Florida's Imperiled Species Management Plan (FWC 2016). In 2017, a biological review group (BRG) was convened by the Florida Fish and Wildlife Conservation Commission (FWC) to review the status of the Sherman's fox squirrel. When the BRG evaluated the species, they accounted for new analyses that found no genetic structure among fox squirrel populations in north and central Florida, indicating that *S. n. niger* is not genetically distinct from *S. n. shermani* or *S. n. bachmani* in Florida (Greene et al. 2015). Taxonomically, it is thus appropriate to group all fox squirrels in Florida north of the Caloosahatchee River as the Southern fox squirrel, *S. n. niger*. Based on their assessment, the BRG concluded the subspecies did not meet any listing criteria. The BRG also noted the importance of proper land conservation and management on a landscape or range-wide scale. Thus, while a primary objective of this plan is to assure the statewide Southern fox squirrel population is stable or increasing in Florida, another important objective is to ensure habitat management is a priority. The final objective is to confirm the level of genetic structuring within fox squirrels and the taxonomic status of Sherman's fox squirrel.

Once hunted in Florida, threats to fox squirrels today include loss, degradation, and fragmentation of its habitats. The fire-maintained mixed pine-hardwood communities where Southern fox squirrels naturally occur have declined due to land use changes and fire suppression. Isolated groups are vulnerable to local extinction from disease outbreaks, hurricanes, low gene flow, and other causes. Urbanized habitats may support fox squirrels, however, the ability to sustain the population long-term is unknown.

To achieve this plan's objectives, the Southern fox squirrel and its habitat must be maintained through science-based management and engagement with public and private entities. 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. The FWC can provide technical and logistical support for implementing actions, and can coordinate with partners to achieve the conservation goal.

A summary of this plan is included in Florida's Imperiled Species Management Plan, in satisfaction of the management plan requirements in Rule 68A-27, Florida Administrative Code, Rules Relating to Endangered or Threatened Species. Florida's ISMP addresses comprehensive management needs for Florida's imperiled species and includes an implementation plan; regulatory framework; relevant policies; anticipated economic, ecological, and social impacts; projected costs of implementation; and a revision schedule. Achieving the objectives of the ISMP depends heavily on stakeholder input and partner support.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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 (AOO): 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]).

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 (EOO): 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.

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: Florida's 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.

MMDM: Mean maximum distance moved

PVA: Population Viability Analysis

SFA: Species Focal Area. An area containing features (such as unique population units or habitat types) important to the long-term conservation of the species, as identified in Species Conservation Measures and Permitting Guidelines.

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

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

Taxonomy

Historically, 10 subspecies of eastern fox squirrel (*Sciurus niger*) have been recognized in the U.S., 4 of which occur in Florida. Sherman's fox squirrel (*Sciurus niger shermani),* Big Cypress fox squirrel (*S. n. avicennia*), Bachman's fox squirrel *(S. n. bachmani),* and the Southern fox squirrel (*S. n. niger*). Research as early as the 1990s indicates that the Bachman's fox squirrel may represent a clinal variation to *S. n. niger* (Turner and Laerm 1993). The designation and proposed areas of occurrence of these subspecies have varied, depending on the source (e.g., Kantola 1992, Koprowski 1994). These subspecies designations have generally been based on morphological measurements and pelage coloration (Hall 1981, Kantola 1992, Turner and Laerm 1993, Figure 1).

In 2015, genetic analyses found no genetic structure among fox squirrel populations in north and central Florida, indicating that *S. n. shermani* is not genetically distinct from *S. n. bachmani* or *S. n. niger* in Florida (Greene et al. 2015; Austin et al., Journal of Mammalogy, in review). When the results of these analyses are reviewed and, as expected, accepted taxonomically, then application of the International Code of Zoological Nomenclature (ICZN 1999), dictates that only 1 of those subspecies names will remain valid. Following the ICZN Principle of Priority (Article 23; ICZN 1999), the *niger* subspecies name would take priority over *bachmani* and *shermani* because *niger* has been in existence the longest (Koprowski 1994).

These results suggest that the conservation and management recommendations outlined in the original Species Action Plan for Sherman's fox squirrel should be extended across the entire Florida panhandle (Greene et al. 2015). Given these results, we are defining the area over which the actions in this plan should be applied to be equivalent to the range of *S. n. niger* in Florida, the area extending from Miami-Dade County along Florida's east coast and the Caloosahatchee River, then north and west to the Alabama border, including the area that historically was classified as the range of *S. n. shermani* (Figure 5).

Description

The Southern fox squirrel is a large tree squirrel typically measuring 600 to 700 mm (23 to 28 in) in length. It has a long, plume-like tail nearly as long as its body. Fox squirrels lack the small, peg-like first upper premolar that is found in gray squirrels (Koprowski 1994). In the southeastern coastal plain, fox squirrels are highly variable in color, varying in dorsal coloration from gray to tan agouti to completely black, with buff or black on the venter (Moore 1956, Kiltie 1989). The tail also varies in color and they almost always have a variable amount of white on the rostrum and ears (Kiltie 1989). Tye et al. (2015) categorized pelage variation of Southern fox squirrels in Florida on the basis of 9 pelage features, each of which had multiple conditions (Figure 1): amount of white on the rostrum, dorsal color (silver, agouti, or melanistic), ventral color (white, tan, black, white-tan, tan-black), presence of a dorsal melanistic stripe, presence and/or completeness of an eye ring, presence of a dark spot on a foot, forearm patterns, hind-leg patterns, and toe color. See Tye et al. (2015) for a more complete description of conditions for each feature.

Figure 1. Examples of pelage color variation in the Southern fox squirrel. Photographs show variation in dorsal and ventral color, foreleg and hindleg patterns, eye ring, and toe color. 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) University of Florida Fox Squirrel Research Team at Ordway-Swisher Biological Station.

Life History

The Southern fox squirrel is dependent upon mature, open, fire-maintained mixed pine-hardwood communities where pine species, typically longleaf pine (*Pinus palustris*), dominate the tree cover with turkey oak (*Quercus laevis*) or other hardwood trees scattered throughout the habitat (Moore 1957, Kantola and Humphrey 1990, Kantola 1992, Florida Natural Areas Inventory [FNAI] 2001). However, Southern fox squirrels occur in multiple land cover classes similar in structure to the historic pine savannas (Greene and McCleery 2017*a*; Tye et al. 2016). Management practices such as frequent fire reduce the woody understory, woody groundcover vegetation and tree canopy cover and are important practices for maintaining the proper structure and heterogeneity across landscapes (Greene and McCleery 2017*a*). Conserving a hardwood component, particularly retaining mature hardwoods trees, is important for food and cover resources (Conner and Godbois 2003, Prince et al. 2016, Greene and McCleery 2017*b*). Perkins et al. (2008) found that in longleaf pine forests, 11.8% hardwood canopy cover was important for occupancy by Southern fox squirrels. Southern fox squirrels also inhabit mixed

pine-hardwood, mature pine forests, cypress domes, pastures, the ecotone between bayheads and pine flatwoods, and other open habitats where mixed pines and oaks occur (Endries et al. 2009).

The Southern fox squirrel is frequently found on agricultural lands and urbanized areas such as parks and golf courses, which often mimic the structure of open sandhills and pine flatwoods (scattered overstory pines and oaks with sparse, low groundcover). It is unclear whether the persistence of fox squirrels in these areas is dependent upon immigration of new individuals.

