

Sherman's Fox Squirrel Biological Status Review Report

October 27, 2017



**FLORIDA FISH AND WILDLIFE CONSERVATION COMMISSION
620 South Meridian Street
Tallahassee, Florida 32399-1600**

Biological Status Review Report
for the
Sherman's fox squirrel
(Sciurus niger shermani)
October 27, 2017

EXECUTIVE SUMMARY

The Florida Fish and Wildlife Conservation Commission (FWC) directed staff to evaluate all species listed as Threatened or Species of Special Concern as of November 8, 2010 that had not undergone a status review in the past decade. The [2011 evaluation](#) 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. A [Species Action Plan](#) for the Sherman's fox squirrel was developed in 2013 and the species was included in the [Imperiled Species Management Plan](#), finalized in 2016. The ISMP identifies the need to re-assess all remaining Species of Special Concern by 2017. In 2017, FWC initiated the request to re-evaluate the Sherman's fox squirrel.

Public information on the status of the Sherman's fox squirrel was sought from May 10 to June 26, 2017. No information was received from the public during our information request period. The members of the Sherman's fox squirrel Biological Review Group (BRG) met on August 14, 2017. Group members were Elina Garrison (FWC lead), Robert McCleery (University of Florida), Mike Conner (Joseph W. Jones Ecological Research Center), Holly Ober (University of Florida) and Andrew Edelman (University of West Georgia) (Appendix 1). In accordance with rule 68A-27.0012, Florida Administrative Code (F.A.C.), the BRG was charged with evaluating the biological status of the Sherman's fox squirrel using criteria included in definitions in 68A-27.001, F.A.C., and following the protocols in the *Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 4.0)* and *Guidelines for Using the IUCN Red List Categories and Criteria (Version 13)*. Please visit <http://myfwc.com/wildlifehabitats/imperiled/listing-process/> to view the listing process rule and the criteria found in the definitions.

The Sherman's fox squirrel BRG evaluated the species based on historical and recently collected population demographic information. The new data addressed previous concerns raised about deficiency of population data about the species. The Sherman's fox squirrel BRG concluded from the biological assessment that the Sherman's fox squirrel did not meet any listing criteria. FWC staff recommends that the Sherman's fox squirrel be removed as a Species of Special Concern from Rule 68A-27.005, F.A.C.

FWC staff gratefully acknowledges the assistance of the biological review group members and peer reviewers. Staff would also like to thank Brooke Talley and Brad O'Hanlon for providing guidance with IUCN criteria and assistance in documenting the meeting.

BIOLOGICAL INFORMATION

Taxonomic Classification – Sherman's fox squirrel (*Sciurus niger shermani*) is considered one of four subspecies of fox squirrels occurring in Florida. Sherman's fox squirrel has been defined to the subspecies *Sciurus n. s.* on the basis of size (it is only slightly larger than southern fox squirrel, *S. n. niger*, but considerably larger than Big Cypress fox squirrel, *S. n. avicennia*; Moore 1956; Turner and Laerm 1993). However, recent genetic data indicate that the Big Cypress fox squirrel is distinct from other subspecies, but Sherman's fox squirrel does not appear to be genetically distinct from Bachman's (*S. n. bachmani*) or southern fox squirrels (Greene et al. 2015).

Life History – Sherman's fox squirrel is a large (600-700mm) tree squirrel with highly variable dorsal fur color ranging from silver to all black (uncommon), with variations of silver over black and black over silver (Florida Natural Areas Inventory 2001, Tye et al. 2015).

Ideal habitat for Sherman's fox squirrels is mature, open, fire-maintained longleaf pine (*Pinus palustris*) - turkey oak (*Quercus laevis*) sandhills and flatwoods (Florida Natural Areas Inventory 2001; Kantola 1992; Kantola and Humphrey 1990; Moore 1957). However, Sherman's fox squirrels occur in multiple land cover classes that are structurally similar to the historic pine savannahs (Greene and McCleery 2017a; 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 2017a). 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 2017a).

Sherman's fox squirrel typically has two breeding seasons each year. The winter breeding season is from October to February and the summer breeding season is 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; see Koprowski 1994 for a summary of breeding behavior in *Sciurus niger*). Females average one litter per year with a mean of 2.3 offspring per litter (Moore 1957; Wooding 1997), compared with 2.5-3.2 young for the midwestern fox squirrel (Kantola 1992). Young are weaned at 90 days and sexual maturity is reached at about 9 months. 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 less than 10 years (Wooding 1997).

Pine seeds and turkey oak acorns appear to be some of the main food items utilized by Sherman's fox squirrels. Squirrels have been observed to move their home ranges into live oak forests if a mast failure of turkey oak occurs (Kantola and Humphrey 1990). The highest quality habitat for 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).

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 Katharine Ordway Research Preserve, nests of Sherman's fox squirrels were found in six tree species: slash pine, post oak, laurel oak, live oak, turkey oak, and longleaf pine (Kantola and Humphrey 1990).

Southeastern fox squirrels generally occur in lower densities than fox squirrels in the Midwestern states (Moore 1957, Weigl et al. 1989, Loeb and Moncrief 1993). Previous reports of Sherman's fox squirrel density estimates in Florida ranged from 7-38 squirrels/km² (Wooding 1997; Humphrey et al. 1985; Kantola 1986; Moore 1957) and densities were believed to be declining over time. However, recent review of fox squirrels densities in the southeast found that past density estimates were incorrectly inflated due to study designs and statistical approaches (Greene and McCleery 2017b). Corrected density estimates range from 2.5-3.7 squirrels/km² and there was little evidence of temporal or geographical variation in the estimates spanning nearly 70 years of research (Greene and McCleery 2017b).

Average home range size for Sherman's fox squirrels is 16.7 ha for females and 42.8 ha for males (Kantola and Humphrey 1990). In contrast, midwestern fox squirrel home ranges average 0.8-7.0 ha (Kantola 1992). 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 Sherman's fox squirrels may result from a food supply that varies in time and space (Kantola and Humphrey 1990).

Geographic Range and Distribution – Four surveys have assessed the distribution of fox squirrels in Florida (Brady 1977; Williams and Humphrey 1979; Wooding 1997, Tye et al. 2016). The most recent state-wide, web-based survey conducted in 2011 and 2012 found fox squirrels are distributed widely across the state, with observations documented in 66 of Florida's 67 counties (Tye et al. 2016).

Based on morphological characteristics, the Sherman's fox squirrel range has been defined as including most of peninsular Florida, extending northward into central and 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, Palm Beach County (Moore 1956; Wooding 1997). However, a recent genetic analysis found no genetic structure with North and Central Florida fox squirrel populations, indicating that Sherman's fox squirrels are not genetically distinct from Bachman's (*S. n. bachmani*) or southern (*S. n. niger*) fox squirrels in Florida (Greene et al. 2015). These results suggest that the range of Sherman's fox squirrel extends farther than previously thought to include the entire Florida panhandle (Greene et al. 2015). For example, the Apalachicola River has been considered a possible biogeographic break between Sherman's fox squirrel and the southern fox squirrel, but the authors found no structure indicating distinct lineages in the panhandle (Greene et al. 2015). The lack of genetic structure among the recognized subspecies in northern Florida does not indicate they lack genetic structure compared to other southeastern fox squirrel populations (Greene et al. 2015). In addition, they may still deserve recognition as separate management units, based on morphological variations.

Population Status and Trend – Due to the 97% loss of historical longleaf pine

ecosystems in the southeast, fox squirrels are thought to have declined significantly from pre-settlement levels (Kantola 1992). The continued loss and fragmentation of upland pine forests, their primary habitat type, and changes in density estimates across time, have been referred to as evidence of further decline (Weigl et al. 1989; Kantola 1992; Loeb and Moncrief 1993; Wooding 1997). However, a recent re-evaluation of historical density estimates of fox squirrels throughout their range in southeastern United States indicated that there is little evidence of distinct spatial or temporal variations in the density estimates spanning nearly 70 years of research, but it also showed that fox squirrels appear to occur at lower densities than previously thought (Greene and McCleery 2017b). Furthermore, recent landscape-level research and state-wide surveys documented fox squirrels in multiple land cover classes in Florida (Tye et al. 2016, Greene and McCleery 2017a). These studies indicate fox squirrels can adapt to landscape changes and may be more resilient to the loss of pine savannahs than originally believed (Greene and McCleery 2017a). However, Greene and McCleery (2017a) caution that nearly all research on fox squirrels in the southeast has been conducted within high quality habitat where fox squirrel populations are often robust and less affected by land use change. Within areas where habitat has been fragmented and degraded, due to lack of fire for example, fox squirrel densities have likely declined (Greene and McCleery 2017a). Sustaining fox squirrel populations outside of the primary habitats, both natural habitats and habitats managed for human use, in the future will require careful planning and management to mimic the open understory of pineland savannahs.

Quantitative Analyses – A population viability analysis was carried out on Sherman’s fox squirrel in 2009 using demographic information from the species as a whole (Root and Barnes 2006; Endries *et al.* 2009). The baseline model estimated a finite growth rate of 1.0034. Initial abundance was estimated at 0.025 while carrying capacity was estimated at 0.18. Results revealed that the risk of extinction in the next 100 years was zero for both managed habitat and all potential habitat. The risk of large declines was also very small (for example, the probability of a 50% decline was ~18%). Although data used were mainly derived from research conducted in the southeast, the density estimates used in the PVA were not corrected and therefore the assumed population density and carrying capacity were likely overestimated, and the validity of the model results are questionable. Given that the PVA model was most sensitive to survival and fecundity, it is unlikely that even with updated data the final outcome of the PVA would change. Changes to the finite growth rate altered the probability of a large decline in the population as a whole, but did not change the probability that the species would not go extinct over the next 100 years.

BIOLOGICAL STATUS ASSESSMENT

Threats – Although Sherman’s fox squirrels can be more resilient to habitat modifications than previously thought, habitat loss, fragmentation and degradation, resulting from conversion for development and other uses, continue to threaten Sherman’s fox squirrel populations (Kantola and Humphrey 1990; Zwick and Carr 2006; FWC 2012). GIS-based habitat affinity and predictive models (Barrett 2017) combined with projected future development data from Zwick and Carr (2006) estimated a 5-12% potential loss of fox squirrel habitat due to urban growth by 2020 and a 12-23% cumulative loss by 2040. That rate of potential habitat loss is a threat, however, it does not meet the criteria for Threatened status. Fox squirrels use a variety of habitat types, but they appear most prolific in open pine savannahs (Moore 1957; Loeb and Lennartz 1989; Tye et al. 2016, Greene and McCleery 2017b). If these and other habitats used by fox squirrels are further degraded due to changes in management, fox squirrel populations could decline. In forested habitats a lack or

inappropriate timing of prescribed fire could eventually lead to fox squirrels being replaced there by eastern gray squirrels (*Sciurus carolinensis*), a potential competitor that prefers closed-canopy hardwood forests (Conner et al. 1999). Beyond natural habitats, fox squirrels utilize Grassland/Improved Pasture habitat (FWC 2012) and similar lands managed for human use where mature nest site trees and food sources are retained at sufficient rates in the landscape to make them suitable for use by fox squirrels. Sustaining fox squirrel populations in the future in habitats managed for human use will require careful planning and management to avoid the loss of essential resources that enable fox squirrel populations to exist in those habitats.

Due to their slow, lumbering gait, Sherman's fox squirrels are vulnerable to road mortality. As Florida's human population increases, mortality due to vehicle collisions is likely to increase, particularly in highly fragmented, high density urban and residential areas.

Hunting of Sherman's fox squirrels has the potential to be detrimental to local populations, particularly small, isolated populations that have low potential for recolonization (Kantola 1992). Additionally, hunting may be a threat because the species has low population densities and low reproductive rates (Wooding 1997). Legal harvest of fox squirrels in Florida ended on wildlife management areas in 1991 and statewide in 1995. Fox squirrels are not included as game mammals in 68A-1.004, F.A.C. and therefore no legal hunting of fox squirrels is allowed within the state, independent of listing status. Although hunting is not a current threat to fox squirrels, it is recommended that this protection remain in place to prevent population declines.

Sciurus niger shermani is currently listed as Lower Risk, near threatened by the IUCN Rodent Specialist Group 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).

Population Assessment – Findings from the BRG are included in a Biological Status Review information findings table. The BRG found the Sherman's fox squirrel did not meet any of the listing criteria. Please see Additional Notes following the table for notes and clarifications.

LISTING RECOMMENDATION

The Sherman's fox squirrel BRG concluded from the biological assessment that the Sherman's fox squirrel did not meet any listing criteria. Staff recommend not listing the Sherman's fox squirrel as State-designated Threatened and removing it from the Species of Special Concern list.

SUMMARY OF THE INDEPENDENT REVIEW

Independent scientific review of the biological assessment was sought and received from 5 scientists. All 5 agreed that the Sherman's fox squirrel did not meet the criteria for listing as a Threatened species. One reviewer recommended maintaining the species as a Species of Special Concern. However, when changes to Rule 68A-27, F.A.C. were adopted in 2010 to revise the state's listing process, the SSC category was only temporarily retained for the 5 SSC that were deemed data deficient during the 2010 review, with direction from the Commission that when there was sufficient data, a decision on whether or not listing as Threatened was warranted would be

made. After re-evaluation of these 5 species (including the Homosassa shrew), the SSC category would be abolished. Reviewers pointed out that additional data is needed to help inform conservation of the species. Staff concur that more data on habitat use and other demographic factors is needed and this will be addressed in the revised Species Action Plan (SAP) for the Sherman's fox squirrel, however staff believe that the data available are sufficient to make a determination on listing status. Staff noted that in the version sent out for peer review, the Additional Notes compiled by the Biological Review Group was not included; the notes include assumptions that the BRG made in drawing their conclusion, and may have assisted some of the reviewers. The notes have been added to this version. Two reviewers pointed out a need for continued monitoring, and staff will address the need to monitor at levels necessary to meet management needs in the revision of the Species Action Plan. One reviewer pointed out the need to complete and publish genetic data that would further strengthen the BRG's final recommendation. Another reviewer made editorial suggestions and pointed out inconsistencies in referenced literature, and these suggestions have been addressed in this version. The BRG noted, and several peer reviewers commented on, the importance of maintaining the Sherman's fox squirrel as a non-hunted nongame species and staff will also address this issue in the Species Action Plan and any future proposed rule changes.

The complete scientific reviews are provided in Appendix 3. Staff of the FWC gratefully acknowledge the assistance of the members of the Biological Review Group and of the Independent Reviewers.

LITERATURE CITED

- Barrett, Mark. 2017. GIS analysis prepared for the Sherman's fox squirrel Biological Status Review. Unpublished report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.
- Brady, J. R. 1977. Status of the fox squirrel in Florida. P-R Final Report, Project W-41-24, Job XV-A-1. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.
- Conner, L. M., J. L. Landers, and W. K. Michener. 1999. Fox squirrel and gray squirrel associations within minimally disturbed longleaf pine forests. *Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies* 53:364–374.
- Endries, M., B. Stys, G. Mohr, G. Kratimenos, S. Langley, K. Root, and R. Kautz. 2009. Wildlife Habitat Conservation Needs in Florida. Fish and Wildlife Research Institute Technical Report TR-15, Tallahassee, Florida, USA.
- Florida Fish and Wildlife Conservation Commission (FWC). 2012. Florida's Wildlife Legacy Initiative: Florida's State Wildlife Action Plan. Tallahassee, Florida, USA.
- Florida Fish and Wildlife Conservation Commission (FWC). 2011. Sherman's Fox Squirrel Biological Status Review Report, March 31, 2011. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

- Florida Fish and Wildlife Conservation Commission (FWC). 2016. Florida's Imperiled Species Management Plan. Tallahassee, Florida, USA. 166 pp.
- Greene, D.U., Boone, W. and R.A. McCleery. 2015. Conservation of Florida's Fox Squirrels. Final Report to Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.
- Greene, D.U., and R.A. McCleery. 2017a. Multi-scale responses of fox squirrels to land-use changes in Florida: Utilization mimics historic pine savannas. *Forest Ecology and Management* 391:42-51.
- Greene, D.U., McCleery, R.A., 2017b. Reevaluating fox squirrel (*Sciurus niger*) population declines in the southeastern United States. *Journal of Mammalogy* 98:502-512.
- Hafner, D.J., E. Yensen, and G.L. Gordon, Jr. (compilers and editors). 1998. North American Rodents. Status Survey and Conservation Action Plan. IUCN/SSC Rodent Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.
- Hipes, D., D. R. Jackson, K. NeSmith, D. Printiss and K. Brandt. 2001. Field guide to the rare animals of Florida. Florida Natural Areas Inventory, Tallahassee, Florida, USA.
- Humphrey, S.R., J.F. Eisenberg, and R. Franz. 1985. Possibilities for restoring wildlife of a longleaf pine savanna in an abandoned citrus grove. *Wildlife Society Bulletin* 13:487- 496.
- Kantola, A.T. 1986. Fox squirrel home range and mast crops in Florida. Thesis, University of Florida, Gainesville, Florida, USA
- Kantola, A.T. 1992. Sherman's fox squirrel *Sciurus niger shermani*. Pages 234-241 in S.R. Humphrey (ed.), Rare and endangered biota of Florida. Vol. I. Mammals. University Press of Florida. Gainesville, Florida, USA.
- Kantola, A.T. and S.R. Humphrey. 1990. Habitat use by Sherman's fox squirrel (*Sciurus niger shermani*) in Florida. *Journal of Mammalogy* 71(3):411-419.
- Koprowski, J.L. 1994. *Sciurus niger*. *Mammalian Species* 479:1-9.
- Moore, J.C. 1956. Variation in the Fox Squirrel in Florida. *American Midland Naturalist* 55(1):41-65.
- Moore, J.C. 1957. The natural history of the fox squirrel *Sciurus niger shermani*. *Bulletin of the American Museum of Natural History*. 113:1-71.
- Prince, A., M. C. Chitwood, M. A. Lashley, C. S. DePerno, and C. E. Moorman. 2016. Resource selection by southeastern fox squirrels in a fire-maintained forest system. *Journal of*

Mammalogy 97:631–638.

