Species Status Assessment

Florida Scrub-Jay (*Aphelocoma coerulescens*)

Version 1.0

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LIST OF ACRONYMS AND ABBREVIATIONS

The following abbreviations are found throughout this document:

ABS	Archbold Biological Station
ac	acre(s)
AOU	American Ornithologists' Union
C	Celsius
CFR	Code of Federal Regulations
cm	centimeter(s)
ed(s).	editor(s)
e.g.	for example
ESA	Endangered Species Act of 1973, as amended
et al.	and others
et seq.	and the following
F.A.C.	Florida Administrative Code
F	Fahrenheit
FNAI	Florida Natural Areas Inventory
FR	Federal Register
F.S.	Florida Statute
ft	feet
FWC	Florida Fish and Wildlife Conservation Commission
g	gram(s)
ha	hectare(s)
i.e.	that is
in	inch(es)
in litt.	in correspondence
km	kilometer(s)
m	meter
MBTA	Migratory Bird Treaty Act
Ma	mega-annum
mi	mile(s)
mm	millimeter(s)
NGO	Non-government organization
No.	number
NWRAA	National Wildlife Refuge System Administration Act
oz	ounce(s)
pers. comm.	personal communication
s.	section
unpubl.	unpublished
U.S.	United States
U.S.C.	United States Code
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
vs.	versus
yd	yard

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A. Introduction

The Species Status Assessment (SSA) Framework is an analytical approach to provide a consistent, integrated, conservation-focused, and scientifically robust assessment of a species' biological status to inform Endangered Species Act (ESA) decisions. The SSA is intended to provide a single source for species' biological information with the ability to update as needed. The SSA is not a decision document; rather, it provides biological information and scientific analysis to support decision-making processes.

The SSA process has three successive stages: 1.) document the species' life history and ecological relationships to provide the foundation for the assessment (best available information), 2.) describe and hypothesize causes for the species' current condition (diagnosis), and 3.) forecast the species' future condition (prognosis). The future condition refers to the species' ability to sustain populations in the wild under plausible future scenarios. The scenarios help explore the species' response to future environmental stressors and to assess the potential for conservation to intervene to improve its status. The SSA process incorporates modeling and scenario planning for prediction of extinction risk and applies the conservation biology principles of representation, resiliency, and redundancy to evaluate the current and future condition. The SSA results in a scientific report distinct from policy application, which contributes to streamlined, transparent, and consistent decision making and allows for greater technical participation by experts outside of the USFWS, for example by state natural resource agencies.

B. Status of Species

The only bird species endemic to Florida, the Florida Scrub-Jay was listed by the U.S. Fish and Wildlife Service (USFWS) as threatened on June 3, 1987 (52 FR 20719). The primary reason for the ESA listing was due to the continuous and substantial range-wide population declines attributed to habitat loss and habitat degradation. The USFWS approved the original *Florida Scrub Jay Recovery Plan* on May 9, 1990 (USFWS 1990). The recovery priority number (explained at 48 FR 43103-43105) for the species is 8C, indicating a moderate degree of threat, a high recovery potential, and conflicts with construction or other development projects. No critical habitat has been designated for this species.

C. Taxonomy and Description

1. Taxonomy

Florida Scrub-Jays (*Aphelocoma coerulescens*) are in the order Passeriformes and the family Corvidae. The Florida Scrub-Jay, which was originally named *Corvus coerulescens* by Bosc in 1795, was transferred to the genus *Aphelocoma* in 1851 by Cabanis. In 1858, Baird made *coerulescens* the type species for the genus and it was considered a subspecies (*A. c. coerulescens*). It regained recognition as a full species from the American Ornithologists' Union (AOU 1995) because of genetic, morphological, and behavioral differences from the other members of this group; the California Scrub-Jay (*A. californica*), the Island Scrub-Jay (*A. insularis*), and the Woodhouse's Scrub-Jay (*A. woodhouseii*) occur in western United States and Central America. The group name is retained for species in this complex; however, it is now hyphenated to "Scrub-Jay." Other jays of the same genus include the Transvolcanic Jay (*A. ultramarina*), the Unicolored Jay (*A. unicolor*), and the Mexican Jay (*A. wollweberi*) of Central America and southwest North America (AOU 2016).

2. Description

Florida Scrub-Jays are about 25 to 30 cm (10 to 12 in) long and weigh about 77 g (3 oz). They are similar in size and shape to Blue Jays (*Cyanocitta cristata*) but differ significantly in coloration (Woolfenden and Fitzpatrick 1996a). Unlike the Blue Jay, the Florida Scrub-Jay lacks a crest. It also lacks the conspicuous white-tipped wing and tail feathers, black barring, and bridle of the Blue Jay. The Florida Scrub-Jay's head, nape, wings, and tail are pale blue, and its body is pale gray on its back and belly. Its throat and upper breast are lightly striped and bordered by a pale blue-gray "bib" (Woolfenden and Fitzpatrick 1996a). Florida Scrub-Jay sexes are not distinguishable by plumage in the visible spectrum (Woolfenden and Fitzpatrick 1984); however, males and females have plumage dimorphism in the ultraviolet spectrum (Tringali and Bowman 2012). Males, on average, are only slightly larger than females (Woolfenden 1978). The sexes may be identified by the female-specific call of jays and relatives most often called the "rattle"; the phrase "hiccup" is most appropriate only for the Lake Wales Ridge populations, as elsewhere they actually do make more of a rattle (Woolfenden and Fitzpatrick 1984, 1986). Florida Scrub-Jays that are less than about five months of age are easily distinguishable from adults; their plumage is smoky grey on the head and back, and they lack the blue crown and nape of adults. Molting occurs between early June and late November and peaks between mid-July and late September (Bancroft and Woolfenden 1982). During late summer and early fall, when the first basic molt is nearly complete, fledgling Florida Scrub-Jays may be indistinguishable from adults in the field (Woolfenden and Fitzpatrick 1984). The wide variety of vocalizations of Florida Scrub-Jays is described in detail by Woolfenden and Fitzpatrick (1996b).

D. Species Needs - Life History and Ecology

1. Diet

Florida Scrub-Jays forage mostly on or near the ground, often along the edges of natural or man-made openings. They visually search for food by hopping or running along the ground beneath the scrub, or by jumping from shrub to shrub. Insects, particularly orthopterans and lepidopteran larvae, comprise the majority of the animal diet throughout most of the year (Woolfenden and Fitzpatrick 1984). Acorns are by far the most important plant food (Fitzpatrick et al. 1991). From August to November each year Florida Scrub-Jays harvest and cache thousands of oak acorns throughout their territory. Each Florida Scrub-Jay may cache 6,500 to 8,000 acorns per year (DeGange et al. 1989). Acorns are mainly cached by hammering into the sand, but are also stuffed into pine needle tufts, Spanish or ball moss, and palmetto fronds (Woolfenden and Fitzpatrick 1996b). Acorns are typically buried 1 to 2 cm (0.4 to 0.8 in) beneath the surface of bare sand in openings in the scrub during fall, and retrieved and consumed in winter and early spring. Other small nuts, fruits, and seeds also are eaten. Vertebrate prey items comprise a minority of the diet, but may include a wide array of species weighing up to 25 g. Notable vertebrate prey species documented for Florida Scrub-Jays on both the Lake Wales Ridge and the Atlantic Coastal Ridge include, green treefrog (*Hyla cinerea*), squirrel treefrog (*H. squirella*), green anole (*Anolis carolinensis*), brown anole (*A. sagrei*), Florida scrub lizard (*Sceloporus woodi*), six-lined racerunner (*Cnemidophorus sexlineatus*), black racer (*Coluber constrictor*), peninsula crowned snake (*Tantilla relicta relicta*), rough greensnake (*Opheodrys aestivus*), house mouse (*Mus musculus*), cotton mouse (*Peromyscus gossypinus*), oldfield mouse (*P. polionotus*), and Florida mouse (*Podomys floridanus*) (Woolfenden and Fitzpatrick 1984).

In suburban areas, Florida Scrub-Jays have a wide variety of supplemental foods and water available not only from bird feeders (peanuts, corn, and sunflower seeds) but also to include outdoor pet foods, garbage cans, compost piles, fruit and berry tress, hoses, irrigation pipes, etcetera. Unfortunately, instances of direct feeding occur along trails in parks, reserves, yards, and undeveloped private properties where people have often been observed providing peanuts to attract the birds. These artificial sources have been shown to have negative consequences on Florida Scrub-Jay demographics.

2. Social Structure

Florida Scrub-Jays have a social structure that involves cooperative breeding, a trait that the western North American populations of other Scrub-Jays species do not exhibit (Woolfenden and Fitzpatrick 1984). Florida Scrub-Jays live in groups ranging from two (a single mated pair) to large, extended families of up to eight adults and one to four juveniles. Surviving offspring typically delay breeding and remain with the breeding pair in their natal territory as “helpers” for at least one year after fledging, with some – especially males – remaining for as long as three years or more before becoming breeders. Pre-breeding numbers are generally reduced to a pair either with no helpers or with families of three or four individuals (a breeding pair plus one or two helpers).

Florida Scrub-Jays have a well-developed intrafamilial dominance hierarchy, with breeder males most dominant, followed by helper males, breeder females, and finally helper females (Woolfenden and Fitzpatrick 1977). Helpers participate in sentinel duties (McGowan and Woolfenden 1989), territorial defense, predator-mobbing, and the feeding of both nestlings (Stallcup and Woolfenden 1978) and fledglings (McGowan and Woolfenden 1990). The well-developed sentinel system involves having one individual occupying an exposed perch watching for predators or territory intruders. When a predator is observed, the sentinel Florida Scrub-Jay gives a distinctive warning call, and all group members seek cover in dense shrub vegetation (Fitzpatrick et al. 1991).

3. Territoriality

Florida Scrub-Jay pairs occupy year-round, multi-purpose territories (Woolfenden and Fitzpatrick 1984; Fitzpatrick et al. 1991, 1994). Territory size averages 9 to 10 ha (22 to 25 ac), with a minimum size of about 5 ha (12 ac). The availability of territories is a limiting factor for Florida Scrub-Jay populations. Because of this limitation, non-breeding adult males may remain at the natal territory as helpers for up to six years, waiting for either a mate or territory to become available (Woolfenden and Fitzpatrick 1996b). New territories are established several ways: by replacing a lost breeder on a territory (Woolfenden and Fitzpatrick 1984); through “territorial budding,” where a helper male becomes a breeder in a segment of its natal territory (Woolfenden and Fitzpatrick 1978); by inheriting a natal territory following the death of a breeder; by establishing a new territory between existing territories (Woolfenden and Fitzpatrick 1984); or through “adoption” of an unrelated helper by a neighboring family followed by resident mate replacement. Territories also can be obtained by colonizing suitable habitat in areas that were previously unsuitable after natural wildfires or following habitat restoration efforts (Thaxton and Hingtgen 1994).

4. Reproduction and Demography

To become a breeder, a Florida Scrub-Jay must acquire a territory and a mate. Evidence presented by Woolfenden and Fitzpatrick (1984) suggests that Florida Scrub-Jays are permanently monogamous. Behavioral evidence suggests, however, that monogamy is not obligate in Florida Scrub-Jays: both Quinn et al. (1999) and Schoech et al. (1996) documented examples of bigamy in which two different females laid eggs in the same nest. Instances of polygamy involving one male and two separately nesting females have also been reported in multiple Florida Scrub-Jay populations (Woofenden 1976; R. Mumme in Schoech et al. 1996), indicating that facultative deviations from social and genetic monogamy do occur in this species. Townsend et al. (2011) reported genetic monogamy dominated among Florida Scrub-Jays in all sites genotyped: 100% of the offspring sampled from the suburban site (144 offspring) and fragmented site (258 offspring) and 99.5% of offspring from the wildland site

(367 of 369 offspring) were produced monogamously. The pair retains ownership and sole breeding-privileges in their particular territory year after year. Courtship to form the pair is lengthy and ritualized, and involves posturing and vocalizations made by the male to the female (Woolfenden and Fitzpatrick 1996b). Copulation between the pair is generally out of sight of other Florida Scrub-Jays (Woolfenden and Fitzpatrick 1984). Age at first breeding in the Florida Scrub-Jay varies from 1 to 7 years, although most individuals become breeders between 2 and 4 years of age (Fitzpatrick and Woolfenden 1988). Persistent breeding populations of Florida Scrub-Jays exist only where there are scrub oaks in sufficient quantity to provide an ample winter acorn supply, cover from predators, and nest sites during the spring (Woolfenden and Fitzpatrick 1996b).

Florida Scrub-Jay nests are typically placed in shrubby oaks, at a height of 1 to 2 m (3.3 to 6.6 ft). *Quercus inopina* and *Q. geminata* are the preferred shrub on the Lake Wales Ridge (Woolfenden and Fitzpatrick 1984), and *Q. myrtifolia* is favored on the Atlantic Coastal Ridge (Toland 1991) and southern Gulf Coast. In suburban areas, Florida Scrub-Jays nest in the same evergreen oak species as well as in introduced or exotic trees; however, they construct their nests in a significantly higher position in these oaks than when in natural scrub habitat (Bowman et al. 1996). Florida Scrub-Jay nests are an open cup, about 18 to 20 cm (7.1 to 7.9 in) outside diameter, and 8 to 9 cm (3.1 to 3.5 in) inside diameter. The outer basket is bulky and constructed of coarse twigs from oaks and other vegetation, and the inside is lined with tightly wound palmetto or cabbage palm fibers. There is no foreign material as may be present in a Blue Jay nest (Woolfenden and Fitzpatrick 1996b).

Nesting is synchronous, normally occurring from 1 March through 30 June (Woolfenden and Fitzpatrick 1990; Fitzpatrick et al. 1994). On the Atlantic Coastal Ridge and southern Gulf Coast, nesting may be protracted through the end of July. In suburban habitats, nesting is consistently initiated earlier (March) than in natural scrub habitat (Fleischer 1996). Food supplementation studies have shown the importance of resources in the timing of reproduction and supplemented Florida Scrub-Jays breed earlier (Bowman and Woolfenden 2001; Schoech and Bowman 2001; Schoech et al. 2004, 2008). Other variables attributed to advanced egg laying in suburban areas include artificial lighting and temperature. Nesting failures are almost always caused by predation, most frequently by ground-based predators including eastern coachwhip (*Masticophis flagellum*), eastern indigo snake (*Drymarchon couperi*), yellow rat snake (*Pantherophis alleghaniensis*), corn or red rat snake (*Pantherophis guttata*), raccoon *(Procyon lotor*), and domestic cat (*Felis catus*) (Fitzpatrick et al. 1991; Schaub et al. 1992).

Clutch size ranges from one to five eggs, but is typically three or four eggs. Clutch size is generally larger (up to six eggs) in suburban habitats, and the birds attempt to rear more broods (Fleischer 1996). Double brooding by as much as 20% has been documented on the Atlantic Coastal Ridge and in suburban habitat within the southern Gulf Coast, compared to about 2% on the Lake Wales Ridge. Florida Scrub-Jay eggs measure 27.08 mm x 20.18 mm (1.1 to 0.8 in) [length x breadth] (Woolfenden and Fitzpatrick 1996b), and coloration "varies from a pea green to pale glaucous green, blotched and spotted with irregularly shaped markings of cinnamon rufous and vinaceous cinnamon, these being heaviest about the larger end" (Bendire 1895 *in* Bent 1946). Eggs are incubated for 17 to 18 days, and fledging occurs 16 to 21 days after hatching (Woolfenden 1974, 1978; Fitzpatrick et al. 1998). Only the breeding female incubates and broods eggs and nestlings (Woolfenden and Fitzpatrick 1984). Average production of young is two fledglings per pair (Woolfenden and Fitzpatrick 1990), and the presence of helpers improves fledging success (Mumme 1992). Offspring production is significantly higher for groups with helpers than without, but the increase clearly drops with greater than four helpers (Fitzpatrick and Bowman 2016). In long-term stable populations, annual productivity must average at least two young fledged per pair for a population of Florida Scrub-Jays to maintain long-term stability (Fitzpatrick et al. 1991).

Fledglings depend on adults for food for about 10 weeks, during which time they are fed by both breeders and helpers (Woolfenden 1975; McGowan and Woolfenden 1990). In optimal scrub, survival of Florida Scrub-Jay fledglings to yearling age class averages about 33%. Survival of nonbreeders between ages 1 and 2 years is about 81% for males, which tend to remain in their natal territory, but only 65% for females, which engage in frequent dispersal forays (Woolfenden and Fitzpatrick 1996b). Annual survival of breeding adult males and females is equal and averages around 78% (Woolfenden and Fitzpatrick 1996b). Figure 1 illustrates the Florida Scrub-Jay life cycle.

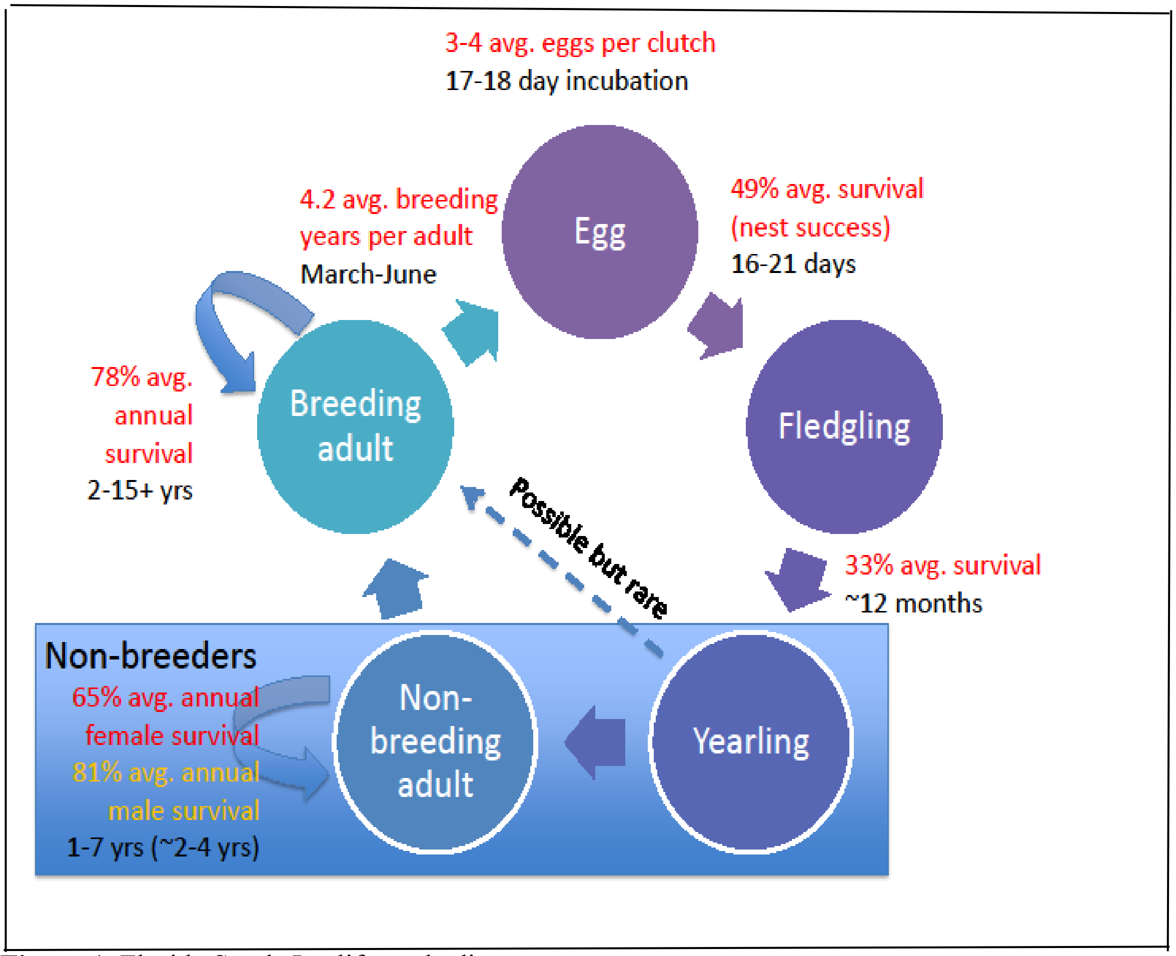

Figure 1. Florida Scrub-Jay life cycle diagram.

Based on data from Archbold Biological Station (ABS), the modal age of breeders is 3 years, median age is roughly 5.5 years, and 20% of breeders are older than 10 years (Woolfenden and Fitzpatrick 1984). The maximum observed lifespan of a Florida Scrub-Jay at ABS is 15.5 years (Woolfenden and Fitzpatrick 1996b). Additional lifespan longevity examples include: a Florida Scrub-Jay banded at Avon Park Air Force Bombing Range in April of 1993 that was last observed in April of 2009 (M. Dent pers. comm.) and a Florida Scrub-Jay from Cape Canaveral Air Force Station banded as a juvenile in June of 2001 (mostly likely hatched in April) that was recaptured in March of 2018 (A. Chambers, R. Brust pers. comm.).

Data from ABS, however, suggest that survival and reproductive success of Florida Scrub-Jays is substantially lower under sub-optimal habitat conditions (Woolfenden and Fitzpatrick 1991) (Table

1). The data help explain why local populations inhabiting unburned, late successional habitats become extirpated.

Similarly, data from Indian River County show that mean annual productivity declines significantly in suburban areas. Toland (1991) reported that productivity averaged 2.2 young fledged per pair in contiguous optimal scrub, 1.8 young fledged per pair in fragmented moderately developed scrub, 1.2 young per pair fledged in highly fragmented suboptimal scrub, and only about 0.5 young per pair in residential lawns. Overall nest success (probability of fledging at least one young) is about 50% on the Lake Wales Ridge and about 70% on the Atlantic Coastal Ridge in Indian River County.

Table 1. Mean survivorship and reproduction of Florida Scrub-Jays in several habitats at Archbold Biological Station, 1969-86 (taken from Woolfenden and Fitzpatrick 1991).

	Optimal Habitat	**Suboptimal Habitat**		
	Periodically burned, open oak scrub	Unburned, overgrown scrubby flatwoods	Unburned southern ridge sandhill (slash pine-turkey oak	Mature citrus bordering unburned scrub
N (pair-years)	429	74	8	21
Seasonal nest attempts	1.38 (593/429)	1.49 (110/74)	1.50 (12/8)	1.11 (20/18)
Fledglings/pair	1.97 (843/429)	1.58 (117/74)	1.38 (11/8)	2.00 (38/18)
Independent young/pair	1.17 (500/429)	0.80 (59/74)	1.13 (9/8)	1.56 (28/18)
Yearlings/pair	0.60 (259/429)	0.36 (27/74)	0.50 (4/8)	0.61 (11/18)
First-year survival	0.307 (259/843)	0.231 (27/117)	0.364 (4/11)	0.289 (11/38)
Breeder survival	0.789 (697/883)*	0.723 (107/148)	0.688 (11/16)	0.619 (26/42)
Expected lifetime success/individual				
Breeding seasons	4.4	3.5	3.2	.6
Fledglings	4.3	2.8	2.2	2.6
Independent young	2.6	1.4	1.8	2.0
Yearlings	1.3	0.6	0.8	0.8

*N=883 breeder years for calculating breeder survival

5. Dispersal

Florida Scrub-Jays are nonmigratory, extremely sedentary, and permanently territorial. Most juveniles remain in their natal territory for at least one year and males may remain as helpers for up to seven years before dispersing to become breeders (Woolfenden and Fitzpatrick 1996b). The length of time Florida Scrub-Jays remain helpers in their natal territories is influenced by many factors including sex, age, breeding opportunities, and mate availability (Breininger et al. 2010).
Florida Scrub-Jay dispersal behavior is affected by the intervening landscape matrix. Protected scrub habitats will most effectively sustain Florida Scrub-Jay subpopulations if they are located within a matrix of surrounding habitats that can be utilized and traversed by Florida Scrub-Jays. Brushy

pastures, scrubby corridors along railway and country road rights-of-way, and open burned flatwoods provide travel corridors for colonization among local Florida Scrub-Jay populations.

Once they pair and become breeders, generally within two territories of their natal territory, they are essentially sedentary for the remainder of their lives (Woolfenden and Fitzpatrick 1984). Natal dispersal events greater than the equivalent of five territories are rare. The species' social structure system dictates that long-distance dispersers even more rarely become breeders (Fitzpatrick et al. 1999). Females tend to disperse significantly farther than males: the maximum documented dispersal distance for females is 60 km (37 mi) versus 13 km (8 mi) for males (unpubl.). Dispersal distances are greater in fragmented habitat versus in continuous landscapes. Individual Florida Scrub-Jays may disperse farther as fragmentation increases, but those that do so are less successful as breeders than those that disperse shorter distances.

Stith et al. (1996) suggest that a dispersal distance of 8 km (5 mi) is close to the biological maximum for Florida Scrub-Jays. In suitable habitat, fewer than 5% of Florida Scrub-Jays disperse more than 8 km (5 mi) (Fitzpatrick et al. 1998). A 12 km (7.5 mi) isolation threshold was inferred from the landscape distribution of occupied territories: occupancy of suitable habitat drops to near zero when distance to nearest occupied patch exceeds 12 km, suggesting that dispersal beyond this is rare and demographically unimportant. To date, all dispersals over 12 km have involved birds passing through a landscape mosaic that includes scrub-habitat "stepping stone" patches no greater than 12 km apart (Coulon et al. 2008).

In suburban habitats, average dispersal distances for Florida Scrub-Jays is much greater than in natural habitat (Thaxton and Hingtgen 1996, Breininger 1999). In their study, these authors also noted that no dispersals were made from preserves to suburban territories, and attributed this to habitat degradation. Table 2 provides estimated distances moved during natal dispersal to breed for Florida Scrub-Jays across different habitat types.

Table 2. Dispersal distances of Florida Scrub-Jays in relation to habitat type (Fitzpatrick et al. 1998).

Habitat Type	Normal Dispersal Distance (km)	Maximum Dispersal Distance (km)
Open water	2	2
Urban areas	2	2
Dense pine forest	2	3
Unbroken, open pasture	3	7
Cropland	3	7
Unbroken citrus groves	5	8
Densely wooded suburbs	5	8
Suburbs with few trees	5	13
Flatwoods	5	17
Broken pasture, fence rows, roadsides	8	24
Overgrown scrub with some clearings	8	24

* Normal dispersal distances (> 95% of those observed) are 8 km (5 mi) or less.

6. Relationship to Other Species

Because Florida Scrub-Jays are endemic to oak scrub habitat in peninsular Florida, they occur with many other species also endemic to this community type. As mentioned previously, the Florida Scrub-Jays are dependent upon evergreen oaks in the scrub. This oak scrub habitat supports at least 21 federally listed plant species on the Lake Wales Ridge and at least two others on the Atlantic Coastal Ridge. The threatened blue-tailed mole skink (*Plestiodon lividus*), sand skink (*Plestiodon reynoldsi*), eastern indigo snake (*Drymarchon couperi*), and state-listed gopher tortoise (*Gopherus polyphemus*) occur on the Lake Wales Ridge.

Florida Scrub-Jays occasionally interact with Blue Jays in scrub and scrubby flatwoods habitats. Blue Jays dominate Florida Scrub-Jays in trees, while Florida Scrub-Jays dominate Blue Jays on or near the ground (Fitzpatrick pers. comm.). It has been suggested that the presence of Blue Jays may limit use of woodland habitat by Florida Scrub-Jays; however, Brian Toland observed successful fledging by both species nesting in close proximity to one another in Indian River, Polk, and Brevard counties. He also reports that in all cases, Florida Scrub-Jays were dominant over Blue Jays in agonistic encounters.

There are relatively few predators that prey on adult Florida Scrub-Jays; however, the most dangerous native predators on adults are the Cooper's Hawk (*Accipiter cooperii*), Sharp-shinned Hawk (*A. striatus*), Merlin (*Falco columbarius*), Northern Harrier (*Circus cyaneus*), and Peregrine Falcon (*F. peregrinus*) in descending magnitude of threat. House cats and bobcats (*Felis rufus*) have been documented to prey on Florida Scrub-Jays (Fitzpatrick et al. 1998). Predators of eggs and small young, in addition to the aforementioned species include snakes (eastern coach whip, eastern indigo snake, corn snake and rat snake), birds (Great Horned Owl [*Bubo virginianus*], Blue Jays, crows [*Corvus spp.*], Eastern Screech Owl [*Otus asio*], and Red-Tailed Hawk [*Buteo jamaicensis*], and several mammals – especially raccoon (Fitzpatrick et al. 1998). Snakes, particularly yellow rat snakes (*Pantherophis alleghaniensis*) at Merritt Island National Wildlife Refuge, are deadly nocturnal nest predators of eggs and nestlings (Carter et al. 2007).

7. Disease

There is considerable evidence that Florida Scrub-Jays are susceptible to periodic epizootic outbreaks that lead to elevated mortality. The most recorded epizootic diseases in Florida Scrub-Jays are vector borne arboviruses. Antibodies to four viruses have been found: eastern equine encephalitis, St. Louis encephalitis, Highlands J encephalitis, and West Nile virus. At least four documented episodes of elevated mortality have occurred at ABS during the last 40 years. The most severe occurred from August 1979 to March 1980, in which almost half the breeding adults and all but one juvenile died (Woolfenden and Fitzpatrick 1984, 1990). This episode coincided with an outbreak of eastern equine encephalitis in Florida. In a study of 219 Florida Scrub-Jays sampled for antibodies from ABS during 1994 and 1995, 22.1% showed positive for eastern equine encephalitis, 15.5% positive for Highlands J encephalitis, and 1.9% for St. Louis encephalitis (Garvin et al. 2004), but no West Nile virus as it had not emerged in the U.S. at that time. Other researchers suggest that during 1997-98 continuing population declines of Florida Scrub-Jays along the Atlantic coast and in central Florida may have been augmented by an epidemic of unknown disease (Breininger 1999). The last elevated mortality event occurred July through August of 2008, and rapid funding from the National Science Foundation allowed immediate serology investigation of surviving Florida Scrub-Jays. Of the 76 Florida Scrub-Jays subsequently captured there was considerable evidence of circulating disease, the most common being eastern equine encephalitis (Table 3: Boughton and Bowman 2009). Unfortunately, during this study only antibodies were observed as all Florida Scrub-Jays had cleared viral infection by the time of sampling. Thus, the disease agent causing mortality remains unknown. A comparison of disease naïve cohorts from 2008 to 2009 showed that positive occurrences of antibodies against eastern equine encephalitis were considerably higher (50%) in 2008 than in 2009 documenting variation in exposure rates.

Table 3. Number of immediate post epidemic samples screened positive for four viruses (West Nile virus, WNV; St. Louis encephalitis, SLE; eastern equine encephalitis, EEE; and Highlands J virus, HJV) using plaque reduction neutralization tests.

	Flavivirus		Alphavirus	
Virus	WNV	SLE	EEE	HJV
Positive	4	11	64	2
Negative	72	65	12	74
Total	76	76	76	76
%Positive	5.26%	14.47%	84.21%	2.63%

These results also showed that diseases circulate within populations even in years of low mortality, suggesting that a more complicated scenario other than purely "exposure to disease" may be causing higher mortality events. In Florida Scrub-Jays, further investigation is warranted to study interactions among levels of exposure, density dependence, genetic susceptibility and harsh environmental conditions such as drought or food limitations in conjunction with disease. There is some evidence that differential selection occurs in Florida Scrub-Jays during epizootic events. A study on 32 breeding male Florida Scrub-Jays found that body condition and an innate immune response measured several months before the 2008 epidemic were both significantly lower in individuals that died during the epidemic (Wilcoxen et al. 2010).

The range-wide effects of disease have probably been underestimated because past disease outbreaks have only been observed in relatively large populations that are regularly monitored (e.g., ABS and some Brevard County populations). A serology survey of samples collected from populations of Florida Scrub-Jays across Florida show that eastern equine encephalitis is ubiquitous and found in all populations ranging from 5-95% positive (Boughton pers. comm.). Many populations have been exposed to West Nile virus and Highlands J encephalitis, and positive serology for St Louis encephalitis is relatively rare. Nonetheless, ongoing monitoring of epizootic-affected populations indicates that large Florida Scrub-Jay populations are capable of rebounding from these periodic mortality events. Smaller populations, especially those in poor quality habitat may take longer to recover or may not recover at all and may be increasingly susceptible to extirpation from stochastic events and/or poor demographic performance common in small populations.

Although large-scale epizootic events rapidly capture our attention, other parasites have been recorded in Florida Scrub-Jays. With increasing levels of stress on individuals from habitat degradation, smaller populations and lower genetic diversity (assuming the lower genetic diversity translates to lower physiological immunity), the ability of populations to deal with various parasites could possibly change. The endoparasites include at least 15 species of helminth of which 6 genera are described as being common in Florida Scrub-Jays (*Brachylecithum, Microtetrameres, Dispharynx, Oxspirura, Cardiofilaria, Mediorhynchus*; Kinsella, 1974). Kinsella (1974) describes *Dispharynx nasuta* a nematode worm as the most worrisome, as it was found in two emaciated hatch year birds that died in a few hours. The hatch year birds, 98 and 99 days of age, had 28 and 30 worms respectively (Forrester and Spalding 2003). All 35 adults and 5 fledglings in Kinsella (1974) were infected with at least one helminth but not one of 5 nestlings. Although very understudied, it is likely that many parasites have their most negative effect on juvenile Florida Scrub-Jays as this is when first exposure occurs. Currently ongoing studies are investigating the role of *Cardiofilaria inornata*, a nematode worm with a blood swimming filarid that is transferred by hematophagous insects, probably mosquitoes. This species infects a high proportion of Florida Scrub-Jays at ABS (>60%) and breeding birds showing filarids in the blood stream produce less young that those with no filarids (Boughton pers. comm.). Other blood protozoan at lower proportions include *Trympansoma avium* (19%), *Haemoproteus danilewskyi* (<1%), *Haemoproteus picae* (rare), *Leucocytozoon sakharoff* (<2%), *Plasmodium cathemerium* (rare; Woolfenden and Garvin 2000), and one intestinal protozoan (*Isospora sp*.)(Boughton unpubl.).

The ectoparasites recorded on Florida Scrub-Jays include dipteran (fly) larvae (*Philornis porteri*), ticks (*Amblyomma americanum, Amblyomma maculatum, Amblyomma tuberculatum, Ixodes scapularis, Haemaphysalis leporispalustris*), chiggers (*Eutrombicula lipsjyana* and *E. alfreddugesi*), feather mites (*Pterodectes sp.*), chewing lice (*Menancanthus eurysternus, Myrisdea sp.*, *Philopterys sp.*), and fleas (*Echidnophaga gallinacea*) (Forrester and Spalding 2003; Woolfenden and Fitzpatrick, 1996; Woolfenden and Garvin 2000; Boughton et al. 2006). Prevalence for some of these ecto-parasites is known only from short snapshots of a year or less: *Myrsidea sp.* 27% (76 of 279) prevalence, *Pterodectes sp.* 33% (69 of 212) prevalence, ticks on 18% of Florida Scrub-Jays (48 of 263) (Woolfenden and Garvin 2000). Chiggers are rare, and *Philornis porteri* larvae infection are irregular and of low intensity. The larvae are found in nares, mouth flanges, base of remiges, and toes, with no serious affects apparent (Woolfenden and Fitzpatrick 1996b). The introduced sticktight flea (*Echidnophaga gallinacea*) until recently had only been recorded once in 1973 on Florida Scrub-Jays. During 2004, an outbreak of fleas was observed around a point source in the southern part of ABS. Of the 81 Florida Scrub-Jays sampled 12 were infested in the soft tissue of the head with 1 to as many as 57 fleas. Subsequent survivorship and variation in health indices concluded that the sticktight flea caused the death of several Florida Scrub-Jays. Within 4 months 46% of sticktight flea-infested Florida Scrub-Jays died, whereas in the nonflea-infested Florida Scrub-Jays, only 5.9% died (Boughton et al. 2006). Fleas continued to be observed for several years. This study indicates that additional rapid disease outbreaks could occur in Florida Scrub-Jay populations.

8. Genetics

Although the Florida Scrub-Jay was only recently taxonomically split from other scrub-jays, divergence within the genus is of relatively ancient origin, probably occurring during the middle-late Miocene - Pliocene (3-8.5 Ma) (McCormack et al. 2011). Within the Scrub-Jay clade, the Florida Scrub-Jay is the sister taxon to all other Scrub-Jay species (Pitelka 1951, Peterson 1992, McCormack et al. 2011), diverging anywhere from 2.5 to 5 Ma. This suggests that cooperative breeding may be an ancestral trait among scrub-jays, and this character has been lost in other species or re-gained in some (e.g., *A. woodhouseii sumichrasti*) (Berg et al. 2012). Fossil evidence of Florida Scrub-Jays dates back to 1.9-2 Ma (Emslie 1996) supporting the phylogenetic estimate of divergence.

McDonald et al. (1999), in a comparative analysis of genetic structure of Western Scrub-Jays (mostly within the present range of *A. californica californica*) and Florida Scrub-Jays, confirmed the ancient divergence between these two sister species. They also found that Florida Scrub-Jays had lower genetic diversity, with fewer alleles, and greater among-population differentiation than in Western Scrub-Jays, either as a result of vicariant founder effects when Florida Scrub-Jays were isolated from their western cousins or the long-term effects of habitat fragmentation, both natural and anthropogenic. Importantly, using neighbor-joining trees, they found support for genetic similarities among disparate geographic regions, consistent with genetic evidence in other taxa (McDonald and

Hamrick 1996), and for which plausible biogeographic hypotheses exist showing historic habitat connections among these regions.

a. Metapopulations - The spatial configuration of Florida Scrub-Jay populations on a larger geographic scale is vital for both long-term survival and maintenance of genetic diversity regionally (Levins 1970, Gilpin 1987, Fitzpatrick et al. 1991). In 1992-93, an effort was made to survey all populations of Florida Scrub-Jays throughout their range. The resulting population estimates and maps of the spatial distribution revealed that Florida Scrub-Jay populations continued to decline throughout the 1980's and the distribution was highly fragmented, consisting of very few large and many small, and relatively isolated, populations (Fitzpatrick et al. 1994). These populations could be clearly aggregated into spatially-distinct clusters, known as metapopulations (Levins 1994).

The term metapopulation was coined by Richard Levins in 1969 to describe a model of population dynamics as he stated it consists of "a population of populations." A very simplified Florida Scrub-Jay metapopulation concept consists of a group of spatially separated distinct local populations living in the same defined geographic area that have the ability to interact through dispersal events typically less than 12 km (7.5 mi) of each other. The distance was determined from histograms of actual Florida Scrub-Jay dispersal data (Stith et al. 1996). Any one of the shaded areas in Figure 2 (conceptual representation) indicates a local population; collectively they represent a metapopulation. The generalized source-sink labels represent the habitat quality's influence on the population, which is explained in the Habitat Characteristics – Focal Habitat Patches section of the document.