The Southern 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 (Figure 2) are weaned at 90 days and sexual maturity is reached at about 9 months.

Figure 2. A juvenile Southern fox squirrel captured in a kestrel box on Camp Blanding Joint Training Center, Clay County. Photograph 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).

Pine seeds and turkey oak acorns appear to be some of the main food items consumed by Southern 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 interspersed with patches of live oak forest or other hardwoods (Kantola and Humphrey 1990). Additional food items include other acorns, fungi, bulbs, vegetative buds, insects, nuts, and staminate pine cones (Kantola 1992).

Southern fox squirrels use several different nests in their home ranges (Kantola and Humphrey 1990). Most nests are leaf nests (Figure 3) 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).

Figure 3. Southern fox squirrel leaf nest in a longleaf pine on the Bell Ridge Longleaf Wildlife and Environmental Area, Gilchrist Co. Photograph by Terry Doonan, FWC.

Wooding (1997) reported average home range size as 35.6 and 33.0 ha for females and 83.0 and 79.5 ha for males. Kantola and Humphrey (1990) reported average home range size as 16.7 ha (41.2 ac) for females and 42.8 ha (105.7 ac) for males. Kantola (1992) stated that midwestern fox squirrel home ranges average 0.8 to 7.0 ha (2.0 to 17.3 ac). Greene and McCleery (2017*a*) calculated a mean maximum distance moved (MMDM), of 573 yd (524 m) from their combined live and camera trapping results for Sherman's fox squirrel, which they interpreted as "a proxy for the diameter of a home range." That MMDM translates to an estimated home range of 21.6 ha (53.4 ac). Greene and McCleery (2017*a*) also calculated a standardized MMDM of 588 yd (538 m) by averaging published movement data for southeastern fox squirrels. That MMDM translates to an estimated home range of 22.7 ha (56 ac). Adult fox squirrels 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).

Density estimates for fox squirrels in Florida have varied. Moore (1957) reported a density of 38 individuals/km^2. However, Wooding (1997) reported 7.4 and 11.7 individuals/km^2 on his 2 study sites and Humphrey et al. (1985) reported 8.4 individuals/km^2. Greene and McCleery (2017*a*) used new analysis methods for mark-recapture data and reported densities of 1.4-3.6 individuals/km^2 across study sites and seasons. Greene and McCleery (2017*a*) also applied their methods to data from previous studies and obtained estimates of 2.4 and 4.1 individuals/km^2 for Wooding's (1997) data and 3.4 individuals/km^2 for Moore's (1957) data.

Density estimates for fox squirrels in Florida (reported as individuals/km^2) have varied. Earlier estimates based on traditional analysis methods generally were higher:

- 38 (Moore 1957)
- 7.4 and 11.7 (Wooding 1997, on separate sites)
- 8.4 (Humphrey et al. 1985)

Estimates based on new analysis methods for mark-recapture data applied by Greene and McCleery (2017*a*) are much lower:

- 3.4 (Moore 1957, adjusted)
- 2.4 and 4.1 (Wooding (1997, adjusted)
- 1.4 to 3.6 (Green & McCleery 2017*a*, across multiple sites and seasons)

Greene and McCleery (2017*a*) believe their approach, which applies a standardized MMDM correction factor to account for potential bias when estimating the area sampled, provides for more accurate estimates of density.

Fox squirrel densities may be lower as a result of lack of high-quality foods, when the availability of foods varies in time and space, or when there are periodic failures of mast crops (Wooding 1997). In general, habitats occupied by fox squirrels with low productivity also show low population densities, large home range sizes, and low production of young per unit area (Kantola and Humphrey 1990, Wooding 1997).

Geographic Range and Distribution

Historically, assessments of the distribution of fox squirrels in Florida (e.g., Moore 1956, Brady 1977, Williams and Humphrey 1979, Kantola 1992, Koprowski 1994, Eisenberg et al. 2011, Tye et al. 2016) have differed in the range limits for the different subspecies. These studies generally accepted *Sciurus n. shermani* as a distinct subspecies, the range of which included most of peninsular Florida (Figure 4), extending northward into southern Georgia and southward on the west coast to the Caloosahatchee River and southward on the east coast to Jupiter in Palm Beach County (Moore 1956, Wooding 1997).

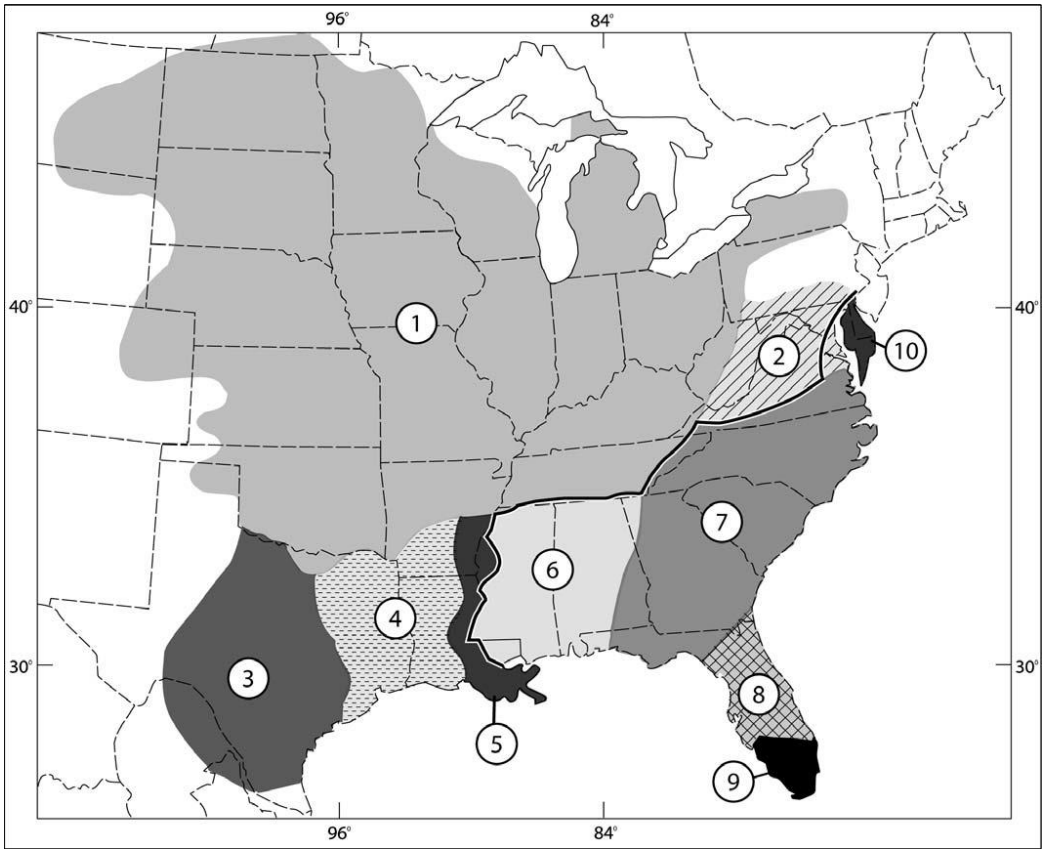

Figure 4. The previously recognized ranges of Eastern fox squirrel subspecies. Map from Moncrief et al. (2010) showing the geographic distribution of subspecies of eastern fox squirrel (*Sciurus niger*-Hall 1981, Koprowski 1994): 1) *S. n. rufiventer*, 2) *S. n. vulpinus*, 3) *S. n. limitis*, 4) *S. 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*.