- Root, K.V. and J. Barnes. 2006. Risk assessment for a focal set of rare and imperiled wildlife in Florida. Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA..
- Turner, D.A. and J. Laerm. 1993. Systematic relationships of populations of the fox squirrel (*Sciurus niger*) in the southeastern United States. Pages 21-36 in N.D. Moncrief, J.W. Edwards, and P.A. Tappe, eds. Proceedings of the second symposium on southeastern fox squirrels, *Sciurus niger*. Va. Museum of Natural History Special Publication. No. 1.
- Tye, C. A., D. U. Greene, W. M. Giuliano, and R. A. McCleery. 2015. Using camera-trap photographs to identify individual fox squirrels (*Sciurus niger*) in the Southeastern United States. Wildlife Society Bulletin 39:645–650.
- Tye, C. A., R. A. McCleery, R. J. Fletcher, D. U. Greene and R. S. Butryn. 2016. Evaluating citizen vs. professional data for modelling distributions of a rare squirrel. Journal of Applied Ecology. doi: 10.1111/1365-2664.12682.
- Williams, K. S. and S. R. Humphrey. 1979. Distribution and status of the endangered Big Cypress fox squirrel (*Sciurus niger avicennia*) in Florida. Florida Scientist 42:201-205.
- Wooding, J.B. 1997. Distribution and population ecology of the fox squirrel in Florida. Dissertation. University of Florida, Gainesville, Florida, USA.
- Zwick, P.D. and M.H. Carr. 2006. Florida 2060: A population distribution scenario for the State of Florida. A research project prepared for 1000 Friends of Florida. Geoplan Center at the University of Florida, Gainesville, Florida, USA.

Biological Status Review Information
Findings

Species: Sherman's Fox Squirrel (SFS)

Date: 08/14/17

Assessors: Elina Garrison (FWRI/Lead), L. Mike Connor (Jones Center)
Robert McCleery (UF), Holly Ober (UF), Andrew Edelman (U. West GA)

Generation length: 3 years (see additional notes)

Criterion/Listing Measure	Data/Information	Data Type*	Criterion Met?	References
*Data Types - observed (O), estimated (E), inferred (I), suspected (S), or projected (P). Criterion met - yes (Y) or no (N).				
(A) Population Size Reduction, ANY of				
(a)1. An observed, estimated, inferred or suspected population size reduction of at least 50% over the last 10 years or 3 generations, whichever is longer, where the causes of the reduction are clearly reversible and understood and ceased ¹	Population reduction due to hunting has ceased, harvest of SFS ended statewide in 1995. Some decline is expected due to habitat loss and degradation, however, based on density estimates over the past 70 years, populations have been stable in high quality habitat. In addition, based on recent statewide survey, there is no evidence that any drastic declines have occurred.	I	N	Kantola 1992, Greene and McCleery 2017b, Tye et al. 2016
(a)2. An observed, estimated, inferred or suspected population size reduction of at least 30% over the last 10 years or 3 generations, whichever is longer, where the reduction or its causes may not have ceased or may not be understood or may not be reversible ¹	FL2060 GIS layer estimates that 6-12% habitat will be lost due to urban growth between 2006-2020 (Zwick and Carr 2006). Some population reduction due to habitat loss, fragmentation and degradation is possible. However, SFS use various habitats and some modifications may be beneficial to them. Extent of decline in last 10 years is unknown, however, based on recent surveys and review of density estimates over last 70 years there is no evidence of 30% population decline.	I	N	Greene and McCleery 2017a, Greene and McCleery 2017b, Greene et al. 2015, Zwick and Carr 2006, Tye et al. 2016

(a)3. A population size reduction of at least 30% projected or suspected to be met within the next 10 years or 3 generations, whichever is longer (up to a maximum of 100 years) ¹	See above notes. In addition, SFS are more resilient than previously thought to habitat fragmentation, therefore there is no reason to suspect an impending decline of at least 30%.	I	N	Greene and McCleery 2017a, Greene and McCleery 2017b, Zwick and Carr 2006, Tye et al. 2016
(a)4. An observed, estimated, inferred, projected or suspected population size reduction of at least 30% over any 10 year or 3 generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or may not be understood or may not be reversible. ¹	See (a)2 and a(3), there is no reason to suspect a decline of 30% over a 10 year period that includes both past and the future.	I	N	Greene and McCleery 2017a, Greene and McCleery 2017b, Zwick and Carr 2006
¹ based on (and specifying) any of the following: (a) direct observation; (b) an index of abundance appropriate to the taxon; (c) a decline in area of occupancy, extent of occurrence and/or quality of habitat; (d) actual or potential levels of exploitation; (e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.				
(B) Geographic Range, EITHER				
(b)1. Extent of occurrence < 20,000 km ² (7,722 mi ²) OR	In a recent statewide survey, fox squirrels were observed in every county except Broward (Tye et al. 2016). Based on all available range estimates, extent of occurrence is greater than 20,000 km ² .	E	N	Wooding 1997, Moore 1956, Kantola 1992, Tye et al. 2016
(b)2. Area of occupancy < 2,000 km ² (772 mi ²)	Based on habitat suitability models estimated SFS AOO is between 10,039 - 15,900 km ² within the generally accepted SFS range (which includes most of peninsular FL). Recent genetic data indicates that the SHF does not appear to be genetically distinct from Bachman's (Sciurus niger bachmani) or southern (Sciurus niger niger) fox squirrels in Florida. All fox squirrels north of Caloosahatchee River are considered to be the same based on genetic structure.	E	N	Greene et al. 2015; Final SWG Project Report
AND at least 2 of the following:				
a. Severely fragmented or exist in ≤ 10 locations	Occurs in more than 10 locations.	O	N	Wooding 1997, Tye 2016

b. Continuing decline, observed, inferred or projected in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent, and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals	See notes from A3.	I	N	
c. Extreme fluctuations in any of the following: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals	No data to indicate extreme fluctuations.	I	N	Greene and McCleery 2017b
(C) Population Size and Trend				
Population size estimate to number fewer than 10,000 mature individuals AND EITHER	Statewide population size is unknown, however, updated density estimates in the southeast range from 2.4 - 3.6 squirrels/km ² (Greene and McCleery 2017b). Using estimated area of occupancy (10,039 - 15,900 km ²) and the lowest density estimate, exceeds 24,000. Even if we assume only 50% of the estimated available habitat is occupied, the population size estimate is above the 10,000 threshold. If we use extended range (12,241-19,138 km ²) based on genetics work, the estimate is increased.	I	N	Greene and McCleery 2017b, Barrett 2017
(c)1. An estimated continuing decline of at least 10% in 10 years or 3 generations, whichever is longer (up to a maximum of 100 years in the future) OR	Does not apply, see above		N	
(c)2. A continuing decline, observed, projected, or inferred in numbers of mature individuals AND at least one of the following:	Does not apply, see above		N	
a. Population structure in the form of EITHER	More than 1000 mature individuals, see above		N	
(i) No subpopulation estimated to contain more than 1000 mature individuals; OR				
(ii) All mature individuals are in one subpopulation	Sub populations do not apply to SFS		N	
b. Extreme fluctuations in number of mature individuals	No evidence of fluctuations, see above		N	
(D) Population Very Small or Restricted, EITHER				
(d)1. Population estimated to number fewer than 1,000 mature individuals; OR	Population minimally estimated to be > 10,000 mature individuals, see above	I	N	Greene and McCleery 2017b, Barrett 2017

(d)2. Population with a very restricted area of occupancy (typically less than 20 km ² [8 mi ²]) or number of locations (typically 5 or fewer) such that it is prone to the effects of human activities or stochastic events within a short time period in an uncertain future	Neither restricted AOO or low number of locations apply to SFS	I	N	
(E) Quantitative Analyses				
e1. Showing the probability of extinction in the wild is at least 10% within 100 years	Previous (Root and Barnes 2006, Endries et al. 2009) PVA indicated that the probability of extinction in the next 100 years was zero for both managed and all potential habitat. Although data used were mainly derived from research conducted in the southeast, the density estimates used in the PVA were not corrected and therefore the assumed population density and carrying capacity were likely overestimated, and the validity of the model are questionable. However, given that model was most sensitive to survival and fecundity, it is unlikely that even with updated data that the final outcome of the PVA would change.		N	Root and Barnes 2006, Endries et al. 2009

Initial Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Does not meet any criteria	
Is species/taxon endemic to Florida? (Y/N)	N
If Yes, your initial finding is your final finding. Copy the initial finding and reason to the final finding space below. If No, complete the regional assessment sheet and copy the final finding from that sheet to the space below.	
Final Finding (Meets at least one of the criteria OR Does not meet any of the criteria)	Reason (which criteria are met)
Does not meet any criteria	

Biological Status Review
Information
Regional Assessment

Species/taxon: Sherman's Fox Squirrel (SFS)
Date: 8/14/17
Assessors: Elina Garrison (FWRI/Lead)
L. Mike Conner (Jones Center)
Robert McCleery (UF)
Holly Ober (UF)
Andrew Edelman (U. West Ga)

Initial finding	
2a. Is the species/taxon a non-breeding visitor? (Y/N/DK). If 2a is YES, go to line 18. If 2a is NO or DO NOT KNOW, go to line 11.	N
2b. Does the Florida population experience any significant immigration of propagules capable of reproducing in Florida? (Y/N/DK). If 2b is YES, go to line 12. If 2b is NO or DO NOT KNOW, go to line 17.	N
2c. Is the immigration expected to decrease? (Y/N/DK). If 2c is YES or DO NOT KNOW, go to line 13. If 2c is NO go to line 16.	
2d. Is the regional population a sink? (Y/N/DK). If 2d is YES, go to line 14. If 2d is NO or DO NOT KNOW, go to line 15.	
If 2d is YES - Upgrade from initial finding (more imperiled)	
If 2d is NO or DO NOT KNOW - No change from initial finding	
If 2c is NO or DO NOT KNOW- Downgrade from initial finding (less imperiled)	
If 2b is NO or DO NOT KNOW - No change from initial finding	No Change
2e. Are the conditions outside Florida deteriorating? (Y/N/DK). If 2e is YES or DO NOT KNOW, go to line 24. If 2e is NO go to line 19.	
2f. Are the conditions within Florida deteriorating? (Y/N/DK). If 2f is YES or DO NOT KNOW, go to line 23. If 2f is NO, go to line 20.	
2g. Can the breeding population rescue the Florida population should it decline? (Y/N/DK). If 2g is YES, go to line 21. If 2g is NO or DO NOT KNOW, go to line 22.	
If 2g is YES - Downgrade from initial finding (less imperiled)	
If 2g is NO or DO NOT KNOW - No change from initial finding	
If 2f is YES or DO NOT KNOW - No change from initial finding	
If 2e is YES or DO NOT KNOW - No change from initial finding	
Final finding	does not meet criteria

Additional Notes

Additional notes - Generation length - Sherman's fox squirrels become sexually mature at 8-9 months, however, they generally do not reproduce until they are over a year old. Using adult mortality of 30% (Wooding 1997) and field observations (R. McCleery, personal communication), we estimated the generation length as 3 years. Since three generations is less than 10 years, we used 10 years as the evaluation time frame.

Geographic Range – Used 2 different models to map potential SFS habitat; habitat affinity model and predictive model. Habitat affinity model was created by selecting primary and secondary upland habitats and using tree canopy cover as determining factor. Predictive model was created by using the professional locations from the statewide FS survey (Tye et al. 2016). For details on both models, please see appendix 3.

Habitat affinity model, total area = 10,039 km²

Predictive model, total area = 15,900 km²

Considering the recent genetic findings, team also considered the extended range for both habitat (12,241 km²) and predictive model (15,900 km²). In addition, using the 2 x 2 km grid as recommended by the IUCN guidelines, estimated AOO ranged from 7,880 to 8,908 km² (current vs. extended range) based on the number of grids with occurrence of sightings. Therefore, regardless of whether we used potential habitat models or actual sighting data, all estimated AOO well exceed the minimum of 2000 km².

Regional assessment - Although the range of Sherman's fox squirrels extends into Georgia, the number of individual fox squirrels that could contribute to reproduction in Florida is minimal and likely localized.

Concluding thoughts - The Sherman's fox squirrel Biological Review Group agreed that based on the current information on range, densities, genetics and ability of SFS to occur in variety of habitats, they do not meet listing criteria. However, the team was concerned that de-listing could increase pressure to open SFS to hunting. Due to their low densities and low reproductive rates, SFS may be particularly vulnerable to hunting (discussed findings by Wooding 1997), especially if they were seen as a novelty game species. Other threats to consider for future SFS management is potential increase in road mortality as urban development and human populations continue to increase in Florida.

APPENDIX 1. Brief biographies of the Sherman's fox squirrel Biological Review Group members.

Robert McCleery received a B.S. in Natural Resource management from Cornell University and a M.S and Ph.D. in Wildlife and Fisheries Sciences from Texas A&M University. He is currently an Associate Professor at the University of Florida in the department of Wildlife Ecology and Conservation. His research focuses on mammal conservation. Dr. McCleery has published 77 peer-reviewed manuscript and book chapters, 15 of which are focused on the ecology and conservation of fox squirrels in the southeastern United States.

Mike Conner received his PhD from Mississippi State University in 1995. He has held a research position at the Joseph W. Jones Ecological Research Center since June of 1997. He currently holds the rank of Scientist. Dr. Conner's research focuses on the process of predation, behavioral response of prey to predation risk, habitat selection, and the influence of forest management activities on animal behaviors and populations. He works with a variety of species and has extensive experience working with fox squirrels.

Holly Ober has a Ph.D. in Wildlife Science and Forest Science from Oregon State University. She is currently an associate professor in the Department of Wildlife Ecology and Conservation at the University of Florida. Dr. Ober has been engaged in wildlife research for over 20 years, with the past 10 focused primarily on imperiled species in Florida.

Andrew Edelman is an Associate Professor of Biology at the University of West Georgia. He has over 15 years of research experience studying the conservation and ecology of wild mammals with a specific focus on tree squirrels, skunks, bats, and other small carnivores and rodents. Dr. Edelman has coauthored over 20 peer-reviewed articles and 100 presentations on his research. Recently, he has collaborated on grant-funded research with the Alabama Department of Conservation and Natural Resources, U.S. Forest Service, and the U.S. Fish and Wildlife Service. He holds a B.S. in biology from Willamette University, an M.S. in Wildlife and Fisheries Sciences from the University of Arizona, and a Ph.D. in biology from the University of New Mexico. He is also a Certified Wildlife Biologist®, an associate editor for the *Southeastern Naturalist* journal, and secretary for the Georgia Chapter of The Wildlife Society.

Elina Garrison has a M.S. in Wildlife Ecology and Conservation from the University of Florida. She has worked as a biologist in FWC's Terrestrial Mammal Research Subsection since 2004. Ms. Garrison has experience with a variety of Florida mammals, including black bears, white-tailed deer, and fox squirrels, and she has assisted with fox squirrel risk assessments and compiling statewide range maps. She was the FWC lead on the 2010 Sherman's fox squirrel and Big Cypress fox squirrel biological status review and was a team member of both subspecies' action plans.

APPENDIX 2. Summary of letters and emails received during the solicitation of information from the public period of May 10 to June 26, 2017

No information was received from the public.

APPENDIX 3. Barrett, Mark. 2017. GIS analysis prepared for the Sherman's fox squirrel Biological Status Review. Unpublished report. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA.

Sherman's Fox Squirrel

Habitat Affinity and Predictive Models

Habitat Affinity Model 2016

Methods

Primary. To map potential habitat, we started by identifying appropriate primary upland habitats within the range of the species that are equivalent or similar to sandhill/upland pine savannah with a low percentage of hardwood midstory and with open groundcover. For the appropriate primary upland habitats we selected sandhill, and mixed hardwood-pine forests, as identified in the CLC v3.2 image. Also included were upland pine, upland coniferous, mesic flatwoods, coniferous plantations, dry flatwoods, scrubby flatwoods, oak scrub, and sand pine scrub.