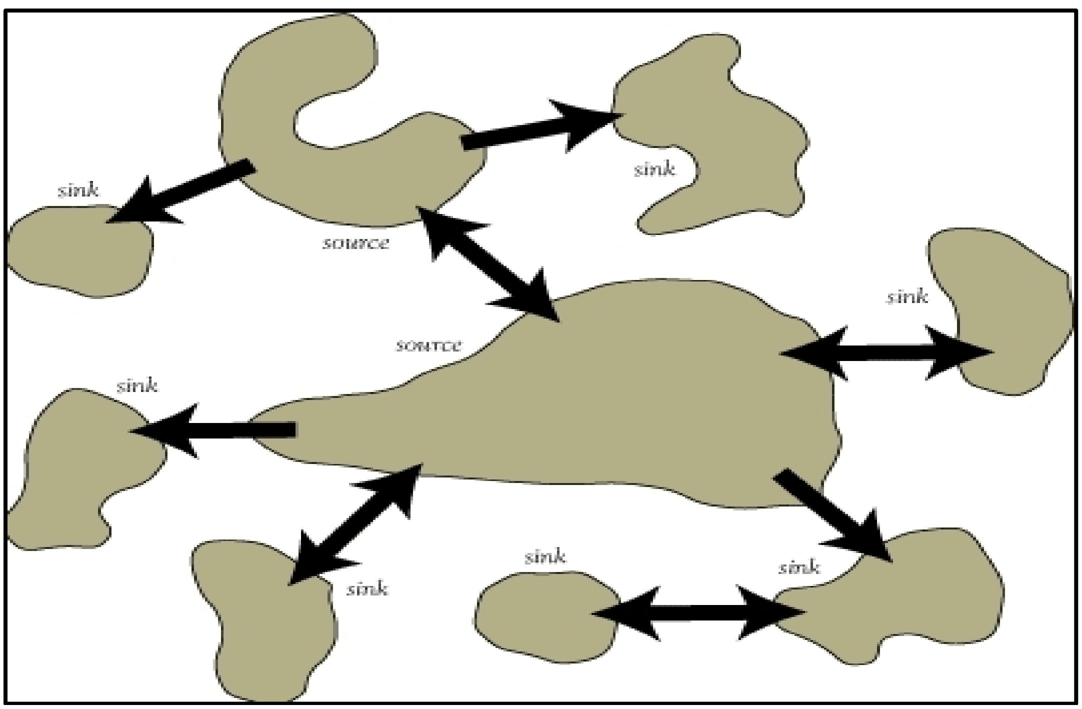

Figure 2. Florida Scrub-Jay generalized metapopulation concept

This dispersal-mediated measure of connectivity assumed individuals within metapopulations were linked by gene flow. Stith (1999) described 21 metapopulations and conducted viability analyses on each to determine relative extinction risks based on variable scenarios of habitat protection and management (Figure 3). These viability analyses suggested that the largest, most contiguous and least vulnerable (e.g., habitat under conservation-oriented management by public agencies or private organizations) metapopulations were at little risk, while small, fragmented metapopulations with little habitat protected in publicly-owned lands were very susceptible (Stith 1999). Assuming fully restored habitat (including additional acquisition and protection) with high occupancy rates, results of simulations indicated that 16 of the 21 metapopulations had a moderate or high risk of quasi-extinction (the probability of a Florida Scrub-Jay metapopulation falling below 10 pairs in 60 years), though the risk of quasi-extinction could be improved for 13 of the metapopulations through increased habitat acquisition and restoration (Stith 1999). In fact, three small, fragmented metapopulations had 100 percent chance of both quasi-extinction and extinction given the existing amount and distribution of currently protected habitat. For four of these metapopulations, these modeling projections have subsequently been confirmed with anecdotal and quantitative data indicating that the Levy (northwest coast) metapopulation and Lee (southwest coast) metapopulation have declined to quasi extinction levels and Flagler-Northeast Volusia (northeast coast) metapopulation and the South Palm Beach (southeast coast) metapopulation have been extirpated.

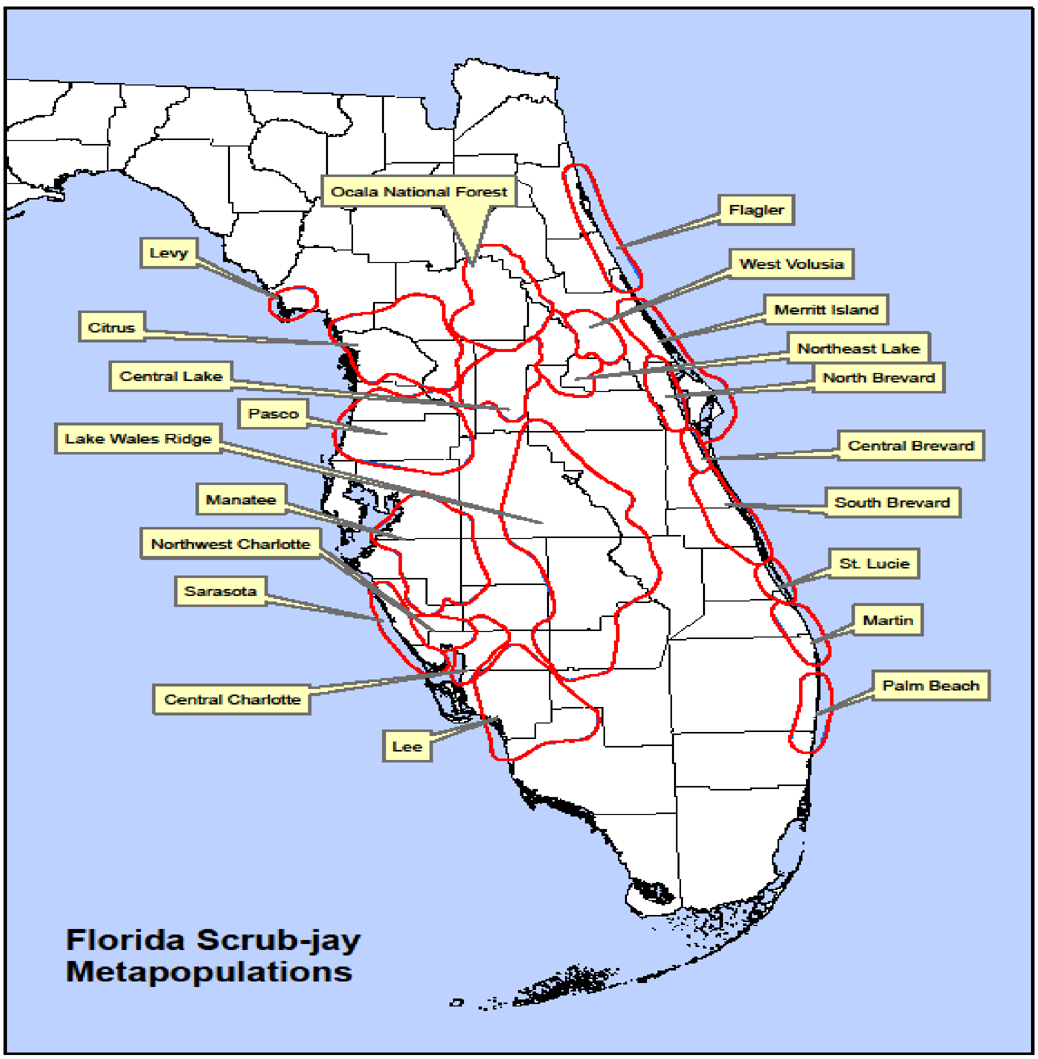

Figure 3. Florida Scrub-Jay Metapopulations (Stith 1999).

b. **Genetic Units** - In a series of papers Coulon et al. (2008, 2010, 2012) analyzed genetic structure and patterns of gene flow of Florida Scrub-Jays relative to metapopulations, habitat fragmentation, and gap width, based on genotyping over 1000 individuals from all 21 metapopulations at 20 microsatellite loci. Coulon et al. (2008) documented distinct genetic structuring throughout the extant range of the Florida Scrub-Jay. They described 10 genetic units, in which most individuals are more similar to other individuals within the genetic unit than to individuals in a different genetic unit (Figure 4).

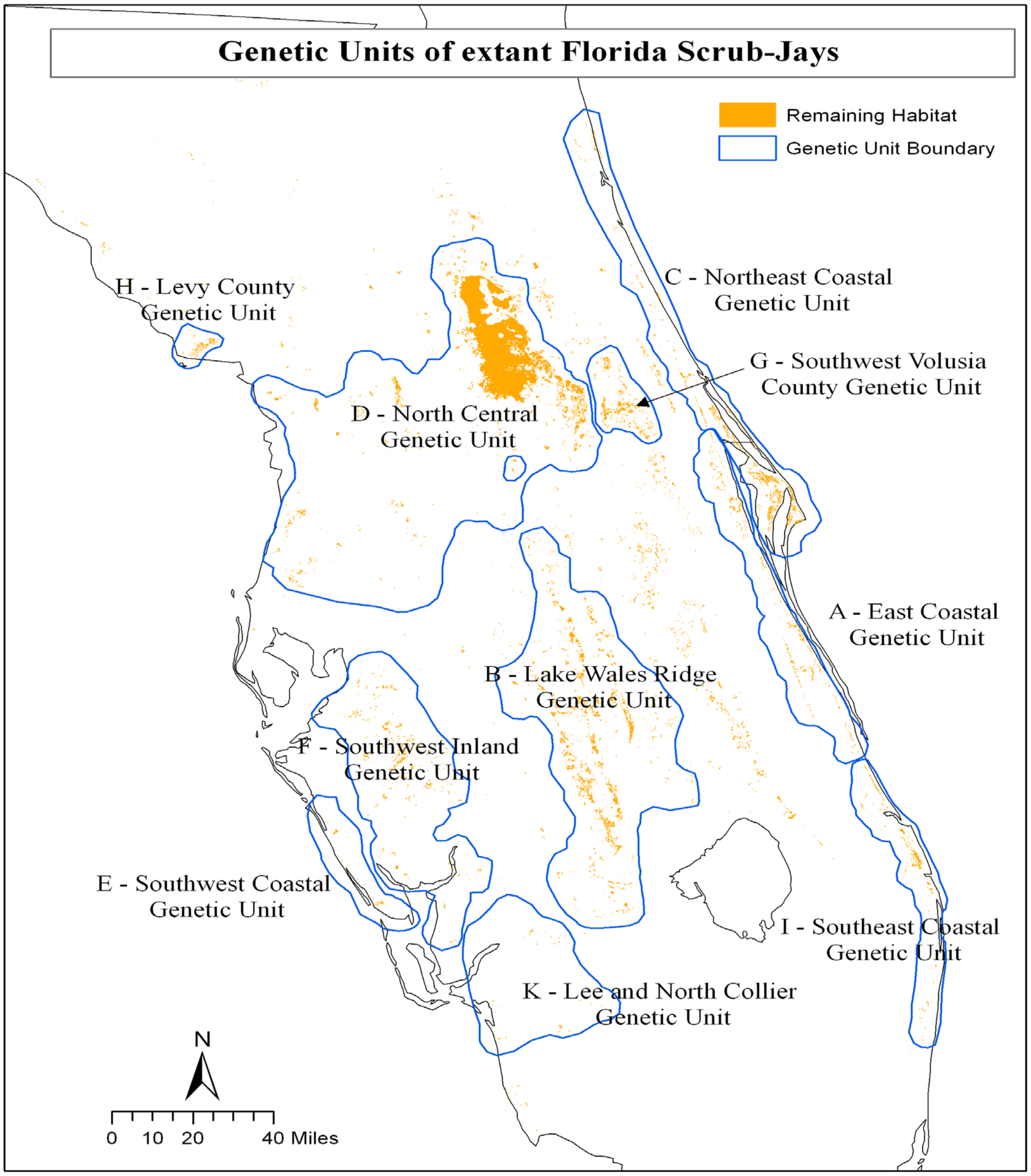

Figure 4. Genetic Units of Florida Scrub-Jays, adapted from Coulon and colleagues (2008).

The genetic units were congruent with metapopulations previously described by Stith et al. (1996) based on dispersal behavior: no metapopulations were split among different genetic units although some genetic units consisted of more than one metapopulation; likely because these genetically-similar metapopulations were only recently fragmented (Figure 5). Indeed, Coulon et al. (2008) remarked “the differences between metapopulations and the genetic units reflects the past existence of now extinct Florida Scrub-Jay populations, then the metapopulations of Stith et al. (1996) may be a good estimate of what the Florida Scrub-Jay genetic structure will be in the future," (i.e., greater differentiation among populations and more loss of genetic diversity). Already some genetic units of Florida Scrub-Jays show as much differentiation as between two closely-related species, the California Scrub-Jay and the Island Scrub-Jay.

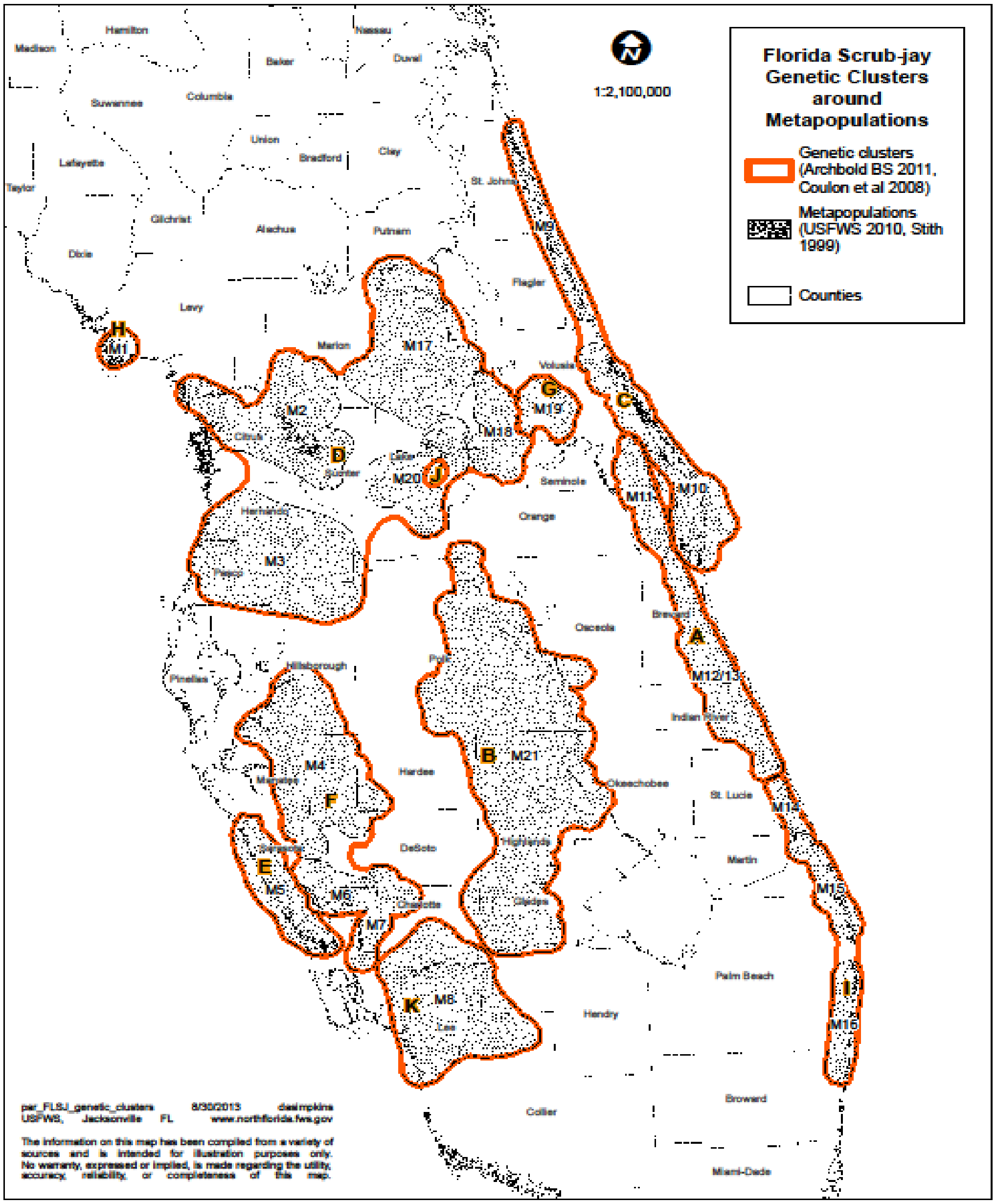

Figure 5. Florida Scrub-Jay metapopulations within genetic units.

Coulon et al.'s subsequent papers (2010, 2012) demonstrated the mechanisms by which fragmentation influences the genetic spatial structure. Habitat fragmentation forces Florida Scrub-Jays to disperse greater distances while actually traversing fewer Florida Scrub-Jay territories. However, effective dispersal distances (gene flow) actually decreases as fragmentation increases (Coulon et al. 2010), likely because birds that disperse greater distance have lower lifetime reproductive success (Fitzpatrick et al. 1999, Mumme et al. 2015, Fitzpatrick and Bowman 2016). In particular, the greatest impediment to gene flow is the width of the non-scrub gaps that separate habitat patches, rather than the geographic distance between those habitat patches (Coulon et al. 2012). These results suggest that fragmentation will always bear a cost, forcing birds to disperse farther and suffer reduced lifetime fitness. In addition, inbreeding is higher in fragmented habitat (Chen et al. 2016) and reduced gene flow decreases effective population sizes, thus potentially increasing the costs of inbreeding and genetic drift. However, protecting and managing stepping stones with existing corridors of appropriate habitat, and having small populations at carrying capacities can help mitigate these costs by facilitating effective dispersal.

E. Species Needs - Habitat Characteristics

1. Optimal Habitat Conditions

The natural communities (scrub and scrubby flatwoods) where Florida Scrub-Jays reside occur on relict dunes and sand ridges in peninsula Florida, primarily concentrated along both the Atlantic and Gulf coasts and on the central ridges (Laessle 1958, Davis 1967, Myers 1990). Florida Scrub-Jays need large, open landscapes of scrub habitat for long-term population persistence (Woolfenden and Fitzpatrick 1984, 1991). Modeling studies suggest that most habitat must be optimal for population recovery and that extinction risk declines rapidly between 10 and 100 breeding pairs if all habitat is optimal (Breininger et al. 1999). "Optimal" habitat is defined as a condition when reproductive success exceeds mortality. Optimal Florida Scrub-Jay landscapes need to include "focal" patches that have optimal characteristics within a "matrix" of habitat that does not lower the suitability of the focal patches.

2. Landscape Characteristics

The landscape attributes of optimal habitat can be described as low and open with low densities of pine trees (Woolfenden and Fitzpatrick 1984, 1991). Florida Scrub-Jays do not use forests and avoid areas near forests (greater than 65% tree cover; Breininger et al. 1995). Nest predation and more importantly juvenile survivorship are factors influencing the Florida Scrub-Jay's preference for landscapes dominated by frequently low, open recently burned scrub structure (Schaub et al. 1992, Breininger et al 1998, Fitzpatrick and Bowman 2016). Vegetation that characterizes open scrub allows Florida Scrub-Jays to monitor a large area while providing refuge and the opportunity for Florida Scrub-Jays to be inconspicuous in their activities.

The fragmentation of scrub landscapes results in an increase of woodlands and forests (Duncan et al. 1999). Disturbances related to human development, fire suppression, and other disruptions of natural fire patterns have made many edges of habitat fragments unsuitable for Florida Scrub-Jays (Breininger 1999, Breininger et al. 1998, 1999). Landscapes, fragmented by woodlands, forests, and tall shrubs, no longer allow Florida Scrub-Jays to scan large areas for predators that may be important for the Florida Scrub-Jay's visual sentinel system, which is adapted for predator detection (McGowan and Woolfenden 1989).

3. Focal Habitat Patches

Optimal Florida Scrub-Jay habitat occurs as focal patches with the following attributes (Breininger et al. 1998, Burgman et al. 2001):

(a) 10-50% of the oak scrub comprised of bare sand or sparse herbaceous vegetation;
(b) greater than 50% of the shrub layer comprised of scrub oaks;
(c) a mosaic of oak scrubs that occur in optimal height (1.2-1.7 m, 4-5.5 ft) and shorter;
(d) less than 15% pine canopy cover; and
(e) greater than 300 m (984 ft) from a forest.

Florida Scrub-Jays have adapted to frequent fires by defending large territories, thereby increasing the probability of having enough patches in optimal condition within a territory at any given time (Woolfenden and Fitzpatrick 1984, 1991; Breininger et al. 1995, Fitzpatrick and Bowman 2016). Oak scrub represents the potential focal habitat, but not all of it is necessarily in optimal condition at the same time. Patches of oak scrub vary in quality depending on the time since fire. Florida Scrub-Jay mortality exceeds reproductive success where there are no patches of oaks at optimal height (1.2-1.7 m; 4-5.5 ft) or where scrub is too tall (> 1.70 m; Breininger and Carter 2003, Breininger and Oddy 2004). Tall oaks impede the ability to spot predators whereas short oaks can still provide numerous foraging opportunities (Table 4).

Table 4. Habitat states and source-sink dynamics for Florida Scrub-Jay territories on the Atlantic Coast (adapted from Breininger et al. 2013).

Habitat state	Description	Demography
Short	Oak <1.2 m tall and recent fires (<4 years ago) that completely burned territories	Sink
Open Medium	Medium-height (1.2-1.7 m) oak >0.4 ha, often as a mosaic amongst short, but no tall patches (>1.7 m) > 0.4 ha; at least half the territory has open sandy areas	Strong Source
Closed Medium	Medium-height (1.2-1.7 m) oak >0.4 ha, often as a mosaic amongst short, but no tall patches (>1.7 m) > 0.4 ha; few openings	Weak Source
Tall Mix	Mosaic of short or medium patches amongst tall oak > 0.4 ha	Sink
Tall	All scrub >1.7 m tall and unburned >20 years	Sink

Some sink areas are expected among areas that are sources where reproductive success exceeds mortality (Breininger and Carter 2003, Breininger and Oddy 2004). This source-and-sink structure was natural and unavoidable given the landscape arrangements of oak scrub among saw palmetto and burn patterns.

4. Matrix Habitat

Native matrix habitats provide prey for Florida Scrub-Jays and habitat for other species of conservation concern. The flammability of native matrix habitats is important for spreading fires into oak scrub, which often burns poorly. Saw palmetto (*Serenoa repens*), gallberry (*Ilex spp*.), and grasses are more flammable and accumulate fuel more rapidly than scrub oaks (Abrahamson 1984, Abrahamson and Hartnett 1990, Myers 1990, Schmalzer et al. 1991, Schmalzer and Hinkle 1992). Degradation or replacement of native matrix habitats with habitat fragments and industrial areas adds predators of Florida Scrub-Jays, such as Fish Crows (*Corvus ossifragus*), that are rare in most regularly burned (every 3-15 years) native matrix habitats (Breininger and Schmalzer 1990, Woolfenden and Fitzpatrick 1991, Breininger and Smith 1992). Matrix habitats often develop into woodlands and forests when there is a disruption of fire regimes. These woodlands and forests are not suitable for Florida Scrub-Jays, decrease the habitat suitability of nearby scrub, and further disrupt fire patterns.

5. Spatial Habitat Arrangements

Florida Scrub-Jays maintain and defend non-overlapping territories ranging from 4 ha (10 ac) to over 16 ha (40 ac) on the landscape. Territory size is not independent of density and territories are larger when density is low. Territory size is also dependent on group size; larger families defend larger territories. Florida Scrub-Jays are the ultimate despots, occupying and defending against other conspecifics to own absolutely as much space as they can (Fitzpatrick and Bowman 2016). Average territory size is 9-10 ha (22-25 ac) when the habitat is in optimal conditions (Woolfenden and Fitzpatrick 1984, 1991; Breininger et al. 1995). Within each territory there should be greater than one hectare of oak scrub that is 1.2-1.7 m (4-5.5 ft) tall (Breininger and Oddy 2004). Remaining oak scrub should be medium height or shorter than 1.2 m (4 ft) and have many openings. The mosaic of optimal height oak scrub and short oak scrub will be dynamic because of the fire frequency. Saw palmetto and herbaceous marshes within Florida Scrub-Jay territories should be short (<1.2 m; Breininger et al. 1995, 1998). Recent studies confirm the area of oak scrub in the natal territory correlated positively with nestling and juvenile body mass and the two had long-term consequences: it was positively related to the probability of becoming a breeder and negatively related to age at first breeding, particularly for males (Mumme et al. 2015).

6. The Importance of Habitat Management

Optimal Florida Scrub-Jay habitat is maintained by relatively frequent fires (Woolfenden and Fitzpatrick 1984, 1991; Breininger et al. 1995, 2006; Duncan et al. 1995). Long-term data suggest that Florida Scrub-Jay populations persist under frequent fire regimes if the fires are not too extensive and if the habitat is not already in a degraded state (Breininger and Oddy 2004). Conversely, too frequent fire can be detrimental as it truncates the post-fire optimal habitat successional stage and increases the relative weight of poor reproductive performance in the 1-2 years post-fire (Bowman pers. comm.). In most scrub landscapes that support Florida Scrub-Jay habitat, natural fire patterns have been disrupted by humans, so that fire no longer spreads across landscape (Duncan et al. 1999, Duncan and Schmalzer 2004).

Infrequent fire is one of the greatest threats to population persistence making restoration and prescribed fire management one of the most important components of Florida Scrub-Jay recovery. Many Florida Scrub-Jays occur in habitat conditions where their long-term persistence is doubtful although they can persist in poor or marginal habitat for long periods of time (Swain et al. 1995; Stith et al. 1996; Root 1998; Breininger et al. 1999, 2006). A primary cause for Florida Scrub-Jay decline is poor demographic success associated with reductions in fire frequency (Woolfenden and Fitzpatrick 1984, 1991; Schaub et al. 1992; Stith et al. 1996; Breininger and Oddy 1998; Breininger et al. 1996, 2006; Breininger 1999, Fitzpatrick and Bowman 2016). The reduction in fire frequency is associated with increases in shrub height, decreases in open space, increases in tree densities, and the replacement of scrub and marshes by forests (Duncan and Breininger 1998; Schmalzer and Boyle 1998; Duncan et al. 1999). These habitat trajectories result in declines in habitat use and demographic success (Breininger et al. 1995, 2006). Consequently, mean family size declines and eventually the number of breeding pairs can decline by 50% every 5-10 years (Woolfenden and Fitzpatrick 1991; Breininger et al. 1999.).

Much of the reduction in fire frequency began before the 1960s (Duncan et al. 1999). It is important to restore and maintain all potential habitats within Florida Scrub-Jay preserves but this is not always a popular decision with land managers or the uninformed public. Sand pines and large oaks have often replaced open scrub savannas that were frequently burned prior to the 1960s. Aerial photography in the 1940s is available for nearly every location and provides information for determining habitat potential (Duncan and Breininger 1998; Breininger et al. 2006; Carter et al.

2006). Prescribed fire and necessary mechanical treatments should be implemented in all potential habitat. Because of human landscape alterations, many declining populations will not persist without the careful attention of natural resource managers. Most scrub species of conservation concern require frequent fire.

Nearly all scrub habitats should be managed for optimal habitat conditions. However, soils disturbance, fragmentation of habitats, and fire suppression result in scrub patches that are difficult to burn except under circumstances in which fires are difficult to control. Reestablishing openings and other characteristics of optimal habitat might take long periods and require techniques not yet established. Many scrub landscapes occur in smoke sensitive areas and have accumulated fuel loadings that make it difficult to manage all conservation lands for optimal habitat conditions without long-term site-specific strategies.

There is variation in vegetation responses to fire because of variation in soils, nutrients, water table, fire intensity, and previous fire history (Abrahamson and Hartnett 1990; Breininger and Schmalzer 1990; Myers 1990; Schmalzer and Hinkle 1992a, b; Menges and Kohfeldt 1995; Hawkes and Menges 1996). More intense fires, resulting from longer periods without fire, can create more openings in Lake Wales Ridge scrubs than Atlantic coast scrubs (Menges and Hawkes 1998). Because site variability influences recovery from fire, natural resource managers should adjust fire frequency and intensity in individual landscapes by using height, openings, tree cover, and other structural features to assist in determining burning objectives for a particular site. Therefore, it is important to identify management goals based on habitat conditions and arrangements.

Fuel moisture, local weather, ignition and suppression techniques influence the amount of habitat that burns (Rothermal 1983). Extensive fires that leave too little habitat unburned can have detrimental impacts to Florida Scrub-Jay survival (Breininger et al. 2010). Therefore, fire management plans must consider fire behavior of previous fires and vegetation responses. It is difficult to write fire prescriptions and detailed management plans for long periods of time, so habitat management programs should be based on spatial and temporal goals in habitat quality, close monitoring of Florida Scrub-Jays and habitat conditions, and adaptive management (Breininger 2004).

7. Fire Management Prescriptions for Achieving Optimal Habitat Conditions

Recommended fire return intervals for scrub habitat management have included 8-25 years (FNAI 1990); 10-20 years (Fitzpatrick et al. 1991); 8-15 years (Woolfenden and Fitzpatrick 1996); 5-20 years (Menges and Hawkes 1998); 5-12 years oak-hickory scrub, 8-16 years scrubby flatwoods, 5-30 years rosemary scrub on Lake Wales Ridge (Menges 2007). A "fixed" prescribed fire return interval for Florida Scrub-Jays is not recommended because of the high degree of variation in such scrub types and site conditions, including an individual site's burn history. Fire return intervals recommended for Florida Scrub-Jay populations in oak scrub on Lake Wales Ridge may be too long for coastal habitats where the vegetative response is faster and the sandy openings in scrub disappear within 3-5 years (Schmalzer and Hinkle 1992a, b; Breininger et al. 2002; Schmalzer 2003). These changes are difficult or impossible to reverse by only prescribed fire (Schmalzer and Boyle 1998). Florida Scrub-Jay habitat use and demographic success is lower in areas without natural openings (Woolfenden and Fitzpatrick 1984, 1991; Breininger et al. 1995, 1998). Almost one third of common plant species on the Lake Wales Ridge are specialized to occupy openings (Menges and Hawkes 1998). No plant species are specifically adapted to long-unburned scrubby flatwoods (Menges and Kohfeldt 1995).

Fitzpatrick et al. (1991) stated that individual patches should burn every 10-20 years when managing oak scrub. This rotation is consistent with optimal Florida Scrub-Jay habitat suitability, and often the relationships between the height of scrub oaks and time since fire (Schmalzer and Hinkle 1992a, b; Duncan et al. 1995; Breininger et al. 1998). However, some scrubs recover very quickly and need a fire interval much shorter than every 10 years because they become too tall and dense to be regularly used by Florida Scrub-Jays (Breininger et al. 2002, Breininger and Carter 2003). Scrub oaks have dominated areas that were once open sandy areas and these are often not reduced in density by a few fires. Therefore, some oak scrub must burn very often to reestablish openings. Oak scrub that burns often might best be areas immediately adjacent to more flammable mesic flatwoods vegetation. Fitzpatrick et al. (1991) recommended the use of patchy fires so that no more than 25% of the scrub burns in a single fire. The rotation for mesic flatwoods is every 2-5 years (Stout and Marion 1993). Therefore, frequent mosaic fires that burn much of the mesic flatwoods and only occasionally burn oak scrub patches thoroughly might provide the fire regime needed at some sites.

Scrub habitat undergoing post-fire succession provides conditions favoring post-fledgling survival all the way to their recruitment as breeders, the ultimate currency of fitness. Pair defending territories in which less than 25% of the oak scrub had burned at least once during the preceding nine years produced 33% fewer offspring that eventually became breeders compared to those pairs defending higher proportions of early successional post-fire scrub habitat (Fitzpatrick and Bowman 2016).

Lightning associated with thunderstorms, which most frequently occur during the growing season (April-September), causes most natural fires (Robbins and Myers 1992; Davidson and Bratton 1986). Typical winter prescribed fire conditions are drier than typical growing season fire conditions except during droughts, which occur at irregular intervals approximately 20 years apart (Davidson and Bratton 1986). Prescribed fires often do not occur during the same season or meteorological conditions as natural fires, which may help explain why optimal habitat conditions are so difficult to achieve (Duncan et al. 2010, 2011). Winter fires do not reduce oak cover as effectively as growing-season fires in north Florida sandhill vegetation (Glitzenstein et al. 1995). However, the importance of growing-season fires in maintaining openings in scrub is unknown. Many growing-season fires may be needed to restore openings to scrub unburned for >20 years. Single hot growing-season fires often do not result in openings that last longer than 1-2 years. This is particularly true for scrubs that have been subject to fire suppression. Growing season fires should eventually be emphasized but fire managers often must burn whenever possible given the narrow windows of opportunity that many fire managers face and large areas of scrub that needs frequent fire. Frequent fires should be used throughout the year until the amount of scrub that is too tall and dense is reduced.

8. Use of Mechanical Techniques

Many areas that have been unburned for long periods can no longer be burned under prescribed conditions (Schmalzer and Boyle 1998). To manage habitat and reduce fuel loads, these areas must be mechanically treated prior to the application of fire. Monitoring data indicates that mechanical treatment followed by burning can be used to develop a habitat structure that can be maintained by prescribed fire (Schmalzer and Boyle 1998). Oak densities are often high in areas that are mechanically treated, and frequent fire may be necessary in the initial stages of restoration to restore and create sandy openings. Mechanical treatments must be careful not to result in excessive soil disturbance so that too much saw palmetto scrub is lost. Excessive soil disturbance can have long lasting effects on scrub that make it difficult to burn for many decades (Breininger and Schmalzer 1990, Duncan et al. 1999). Excessive soil disturbance can also increase exotics such as Brazilian pepper that require control.

Restoration activities must also be directed towards restoration of landscapes. Restoration efforts can fail to enhance Florida Scrub-Jay demographic success if they occur as small patches in a landscape that has burned infrequently and if subsequent fires do not occur often enough in surrounding areas

(Breininger and Carter 2003). Florida Scrub-Jays will use cut and burned areas soon after restoration, but adjacent areas can become overgrown and unsuitable. Although some scrub must be left for existing families, it is important to not have most of the landscape remain in a state with tall oaks in restored scrub. Areas that are left for existing families should be medium height and not adjacent to forests so that Florida Scrub-Jays can see predators in time to evade capture.

9. Summarizing Biological Constraints and Needs

The USFWS (2010) defines biological constraints as factors that are biologically inherent in the species, non-modifiable, and must be taken into account in planning and management. This section summarizes the key biological constraints discussed in more detail in the sections above. First, Florida Scrub-Jays are non-migratory and extremely sedentary, occupying year-round territories. Florida Scrub-Jays also have specific habitat requirements, including the type, structure, and quantity of habitat:

- Type: Florida Scrub-Jays are restricted to scrub, scrubby flatwoods, and the immediately adjacent natural communities, with few exceptions.
- Structure: Within these natural communities, Florida Scrub-Jays require a low, open structure maintained by periodic disturbance in order to persist. Florida Scrub-Jays disappear when scrub oaks become tall or when pine densities increase. On the other hand, Florida Scrub-Jays cannot persist if all habitat within a territory becomes too short. Florida Scrub-Jays need sufficient shrub-sized oaks within each territory to provide cover from predators, acorns, and nest sites. Thus, extensive, all-black burns or mechanical disturbance can displace Florida Scrub-Jays, resulting in the decline of small populations.
- Quantity: Florida Scrub-Jays are extremely territorial, with territories that average 10 ha (25 acres) in size in optimal quality habitat. Without sufficient immigration, small isolated local populations of Florida Scrub-Jay are highly vulnerable to extirpation. Given the size of Florida Scrub-Jay territories and the short dispersal distances exhibited by the species, it is critical to maintain large, contiguous blocks of Florida Scrub-Jay habitat to support local populations that are relatively resistant to local extinction.
- Inbreeding: Florida Scrub-Jays natural dispersal behavior is short-distance, resulting high levels of local inbreeding even within large contiguous populations (Aguillon et al. 2017). When populations lose connectivity with other Florida Scrub-Jay populations on a regional scale, they are prone to become inbreed, thereby reducing reproductive success and launching them in the extinction vortex. There is evidence that even the well-managed and relatively large Florida Scrub-Jay population at ABS has begun to show signs of inbreeding as a consequence of reduced immigration rates compared to earlier decades. This constraint may become the most important one of all if the trend toward further isolation of separate populations continue (Fitzpatrick pers. comm.).

In summary, Florida Scrub-Jays rarely disperse long distances. This underscores the need to maintain habitat patches in close proximity to other patches. The nature of the matrix between habitat patches also is important, because Florida Scrub-Jays do not cross large bodies of water and are unlikely to traverse extensive tracts of dense forest or dense urban development. The Florida Scrub-Jay’s territorial, habitat-specific, sedentary nature necessitates the conservation of large, well-connected patches of properly-managed habitat.

F. Distribution and Population Trends

Florida Scrub-Jays once occupied 39 of the 40 counties south of, and including Levy, Gilchrist, Alachua, Clay, and Duval counties. Historically, many of these counties would have contained hundreds or even thousands of breeding pairs (Fitzpatrick et al. 1994). Only the southernmost county, Monroe, lacked Florida Scrub-Jays (Woolfenden and Fitzpatrick 1996a).

Considerable evidence exists that the extant populations of Florida Scrub-Jays have declined to less than 10% of their historic, pre-European settlement numbers (Boughton and Bowman 2011). Byrd (1927) first noted the decline in Florida Scrub-Jay population numbers in the literature, though Cox (1987) posited that Florida Scrub-Jay numbers probably had been declining since well before that time. Others continued to report population declines throughout the 20th century due to habitat loss from development and agriculture and habitat degradation from the exclusion of fire (Grimes 1940, 1943; Sprunt 1946; Early 1952; Longstreet 1954; Brigham 1973; Austin 1976; Woolfenden 1978; Cox 1987; Fitzpatrick et al. 1994; Toland 1999). Woolfenden and Fitzpatrick (1996b) estimated that Florida Scrub-Jay populations had declined by 90% or more since European settlement. The 90% decline estimate is based on a detailed analysis of soil types across the peninsula, which suggested a conservative estimate that exceeded 100,000 total Florida Scrub-Jays.

By 1983, Florida Scrub-Jays had become extirpated from 7 of the original 39 counties: Broward (mid-1970s), Dade (1960), Duval (1940-50), Gilchrest (1900), Hendry (1970) Pinellas (1960), and St. Johns (1970) (Woolfenden and Fitzpatrick 1996b). Cox (1987) estimated between 15,600-22,800 individual Florida Scrub-Jays remained on the landscape in the early 1980's and speculated a 50% decline over the past century, suggesting a potential historic range from 31,200-45,600 birds in the late 1800's.

An extensive, statewide survey of Florida Scrub-Jays in 1992-93 estimated 3,961 Florida Scrub-Jay family groups with 10,972 individuals (Fitzpatrick et al. 1994). The survey most likely overestimated the abundance of Florida Scrub-Jays at Merritt Island National Wildlife Refuge and Cape Canaveral Air Force Station (Boughton and Bowman 2011) but underestimated the abundance of Florida Scrub-Jays in Ocala National Forest (ONF), some areas in southwest Florida, and some areas in southern Brevard and northern Indian River counties (Miller and Stith 2002, Breininger et al. 2003). By the early 1990s, Florida Scrub-Jays had become extirpated from two more counties (Alachua and Clay), though at least one Florida Scrub-Jay group was later discovered in Clay County (Bowman and Boughton 2011). Ten or fewer Florida Scrub-Jay groups remained in an additional seven counties (Flagler, Hardee, Hendry, Hernando, Levy, Orange, and Putnam) (Fitzpatrick et al. 1994). Population numbers in 27 of the original 39 counties had 30 or fewer breeding pairs (Fitzpatrick et al. 1994). Fitzpatrick et al. (1994) estimated that Florida Scrub-Jays had declined between 25-50% in the northern third of the species' range since the surveys by Cox (1987).

As of 1993, Florida Scrub-Jays were extirpated from 9 of the 39 counties previously occupied (Alachua, Broward, Clay, Dade, Duval, Gilchrest, Hendry, Pinellas, and St. Johns) and most likely extirpated or nearly so (functionally extirpated) from an additional 12 counties. Only 9 counties had more than 30 Florida Scrub-Jay groups – not necessarily a local population consisting of 30 interacting groups – on managed conservation lands as of 2010.

Post-breeding 2015 surveys suggests extirpation from an addition 4 counties (Collier, Flagler, Levy, and Palm Beach) resulting in 13 of the original 39 counties lacking occupancy on public conservation lands. Figure 6 depicts the status of Florida Scrub-Jays groups currently on conservation lands within a county boundary.

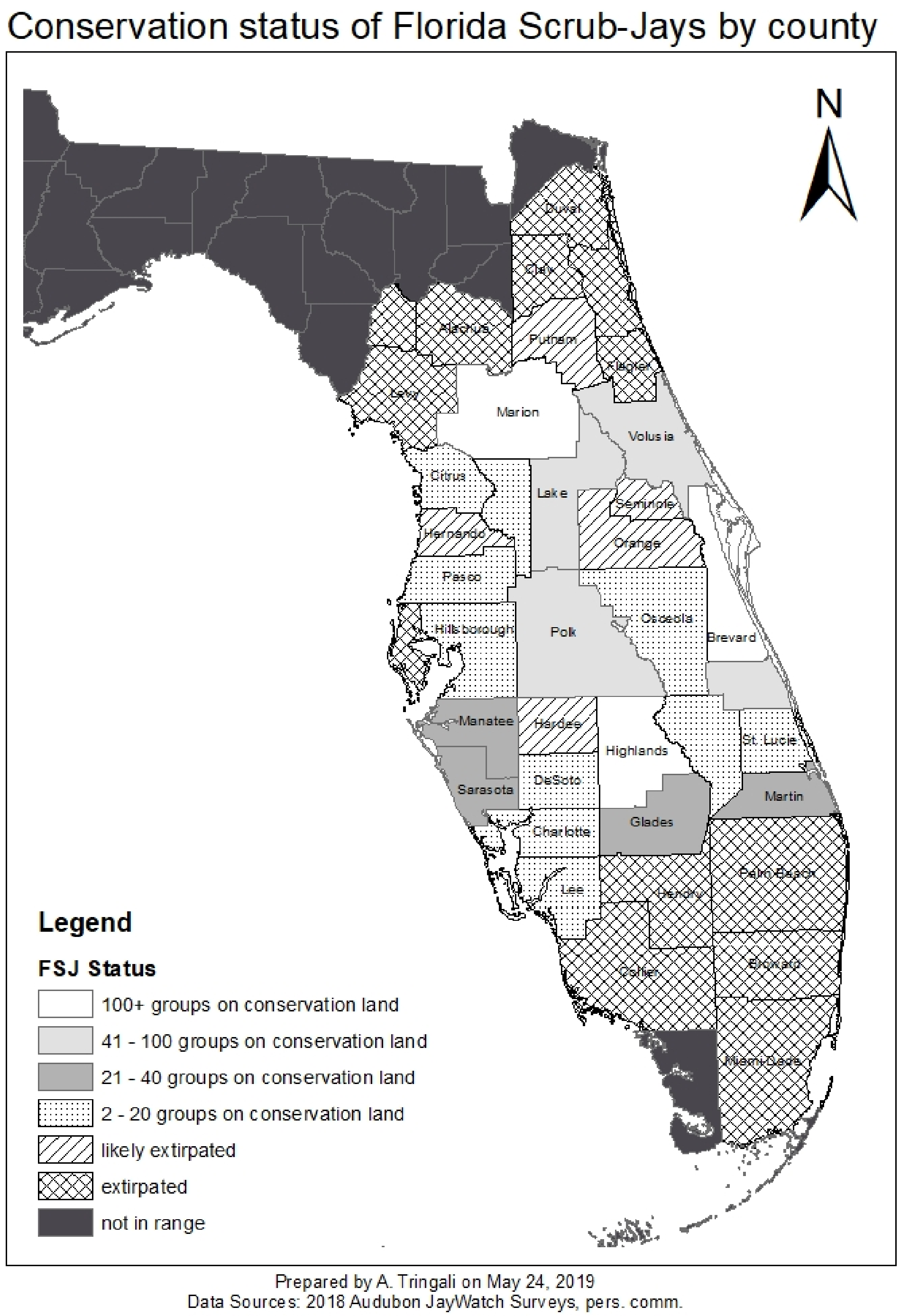

Figure 6. Number of Florida Scrub-Jay groups on conservation lands per county estimates.