Analysis indicating that *S. n. shermani* is not genetically distinct from *S. n. bachmani* or *S. n. niger* in Florida (Greene et al. 2015; Austin et al., Journal of Mammalogy, in review). Given these results, we are defining the range of *S. n. niger* to be the area extending from Miami-Dade County along Florida's east coast and the Caloosahatchee River, then north and west to the Alabama border, including the area that historically was classified as the range of *S. n. shermani*.

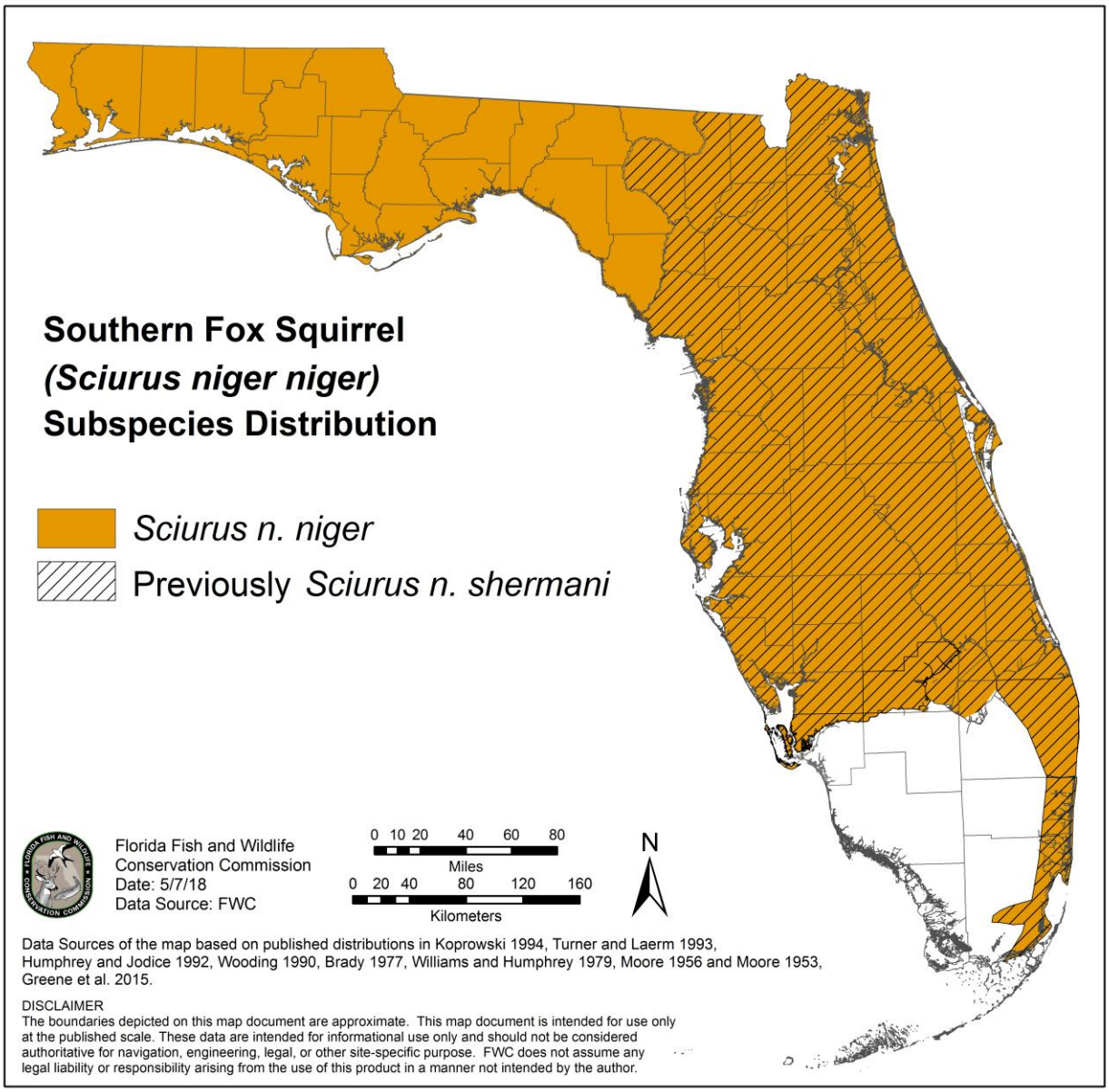

Figure 5. Florida range, as defined in this plan, of the Southern fox squirrel, *S. n. niger*.

Conservation History

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

Sherman's fox squirrel was listed in Florida as state Threatened from 1975 to 1978 and as a Species of Special Concern from 1980 to 2017. 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 designated the Sherman's fox squirrel as Threatened (Kantola 1992), and FNAI (18 April 2018) ranks 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).

There has been extensive loss of habitat for fox squirrels, but 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, underscoring that proper management of conservation lands is critical to ensure there is adequate suitable habitat for the Sherman's fox squirrel.

FWC initiated the Wildlife Conservation, Prioritization, and Recovery (WCPR) program in 2008 to provide assessment, recovery, and planning support for the Wildlife Management Area (WMA) and Wildlife and Environmental Area (WEA) system to emphasize management for focal species and recovery of listed species. The program helps assesses conservation needs for those species and prioritizes how FWC addresses those needs on system lands. The Sherman's fox squirrel is a WCPR focal species. As a result, conservation strategies are developed for Sherman's fox squirrel on WMAs and WEAs that have a role in its conservation. In addition, FWC biologists in the WCPR program provide technical assistance to other public agencies' land mangers regarding the Sherman's fox squirrel.

In 2010, the Florida Fish and Wildlife Conservation Commission (FWC) directed staff to evaluate all species listed as Threatened or Species of Special Concern that had not undergone a status review in the preceding decade. The 2011 Biological Review Group (BRG) found that the Sherman's fox squirrel did not meet any listing criteria. After considering reviewers' comments about insufficient data, staff reviewed the BRG findings and recommended that the Sherman's fox squirrel be maintained as a Species of Special Concern until additional data could be collected. The findings are published in the 2011 Biological Status Review report (BSR, FWC 2011). The original Species Action Plan for the Sherman's Fox Squirrel (predecessor of this

plan) was developed in 2013 and the species was included in Florida's Imperiled Species Management Plan (ISMP, FWC 2016).

The ISMP identifies the need to re-assess all remaining Species of Special Concern by 2017. The 2017 BRG determined that the subspecies does not meet state-listing criteria, and the staff recommendation was to remove the Sherman's fox squirrel (now understood to be Southern fox squirrel) from the Florida Endangered and Threatened Species List so that it is no longer listed as a Species of Special Concern (see recommended listing status). These findings are published in the 2017 Biological Status Review report (FWC 2017).

The change in listing status initiated the 2018 revision of this plan. Since the original Species Action Plan for the Sherman's Fox Squirrel was published in 2013, research has determined that the that *S. n. shermani* is not genetically distinct from *S. n. bachmani* or *S. n. niger* in Florida (Greene et al. 2015; Austin et al., Journal of Mammalogy, in review). This revision of the plan incorporates this new knowledge and builds upon the actions outlined in the original plan by expanding the geographic area over which they should be implemented. New research actions and an emphasis on further clarification on clinal variation are also included.