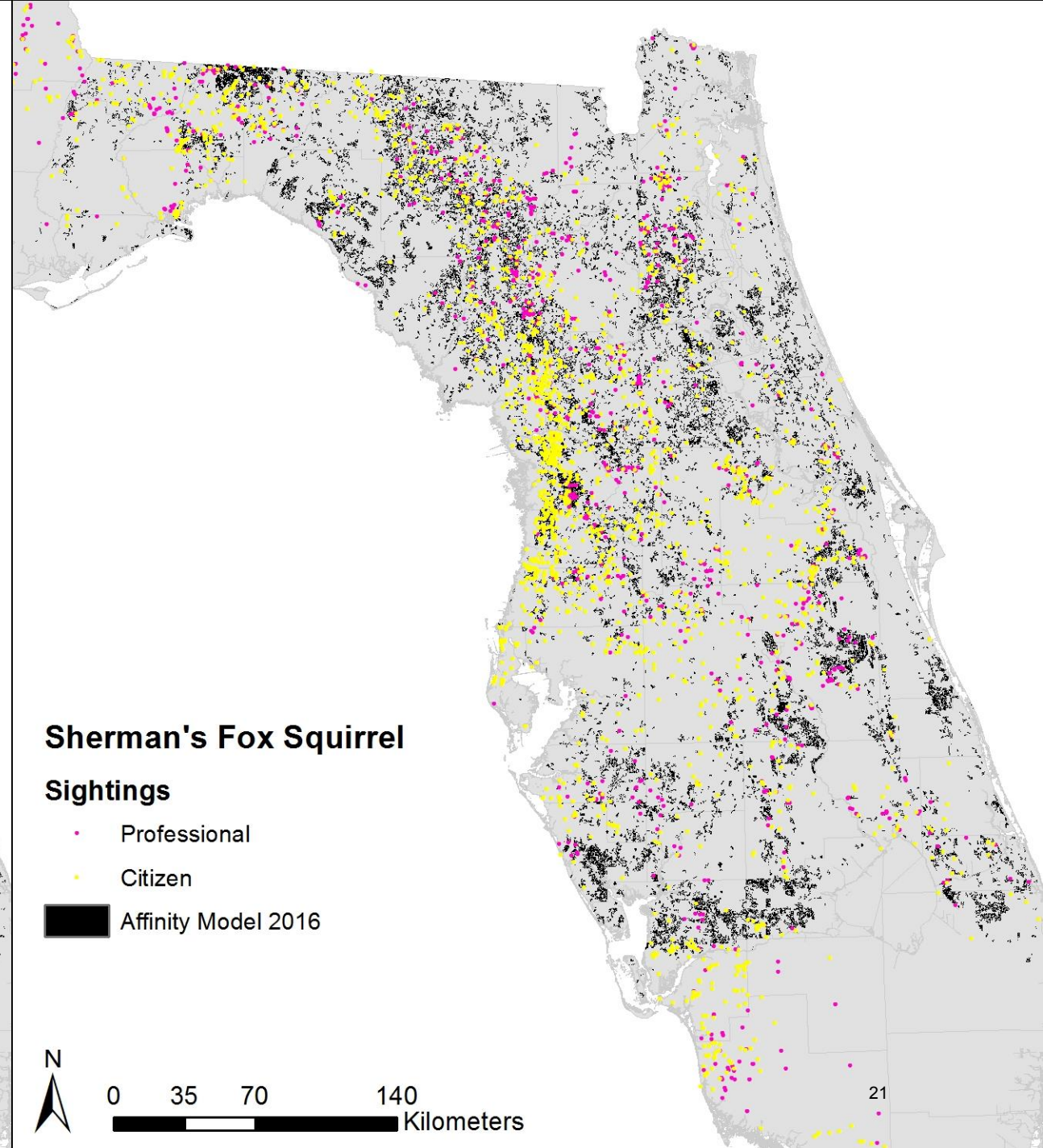
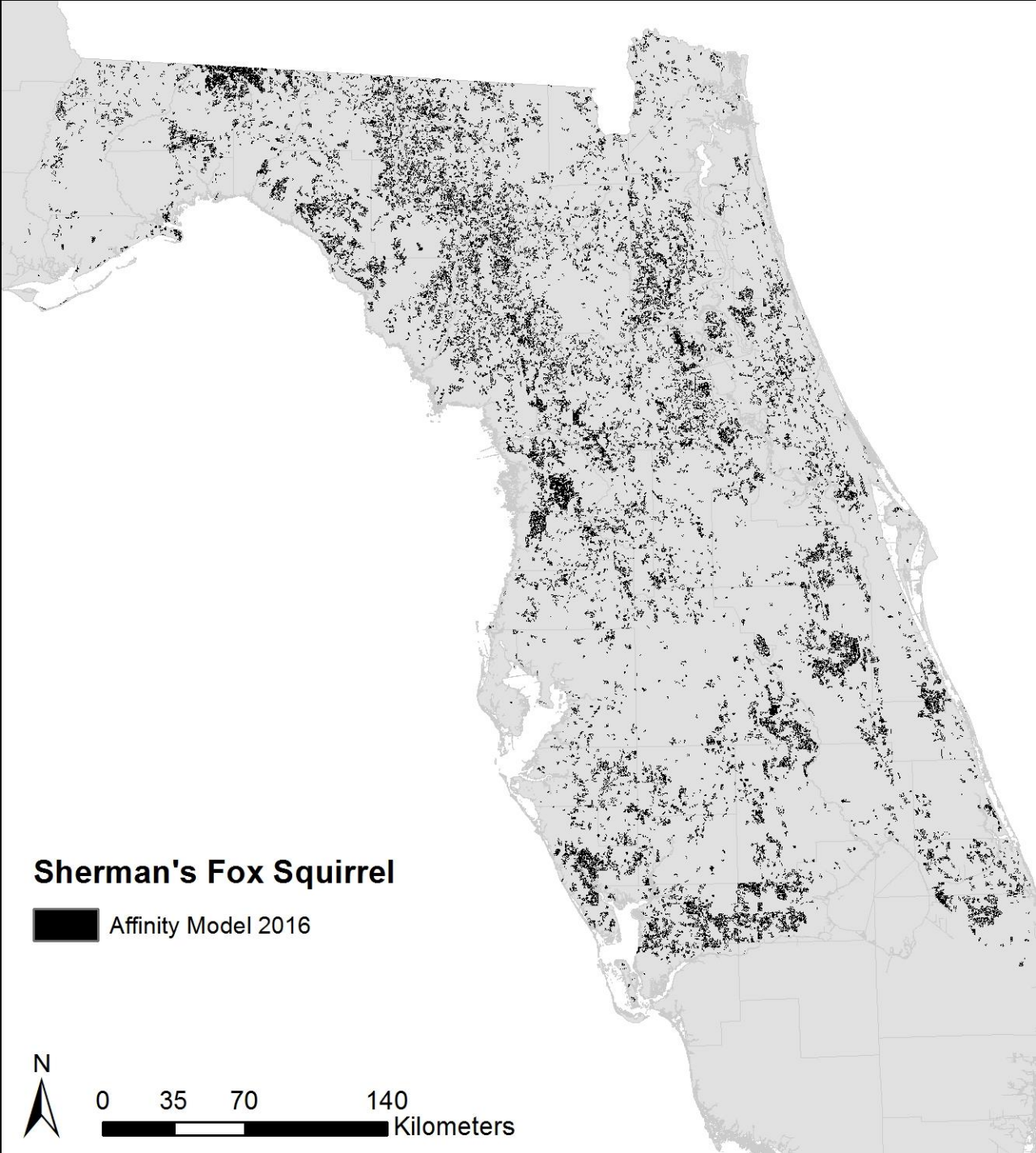
Secondary. We selected all areas of improved pasture, unimproved pasture, shrub and brushland, and Urban Open Pine (CLC 182112) within 60 m of primary or secondary habitats in the CLC v3.2 image. These areas were merged with the primary upland habitats layer.

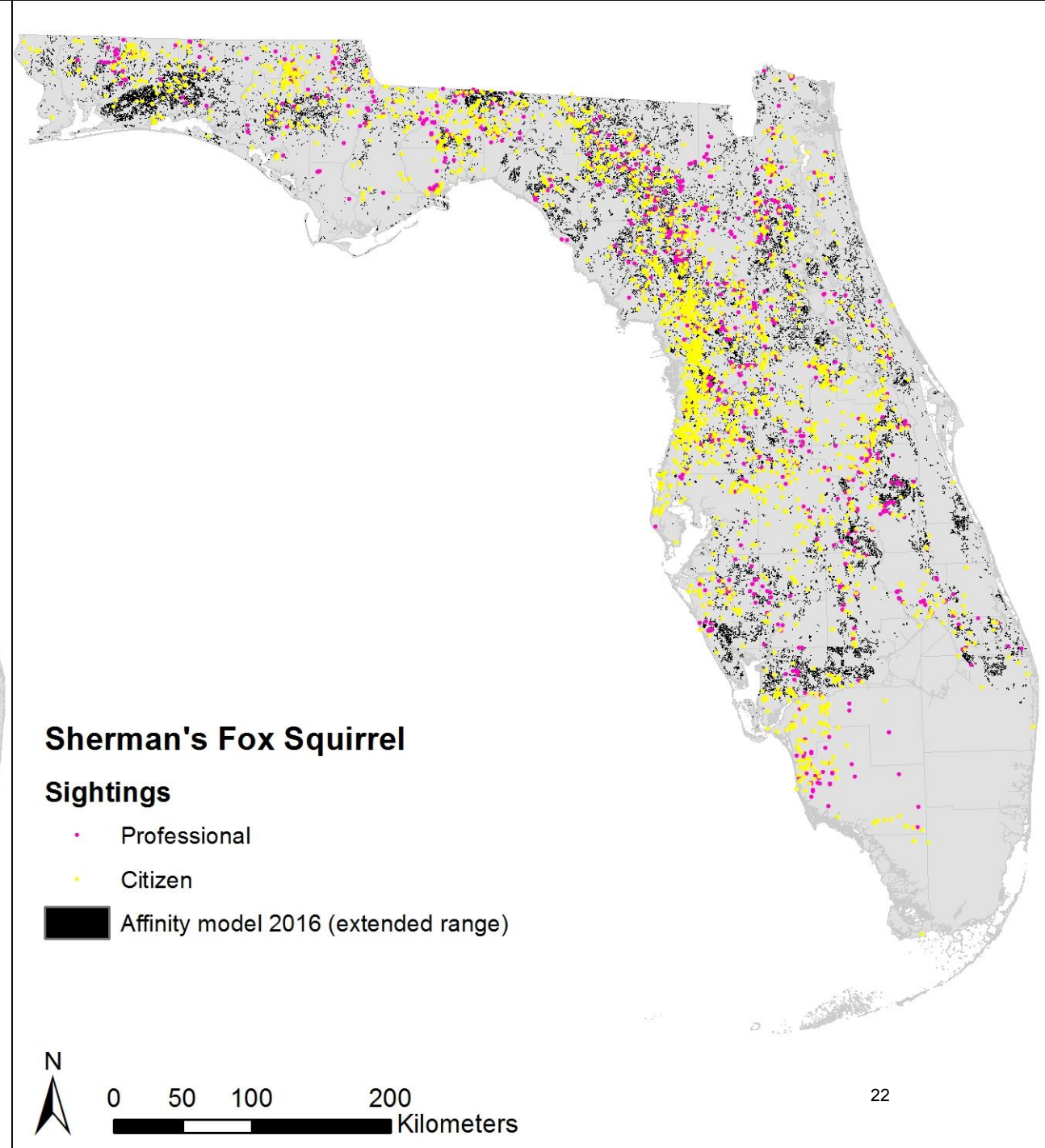
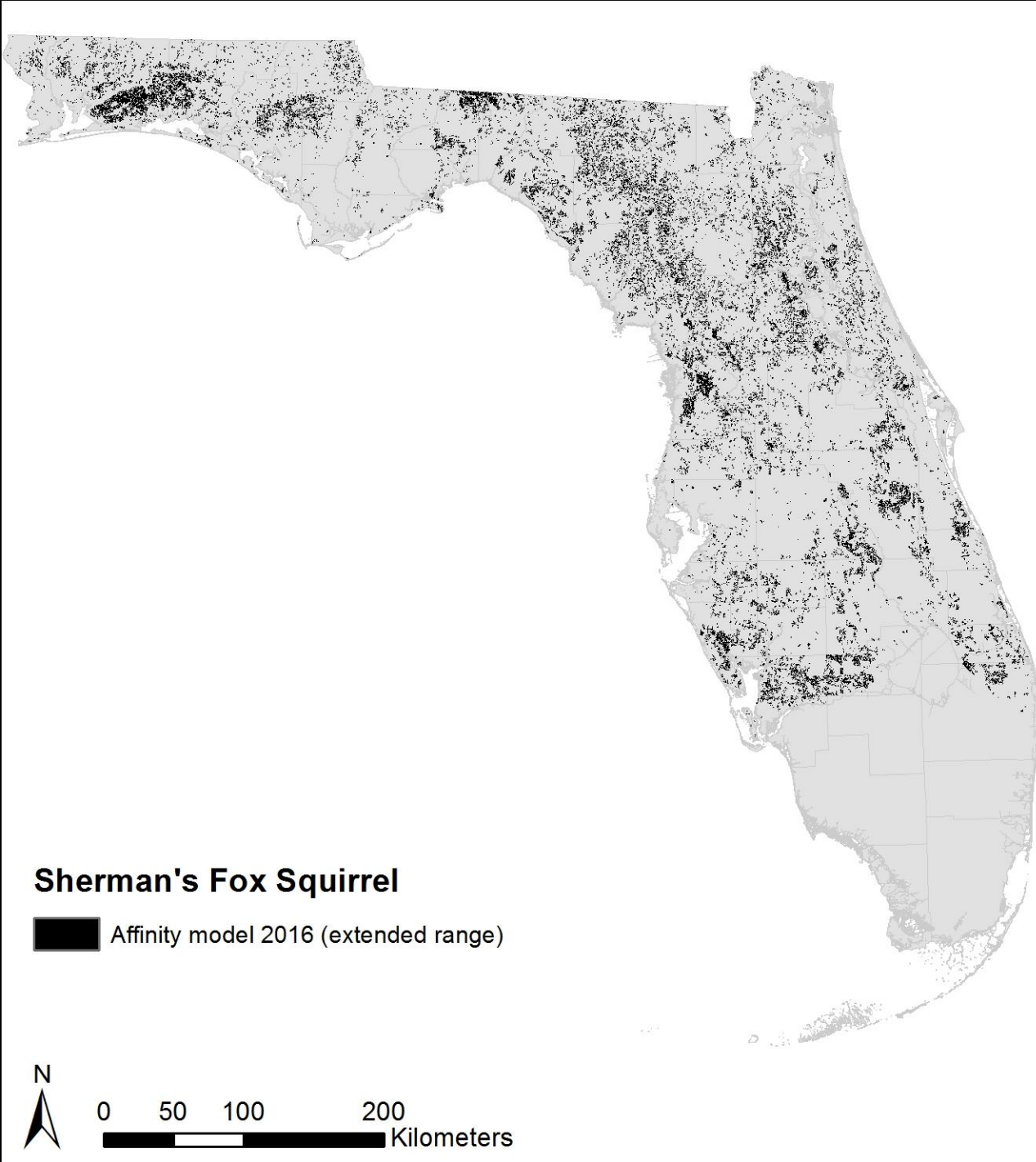
Tree canopy cover was included as a determining factor using the range of 15%-50% (using NLCD Canopy Cover 2011). Also, to include interspersed areas of canopy cover, we ran a neighborhood analysis across the landscape using a 200m moving window and produced the mean canopy cover within the window. The mean canopy cover of 15-50% from this layer was combined with the 15-50% canopy cover layer and used to filter the primary and secondary land cover layers. After the canopy filter was run, the layer was buffered by 30 m so any habitat patches that were within 60 m of each other would be connected. The final step in creating the habitat map was to remove all habitat patches less than 40 ha (the average home range size of male fox squirrels) that are not contiguous with larger patches of primary or secondary habitat.

Analyses with different Ranges

A) Original. For our analysis we modified the range extent presented in Ehrhart (1992). The range we selected extends from north of the Caloosahatchee River to the Georgia state line and west to the Apalachicola River. South of the Caloosahatchee River is where you find the Big Cypress fox squirrel (*Sciurus niger avicennia*) and

B) Extended Range. The range was extended west from the Apalachicola River to the Alabama border. So the range would cover all of Florida north and west from the southern range limit all the way across the panhandle to the Alabama border. **Why?** There has been some recent data (Greene 2015, Greene and McCleery 2015) that indicates genetically all fox squirrels north of the Calasooatchee River may all be one subspecies.