Florida Scrub-Jay populations have continued to decrease since the 1992-93 statewide survey and Stith's metapopulation model. For example, Toland (1999) estimated a decline of over 50% in many areas in Brevard County that were re-surveyed in 1998. Part of this decline may be attributed to a possible rare epidemic in 1997-98 (Breininger and Oddy 1998, cited in Toland 1999). Reductions have not been confined solely to unprotected lands. Florida Scrub-Jay populations declined by 25% on managed conservation lands, excluding ONF, from 1992-93 to 2009-10 due to inadequate habitat management (1,495 to 1,116 groups on 178 managed lands that were surveyed during both time periods; Boughton and Bowman 2011). Although population estimates were not available for ONF, the amount of suitable Florida Scrub-Jay habitat decreased by 22% from 1999-2012 (USFS, unpubl. data).

The decline of Florida Scrub-Jay populations has been even more severe on unprotected lands, especially in suburban areas, where Florida Scrub-Jays have reduced demographic success compared to wildlands (Bowman 1998, Breininger 1999). For example, a suburban population in Highlands County (Lake Placid Estates) decreased from over 100 groups in the early 1990s to 7 groups by 2013 (Bowman, unpubl. data). Similarly, Florida Scrub-Jays in the city of Palm Bay declined from 54 groups in 1993 to 16 groups by 2009 (Toland 1999; Larson, in litt. 2012).

Boughton and Bowman (2011) estimated 2,400-2,600 Florida Scrub-Jay groups remaining, excluding ONF. Based on extrapolated data of known Florida Scrub-Jay group densities in timber management areas of ONF to other areas of suitable habitat (~ 2-meter vegetative structure height) of unknown occupancy, the population has been estimated at greater than 1,000 Florida Scrub-Jay groups within the forest boundaries (Miller FWC and Garcia USFS pers. comm. 2017). Range-wide, Florida Scrub-Jay groups could be 3,400-3,600 providing the assumptions for the estimates are valid.

Summarizing Florida Scrub-Jay, population trends from historical estimates to present day, the overwhelming majority of populations range-wide have continued to decline since the species was listed (Figure 7).

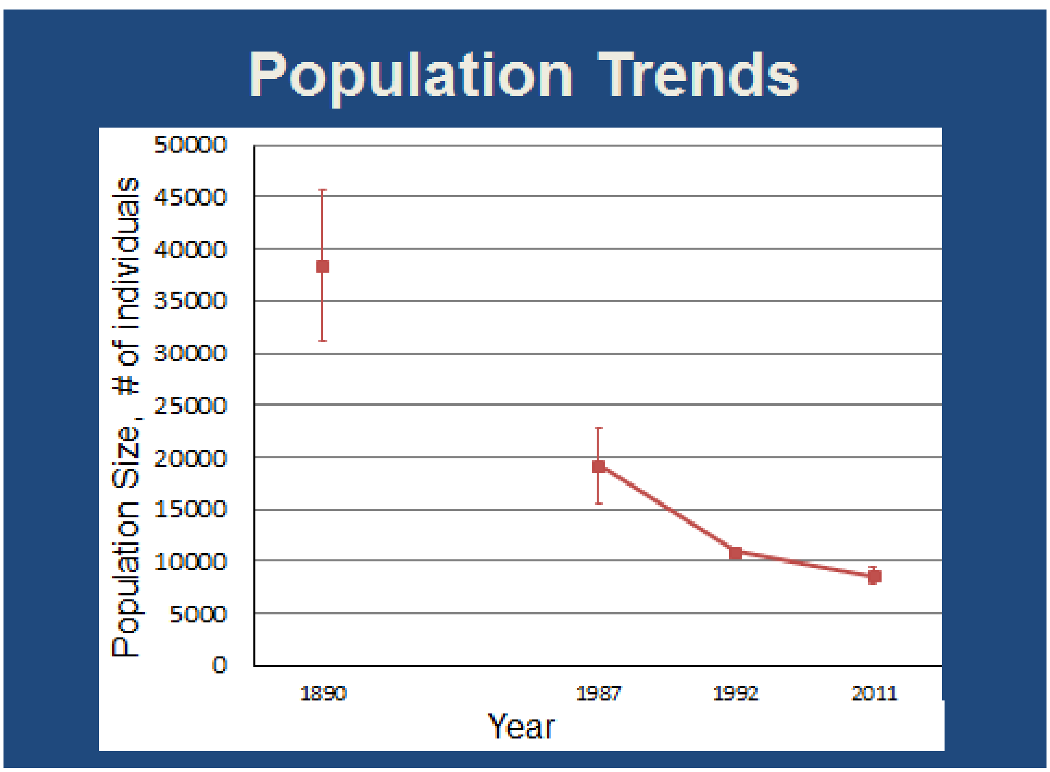

Figure 7. Florida Scrub-Jay population trends from historic to present.

G. Current Condition

The current condition for the Florida Scrub-Jay was assessed in terms of resiliency, redundancy, and representation as follows.

1. Defining Populations

Florida Scrub-Jays distributed across the landscape interact as metapopulations, but resilience was assessed at the local population scale, where a metapopulation is made up of multiple local populations. As previously presented in the genetic section, a metapopulation is a collection of relatively isolated, spatially distributed, local populations bound together by occasional dispersal between populations. Within local populations, the collection of family groups interact regularly through dispersal. Local populations were delineated using a habitat mapping exercise in GIS. Habitat patches having any significant probability of supporting local Florida Scrub-Jay populations were identified, both within and outside existing conservation areas. Potential local populations were defined using Breininger and colleagues' (2006) criteria for a "territory cluster," which includes all patches of potential habitat within 670 m (2,198 ft) of one another (the average diameter of two Florida Scrub-Jay family group territories). Local populations can and often do span multiple properties, and single properties can have Florida Scrub-Jay groups from multiple local populations.

Potential local populations were categorized as core areas, support areas, or auxiliary areas based on their potential carrying capacity and connectivity, regardless of the area's current status. A core area is defined as a potential local population that contains sufficient habitat to support 40 or more family groups at 70% carrying capacity. A support area is defined as a potential local population that (a) contains sufficient habitat to support 10-39 family groups at 70% carrying capacity, and (b) is either within 3.5 km (2.2 mi) of a core area or is within 3.5 km of other support areas that together contain enough potential habitat to support 40 or more family groups at 70% carrying capacity. An auxiliary area is defined as a potential local population that contains sufficient habitat to support 10 or more family groups at 70% carrying capacity but does not meet the definition of a core or support area. The strategy targets a 70% carrying capacity because it is unrealistic to assume that all habitat will be occupied at any given time (Boughton and Bowman 2011). Certain portions of any habitat patch often are suboptimal or even unsuitable for Florida Scrub-Jays because of vegetative structure (either very recently burned or long unburned and therefore overgrown) or management constraints. On the other hand, the capability to maintain Florida Scrub-Jays at 70% of overall carrying capacity through informed habitat management has been well documented at a number of public and private habitat preserves across the range of the species.

Scrub-Jay habitat and family groups do exist in groupings that do not meet the definitions of core, support, or auxiliary areas (habitat cannot support 10 or more family groups); little data is available on these small and isolated patches, and they are not considered in the following assessments of current and future conditions. These smaller scrub patches not captured in the classification scheme described above are important and can contribute to Florida Scrub-Jay conservation. All existing populations of Florida Scrub-Jays, regardless of their size or location on the landscape, have intrinsic genetic and ecological value and can contribute to the conservation and recovery of the species. Each population throughout the species range is an important reservoir of genetic diversity and potential dispersers. Where possible, any such population should be retained. Support populations are an essential source of immigrants for the core populations as they increase the overall genetic variation of the core populations. In addition, even the smaller, isolated, and sometimes apparently peripheral populations are of value. These populations have the capability to increase the genetic diversity of other populations through rare long distance dispersals or assisted movements (i.e., translocation).

Alleviating the loss of genetic diversity in declining populations will become essential as ever-more populations become tiny and isolated.

2. Current Population Resiliency

Resiliency refers to a population's ability to persist and withstand demographic and environmental stochastic events. The probability of long-term persistence for local populations of Florida Scrub-Jays depends on population size, amount of habitat, habitat quality, and connectivity with other local populations. Based on simulation models developed in 1991 of the survival probabilities for Florida Scrub-Jay populations under a variety of circumstances, in the absence of immigration, local populations of 40 or more Florida Scrub-Jay family groups are relatively resistant to local extinction. Isolated populations with fewer than 10 family groups are highly vulnerable to local extinction (Fitzpatrick et al. 1991; Figure 8). This modeling was based on a very simple, single-population demographic model assuming optimal habitat conditions (demographic rates in well-managed habitat). If the habitat is not well managed, demographic rates will be lower and local populations will be less resilient. Although it included epizootics, the frequency was 1 in 20 years, which is now known to occur more frequently, possibly every 5-10 years with varied intensities. It also did not include the caveat that likely only 70% of any site can be suitable at any given time, nor did it incorporate genetic factors that are extremely important, and potentially devastating even for large populations that become isolated from immigration. Thus, this simplified Florida Scrub-Jay ecology model probably underestimates extinction risks.

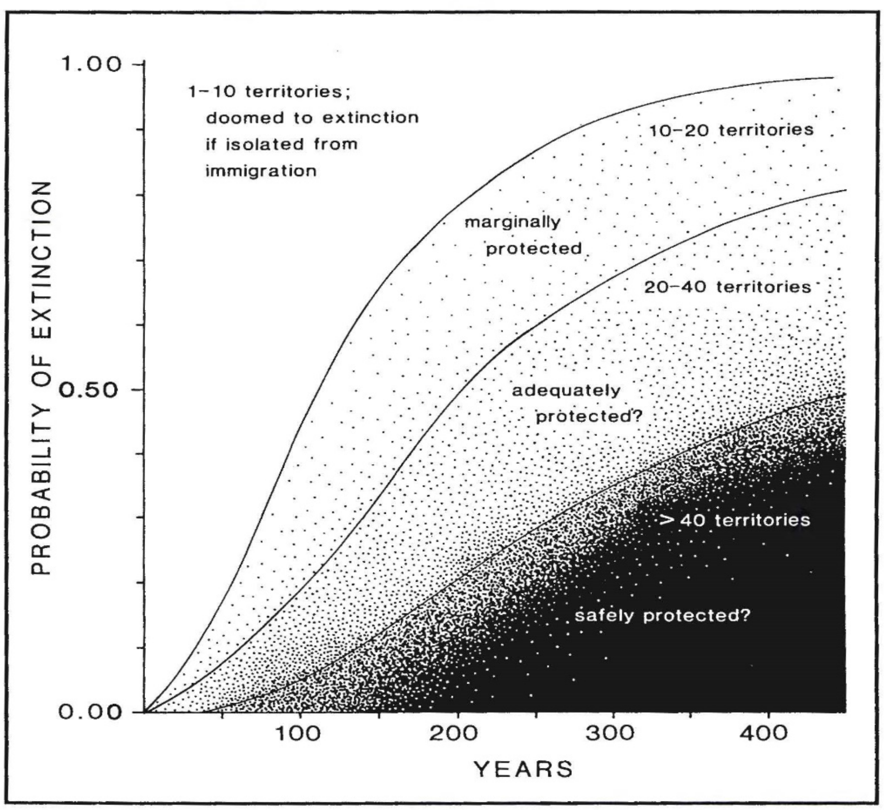

Figure 8. Schematic relationship between Florida Scrub-Jay population size within a habitat preserve and the degree of protection from demographic extinction.

Based on the above population simulations and resulting extinction probabilities, resilience categories were derived as follows (relative to the extant populations). Populations with fewer than 10 family groups have very low resiliency, particularly if they are isolated from other local populations. Populations with 10 -39 family groups have a moderate resiliency compared to the lower category, whereas populations with 40 or more family groups were classified as having the highest resiliency (Table 5). Populations were categorized into resilience classes based on populations' sizes from a range-wide survey in 2009-2010 (Boughton and Bowman 2011). Ocala National Forest is an exception; no forest-wide surveys have been conducted at this very large property. Consequently, estimates for the number of territories here were calculated by dividing the area of available habitat by an average territory size, and are likely overestimates of true population sizes. Population sizes include only family groups on conservation lands; little to no information is available about abundance and trends on private lands, and they are presumed to have poor demographic rates (Bowman 1998, Toland 1999) and do not contribute highly to species resilience.

Table 5. Number of local populations on conservation lands within each genetic unit with high, moderate, and low resiliency. The number of family groups is given in parentheses after the number of populations (Boughton and Bowman 2011).

Genetic Unit	High Resiliency	Moderate Resiliency	Low Resiliency	**Total**
East Coastal - A	1 (46)	1 (22)	8 (39)	**10 (107)**
Lake Wales Ridge - B	2 (234)	7 (113)	14 (61)	**23 (408)**
Northeast Coastal - C	2 (402)	0	1(4)	**3 (406)**
North Central - D*	2 (1,010)*	3 (59)	8 (30)	**13 (1,099)***
Southwest Coastal - E	0	1 (17)	1 (7)	**2 (24)**
Southwest Inland - F	0	1 (10)	4 (18)	**5 (28)**
Southwest Volusia - G	0	2 (41)	1 (4)	**3 (45)**
Levy County - H	0	0	1 (4)	**1 (4)**
Southeast Coastal - I	0	1 (20)	3 (14)	**4 (34)**
Lee and North Collier - K	0	0	1 (5)	**1 (5)**
Total	**7 (1,692)**	**16 (282)**	**42 (186)**	**65 (2,160)**

* The estimate for Ocala National Forest in Genetic Unit D was calculated by dividing the area of available habitat by Florida Scrub-Jay territory size, and is likely an overestimate of true population sizes.

Seven populations currently have the highest resiliency of the extant populations based on a metric of greater than 40 family groups; however, four of these populations are much more robust, with population sizes dramatically higher than 40 family groups:

- Ocala National Forest (North Central D) – including portions Seminole State Forest – is the largest population range-wide with an estimated population of roughly 1,000 family groups (due to mapping conventions this population is considered two populations in Table 5). The estimate for Ocala National Forest was not based on surveys, which are logistically and financially challenging, but by extrapolating densities in known areas and dividing the amount of available habitat by Scrub-Jay territory size; this may be an overestimate of true population size.

- Merritt Island National Wildlife Refuge and Cape Canaveral Air Force Station – including Canaveral National Seashore (Northeast Coastal C) – are the second and third largest populations with a combine population around 400 family groups. Approximately 63% of the family groups reside on the refuge.

- Archbold Biological Station and the adjacent Lake Wales Ridge Wildlife Environmental Areas (Placid Lake Scrub, Gould Road, and McJunkin Tract) is the fourth largest population having approximately 180 family groups. The population is located in the southern portion of the Lake Wales Ridge Genetic Unit B.

Nevertheless, these four very highly resilient populations support 73% of known family groups on conservation lands (1,580 out of 2,160). The two remaining populations classified with high resiliency have roughly 50 to 45 family groups each (Avon Park Air Force Range and St. Sebastian River Preserve State Park respectively). There are 16 populations (roughly 25%) with moderate resiliency (10 - 39 family groups), and greater than 65% of the assessed populations (42 out of 65) have low resiliency and currently support fewer than 10 family groups. The total number of family groups on conservation lands, based on the 2009-2010 surveys, represent a > 25% decline in abundance since the 1992-1993 surveys.

3. Current Species Redundancy

Redundancy refers to the distribution and number of the populations across the landscape (range-wide); redundant, resilient populations reduce the threat of a single catastrophic event threatening the entire species. There are currently 65 Florida Scrub-Jay populations on conservation lands, spanning the entire width and nearly the length of the Florida peninsula, with the highest redundancy in the central inland ridges and the east coastal area (Figure 9).

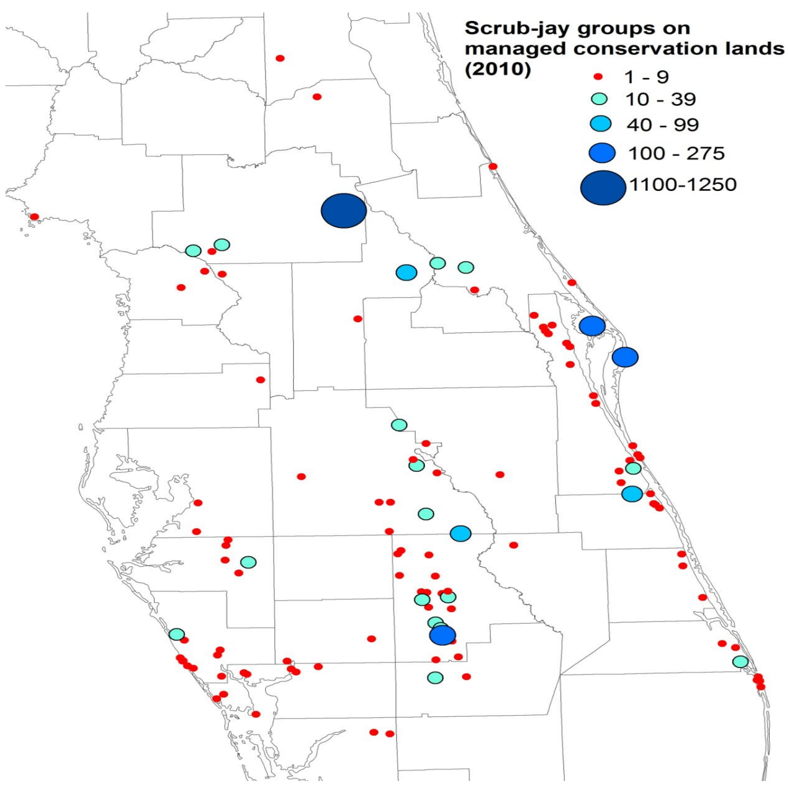

Figure 9. Distribution and approximate population sizes of Florida Scrub-Jays on managed conservation lands.

Forty-nine populations (75%) occur in four of the genetic units (A, B, C, and D) with various degrees of connectivity among the populations. Only 7 of the 49 populations in these four genetic units have high population resilience. Eleven populations are categorized as moderate and 31 populations ranked as having low resiliency within these four genetic units. The remaining 16 populations (25%) occurring in the other six genetic units (E, F, G, H, I and K) have low resiliency ranging from one group up to five groups (see Table 5).

If the habitat is not well managed with prescribed fire, demographic rates will be lower and local populations will be less resilient. As the population's resiliency declines, inbreeding and loss of genetic diversity are likely to lead to reduced fitness over time, even at population levels considered resilient to demographic and environmental stochasticity. The majority of the local populations are small, highly fragmented, and have poor connectivity. This is exacerbated by the relatively low dispersal distances of Florida Scrub-Jays.

4. Current Species Representation

Genetically diverse species have a higher evolutionary potential and are better able to adapt to changes in their environment over time. Despite the presumed loss of genetic variability that has occurred since pre-settlement times, the variation that still exist is robust. A significant component of this genetic variation occurs across genetic units, several of which exhibit a high degree of differentiation from one another. Of the 10 genetic units, only 4 genetic units currently have populations with high resiliency and redundancy, which will certainly affect the species' future representation outside of these 4 genetic units.

I. Factors Influencing Viability – 5 Factors

The Florida Scrub-Jay was listed as Threatened throughout its range primarily because of dramatic and continuing population declines resulting from extensive habitat loss and degradation of existing habitat patches resulting from development and fire suppression. Shooting, collection as pets, and road mortality also were cited as factors that may have resulted in the local or regional decline of some Florida Scrub-Jay populations (USFWS 1987). Habitat loss was specifically related to permanent, physical destruction of habitat associated with conversion of the Florida Scrub-Jay's required natural vegetative communities to commercial, residential, or agricultural uses. Habitat degradation was primarily the result of fire suppression, which by 1987 already was suspected to alter vegetative composition and community structure to the point that Florida Scrub-Jays could not maintain viable populations in the habitat. All other identified threats applied only to local situations, and were not suspected to be stressors affecting the persistence of the species.

Since the original description of threats to Florida Scrub-Jays, substantial research, management, and monitoring efforts have been undertaken across the range of the species, and a large number of local populations have disappeared entirely. As a result, both historic and contemporary threats are much better understood today than they have ever been. Below summarizes current threats organized according to the five listing factors in section 4(a)(1) of the ESA (Table 6).

Table 6. The five listing factors from section 4(a)(1) of the ESA.

Listing Factor A:	The present or threatened destruction, modification, or curtailment of its habitat or range.
Listing Factor B:	Overutilization for commercial, recreational, scientific, or educational purposes.
Listing Factor C:	Disease or predation.
Listing Factor D:	The inadequacy of existing regulatory mechanisms.
Listing Factor E:	Other natural or manmade factors affecting its continued existence.

1. The Present or Threatened Destruction, Modification, or Curtailment of its Habitat or Range

a. **Direct Habitat Loss -** Consistent with the original threats assessment, habitat loss resulting from conversion to commercial, residential, and agricultural uses remains a significant risk to the Florida Scrub-Jay. Unabated growth of the human population throughout peninsular Florida no doubt will persist well into the future, and will be accompanied by substantially increased infrastructure needs. Given the rarity of oak scrub habitat, and its development value as well-drained high ground, progressive habitat loss inevitably will continue to reduce the distribution of Florida Scrub-Jays until no usable habitat patches remain outside of formally protected and managed scrub preserves. Coupled with direct habitat conversion, inadequate habitat management also remains a significant risk to populations. As stated previously, estimates based on inferences from soil maps across Florida suggest that as of 1993 the remaining Florida Scrub-Jay habitat has been reduced to at or below 10% of presettlement numbers; between 1983 and 1993, the population declined 25% (Woolfenden and Fitzpatrick 1996b). Additionally, from 1993 to 2010 the population declined by 25% on managed conservation lands due to inadequate habitat management (Boughton and Bowman 2011). Losses have continued through the present (Chen et al. 2016).

b. **Habitat Fragmentation -** Widespread conversion of oak scrub vegetation has resulted in extreme fragmentation of Florida Scrub-Jay habitat, and the threats associated with this phenomenon certainly now exceed in importance those associated with outright habitat loss. Small, isolated populations suffer higher risks of extirpation owing to both demographic and genetic problems. Management of isolated habitat tracts is difficult, especially those tracts surrounded by human residential development. Edge effects – in particular, increased predation by feral and domestic house cats – render small patches of scrub less suitable for successful reproduction and offspring survival than larger patches. Consequently, many small scrub patches represent population sinks.

c. **Habitat Degradation from Fire Suppression -** The Florida peninsula has the highest lightning-strike frequency in North America. Therefore, for millions of years, Florida's native habitats and species have adapted to the periodic recurrence of lightning-induced wildfire, mainly during the rainy season months of May through September (Myers 1990). Human interference with natural fire regimes has become a major contributor to the ongoing decline of the Florida Scrub-Jay. Without any doubt, fire suppression represents one of the two most important threats to persistence of the species across its range – the other is demographic instability amidst human residential development. This fact bears repeating: disruption of natural fire regimes exceeds habitat loss and habitat fragmentation as limiting factors causing local population declines (Woolfenden and Fitzpatrick 1991, 1996a; Fitzpatrick et al. 1994, 1999).

Lightning strikes cause virtually all naturally-occurring fires in peninsular Florida scrub habitat (Abrahamson 1984, Hofstetter 1984, Woolfenden and Fitzpatrick 1990), and these fires are vital to maintenance of scrub habitat in its natural structure and composition (Nash 1895, Harper 1927, Webber 1935, Davis 1943, Laessle 1968, Abrahamson et al. 1984). Prevention and containment of fires results in oak scrub habitat succeeding from its typical structure (short and sparse, with much open sand and only a few tall pines) to a dense, tall structure (oaks many meters tall, closed canopy including many tall pines, leaf litter covering all ground surfaces). Florida Scrub-Jays clearly prefer the former; their numbers decline in the latter. Eventually, Florida Scrub-Jays disappear from long-unburned, overgrown scrub (Breininger et al. 2013; Fernald 1989; Fitzpatrick et al. 1994, 1999; Percival et al. 1995; Stith et al. 1996; Thaxton and Hingtgen 1996; Woolfenden and Fitzpatrick 1990, 1996a; Toland 1999).

The threat of fire is more complicated than just suppression. Lightning-strike fire is often not suppressed, but small isolated patches embedded in inflammable habitat matrices rarely burn. The alternative is prescribed fire, but it is not easy to mimic nature. Prescribed fire also is dependent on safety (both to managers and the public), existing laws, regulations and permit requirements. Additionally, variation in ecological responses, differences in Florida Scrub-Jay responses at a landscape scale, and a continuing lack of knowledge regarding subtle influences of fire on habitat structure and community response (seasonality, patchiness, intensity) are confounding.

2. Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

The USFWS is aware of only a few cases where Florida Scrub-Jays have been shot. One was in Volusia County, which was investigated and prosecuted under Migratory Bird Treaty Act (J. Oliveros, USFWS, pers. comm.). The Florida Fish and Wildlife Conservation Commission (FWC) investigated a case, in which three Florida Scrub-Jays were shot in Highlands County (N. Douglass, FWC, pers. comm.). It does not appear that the small number and infrequent occurrence of Florida Scrub-Jays taken in this manner has had an impact on the species.

3. Disease or Predation

As populations of Florida Scrub-Jays decline due to habitat loss, habitat degradation and associated lowered demographic performance, the threat of catastrophic disease and demographic impacts of chronic disease increase. It is likely that smaller populations of Florida Scrub-Jays are less genetically diverse lowering the probability of survival and increasing the risk of population-wide mortality events. If habitats are degraded and Florida Scrub-Jays become increasingly “stressed” small populations are more likely to succumb to chronic diseases and parasites, reduce demographic performance, and probably suffer from the “Allee effect” (Breininger 1999, Stephens et al. 1999). Furthermore, diseased individuals are more likely to be clinically ill reducing their ability to escape predators and exacerbating predation pressure.

Florida Scrub-Jays experience substantially elevated mortality during periodic episodes thought to represent epizootic outbreaks (Woolfenden and Fitzpatrick 1991). Based on analysis of antibodies, the most common diseases appear to be caused by encephalitic viruses. Antibodies consistent with an eastern equine encephalitis outbreak were found in 80% of sampled Florida Scrub-Jays in 2008 (ABS, unpubl. data), and antibodies responsive to Highlands J and St. Louis encephalitis are also routinely present. Additionally, 10% of Florida Scrub-Jays sampled from across the range in 2005 (n = 60) contained antibodies for West Nile virus. Avian malaria (*Plasmodium* spp. and *Haemoproteus* spp.) occurs in all sampled Florida Scrub-Jay populations, although insufficient data exists to evaluate whether these infections constitute any risk to individuals or populations.

At ABS, four significant spikes in mortality have been documented over a 42-year study. These mortality events have resulted in atypically high adult and juvenile mortality, but the effects have been isolated. In late summer of 2008, for example, extraordinary mortality among all age classes was observed over a 3-month period, coinciding with a greatly elevated population of mosquitoes known to be carriers of eastern equine encephalitis. This event began shortly after the passage of a tropical storm whose rains created or expanded many standing bodies of water in which mosquitoes could breed, and coincided with the high frequency of eastern equine encephalitis antibodies.

The above noted diseases are vector-borne and the primary vectors are mosquitos. Climate change models throughout the world show expanding range and numbers of disease vectors thus the extent, frequency and intensity of epizootics, as well as the intensity of baseline disease mortality may increase in all Florida Scrub-Jay populations.

The range-wide effects of disease have probably been underestimated because past disease outbreaks have only been observed in relatively large populations that are regularly monitored (e.g., ABS and some Brevard County populations). Nonetheless, ongoing monitoring of affected populations confirms that large Florida Scrub-Jay populations are more capable of rebounding from periodic mortality events resulting from epizootics. Smaller populations and/or those in poor quality habitat may take longer to rebound following a disease outbreak, and therefore be increasingly susceptible to extirpation from stochastic events and/or poor demographic performance typical of small populations.

Reducing the threat diseases and parasites pose to Florida Scrub-Jays would aid in maintaining large contiguous Florida Scrub-Jay populations. Reducing disease impacts is best achieved by increasing the size and demographic performance of Florida Scrub-Jay metapopulations.

4. The Inadequacy of Existing Regulatory Mechanisms

At the time of listing, the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703 et seq.) protected individual Florida Scrub-Jays from take throughout their range, but did not protect their habitat. Regulations finalized in February 2007 authorize incidental take of migratory birds, including Florida Scrub-Jays, for military readiness training.

The National Wildlife Refuge System Administration Act (NWRAA) represents legislation that set up the administration of a national network of lands and water for the conservation, management, and restoration of fish, wildlife, and plant resources and their habitats for the benefit of the American people. Amendment of the NWRAA in 1997 required the refuge system to ensure that the biological integrity, diversity, and environmental health of refuges be maintained. The ability to meet these statutory requirements varies among refuges depending on local constraints.

The Florida Scrub-Jays is included in Florida Endangered and Threatened Species List as a Federally-designated Threatened Species. Florida State Law (Rule 68A-27.003, Florida Administrative Code) prohibits taking of individuals of threatened species, or parts thereof, or their nests or eggs, except as authorized. To eliminate the need for both a state and federal permit, activities that result in take of Federally-designated Threatened Species do not require a permit from the FWC when authorized by the USFWS (Rule 68A-27.007, Florida Administrative Code). To date, the FWC has not developed a regulatory program that ensures compliance with this statute. Instead, the FWC relies on USFWS implementation of the ESA through sections 7 and 10 and enforcement of the prohibitions in section 9 of the ESA.

On state wildlife management areas, regulations protect individual Florida Scrub-Jays because they are not listed as a game bird and therefore have no legal seasons established for taking. Wildlife management area regulations prohibit destruction or modification of habitat, except for management and restoration activities.

Many county governments have developed protective ordinances, but all such ordinances are based on compliance with the ESA rather than local laws and therefore provide no additional protection. Within the current range of the Florida Scrub-Jays, several counties and municipalities have provisions for reviewing all development proposals for impacts to scrub and/or Florida Scrub-Jays and for referring projects that may potentially affect Florida Scrub-Jays to the USFWS for ESA compliance. Several other counties occasionally invoke threatened and endangered species screening, depending on the level of controversy surrounding pending developments. The remaining counties do not have environmental resource staff dedicated to habitat protection and/or have not developed protective ordinances.

5. Other Natural or Manmade Factors Affecting its Continued Existence

a. Suburban Demographic Sinks - As of 2018, it is estimated that less than a fifth of all extant Florida Scrub-Jays reside on tracts of habitat located in rural or suburban residential communities, where occupied patches of habitat are small, mostly privately owned, and bordering or interspersed with human dwellings, roads and parking lots, clearings, lawns, and nonnative ornamental plantings. Abundant data on Florida Scrub-Jays in these habitats has been gathered over the past decades, and all information points to the same conclusion: the prognosis for Florida Scrub-Jays occupying suburban residential communities – even in low housing density – is very poor.

The primary issue in residential habitat is that fledgling survival is dramatically lower than in contiguous tracts of well-managed native scrub. It is highly likely that this pervasive demographic response is a consequence of predation by house cats. In addition, supplemental foods made available through bird feeders or domestic pet food induce Florida Scrub-Jays to breed early, but survival of these early nestlings is lower than later nestlings because insects, a primary food source of young Florida Scrub-Jays, are not yet abundant in early spring (Sauter et al. 2006). To make matters worse, non-native ornamental shrubs also create hazardous nest sites for Florida Scrub-Jays because ornamental vegetation does not provide a sturdy nest structure and nests tend to be blown out of tall shrubbery (Bowman 1998). As a result of all these factors, recruitment of young in suburban landscapes is extremely low (Bowman and Averill 1993, Bowman 1998).

Florida Scrub-Jay populations in suburban landscape settings are declining and disappearing all across Florida, and the only ones still appearing to be stable are those that are supplemented by immigration from surrounding regions. Florida Scrub-Jay populations situated within a matrix of human residential settlement will decline over time, owing to poor demographic performance.

b. Extirpation of Small Populations - An axiom of conservation biology is that tiny populations suffer high probabilities of extinction (Primack 2010). This sensitivity to population reduction has been modeled explicitly for the Florida Scrub-Jay since the early 1990s (Fitzpatrick et al. 1991, Stith 1999). The problem has become a huge threat for the species today, because so many of its remnant populations – including genetically unique populations at the corners of the historic range limits of the species – are extremely small.

c. **Inbreeding and Loss of Genetic Diversity** - As populations become more isolated they receive progressively fewer immigrants. Populations begin to lose genetic diversity, and can diverge from one another in non-adaptive directions as a consequence of genetic drift. Non-scrub habitat gaps greater than about 5 km (3 mi) have been shown to increase the rate of genetic divergence between adjacent Florida Scrub-Jay populations (Coulon et al. 2012). In very small populations (e.g., those containing fewer than 50 breeding individuals), offspring recruited into the population are more likely to breed with genetically related individuals, further reducing the genetic diversity of succeeding generations. Reduced fitness of individuals subjected to inbreeding depression is well documented across the biological world. Recent, published analyses confirm that inbred Florida Scrub-Jays experience reduced survival compared with offspring produced by unrelated pairs (Chen 2016). The inevitable consequence of inbreeding depression is that tiny, isolated Florida Scrub-Jay populations face a much higher extinction probability than larger and more connected populations. It seems certain that many of the local extirpations documented since the 1980s have been accelerated by genetic factors.

d. **Road Mortality** - Urban development and associated roadway infrastructure create hostile environments for Florida Scrub-Jays and represent a growing management concern (Dreschel et al. 1990; Mumme et al. 2000). High-speed roads are particularly devastating to Florida Scrub-Jays because birds with territories adjacent to roads tend to forage on road shoulders and rights-of-way. Research along a two-lane paved road indicated that clusters of Florida Scrub-Jay territories found next to the roadside represented population sinks (breeder mortality exceeded production of breeding-aged recruits), which could be supported only by immigration (Mumme et al. 2000). Road impacts are likely to increase in the future as the human population of Florida expands and the resulting increase in roads intersect Florida Scrub-Jay habitat. Proximity to high-speed paved roads needs to be evaluated when considering the location of Florida Scrub-Jay conservation areas (Fitzpatrick et al. 1991; Woolfenden and Fitzpatrick 1996a).

e. **Climate Change** - "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, sea level has risen, and the concentrations of greenhouse gases have increased. Human influence on the climate system is clear. This is evident from the increasing greenhouse gas concentrations in the atmosphere, positive radiative forcing (balance of incoming and outgoing energy), observed warming, and understanding of the climate system. Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of greenhouse gas emissions" (IPCC, 2013).

The National Climate Team summarized the following scientific and ecological information on climate change and implications to USFWS and staff from the 2014 publication entitled *Climate Change Impacts in the United States: The Third National Climate Assessment* (NCA) (NCA, 2014). This team also summarized the 2013 publication from the IPCC entitled *Highlights of the IPCC 5th Assessment Report: The Physical Science Basis of Climate Change (WGI), Summary for Policymakers* (IPCC, 2013). This information is further condensed with a primary focus on Florida. Florida is exceptionally vulnerable to sea level rise, extreme heat events, and hurricanes. With an ever-growing population within Florida's coastal plain, annual visitors range from 10 to 15 million stressing the already decreasing water availability.

This climate change information is critical when conducting required USFWS analyses, conservation planning, and decision-making. Released by the White House on May 6, 2014, the NCA was prepared by a Federal Advisory Committee based on requirements of the Global Change Research Act of 1990.

Temperatures

According to the NCA, U.S. average temperatures have increased 0.77° - 1.1° C (1.3° - 1.9° F) since record keeping began in 1895 (the range reflects differences in comparison methods); most of the increase has been since about 1970. The decade of 2000 to 2009 was the warmest on record and 2012 was the warmest year on record for the contiguous U.S. Temperatures have continued to increase since these timeframes with the summer monthly temperatures surpassing the previous year's records most years. Temperature changes vary by location. Since 1991, average temperatures in south Florida have been greater than 0.8° C (1.5º F), 0.5° - 0.8° C (1º F to 1.5º F) in central Florida, and 0.3° - 0.5° C (0.5º F to 1º F) in northern Florida.

Extreme heat events in Florida are projected to increase relative to 1986-2005. By the late 21st century, the average temperatures on the hottest days will be 1.7° - 4°C (3º F to 8° F). Due to human-induced emissions of GHGs that already have occurred, another 0.5° F (0.3° C) increase in surface air temperature would be expected even if there were a sudden end to all greenhouse gas emissions caused by humans (NCA, 2014). Significantly more hot days (35° C [95° F] or above) and fewer freezing events are projected. For the State of Florida, this equates to an increase of >50 days for western and southwestern Florida, 40 to 50 days for the interior of Florida, and 30 to 40 days for Florida's coastal areas.

Ecological Implications of Temperature Increases

On-going and projected changes in temperature vary considerably in different locations and with seasonal variations. Thus, "downscaled" projections (at the county level or finer scale) for different seasons are more suitable and useful than global, national, or regional projections of average annual temperatures.

Species and habitats vary in how they respond to increasing temperatures, and there is uncertainty in how exactly increasing temperatures will affect Florida Scrub-Jays. Possible impacts include:

- Some species are physiologically capable of tolerating increased temperature, some will be able to adjust behaviorally, some will shift their ranges if dispersal is possible, some will eventually undergo genetic changes, and some will respond in a combination of ways.
- Studies have shown that some species may initially benefit from the early stages of a warming climate, but then deteriorate (Bertelsmeier, 2013).
- Although some species may tolerate or adapt to increasing temperatures, there may be thresholds beyond which they are unable to adapt quickly enough, creating a risk of local or range-wide extinction due to higher temperatures or combinations with other stressors.
- For a variety of reasons, populations within a species can vary in response to increasing temperatures. We seldom have the information to identify such differences in advance, thus analyses and planning typically assume that responses will be the same.
- Species that are more tolerant of increasing temperatures may be able to outcompete and displace other species in the same area. Some invasive species of plants and animals that tolerate higher temperatures already are increasing in abundance and/or distribution, and may become competitors or predators of native species, perhaps even displacing them.
- Habitat changes also will vary in relation to temperature. In many locations vegetation composition and structure is already changing. Changes will occur on different temporal and spatial scales, and will result in changes in habitat suitability for many species

- High temperatures and prolonged drought can increase the risk and extent of wildfires.

Precipitation

Precipitation patterns are changing. The NCA reports that average precipitation has increased by 5 to 10% since 1900 in South Florida and 0 to 5% in northeastern Florida. However, decreases in precipitation have occurred in central Florida and the Florida Panhandle of 5 to 10%.

Heavy downpours are increasing, especially over the last 30 to 50 years. Increased inland flooding is predicted during heavy rain events in low-lying areas. Increases of up to 27% in the frequency and intensity of these events have occurred across Florida since the 1970s.

Precipitation projections are less certain, but many models project increases in precipitation during the Wet Season (rainy season) across southern Florida and the Caribbean. Projections of future changes in precipitation show substantial shifts in where and how precipitation will fall. Models are in agreement regarding changes in tropical storm and hurricane rainfall events. Greater rainfall rates are expected with about a 20% increase near the center of storms. Scientists continue to research the expectation of precipitation changes in other severe storms.