In 2018, FWC staff developed Species Conservation Measures and Permitting Guidelines (FWC 2018) for the Southern fox squirrel to further inform the public on measures that may benefit the species during project planning and other activities.

Threats and Recommended Listing Status

Threats

Southern fox squirrels can be more resilient to habitat modifications than previously thought (Greene and McCleery 2017*b*), but habitat loss, fragmentation and degradation, resulting from conversion for development and other uses, continue to create threats for the long-term conservation of Southern fox squirrel populations (Kantola and Humphrey 1990, FWC 2005, FWC 2017). Such habitat loss has already been significant; it is estimated that only 10 to 20% of the Southern fox squirrel's historic habitat is still intact (Bechtold and Knight 1982 as cited in Kantola 1992). Most of its habitat has been logged; degraded by lack of fire; or converted either for agriculture uses or commercial and residential development (Bechtold and Knight 1982 as cited in Kantola 1992). Specifically, Florida's longleaf pine forests 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 remaining habitat types, including mixed pine-hardwood forest, natural pineland, sandhill, and scrub are in poor condition and declining as a result of inadequate or inappropriate management.

Habitat loss and degradation also are expected to continue as Florida's human population continues to expand (FWC 2005, Zwick and Carr 2006, FWC 2008). Kantola and Humphrey (1990) suggested that most remaining tracts of longleaf pine savanna in Florida were not of good quality. Logging has led to the loss of pine trees that have not been replaced in some areas across the Southern fox squirrel range and fire suppression has created unnaturally high turkey oak densities in other parts of that 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).

Fragmentation of habitat poses an ongoing risk to the Southern fox squirrel. Due to their slow, lumbering gait, fox squirrels are vulnerable to road mortality (Figure 6). Such mortality is likely to increase as Florida's human population increases. Better understanding of Southern fox squirrel populations, habitat preference, and habitat use may help in land use planning activities and road-construction projects to avoid some hazards. Fragmentation of suitable habitat further isolates local populations, increasing vulnerability to local extinction events.

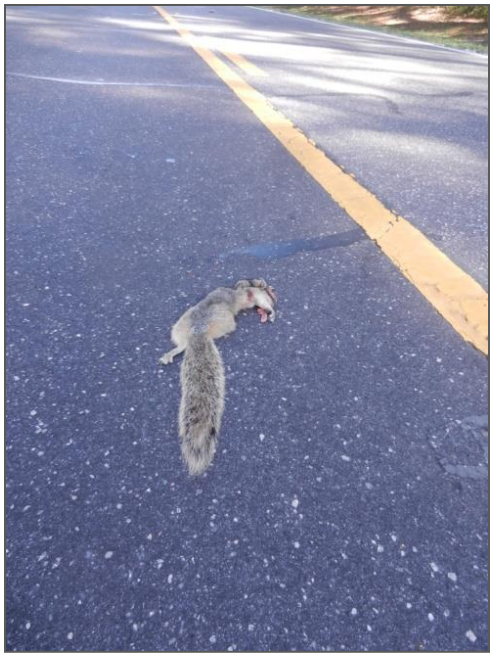

Figure 6. Southern fox squirrel killed by a vehicle near Reddick. Road mortality can have a significant impact on fox squirrel populations. Photograph by Jeff Gore, FWC.

Hunting of the Southern 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). Hunting has been prohibited since 1995 and there is no data to suggest that hunting remains a threat.

Diseases may pose a significant threat to population stability and viability. For example, White Oak Conservation Center (WOCC) in Nassau County recorded a fox squirrel die-off due to a fibromatosis outbreak throughout the property in 2002-2003 (S. Citino, WOCC, personal communication). 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). The potential impacts this disease may have on the Southern fox squirrel is unknown (USFWS 2002; see Appendix 2 for additional details).

Recommended Listing Status

In 2017, FWC convened a second BRG to re-evaluate the listing status of the Sherman's fox squirrel (FWC 2017) using criteria specified in Chapter 68A-27.001, F.A.C. When the BRG evaluated the species, they accounted for new analyses that found no genetic structure among fox squirrel populations in north and central Florida, indicating that *S. n. shermani* is not genetically distinct from *S. n. bachmani* or *S. n. niger* in Florida (Greene et al. 2015). One outcome then is that taxonomically it is appropriate to group all fox squirrels in Florida north of the Caloosahatchee as the Southern fox squirrel (*S. n. niger*). The 2017 BRG concluded from the biological assessment that the Sherman's fox squirrel does not meet any listing criteria. Staff recommended that the Sherman's fox squirrel be removed as a Species of Special Concern from Rule 68A-27.005, F.A.C (FWC 2017). The change in listing status was informed by recent research (Greene et al. 2015) that filled data gaps on density estimates and habitat occupancy, compared survey methods for detecting fox squirrels, evaluated responses of fox squirrels to land use change and land management practices, and examined genetic diversity and structuring in fox squirrel populations statewide.

CONSERVATION GOAL AND OBJECTIVES

Goal

The conservation status of the Southern fox squirrel is maintained or improved so that the species will not again need to be listed on the Florida Endangered and Threatened Species List.

Objectives

I. Ensure the statewide population of the Southern fox squirrel is stable or increasing.

Rationale

Estimates of the Southern fox squirrel's population size in Florida have been based on occupancy data and extrapolations of published minimum densities of fox squirrels. These density estimates indicate the population has been stable on high quality habitat over the past 70 years, although some declines may occur due to habitat loss and degradation (FWC 2017). To achieve the conservation goal for this species, it is important to avoid or minimize further isolation of local populations and maintain or increase the statewide population. Further, climate change may affect persistence through changes in forest structure and the distributions of trees and other plant species (Greller 1980, Crumpacker et al. 2001).

To effectively achieve this objective, it will be important to understand how dispersal, or other movements of individuals (i.e., their behaviors) are affected by both intrinsic factors and the qualities or condition of the landscape where they occur (Vasudev et al. 2015). Landscapes can vary in their relative connectivity and the extent to which they facilitate the movements of organisms (Belisle 2005). The physical arrangement of landscape elements and the condition or quality of those elements also affect relative permeability for movements by individuals (Vasudev et al. 2015). Fragmentation and declines in the quality of habitat can thus negatively affect dispersal or other movements.

II. Clarify the taxonomy of fox squirrel subspecies that occur in the Southeastern United States.

Rationale

Recent genetic analyses found no genetic structure among fox squirrel populations in north and central Florida, indicating that *S. n. shermani* is not genetically distinct from *S. n. bachmani* or *S. n. niger* in Florida (Greene et al. 2015; Austin et al., Journal of Mammalogy, *in review*). One weak point to those recent genetic analyses is that they included few samples from portions of the subspecies' ranges outside Florida. Further genetic research that includes additional samples from the coastal plain areas of Georgia and Alabama would help clarify the taxonomic relationships among the subspecies.

III. Maintain or improve habitat management efforts on public and private conservation lands to maximize the size and productivity rates for extant populations of the Southern fox squirrel.