Predictive Model 2016

Methods

Habitat selection estimated from the Resource Selection Function (RSF; Manly et al. 2002)

Logistic Regression

- Used professional locations (n=1,065) and compared to 9,995 random locations
- 9 predictor variables (eg. Canopy, distance to forest, forest edge and urban, habitat type)

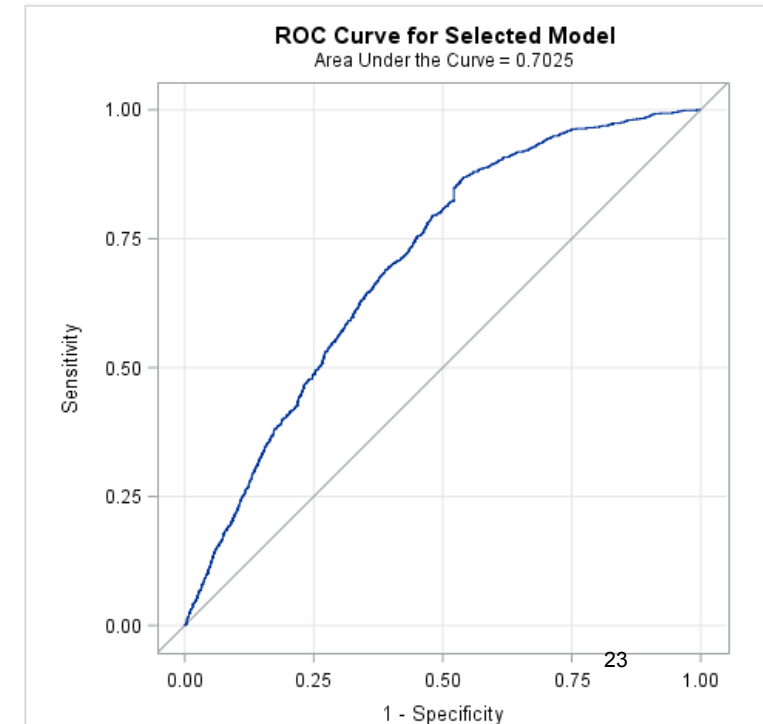
Most recent Cooperative Land Cover 2016 (CLC, v3.2) was used as the underlying habitat map.
Reclassified to classes in Tye et al. (2016)

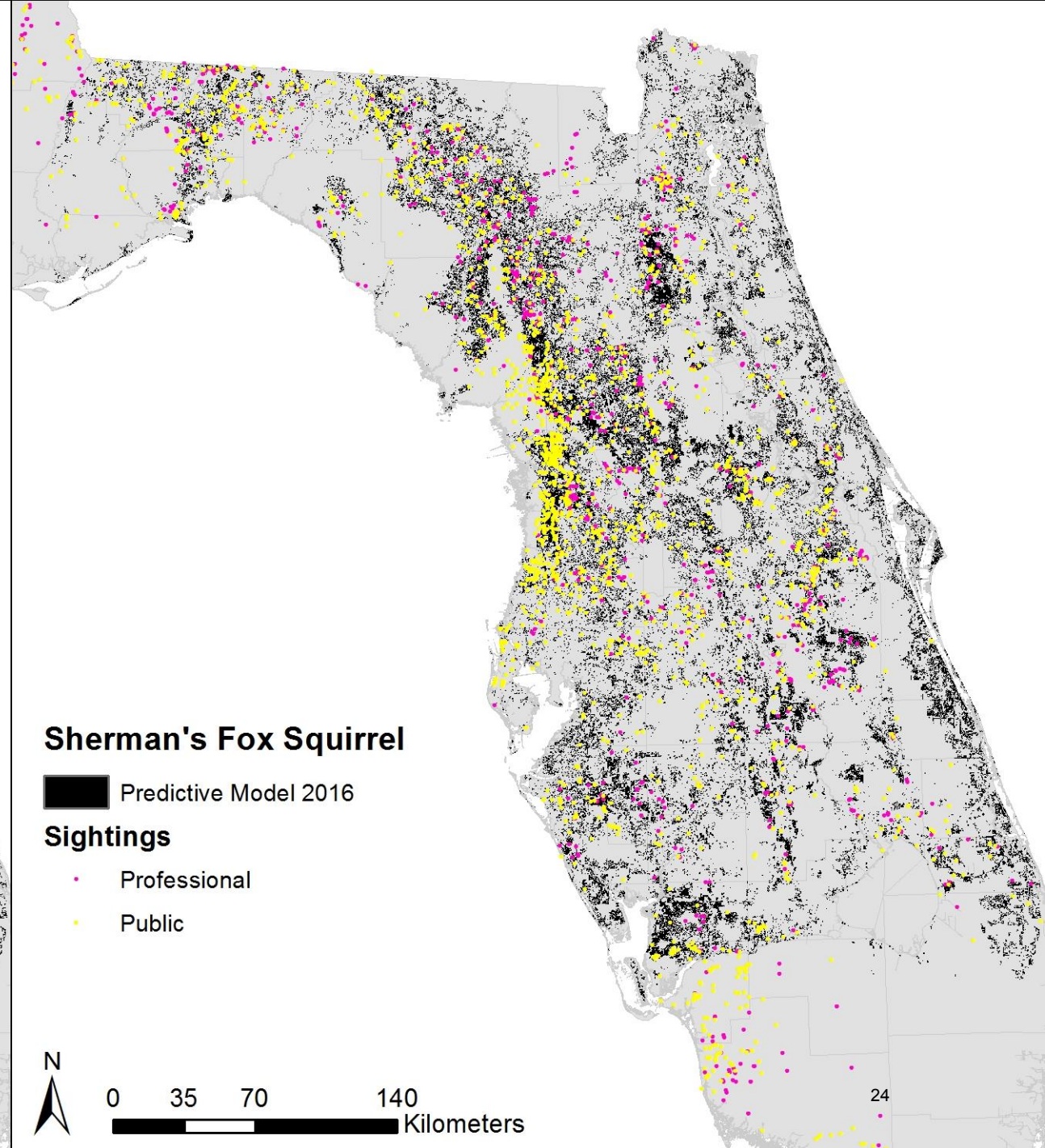
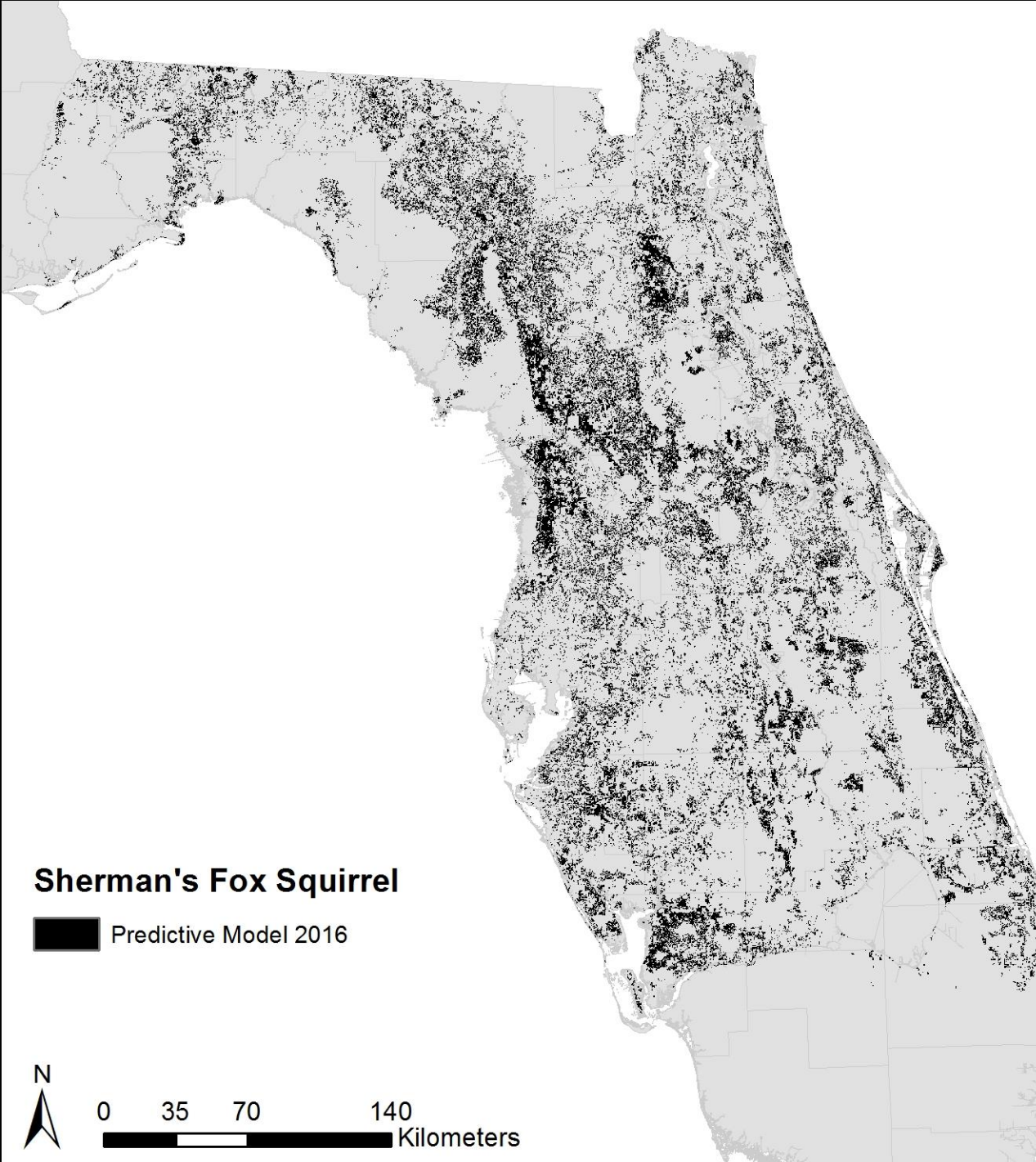
Results for predictive model

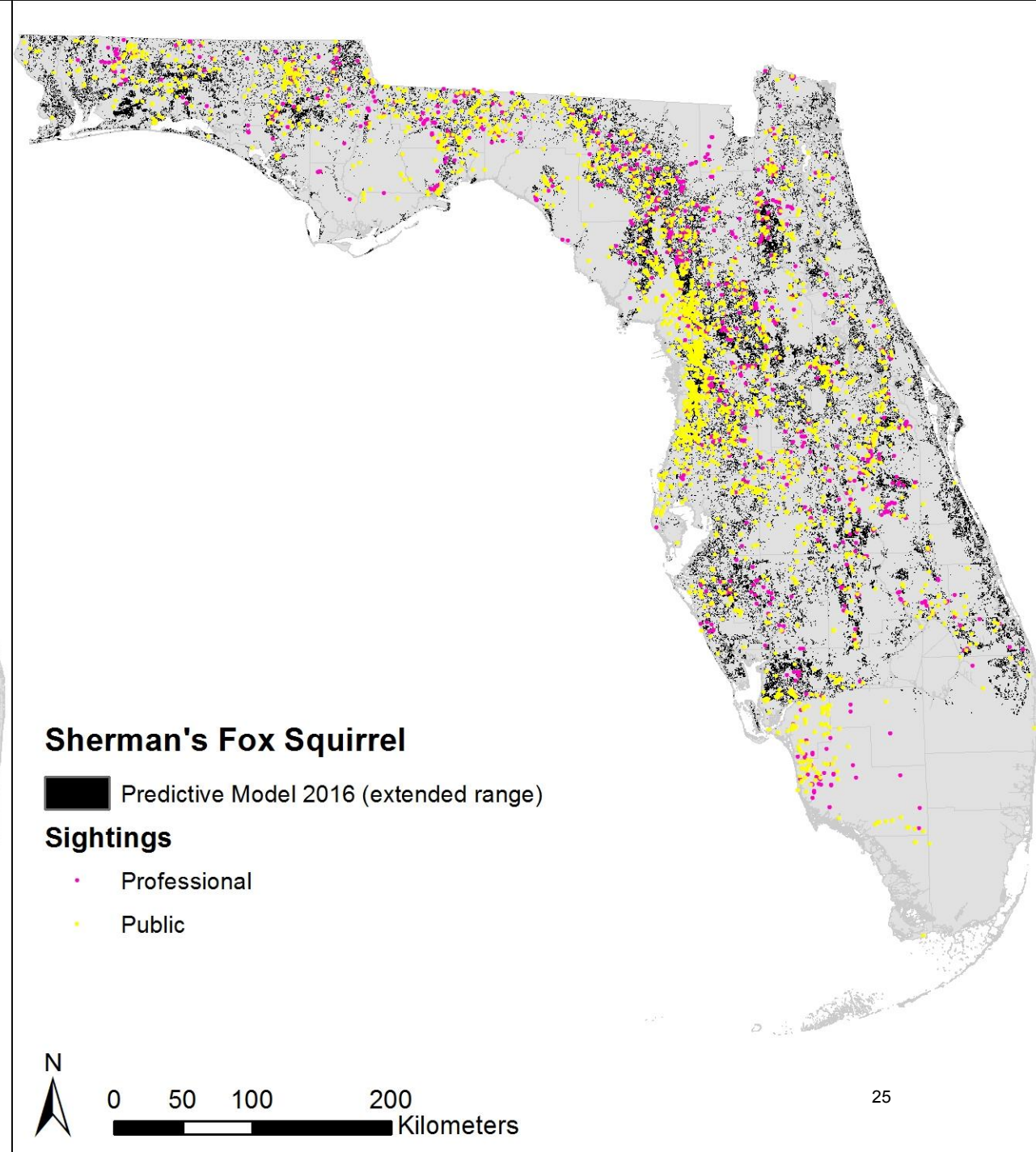
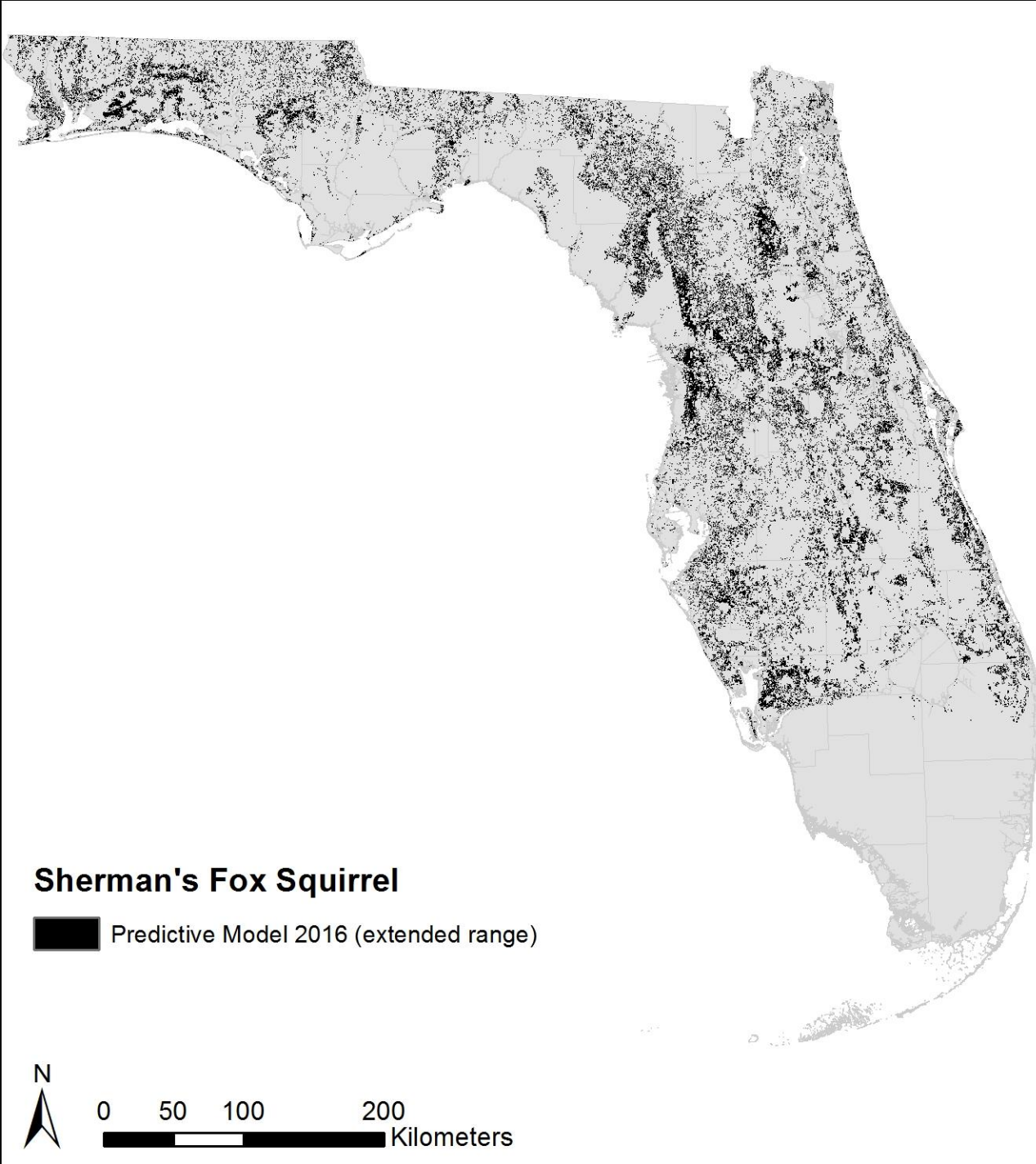
Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	1	-0.7202	0.0884	66.3784	<.0001
Dist_edge	1	-0.00013	0.000053	5.7997	0.0160
Dist_urban	1	-0.00018	0.000031	32.6694	<.0001
Dist_uplandfor	1	-0.00161	0.000159	102.4052	<.0001
Mean_canopy	1	-0.0107	0.00126	72.8265	<.0001
Majority_habitat	1	-0.0466	0.00634	53.9728	<.0001

Majority habitat type (pineland, pasture, tree plantations), mean % canopy cover, and distance to upland forest cover were most important.