Ecological Implications for Precipitation Changes

Although warming means larger amounts of water in the atmosphere, not all areas will get wetter. As discussed above, some areas could become drier. It is important to remember that climate change can trigger both droughts and floods. Flooding events will accelerate soil erosion and related impacts. Increased precipitation and/or flooding will affect certain species and their ability to forage and nest. These increases may also displace certain species.

Extreme Events

Extreme events are expected to increase in strength and frequency with accelerated climate change.

Drought

As mentioned in the Precipitation section, dry consecutive days are expected to increase 10 to 20% for most of Florida with up to 30% for South Florida, which could negatively impact Florida Scrub-Jay habitat and food availability.

Wildfires

In some areas, prolonged periods of record high temperatures associated with droughts contribute to dry conditions that are driving wildfires. Wildfires can cause drastic changes in species composition, changes in tree density, increased flooding and erosion risks, and decreased carbon storage capacity. The effects of climate change weaken the natural protections ecosystems have against these extreme events, making them more vulnerable. While wildfires can be initially catastrophic, they can improve habitat quality in the long run.

Hurricanes

There has been a substantial increase in most measures of Atlantic hurricane activity since the early 1980s, the period during which high-quality satellite data are available. These include measures of intensity, frequency, and duration as well as the number of strongest (Category 4 and 5) storms. The recent increases in activity are linked, in part, to higher sea surface temperatures in the region that Atlantic hurricanes form in and move through. Numerous factors have been shown to influence these local sea surface temperatures, including natural variability of the Atlantic Multi-decadal Oscillation (AMO), human-induced emissions of heat-trapping gases, and particulate pollution.

Tropical storms and hurricanes are projected to be fewer in number but stronger in force, with more Category 4 and 5 hurricanes. Almost all existing studies project greater rainfall rates in hurricanes in a warmer climate, with projected increases of about 20% averaged near the center of hurricanes. Models also project changes in hurricane tracks and where they strike land. As is the case for wildfires, hurricanes can destroy habitat in the short term, but improve habitat in the long run, as the habitat depends on frequent disturbance.

Sea Level Rise

The NCA reports that global mean sea level rise (SLR) has been approximately 20.3 cm (8 in) since 1880, the rate over the past 20 years has roughly doubled, and SLR is projected to increase another 1 to 4 feet (ft) by the end of the 21st century. Global average SLR less than 20.3 cm (8 in) or greater than 2 m (6.6 ft) by the end of the century is plausible.

SLR varies locally depending primarily on land subsidence or uplift in response to historic glacial activity across the continent. Storm surges and tides combine with SLR to increase flooding and erosion in many areas. SLR impacts coastal erosion, changes in sediment transport and tidal flows, more frequent flooding from higher storm surges, landward migration of barrier shorelines, fragmentation of islands, and saltwater intrusion into aquifers and estuaries.

SLR is expected to continue for many centuries at rates equal to or higher than those of this century due to past, current, and future emissions of GHGs (from human activities). GHGs result in warmer air which contributes to additional expansion of warmer ocean water and additional melt of ice sheets and glaciers. Vertical land movement is also incorporated in the recent NOAA update for relative sea level (RSL) changes. The newest sea level range projected by NOAA in 2017 is for an "extreme" possibility of 2.4 m (8 ft) global sea level rise by 2100 (NOAA, 2017). These revised scenarios by NOAA were based on improved climate information regarding shifts in oceanic circulation, changes in the flexing of the Earth's mantle and crust, vertical land movement due to glacial melting, and groundwater and fossil fuel withdrawals. Latest findings indicate that Florida is subsiding at a rate of 0.1 cm/year (0.04 inch/year).

It is important to consider storm/tidal surge in combination with SLR, as storm/tidal surge impacts can be more substantial than SLR alone. The latest tidal information from NOAA Florida gauges indicates that the 5-year recurrence interval (20% chance of occurring in any given year) for the medium high high-tide is 50.8 cm (20 in) higher than historically. This equates to the National Weather Service's definition of moderate flooding at NOAA tidal gauges and currently leads to an issuance of a coastal flood warning of a serious risk to life and property. This 5-year frequency increases 25-fold and becomes the "norm" by the year 2035.

The common thread regarding weather predictions for Florida is that extreme events will become more extreme and more frequent. This will increase annual variation and likely increase annual variation in Florida Scrub-jay demographic rates. Increasing variation increases the strength of stochastic effects and typically has the greatest effects on small populations, hence greatly increasing their extinction risk.

Currently, not all climate change consequences relevant to Florida Scrub-Jays are predictable with absolute certainty such as possible negative effects of increase temperature along with drought on insect prey abundance or growth rate and acorn production of scrub oaks. Decreases in precipitation could make it more difficult to apply prescribed fire safely. Conversely, sea level rise along with extreme events (e.g. hurricanes) will certainly have negative impacts on coastal Florida Scrub-Jay populations.

I. Factors Influencing Viability – Ongoing Conservation Efforts

Many partners have worked together towards recovery of the species since the publication of the original Florida Scrub-Jay Recovery Plan. Through federal, state, and local statutes and regulations, Florida Scrub-Jays are offered protection. Many acres of land have been bought for preservation of Florida Scrub-Jays and associated scrub species. Research and monitoring have answered many questions about the biology and ecology of Florida Scrub-Jays throughout Florida. Outreach and education have helped the general public to understand the uniqueness and value of scrub habitat.

1. Regulatory Protection

Federal Regulatory Protection. Florida Scrub-Jays continue to receive regulatory protections under the ESA. Section 9 of the ESA and its implementing regulations (50 CFR § 17.31) prohibit any person from taking (i.e., harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting) Florida Scrub-Jays. Regulations implementing the ESA (50 CFR § 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by impairing significantly essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to disrupt significantly normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. All potentially suitable habitat in which activities are likely to result in take should be surveyed for the presence of Florida Scrub-Jays following the procedures recommended in the "Guidelines for Conducting Surveys for Florida Scrub-Jays."

Section 7 of the ESA requires federal agencies to consult with the USFWS before authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. There have been over 405 ha (1,000 ac) of scrub habitat preserved and managed as conservation measures in peninsular Florida as a result of section 7 consultations since 1990.

Section 10(a)(1)(A) of the ESA and related regulations allow for permits that may be granted to authorize activities otherwise prohibited under section 9, for scientific purposes or to enhance the propagation or survival of a listed species. As a result of the research authorized, numerous scientific publications have increased our understanding of the Florida Scrub-Jay's behavior and environmental requirements.

Section 10(a)(1)(B) of the ESA also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the USFWS determines that certain conditions have been met. Mitigation incorporated into Habitat Conservation Plans for the activities permitted has resulted in excess of 491 ha (1,212 ac) of scrub habitat acquired and managed.

A Safe Harbor Agreement [under section 10(a)(1)(A)] is a relatively new conservation tool that has not been used for Florida Scrub-Jays to date, but there is the potential for these agreements to supply substantial conservation benefits for the species. These are voluntary agreements between a landowner and the USFWS (or other intermediary) under which a landowner agrees to carry out specific management activities for an agreed-upon period for the benefit of listed species. The Federal government, in return, gives the landowner assurance that no new or additional ESA restrictions on the use of the property will be imposed as a result of the landowner's success in restoring or increasing listed species on their land.

Florida Scrub-Jays are protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct. No protection is given to habitat under this authority.

State Regulatory Protection. Florida Scrub-Jays also receive protection from the State of Florida as a threatened species under Rule 68A-27.003, Florida Administrative Code (F.A.C.), which prohibits possessing, or selling individuals, including parts, nests, or eggs except allowed by specific federal or state permit or authorization. Take is further defined in Rule 68A-27.001, F.A.C. Florida Scrub-jay active nests, eggs, and young are also protected under Rules 68A-4.001 and 68A-16.001, F.A.C.

Local Regulatory Protections. Existing regulations in county and city jurisdictions containing populations of Florida Scrub-Jays vary greatly around the state. Applicable local jurisdictional agencies should be contacted before conducting any activity on property that may contain Florida Scrub-Jays.

2. Habitat Protection

There has been a statewide effort made by many partners to purchase scrub habitat for the purposes of conservation since the original 1990 Recovery Plan was completed. Local, county, state, and federal agencies have all worked towards obtaining important remaining patches of scrub for the purposes of protecting Florida Scrub-Jays and other scrub species. These efforts, combined with a continuing campaign to manage publicly owned scrub, will help to stabilize Florida Scrub-Jays over time.

Current assessments, based on a statewide mapping exercise in 2015 (unpubl.), estimate that there are approximately 139,716 ha (345,233 ac) in conservation, which is roughly 78% of the potential remaining scrub habitat in peninsular Florida. There are opportunities to manage the remaining private lands for the benefit of wildlife including conservation easements, conservation banking, along with federal and state initiatives such as Safe Harbor Agreements and Private Lands programs.

3. Habitat Restoration and Management

Habitat restoration and management is and will continue to be a challenge for many land managers. Lack of consistent funding, equipment, and available personnel tend to be a primary theme on conservation lands throughout all of the agencies creating a backlog of habitat not optimal for Florida Scrub-Jay utilization. In addition, the constraints imposed by smoke management when implementing prescribed fire on lands with an urban interface pose significant impediments. However, great strides have been made to address and overcome these obstacles. FWC's Scrub

Management Guidelines, assistance from agencies and NGO fire strike teams, along with information sharing at scrub working group meetings throughout the state have had a beneficial impact.

Over time, ongoing habitat restoration activities on many conservation lands are finally coming to fruition. Numerous habitat restoration success stories involving multiple agencies throughout Florida have benefited local Florida Scrub-Jay populations. A short list of conservation lands where restoration activities have increased the amount of optimal conditions resulting in increased Florida Scrub-Jay occupancy include: USFS Ocala National Forest (Marion), Seminole State Forest (Lake), St. Sebastian River Preserve State Park (Brevard), Duette County Preserve (Manatee), Cross Florida Greenways (Marion), Lyonia Preserve and Blue Spring State Park (Volusia), and Oscar Scherer State Park (Sarasota).

In general, as the restoration activities create optimal habitat conditions the occupancy increases at a fairly slow rate (intrinsic growth); however, there are examples of dramatic increases in the number of territories established by family groups in a relatively short duration of time. These "colonization" events are predicated on immigration from surrounding developed landscapes where the Florida Scrub-Jay populations are declining. The influx of immigrants can also increase the population well above the carrying capacity of the site triggering density dependent limiting factors. Most often, these rapid increases are not sustainable and the population declines over time as the source of immigrants decline along with exploitation of often-limited resources. These rapid, non-internal population growths are far less likely to occur as fragmentation increases and small populations in suburban areas are lost. The following examples describe different outcomes associated with the surrounding landscape.

Oscar Scherer State Park in Sarasota County is embedded in a suburban landscape. The initial habitat restoration activities began in 1988. The Florida Scrub-Jay population grew from roughly 7 territories (27 individuals) to approximately 34 territories (161 individuals) by 1999. At this point, the average territory size was roughly half the size of a typical territory statewide (4.8 ha [12 ac] compared to 10 ha [25 ac]), the breeding pair turnover (adult mortality) was very high (66% compared to ~20%), and there was very low internal recruitment (offspring). The population was well over carrying capacity estimate of approximately 16 territories and began to steadily decline. By 2009, the population was down to 17 territories (43 individuals), which only produced 3 offspring. The population's precipitous decline continued down to 5 territories with the total individuals ranging between 14 and 22 Florida Scrub-Jays (from 2016 through 2018).

A similar example involving a suburban matrix occurred in Volusia County. Lyonia Preserve underwent a massive restoration effort beginning in 1994. At that point in time the overgrown scrub habitat was unoccupied, but having ample Florida Scrub-Jays residing in the adjacent less optimal suburban matrix. As the habitat structure improved to suitable conditions, over 30 family groups were residing in the Preserve by 2006. The number of territories has since fluctuated over the past decade with an increase to the high-30s in some years but also a decline to mid-20s in other years. This population appears to be more stable than the previous example; however, it occurs in a landscape that continues to be developing at a rapid pace. As the source of immigrants decline from the surrounding landscape resulting from additional development of occupied habitat, the Preserve may experience a similar fate as the previous example.

Another situation where habitat conditions improved and an abundant source of immigrants quickly established territories occurred at Maggie Jones-Airstrip Territorial Core Area within Seminole State Forest, Lake County. In 2007, one Florida Scrub-Jay territory occurred on an 8 ha (20 ac) patch of scrub that had been logged of its sand pine overstory in 1999. Two wildfires occurred between the fall of 2006 and late spring of 2007. Following the second fire, the sand pine overstore killed by the fire was salvaged logged along with several other unburned areas. By the fall of 2007, a total of 177 ha (437 ac) were recovering into potential suitable habitat. Seminole Forest Service has been monitoring the Florida Scrub-Jay population growth attributed to intrinsic growth of the resident individuals along with the immigration occurring. The 2014 monitoring data documented 12 territories consisting of 46 individuals. In 2015, there were 9 territories consisting of 53 individuals (unusually high number of individuals per family group). This local population may have long-term sustainability since the area is not under high development pressure and occurs adjacent to large acreages of public conservation lands actively managed for optimal Florida Scrub-Jay habitat.

4. Population Management

Translocation. Translocation is the deliberate and mediated movement of species from one place to another. Translocation could contribute to Florida Scrub-Jay conservation by augmenting small populations and reintroducing Florida Scrub-Jays to areas from which they have become extirpated. Translocation may prove useful for Florida Scrub-Jays because many local populations are well below carrying capacity, habitat loss and fragmentation have increased the distance between local populations, and Florida Scrub-Jays rarely disperse long distances.

The original Recovery Plan highlighted the need to explore translocation as a conservation tool for Florida Scrub-Jays (1990). Since that time, translocation efforts have yielded important insights and led the USFWS and FWC to produce a set of translocation guidelines. As of 2015, 121 individual Florida Scrub-Jays have been translocated to conservation lands. A large percentage of these translocated individuals met one of the following criteria for short-term success: (1) remained on site for a year or more, (2) established a territory and attempted to breed, or (3) defended a territory as a helper.

Mumme and Below (1995, 1999) pioneered the methodology for Florida Scrub-Jay translocation. From 1989-1995, biologists translocated 14 helpers and 3 breeding pairs from ABS to Rookery Bay National Estuarine Research Reserve. Eleven of 20 individuals (55%) met the criteria for short-term success (Mumme and Below 1995, 1999), but the population became extirpated in 2005 due to inadequate habitat management and the small size of the recipient site (R. Mumme, in litt. 2011).

Based on Mumme and Below's work, Mosaic Company (phosphate mining), Quest Ecology, and ABS translocated 51 Scrub-Jays from Mosaic mining lands to the Mosaic Wellfield (conservation area) from 2003-2005 and 2007-2011. Only helpers were translocated in 2003 through 2005. Initially short-term success was 35% (6 of 17 helpers). The project sought to establish a large, self-sustaining population in the part of the genetic unit with the most potential for long-term persistence. Thirty-two of 51 individuals (63%) met the criteria for short-term success. Short-term success increased to over 80% after 2006, when the project switched the time of year (November-December rather than February-March) for translocations and began to move whole family groups instead of helpers. The number of Florida Scrub-Jay groups on the Mosaic Wellfield and adjacent Duette Preserve has grown substantially since 2003 due to the translocation.

The Brevard Zoo has led a broad, partnership-based translocation effort with St. Johns River Water Management District, Brevard County Environmentally Endangered Lands program, USFWS, FWC, David Breininger, and others since 2008. By 2015, this effort translocated 40 Florida Scrub-Jays from areas permitted for development to conservation lands in Brevard and Volusia Counties. Thirty-nine of 50 individuals (78%) met the criteria for short-term success. So far, the three major case studies suggest:

- Translocated birds are better able to establish territories if moved between November through January, when Florida Scrub-Jays tend to be less territorial.
- Translocating entire groups may be more effective for augmenting existing populations.

Insights learned from the case studies informed the development of the USFWS/FWC Florida Scrub-Jay Translocation Guidelines (see USFWS North Florida Ecological Services Office website). The guidelines contain details on capture, transport, and monitoring of translocated Florida Scrub-Jays as well as characteristics of appropriate source populations and recipient sites.

Translocation appears to be a promising tool for Florida Scrub-Jays, but additional information is needed to inform more widespread application. Challenges to translocation include limited source populations and recipient sites, underscoring the need to increase existing populations and prepare potential recipient sites through habitat restoration and management.

<u>Supplemental feeding</u>. There is some evidence that providing the right kind of supplemental food during the pre-breeding season can increase reproductive output of Florida Scrub-Jays in wildlands when environmental conditions are poor (Schoech et al. 2008). However, supplemental feeding of birds can have unintended negative consequences (see Robb et al. 2008 for a review), including the potential for disease transmission (Fischer et al. 1997). More information is needed before supplemental feeding can be considered as a tool to increase reproductive output in small Florida Scrub-Jay populations.

5. Monitoring and Research

<u>Monitoring.</u> The 1992-93 Statewide Mapping Project was the last statewide survey of Florida Scrub-Jays. However, several programs continue to monitor Florida Scrub-Jay populations throughout the species' range. The vast majority of these monitoring programs focus on managed conservation lands, where surveys have documented declines in Florida Scrub-Jay populations since 1992-93 (Boughton and Bowman 2011). The few long-term monitoring programs on private lands indicate rapid population declines (Bowman 1998, Toland 1999), but the general lack of data on private lands complicates assessment of statewide population numbers.

Florida Scrub-Jay monitoring programs fall into two broad tiers: periodic monitoring and demographic monitoring. The former is the most basic form of monitoring and involves periodic (often annual) surveys of banded or unbanded populations. Periodic monitoring provides valuable information to biologists and land managers, including the location of Florida Scrub-Jays relative to management units and the status and trend of populations. Surveys can also provide an index to productivity if conducted from mid-June to late-July, when independent juveniles are conspicuous and distinguishable from adults by plumage (Fitzpatrick et al. 1991, Breininger 2004). Annual monitoring by biologists or volunteers now occurs on many conservation lands important to Florida Scrub-Jays (Boughton and Bowman 2011). Since 2002, the Jay Watch program has recruited citizen scientists to assist with surveys where land managers lack the resources necessary for monitoring. Originally organized by The Nature Conservancy and now run by Audubon of Florida, the Jay Watch program uses consistent protocols (Fitzpatrick et al. 1991) to collect data on managed conservation lands throughout much of the Florida Scrub-Jay's range. Since 2011, annual surveys have taken place in Ocala National Forest through a partnership between the FWC and the USFS. At the local scale, periodic monitoring has assisted land managers with planning and evaluation of management actions. At the statewide scale, periodic monitoring programs provided the data necessary to document the changes in Florida Scrub-Jay populations on managed conservation lands since 1992-93 (Boughton and Bowman 2011).

Although periodic monitoring provides necessary information to land managers and biologists, it is important to recognize limitations in some of these programs. Surveys of population density may provide a misleading indicator of habitat quality and may fail to identify population sinks that are being sustained through immigration (Van Horne 1983, Howe et al. 1991). This underscores the importance of demographic monitoring programs, which can guide management by identifying conditions under which recruitment exceeds mortality (Breininger et al. 2006).

Demographic monitoring involves color-banding of most individuals and frequent surveys to obtain data on survival, recruitment, and dispersal. Several programs have involved long-term demographic monitoring of Florida Scrub-Jays in both wildland and urban/suburban environments since the original Florida Scrub-Jay Recovery Plan (Table 7). These programs have provided invaluable insight into the ecology and management of Florida Scrub-Jays. For example, long-term demographic monitoring programs at ABS, Avon Park Air Force Range, Merritt Island National Wildlife Refuge, and mainland Brevard County have provided an important baseline for demographic parameters and have been critical to our understanding of Florida Scrub-Jay life history, dispersal, disease ecology, and demography-habitat relationships (e.g., Woolfenden and Fitzpatrick 1996b, Breininger et al. 1998, Fitzpatrick et al. 1999, Breininger et al. 2006). Breininger and colleagues have coupled demographic monitoring with habitat monitoring at the territory scale to assist land managers with decision-making. Monitoring of suburban populations documented steep declines and elucidated some of the reasons why Florida Scrub-Jays perform poorly in these environments (Bowman 1998, Toland 1999, Breininger 1999).

Table 7. Locations of long-term (> 5 years) demographic monitoring of Florida Scrub-Jays.

Location	Habitat Type	Years of Monitoring
Archbold Biological Station	Wildland	1969-present
Merritt Island National Wildlife Refuge	Wildland	1980-present
Avon Park Air Force Range	Wildland	1991-present
Placid Lake Estates	Urban/Suburban	1991-2010
Cape Canaveral Air Force Station	Wildland	1994-present
Mainland Brevard & Indian River Counties	Wildland & Urban/Suburban	1997-2009
Duette Preserve	Wildland	1999-present
Disney Wilderness Preserve	Wildland	2002-present
Mosaic Wellfield	Wildland	2003-present
Deep Creek & Harbor Heights, Charlotte County	Urban/Suburban	2003-2007
Seminole State Forest	Wildland	2006-present
Moody Branch	Wildlands	2009-present

<u>Research.</u> Research programs have made important contributions to our understanding of Florida Scrub-Jay ecology and management since the original Florida Scrub-Jay Recovery Plan:

- Stith (1999) identified 21 Florida Scrub-Jay metapopulations thought to be demographically isolated from one another, and he evaluated the vulnerability of each to extinction.
- Coulon and colleagues (2008) identified 10 major Genetic Units, each of which corresponded with and encompassed one or more of Stith's (1999) metapopulations.
- Multiple studies found that Florida Scrub-Jays in fragmented areas move farther on average than in contiguous habitat (Thaxton and Hingtgen 1996, Breininger 1999, Coulon et al. 2010), though most Florida Scrub-Jays still tend to disperse short distances. Despite longer dispersal distances

in fragmented landscapes, Coulon and colleagues (2010) found that levels of gene flow are reduced with increasing fragmentation.

- Research by biologists at ABS and University of Memphis increased knowledge of Florida Scrub-Jay disease ecology.
- Coulon and colleagues (2012) demonstrated how gaps of more than 2-3 km (1.2-1.8 mi) between scrub patches can result in reduced levels of gene flow.
- Breininger and colleagues have made significant contributions to the understanding of how Florida Scrub-Jay demography relates to habitat structure (Breininger et al. 1998, Breininger and Oddy 2004, Breininger et al. 2006), particularly the relationship between demography and habitat states (Breininger and Carter 2003, Breininger et al. 2013). Breininger and colleagues also described how Florida Scrub-Jay territories on the Atlantic Coast often encompass the adjacent flatwoods in addition to the scrub ridges (Breininger and Oddy 2004).
- Several studies increased the understanding of why Florida Scrub-Jay populations tend to decline sharply in suburban areas. Researchers at ABS and University of Memphis demonstrated how Florida Scrub-Jays in suburban environments breed earlier but have higher rates of brood reduction and post-fledgling mortality compared to Florida Scrub-Jays in wildlands (Bowman and Averill 1993, Bowman 1998, Schoech and Bowman 2001, Schoech et al. 2004, Aldredge et al. 2014). Thaxton and Hingtgen (1996) noted that Florida Scrub-Jays in wildlands did not disperse into suburban environments. Mumme and colleagues (2000) highlighted the hazards posed by cars to Florida Scrub-Jays along roadsides. In contrast to other studies, Miller (unpubl.) did not observe significant declines in a suburban Florida Scrub-Jay population during a five-year period in southwest Florida.
- Miller and colleagues (unpubl.) recently began research projects aimed at better understanding the dynamics of Florida Scrub-Jay populations in a mosaic of sand pine clear cuts in USFS's Ocala National Forest.

Despite significant progress, many questions remain such as:

- the optimal size and shape of sandy openings to benefit Florida Scrub-Jays,
- the relationship between Florida Scrub-Jay demography and different kinds of forest edges,
- how much medium-height scrub is enough to provide optimal habitat,
- how much tall scrub can be present without degrading habitat quality within a territory,
- inbreeding affects,
- potential role of translocation for accomplishing genetic rescue of local populations,
- effects of epizootic diseases in small populations.

6. Education and Outreach

Education and outreach programs increase interest in Florida Scrub-Jays and promote understanding of the management actions needed to promote their long-term persistence. There have been notable developments in education and outreach for both conservation partners and the public since the original recovery plan.

For conservation partners, scrub and uplands working groups provide opportunities for continuing education, sharing of information and experiences, and partnership-building. Five of these working groups cover most of peninsular Florida. The Lake Wales Ridge Ecosystem Working Group formed in 1991, and the other groups established more recently (2006-2008). Working group members include representatives from county, state, and federal agencies as well as non-governmental organizations, consultants, and private landowners with an interest in scrub and uplands conservation.

The working groups use presentations, workshops, and field trips to address topics ranging from habitat restoration and management to monitoring and research.

Public education and outreach efforts play an important role by raising awareness of the needs of Florida Scrub-Jays and other scrub species. ABS has a long-standing education program that now includes the Frances Archbold Huffy Learning Center, completed in 2011. Over 1,300 children participate annually in ABS's education programs for grades 3-5 in south central Florida, and ABS also conducts a summer day camp. Completed in 2009 next to Lyonia Preserve in Deltona, the Lyonia Environmental Center provides field trips, educational programs, hands-on displays, and a summer camp. Since 2009, the annual Florida Scrub-Jay Festival has moved to different locations throughout peninsular Florida to raise awareness about Florida Scrub-Jays and habitat management.

Education and outreach programs that promote understanding of prescribed fire also benefit Florida Scrub-Jays. Jonathan Dickinson and Savannas Preserve state parks hold an annual festival, FireFest, which includes a prescribed burn demonstration. The Florida Forest Service provides educational opportunities, including the Fire in Florida's Ecosystems curriculum for grades 3-12. Florida Forest Service's Firewise program, which seeks to reduce wildfire risk for local communities, increases the awareness and safety for conservation professionals burning in the wildland-urban interface.

J. Future Conditions

1. Future Scenario Considerations

In an attempt to predict future conditions for the Florida Scrub-Jay, one must acknowledge that the species has been steadily and rapidly declining essentially everywhere. For this reason, this highly fragmented species requires maximizing potential opportunities for persistence across the entire current range, incorporating representation (genetic and ecological diversity), resiliency (sufficient population size), and redundancy (sufficient number of populations) into a strategy to realize a comprehensive conservation approach. The three Rs framework approach fulfills the ESA recovery requirements for geographic representation, ecosystem conservation, and threats abatement (Wolf et al. 2015). Based on this framework, the following principles guided the development of this approach:

- Preserve populations in all potentially viable genetic units across the species' remaining range of genetic variability (representation);
- Maintain or improve connectivity and prevent fragmentation among populations of the largest landscapes within these genetic units in order to provide the best opportunity for long-term persistence of each unit (resiliency);
- Conserve multiple populations in strategic areas wherever possible, emphasizing the most potentially viable genetic units across the species' range (redundancy).

Consequently, the more genetic units that are conserved, the greater the range of genetic variation is protected (representation). Conserving as much remaining genetic variation as possible, and as soon as possible, is rendered urgent by the fact that most populations are in sharp decline (USFWS 2007, Boughton and Bowman 2011). Given the rapid losses underway today, it is reasonable to protect as much genetic variation as possible because once it is lost, it is lost forever.

2. Future Conditions Approach

Incorporating the three Rs to assess current population viability and to predict potential future scenarios, a hierarchical prioritization scheme was developed from a comprehensive, range-wide habitat mapping exercise using the best available data in each genetic unit. This prioritization scheme focuses on large, well-connected landscape scale expanses of suitable or potentially restorable habitat in as many genetic units as possible.

The comprehensive range-wide habitat mapping exercise examined potential habitat both within and outside existing conservation areas, using GIS. The spatial assessment was based on known demographic and dispersal parameters to identify Florida Scrub-Jay habitats essential for conservation planning. Developing the prioritization scheme required (1) identifying potential local populations based on the available potential habitat, (2) categorizing potential local populations according to their probability of persistence, and (3) identifying well-connected landscapes with large potential local populations.

Habitat patches having any significant probability of supporting local Florida Scrub-Jay populations were identified and prioritized. A local population refers to a collection of Florida Scrub-Jay family groups that interact regularly through dispersal. Potential local populations were defined using Breininger and colleagues' (2006) criteria for a "territory cluster," which includes all patches of potential habitat within 670 m (2,198 ft) of one another (the average diameter of two Florida Scrub-Jay family group territories). The probability of persistence improves with increasing connectivity, but gaps between habitat patches greater than 2-3 km (1.2-1.9 mi) can inhibit connectivity among local populations, thereby reducing gene flow as well as the probability of demographic rescue (Coulon et al. 2012). The mapping exercise identified potential habitat possessing the ability for long-term persistence of a population, regardless of whether the potential habitat is currently occupied or suitable.

Habitat patches were categorized based on presumed carrying capacity and proximity to other habitat. The carrying capacity is an estimate of the maximum number of Florida Scrub-Jay territories that a specific area could reasonably be expected to support. The carrying capacity estimates in the conservation strategy assume that a Florida Scrub-Jay family group requires 10 ha (25 ac) per territory, which corresponds to the average territory size in well-managed habitat at carrying capacity (i.e., saturated habitat conditions) (Woolfenden and Fitzpatrick 1984, 1996; Fitzpatrick et al. 1991). The strategy targets a 70% carrying capacity because it is unrealistic to assume that all habitat will be occupied at any given time (Boughton and Bowman 2011). Certain portions of any habitat patch often are suboptimal or even unsuitable for Florida Scrub-Jays because of vegetative structure (either very recently burned or long unburned and therefore overgrown) or management constraints. On the other hand, the capability to maintain Florida Scrub-Jays at 70% of overall carrying capacity through informed habitat management has been well documented at a number of public and private habitat preserves across the range of the species.

Potential local populations were categorized as core areas, support areas, or auxiliary areas based on their potential carrying capacity, regardless of the area's current status. A "core area" is defined as a potential local population that contains sufficient habitat to support 40 or more family groups at 70% carrying capacity. A "support area" is defined as a potential local population that (a) contains sufficient habitat to support 10-39 family groups at 70% carrying capacity, and (b) is either within 3.5 km (2.2 mi) of a core area or is within 3.5 km of other support areas that together contain enough potential habitat to support 40 or more family groups at 70% carrying capacity. An "auxiliary area" is defined as a potential local population that contains sufficient habitat to support 10 or more family groups at 70% carrying capacity but does not meet the definition of a core or support area.

Maintaining connectivity among local populations is important for conserving Florida Scrub-Jays (Coulon et al. 2010, 2012) and may necessitate the protection of smaller important scrub patches or "stepping stones" and other permeable habitats (e.g., fire maintained flatwood or sandhill habitats) in some genetic units (Chen et al. 2016) A "stepping stone" is here defined as a tract of suitable habitat situated between two or more scrub habitats, permitting dispersing individuals to move across the landscape more readily than they could in areas without tracts of scrub patches. These smaller scrub patches not captured in the prioritization scheme described above are important and can contribute to Florida Scrub-Jay conservation. All existing populations of Florida Scrub-Jays, regardless of their size or location on the landscape, have intrinsic genetic and ecological value and can contribute to the conservation and recovery of the species. Each population throughout the species range is an important reservoir of genetic diversity and potential dispersers. Where possible, any such population should be retained. Support populations are an essential source of immigrants for the core populations as they increase the overall genetic variation of the core populations. In addition, even the smaller, isolated, and sometimes apparently peripheral populations are of value. These populations have the capability to increase the genetic diversity of other populations through rare long distance dispersals or assisted movements (i.e., translocation). Alleviating the loss of genetic diversity in declining populations will become essential as ever-more populations become tiny and isolated. Many existing populations, even those within core and support areas, are currently well below the population sizes necessary to withstand the stressors of demographic, environmental, and genetic stochasticity.

This conservation tactic emphasizes habitat availability, suitability, and connectivity. This multi-parameter approach addresses the major threats of habitat loss, habitat degradation, and habitat fragmentation, all of which have contributed to the isolation and decline of Florida Scrub-Jay populations throughout the species' historic and current range. It is now well documented that concentrating recovery actions on improving habitat conditions, through scrub restoration and management reduces the major stressors and causes Florida Scrub-Jay populations to respond positively (Fitzpatrick and Bowman 2016, Breininger et al. 2006, 2013 and references therein).

The following three conservation future scenarios – Optimal Conservation, Focal Landscapes, and Status Quo – are presented as options that may be utilized in an attempt not only to stabilize current populations from their continual decline, but also to ensure future population viability range-wide where possible. It is important to highlight that these scenarios do not incorporate risk factors (e.g., development, poor habitat management, climate change, etc.). These scenarios deal only with the quantity and distribution of protected habitat across the landscape. The ability of Florida Scrub-Jays to occupy and thrive in this habitat depends on the long-term status of these risk factors, in which there are high levels of uncertainty.

K. Long-Term Conservation Scenarios

1. Conservation Scenario 1. Optimal Conservation – Full Acquisition and Management

The most ambitious and certainly an extremely arduous effort would be that of the optimal conservation scenario. This would entail protection (additional acquisitions or conservation easements) of all remaining habitat that is occupied by Florida Scrub-Jays currently not in conservation and also habitat that has the potential to support future Florida Scrub-Jay populations. Complementing the protection of lands to ensure large conservation areas, habitat management in perpetuity would also be required to ensure the habitat is optimal for Florida Scrub-Jay long-term viability. For each of the genetic units, the previously described spatial assessment identified areas currently in conservation and those that could be potential candidates for additional acquisitions, conservation easements, and management. This information is presented in table format following the *Summary of Future Scenarios* (Tables 9-17). Optimal Conservation descriptions of each genetic unit, potential populations (core, support, and auxiliary areas), and other patches along with habitat illustrations can be found in Appendix A.

2. Conservation Scenario 2. Focal Landscapes – Land Acquisition Focused on Linkages and Management

The Focal Landscape approach attempts to maintain genetic diversity by placing special focus on conserving those populations that have the highest likelihood of remaining demographically viable (i.e., populations in focal landscapes). To achieve resiliency and redundancy, this conservation strategy emphasizes well-connected landscapes critical for viability while retaining flexibility to expand conservation efforts to smaller areas as resources allow. Maintaining multiple populations and ensuring connectivity among the populations via corridors or stepping stones buffers against local catastrophes, including disease outbreaks and extreme weather. Connectivity among local populations increases resiliency by allowing exchange of genetic material and by reducing the risk of extirpation for small populations through immigration. Dispersal events may be infrequent, but will occur often enough to allow occasional recolonization of populations that have suffered local extinction or small populations experiencing inbreeding depression.

Although this conservation strategy concentrates on large landscapes, it is important to emphasize again that all remaining Florida Scrub-Jays populations, regardless of their size or location, can contribute to the conservation and recovery of the species. All actions that serve to protect and benefit Florida Scrub-Jays on native habitat are important and of value regardless of where they occur. Although large populations are critical to species conservation, small populations that occur within a network of sites in reasonable proximity to one another can supply immigrants into large, well-managed populations, thereby reducing inbreeding and helping maintain overall genetic diversity in these essential core populations. In turn, smaller populations occasionally receive colonists dispersing from the larger populations, thereby reducing local extirpations or providing "rescue" following extirpation. Such metapopulation dynamics increase the resiliency and persistence of all populations within these networks.

Utilizing a recovery team GIS mapping exercise, 7 focal landscapes were selected representing 6 of the 10 genetic units. The focal landscapes generally consist of networks of core and support areas; however, not all identified core, support, or auxiliary areas were designated as focal landscapes.

Three Genetic Units – North Central, Northeast Coastal, and Lake Wales Ridge – provide the greatest conservation opportunities, as these contain the four largest focal landscapes possessing expansive terrain and having high habitat connectivity. In addition, a high percentage of the scrub habitat in these genetic units is currently in public ownership with existing habitat management plans. Although current management on these protected tracts does vary with the representative agencies' missions, their management plans include improving Florida Scrub-Jay populations and their habitat.

The three remaining focal landscapes have smaller potential carrying capacities than those previously described. Although their potential population sizes and opportunities for connectivity are not as great as in the four larger ones, these focal landscapes contain genetically and behaviorally distinct Florida Scrub-Jay populations, as well as significant parcels of native Florida scrub that are critical for a host of other at risk scrub-endemic organisms. Recovery of these three focal landscapes is essential for ensuring the long-term representation, redundancy, and resiliency of Florida Scrub-Jays. The three remaining focal landscapes occur in the East Coastal, Southwest Inland, and Southeast Coastal Genetic Units.

Focal Landscape descriptions of each genetic unit, potential populations (core, support, and auxiliary areas), potential acreages to be protected, and other patches along with habitat illustrations can be found in Appendix B.

3. Conservation Scenario 3. Status Quo – Management of Existing Conservation Lands

The Status Quo scenario strategy requires no additional land acquisition but merely attempts to manage habitat on existing conservation lands for optimal Florida Scrub-Jay occupancy. This approach will almost certainly further reduce the current range of the species – short-term and long-term demographic viability – as fragmentation and limited carrying capacity stressors will continue to negatively affected the vast majority of the populations.

As noted previously, with the lack of immigration, isolated populations with fewer than 10 family groups are highly vulnerable to local extinction strictly from stochastic demographic fluctuations (Fitzpatrick et al. 1991). Populations ranging from 15 to 30 territories would be considered marginally secure; however, a population of 15 territories (15 breeding pairs) is well below a generally accepted population size at which genetic variability is maintained (Soule 1980). Demographic models indicate that populations containing 30 or more territories are the smallest populations in which the probability of persisting for 100 years is at least 90%. Even in populations of this size, habitat management is essential, because long-term persistence in this cooperatively-breeding species requires successful annual reproduction, high rates of offspring survival, and a significant standing population of non-breeding "helpers" that serve as demographic and genetic buffers against population decline (Fitzpatrick et al. 1991). Moreover, recent genetic studies (Chen et al. 2016, Aguillon et al. 2017) have demonstrated that reduced immigration leads to loss of genetic variability even within populations containing as many as 125 breeding pairs. These studies underscore the importance of protecting small satellite populations that are within dispersal distance of larger core populations, as colonists from these satellite populations provide a constant source of new genetic variation, reducing the negative effects of inbreeding within the target population.

Implementing solely a status quo strategy, three of the genetic units will be limited to future populations smaller than 30 breeding pairs. Furthermore, an additional three genetic units will only have the potential to support 1 core area greater than 40 breeding pairs, which is considered the minimal threshold to ensure less than a 5% extinction risk over 100 years.

This approach may have some utility for populations currently with large landscapes in conservation or where there is little to no additional acquisition potential.

Status Quo descriptions of each genetic unit, potential populations (core, support, and auxiliary areas), and other patches along with a habitat illustration can be found in Appendix C.

4. Future Resiliency, Redundancy, and Representation

Based on potential population carrying capacities within each genetic unit under each of the three conservation scenarios, the number of populations achieving high resiliency is expected to be highest under the Optimal Conservation scenario, where all lands that could potentially support Florida Scrub-Jays are protected and managed. Future comparisons of the potentially high resilient populations in each genetic unit for the three scenarios are shown in Table 8.

Table 8. Number of populations projected to be have high resiliency in Optimal Conservation, Focal Landscapes, and Status Quo scenarios.

Genetic Unit	Optimal Conservation	Focal Landscapes	Status Quo
A	5	3	1
B	12	12	7
C	3	3	2
D	6	4	4
E	0	0	0
F	3	3	1
G	3	0	0
H	1	0	0
I	1	1	1
K	0	0	0
Total Populations	34	26	16

5. Summary of Long-Term Conservation Scenarios

The conservation scenarios were presented as three separate conservation approaches for all the genetic units; however, depending on the various opportunities or constraints within the individual genetic units, all three options may be utilized in a final conservation strategy. Populations within some genetic units might only necessitate management of existing conservation lands to ensure viability, while other populations may require additional land acquisitions (or conservation easements) to reduce fragmentation and increase connectivity for greater representation, resiliency, and redundancy.

As noted previously but worthy of restating, the potential carrying capacities projected in the table are not the current number of breeding pairs. These numbers of breeding pairs assume that populations are at 70% carrying capacity, which will require significant increases in population sizes from the *Current Condition* and ongoing habitat management. Thus, the expected outputs from these scenarios are all optimistic, showing how many Florida Scrub-Jay groups could be supported at an undetermined future time if all risk factors are mitigated to support population growth.

Below (Tables 9-17) is a comparison of projected potential population carrying capacities within each genetic unit under each of the three conservation scenarios. Because an area had to have a 70% carrying capacity of at least 10 family groups to be classified as a core, support, or auxiliary population, no low-resilience (< 10 family groups) populations emerge in these long-term projections where all populations reach 70% of carrying capacity. In order to reach this ambitious goal, habitat for all managed populations must be managed well in perpetuity.