Rationale

Southeastern fox squirrels do not appear to need large swaths of forest as previously suggested (Greene and McCleery 2017*b*). However, tracts of high-quality, well-managed habitat, particularly on conservation lands will be important for long-term conservation of the subspecies. Conservation of the Southern fox squirrel across smaller tracts will require

coordination among land managers to ensure the long-term security of populations. Habitat management will have to be an ongoing conservation emphasis to achieve the conservation goal for the Southern fox squirrel.

Conservation lands in less than optimal condition, but with high potential to support robust Southern fox squirrel populations, should be considered for restoration by land managers, and included in multi-species habitat restoration priorities. Long-term population viability and productivity is likely to be directly linked to habitat quality. Publicly owned conservation lands are uniquely suited to provide areas of high quality habitat that are essential to enhance the security of the species. Prioritizing areas for restoration that have a high potential to support fox squirrel populations will help achieve this objective. Further, managers should make every effort to engage owners of nearby or adjoining private lands in cooperative efforts to improve the quantity and connectivity of available habitat.

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, likely effectiveness, identified partners, and leads for implementation.

Habitat Conservation and Management

Throughout its range, the Southern fox squirrel inhabits natural, agricultural, and urbanized habitats. Important natural communities for the species are characterized by open, mature, upland mixed pine-hardwood communities, most often dominated by longleaf pine and turkey oaks (e.g., upland mixed woodland, upland pine, and sandhill [Florida cooperative land cover, v3.2, 2016]) (Figure 7). Other natural communities utilized by this squirrel include pine flatwoods and upland hardwood forests. Both pine savannas 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 hardwoods, especially mature oaks, for nesting sites and food production (Perkins et al. 2008). Management of upland longleaf pine savannas for other species (e.g., gopher tortoise [*Gopherus polyphemus*], red-cockaded woodpecker [*Picoides borealis*], and northern bobwhite [*Colinus virginianus*]) can be compatible with the needs of the Southern fox squirrel (Perkins et al. 2008) if sufficient mast-producing trees are retained in those communities. Managers should retain site-appropriate mature oaks when managing or restoring longleaf pine savannas (Perkins et al. 2008). Perkins et al. (2008) recommended "11.8% hardwood cover" within mature pine savanna habitats as optimum for fox squirrels and they found that hardwoods were distributed within an average of 5.81 patches per hectare of mature longleaf pine sandhill or savanna habitat.

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

To manage habitat appropriately for Southern fox squirrel, prescribed fire is essential to prevent encroachment of excessive hardwoods and to maintain the open understory structure preferred by these squirrels 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). Application of herbicides should not be considered equivalent to prescribed fire to reduce shrub encroachment because herbicide treatments have been demonstrated to reduce fox squirrel occurrence (Boone et al. 2017). Representative photos (Figures 7, 8, 9, 10, and 11) show good quality fox squirrel habitat characterized by open understory structure, diverse ground cover, and the presence of mature oaks.

Southern 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 structure 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 Southern fox squirrel populations for the foreseeable future. However, McCleery and Parker (2011) made the point that because urban environments have unique human-created characteristics, the species attempting to live there "must have the mechanisms and plasticity to adjust to this novel environment."

Greene and McCleery (2017*b*) found that the amount of suitable habitat available to fox squirrels did not affect occurrence at the landscape scale. They found that Southern fox squirrels occurred in a range of pine-dominated habitats including sandhills, pine flatwoods, and pine plantations as well as pastures and croplands, and scrub. Prince et al. (2016) reported that "fox squirrels selected southern yellow pine over other cover types." At the population scale fox squirrels select areas with higher densities of mature oak trees (Prince et al. 2016, Boone et al. 2017). Greene and McCleery (2017*b*) were clear though that too much tree cover had a negative effect on habitat use and that stand-level measures such as forest heterogeneity (which they interpreted as interspersion of patches of oaks and other hardwood tree species within the pine-dominated habitat) were better determinants of habitat use. Greene and McCleery (2017*b*) reported a positive association between oak density and interspersion on fox squirrel numbers, which supports the importance of oak trees and other hardwoods for Southern fox squirrels. Managers should work to maintain mature oaks and other hardwoods scattered throughout areas of upland pine habitat (Prince et al. 2016, Boone et al. 2017). Oak trees have been acknowledged as important sites for cover or refuge from predators, sources of food, and nests (Weigl et al. 1989; Kantola and Humphrey 1990, Kantola 1992, Perkins et al. 2008).

The following actions are identified based on known habitat needs of the Southern fox squirrel, and they address the threats of habitat loss and degradation.

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

Habitat Conservation

Action 1 Identify priority areas for conservation of Southern fox squirrel throughout its range, on public and, where possible, private lands to ensure that habitats with the greatest potential to benefit the species are protected, connected, and improved.

Action 2 Retain and restore as appropriate habitat features on private and public lands that promote habitat connectivity across the landscape.

Fragmentation and loss of habitat were identified in the BSR as threats to the Southern fox squirrel. To counteract this threat, high priority regions should be identified as Southern fox squirrel Species Focal Areas (SFAs) to recognize those places essential for effective species

conservation (Action 1). Identification of SFAs should be completed in cooperation with landowners and land managers. Initial suggestions for SFAs, based on data from Tye et al. (2016) are shown in Appendix 1.

Figure 8. Upland pine habitat with multiple oak species present. Photograph by Dan Greene, UF Fox Squirrel Research Team.

Within SFAs and other priority conservation areas, habitat management plans should account for resource requirements of the Southern fox squirrel in appropriate habitats and include strategies to maximize habitat quality for Southern fox squirrel. Further, management actions should be identified that minimize known threats (e.g., road mortality). The identification of priority regions 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 crucial focal areas for conservation. These regions can be updated as appropriate through an adaptive management process. This action addresses habitat loss and degradation at a landscape level by identifying areas most important to species conservation, and is critical to achieving Objective III. Considerations for designating SFAs for the Southern fox squirrel may include areas with proximity to other conservation land, importance for habitat connectivity, presence of existing populations, and presence of suitable habitat. The potential for road mortality rates should be considered when evaluating habitat connectivity.

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 Southern fox squirrel, there is a need to increase the relative connectivity among habitat patches at the local or population scale (e.g., between sub-populations on different sites within a SFA). Connectivity is based on the ability of squirrels to move among sites, thus increasing the effective amount of available habitat (Action 2). Movement of individuals also will be important at a landscape scale, between SFAs. Connectivity will also facilitate dispersal of fox squirrels into unoccupied potential habitat. The resulting increase in habitat availability will allow both urban and natural sites to support larger, more viable populations. On private land, the planting of native mast-producing trees along fencerows could be promoted to 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 Southern 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 9).

Habitat Management

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

Action 4 Continue to implement prescribed fire as a management tool at appropriate return intervals.

Figure 9. 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. Developing a monitoring program is addressed in Action 5, and the results of that work will need to be incorporated into the land manager recommendations for fox squirrel habitat management.

The Southern 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, Greene and McCleery 2017*b*). 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. While occurrence locations can provide useful information concerning habitat use, the presence of Southern fox squirrels does not necessarily indicate preferred or optimal habitat. Identifying habitat preferences requires assessing the density and productivity of squirrels using the available habitats.

Habitat quality is a primary factor determining Southern 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. In higher quality habitat, individuals may meet their foraging needs through fewer or shorter movements, reducing road mortality and exposure to predation.