Threshold value determined by top 2 natural breaks (0.157)

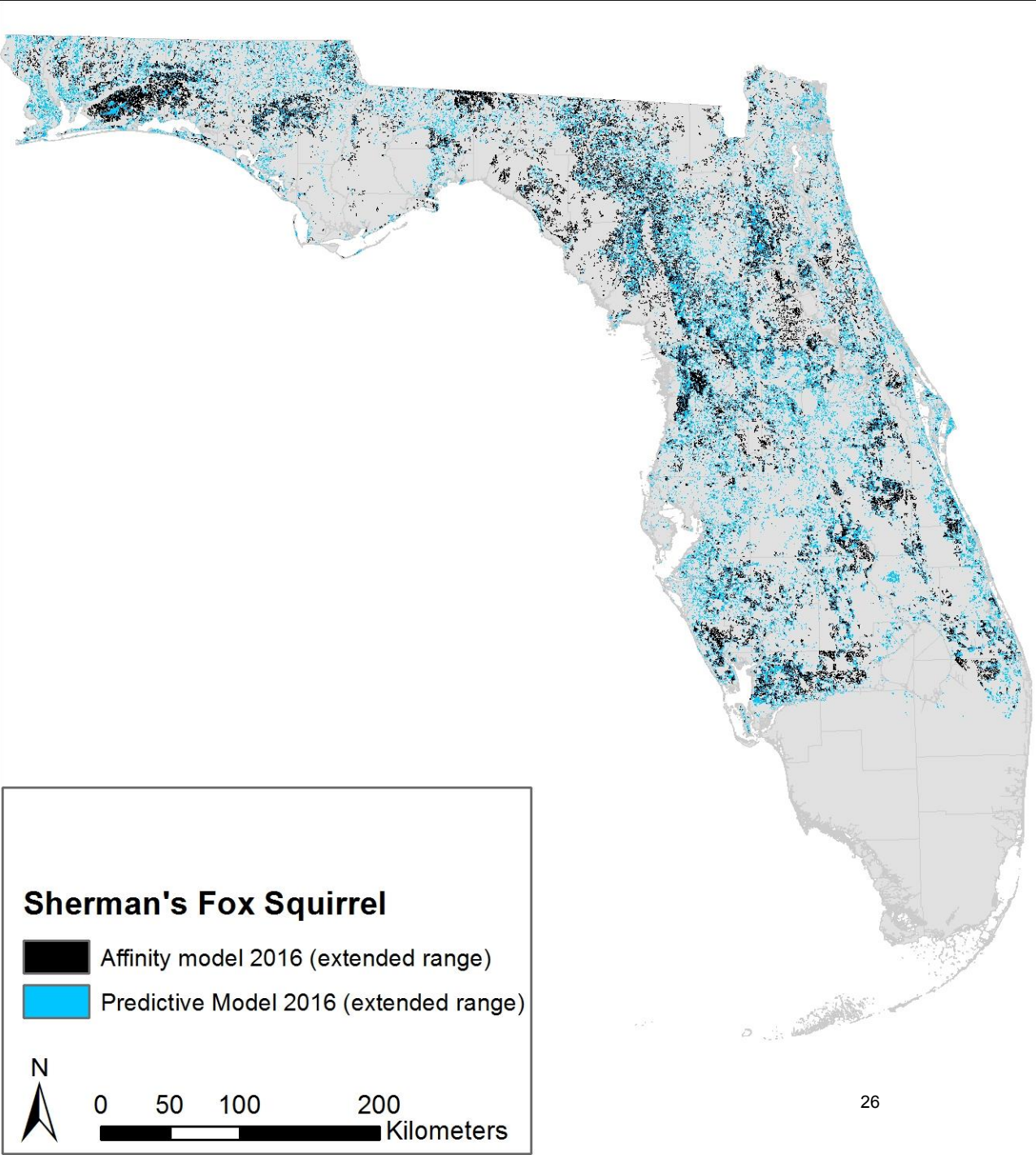
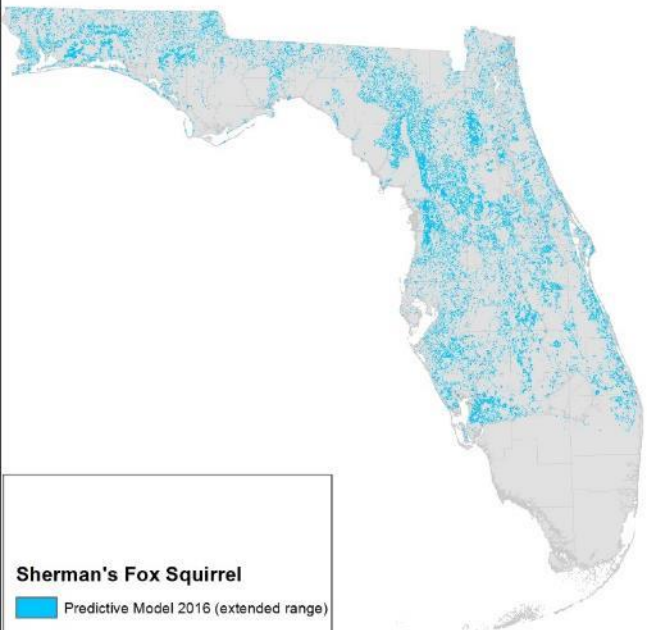
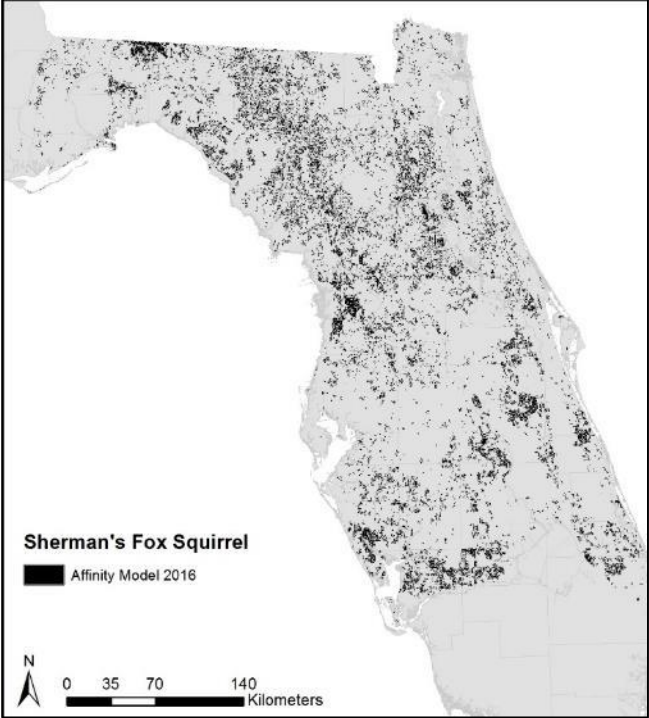


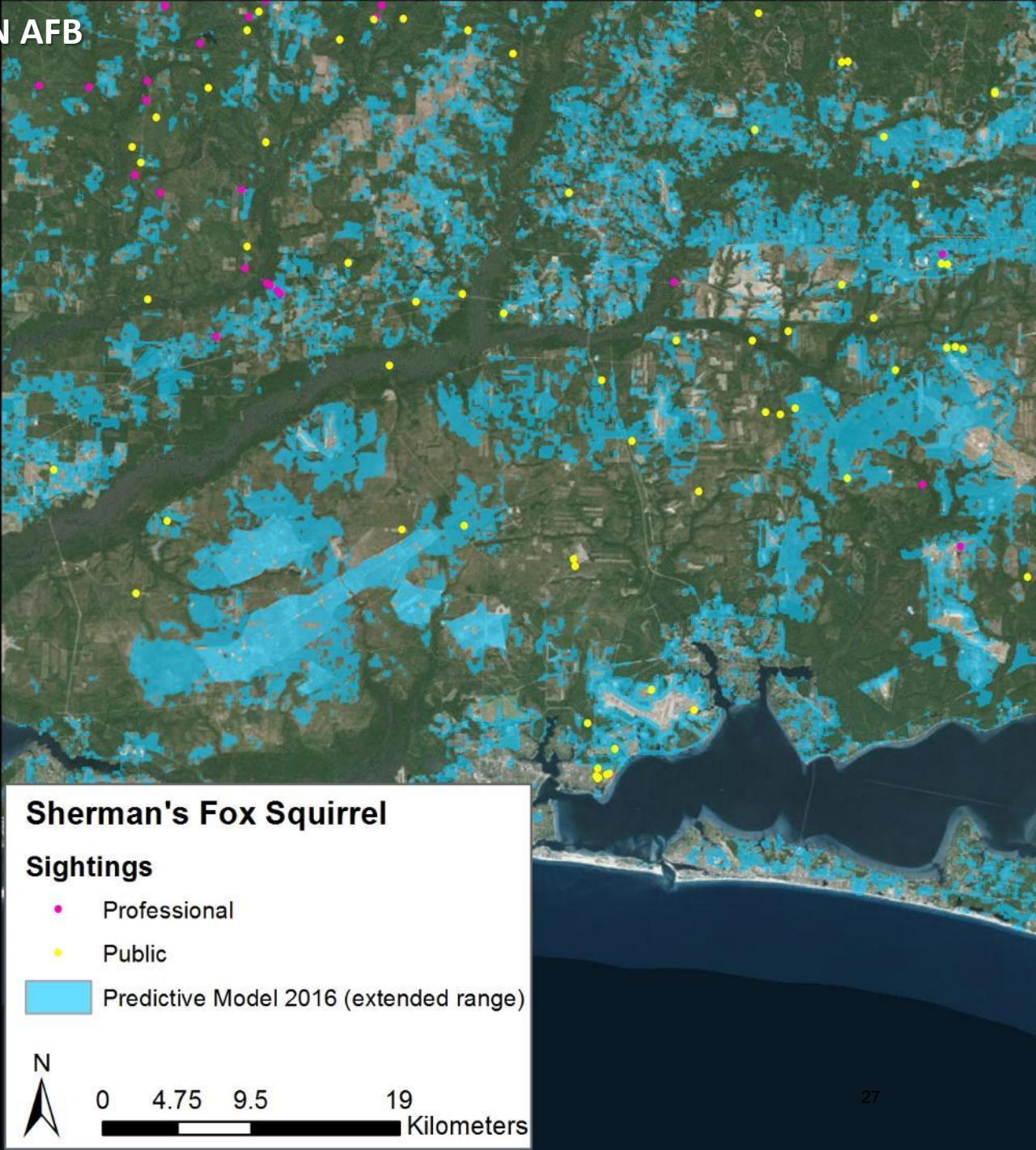
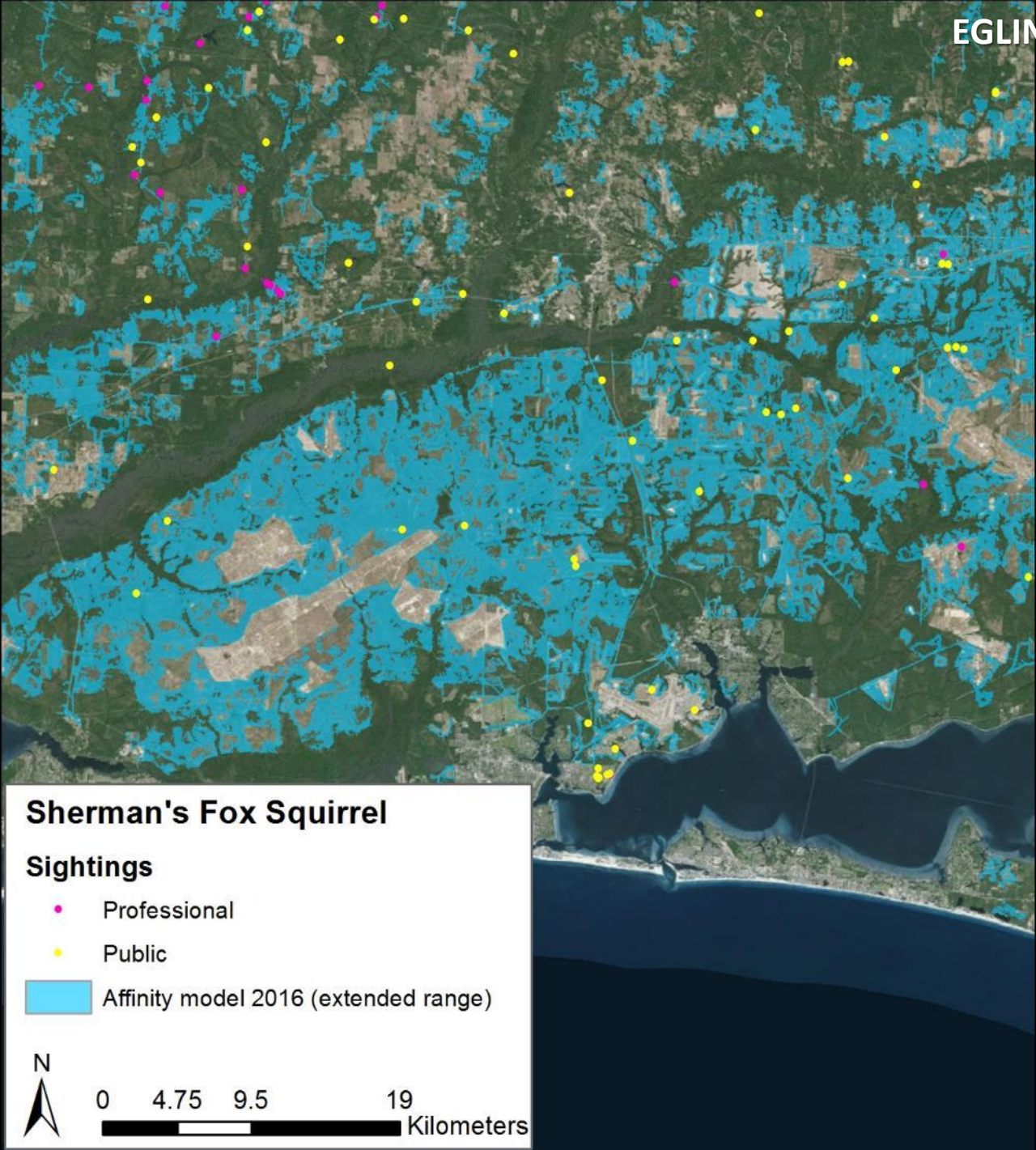