As noted prior, the number of populations and family groups is expected to be highest under the Optimal Conservation scenario, where all lands that could potentially support Florida Scrub-Jays are protected and managed. This scenario would be massively cost and labor intensive, and is considered to be the least likely to occur out of these three scenarios. The Focal Landscapes and Status Quo scenarios are more likely to occur, and are even likely to occur as a combined strategy depending on local conservation resources and priorities. In the Focal Landscapes scenario, approximately 5,096 Florida Scrub-Jay family groups could potentially be supported in 42 populations, with almost 95% of the family groups occurring in 26 highly resilient populations. More populations exist under the Status Quo scenario than under the Focal Landscapes scenario, but they are of lower resilience, and fewer family groups are supported range-wide. This illustrates the benefit of the Focal Landscapes approach in connecting fragmented populations to improve population resilience.

The following tables are a comparison of the three future scenarios projected potential family groups per genetic unit:

Table 9. East Coastal Genetic Unit (Genetic Unit A) Future Scenarios

Genetic Unit A – East Coastal					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core A-1	117	Core A-1	117	Core SQA-1	84
Core A-2	68	Core A-2	68	Auxiliary SQA-2	17
Core A-3	66				
Core A-4	53	Core A-4	53	Support SQA-4	29
Core A-5	50			Auxiliary SQA-5	10
	354		**238**		**140**
Support A-6	30	Support A-6	30		
Support A-7	30				
	60		**30**		
Auxiliary A-8	17				
Auxiliary A-9	16			Auxiliary SQA-9	16
Auxiliary A-10	12			Auxiliary SQA-10	11
Auxiliary A-11	11				
Auxiliary A-12	10				
	66				**27**
Total	**480**		**268**		**167**

Table 10. Lake Wales Ridge Genetic Unit (Genetic Unit B) Future Scenarios

Genetic Unit B – Lake Wales Ridge					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core B-1	245	Core B-1	245	Core SQB-1	182
Core B-2	209	Core B-2	209	Core SQB-2a Core SQB-2b	163 40
Core B-3	183	Core B-3	183	Core SQB-3	83
Core B-4	172	Core B-4	172	Core SQB-4	105
Core B-5	107	Core B-5	107	Core SQB-5	60
Core B-6	99	Core B-6	99	Auxiliary SQB-6	14
Core B-7	70	Core B-7	70	Support SQB-7	34
Core B-8	60	Core B-8	60	Auxiliary SQB-8	16
Core B-9	55	Core B-9	55	Core SQB-9	41
Core B-10	47	Core B-10	47		
Core B-11	41	Core B-11	41	Auxiliary SQB-11	31
Core B-12	40	Core B-12	40	Support SQB-12	23
	1328		**1328**		**407**
Support B-14	36			Auxiliary SQB-14	22
Support B-15	31	Support B-15	31	Support SQB-15	31
Support B-16	29	Support B-16	29	Auxiliary SQB-16	16
Support B-18	22	Support B-18	22	Support SQB-18	23
Support B-19	19				
Support B-20	18	Support B-20	18	Auxiliary SQB-20	15
Support B-24	14	Support B-24	14		
	169		**114**		**107**
Auxiliary B-13	39			Auxiliary SQB-13	39
Auxiliary B-17	26				
Auxiliary B-21	18				
Auxiliary B-22	16				
Auxiliary B-23	15				
Auxiliary B-25	14				
Auxiliary B-26	13			Auxiliary SQB-26	13
Auxiliary B-27	12			Auxiliary SQB-27	12
Auxiliary B-28	12				
Auxiliary B-29	12				
Auxiliary B-30	11				
Auxiliary B-31	10				
Auxiliary B-32	10			Auxiliary SQB-32	11
Auxiliary B-33	10			Auxiliary SQB-33	10
	218				**85**
Total	**1715**		**1442**		**599**

Table 11. Northeast Coastal Genetic Unit (Genetic Unit C) Future Scenarios

Genetic Unit C – Northeast Coastal					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core C-1	404	Core C-1	587	Core SQC-1	358
Core C-2	224	Core C-2	229	Core SQC-2	224
Core C-3	46	Core C-3	47		
	674		**863**		**582**
Support C-6	20	Support C-6	20		
	20		**20**		
Auxiliary C-4	30			Auxiliary SQC-4	18
Auxiliary C-5	24			Auxiliary SQC-5	22
Auxiliary C-7	10			Auxiliary SQC-7	10
	64				**50**
Total	**758**		**[1]883**		**632**

[1] Focal Landscape metrics derived from grid cell mapping for Merritt Island NWR, Cape Canaveral Air Force Station and Core C-3 statewide mapping: 587 groups, 229 groups, 47 groups respectively (70% carrying capacity).

Table 12. North Central Genetic Unit (Genetic Unit D) Future Scenarios

Genetic Unit D – North Central					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core D-1	6557	Core D-1	*1851	Core SQD-1	6345
Core D-2	277	Core D-2	*83	Core SQD-2	277
Core D-3	78				
Core D-4	78	Core D-4	*78	Core SQD-4	40
Core D-5	67			Auxiliary SQD-5	31
Core D-6	61	Core D-6	**61	Core SQB-6	57
	7118		**2073**		**6750**
Support D-10	23	Support D-10	**23	Support SQD-10	23
Support D-11	22			Support SQD-11	11
Support D-12	20	Support D-12	*20	Support SQD-12	20
Support D-15	19			Support SQD-15	19
Support D-16	18				
Support D-17	18	Support D-17	**18	Support SQD-17	17
Support D-20	13			Auxiliary SQD-20	13
Support D-22	11				
Support D-24	11				
Support D-26	10			Support SQD-26	10
	165		**61**		**86**
Auxiliary D-7	34				
Auxiliary D-8	25			Auxiliary SQD-8	25
Auxiliary D-9	24			Auxiliary SQD-9	21
Auxiliary D-13	20			Auxiliary SQD-13	18
Auxiliary D-14	20				
Auxiliary D-18	17			Auxiliary SQD-17	17
Auxiliary D-19	16				
Auxiliary D-21	13				
Auxiliary D-23	11			Auxiliary SQD-23	11
Auxiliary D-25	10			Auxiliary SQD-25	10
Auxiliary D-27	10				
Auxiliary D-28	10			Auxiliary SQD-28	10
	210				**127**
Total	**7493**[2]		**2134**[3]		**6963**[4]

[2] Optimal Conservation metrics were derived from the mapping exercise, which are not realistic because of the magnitude and multi-use of Ocala National Forest. Ocala National Forest has over 226,000 acres of potential scrub habitat.

[3] Focal Landscape metrics were derived from Ocala National Forest Plan Based on *70,000 acres for ecosystem management within forest boundaries and **6,200 acres of existing public conservation lands within the focal landscape boundary at a 70% carrying capacity.

[4] Status Quo metrics were also derived from the mapping exercise, which are not realistic because of the magnitude and multi-use of Ocala National Forest.

Table 13. Southwest Coastal Genetic Unit (Genetic Unit E) Future Scenarios

Genetic Unit E – Southwest Coastal					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Auxiliary E-1	86				
Auxiliary E-2	16			Auxiliary SQE-2	16
Auxiliary E-3	12				
	114				
Total	**114**		**0**		**16**

Table 14. Southwest Inland Genetic Unit (Genetic Unit F) Future Scenarios

Genetic Unit F – Southwest Inland					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core F-1	82	Core F-1	82	Core SQF-1	80
Core F-2	51	Core F-2	51		0
Core F-3	43	Core F-3	43	Support SQF-3	37
	176		**176**		**117**
Support F-7	18	Support C-7	18		
Support F-8	16	Support F-8	16		
Support F-9	14	Support F-9	14		
	48		**48**		
Auxiliary F-4	34	Auxiliary F-4	34	Auxiliary SQF-4	30
Auxiliary F-5	21			Auxiliary SQF-5	20
Auxiliary F-6	19			Auxiliary SQF-6	16
Auxiliary F-10	13				
	87		**34**		**66**
Total	**311**		**258**		**183**

Table 15. Southwest Volusia County Genetic Unit (Genetic Unit G) Future Scenarios

Genetic Unit G – Southwest Volusia County					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core G-1	91				
Core G-2	67			Auxiliary SQG-2	25
Core G-3	45				
	203				
Support G-4	30			Auxiliary SQG-4	15
Support G-5	13				
Support G-6	12				
Support G-7	11				
Support G-8	10				
	76				
Total	**279**		**0**		**40**

Table 16. Levy County Genetic Unit (Genetic Unit H) Future Scenarios

Genetic Unit H – Levy County					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core H-1	113			Auxiliary SQH-1	22
	113				**22**
Total	**113**		**0**		**22**

Table 17. Southeast Coastal Genetic Unit (Genetic Unit I) Future Scenarios

Genetic Unit I – Southeast Coastal					
Optimal Conservation		Focal Landscape		Status Quo	
Location	70% K	Location	70% K	Location	70% K
Core I-1	100	Core I-1	84	Core SQI-1	81
	100		**84**		**81**
Support I-3	16	Support I-3	16	Auxiliary SQI-3	16
Support I-4	11	Support I-4	11		
	27		**27**		**16**
Auxiliary I-2	28			Auxiliary SQI-2	15
Auxiliary I-5	11			Auxiliary SQI-5	10
	39				**25**
Total	**166**		**111**		**122**

Literature Citation

Abrahamson, W.G. 1984. Post-fire recovery of Florida Lake Wales Ridge vegetation. American Journal of Botany 71(1):9-21.

Abrahamson W. G. and D. C. Hartnett. 1990. "Pine flatwoods and dry prairies" Ecosystems of Florida. Ed. R.L. Myers and J.J. Ewel. Orlando, FL: University of Central Florida Press, 1990. 103-149.

Abrahamson, W.G., A.F. Johnson, J.N. Layne, and P.A. Peroni. 1984. Vegetation of the Archbold Biological Station, Florida: an example of the southern Lake Wales Ridge. Florida Scientist 47(4):209-250.

Aguillon, S.M., J.W. Fitzpatrick, R. Bowman, S.J. Schoech, A.G. Clark, G. Coop, N. Chen. 2017. Deconstructing isolation-by-distance: the genomic consequences of limited dispersal. PLoS Genetics, doi.org/10.1371/journal.pgen.1006911.

Aldredge, R.A., R.K. Boughton, M.A. Rensel, S.J. Schoech, R. Bowman. 2014. Hatching asynchrony that maintains egg viability also reduces brood reduction in a subtropical bird. Oecologia (2014) 174: 77.

American Ornithologists' Union [AOU]. 1995. Fortieth supplement to the American Ornithologists' Union check-list of North American Birds. The Auk 112(3):823-824.

American Ornithologists' Union [AOU]. 2011. Fifty second supplement to the American Ornithologists' Union check-list of North American Birds. The Auk 128(3):600-613.

American Ornithologists' Union [AOU]. 2016. Fifty seventh supplement to the American Ornithologists' Society check-list of North American Birds. The Auk 133:544-560.

Austin, D.F. 1976. Florida scrub. Florida Naturalist 49(4):2-5.

Bancroft, G.T. and G.E. Woolfenden. 1982. The molt of scrub jays and blue jays in Florida. Ornithological Monographs Number 29. American Ornithologists' Union; Washington, D.C. 51 pages.

Bendire, C.E. 1895. Life histories of North American birds. U.S. National Museum Special Bulletin No. 3. U.S. Government Printing Office, Washington D.C. 518 pages.

Bent, A.C. 1946. Life histories of North American jays, crows, and titmice. U.S. National Museum Bulletin 191. U.S, Government Printing Office, Washington D.C.

Berg, E.C., R.A. Aldredge, A.T. Peterson, J.E. McCormack. 2012. New phylogenetic information suggest both an increase and at least one loss of cooperative breeding during the evolutionary history of Aphelocoma jays. Evolutionary Ecology 26:43-54.

Bertelsmeier, C., G.M. Luque, F. Courchamp. (2013). The impact of climate change changes over time. Biological Conservation 167: 107-115.

Boughton, R.K., J.W. Atwell, and S.J. Schoech. 2006. An introduced generalist parasite, the sticktight flea (*Echidnophaga gallinacea*), and its pathology in the threatened Florida scrub-jay (*Aphelocoma coerulescens*). Journal of Parasitology 92: 941-948.

Boughton, R.K. and R. Bowman. 2009. Final Report to National Science Foundation for Small Grants for Exploratory Research, Division of Environmental Biology #0855879.

Boughton, R.K. and R. Bowman. 2011. State wide assessment of Florida Scrub-Jay on managed areas: a comparison of current populations to the results of the 1992-93 survey. Report to U.S. Fish and Wildlife Service.

Bowman, R. 1998. Population dynamics, demography, and contributions to metapopulation dynamics by suburban populations of the Florida scrub-jay, *Aphelocoma coerulescens*. Final report on Project No. NG94-032 to Florida Fish and Wildlife Conservation Commission, Tallahassee, FL. 138 pages.

Bowman, R. and L. Averill. 1993. Demography of a suburban population of Florida scrub jays. Annual progress report for Agreement No. 14-16-0004-91-950 with U.S. Fish and Wildlife Service. December 1993. 27 pages + appendices.

Bowman, R. and G.E. Woolfenden. 2001. Nest success and the timing of nest failure of Florida scrub-jays in suburban and wildland habitats. Pages 383-402 *in*: Marzluff, J.M., R. Bowman, and R. Donnelly (eds.). Avian Ecology and Conservation in an Urbanizing World. Kluwer Academic Publishers, Norwell, MA.

Bowman, R., G.E. Woolfenden, A.L. Fleischer, Jr., and L.M. Walton. 1996. Nest site selection by Florida scrub-jays in natural and modified habitats. Abstract, Archbold Biological Station 1996 Symposium. 12 September 1996. Lake Placid, Florida. 1 page.

Breininger, D.R. 1999. Florida scrub-jay demography and dispersal in a fragmented landscape. The Auk 116(2):520-527.

Breininger, D.R. 2004. An adaptive approach to managing Florida scrub-jay habitat. NASA Technical Memorandum NASA/TM-2004-211532.

Breininger, D.R. 2006. Landcover change and population dynamics of Florida scrub-jays and Florida grasshopper sparrows, Ph. D. Dissertation. University of Central Florida, Orlando, Florida. 222 pages.

Breininger, D.R. and G.M. Carter. 2003. Territory quality transitions and source-sink dynamics in a Florida Scrub-Jay population. Ecological Applications 13:516-529.

Breininger, D.R. and D.M. Oddy. 2004. Do habitat potential, population density, and fires influence Scrub-Jay source-sink dynamics? Ecological Applications 14:1079-1089.

Breininger, D.R. and D.M. Oddy. 1998. Biological criteria for the recovery of Florida scrub-jay populations on public lands in Brevard county. Final Report to U.S. Fish and Wildlife Service. Jacksonville Filed Office. 54 pages.

Breininger, D.R. and P.A. Schmalzer. 1990. Effects of fire and disturbance on plants and birds in a Florida oak/palmetto scrub community. American Midland Naturalist 123(1):64-74.

Breininger, D.R. and R.B. Smith. 1992. Relationships between fire and bird density in coastal scrub and slash pine flatwoods in Florida. The American Midland Naturalist 127:233-240.

Breininger, D.R., V.L. Larson, B.W. Duncan, R.B. Smith, D.M. Oddy, and M.F. Goodchild. 1995. Landscape patterns of Florida scrub jay habitat use and demographic success. Conservation Biology 9(6):1442-1453.

Breininger, D.R., V.L. Larson, D.M. Oddy, R.B. Smith, and M.J. Barkaszi. 1996. Florida Scrub-jay demography in different landscapes. The Auk 113(3):617-625.

Breininger, D.R., V.L. Larson, B.W. Duncan, and R.B. Smith. 1998. Linking habitat suitability to demographic success in Florida scrub-jays. Wildlife Society Bulletin 26(1):118-128.

Breininger, D.R., M.A. Burgman, and B.M. Stith. 1999. Influence of habitat quality, catastrophes, and population size on extinction risk of the Florida scrub-jay. Wildlife Society Bulletin 27(3):810-822.

Breininger, D.R., B.W. Duncan, and N.J. Dominy. 2002. Relationships between fire frequency and vegetation type in pine flatwoods of east-central Florida, USA. Natural Areas Journal 22(3):186-193.

Breininger, D.R., B. Toland, D. Oddy, M. Legare, J. Elseroad, and G. Carter. 2003. Biological criteria for the recovery of Florida scrub-jay populations on public lands in Brevard County and Indian River County. Final Report to Endangered Species Office, U.S. Fish and Wildlife Service, Jacksonville, Florida. 104 pages.

Breininger, D.R., B. Toland, D.M Oddy, and M.L. Legare. 2006. Landcover characterizations and Florida Scrub-jay (*Aphelocoma coerulescens*) population dynamics. Biological Conservation 128:169-181.

Breininger, D.R., J.D. Nichols, G.M. Carter and D.M. Oddy. 2009. Habitat-specific breeder survival of Florida Scrub-Jays: inferences from multistate models. Ecology. 90(11) pp. 3180-3189.

Breininger, D.R., E.D. Stolen, D.M. Oddy and G.M. Carter. 2010. A model selection approach to predicting whether Florida Scrub-Jays delay breeding. Condor.112:378-389.

Breininger, D.R., J.D. Nichols, B.W. Duncan, E.D. Stolen, G.M. Carter, D. Hunt and J.H. Drese. 2010. Multistate modeling of habitat dynamic: factors affecting Florida scrub transition probabilities. Ecology. 91:3354-3364.

Breininger, D.R., B.W. Duncan, M. Eaton, F. Johnson and J. Nichols. 2014. Integrating land cover modeling and adaptive management to conserve endangered species and reduce catastrophic fire risk. Land 3:874-897.

Breininger, D.R., T.E. Foster, G.M. Carter, B.W. Duncan, E.D. Stolen and J.E. Lyon. 2018. The effects of vegetative type, edge, fire history, rainfall and management in fire-maintained habitat. Ecosphere 9:1-15.

Breininger, D.R., E.D. Stolen, G.M. Carter, D.M. Oddy and S.A Legare. 2014. Quantifying how territory quality and sociobiology affect recruitment to inform fire management. Animal Conservation. 17:72-79.Brigham, D. 1973. Scrub jay. Florida Naturalist 46:22.

Burgman, M.A., D.R. Breininger, B.W. Duncan, and S. Ferson. 2001. Setting reliability bounds on habitat suitability indices. Ecological Applications 11:70-78.

Burt, D.B., and A.T. Peterson. 1993. Biology of cooperative-breeding scrub jays (*Aphelocoma coerulescens*) of Oaxaca, Mexico. The Auk 110(2):207-214.

Byrd, H. 1927. Notes from correspondents: Florida jay. Florida Naturalist 1(4):87.

Carter, G.M., E.D. Stolen, D.R. Breininger. 2006. A rapid approach to modeling species-habitat relationships. Biological Conservation 127:237-244.

Carter, G.M., M.L. Legare, D.R. Breininger, and D.M. Oddy. 2007. Nocturnal nest predation: a potential obstacle to recovery of a Florida scrub-jay population. Journal of Field Ornithology 78(4):390-394.

Chen, N. 2014. Genomics of population decline in the Florida scrub-jay. Cornell University, Ithaca, New York. 148 pages.

Chen, N., E.J. Cosgrove, R. Bowman, J.W. Fitzpatrick, and, A.G. Clark. 2016. Genomic consequences of population decline in the endangered Florida scrub-jay. Current Biology 26(21):2974-2979.

Christman, S.P. 2000. Florida scrub-jay distribution and habitat analysis, Sarasota County. Unpublished report prepared for Sarasota County Natural Resources. November 2000. 138 pages.

Coulon, A., J.W. Fitzpatrick, R. Bowman, B.M. Stith, C.A. Makarewich, L.M. Stenzler, and I.J. Lovette. 2008. Congruent population structure inferred from dispersal behaviour and intensive genetic surveys of the threatened Florida scrub-jay (*Aphelocoma coerulescens*). Molecular Ecology 17:1685-1701.

Coulon, A., J.W. Fitzpatrick, R. Bowman, and I.J. Lovette. 2010. Effects of habitat fragmentation on effective dispersal of Florida scrub-jays. Conservation Biology 24(4):1080-1088.

Coulon, A., J.W. Fitzpatrick, R. Bowman, and I.J. Lovette. 2012. Mind the gap: genetic distance increases with habitat gap in of Florida scrub jays. Biology Letters 0, 1-4.

Cox, J.A. 1987. Status and distribution of the Florida scrub jay. Florida Ornithological Society Special Publication Number 3. Gainesville, Florida. 110 pages.

Davidson, K.L. and S.P. Bratton. 1986. The vegetative history of Canaveral National Seashore, Florida. U.S. National Park Service. Cooperative Park Studies Unit Technical Report 22. 75 pages.

Davis, J.H., Jr. 1943. The natural features of southern Florida: especially the vegetation, and the Everglades. Florida Department of Conservation, Florida Geological Survey Geological Bulletin No. 25. 311 pages.

Davis, J.H., Jr. 1967. General map of natural vegetation of Florida. Agricultural Experiment Station, Institute of Food and Agricultural Sciences, University of Florida, Gainesville. 1 page.

DeGange, A.R., J.W. Fitzpatrick, J.N. Layne, and G.E. Woolfenden. 1989. Acorn harvesting by Florida scrub jays. Ecology 70(2):348-356.

Dreschel, T.W., R.B. Smith, and D.R. Breininger. 1990. Florida scrub jay mortality on roadsides. Florida Field Naturalist 18(4):82-83.

Duncan, B.W. and D.R. Breininger. 1998. Quantifying habitat change: modeling historic and current Florida scrub-jay habitat suitability. Proceedings of GIS/LIS 1998 Annual Conference, Ft. Worth, Texas. 9 pages.

Duncan, B.W. and P.A. Schmalzer. 2004. Anthropogenic influences on potential fire spread in a pyrogenic ecosystem of Florida. Landscape Ecology 19:153-165.

Duncan, B.W., D.R. Breininger, P.A. Schmalzer, and V.L. Larson. 1995. Validating a Florida scrub jay habitat suitability model, using demography data on Kennedy Space Center. Photogrammetric Engineering & Remote Sensing 61(11):1361-1370.

Duncan, B.W., S. Boyle, D.R. Breininger, and P.A. Schmalzer. 1999. Coupling past management practice and historic landscape change on John F. Kennedy Space Center, Florida. Landscape Ecology 14:291-309.

Duncan, B.W., V.L. Larson, and P.A. Schmalzer. 2004. Historic landcover and recent landcover change in the North Indian River Lagoon Watershed, Florida. Natural Areas Journal 24:198-215.

Early, R.N. 1952. The Florida jay. Florida Naturalist 25:57-58.

Emslie SD. 1996. A fossil Scrub-Jay supports a recent systematic decision. Condor 98:675-680.

Fernald, R.T. 1989. Coastal xeric scrub communities of the Treasure Coast Region, Florida: a summary of their distribution and ecology, with guidelines for their preservation and management. Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program Technical Report Number 6. Tallahassee, Florida. 113 pages.

Fitzpatrick, J.W. and R. Bowman. 2016. Florida scrub-jay: oversized territories and group defense in a fire-maintained habitat. Chapter 5, in Koenig, W. and J. Dickinson, eds., Cooperative Breeding in Vertebrates: Studies in Ecology, Evolution, and Behavior. Cambridge Univ. Press, Cambridge.

Fitzpatrick, J.W. and G.E. Woolfenden. 1988. Components of lifetime reproductive success in the Florida scrub jay. Pages 305-320 in: Clutton-Brock, T.H. (ed.). Reproductive success. University of Chicago Press; Chicago, Illinois.

Fitzpatrick, J.W., D.R. Breininger, M.A. O'Connell, B.M. Stith, J.E. Thaxton, B.R. Toland, and G.E. Woolfenden. 1998. Habitat conservation plans for the Florida scrub jay: a biological framework. Ornithological Monographs. 175 pages.

Fitzpatrick, J.W., G.E. Woolfenden, and M.T. Kopeny. 1991. Ecology and development-related habitat requirements of the Florida scrub jay (*Aphelocoma coerulescens coerulescens*). Florida Game and Fresh Water Fish Commission Nongame Wildlife Program Technical Report Number 8. Tallahassee, Florida. 49 pages.

Fitzpatrick, J.W., B. Pranty, and B.M. Stith. 1994. Florida scrub jay statewide map, 1992-1993. Archbold Biological Station. Lake Placid, Florida. 14 pages + appendices.

Fleischer, A.L., Jr. 1996. Pre-breeding time budgets of female Florida scrub-jays in natural and suburban habitats. Abstract, Archbold Biological Station 1996 Symposium. 12 September 1996. Lake Placid, Florida. 1 page.

Florida Natural Areas Inventory. 1990. Guide to natural communities of Florida. Florida Natural Areas Inventory. Tallahassee, Florida. 111 pages.

Forrester, D.J, and M. G. Spalding. 2003. Parasites and diseases of wild birds in Florida. University Press of Florida, Gainesville, Florida.

Garvin, M.C., Tarvin, K.A., Stark, L.M., Woolfenden, G.E., Fitzpatrick, J.W. & Day, J.F. 2004. Arboviral infection in two species of wild jays (Aves: Corvidae): Evidence for population impacts. Journal of Medical Entomology 41:215-225.

Gilpin, K.T. 1987. Spatial structure and population vulnerability. Pages 125-139 in Soule, M.E. (ed.) Viable populations for conservation. Cambridge University Press, New York, N.Y.

Glitzenstein, J.S., W.J. Platt, and D.R. Streng. 1995. Effects of fire regime and habitat on tree dynamics in north Florida longleaf pine savannas. Ecological Monographs 65(4):441-476.

Grimes, S.A. 1940. Scrub jay reminiscences. Bird-Lore 42:431-436.

Grimes, S.A. 1943. Notes from northeast Florida. Florida Naturalist 16: 15-19.

Harper, R.M. 1927. Natural resources of southern Florida. Florida State Geological Survey Eighteenth Annual Report 18:27-206.

Hanski, I., and M. Gilpin. 1991. Metapopulation dynamics: brief history and conceptual domain. *Biological Journal of the Linnean Society.* 42:3-16.

Hawkes, C.V. and E.S. Menges. 1996. The relationship between open space and fire for species in a xeric Florida shrubland. Bulletin of the Torrey Botanical Club 123(2):81-92.

Hofstetter, R.H. 1984. The effect of fire on the pineland and sawgrass communities of southern Florida. Pages 465-476 *in*: Gleason, P.J. (ed.). Environments of south Florida: present and past II. Miami Geological Society, Coral Gables, Florida.

Howe, R. W., Davis, G. J., & Mosca, V. 1991. The demographic significance of 'sink'populations. Biological Conservation, *57*(3), 239-255.

Intergovernmental Panel on Climate Change. 2013. Summary for Policymakers. In Stocker, T.F., D. Qin, G.K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (pp. 3-29). Cambridge, United Kingdom: Cambridge University Press.

Johnson, F.A., D.R. Breininger, B.W. Duncan, J.D. Nichols, M.C. Runge, and B.K. Williams. 2011. A Markov decision process for managing habitat for Florida Scrub-Jays. Journal of Fish and Wildlife Management 2:234-246.

Kinsella, J.M. 1974. Helminth fauna of Florida Scrub Jays - host and ecological relationships. Proceedings of the Helminthological Society of Washington, pp. 127-130.

Laessle, A.M. 1958. The origin and successional relationship of sandhill vegetation and sand-pine scrub. Ecological Monographs 28(4):361-387.

Laessle, A.M. 1968. Relationship of sand pine scrub to former shore lines. Quarterly Journal of the Florida Academy of Sciences 30(4):269-286.

Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. Bulletin of the Entomological Society of America. Vol. 15 pp 237-240.

Levins, R. 1970. Extinction. Pages 77-107 in Gustenhaver, M. (ed.). Some mathematical questions in biology, Volume 2. American Mathematical Society, Providence, R.I.

Levin, S.A. 1974. Dispersion and Population Interactions. The American Naturalist 108: 207.

Longstreet, R.J. 1954. Ornithology of the mosquitoes – part 5. Florida Naturalist 27:79-88.

Lyon, C. 2007. Demographic consequences of managing for Florida scrub-jays (*Aphelocoma coerulescens*) on an isolated preserve. M.S. Thesis. University of Central Florida, Orlando. 54 pages.

McCormack J.E., J. Heled, Delaney K.S., Peterson AT, Knowles L.L. 2011. Calibrating divergence times on species trees versus gene trees: implications for speciation history of Aphelocoma jays. Evolution 65-1:184-202.

McDonald, D.B. and J.L. Hamrick. 1996. Genetic Variation in Some Plants of Florida Scrub. American Journal of Botany. 83: 21-27.

McDonald, D. B., W. K. Potts, J.W. Fitzpatrick, and G. E. Woolfenden. 1999. Contrasting genetic structures in sister species of North American scrub-jays. Proceedings of the Royal Society of London B: Biological Sciences, 266(1424), 1117-1125.

McGowan, K.J. and G.E. Woolfenden. 1989. A sentinel system in the Florida scrub jay. Animal Behaviour 37(6):1000-1006.

McGowan, K.J. and G.E. Woolfenden. 1990. Contributions to fledgling feeding in the Florida scrub jay. Journal of Animal Ecology 59(2):691-707.

Menges, E.S. 1999. Ecology and conservation of Florida scrub. Pages 7–22 in: Anderson, R. C., J.S. Fralish, and J. Baskin, J. (eds.), The savanna, barren, and rock outcrop communities of North America. Cambridge University Press, Cambridge, UK.

Menges, E. 2007. Integrating demography and fire management: an example from Florida scrub. Australian Journal of Botany 55: 261-272.

Menges, E.S. and C.V. Hawkes. 1998. Interactive effects of fire and microhabitat on plants of Florida scrub. Ecological Applications 8(4):935-946.

Menges, E.S. and N. Kohfeldt. 1995. Life history strategies of Florida scrub plants in relation to fire. Bulletin of the Torrey Botanical Club 122(4):282-297.

Miller, K.E., T.J. Doonan, and D.W. Pearson. 2003. Florida scrub-jay monitoring program at Cedar Key scrub reserve and vicinity. Final Performance Report April 2000 - August 2000. 204 pages.

Miller, K.E. and B.M. Stith. 2002. Florida scrub-jay distribution and habitat in Charlotte County. Final Report. Contract No. 2001000116: Scrub-Jay Survey. December 2002. 204 pages.

Mumme, R.L. 1992. Do helpers increase reproductive success? An experimental analysis in the Florida scrub jay. Behavioral Ecology and Sociobiology 31:319-328.

Mumme, R.L. and T.H. Below. 1995. Relocation as a management technique for the threatened Florida scrub jay. Project report, Florida Game and Fresh Water Fish Commission, Nongame Wildlife Program, December 1995. 48 pages.

Mumme, R.L. and T.H. Below. 1999. Evaluation of translocation for the threatened Florida scrub-jay. Journal of Wildlife Management 63(3):833-842.

Mumme, R.L., S.J. Schoech, G.E. Woolfenden, and J.W. Fitzpatrick. 2000. Life and death in the fast lane: demographic consequences of road mortality in the Florida scrub-jay. Conservation Biology 14(2):501-512.

Mumme, R.L., R. Bowman, M.S. Pruett, and J.W. Fitzpatrick. 2015. Natal territory size, group size, and body mass affect lifetime fitness in the cooperatively breeding Florida scrub-jay. The Auk 132:634-646.

Myers, R.L. 1990. Scrub and high pine. Pages 150-193 *in*: Myers, R.L. and J.J. Ewel (eds.). Ecosystems of Florida. University of Central Florida Press; Orlando, Florida.

Nash, G.V. 1895. Notes on some Florida plants. Bulletin of the Torrey Botanical Club 22(4):141-161.

National Climate Assessment. 2014. *Climate Change Impacts in the United State: The Third National Climate Assessment.* U.S. Global Change Research Program. Washington, D.C.

Nesmith, K., S. Jue, and G.E. Shultz. 2004. Survey for Florida scrub-jays and inventory of scrub habitat in Volusia County, Florida. Florida Natural Areas. Tallahassee, Florida. 49 pages.

National Oceanic and Atmospheric Administration. 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report NOS CO-OPS 083. Silver Spring, MD.

Noss, R.F., M.A. O'Connell, D.D. Murphy. 1997. The Science of Conservation Planning: Habitat Conservation under the Endangered Species Act, World Wildlife Fund and Island Press, Washington, DC, 246 pages.

Percival, H.F., D.B. McDonald, and M.J. Mazurek. 1995. Status and distribution of the Florida scrub jay (*Aphelocoma c. coerulescens*) on Cape Canaveral, Florida. Final report, research work order 136. Technical Report No. 51. Florida Fish and Wildlife Research Unit, Gainesville, Florida. 14 pages + appendices.

Peterson, A.T. 1992. Phylogeny and Rates of Molecular Evolution in the Aphelocoma Jays (Corvidae). The Auk 109:133-147.

Pitelka, F.A. 1951. Speciation and ecological distribution in American jays of the genus *Aphelocoma*. University of California Published In Zoology 50:195-464.

Pranty, B. 1996. Distribution of the Florida scrub-jay, 1992 - 1993. Cooperative Agreement No. 14-16-0004-91-950 Modification No. 5. Archbold Biological Station Venus, Florida. 272 pages.

Pranty, B. 1998. Field observations winter report: December 1997–February 1998. Florida Field Naturalist, 26:100-108.

Primack, R.B. 2010. Essentials of Conservation Biology, fifth edition. Sinauer Associates, Inc., Sunderland, MA. 601 pages.

Quinn, J.S., G.E. Woolfenden, J.W. Fitzpatrick, and B.N. White. 1999. Multi-locus DNA fingerprinting supports genetic monogamy in Florida scrub-jays. Behavioral Ecology and Sociobiology 45:1-10.

Robb, G. N., R.A. McDonald, D.E. Chamberlain., and S. Bearhop. 2008. Food for thought: supplementary feeding as a driver of ecological change in avian populations. Frontiers in Ecology and the Environment 6(9), 476-484.

Robbins, L.E. and R.L. Myers. 1992. Seasonal effects of prescribed burning in Florida: a review. Miscellaneous Publications/Tall Timbers Research, Inc. USA.

Root, K.V. 1998. Evaluating the effects of habitat quality, connectivity, and catastrophes on a threatened species. Ecological Applications 8(3):854-865.

Rothermel, R.C. 1983. How to predict the spread and intensity of forest and range fires. 5 pages.

Sauter, A., R. Bowman, S.J. Schoech, G. Pasinelli. 2006. Does optimal foraging theory explain why suburban Florida scrub-jays (*Aphelocoma coerulescens*) feed their young human-produced food? Behavioral Ecology and Sociobiology 60(4), 465-474.

Schaub, R., R.L. Mumme and G.E. Woolfenden. 1992. Predation on the eggs and nestlings of Florida scrub jays. The Auk 109(3):585-593.

Schmalzer, P.A. and S.R. Boyle. 1998. Restoring long-unburned oak-saw palmetto scrub requires mechanical cutting and prescribed burning (Florida). Restoration and Management Notes 16(1):96-97.

Schmalzer, P.A. and C.R. Hinkle. 1992a. Recovery of oak-saw palmetto scrub after fire. Castanea 57(3):158-173.

Schmalzer, P.A. and C.R. Hinkle. 1992b. Species composition and structure of oak-saw palmetto scrub vegetation. Castanea 57(4):220-251.

Schoech, S. J., and R. Bowman. 2001. Variation in the timing of breeding between suburban and wildland Florida Scrub-Jays: Do physiologic measures reflect different environments? In Avian Ecology and Conservation in an Urbanizing World (pp. 289-306). Springer US.

Schoech, S. J., R. Bowman and S. J. Reynolds. 2004. Food supplementation and possible mechanisms underlying early breeding in the Florida Scrub-Jay (*Aphelocoma coerulescens*). Hormones and Behavior, 46(5), 565-573.

Schoech, S.J., E.S. Bridge, R.K. Boughton, S.J. Reynolds, J.W. Atwell, and R. Bowman 2008. Food supplementation; a tool to increase reproductive output? A case study in the threatened Florida scrub-jay. Biological Conservation 141:162-173.

Schoech, S.J., R. Mumme, J.C. Wingfield. 1996. Delayed breeding in the cooperatively breeding Florida scrub-jay (*Aphelocoma coerulescens*): inhibition or absence of stimulation? Behavioral Ecology and Sociobiology 39:77-90.

Scott, J. 2009. Florida's wildlife: on the front line of climate change. Report, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida, USA 1990. 44 pages.

Snodgrass, J.W., T. Townsend, P. Brabitz, M. Chitwood, and D. Jordan. 1991. An inventory of scrub habitat and Florida scrub jays (*Aphelocoma coerulescens coerulescens*) in Brevard County, Florida. Brevard County Office of Natural Resources Management and Geographic Research Division, Melbourne, Florida. 22 pages + appendices.

Soule, M.E. 1980. Thresholds for survival: maintaining fitness and evolutionary potential. Pages 151-169 In Soule, M.E. and B.A. Wilcox (eds.). Conservation biology: an evolutionary-ecological perspective. Sinauer Assoc., Sunderland, Massachusetts.

Sprunt, A. 1946. *Aphelocoma coerulescens* (Bosc), Florida jay. Pages 77-88 in: Bent, A.C. (ed.). Life histories of North American jays, crows and titmice. U.S. National Museum Bulletin number 191. U.S. Government Printing Office; Washington, D.C.

Stallcup, J.A. and G.E. Woolfenden. 1978. Family status and contributions to breeding by Florida scrub jays. Animal Behaviour 26(4):1144-1156.

Stephens, P.A., W.J. Sutherland, and R.P. Freckleton. 1999. "What is the Allee effect?", Oikos, 87, 185-90.

Stith, B.M. 1999. Metapopulation viability analysis of the Florida scrub-jay (*Aphelocoma coerulescens*): a statewide assessment. Final Report to the U.S. Fish and Wildlife Service; Jacksonville, Florida, Contract No. 1448-40181-98-M324. August 1999. 201 pages.

Stith, B.M., J.W. Fitzpatrick, G.E. Woolfenden, and B. Pranty. 1996. Classification and conservation of metapopulations: a case study of the Florida scrub jay. Pages 187-215 in: McCullough, D.R. (ed.). Metapopulations and Wildlife Conservation. Island Press; Washington, D.C.

Stout, I.J. and W.R. Marion. 1993. Pine flatwoods and xeric pine forests of the southern (lower) coastal plain. Pages 373-446 *in*: Martin, W.H., S.G. Boyce, and A.C. Echternacht (eds.). Biodiversity of the Southeastern United States/ lowland terrestrial communities. John Wiley and Sons; New York.

Swain, H.M., R. Bowman, D. Breininger, P. Schmalzer, K. Root, S. Boyle, S. Bergen, and S. MacCaffree. 1995. Out of the pyrogenic frying pan and into the political fire: developing reserve designs for the Florida scrub jay. ABSTRACTS. Society of Conservation Biology annual meeting, page 79.

Thaxton, J.E. and T.M. Hingtgen. 1994. Response of Florida scrub jays to management of previously abandoned habitat. District 4 Annual Report, Florida Park Service; Tallahassee, Florida.

Thaxton, J.E. and T.M. Hingtgen. 1996. Effects of suburbanization and habitat fragmentation on Florida scrub-jay dispersal. Florida Field Naturalist 24(2):25-37.

Toland, B.R. 1991. Nest site characteristics of a Florida scrub jay population in Indian River County. Abstract. Florida scrub jay workshop. 23-24 May 1991. Ormond Beach, Florida. 1 page.

Toland, B.R. 1999. Current status and conservation recommendations for the Florida scrub-jay in Brevard County. Report to the Brevard County Board of County Commissioners. Brevard County Natural Resources Management Office, Viera, Florida. 40 pages.

Townsend, A., R. Bowman, J. W. Fitzpatrick, M. Dent, and I. Lovette. 2011. Genetic monogamy across variable demographic landscapes in cooperatively breeding Florida Scrub-Jays. Behavioral Ecology 22:464-470.

Tringali, A. and R. Bowman. 2012. Plumage reflectance signals dominance in Florida scrub-jay, *Aphelocoma coerulescens*, juveniles. Animal Behaviour 84: 1517-1522.

U.S. Fish and Wildlife Service (USFWS). 1987. Final Rule. Department of the Interior. Fish and Wildlife Service. 50 CFR Part 17. Endangered and threatened wildlife and plants: threatened status for the Florida scrub jay. 52 FR 20715-20719.

U.S. Fish and Wildlife Service (USFWS). 1990. Florida scrub jay recovery plan. U.S. Fish and Wildlife Service; Atlanta, Georgia. 23 pages.

U.S. Fish and Wildlife Service [Service]. 2007. Florida Scrub-Jay (*Aphelocoma coerulescens*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service; Atlanta, Georgia. 53 pages.