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

Where possible, preserve and restore large areas (at least 25 km^2 [9.65 mi^2]) of fox squirrel habitat (Kantola 1992, Hafner et al. 1998).

Patch size may not be critical, but the quality of the habitat available is important. At the landscape level fox squirrels appear to favor habitat with increased heterogeneity and low tree cover (i.e., BA). At a local or patch scale, the amount of hardwoods present is important. A reduced understory with a diverse but open groundcover also are key (Greene and McCleery 2017*b*).

Maintaining landscape connectivity for fox squirrels – the movement of individuals across the landscape – will be important. Mature oak trees are important components of the habitat (Greene and McCleery 2017b) that are used 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).

Figure 10. Mesic flatwoods habitat on Big Bend Wildlife Management Area, Taylor County. Photograph by Scotland Talley, FWC.

Maintaining single large hardwood trees and small patches of oaks within pine uplands creates the highest-quality fox squirrel habitat. One study by Perkins et al. (2008) recommends 2.68 m^2 basal area (BA) of hardwood for every hectare, where that is distributed among 6 hardwood patches, with each patch having 1-3 mature trees totaling 0.448 m^2 BA/0.02 ha.

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 (Figure 12) is an effective and efficient tool for managing habitat. Recommended fire frequency for optimizing Southern 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. 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).

Population Management

No specific population management actions are currently proposed for the Southern 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.

Figure 11. 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.

There are concerns that squirrel poxvirus will negatively impact survivorship and productivity in Southern 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 11).

It has been shown that urban populations can have higher rates of reproduction and juvenile survival than populations in rural areas or natural habitats, although road mortality is typically higher for adults in urban areas (McCleery 2009). If monitoring indicates that road-based mortality offsets or exceeds benefits from higher reproduction and reductions in predation in urban areas, then it may be appropriate to propose population management actions in the future to address those challenges.

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, Weyerhaeuser Corp., personal communication). 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 Southern 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 Southern 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 for translocation as a population management tool for the Southern fox squirrel. Wooding (1997) translocated 3 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.

Monitoring and Research

In the 2017 BSR (FWC 2017) the BRG and FWC staff concurred that more data on habitat use and demographic factors are needed. Monitoring and Research actions focus on answering basic questions about demography and on developing more precise understanding of habitat characteristics affecting use by fox squirrels. The following are the most critical pieces of information needed to ensure the Southern fox squirrel population remains stable or increases going forward.

Action 5 Implement a robust monitoring program that will track status and trends in Southern fox squirrel populations on selected conservation lands within SFAs at 5-year intervals.

In the southeastern United States, fox squirrels occur in low densities. Monitoring techniques based on live trapping have had low success and low overall capture rates due to the shyness of fox squirrels in natural habitat, making them unreliable measures of detection. (Weigl et al. 1989). That combination of factors generates uncertainty about the status of the monitored populations. Further, live capture methods for fox squirrels are extremely time consuming. However, other research needs may require live-trapping of individuals such as increasing the precision in estimating density and demographic data and collecting samples for physiological studies. Live trapping also will be required for telemetry studies (Action 13). Telemetry will make it possible to more accurately assess habitat use, movements, and dispersal.

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 developed for 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). Variations in color patterns and physical anomalies among individual fox squirrels in Florida (Kiltie 1992, Tye et al. 2015) make those reliable characters for identifying individual fox squirrels in camera-trap photographs (Tye et al. 2015).

Camera trapping is clearly better than live trapping for fox squirrels in the southeast to achieve many objectives, including detecting individuals Greene et al. 2015, Tye et al. 2015, Greene and McCleery 2017*a*). Camera traps are recommended for monitoring whenever handling of live

animals is not needed to accomplish other study objectives (Greene and McCleery 2017*a*). Camera traps detect higher numbers of individuals and generate a greater overall number of observations, which leads to more precise density estimates (Greene and McCleery 2017*a*). Camera-trap-based monitoring provides the most effective way to determine habitat occupancy rates and long-term population trends for fox squirrels (Greene and McCleery 2017*a*, b).

Fox squirrel densities vary by season, so monitoring protocols will need to account for variation in numbers over time when estimating densities (Greene and McCleery 2017*a*). Additionally, robust statistical methods for calculating the area surveyed during a study should be applied and a correction factor should be incorporated as appropriate to limit bias in density and abundance estimates (Greene and McCleery 2017*a*).

Monitoring (Action 5) should be conducted at multiple locations in a variety of habitats to account for variation in habitat occupancy of Southern fox squirrels. Future land use plans also should be considered when establishing survey sites to account for expected changes in habitat availability and connectivity. Ideally, monitoring would be conducted at least every 10 years on selected sites within the identified SFAs. A subset of those sites should include lands that are degraded or fragmented, or managed for purposes other than conservation. 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). Long-term monitoring data, combined with updated landcover data (e.g., Florida cooperative land cover, v3.2, 2016), can provide guidance on several habitat management actions (Actions 1 through 3).

Action 6 Implement research to estimate demographic parameters (e.g., fecundity, population growth, recruitment, mortality, immigration and emigration rates, etc.) for populations on selected conservation lands and where possible on private lands to generate robust population models and population viability analyses (PVA).

A PVA is used to estimate the likelihood of a population's extinction, compare proposed management options, and assess species recovery efforts. 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. A PVA for the Sherman's fox squirrel was conducted using demographic information from fox squirrel species throughout the southeast (Root and Barnes 2006, Endries et al. 2009). When reviewing the PVA, the 2011 BRG expressed concerns about the adequacy of the data currently available. In particular, there were concerns over the results, due to the lack of Florida-specific demographic data to build the PVA model. However, the 2011 BRG concluded that since the model was most sensitive to survival and fecundity, updated Florida-specific data was unlikely to change the final outcome of the PVA (a 0 probability of extinction in the next 100 years).

Conservation efforts can be directed toward understanding factors that would increase dispersal, or other movements, and landscape connectivity. Dispersal behavior would be expected to vary with landscape configuration. Dispersal could be measured with either telemetry or possibly

landscape genomics. While the number of individuals within subpopulations may fluctuate, the overall statewide population should be expected to remain stable or increase. The new survey tools should be applied to detect potential threats to the viability of local populations.

Data on demographic parameters such as age-specific fecundity and survival rates, and dispersal rates and distances (Action 6) must be obtained from variety of habitat types and configurations. Research on the relationship between habitat and landscape connectivity will be key to better understand factors that optimize population growth and stability for the Southern fox squirrel. Studies on dispersal and movements will necessitate use of radio telemetry. Ideally, telemetry studies would be conducted in a subset of study areas that are used for long-term monitoring (Action 5). Data from camera-based monitoring (Action 5) could be used to locate optimal capture sites for radio-collaring.

Rule and Permitting Intent

This section identifies the current regulations addressing conservation of the Southern fox squirrel and discusses some of the potential issues with protections and the development of appropriate permitting guidelines.

Current Protections

Upon removal from listing under Rule 68A 27.005(2)(d), F.A.C., the Southern fox squirrel will retain protections specified in the general prohibitions, Rule 68A-4.001, F.A.C. The Rule 68A-4.001, F.A.C. states that "no wildlife or freshwater fish or their nests, eggs, young, homes or dens shall be taken, transported, stored, served, bought, sold, or possessed in any manner or quantity at any time except as specifically permitted by these rules nor shall anyone take, poison, store, buy, sell, possess or wantonly or willfully waste the same except as specifically permitted by these rules." Permits are issued through Rule 68A-9.002, F.A.C. for "scientific, educational, exhibition, propagation, management or other justifiable purposes," although no permitting standard is provided.