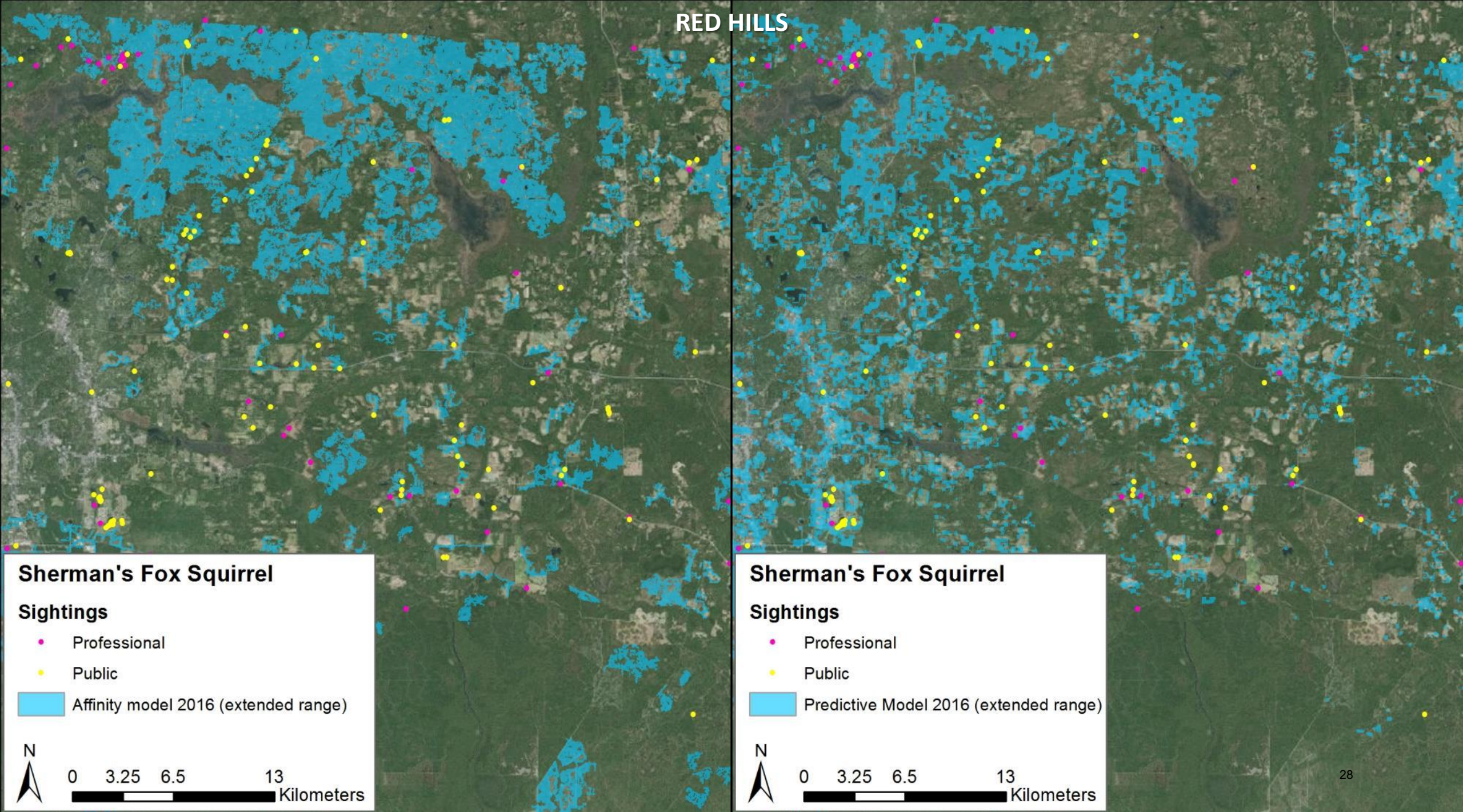
Model Comparisons

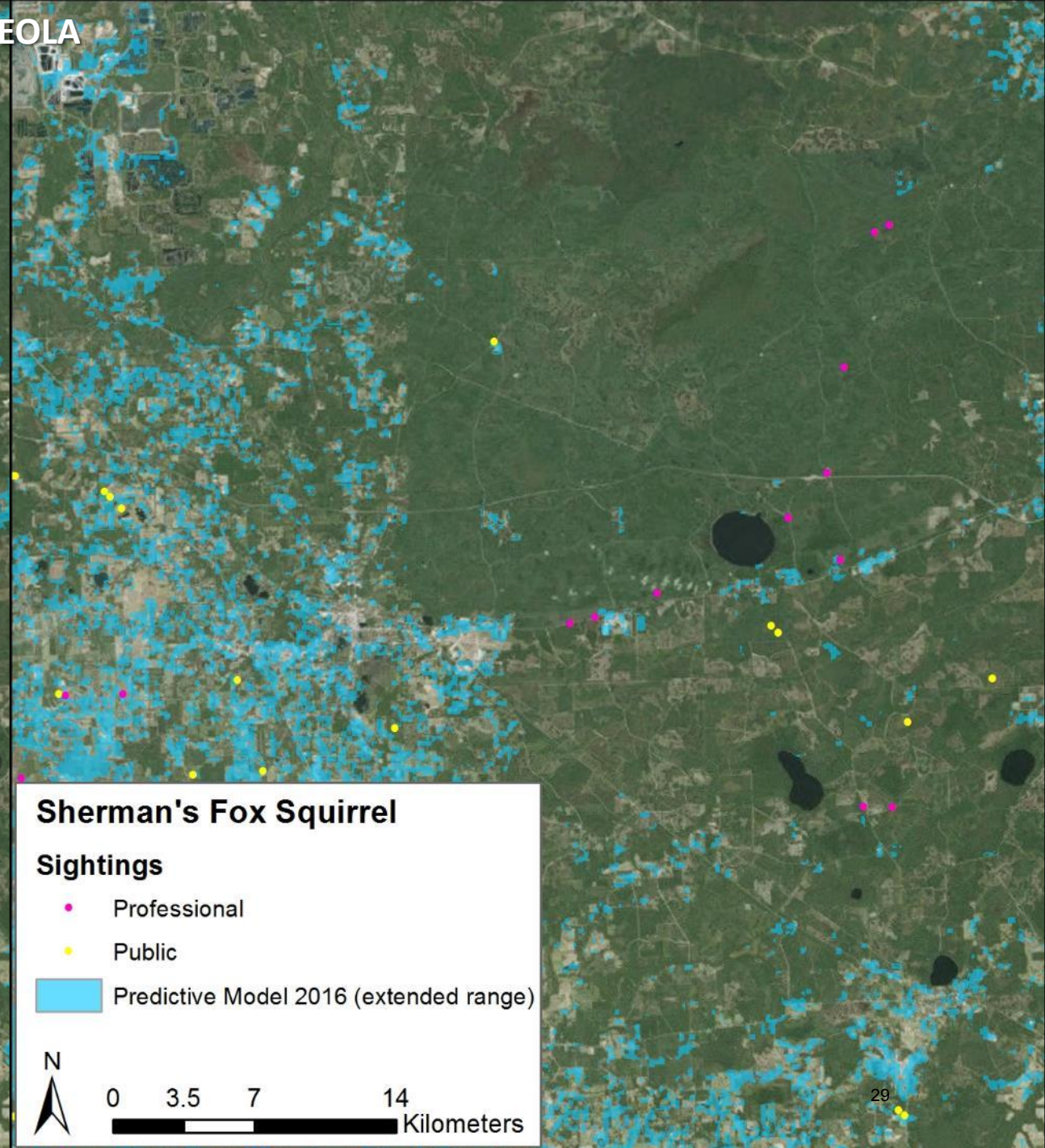
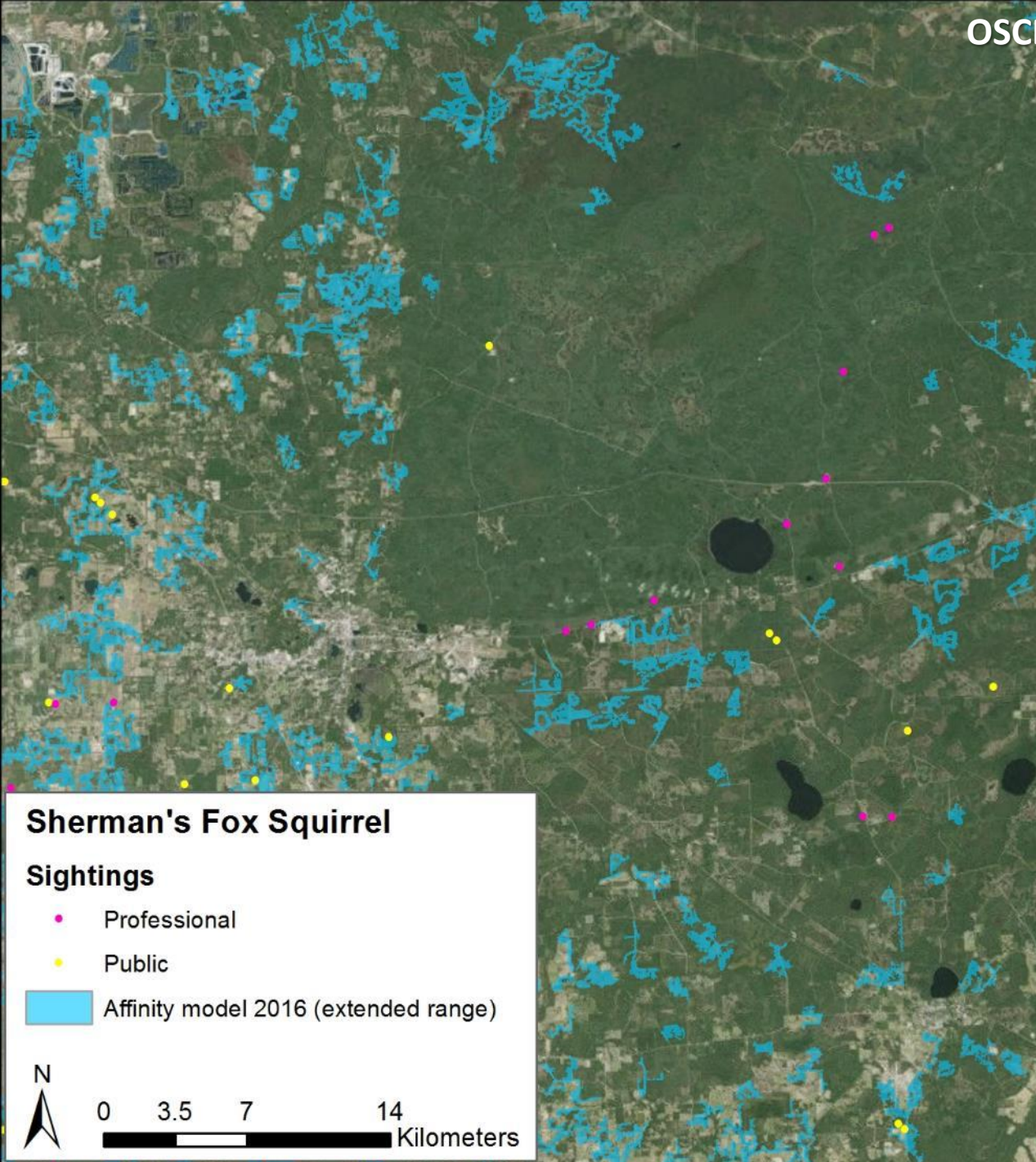
Comparison of the
Affinity Model 2016
and
Predictive Model 2016



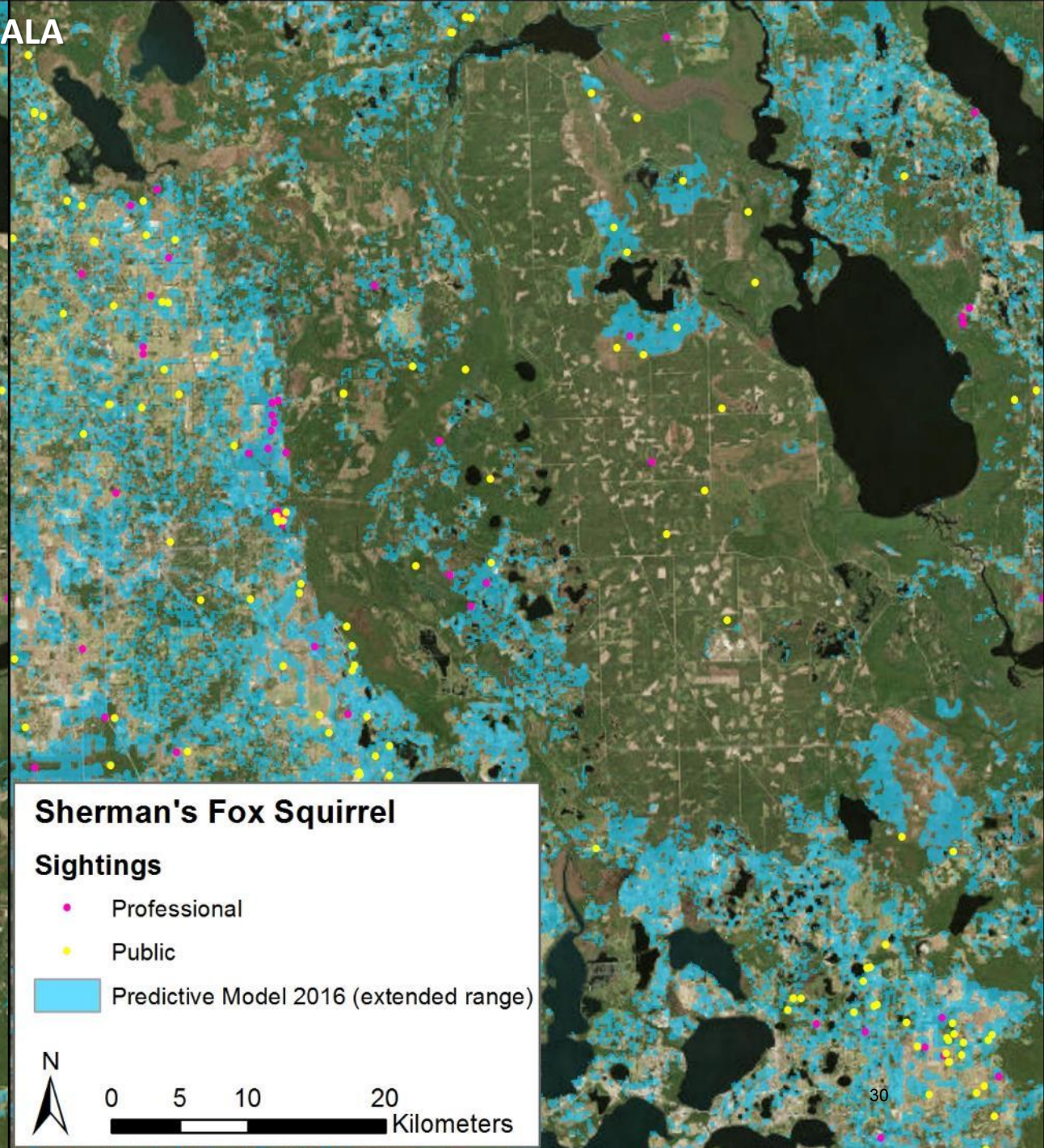
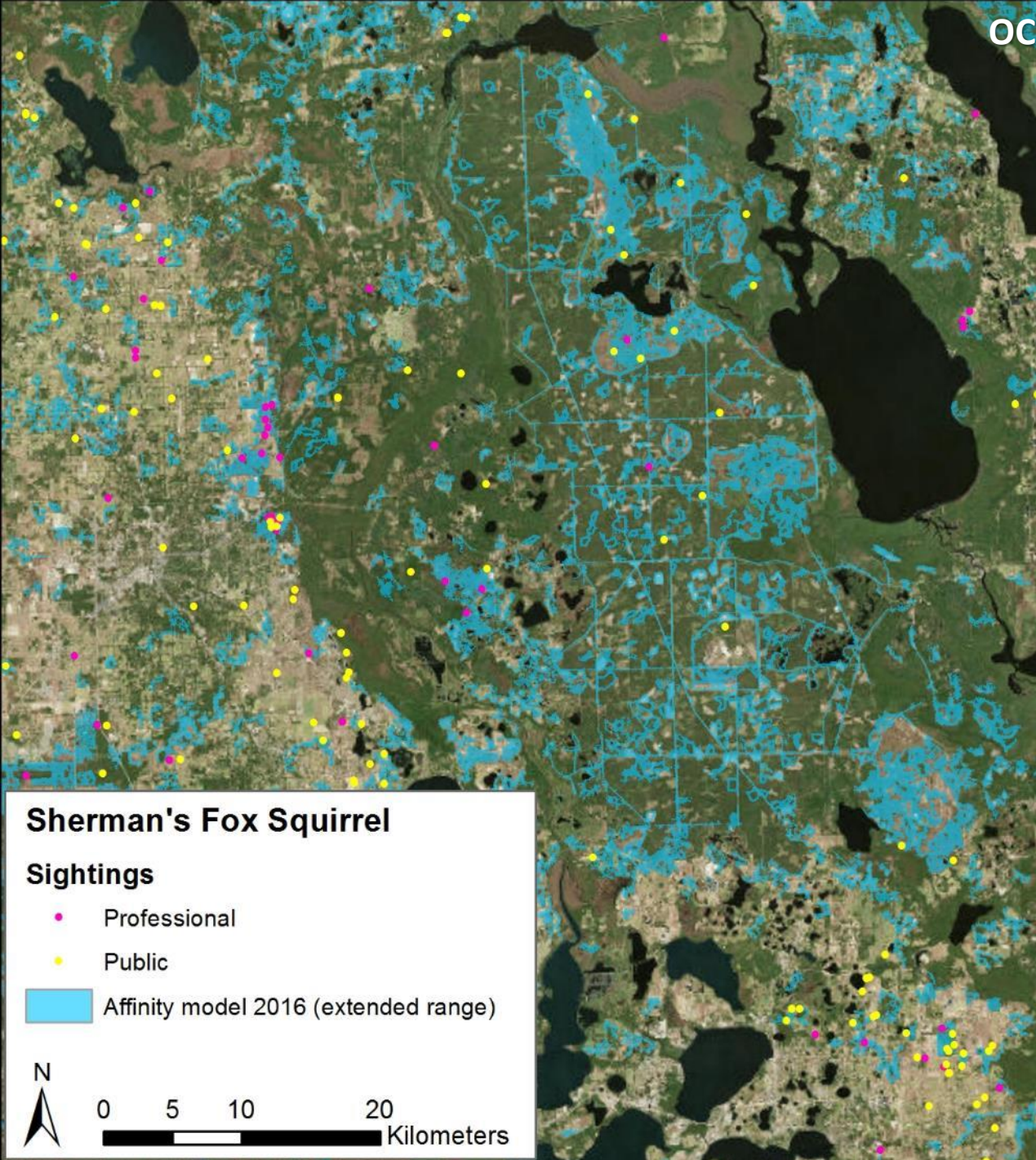