U.S. Fish and Wildlife Service (USFWS). 2010. Interim endangered and threatened species recovery planning guidance version 3.1. National Marine Fisheries Service; Silver Springs, Maryland. U.S. Fish and Wildlife Service; Arlington, Virginia. 122 pages.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. The Journal of Wildlife Management 893-901.

Webber, H.J. 1935. The Florida scrub, a fire-fighting association. American Journal of Botany 22(3):344-361.

Weekley, C.W., E.S. Menges, D. Berry-Greenlee, M.A. Rickey, G.L. Clarke, and S.A Smith. 2011. Burning more effective than mowing in restoring Florida scrub. Ecological Restoration 24(4):357-373.

Wilcoxen, T.E., R.K. Boughton. and S.J. Schoech. 2010. Selection on innated immunity and body condition in Florida scrub-jays throughout an epidemic. Biology Letters.

Wolf, S., B. Hartl, C. Carroll, M.C. Neel, and D.N. Greenwald. 2015. Beyond PVA: Why Recovery under the Endangered Species Act Is More than Population Viability. BioScience 65(2), 200-207.

Woolfenden, G.E. 1974. Nesting and survival in a population of Florida scrub jays. The Living Bird 12:25-49.

Woolfenden, G.E. 1975. Florida scrub jay helpers at the nest. The Auk 92(1):1-15.

Woolfenden, G.E. 1976. A case of bigamy in Florida scrub jay. The Auk 93: 443-450.

Woolfenden, G.E. 1978. Growth and survival of young Florida scrub jays. Wilson Bulletin 90(1):1-18.

Woolfenden, G.E. and J.W. Fitzpatrick. 1977. Dominance in the Florida scrub jay. The Condor 79(1):1-12.

Woolfenden, G.E. and J.W. Fitzpatrick. 1978. The inheritance of territory in group-breeding birds. BioScience 28(2):104-108.

Woolfenden, G.E. and J.W. Fitzpatrick. 1984. The Florida scrub jay: demography of a cooperative-breeding bird. Princeton University Press; Princeton, New Jersey. 406 pages.

Woolfenden, G.E. and J.W. Fitzpatrick. 1986. Sexual asymmetries in the life history of the Florida scrub jay. Pages 87-107 in: Rubenstein, D.I. and R.W. Wrangham (eds.). Ecological aspects of social evolution: birds and mammals. Princeton University Press, Princeton, New Jersey.

Woolfenden, G.E. and J.W. Fitzpatrick. 1990. Florida scrub jays: a synopsis after 18 years of study. Pages 241-266 in: Stacey, P.B. and W.B. Koenig (eds.). Cooperative breeding in birds: long term studies of ecology and behavior. Cambridge University Press, Cambridge.

Woolfenden, G.E. and J.W. Fitzpatrick. 1991. Florida scrub jay ecology and conservation. Pages 542-565 in: Perrins, C.M., J.D. Lebreton, and G.J.M. Hirons (eds.). Bird population studies: relevance to conservation and management. Oxford University Press; Oxford, United Kingdom.

Woolfenden, G.E. and J.W. Fitzpatrick. 1996a. Florida scrub-jay, *Aphelocoma coerulescens,* Family Corvidae, Order Passeriformes. Pages 267-280 in: Rodgers, J.A., Jr., H.W. Kale, II, and H.T.

Smith (eds.). Rare and endangered biota of Florida, volume V. Birds. University Press of Florida; Gainesville, Florida.

Woolfenden, G.E. and J.W. Fitzpatrick. 1996b. Florida scrub-jay, (*Aphelocoma coerulescens*). Pages 1-27 in: Poole, A. and F. Gill (eds.). The Birds of North America, No.228. The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union; Washington, D.C

Woolfenden, G.E. and M.C. Garvin. 2000. Florida Scrub-jay disease analysis. Final Report to the Florida Wildlife Commission for project E-1 III-1-6.

Appendix A – Optimal Conservation

East Coastal Genetic Unit Description (Genetic Unit A)

The East Coastal Genetic Unit includes local populations along the Atlantic Coastal Ridge and Ten Mile Ridge from southeastern Volusia County to northern St. Lucie County. Smaller scrub ridges, mesic flatwoods, and ephemeral marshes adjacent to the primary scrub ridges also are important to Florida Scrub-Jays in this genetic unit (Breininger et al. 2006). The genetic unit encompasses Stith's (1999) Metapopulations 11, 12, and 13. The East Coastal Genetic Unit is separated from the Northeast Coastal Genetic Unit by Turnbull Hammock and from the Southeastern Coastal Genetic Unit by the city of Fort Pierce (Stith 1999). Extensive expanses of non-scrub habitat separate this genetic unit from those to the west.

Florida Scrub-Jay populations in this genetic unit have experienced significant declines due to habitat loss and degradation (Toland 1999, Breininger et al. 2003). Snodgrass et al. (1993) estimated a loss of greater than three fourths of scrub and scrubby flatwoods in mainland Brevard County from pre-settlement times to 1990.

The populations have continued to decrease in recent decades. From 1993-2003, the population decreased from 407 to 288 Florida Scrub-Jay groups in the genetic unit (Fitzpatrick et al. 1994, Breininger et al. 2003). The population in mainland Brevard and Indian River counties experienced declines of 4% per year from 1992-2002 and 10% per year from 2006-2009 (Breininger et al. 2006, Breininger 2009). By the late 2000s, only 100 Florida Scrub-Jay groups remained on managed conservation lands, and populations on all but a few managed conservation lands had fallen below 10 groups (Breininger 2009, Boughton and Bowman 2011). St. Sebastian River Preserve State Park (SSRPSP) contained nearly half of the remaining Florida Scrub-Jay groups on managed conservation lands (Boughton and Bowman 2011). Florida Scrub-Jays continue to persist on private lands, but populations are declining rapidly. For example, the Florida Scrub-Jay population in the city of Palm Bay declined from 54 to 16 groups from 1993-2009 (Toland 1999; V. Larsen, unpublished data).

The Brevard County population was the subject of a Scrub Conservation and Development Plan (SCDP; Swain et al. 1995) that was regarded as an outstanding example of conservation science and Habitat Conservation Planning (Noss et al. 1997), but the plan was never fully implemented, producing many fragmented conservation areas. Most public lands in the genetic unit are part of an Adaptive Resource Management program that involves the collaboration of dozens of managers and scientists from many federal, state, local, and private organizations in attempt to manage remaining populations in an optimal manner.

<u>Conclusions/Recommendations</u>

The genetic unit has considerable conservation lands that have great potential to support Florida Scrub-Jays for the long-term. Restoring, managing, and potentially acquiring habitat within the core, support, and auxiliary areas would improve connectivity as well as the opportunity to potentially increase the number of Florida Scrub-Jay groups quite considerably.

This genetic unit has five core areas, two support areas, and five auxiliary areas (Figure A1 and Figure A2).

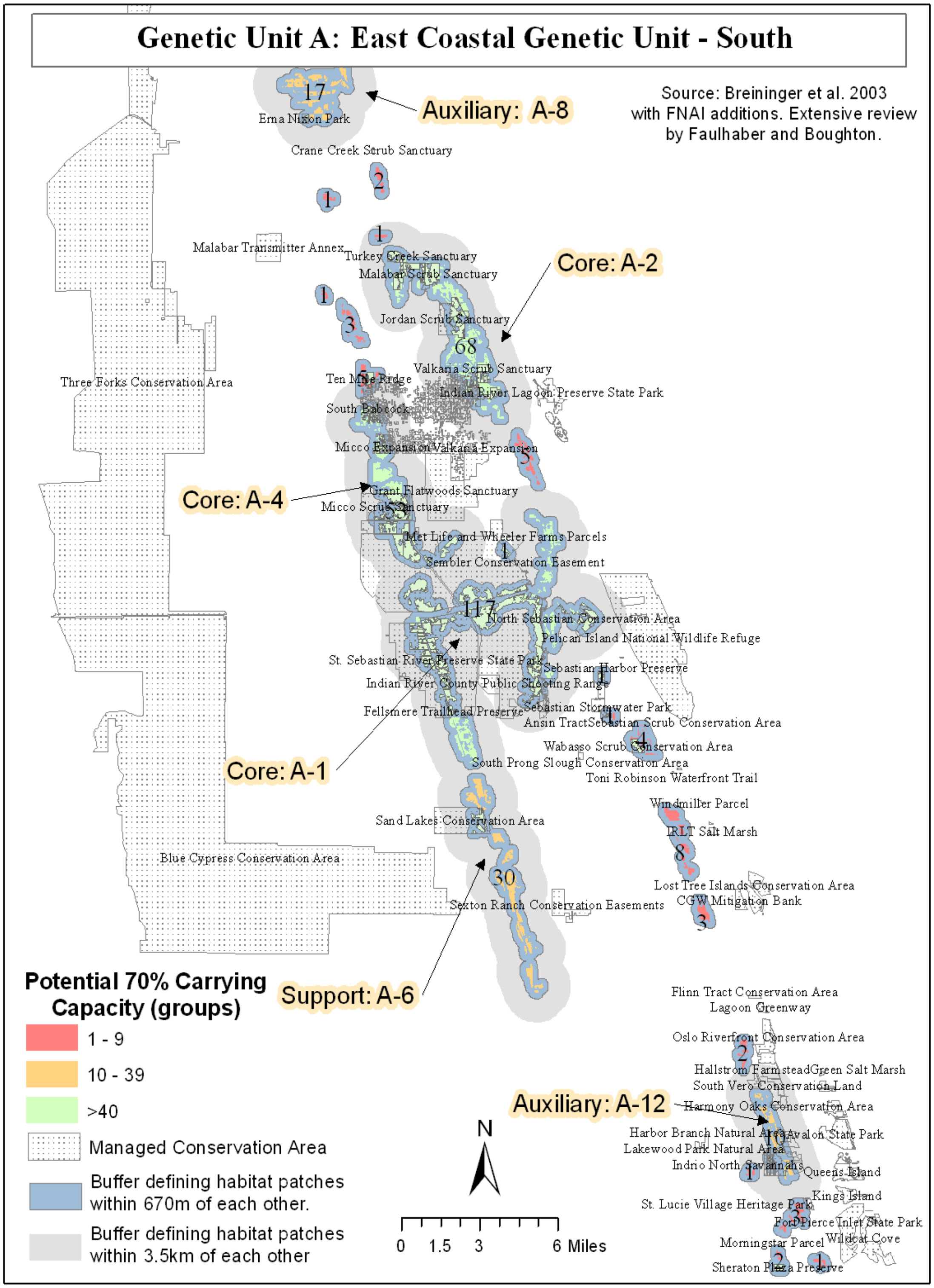

Figure A1. East Coastal Genetic Unit South.

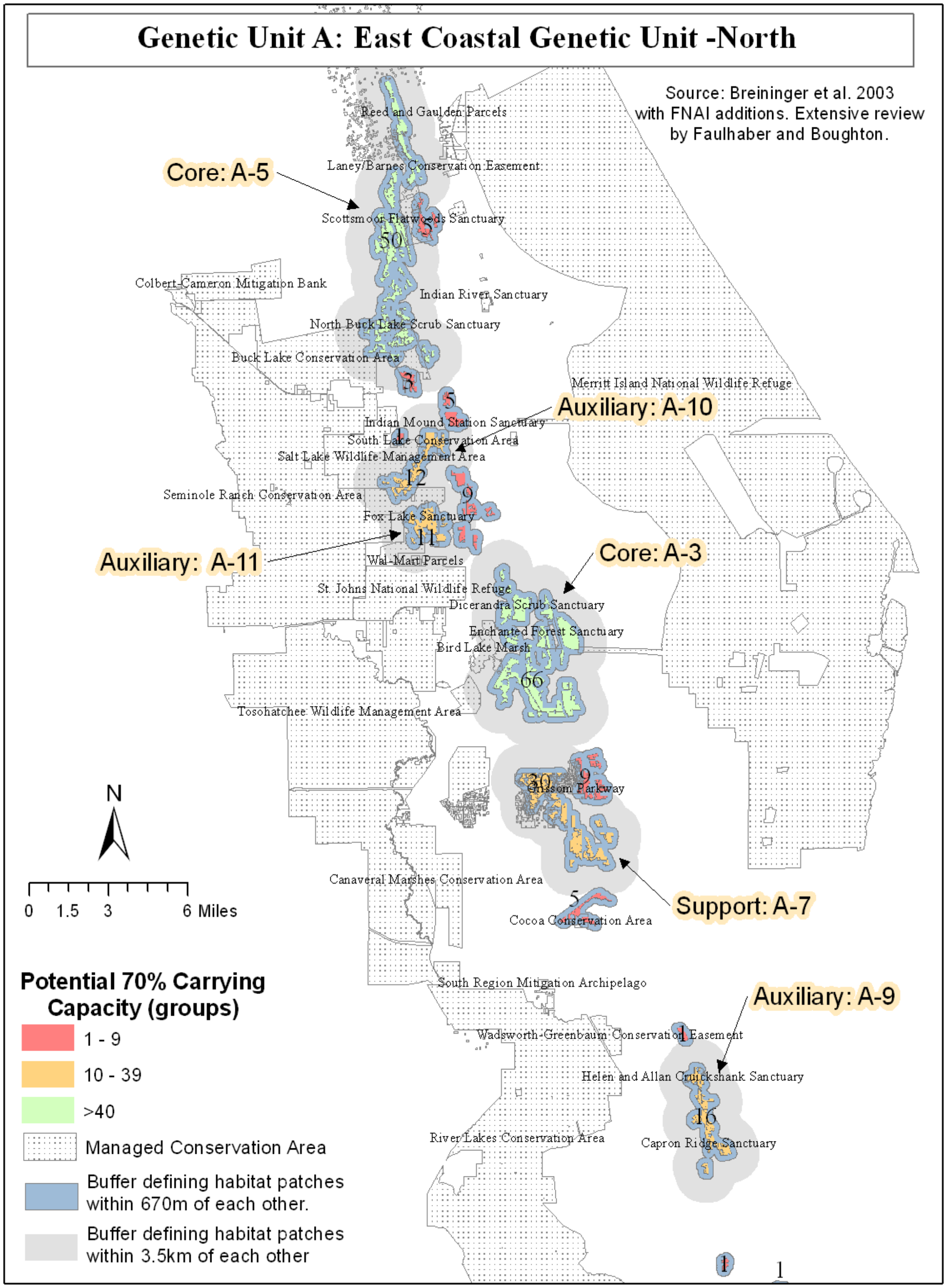

Figure A2. East Coastal Genetic Unit North.

Lake Wales Ridge Genetic Unit Description (Genetic Unit B)

Historically this unit would have extended the whole length of the Lake Wales Ridge, the nearby Bombing Range Ridge, and possibly north to the Mount Dora Ridge (Stith's Metapopulation 21). The southern terminus of the genetic unit near Fisheating Creek Wildlife Management Area and Platt Branch Mitigation Park are a collection of narrow scrub patches that loosely connect to Archbold Biological Station and the surrounding Lake Placid Scrub, Gould Road, and McJunkin Tracts. Habitat connectivity continues north through several of the State's Lake Wales Ridge Wildlife and Environmental Areas (Homes Avenue, Royce Ranch, Jack Creek) to Highlands Hammock State Park and Lake Wales Ridge National Wildlife Refuge (Flamingo Villas) juxtaposition to the city of Sebring. Habitat connectivity along the ridge is severed in this area, but resumes just north of the city of Sebring at Carter Creek Wildlife and Environmental Area. Lake Wales Ridge State Forest, Avon Park Bombing Range, Tiger Creek, and Allen David Broussard Catfish Creek Preserve State Park provide continuity northward. Smaller, isolated scrub patches occurring within Disney Wilderness Preserve, Upper Lakes Basin Watershed, and Lake Wales Ridge National Wildlife Refuge (Marion) are the northern extent of remaining habitat along the ridge.

Considerable loss of scrubby habitats has occurred along the ridge, due initially to intensification and expansion of agriculture, mostly citrus, and, in more recent times (last 30 years) to an increasingly more urbanized landscape. The flow of genetic material along the ridge is almost certainly broken into more localized clusters, and the once expansive metapopulation now contains multiple smaller metapopulations, many at high risk of extinction. This genetic unit is among the largest in terms of remaining Florida Scrub-Jay groups.

<u>Conclusion/Recommendations</u>

Megaparcels – already platted regions in Genetic Unit B – are a serious management issue within the genetic unit. Several core areas (B-3, B-6, B-7, B-8, B-9, B-10 and B-12) have platted, multi-owned small lots numbering in the thousands, which complicates protection and management in these areas. Additionally, some of these small lots are being built upon, which increases fragmentation and further complicates management. Large (i.e., greater than 500 acres) parcels of appropriate habitat under single ownership are almost nonexistent within these core areas.

Overall, opportunity for conservation is high in this genetic unit. Large populations of Florida Scrub-Jays exist throughout the 12 core and the many support and auxiliary areas. The current mapping efforts suggest connectivity has been reduced and perhaps eliminated around the city of Sebring creating a northern and southern metapopulation. Although, much of this habitat is now devoid of Florida Scrub-Jays and in need of management and improved connectivity, it remains a stronghold for Florida Scrub-Jays along the central ridge of Florida.

There are 12 core areas, 7 support areas, and 11 auxiliary areas identified in this genetic unit (Figure A3 and Figure A4).

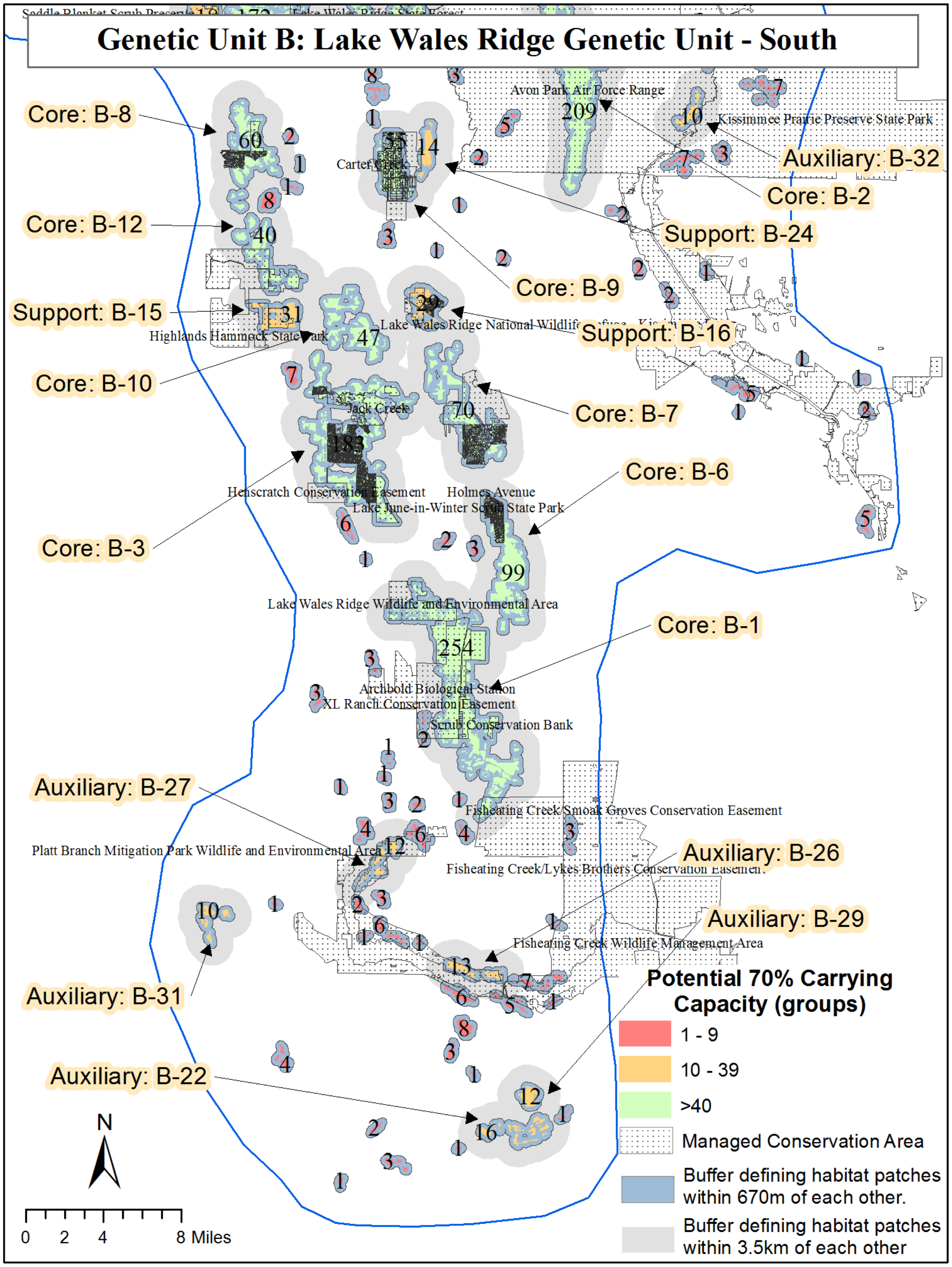

Figure A3. Lake Wales Ridge Genetic Unit South.

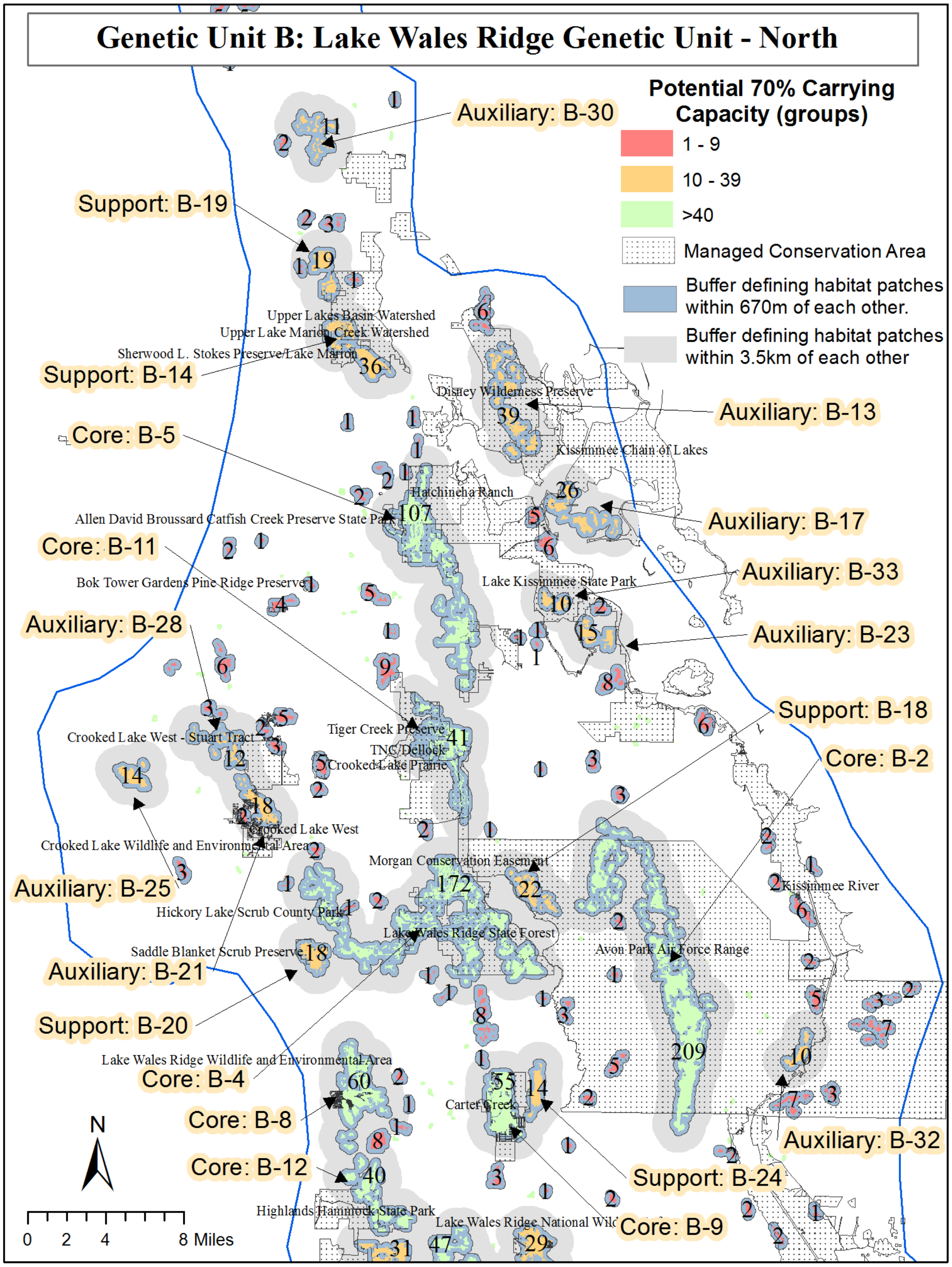

Figure A4. Lake Wales Ridge Genetic Unit North.

Northeast Coastal Genetic Unit Description (Genetic Unit C)

The Northeast Coastal Genetic Unit includes populations of Florida Scrub-Jays along the Atlantic Coast from Cape Canaveral/Merritt Island in Brevard County north to Nocatee Preserve/Guana River Wildlife Management Area, St. Johns County. The genetic unit encompasses Stith's (1999) Metapopulations 9 and 10. The Northeast Coastal Genetic Unit is separated from the East Coast Genetic Unit (Genetic Unit A) to the west by the Indian River and from the Southwest Volusia County Genetic Unit (Genetic Unit G) by extensive expanses of non-scrub habitat.

The Florida Scrub-Jay populations in this genetic unit are mainly concentrated in and around the federally-owned properties of Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), and Canaveral National Seashore (CNS) in the southern extent of the unit. Northward along the coastline from these properties extensive development has occurred resulting in small conservation lands intermixed in an urban matrix. The combined KSC and CCAFS lands comprise the second largest contiguous Florida Scrub-Jay populations in the species range. The proximity to the Atlantic Ocean coastline along with the low elevations renders this genetic unit susceptible to climate change events and trends.

Genetic Unit C contains three core areas, one support area, and three auxiliary areas. The largest core area in this unit having the highest Florida Scrub-Jay population potential is the KSC Complex Core Area C-1 with the National Aeronautics and Space Administration's (NASA) non-mission critical areas managed by the USFWS as the Merritt Island National Wildlife Refuge (MINWR). Three types of Florida Scrub-Jay habitats have been defined to categorize the importance and roles of different landscapes for maintaining Florida Scrub-Jay populations. Primary habitat consists of oak scrub on well drained soils; adjacent secondary habitat of large oak scrub ridges on poorly drained soils that provide for large, contiguous clusters of territories; and tertiary habitat adjacent to primary or secondary habitat consisting of flatwoods with small scrub oak patches. The Refuge's Habitat Management Plan identified an annual target between 11,000 to 13,000 acres of oak scrub in optimal conditions supporting 440 to 520 Florida Scrub-Jay groups in these areas. Their Comprehensive Conservation Plan for the entire refuge property's Florida Scrub-Jay habitat (17,000-20,000 acres) suggests a range between 680 to 800 family groups; however, their management actions are often restricted from limitations necessitated by NASA and CCAFS. Additional habitat analysis by NASA researchers utilizing a grid cell method suggests 837 potential Florida Scrub-Jay groups within the KSC/MINWR boundaries. Implementing a 70% carrying capacity – to account for habitat that will not be suitable when the vegetative structure is not optimal – results in 587 Florida Scrub-Jay groups (grid cell metrics).

The CCAFS Core Area C-2 also has a high potential to support large Florida Scrub-Jay populations; however, the habitat management opportunities (prescribed fire) are often compromised by the constraints imposed by their mission. Mechanical reduction of vegetative structure to provide appropriate habitat conditions without the ability to apply fire to the landscape often reduces the sand open spaces necessary for Florida Scrub-Jays, possibly limiting utilization in many areas. The central portion of the cape has succeeded from xeric oak scrub to xeric oak hammock – also referred to as maritime hammock – as a result of fire suppression. Additional opportunities for Florida Scrub-Jay occupancy potentially exist in these areas.

The third Core Area C-3 and the adjacent Support Area C-6 are located just north of MINWR and south of the Edgewater Community. Currently, there are no Florida Scrub-Jays or conservation lands in these areas with the exception of a narrow easement in the Support Area C-6 (East Central Rail Trial, 12% public ownership).

Auxiliary Area C-4, Auxiliary Area C-5, and Auxiliary Area C-7 are isolated locations along the east coastline. As of 2013, C-4 has no Florida Scrub-Jays; C-5 may have one individual; and C-7 contains three territories with six individuals.

Conclusions/Recommendations

The Northeast Coastal Genetic Unit currently supports the second largest contiguous population of Florida Scrub-Jays in the species range. The potentially large landscape, along with the current habitat management beneficial to Florida Scrub-Jays, provides favorable conditions for long-term persistence of these populations. Increasing habitat management on the federal lands and addressing climate change and sea level rise are the main priorities for this genetic unit.

There are three core areas, one support area, and three auxiliary areas described in this genetic unit (Figure A5).

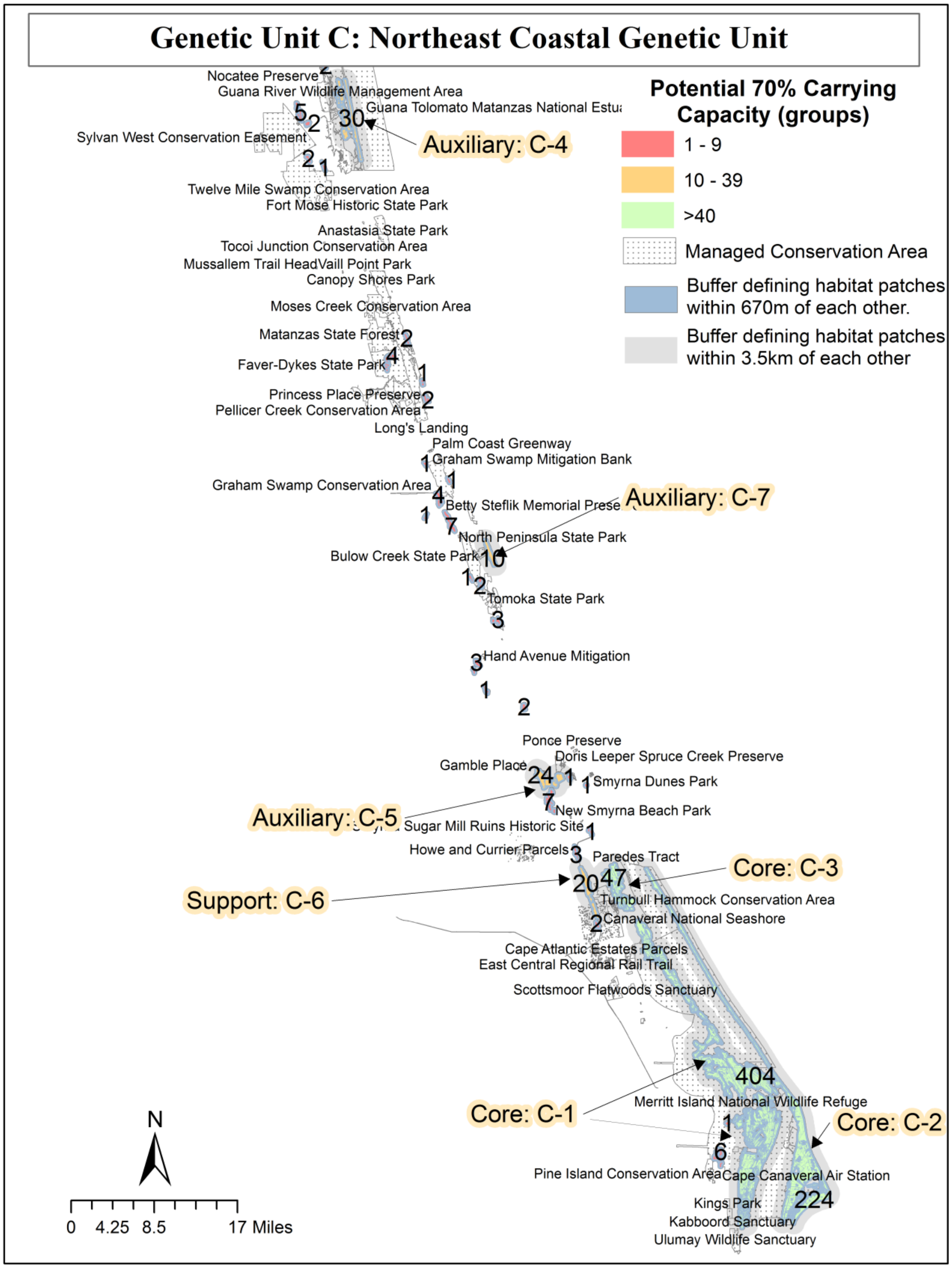

Figure A5. Northeast Coastal Genetic Unit.

North Central Genetic Unit Description (Genetic Unit D)

The North Central Genetic Unit includes a broad area comprising many distinct landscapes, ranging from Lake George in the Ocala National Forest (ONF) to northern Pasco County on the Gulf Coast (*Coulon et al.* 2008). The eastern half encompasses eastern Marion County and portions of Lake County and includes Stith's (1999) Metapopulations 17, 18, and 20. The western half encompasses southwestern Marion County and portions of Citrus, Sumter, and Pasco counties and includes Stith's (1999) Metapopulations 2 and 3.

Genetic Unit D is separated from Genetic Unit G to the east by the St. John's River and associated forested wetlands. It is probable that Florida Scrub-Jays in Genetic Unit D were once more connected to the west with the now isolated Florida Scrub-Jay populations in Genetic Unit H (Levy County Genetic Unit), given that much of the intervening landscape is characterized by sandhills and pastures. In fact, the genotype of one Florida Scrub-Jay sampled in Genetic Unit H closely resembled the Florida Scrub-jays in Genetic Unit D, possibly indicating recent long-distance immigration (Coulon et al. 2008).

The 1992-1993 statewide mapping project documented 137 scrub-jay family groups in the western half of Genetic Unit D, although its inventory of scrub habitat and Florida Scrub-Jays should be treated as "very incomplete" (Stith 1999). Most Florida Scrub-Jay habitat in this metapopulation is heavily overgrown and occurs as a complex mosaic of scrub, scrubby flatwoods, sandhill, and sand pine scrub. The current status of Florida Scrub-Jay populations in many of these areas is not known but is likely small and declining. In contrast, the statewide mapping project documented a minimum of 592 Florida Scrub-Jay family groups in the eastern half of Genetic Unit D, the large majority of which were in ONF (Stith 1999). However, the population estimate used for ONF (448 family groups) was based on an incomplete survey of the property.

There are roughly 226,000 ac of scrub habitat on the ONF that is managed for multiple objectives including: timber, recreation, wildlife habitat, wilderness values, and watershed protection. The mapping exercise (Genetic Unit D table) calculated approximately 236,000 ac as a result of different habitat classifications within the base maps. Sand pine scrub stands are harvested after 35-55 years which then become suitable for Florida Scrub-Jays beginning around the third year after harvest and remain suitable for the next 8-10 years, depending on site conditions and site preparation activities. Management directives in the decades past resulted in small (< 100 ac) forest stand sizes, and current harvest practices are focused on combining adjacent stands to yield larger openings that minimize the amount of forest edge relative to the amount of interior habitat.

Approximately 205,900 ac of scrub on the ONF are managed with timber harvest as a method of regenerating scrub. An additional 2,900 ac of sand pine scrub are managed with the focus of maintaining high quality Florida Scrub-Jay habitat through prescribed burning. Scrub in Federally designated Wilderness Areas account for 11,900 ac of scrub habitat, and another 5,300 ac between of scrub occurs on the Pinecastle Naval Bombing Range. Options for active management in these both these areas are limited, but natural fire regimes and the nature of activities in the bombing range have maintained much of the scrub in these areas in early successional states. The US Forest Service initiated a Forest Management Plan amendment in 2015 to increase the 2,900 ac dedicated to scrub habitat management for a total of 49,500 ac. Combining the scrub management areas with the acreage of suitable Florida Scrub-Jay habitat (e.g. 3-12 year age class) in timber harvest, roughly 70,000 ac have the potential to be occupied by Florida Scrub-Jays (excluding the wilderness areas and the bombing range).

Genetic Unit D contains 6 core areas, 10 support areas, and 12 auxiliary areas. The eastern half of the genetic unit contains four core areas, six support areas, and one auxiliary area. The two largest core areas in Genetic Unit D lie almost entirely within the boundaries of the ONF. Core Area D-1 is the largest in the entire range of the Florida Scrub-Jay. Core Area D-2, the second largest core area in the genetic unit, is surrounded by D-1, lacking connection only due to separation by a relict longleaf island.

Core Area D-1 is mainly comprised of a large contiguous section of sand pine scrub atop Astatula soils (i.e. "Big Scrub"). The far eastern and southeastern portions of Core Area D-1 are more scrubby flatwoods in character due to the prevalence of "white sand" soil types (e.g., Paola, Pomello) that provide slightly greater water availability. These areas exist in a matrix alongside pine flatwood and sandhill habitats, and in general experience a higher fire frequency than the Big Scrub area. A series of core areas and support areas on scrubs associated with white sand soil types stretch from the southeastern corner of the ONF down to Wekiva Springs State Park. Core Area D-2 contains sand pine scrub of the same character as the central Big Scrub portion of Core Area D-1. The collective piece of scrub within Core Areas D-1 and D-2 is extremely important for the Florida Scrub-Jays within Genetic Unit D and as a whole due to its large size and protection status as a Federally owned property.

Core Area D-1 has four support areas; three north of the ONF (D-11, D-15, and D-26) and one to the southeast (D-12). Support Area D-12 is a section of scrubby flatwoods on the ONF bordered by sandhill habitat to its west and Spring Creek to its east. It is separated from Core D-1 by approximately 725 meters at their closest points.

Core Area D-4 is located southeast of Core Area D-1 and contains some large, contiguous patches of Florida Scrub-Jay habitat to the east and west, though much of the central portion of the area contains habitat patches interspersed with wetlands and development. Roughly half of the area occurs on public conservation land, including Seminole State Forest and South Pine Lakes Reserve.

Farther south of Core Area D-4, the Sulfur Ridge/Lako Loop Core Area D-6, contains large blocks of contiguous, managed habitat on Seminole State Forest. Core Area D-6 has two support areas. The closest, Bear Pond Support Area D-17, occurs within Seminole State Forest and is occupied by Florida Scrub-Jays. The Rock Springs Run Support Area D-10, managed by Rock Springs Run State Park, currently is unoccupied.

The western half of the genetic unit contains 2 core areas, 4 support areas, and 11 auxiliary areas. Ocala Greenways and Trails and vicinity (Core Area D-5), includes a large contiguous patch of Florida Scrub-Jay habitat under public ownership and several patches of nearby sand pine scrub in private ownership to the south. Core Area D-5 is vital to the persistence of Florida Scrub-Jays in the western half of this genetic unit. Jay Watch surveys estimated the number of family groups at 14 in 2009 (Boughton and Bowman 2011), down from 16 at the time of the statewide mapping project. Core Area D-3 is an unfragmented parcel of overgrown scrub, hammock, and sand pine forest situated in the middle of a suburban/exurban matrix. Although its history is unclear, old surveyor records and soil maps indicate that it was formerly scrub and is potentially restorable.

Support Area D-24 and Auxiliary Areas D-8, D-13, and D-28 are the nearest populations with recorded dispersal to Core Area D-5. The support area is in private ownership and the three auxiliary areas are publicly owned (Halpata Tastanaki Preserve, Potts Preserve, and Ross Prairie State Forest).

The three support areas in the southwest portion of the genetic unit (D-16, D-20, and D-22) are isolated in the landscape relative to other areas and have limited number of individuals. The first two support areas are within the Starkey Wilderness Preserve boundaries and the last support area occurs on private lands.

Conclusions/Recommendations

In the eastern half of the genetic unit, the main central section of Core Area D-1 in the ONF has high connectivity. While the suitable Florida Scrub-Jay habitat in this section is mixed with mature sand pine scrub unsuitable for Florida Scrub-Jays, harvest stands are placed by land managers to ensure that new habitat is created adjacent to or near habitat that is waning in quality. In the southeastern section of Core Area D-1, connectivity is still adequate, but the scrub habitat is interspersed with smaller developed tracts of privately held land in addition to other habitat types. Core Area D-2 is separated from Core Area D-1 by permeable habitats so connectivity between these two areas should be considered adequate. Connectivity among Core Areas D-1, D-4, and D-6 should remain adequate, provided protected habitat in the central portion of Core Area D-4 can be restored and managed. After the U.S. Forest Service amended their ONF Forest Management Plan and initiates the implementation over the following 20 years, approximately 50,000 acres of dedicated scrub habitat will be managed for Florida Scrub-Jays. Another 20,000 acres in the timber rotation will be potentially suitable habitat, along with opportunities in the wilderness and bombing range areas (~13,000 ac).