Protections and Permitting Considerations

The BSR (FWC 2017) found that the Sherman's fox squirrel does not meet any criteria for listing and staff recommended removal from the Florida Endangered and Threatened Species List. However, the fox squirrel still faces threats from habitat loss, habitat degradation, and fragmentation. Because Southern fox squirrels can occur at low densities, in some parts of the species' range the viability of some populations may be vulnerable to losses of individuals. To meet the plan goal and prevent relisting of the Southern fox squirrel, some protections are still needed. The potential take of the Southern fox squirrel as game was an area of concern for the BRG (FWC 2017). The Southern fox squirrel is not included in the list of game mammals specified in Rule 68A-1.004. The FWC Hunting and Game Management staff have confirmed that fox squirrels cannot be taken by hunting, and they have received no rule change requests to alter this. Currently "squirrels" may be maintained as personal pets without a permit (Rule 68A-6.0022(2)(i), F.A.C.). To help ensure the Southern fox squirrel is not exploited for commercial purposes and breeding is not allowed, staff recommend that possession of fox squirrels for personal use should be not be allowed.

Action 7 Implement appropriate levels of protection needed to achieve conservation goals for the Southern fox squirrel and revise rules as needed to achieve those protections.

As stated above, some protections are still needed to maintain or improve the status of the statewide fox squirrel population. Protections should be implemented to protect fox squirrels from known threats that may impact population trends.

Law Enforcement

Action 8 Use materials from education and outreach to train law enforcement to identify fox squirrels, their nests, evidence of presence, so they can identify potential take situations.

To enforce existing rules and any new rules or protections developed under Action 7, law enforcement personnel will need training in identification of fox squirrels 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 8).

Incentives and Influencing

While conservation lands in public ownership are critical to fox squirrel conservation, over half of Florida is privately owned. Efforts to conserve Southern fox squirrels will depends in part on encouraging private landowners to implement management actions that maintain or improve fox squirrel habitat on their lands. Private lands can directly expand the potential habitat that is available and will be important for maintaining connectivity within and among populations (Action 2). When developing efforts to talk with private landowners, focus initially on areas within the identified SFAs (Appendix 1) where Tye et al. (2016) recorded higher numbers of fox squirrel observations.

County growth management plans and land development regulations provide an avenue by which FWC can inform and influence land use change that is relevant to the conservation of the Southern fox squirrel and its associated community types. Road mortality rates and locations should be analyzed to determine if patterns exist that identify issues that should be addressed. This will assist in placement of corridors to help minimize road mortality.

Action 9 Develop new incentive programs (or enhance existing ones) to encourage creation of habitat corridors and implementation of habitat management practices that are consistent with habitat management guidelines for Southern 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 Conservation Reserve Program, Florida Forest Stewardship 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. Landowners could be asked to consider practices and management actions expected to improve the quality of habitats in ways that can benefit the Southern fox squirrel where appropriate. Updates to the FWCG could incorporate this approach.

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., Wildland Restoration

International, Florida Forest Service, 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.

Where fox squirrels are expected to be present on or near agricultural land, agricultural entities could be contacted about their interest in participating in incentive programs, particularly the Environmental Quality Incentives Program, to benefit the fox squirrels. This approach could provide additional or more effective corridors for fox squirrels. Hedgerows and fence lines could be supplemented with hardwood, mast-producing trees and pine trees that would provide both cover and food. In urbanized areas, providing guidance for managers of golf courses and parks on steps to take to improve habitat quality for fox squirrels could help to maintain viable populations in those areas.

Education and Outreach

Action 10 Develop and disseminate habitat management guidelines and monitoring protocols to private landowners and public land managers.

Action 11 Implement outreach to partners, stakeholders, and the public to ensure there is awareness of rule changes while promoting ongoing conservation activities for the Southern 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 numbers of Southern fox squirrels indicate high-quality habitat conditions well suited for many species of Florida's wildlife, including game species and rare or imperiled species.
- Making the public aware of the life history of the Southern fox squirrel, especially the fact that they are relatively long lived and slow to reproduce, making them especially vulnerable to habitat loss and degradation.
- Fragmentation of Southern fox squirrel habitat increases the threat of road kill.
- While feeding of Southern 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 Southern 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 Southern 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 will enhance the quality of life for some Floridians.

Coordination with Other Entities

No specific actions have been identified. However, Action 5 and Action 6 in Monitoring and Research will require coordination between FWC and researchers.

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 Southern 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 Southern 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 Southern fox squirrel and other imperiled species such as the Florida pine snake, and the Southeastern American kestrel.

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 occur on the property. The plan then needs to contain management strategies to protect those resources. For lands that support, or have the potential to support Southern fox squirrels, the FWC staff should be prepared to provide the lead management agency with guidance, information, and recommendations appropriate to maintain or improve Southern fox squirrel populations there.

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. Southern 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	Status	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgency: Is the action immediately critical to the species' survival?
I, III	2	1	Identify priority areas for conservation of Southern fox squirrel throughout its range, on public and, where possible, private lands to ensure that habitats with the greatest potential to benefit the species are protected, connected, and improved	Habitat Conservation & Mgmt	NEW	FWRI, WHM, HSC	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Identifying priority areas help ensure habitat management and restoration are focused.	Moderate - depends on interest and coordination among staff and partners	No - no evidence of dire threats to Sherman's fox squirrel populations.
I, III	2	2	Retain and restore as appropriate habitat features on private and public lands that promote habitat connectivity across the landscape.	Habitat Conservation & Mgmt	NEW	WHM	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Providing necessary connectivity of key habitats throughout the range of the fox squirrel will further enhance conservation of the species.	Moderate - depends on interest and coordination among staff and partners	No - no evidence of dire threats to Sherman's fox squirrel populations.
I, III	3	3	Develop habitat management guidelines for public land managers and private landowners.	Habitat Conservation & Mgmt	ONGOING	HSC, SCP	NA	Highly Effective at achieving desired outcome. Management guidelines and monitoring recommendations implemented on public and private lands will help to effectively conserve fox squirrel habitat.	Feasible and already under way.	No - no evidence of dire threats to Sherman's fox squirrel populations.
I, III	1	4	Continue to implement prescribed fire as a management tool at appropriate return intervals.	Habitat Conservation & Mgmt	ONGOING	WHM	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Implementing appropriate habitat management actions will help improve and conserve fox squirrel habitat.	Feasible and already under way.	No - no evidence of dire threats to Sherman's fox squirrel populations.
I, III	2	5	Implement a robust monitoring program that will track status and trends in Sherman’s fox squirrel populations on selected conservation lands within SFAs at 5-year intervals.	Monitoring & Research	NEW	FWRI, WHM, HSC	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Monitoring will provide important information to assess the distribution and status of fox squirrels across their range.	High - depends on funding and coordination among partners	No - no evidence of dire threats to Sherman's fox squirrel populations.
I, II, III	2	6	Implement research to estimate demographic parameters (e.g., fecundity, population growth, recruitment, mortality, immigration and emigration rates, etc.) for populations on selected conservation lands and where possible on private lands to generate robust population models and population viability analyses (PVA).	Monitoring & Research	ONGOING	FWRI, WHM, HSC	Universities, DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Understanding population dynamics will to monitor the population status. Demographic information can increase the success of management and conservation of this species.	High - depends on funding and coordination among partners	No - no evidence of dire threats to Sherman's fox squirrel populations.
I	2	7	Implement appropriate levels of protection needed to achieve conservation goals for the Sherman’s fox squirrel and revise rules as needed to achieve those protections.	Protections & Permitting	ONGOING	HSC, SCP	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Permitting protections will help prevent intention take or exploitation of fox squirrels. Information gained from scientific collection permits can increase knowledge.	High - current efforts underway, depends on Commission approval	No - no evidence of dire threats to Sherman's fox squirrel populations.
I	3	8	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	ONGOING	HSC, LE	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Increase in awareness and understanding of the species promotes the effectiveness of legal protections.	High - coordination between HSC and LE already underway	No - no evidence of dire threats to Sherman's fox squirrel populations.