RED HILLS

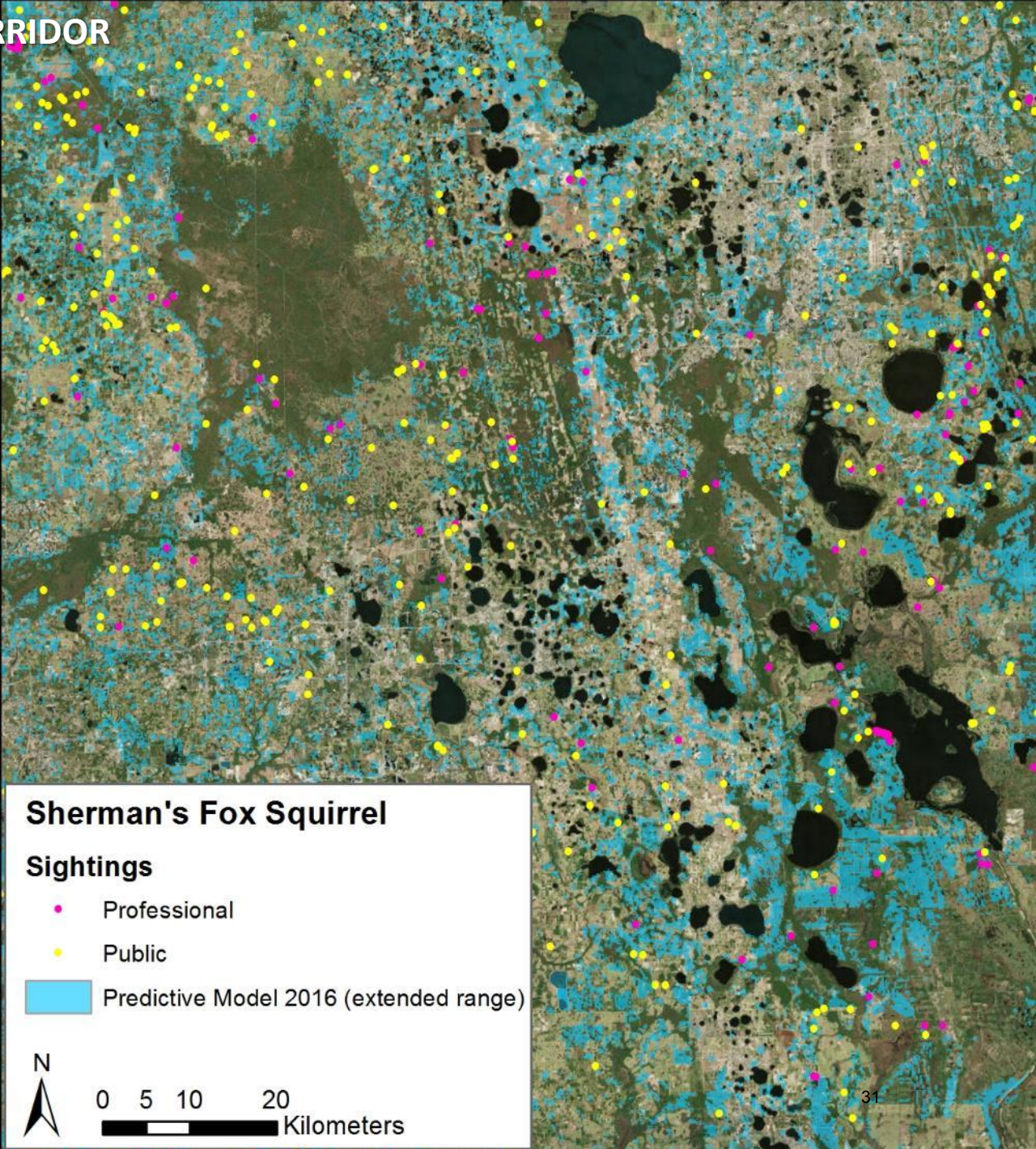
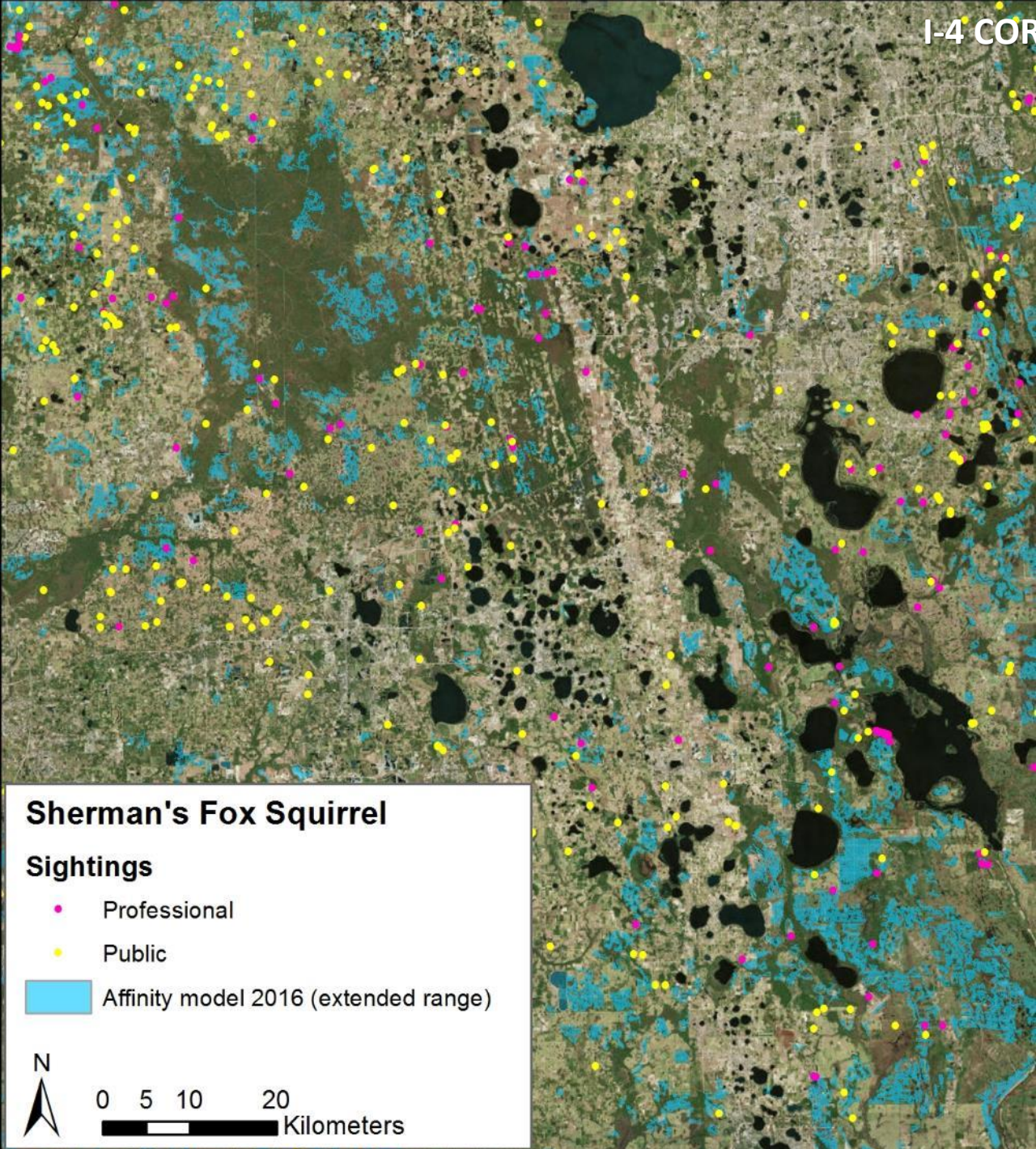




Ocala



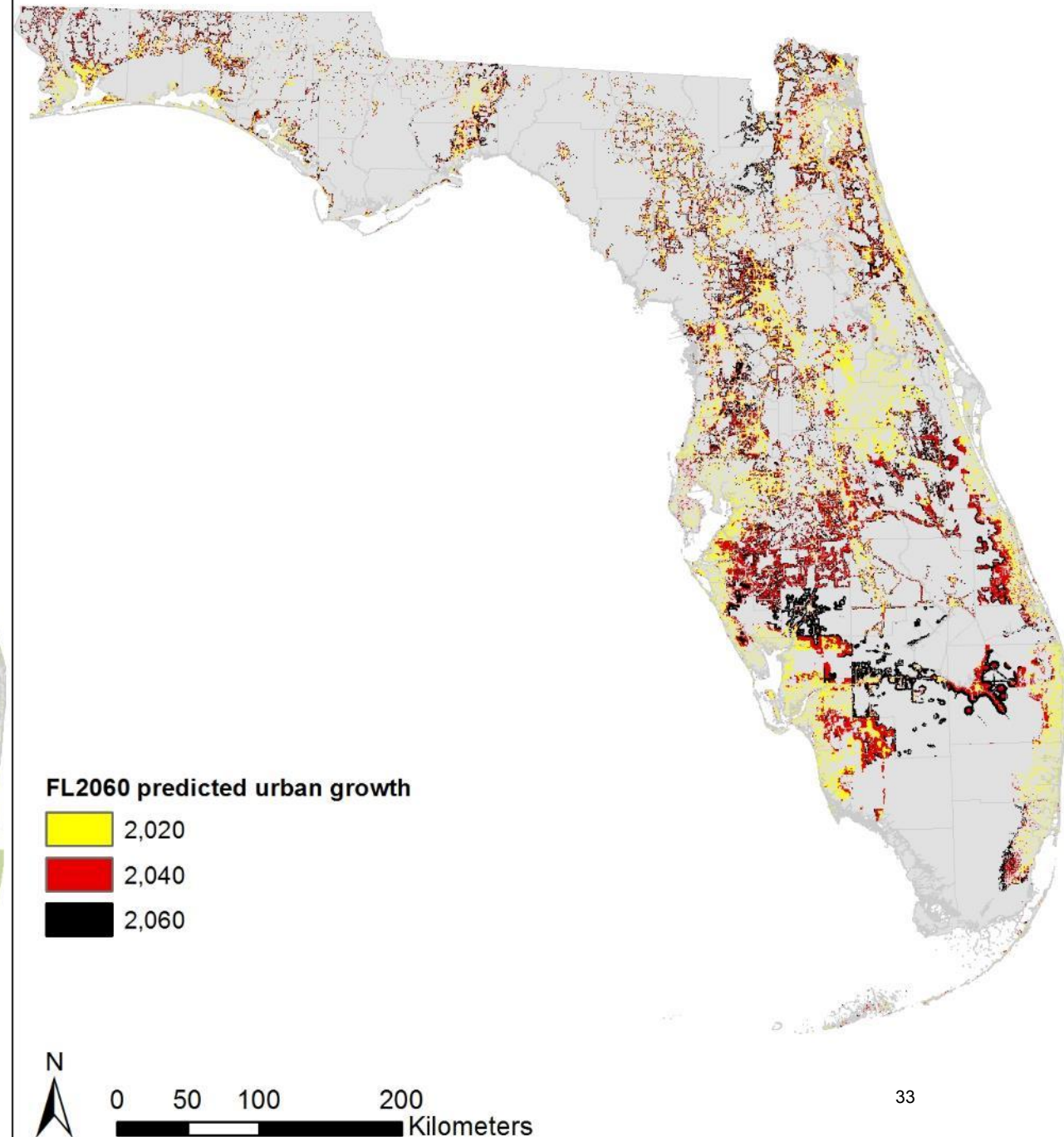
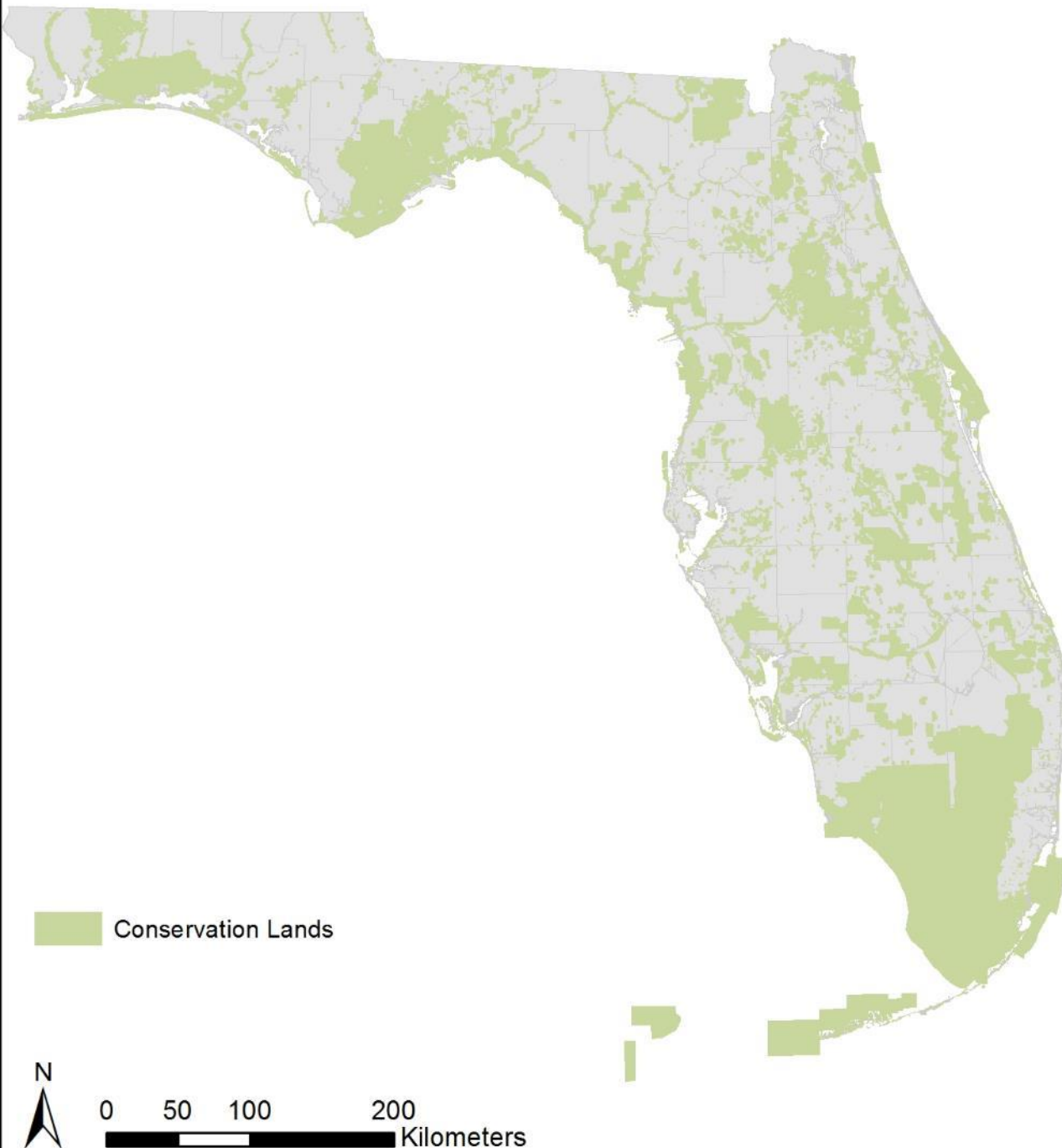
I-4 CORRIDOR



All Model Comparisons

Area (km²) of potential habitat models for limited range area and extended range area

MODEL	AREA (km²)
Affinity 2016	10,039
Predictive	15,900
Affinity 2016 (extended range)	12,241
Predictive (extended range)	19,138



Conservation lands

GIS layer: Managed Areas FNAI 2017

Area (km²) of potential habitat models (2016) that occur on conservation lands for limited range area and extended range area

	Conservation							
Model	Local	State	Federal	Private	Total	Private	Total area	Percent on Conservation
Affinity	303	1,766	636	181	2,885	7,154	10,039	29
Predictive	352	1,656	414	128	2,550	15,900	13,350	16
Affinity extended	303	1,964	1,422	183	3,872	8,369	12,241	32
Predictive extended	354	1,820	904	131	3,209	19,138	15,929	17

Conservation lands

GIS layer: Managed Areas FNAI 2017

Number of fox squirrel sightings (2011-2012) that occur on conservation lands for limited range area and extended range area

	Conservation							
Type	Local	State	Federal	Private	Total	Private	Total count	Percent on Conservation
Professional	28	310	40	27	405	498	903	45
Citizen	30	225	86	16	357	2,421	2,778	13
Total	58	535	126	43	762	2,919	3,681	21
Professional extended	30	369	44	27	470	554	1,024	46
Citizen extended	31	266	114	16	427	2,615	3,042	14
Total extended	61	635	158	43	897	3,169	4,066	22

Urban growth

GIS layer: FL 2060 growth

Area (km²) of potential habitat models (2016) potentially lost to urban growth for limited range area and extended range area

Model	Total area	2020 area lost	2020 % loss	2040 area lost	2040 % loss	2040 cumul. area lost	2040 cumul. % loss	2060 area lost	2060 % loss	2060 cumul. area lost	2060 cumul. % loss
Affinity	10,039	567	6	802	8	1,369	14	826	8	2,194	22
Predictive	15,900	1,867	12	1754	11	3,621	23	1,272	8	4,893	31
Affinity extended	12,241	627	5	878	7	1,506	12	900	7	2,406	20
Predictive extended	19,138	2,082	11	1,977	10	4,059	21	1,453	8	5,512	29

Urban growth

GIS layer: FL 2060 growth

Number of fox squirrel sightings (2011-2012) potentially lost to urban growth for limited range area and extended range area

Model	Total number	2020 num lost	2020 % loss	2040 num lost	2040 % loss	2040 cumul. num lost	2040 cumul. % loss	2060 num lost	2060 % loss	2060 cumul. num lost	2060 cumul. % loss
Professional	903	40	4	52	6	92	10	65	7	157	17
Citizen	2,778	229	8	199	7	428	15	611	22	1,039	37
Total	3,681	269	7	251	7	520	14	676	18	1,196	32
Professional extended	1,024	40	4	55	5	95	9	67	7	162	16
Citizen extended	3,042	238	8	208	7	446	15	617	20	1,063	35
Total extended	4,066	278	7	263	6	541	13	684	17	1,225	30

APPENDIX 4. Peer Reviews of Independent Scientists

Evaluation of the Biological Status Review of the Sherman's Fox Squirrel
in Florida

Peter D. Weigl
Professor of Biology Emeritus
Wake Forest University
Winston-Salem, NC 27109
336 758-5314; 336 924-4021

October 4, 2017

Biological Status Review of the Sherman's Fox Squirrel in Florida

General

This BSR is a significant document with far-reaching implications. It summarizes much of the biology of this subspecies, provides an outstanding bibliography (beyond the literature cited), and points to some of the problems associated with studies of such a relatively rare and widely dispersed tree squirrel in the Southeast. While I tentatively agree with the final delisting conclusion of the Executive Summary on the basis of recent survey work, I have some concerns about scope of the biology described and the probability of the fox squirrel's future conservation.