The North Central Genetic Unit is perhaps the least vulnerable to extirpation due to ONF, which is critical to the persistence of the species. Seminole State Forest and adjacent conservation lands also have great potential to support Florida Scrub-Jays for the long-term. Restoring and managing habitat in southwestern Marion County may represent the best opportunity to conserve within-unit genetic diversity. Uncertainty remains about the extent and quality of potential Florida Scrub-Jay habitat in the western half of this genetic unit and improved mapping and ground-truthing in this region remain important priorities.

This genetic unit consists of 6 core areas, 10 support areas, and 12 auxiliary areas (Figure A6 and Figure A7).

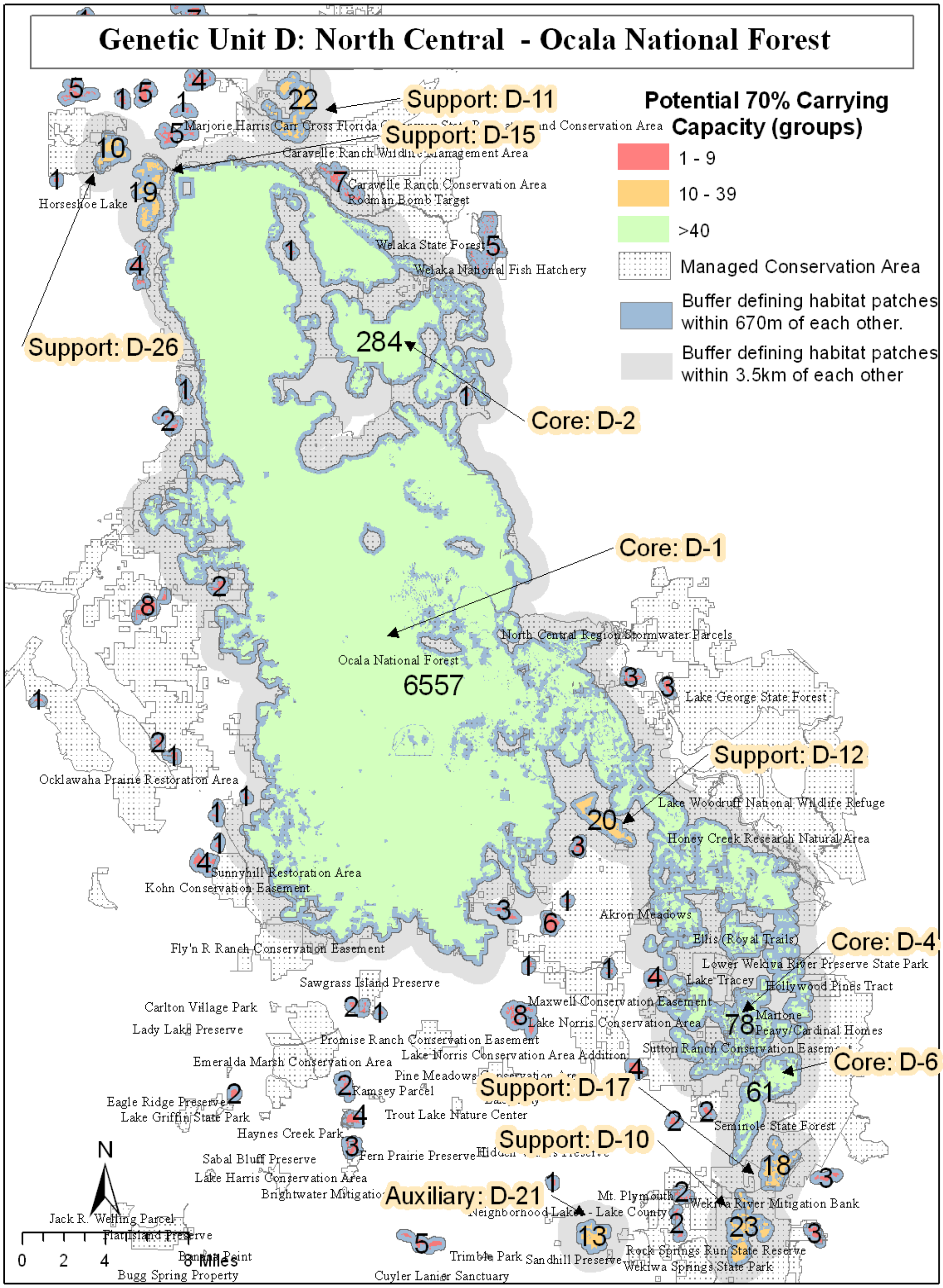

Figure A6. North Central Genetic Unit Ocala National Forest.

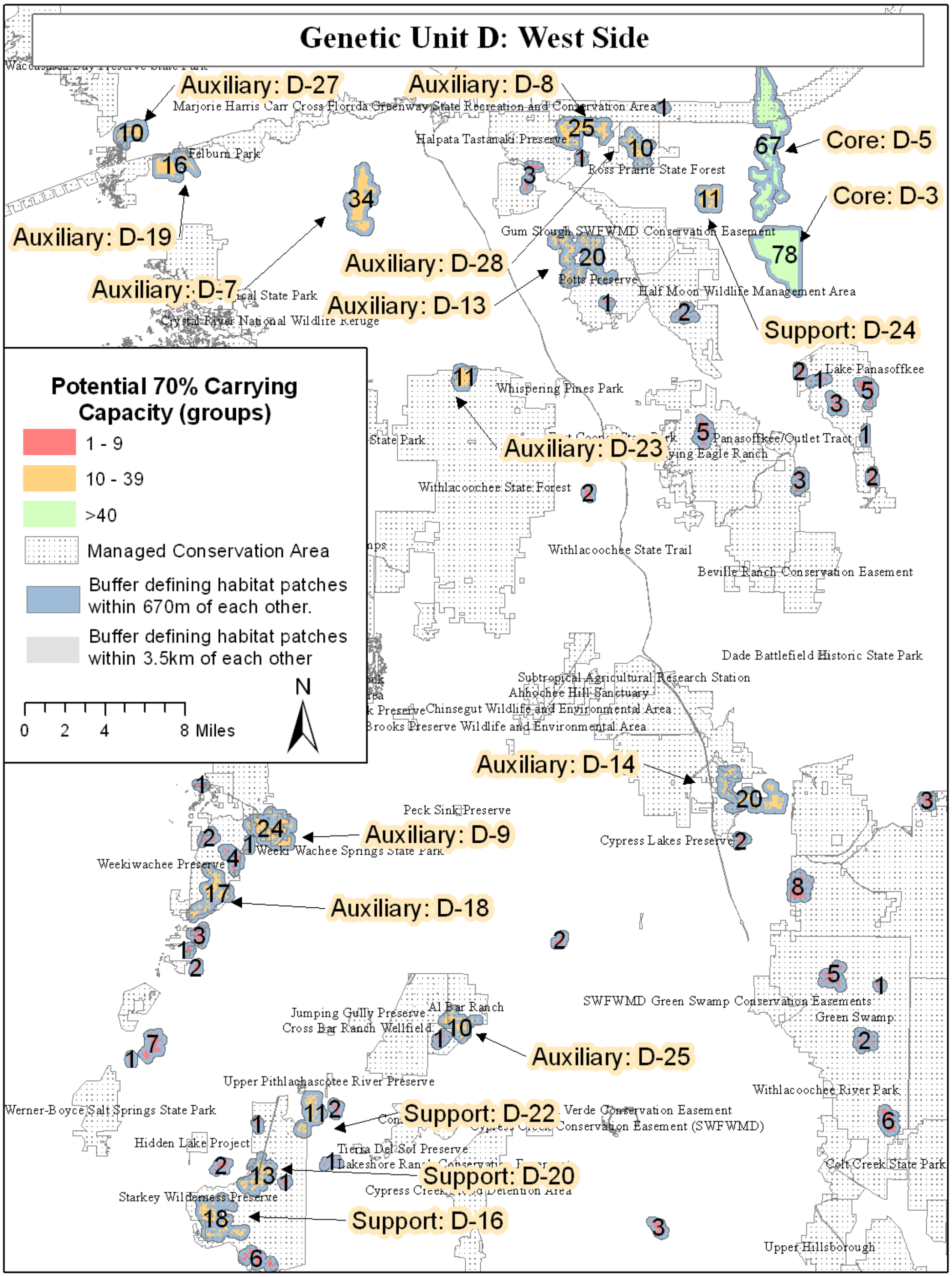

Figure A7. **North Central Genetic Unit West Side.**

Southwest Coastal Genetic Unit Description (Genetic Unit E)

The Southwest Coastal Genetic Unit includes populations along the Gulf Coast of Sarasota and Charlotte Counties consisting of a single Metapopulation 5 (Stith, 1999). This genetic unit is separated from the Southwest Inland Genetic Unit (Genetic Unit F) to the east by the Myakka River.

Most of the Florida Scrub-Jay habitat in this genetic unit has been converted to residential development. Sarasota County was estimated to have 19,768 ac of suitable Florida Scrub-Jay habitat of which less than 1,977 ac persisted in the mid 90's. Included in this genetic unit is a small portion of western Charlotte County (Gulf Cove, Rotunda, Grove City, and Cape Haze) at the southern terminus. The only intact large landscape of suitable habitat in the Southwest Coastal Genetic Unit occurs in Oscar Scherer State Park (568 ac) in west-central Sarasota County. The remaining habitat is embedded within suburban matrices resulting in Florida Scrub-Jays widely separated in small patches across the extent of the genetic unit.

The Florida Scrub-Jay population was fairly abundant in 1924, but clearing of much of the scrub in 1925 caused the population size to decline (Byrd 1927). Cox (1987) noted that with the exception of Oscar Scherer State Park, the Florida Scrub-Jay populations are in locations likely to be developed. He documented 14 sites with 47 individuals in Sarasota County all within 3-4 miles of the coast, and 4 Florida Scrub-Jay groups consisting of 10 individuals in Charlotte County that same year. The statewide surveys in 1992-1993 recorded 145 Florida Scrub-Jay groups with 413 individuals for Sarasota County; Charlotte County census included the entire county, which would include portions of Metapopulations 6, 7, and 8 (128 groups ; 296 individuals). Christman (2000) surveyed twelve sites in Sarasota County and reported 158 Florida Scrub-Jay groups with 414 individuals. Miller and Stith (2002) compared survey results at six locations to the previous statewide surveys in Metapopulation 5 in Charlotte County. A decline from 51 groups (117 individuals) to 35 groups (89 individuals) was observed.

This genetic unit is composed of three auxiliary areas with no core or support areas. Auxiliary Area E-1 (Gulf Cove and western edge of Myakka State Forest) has the largest habitat potential with an estimated 70% carrying capacity of 20 Florida Scrub-Jay groups; however, the Florida Scrub-Jays exist in a suburban setting. The scrub habitats are within platted communities with existing infrastructure primed for future development at roughly a 20% built out. Currently there are no lands in conservation for this area.

Oscar Scherer State Park (Auxiliary Area E-2) currently has the largest population of Florida Scrub-Jays. The entire scrub habitat of this auxiliary area occurs within the publicly managed lands of the state park with an estimated 70% carrying capacity of 16 Florida Scrub-Jay groups. The Florida Scrub-Jay population has fluctuated over the years from 2 individuals in 1987 (Cox) up to 24 Florida Scrub-Jay groups consisting of 80 individuals in 2000 (Miller and Stith). The most current survey conducted by Jay Watch in 2013 counted 12 Florida Scrub-Jay groups with 28 individuals. No juveniles have been observed over the last two breeding seasons.

Auxiliary Area E-3 (Charlotte Harbor Preserve State Park and Amberjack Environmental Park) is the southernmost auxiliary area for this genetic unit. Nearly all of the scrub habitats exist in a suburban setting. Similar to Auxiliary Area E-1, the entire infrastructure has been developed to allow residential development, precluding the ability to manage for optimal Florida Scrub-Jay vegetative structure as these neighborhoods increase their housing densities.

Other scrub patches within conservation lands occur along Sarasota's western boarder that harbors Florida Scrub-Jays. Small cluster of scrub habitat along the Gulf Coast are within dispersal distance of one another; however, the total 70% carrying capacity for Shamrock Park, Caspersen Beach County Park, South Venice Lemon Bay Preserve, and Manasota Scrub Preserve is 12 Florida Scrub-Jay groups.

<u>Conclusions/Recommendations</u>

Genetic Unit E has declined considerably and will require active and extensive collaboration of private owners and managers to achieve a sustainable population.

Three auxiliary areas were delineated in this genetic unit by the mapping effort (Figure A8).

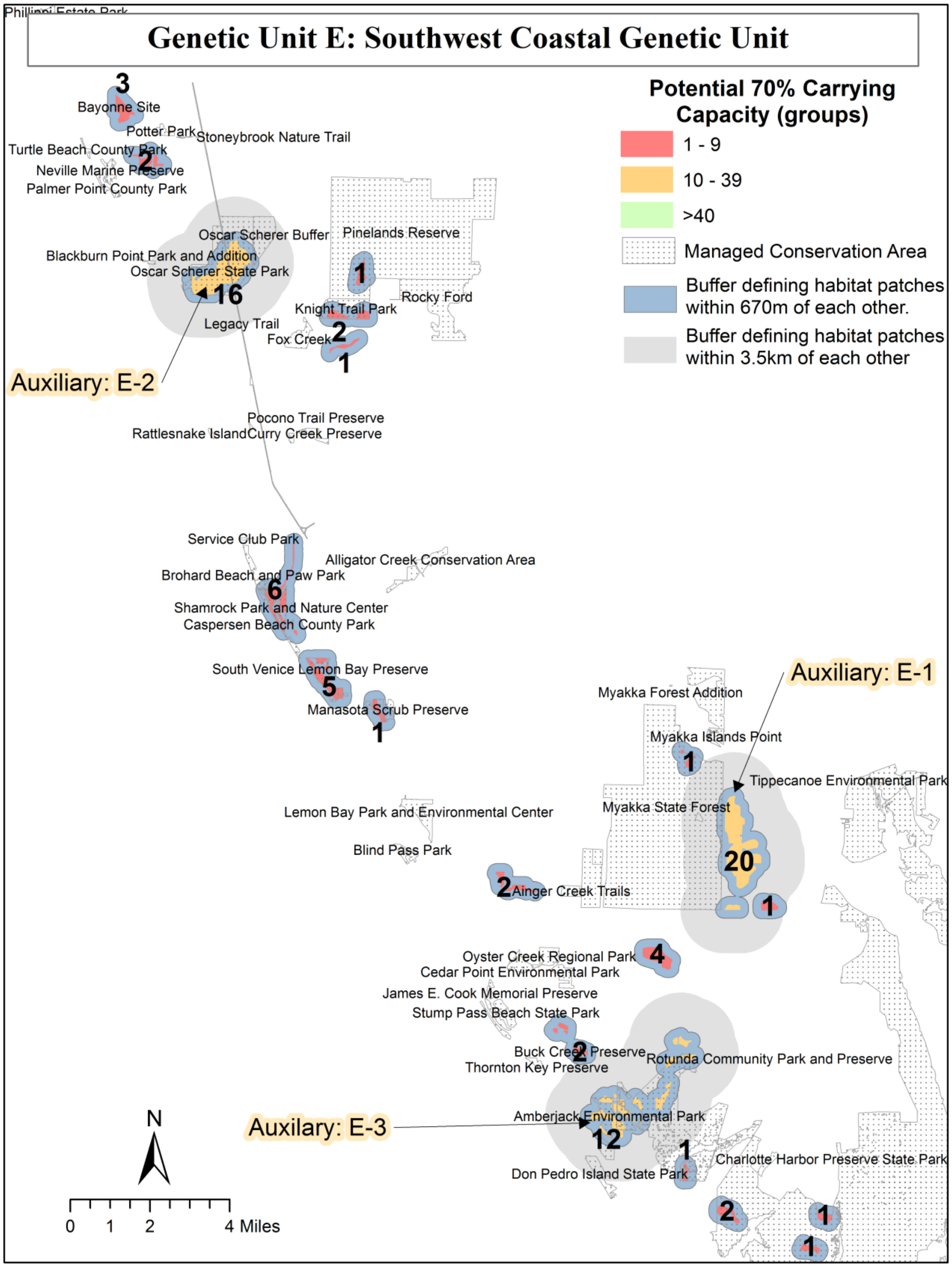

Figure A8. Southwest Coastal Genetic Unit.

Southwest Inland Genetic Unit Description (Genetic Unit F)

The Southwest Inland Genetic Unit includes populations from south Hillsborough, central Manatee, southwest Hardee, eastern Sarasota, northwest and southwest DeSoto, western Charlotte (east of the Myakka River), and northwest Lee Counties. The genetic unit encompasses Stith's (1999) Metapopulations 4, 6, and 7. The Southwest Inland Genetic Unit is separated from the Southwest Coastal Genetic Unit (Genetic Unit E) to the west by the Myakka River and from the Lee and North Collier Genetic Unit (Genetic Unit K) to the southeast by heavily forested Babcock-Cecil Webb Wildlife Management Area.

The xeric landscapes in this genetic unit have been severely reduced in area over the past century (Fernald 1989, Myers and Ewel 1990, Fitzpatrick et al. 1991, Woolfenden and Fitzpatrick 1996). An 82% reduction in potential scrub habitat (154,902 - 28,053 ac) has occurred and the number of patches decreased from 4,663 ac to 1,117 ac from the late 1880's through 1992 (Coulon 2008). Genetic diversity increases with the geographical extent and because this unit is very large, conserving the widely separated populations within the genetic unit would maximize genetic diversity; however, the configuration of habitat occurs in isolated patches separated by small to moderate distances with considerable conservation opportunities in the northern part of the unit. Previously described as containing three metapopulations, the southern two metapopulations available habitat has been reduced extensively to the point that those areas no longer contain enough potential habitat for core area populations.

This genetic unit contains habitat to support three core areas (F-1, F-2, and F-3), three support areas (F-7, F-8, and F-9) and four auxiliary areas (F-4, F-5, F-6, and F-10) with many smaller patches to create stepping stones and increase the potential dispersal among these larger patches. Furthermore, extensive protection already exists at a high proportion on these sites. A notable exception is Core Area F-2 and its' Support Area F-7, which currently have no protection. From aerial interpretation it is also likely that there is a greater amount of habitat between and around Core Area F-2 and Support Area F-7 and efforts should be made to investigate these areas more thoroughly.

The two large core areas (F-1 and F-3) are nearly connected and occur in Manatee County's Duette Preserve and Mosaic's Wellfield Conservation Scrub Site (98% protected) and have a potential 70% carrying capacity of 125 Florida Scrub-Jay groups. These areas are supported by F-8 and F-9. Located less than 8 miles to the southeast of Core Area F-3 is the third Core Area F-2 and its' Support Area F-7. A key patch for connectivity is Support Area F-8, which is a priority to connect to the Core Area F-2.

The southern areas of Deep Creek, Prairie/Shell Creek and Washington Oaks connector is estimated to have previously contained greater than 100 Florida Scrub-Jay groups but urban development has reduced the carrying capacity to possibly 20 Florida Scrub-Jay groups distributed across multiple now isolated and fragmented patches. Furthermore the Tippecanoe/Eleanor Ave/North Port/Myakka River areas are also becoming urbanized and fragmented with dispersal between Tippecanoe and Deep Creek increasingly unlikely. Once the exurban area is removed, this metapopulation is unlikely to sustain any populations greater than six Florida Scrub-Jay groups.

Conclusion/Recommendations

The greatest potential for this genetic unit occurs around Duette Preserve (Core Areas F-1, F-3; Support Area F-9; Auxiliary Area F-4) in eastern Manatee County with additional opportunities southeast of this area. A large portion of the scrub habitat in the area is protected and managed for conservation complemented by large adjacent permeable landscapes (Figures A9 and A10).

Genetic Unit F has three core areas, three support areas, and four auxiliary areas (Figure 16 and 17).

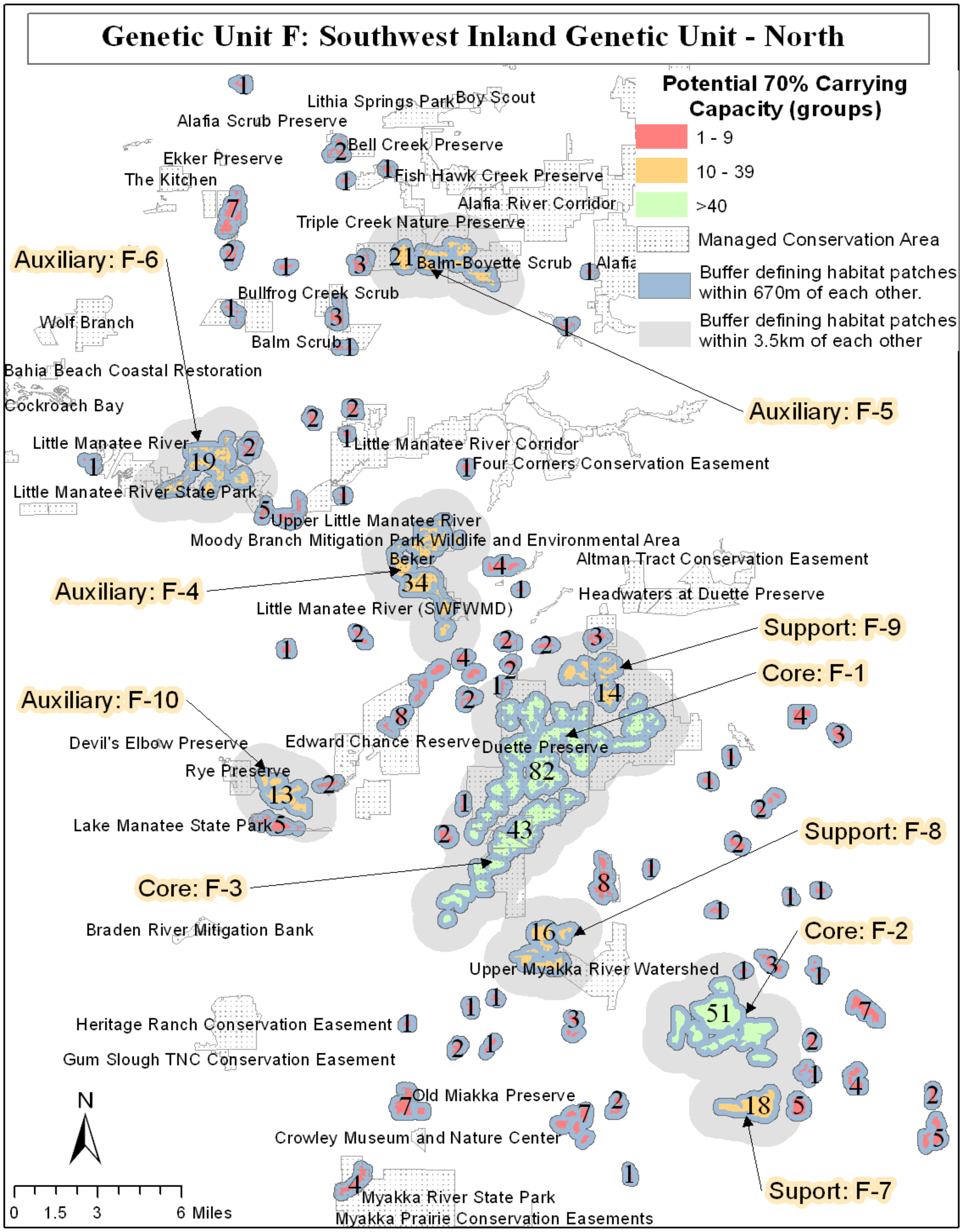

Figure A9. Southwest Inland Genetic Unit North.

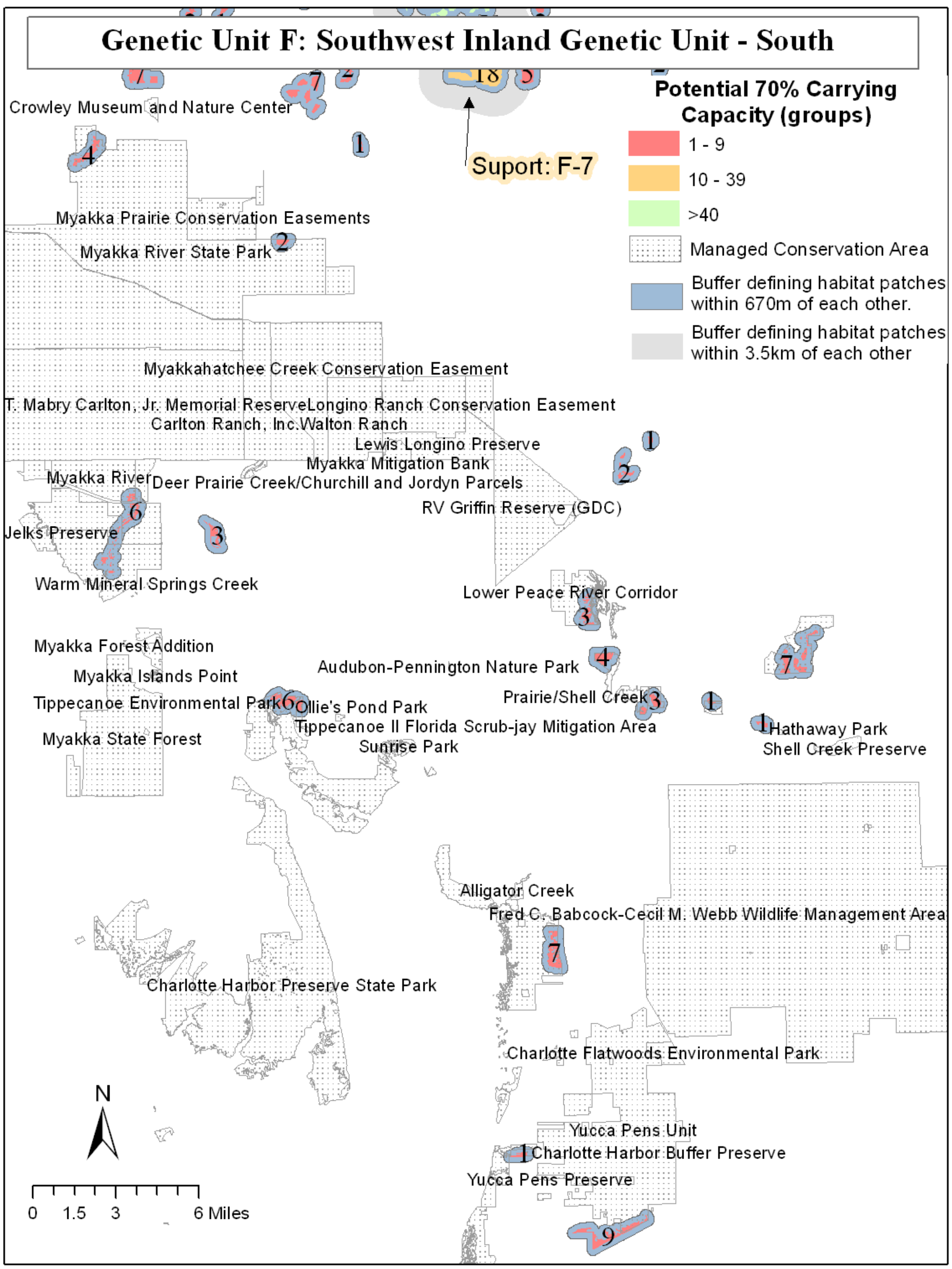

Figure A10. Southwest Inland Genetic Unit South.

Southwest Volusia County Genetic Unit Description (Genetic Unit G)

The Southwest Volusia County Genetic Unit includes local populations of Florida Scrub-Jays along the Deland Ridge in western Volusia County. The genetic unit encompasses Stith's (1999) Metapopulation 19 and is separated from the adjacent North Central Genetic Unit (Genetic Unit D) to the west by the St. Johns River and associated forested wetlands. Extensive expanses of non-scrub habitat to the east separate this genetic unit from scrub ridges in central and eastern Volusia County - Northeast Coastal Genetic Unit (Genetic Unit C).

It is probable that Florida Scrub-Jays once occurred across the length of the Deland Ridge, though surveys over the last several decades documented Florida Scrub-Jays only in the southern portion of the Deland Ridge, between Deland and Osteen (Cox 1987, Fitzpatrick et al. 1994, NeSmith 2004). The Deland Ridge has undergone extensive and rapid urban, commercial, and agricultural development, resulting in the loss of much of the potential Florida Scrub-Jay habitat (Stith 1999, NeSmith 2004). The 1992-1993 survey documented about 54 Florida Scrub-Jay groups but did not survey all habitat in suburban areas (Fitzpatrick et al. 1994, Stith 1999). NeSmith (2004) located 91 Florida Scrub-Jay groups in this genetic unit in 2003-2004 surveys and suggested that the observed increase resulted from restoration of habitat in Lyonia Preserve, Blue Spring State Park, and Lake Monroe Conservation Area. NeSmith (2004) also observed Florida Scrub-Jays opportunistically using private lands where sand pines had been logged and suggested that the reduction in the sand pine canopy resulting from hurricanes in 2004 may have expanded the area suitable for Florida Scrub-Jays on private lands (NeSmith 2004).

Florida Scrub-Jays occur on four managed conservation lands in the genetic unit (in declining order of population size): Lyonia Preserve, Blue Spring State Park and the county's adjacent Lake Beresford property, and Lake Monroe Conservation Area. The Florida Scrub-Jay population at Lyonia Preserve occurs at an unusually high density, with an average of greater than 30 Florida Scrub-Jay groups on only 358 acres from 2006-2013 (Jay Watch 2013). None of the four conservation lands are capable of supporting 40 or more Florida Scrub-Jay groups independently, underscoring the urgent need for additional habitat protection in the genetic unit. Florida Scrub-Jays still persist on private lands between the communities of Deland and Osteen and could provide a source of dispersers to colonize restored habitat, similar to what occurred following restoration of the genetic unit's other conservation lands.

The Southwest Volusia County Genetic Unit includes three core areas and five support areas. The Deltona/Orange City/Cassadaga Core Area (G-1) contains some of the largest contiguous blocks of potential Florida Scrub-Jay habitat in the genetic unit. However, the area is developing rapidly and none of the habitat is protected. Although the conservation potential is high due to the amount of potential habitat, the level of opportunity for conservation is low due to ongoing development pressure and proximity to major highways.

The greatest potential for Florida Scrub-Jay conservation and management, with the lowest development conflict for this genetic unit exists in the Blue Spring Core Area (G-2). The centrally positioned Blue Spring State Park and adjacent Lake Beresford are the current conservation lands in this core area. Currently, only 39% of the core area is in public ownership. Areas northeast of and especially south of Blue Spring State Park contain significant blocks of potential Florida Scrub-Jay habitat.

In the Deleon Core Area (G-3), some reasonably large blocks of potential habitat remain mixed in among large lots with houses. However, there were no reports of Florida Scrub-Jays from the 1992-1993 statewide surveys, nor have there been recent sightings. The area is fairly isolated, and no managed conservation lands with Florida Scrub-Jay habitat occur in the area. It would take significant land acquisition, restoration, and translocations to establish Florida Scrub-Jays in this area. Given the area's isolation and lack of resident Florida Scrub-Jays, this area has a low level of opportunity for conservation relative to other areas in the county.

Of the five support areas for the genetic unit, two of these contain managed conservation lands (Lyonia Preserve and Lake Monroe Conservation Area). Three support areas occur around the Deltona/Orange City/Cassadaga Core Area (Support Areas G-5, G-6, and G-8). Lyonia Preserve (G-6) contains the largest protected Florida Scrub-Jay population in the genetic unit, but the population will become isolated if habitat protection does not occur in the adjacent Core Area G-1. Florida Scrub-Jays have been observed using the transmission line adjacent to Lyonia Preserve (Fitzpatrick et al. 1994, NeSmith 2004), and this transmission line may facilitate connectivity. The other two support areas north of Core Area G-1 and southeast of the Deland community (G-5 and G-8) contain no public conservation lands. The former Stewart Ranch (G-5) harbored 24 Florida Scrub-Jay groups in the 1992-1993 survey, but few groups remained by the 2003-2004 surveys (Fitzpatrick et al. 1994, NeSmith 2004).

Farther to the south, the Lake Monroe Conservation Support Area (G-4) provides significant potential for Florida Scrub-Jays. Roughly 50% of the scrub habitat in this support area is managed as conservation land and the property has been the recipient site for prior Florida Scrub-Jay translocations. The adjacent Support Area G-7 contains small patches of scrub and scrubby flatwoods embedded in a matrix of forested wetlands, which could limit – or perhaps even preclude – the area's ability to support Florida Scrub-Jays over the long-term.

<u>Conclusions/Recommendations</u>

The Southwest Volusia County Genetic Unit is vulnerable to extirpation due to continued development pressure and the lack of protected, managed land for Florida Scrub-Jays. Patches of scrub embedded in an urban matrix currently provide connectivity among the core and support areas, with the exception of Core Area G-3, which is isolated. Connectivity is likely to decrease and may eventually disappear as urban development continues.

The highest potential for Florida Scrub-Jay conservation exists in the Blue Spring Core Area G-2. Blue Spring State Park is crucial to the persistence of Florida Scrub-Jays in the genetic unit. Areas northeast of and especially south of Blue Spring State Park contain significant blocks of potential Florida Scrub-Jay habitat. The presence of the state park, adjacent county land, and contiguous blocks of potential habitat provide the greatest, most realistic opportunity in the genetic unit.

Three core areas and five support areas make up this genetic unit (Figure A11).

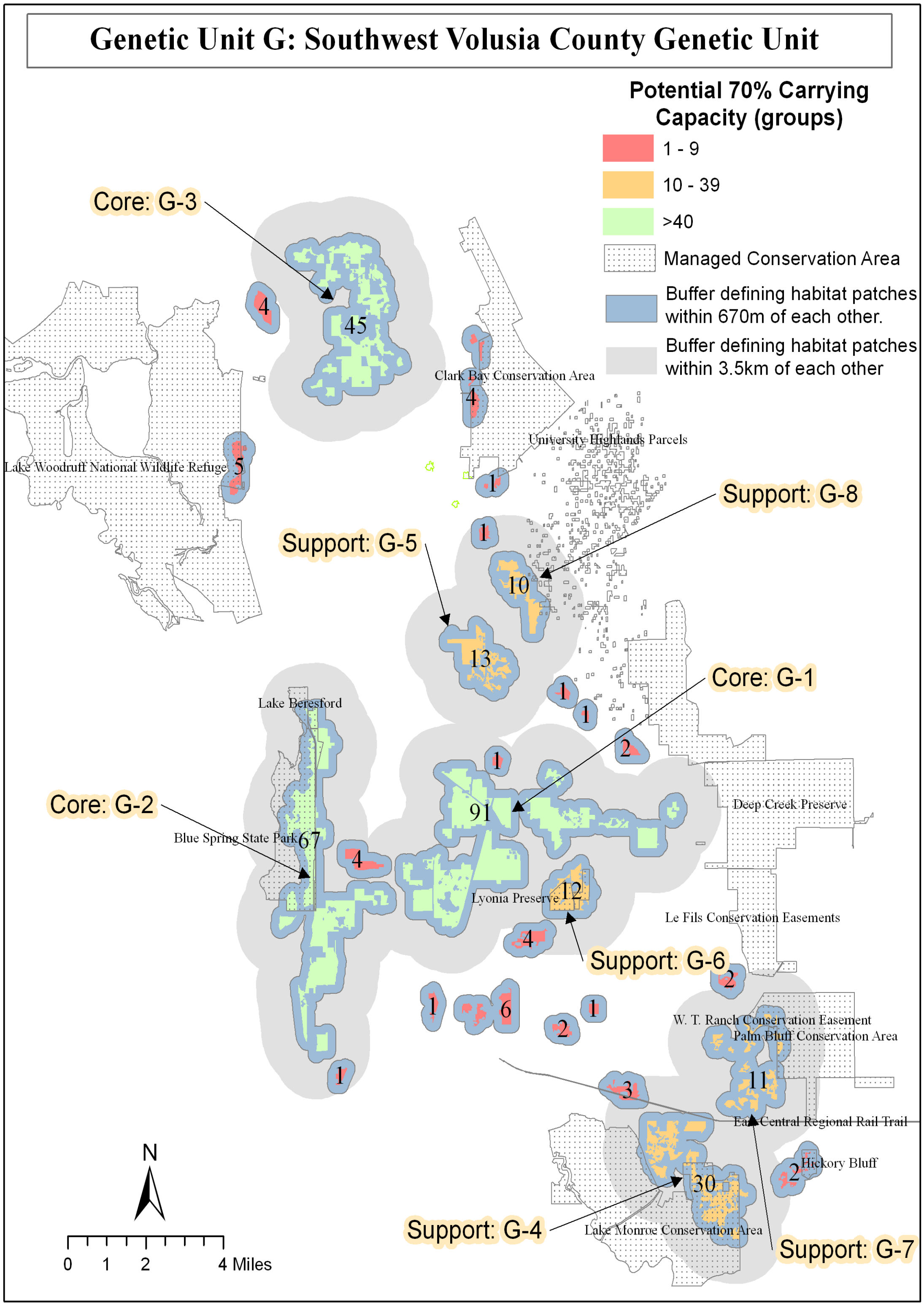

Figure A11. Southwest Volusia Genetic Unit.

Levy County Genetic Unit Description (Genetic Unit H)

The Levy County Genetic Unit encompasses Stith's (1999) Metapopulation 1 and constitutes the northernmost Gulf Coast population located in the western portion of the county near the coastline northeast of the town of Cedar Key. The Levy County Genetic Unit is a highly isolated population separated from the North Central Genetic Unit (Genetic Unit D) to the east by extensive mesic hammocks, sandhills, and pastures. The genotype of the one Florida Scrub-Jay sampled in Genetic Unit H closely resembled those in Genetic Unit D, possibly indicating recent long-distance immigration (Coulon et al. 2008).

Florida Scrub-Jays have historically resided in and around Cedar Key Scrub State Reserve (Reserve). The Reserve is managed as a unit of the Florida State Park System (FSP) and also as a Wildlife Management Area by Florida Fish and Wildlife Conservation Commission (FWC) in cooperation with the Florida Forest Service. The Reserve consists of a mosaic of sand pine and oak scrub, scrubby flatwood, sandhill, mesic flatwood, basin marsh, hydric hammock, basin swamp, and tidal salt marsh communities. Scrub communities in the Reserve total approximately 800 acres and usually occur as small patches less than 37 acres in size separated by mesic flatwoods and large basin marshes. There is slightly more than 4,000 acres of potential scrub habitat in the genetic unit extending from the southern boundary of the Reserve along State Road 24, north along County Road (CR) 347, past CR 326, then east to the town of Rosewood along CR 345.

Levy County Genetic Unit contains only one core area (H-1) with no support or auxiliary areas. The Florida Scrub-Jay population has continued to decline since the early 1980s when Cox (1987) counted 52-55 individuals and estimated the total population size at approximately 100 individuals. The statewide surveys in 1992-1993 (Pranty 1996) reported only 8 Florida Scrub-Jay groups with 27 individuals. Surveys during 1997-1998 documented 8 to 9 groups with only 1 group remaining in the Reserve (FPS, unpublished data). Surveys during the 2000 breeding season documented 4 groups consisting of 19 individuals with 1 group in the Reserve (Miller et al. 2003). Three transient individuals were also observed in 2000 suggesting there were undetected birds in the surrounding areas, particularly in the Rosewood area, for a total of approximately two dozen Florida Scrub-Jays. Jay Watch, a citizen-science program, surveyed the Reserve from 2009 through the present. Four Florida Scrub-Jay groups were observed each year in 2009 and 2010, 3 groups in 2011, and 2 groups in 2012. No Florida Scrub-Jays were observed in 2013.

<u>Conclusions/Recommendations</u>

The Florida Scrub-Jay population near Cedar Key in western Levy County has declined from an estimated 100 individuals as recently as 1982 to potentially only a few remaining individuals. Previous computer simulations performed by Stith (1999) using survey data from 1992 to 1993 indicated that there was 100% risk that this Florida Scrub-Jay population, at its current size and spatial configuration, will go extinct within 60 years.

One core area was identified per the mapping standards (Figure A12).