Table 1. Southern Fox Squirrel *(Sciurus niger shermani)* Conservation Action Table

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Status	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgency: Is the action immediately critical to the species' survival?
I	3	9	Develop new incentive programs (or enhance existing ones) to encourage creation of habitat corridors and implementation of habitat management practices that are consistent with habitat management guidelines for Sherman's fox squirrel.	Incentives & Influencing	NEW	HSC, SCP	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. - Incentives to manage habitat for fox squirrels increases the amount of habitat restored or conserved.	High - depends on interest and coordination among partners	No - no evidence of dire threats to Sherman's fox squirrel populations.
I, III	2	10	Develop and disseminate habitat management guidelines and monitoring protocols to private landowners and public land managers.	Education & Outreach	ONGOING	WHM, HSC	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Well informed citizens are more likely to support conservation efforts such as habitat conservation and management	High - depends on interest and coordination among partners	No - no evidence of dire threats to Sherman's fox squirrel populations.
I	2	11	Implement outreach to partners, stakeholders, and the public to ensure there is awareness of rule changes while promoting ongoing conservation activities for the Sherman's fox squirrel.	Education & Outreach	NEW	HSC, SCP	DEP, FFS, USFS, USFWS, WMD, County Environmental Land Programs	Highly Effective at achieving desired outcome. Well informed citizens are more likely to support conservation efforts such as habitat conservation and management	High - depends on interest and coordination among FWC staff	No - no evidence of dire threats to Sherman's fox squirrel populations.
2	1	Complete	Develop a GIS-based habitat model to identify areas to survey for SFS presence and absence.	Monitoring & Research	COMPLETE	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	Complete	Develop an occupancy-based survey protocol to determine presence and absence of SFS in potential habitat.	Monitoring & Research	COMPLETE	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	Complete	Develop protocol for collecting and handling tissue samples for genetic analysis.	Monitoring & Research	COMPLETE	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	Complete	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	COMPLETE	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	Complete	Trap to collect tissue samples by using sites identified from reported locations and based on gaps in data from road-killed specimens.	Monitoring & Research	COMPLETE	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	Complete	Conduct genetic analyses to precisely determine the current extent of occurrence and area of occupancy for SFS.	Monitoring & Research	COMPLETE	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.
3	2	Complete	Develop a scientifically sound monitoring protocol for SFS.	Monitoring & Research	COMPLETE	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	Complete	Develop a protocol to estimate density and abundance of SFS in different habitat types.	Monitoring & Research	COMPLETE	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.
2	1	Complete	Determine habitat associations and identify preferred habitat types.	Monitoring & Research	COMPLETE	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.

Table 1. Southern Fox Squirrel *(Sciurus niger shermani)* Conservation Action Table

Objective(s) Addressed	Team Assigned Priority Level	Action Item Number	Action Items	Conservation Action Category	Status	Lead for Implementation: FWC Program(s) and/or Section(s)	External partners	Likely Effectiveness	Feasibility	Urgency: Is the action immediately critical to the species' survival?
3	2	Complete	Develop GIS-based potential habitat maps stratified by habitat quality.	Monitoring & Research	COMPLETE	HSC	UF	Effective at achieving desired outcome.	Feasible and already under way.	Yes, this data is critical to understanding occurrence.
3	4	Complete	Develop comprehensive outreach program (including brochures, kiosks, Project Wild, Land Use Planning, etc.) that target a variety of audiences.	Education & Outreach	COMPLETE	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.

Acronyms used in this table:

CPS:	FWC's Office of Conservation Planning Services
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:	FWC's Office of Policy and Accountability
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:	FWC's Wildlife and Habitat Management Section
WMD:	Water Management District(s)

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APPENDICES

Appendix 1. Initial recommendations for Species Focal Areas (SFAs) for Southern fox squirrel.

The areas listed below are conservation lands recommended for inclusion as elements of SFAs for Southern fox squirrel. These SFAs are designated as a means of identifying key regions that are considered important for effective conservation. These recommended SFAs and indicated priorities are based on current understanding of Big Cypress fox squirrel local abundance and area of occupancy (AOO), information in the Florida Natural Areas Inventory conservation lands inventory database (http://www.fnai.org/conservationlands.cfm), data from Tye et al. (2016). The SFAs should be re-evaluated periodically as new information becomes available on Southern fox squirrel numbers, status of extant local populations, and the AOO. The map (Figure A) shows the approximate location of each SFA as a reference only (the map should not be interpreted as having any meaning other than approximate locations of sites identified in this list).

First Priority

Brooksville Ridge Area

- Withlacoochee State Forest
- Goethe State Forest
- San Felasco Hammock Preserve State Park
- Chassahowitzka Wildlife Management Area

Blackwater-Eglin Area

- Blackwater River State Forest
- Eglin Air Force Base

Second Priority

Econfina Creek Area

- Econfina Creek Conservation Area
- Econfina Creek Wildlife Management Area

Suwannee Ridge Area

- Suwannee Ridge Wildlife and Environmental Area
- Twin Rivers State Forest
- Suwannee River State Park
- Woods Ferry Conservation Area
- Troy Spring Conservation Area
- Little River Conservation Area

Third Priority

Wakulla-Monticello Area

- Apalachicola National Forest
- Wakulla State Forest

- Wakulla Springs State Forest
- Tall Timbers Research Station

Trail Ridge Area

- Camp Blanding Joint Training Center
- Jennings State Forest
- Goldhead Branch State Park

Figure A. The red-outlined areas designate the approximate locations of recommended Southern fox squirrel Species Focal Areas (SFAs). Locations are shown only as a reference for sites identified in the list above. The SFAs are: 1) Brooksville Ridge Area, 2) Blackwater-Eglin Area, 3) Econfina Creek Area, 4) Suwannee Ridge Area, 5) Wakulla-Monticello Area, and 6) Trail Ridge Area. See the list above for details on the priority conservation lands encompassed by each SFA.

Appendix 1 - Literature Cited

Tye, C.A., R.A. McCleery, R.J. Fletcher Jr, D.U. Greene, and R.S. Butryn, R.S., 2016. Evaluating citizen vs. professional data for modelling distributions of a rare squirrel. Journal of Applied Ecology 54:628-637.

Appendix 2. Additional information on squirrel poxvirus, a potential threat to the viability of Southern 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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