My interest in this work – and perhaps my peculiar point of view – stem from over 50 years of research on the ecology, behavior, and energetics of a number of squirrel species and over 15 years of field, laboratory and comparative morphological (museum) work on the fox squirrels of North Carolina and throughout the species range. Although I was fortunate to have worked with a number of dedicated graduate students, wildlife and forestry personnel, and people from other labs, I am painfully aware of the limitations of our research and thus have learned much from the BSR and the bibliography you have provided. Two of our major publications are listed among your reference material: Weigl et al., 1989 and Weigl et al., 1998; some of the rest are in papers cited by Greene et al. Many of my observations expressed in this review are drawn from this work. Also, in recent years, I have reviewed three delisting documents for squirrel species – one of which was for the Delmarva fox squirrel. I have at times been haunted by a sense of a rush to judgment for economic and political concerns rather than strictly biological considerations.

Biology

General information: The Sherman's fox squirrel is an especially significant subspecies of the Southeastern coastal plain. It is the largest tree squirrel in the western hemisphere and, with the other southeastern forms, displays the

greatest color polymorphism of any mammal in North America (Weigl, 1998). It is part of a reverse Bergmann size cline in the east, while those west of the Appalachians show typical Bergmann size variation (large in the north, smaller in the south). The unique size and many other characteristics of this fox squirrel are most likely a product of their adaptation to their primary or “ideal” habitat of longleaf pine- turkey oak, once the predominant forest type of the southeastern coastal plain. A fire maintained, old growth forest of large widely spaced pines with scattered oaks in the mid-story provides a small but adequate array of food sources as well as nesting sites. The reduced energy cost of thermoregulation in Florida, the patchy and often unpredictable food sources that require long distance travel along the ground, and the strength required to effectively handle to the large, heavy, green longleaf cones at a critical time of year may help explain the large body size of the fox squirrel (Weigl, 1989). Such a habitat would also tend to exclude the grey squirrel as a competitor since the smaller species is dependent on movement through the forest canopy. Given the above, the decline and fragmentation of mature pine-oak forest, the eradication of almost all oaks in commercial forests and plantations, and the replacement of longleaf with other pine species maintained on short rotations has often reduced prime habitat for the fox squirrel. As mentioned in the BSR, while fox squirrels are versatile enough to exploit human modified environments such as agricultural fields and forested developments and golf courses, they are especially vulnerable to roads and traffic and sometimes to free ranging dogs. Such areas are also often invaded by hardwoods favorable to large gray squirrel populations and the establishment of resident predators capable of taking fox squirrels.

Specific concerns:

1. Sherman’s fox squirrels have apparently been observed in most counties in Florida. How often and over what period was this survey work done and how many records consisted of breeding populations or just isolated individuals? What habitats were included?
2. Most studies listed in the bibliography were short term in nature and concentrated on especially good islands of habitat. How representative were

these forest areas of the state as a whole? Is there any evidence of a source/sink population structure - where there are centers of breeding activity and then one way dispersal to areas of little or no reproduction? There is virtually no new data on reproduction in general - a subject that reflects the condition of populations but would require longer study periods and the use of nest boxes or some other techniques.

3. Is there evidence in Florida of a mutualistic relationship between fox squirrels, longleaf pines and certain mycorrhizal fungi such as Elaphomyces, as has been observed in other parts of the range (Weigl, 1989)? This underground fungus forms a complex with longleaf roots, capturing water and minerals which are translocated to the tree, and produces a sporocarp (truffle) which is avidly dug up by the squirrel. The squirrel obtains energy and scarce minerals, but can't digest the spores. After eating the fungus the squirrel releases spores for several weeks and may inoculate pine seedlings in open or burned areas. (longleaf pine regeneration has been a problem in many parts of the Southeast.) Our behavioral studies and chemical analyses of the sporocarps reveal that the fungus releases a steroid odorant which allows its detection by the squirrel. This whole mutualism parallels the famous truffle, oak, pig phenomenon in Europe.

Threats

1. End of monitoring. Once this subspecies is delisted, will there be any further surveys and state supported studies of these animals? Working with these squirrels is expensive, time consuming and demanding of wildlife personnel. There are always other species in need of study, and it is easy to forget those already reviewed, even as significant environmental conditions change. This could lead to a lack of awareness of future range contraction.

2. Loss of habitat. While there are estimates of only limited land use changes well into the future, these may be too optimistic. Florida is a mecca for land development for retirement communities, plantations, shopping centers, and general growth, especially within a short drive to some body of water. Because of

the vast profits and local tax revenues involved, this development is often rapid, government-driven, and unstoppable, with dire implications for wildlife. Protection of forest lands and the propagation of longleaf-oak woodlands in commercial forests needs to be aggressively pursued. Good pine-oak land supports vast food webs of vertebrates and many popular game species, and this may help with conservation efforts. In fact, the fox squirrel may be a good indicator species for the health of Florida's forests.

22 October 2017

Florida Fish and Wildlife Conservation Commission
1239 SW 10th Street
Ocala, FL 34471

Dear Colleagues:

I have completed my review of the Biological Review Group's (BRG) "Sherman's Fox Squirrel Biological Status Review Report" and outline my thoughts in the remainder of this letter. I am a Professor of Wildlife Conservation and Management at the University of Arizona and specialize in the management and conservation of rare vertebrates, especially squirrels. I first studied fox squirrels as a graduate student in 1983 and have continued to investigate the ecology and conservation of squirrels continuously over the subsequent 34 years resulting in more than 120 peer-reviewed scientific papers on this taxonomic group. I have long been fascinated by and thus have remained familiar with the ever-growing body of scientific literature on the group. While I know that I still have much to learn and thus continue my studies, I believe that I have accrued a significant amount of expertise on the ecology and conservation of squirrels that facilitates my critical review. I am happy to share my thoughts based upon my review of the literature and the BRG's Status Review Report.

I find the review of the biology and conservation status of Sherman's fox squirrels by the BRG to be thorough and well-reasoned. The BRG is composed of an extremely knowledgeable and diverse group of highly respected biologists with expertise in the region that further informed the decisions of the group. The literature review is quite thorough and includes all of the major works from the published and 'gray' literature. I am currently the IUCN Red List North American Coordinator for Small Mammals and the BRG's interpretation of the *Guidelines for Application of the IUCN Red List Criteria at Regional Levels (Version 4.0)* and *Guidelines for Using the IUCN Red List Categories and Criteria (Version 13)* is appropriate and consistent with my own knowledge of these protocols.

The Biological Status Review examines 5 critical criteria to determine if the Sherman's fox squirrel should be listed as Threatened within Florida. These 5 criteria are: a. Population Size Reduction, b. Geographic Range, c. Population Size and Trend, d. Population Very Small or Restricted, and e. Quantitative Analyses. The review concludes that compelling evidence does not exist to support listing based upon any of these 5 criteria. I concur with this conclusion for I do not find sufficient support to determine that Sherman's fox squirrels are experiencing reduction in population size or geographic range, nor is there evidence of population decline or small extant populations, and quantitative analyses do not suggest the need for concern.

My minor concerns with the review involve a few issues that do not change my thinking but I believe are noteworthy:



1. The reference to Sherman's fox squirrels as 'adaptable' is not recommended for use in the future. Firstly, the term 'adapt' has a very specific meaning in biology that infers an improvement of function in the face of natural selection. Data to justify this word usage are simply not available. The fact that Sherman's fox squirrels are able to use and persist in a diversity of habitats is clear but is not to be considered evidence of adaptation to the habitat and landscape changes in a scientific sense.
2. I do find the arguments compelling that the PVA, even if repopulated with more recent data, would not indicate a significant probability of decline. However, an updated PVA would have provided these results. The lack of genetic differences among Sherman's and other southeastern fox squirrels (exclusive of Big Cypress fox squirrels) further allays any concern about population size, extent of occurrence/area of occupancy, and population trends in Florida.
3. The lack of peer-reviewed and published genetic data at the time of my review to support the minimal differentiation among the southeastern fox squirrels is unfortunate. Such lack of differentiation itself is a powerful fact in strong support of the BRG's final recommendation. These data are available in report form through the FWC and were considered by the BRG. The finding of minimal differentiation among the southeastern fox squirrel subspecies (exclusive of Big Cypress fox squirrels) would result in the Sherman's fox squirrel being subsumed into *S. n. niger*, which was described much earlier than *S. n. shermani*. Furthermore, they would extend the range, expand the extent of occurrence and area of occupancy, and substantially increase population size within Florida and the region. All of these provide considerable support for the BRG's recommendation.

None of these 3 minor criticisms causes me to doubt the conclusion reached by the BRG and I agree with their conclusion that Sherman's fox squirrel does not require or warrant listing as Threatened in Florida.

Thank you again for the opportunity to assist with the conservation of Florida's wildlife. If you have further questions do not hesitate to contact me.

Sincerely,



John L. Koprowski, Professor and Associate Director
School of Natural Resources & the Environment
N335 Environment and Natural Resources 2 Building
University of Arizona
Tucson, AZ 85721 USA

Email: squirrel@ag.arizona.edu Phone: (520) 626-5895

Web: www.ag.arizona.edu/research/redsquirrel



Dear members of the Biological Review Group,

It was a pleasure reviewing the Biological Status Review for the Sherman's fox squirrel. This review is rather brief, as I think the team members did an excellent job reviewing the literature and supporting the most recent research results. Overall, I agree with the outcome of the review, including that the subspecies does not meet any listing criteria and should not list it as State Threatened, and should be removed as a state listed Species of Special Concern. I also agree with the recommendation that the subspecies should not be included as a game mammal and legal hunting should not be considered until data are available that quantify where, when, and to what extent hunting should be permitted that won't affect the subspecies severely, especially to the extent that listing might be warranted. I had no substantial comments regarding the Findings, and agree that the Criterion/Listing Measures, Data/Information used, Data Types, Criterion met, and References used are appropriate.

I don't include many editorial comments since that was not requested, but the final draft does require several edits, including matching the references and literature cited (e.g., Tye et al. 2015, Barrett 2017 are missing). Additionally, I include the Turner and Laerm PDF in my e-mail so that document is available to the team, who included it as being cited in Wooding (1997).

Beyond the findings, I would suggest that the mention of Longleaf Pine be lessened to simply 'Pines'. This is important for many reasons, but the primary one being that there are numerous pine species that occur in the southeastern United States, and longleaf is not always the dominant pine within habitats occupied by Sherman's fox squirrel. In fact, the pine species is absent in many tracts of habitat where Sherman's fox squirrel occurs. This comment is particularly addressing the last paragraph on page 3, which says that "Longleaf pine seeds...the main food items...". Regardless of what the reference says, longleaf pine, and even turkey oak, are only dominant at certain sites. This is somewhat addressed later in the paragraph, but the first sentence is too specific.

In the middle of last paragraph on Page 4. Although it is clarified later, the paragraph that starts with "However, a recent genetic analysis..." should end with "in Florida". As written, it suggests that Sherman's, Bachman's, and southeastern fox squirrels are not differentiated anywhere in their range, which was not assessed in that study. Also, I recommend that the use of 'southeastern' be changed to 'southern' when referencing that subspecies; although that subspecies is often named 'southeastern' in the literature in addition to 'southern', the term 'southeastern' is commonly used to describe the group of multiple subspecies occurring in the region.

If anything is unclear, or you wish to discuss further, please don't hesitate to contact me.

Best,
Daniel Greene

Daniel U. Greene, Ph.D.
Wildlife Scientist, Environmental Research South
Weyerhaeuser Company
Southern Timberlands Technology
P.O. Box 2288, Columbus, MS 39704
Office: 662-245-5220; Cell: 850-890-9360

From: [Kellam, John](#)
To: [Imperiled](#)
Cc: [Tucker, Melissa](#); [Sunquist, Claire](#)
Subject: John Kellam_Sherman"s fox squirrel BSR peer review.
Date: Monday, October 23, 2017 9:13:07 PM

Although the Biological Review Group (BRG) found that the Sherman's fox squirrel (SFS, *Sciurus niger shermani*) did not meet sufficient International Union for Conservation of Nature (IUCN) listing criteria to warrant being listed as a Threatened species, due to the lack of population/demographic data and increasing threats (e.g., habitat fragmentation, degradation [including exclusion of fire], and loss, and road mortality), I urge the Florida Fish and Wildlife Conservation Commission (FWC) to maintain the SFS as a Species of Special Concern (SSC) until these information gaps are filled and their population viability status known.

The 2011 BRG (after finding that the SFS did not meet IUCN listing criteria) expressed concerns about the adequacy of the data used to make their determination (including area of occupancy, recent trends, and population size) which resulted in FWC staff recommending that the SFS be maintained as a SSC until additional data could be collected (FWC 2011).

Although new SFS information has been collected—including: (a) state-wide surveys and landscape-level research that provide a clearer extent of occurrence and documentation of SFS in a variety of landscape types in Florida (Tye et al. 2016, Greene and McCleery 2017a); (b) two reliable SFS density estimates (based on modern methodological/analytical approaches) at 2 Florida locations within sandhill and mesic flatwood habitat (Greene and McCleery 2017b); and (c) recent genetic analysis that suggests the range of SFS in Florida is larger than previously thought (Greene et al. 2015), important SFS demographic information necessary to make reliable population viability analysis models (e.g., fecundity, adult and juvenile survival, dispersal, and reliable density estimates outside of sandhill or natural pine savannas [including altered landscapes, e.g., developed, agriculture] across the subspecies range) are unknown. In addition, due to a lack of occupancy data, the area of occupancy is largely unknown.

Therefore, I recommend a conservative approach to the management of the SFS, and following the precautionary principle (Cooney and Dickson 2005), encourage the FWC to support ongoing research and keep the SFS listed as a SSC until information gaps are filled and evidence suggests otherwise.

Reference

Cooney, R., and B. Dickson. 2005. Biodiversity and the precautionary principle: Risk and

uncertainty in conservation and sustainable use. Earthscan, London. 314 pp.

Florida Fish and Wildlife Conservation Commission (FWC). 2011. Sherman's Fox Squirrel Biological Status Review Report, March 31, 2011. Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida. 15 pp.

Greene, D.U., Boone, W. and R.A. McCleery. 2015. Conservation of Florida's Fox Squirrels. Final Report to Florida Fish and Wildlife Conservation Commission. 191 pp.

Greene, D.U., and R.A. McCleery. 2017a. Multi-scale responses of fox squirrels to land-use changes in Florida: Utilization mimics historic pine savannas. *Forest Ecology and Management* 391:42-51.

Greene, D.U., McCleery, R.A., 2017b. Reevaluating fox squirrel (*Sciurus niger*) population declines in the southeastern United States. *Journal of Mammalogy* 98:502-512.

Tye, C. A., R. A. McCleery, R. J. Fletcher, D. U. Greene and R. S. Butryn. 2016. Evaluating citizen vs. professional data for modelling distributions of a rare squirrel. *Journal of Applied Ecology*. doi: 10.1111/1365-2664.12682.

--

John Kellam

Wildlife Biologist

Red Cliffs National Conservation Area

Beaver Dam Wash National Conservation Area

Bureau of Land Management, St. George Field Office

345 East Riverside Drive, St. George, Utah 84790

Office: (435) 688-3333, Cell: (239) 588-0603

Micah W. Perkins
Owensboro Community and Technical College
4800 New Hartford Road
Owensboro, Kentucky 42303
(270) 686-4610
Email: micah.perkins@kctcs.edu
October 20, 2017

Dear Commissioners of the Florida Fish and Wildlife Conservation Commission:

I have been asked to serve as an independent peer reviewer of the Sherman's Fox Squirrel (*Sciurus niger shermani*) Biological Status Review Report. To give my expertise on the subject, I have two peer-reviewed scientific articles on Sherman's fox squirrel biology in which these articles have been cited by 64 other research studies.

After review of the biological status review, I concur with the findings of the Biological Review Group indicating that the Sherman's fox squirrel should be removed as a Species of Special Concern by the State of Florida. The review report has adequate data interpretations, reasonable assumptions and incorporated a wealth of relevant literature on the topic. However as Sherman's fox squirrel habitat has declined through time, the Florida Fish and Wildlife Conservation Commission will need to monitor and manage open understory pine savannahs for maintaining squirrel populations.

As a wildlife ecologist and conservation biologist, I strive to protect and understand wildlife and their habitats but I support the Biological Review Group's decision of delisting Sherman's fox squirrel from being a Species of Special Concern as this species did not meet any listing criteria. Please let me know if you have any questions about my decision on this matter.

Sincerely,



Micah W. Perkins, Ph.D.
Professor of Biology
Owensboro Community and Technical College