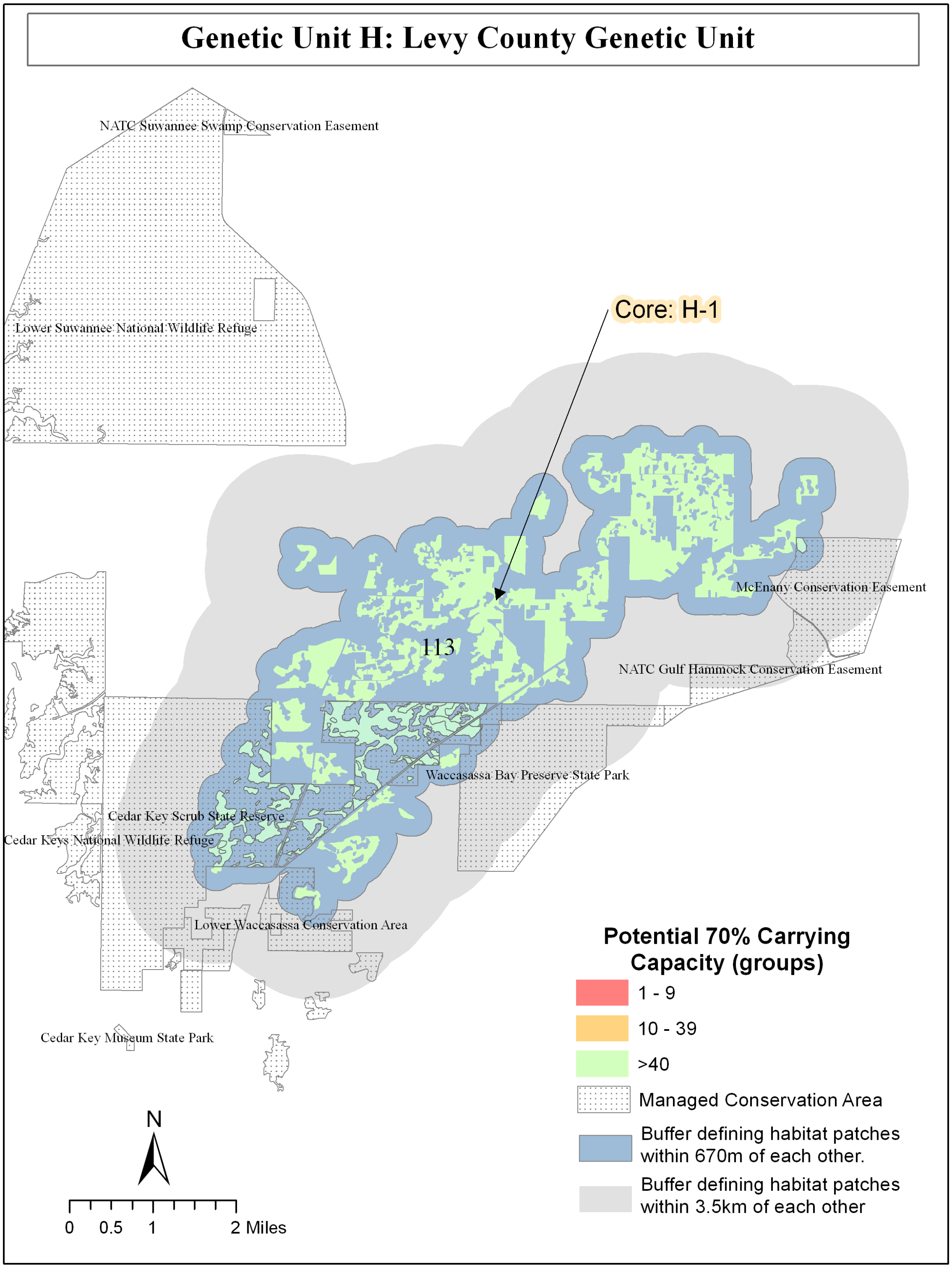

Figure A12. Levy County Genetic Unit.

Southeast Coastal Genetic Unit Description (Genetic Unit I)

The Southeast Coastal Genetic Unit includes local populations of Florida Scrub-Jays along the Atlantic Coastal Ridge from the southern two-thirds of St. Lucie County to northern Palm Beach County. The genetic unit encompasses Stith's (1999) Metapopulations 14 and 15; Metapopulation 16 is now extirpated. The Southeast Coastal Genetic Unit is separated from the East Coast Genetic Unit (Genetic Unit A) by the city of Fort Pierce.

Florida Scrub-Jays once occurred along the length of the Atlantic Coastal Ridge, but extensive urban development resulted in the loss of most Florida Scrub-Jay habitat in the genetic unit (Fernald 1989). The remaining habitat became overgrown due to the exclusion of fire (Fernald 1989), rendering populations small even on the few undeveloped large tracts. By the early 1990s, the population in the genetic unit declined to approximately 150 Florida Scrub-Jay groups (Fitzpatrick et al. 1994, Stith 1999).

The decline in Florida Scrub-Jay numbers has continued, and current local population sizes are alarmingly small. Florida Scrub-Jays have become extirpated in southern Palm Beach County and are near extirpation in the northern part of the county. Currently, the largest local populations of Florida Scrub-Jays exist on public conservation lands in Jonathan Dickinson State Park and Savannas Preserve State Park. However, there were less than 30 Florida Scrub-Jay groups across all managed conservation lands as of 2013 (Jay Watch 2013), and there are no known large local populations on private lands.

Few large tracts of scrub remain in this genetic unit, including one core area, two support areas, and two auxiliary areas. The Jonathan Dickinson Core Area (I-1) is by far the largest remaining area of Florida Scrub-Jay habitat in the genetic unit, with the potential for 100 Florida Scrub-Jay groups at 70% carrying capacity. This makes Jonathan Dickinson State Park and surrounding properties the key to the long-term persistence of Florida Scrub-Jays in southeastern Florida. The future of Support Area I-4 depends on restoration and management of atypical habitat on private lands. The Seabranch Support Area I-3 currently is unoccupied. The Savannas Auxiliary Area I-2 represents the best opportunity to maintain within-unit genetic variability.

Several stepping stones provide potential for connectivity between the Jonathan Dickinson Core Area and its associated support areas to the north. Stepping stones also exist between the Jonathan Dickinson Core Area and Juno Dunes Auxiliary Area (I-5), but extensive urban development and the Jupiter Inlet limit the probability of dispersal. The St. Lucie River likely limits dispersal between the Seabranch Support Area (I-3) and the Savannas Auxiliary Area (I-2), which currently contains the second largest local population in the genetic unit.

<u>Conclusions/Recommendations</u>

The potential of the genetic unit is high due to the large tracts of protected habitat in the Jonathan Dickinson Core Area. However, the genetic unit currently is extremely vulnerable to extirpation due to the small size of the remaining Florida Scrub-Jay populations.

Genetic Unit I has one core area, two support areas, and two auxiliary areas (Figure A13).

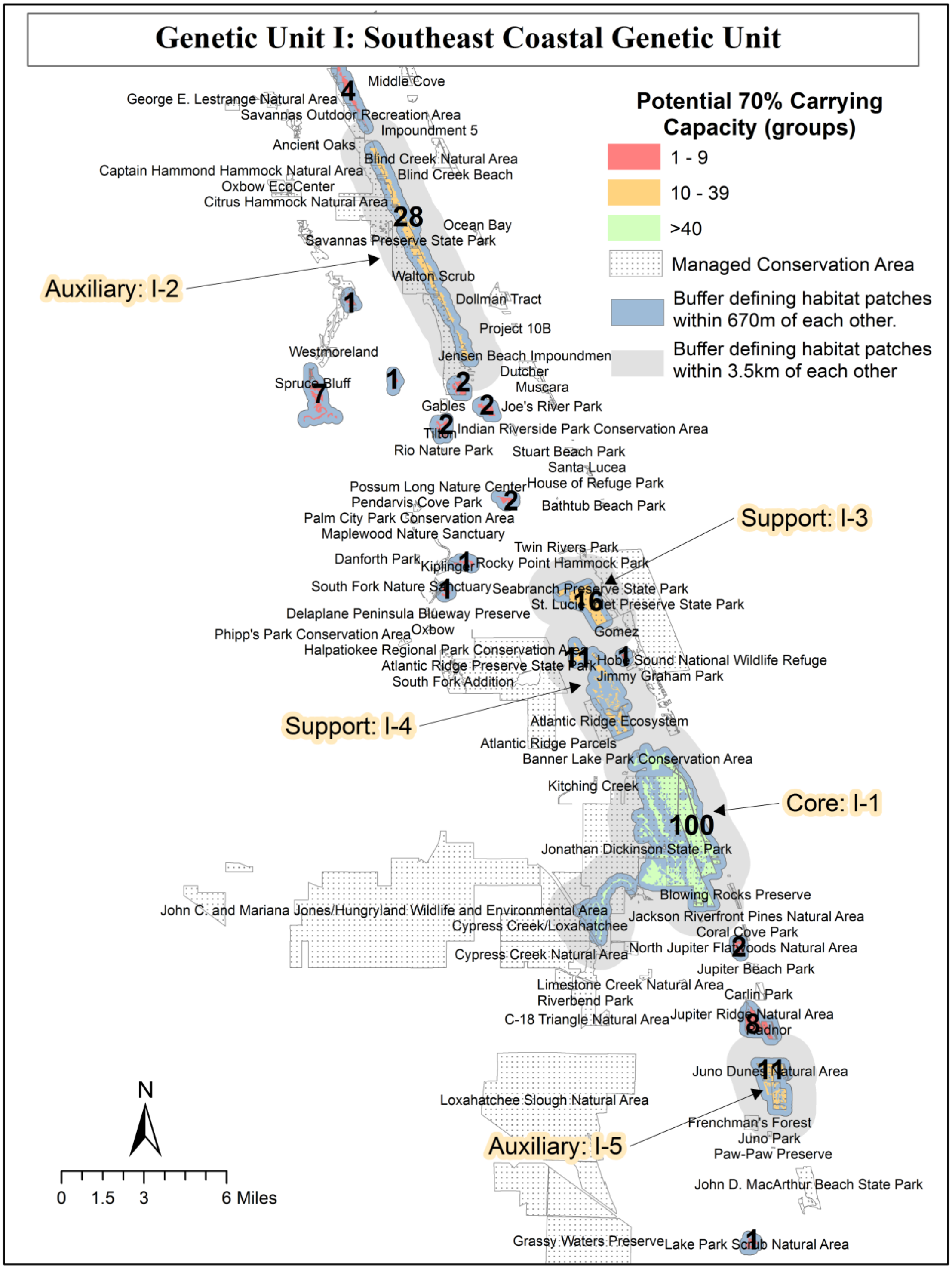

Figure A13. Southeast Coastal Genetic Unit.

Lee and North Collier Genetic Unit Description (Genetic Unit K)

The Lee and North Collier Genetic Unit include widely-scattered patches of scrub and scrubby flatwoods in Lee and northern Collier Counties in southwest Florida. The genetic unit encompasses Stith's (1999) Metapopulation 8. The genetic unit is separated from the Southwest Inland Genetic Unit (Genetic Unit F) to the north by extensive non-scrub areas in the Fred C. Babcock-Cecil M. Webb Wildlife Management Area. However, Florida Scrub-Jays observed in North Fort Myers in 1986 (Pranty et al. 1998) and in Cape Coral's Festival Park in the late 2000s suggest that there was historical interaction between the genetic units near what is now the City of Cape Coral. Patches of scrub and scrubby flatwoods along the Caloosahatchee River may have provided some historical connectivity to the Lake Wales Ridge Genetic Unit (Genetic Unit B).

The 1992-93 surveys located approximately 40 Florida Scrub-Jay groups in the genetic unit, with most restricted to three regions: along the Caloosahatchee River in north-central and northeastern Lee County, along the Gulf Coast, and around the city of Immokalee (Fitzpatrick et al. 1994, Stith 1999). An experimental translocation established a population in Rookery Bay National Estuarine Research Reserve in southern Collier County in the 1990's (Mumme and Below 1999), but this population became extirpated in 2005 (R. Mumme, personal communication).

Florida Scrub-Jays still persist along the Caloosahatchee River, where Hickey's Creek Mitigation Park (3 Florida Scrub-Jay groups) and Alva Scrub Preserve (1 group) harbor the only Florida Scrub-Jays on managed conservation lands in the genetic unit. Florida Scrub-Jays have not been reported from areas along the Gulf Coast in recent years, with the last report of Florida Scrub-Jays in Estero Bay Preserve State Park in 2001 (S. Giguere, personal communication). John Fitzpatrick observed Florida Scrub-Jays at Immokalee Airport in 2011.

Available habitat maps may have underestimate the amount of available habitat in Hickey's Creek Mitigation Park and Alva Scrub, where patches of scrubby flatwoods occur in areas where soil maps suggest mesic flatwoods. Florida Scrub-Jays along the Caloosahatchee River and those near Immokalee are separated by more than 30 kilometers.

Conclusions/Recommendations

The Lee and North Collier Genetic Unit is extremely vulnerable to extirpation, with few Florida Scrub-Jay groups and little potential habitat remaining. Areas along the Caloosahatchee River, including Hickey's Creek Mitigation Park, Alva Scrub Preserve, Telegraph Creek Preserve, and Babcock Ranch Preserve, offer the best hope for conserving Florida Scrub-Jays in this genetic unit.

This genetic unit contains no core, support, or auxiliary areas (Figure A14).

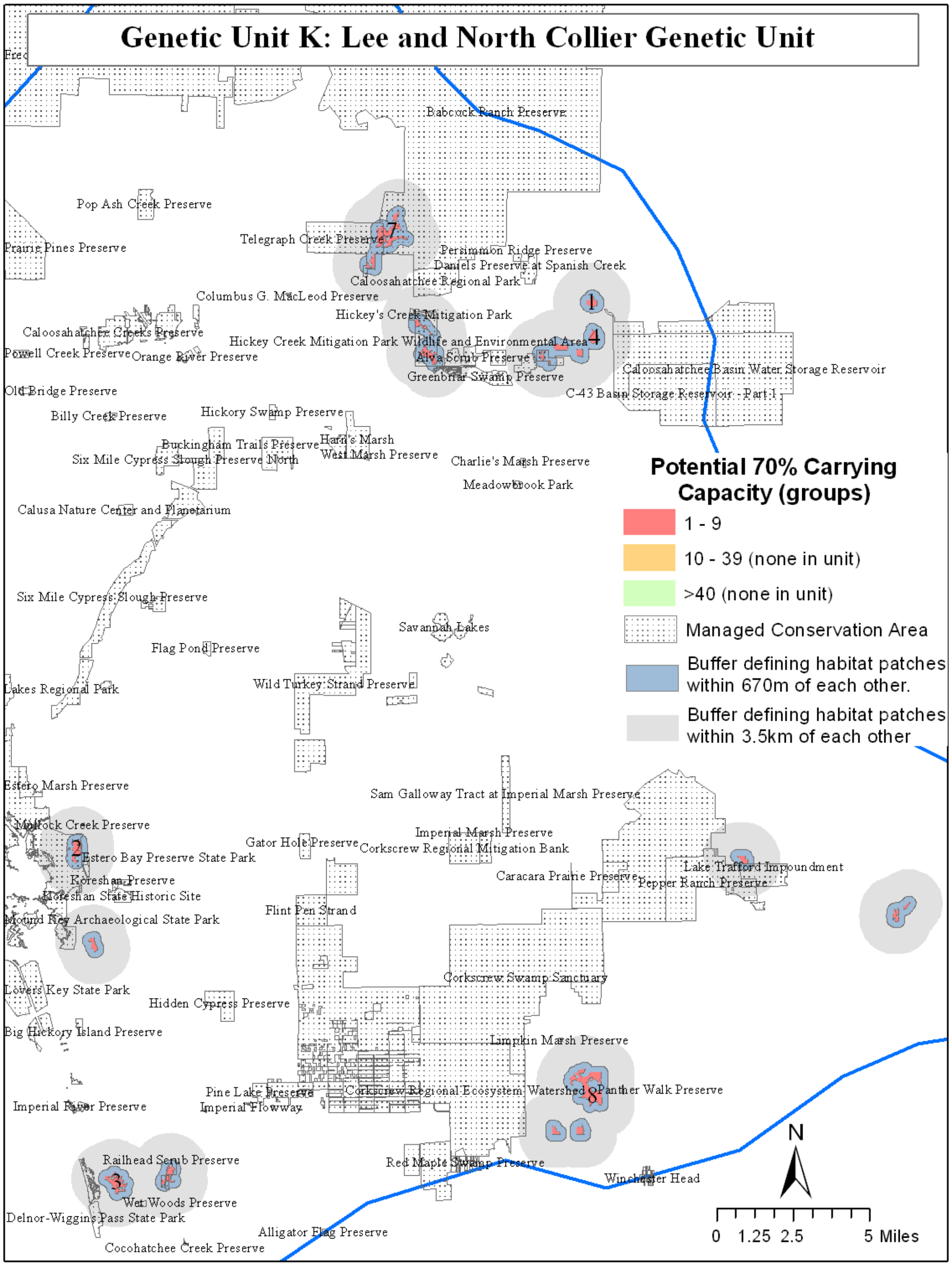

Figure A14. Lee and North Collier Genetic Unit.

Appendix B - Focal Landscapes

East Coastal Genetic Unit Focal Landscapes (Genetic Unit A)

The **East Coastal Genetic Unit - South Focal Landscape** contains three core areas and one support area in southern Brevard and northern Indian River counties. The Sebastian Core Area (A-1) includes some of the largest contiguous blocks of Florida Scrub-Jay habitat remaining and is key to the long-term persistence of Florida Scrub-Jays in the genetic unit. Most of the potential habitat is within SSRPSP. Support Area A-6 has little protected land and includes Sand Lakes Conservation Area. This area is a long string of scrub islands (Ten Mile Ridge) in mostly contiguous natural habitat connected to the SSRPSP. The potential would be greatly increased with additional habitat protection, especially between Sand Lakes Conservation Area and SSRPSP.

The Malabar/Jordan/Valkaria Core Area (A-2) contains a string of managed conservation lands (Malabar, Jordan, and Valkaria Scrub Sanctuaries) along the Atlantic Coastal Ridge. Roads, houses, and private inholdings complicate management in this core area. For example, the Valkaria Scrub Sanctuary is a megaparcel conservation project with many private inholdings. There are additional public lands (e.g., Valkaria Airport, Cameron Reserve) that could be managed to support Florida Scrub-Jays and enhance connectivity between managed areas.

Micco Core Area (A-4) includes Micco Scrub Sanctuary, Micco Expansion, South Babcock, and the northern portion of SSRPSP. The conservation lands are managed by the Brevard County Environmentally Endangered Lands (EELS) program and the Florida Park Service. Many other parcels have been bought as part of the Brevard County's SCDP for Florida Scrub-Jay mitigation, but are part of the state megaparcel project that remains incomplete (Figure B1).

Acreage in Conservation:	**5,703 ac (60%)**
Additional Acreage Proposed:	**3,740 ac**
Total Focal Landscape Acreage:	**9,443 ac**

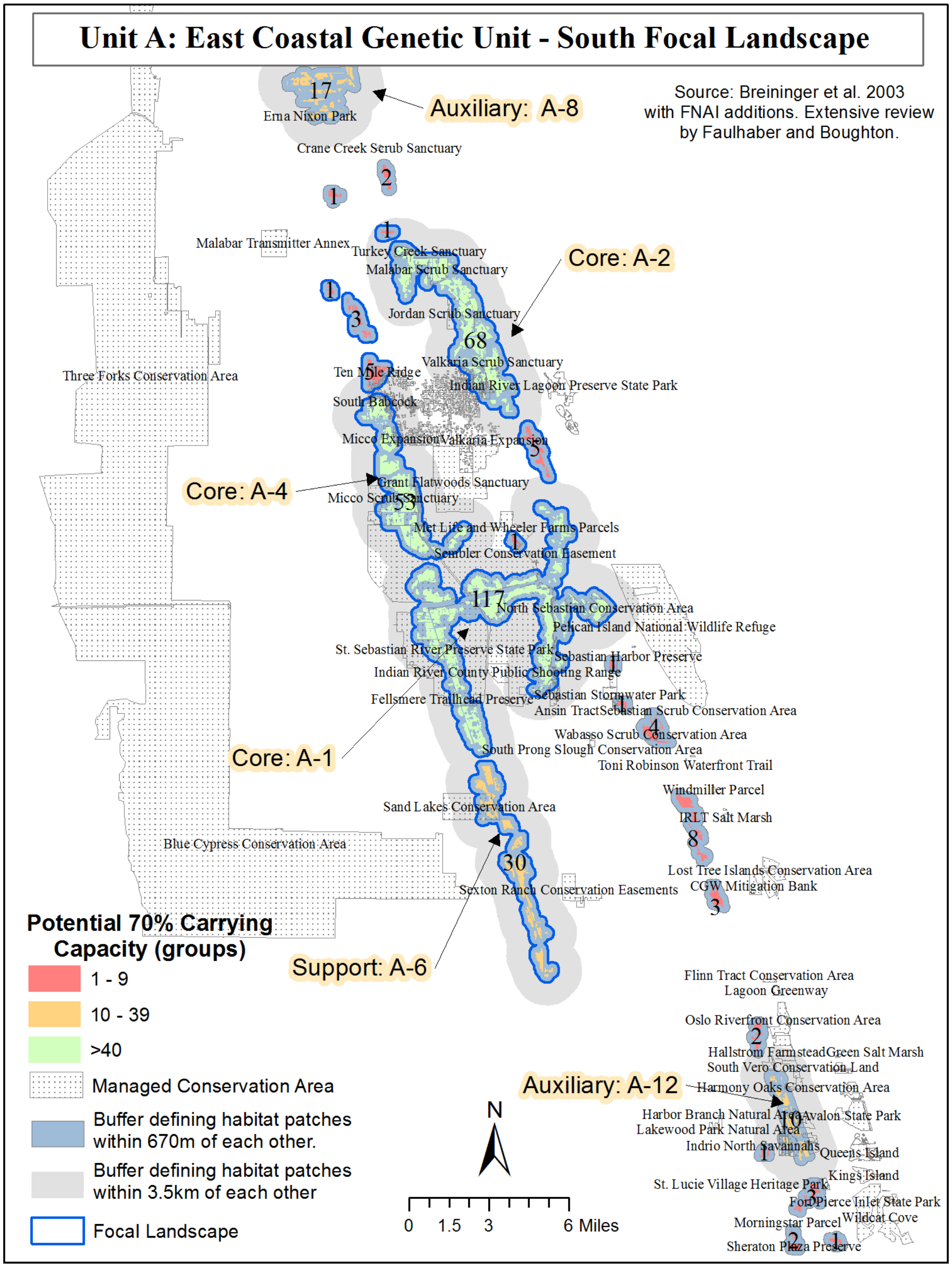

Figure B1. East Coastal Genetic Unit South Focal Landscape.

Lake Wales Ridge Genetic Unit Focal Landscape (Genetic Unit B)

The **Lake Wales Ridge Genetic Unit** consists of two focal landscapes referred to as "South" and "North." The **Lake Wales Ridge Genetic Unit - South Focal Landscape** has seven core areas (B-1, B-3, B-6, B-7, B-8, B-10, and B-12) and two support areas (B-15 and B-16). These begin in the northern portion of the focal landscape near Silver Lake and Sun N Lake North Core Area B-8 and continue southward through Highlands Hammock State Park Core Area B-12 and Support Area B-15. The focal landscape then follows an easterly path through Core Area B-10 (private ownership) to Lake Wales Ridge National Wildlife Refuge - Flamingo Villas Support Area B-16. From these areas the focal landscape proceeds south encompassing Jack Creek; Lake Wales Ridge Wildlife and Environmental Area (LWRWEA) - Highlands Ridge and Henscratch, and Lake June-in-Winter Scrub State Park Core Area B-3; west to LWRWEA - Royce Ranch, Highland Park Estates Core Area B-7; and continuing south through LWRWEA and The Nature Conservancy - Holmes Avenue Core Area B-6. The southern terminus includes the largest core area in the genetic unit consisting of: LWRWEA - Placid Lake Scrub, Gould Road, McJunkin Tract, Archbold Biological Station (Core Area B-1), Hendrie Ranch, and ending at Smoak Ranch and Fisheating Creek Conservation Easement area to the east and west respectively.

Maintaining connectivity and restricting within core fragmentation is important to the functionality and long-term persistence of the seven core areas. Fragmentation through urban development is ongoing especially in the core areas in the north part of the south focal landscape, as is the lack of appropriate habitat management through fire. The largest and highest priority core in Genetic Unit B (Core B-1) and the southern metapopulation with a carrying capacity of up to 254 breeding pairs includes Archbold Biological Station, LWRWEA - Lake Place Scrub, and extensions of these protected areas to the south. South of this main core scrubby habitat naturally becomes sparse, with the highest potential occurring on conservation lands at Platt Branch Mitigation Park and Environmental Area and Fisheating Creek Wildlife Management Area (Auxiliary Areas B-27 and B-26). Some small, naturally loosely connected patches also remain even further south (Auxiliary Areas B-22 and B-29).

North of Core Area B-1 is the Holmes Avenue megaparcel and the adjacent, unprotected platted area of Sun-N-Lakes South Core B-6, which currently supports upwards of 35 Florida Scrub-Jay groups. Although somewhat fragmented, this core area still has considerable potential and provides critical connectivity along the eastern side of the Lake Wales Ridge. Further north along the eastern side of the ridge are Royce Ranch Core Area B-7, Highlands Park Estates Core Area B-7, Lake Wales Ridge National Wildlife Refuge's Flamingo Villas Support Area B-18. The latter two are megaparcels, and scattered development complicates management at Highlands Park Estates.

The remainder of the south focal landscape has many protected lands at Henscratch, Jack Creek, Lake June-in-Winter Scrub State Park, and Highlands Ridge Core Area B-3; Highlands Hammock Core Area B-12 and Support Area B-15; and Silver Lake/Sun-n-Lakes North Core Area B-8 that occur from south to north along the western side of the ridge. Core Area B-10 is in private ownership north of Core Area B-3 and without protection of the privately owned regions this will increasingly fragment and create gaps resistant to Florida Scrub-Jay dispersal among these core and support areas (Figure B2).

Acreage in Conservation: **14,213 ac (49%)**
Additional Acreage Proposed: **14,801 ac**
Total Focal Landscape Acreage: **29,014 ac**

The **Lake Wales Ridge Genetic Unit - North Focal Landscape** has five core areas (B-2, B-4, B-5, B-9, and B-11) and three support areas (B-18, B-20, and B-24) centered on Lake Wales Ridge State Forest (LWRSF) radiating north through Tiger Creek Preserve to Allen David Broussard Catfish Creek Preserve State Park and Hatchineha Ranch, east to Avon Park Air Force Bombing Range (APAFBR), south to Carter Creek, and west to Saddle Blanket Scrub Preserve.

The northern focal landscape consists of five loosely connected cores. The APAFBR Core Area B-2 and LWRSF's Arbuckle Tract Core Area B-4 contain the largest, most contiguous areas of potential habitat in the northern metapopulation and are the most important to its persistence. Support Area B-18 on the APAFBR is a critical patch maintaining connection between Core Area B-2 and Core Area B-4. Support Area B-20 at Saddle Blanket Scrub Preserve has exemplary habitat management but little growth or immigration of Florida Scrubs-Jays, suggesting a highly reduced population in the surrounding landscape.

South of Core Area B-4 and west of Core Area B-2, is the Carter Creek Core Area B-9. Until recently, immigration occurred among Core Area B-9 and Core Area B-2 through the patch network of Support Area B-24, and smaller "stepping stones" between these cores. Core Area B-9 has a documented decline (almost extinction) of over 30 Florida Scrub-Jay families; however, habitat restoration activities are currently ongoing and it is nearly all protected.

North of Core Area B-4, LWRSF's Walk-in-the-Water Tract and Tiger Creek Preserve Core Area B-11 contain a mix of scrubby flatwoods and southern ridge sandhill and provide important connectivity between Core Area B-4 and Core Area B-5 to the north. The Florida Scrub-Jay population in Core Area B-11 currently is quite small, and much of the habitat is overgrown. Allen David Broussard Catfish Creek Preserve State Park comprises the bulk of Core Area B-5, and LWRSF's Hesperides Tracts help maintain connectivity between Core Area B-5 and Core Area B-11. There is also considerable degradation of scrubby communities north of Core Area B-5. Auxiliary Area B-30 and two patch networks near Upper Lakes Basin Watershed (Support Areas B-19 and B-14) are isolated. A series of isolated smaller networks still remain east of Core Area B-5 at the Disney Wilderness Preserve south to the Lake Kissimmee State Park (Auxiliary Area B-13, B-17, and B-29), which still contain Florida Scrub-Jays. Northeast of Core Area B-4 are the Cooked Lakes lands (Auxiliary Area B-21, B-25, and B-28). Although these areas maybe important locally, they are lower priorities compared to other areas in the genetic unit (Figure B#).

Acreage in Conservation: **17,417 ac (76%)**
Additional Acreage Proposed: **5,440 ac**
Total Focal Landscape Acreage: **22,857 ac**

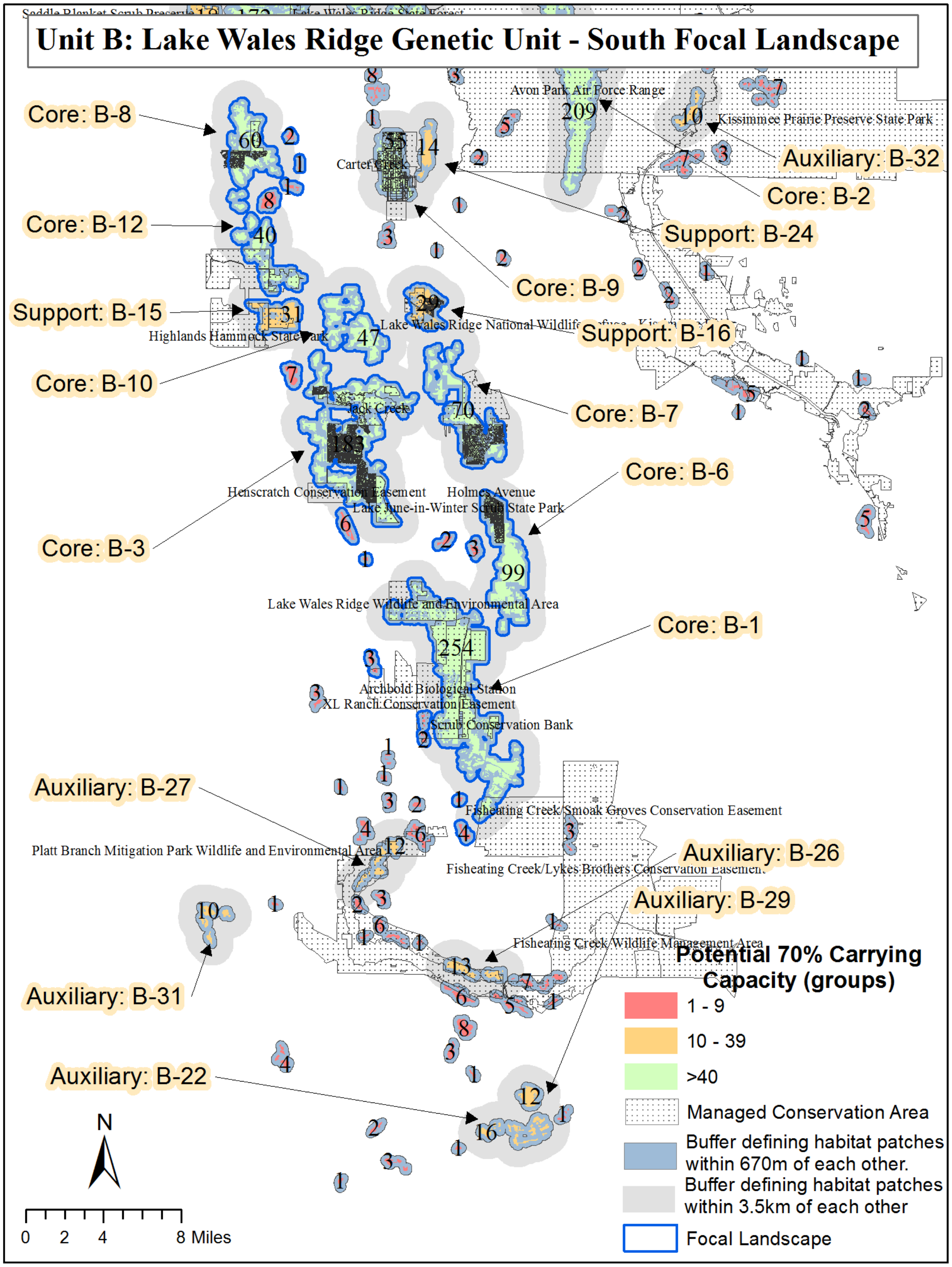

Figure B2. Lake Wales Ridge Genetic Unit South Focal Landscape.

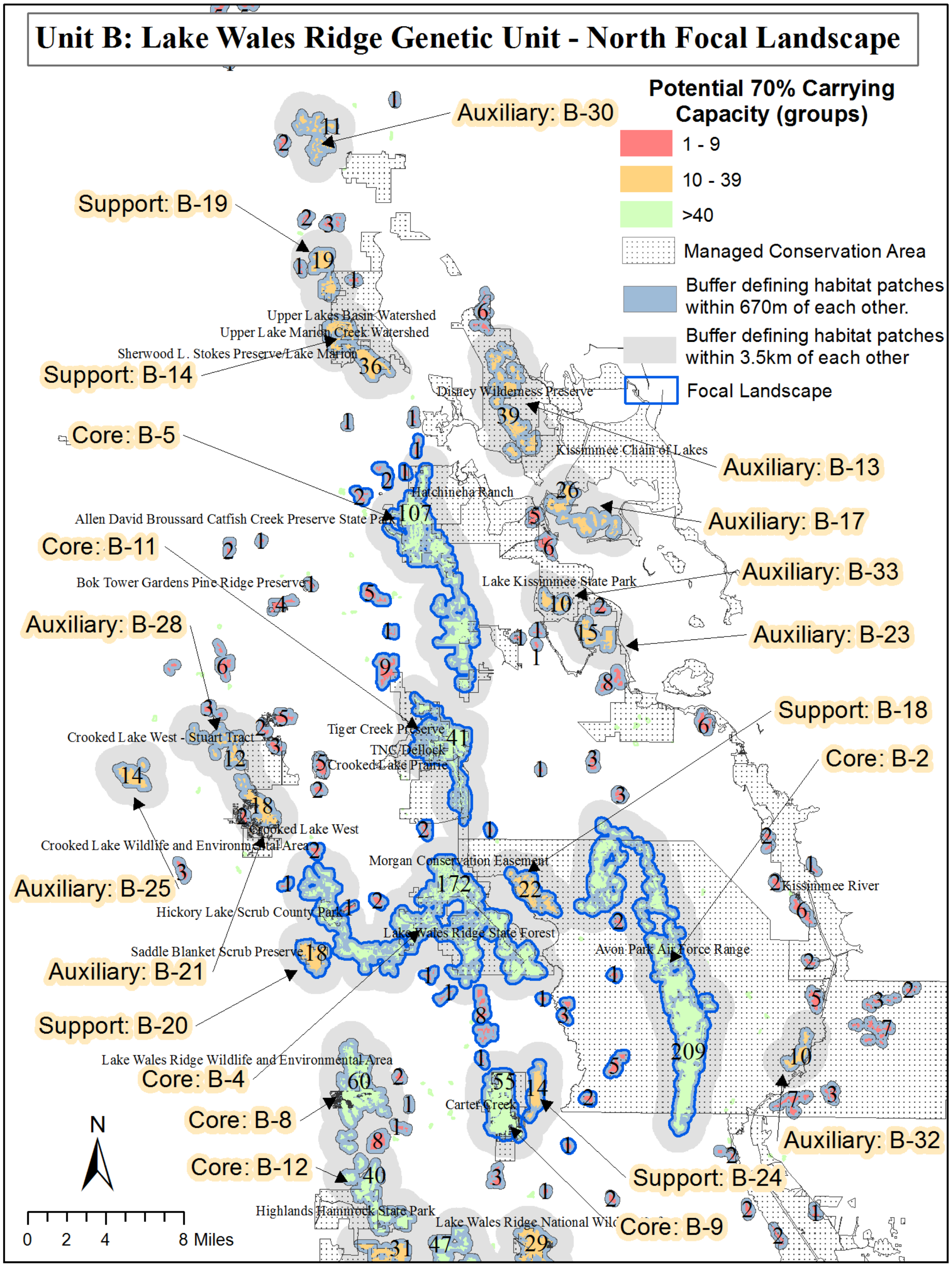

Figure B3. Lake Wales Ridge Genetic Unit North Focal Landscape.

Northeast Coastal Genetic Unit Focal Landscape (Genetic Unit C)

The **Northeast Coastal Genetic Unit Focal Landscape**, with three core areas (C-1, C-2, and C-3), is comprised of Kennedy Space Center's Merritt Island National Wildlife Refuge (MINWR), Cape Canaveral Air Force Station (CCAFS), Canaveral National Seashore, and the Oak Hill and Edgewater communities (core areas). The xeric soils within MINWR and CCAFS boundaries are estimated to be over 8,100 ha (20,000 ac). The vast majority of the scrub habitat in this focal landscape is in public ownership, with habitat management targeting optimal Florida Scrub-Jay conditions mandated by their federal responsibilities where feasible (Figure B4).

Acreage in Conservation: **20,819 ac (85%)**
Additional Acreage Proposed: **3,763 ac**
Total Focal Landscape Acreage: **24,582 ac**

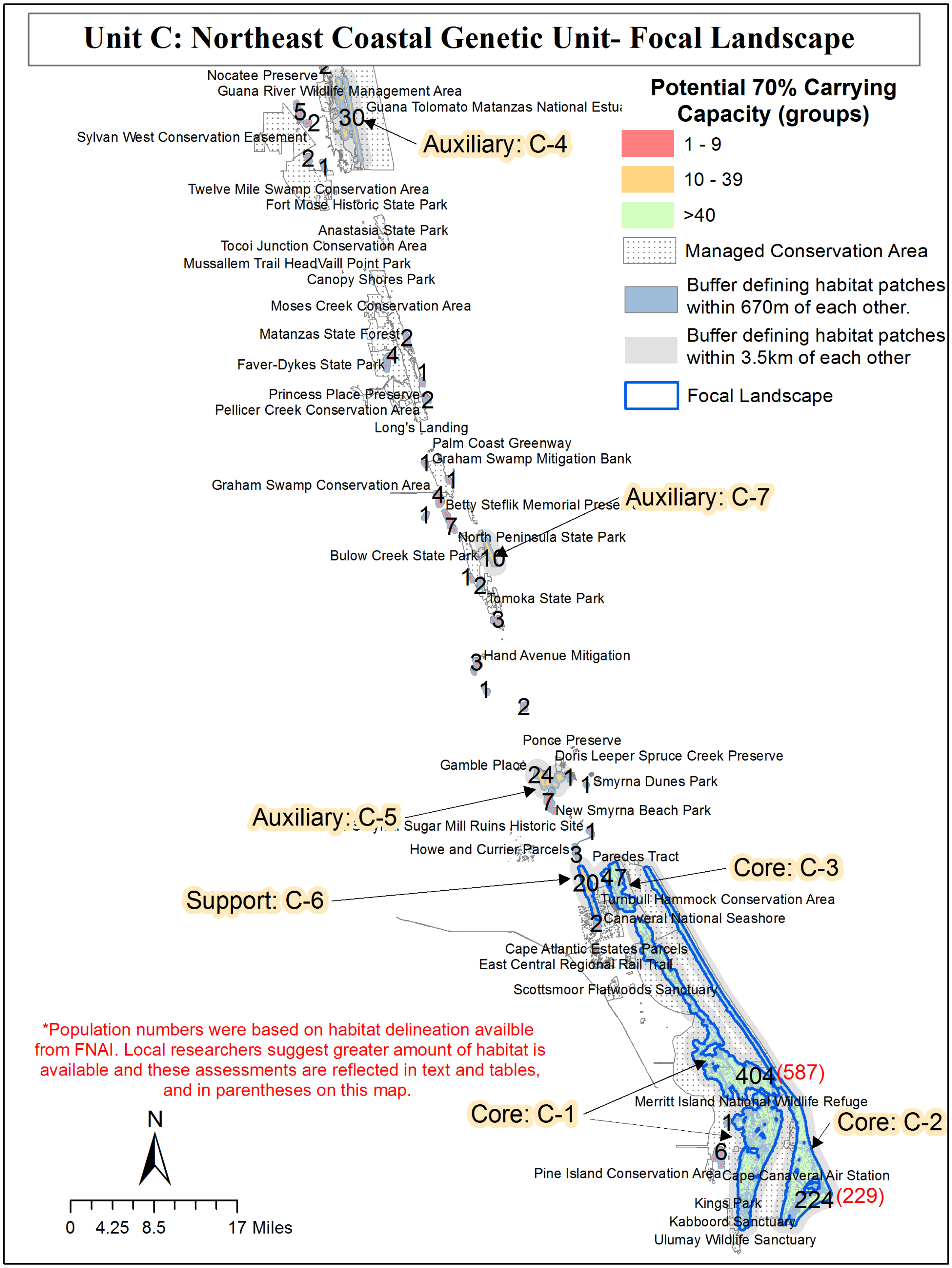

Figure B4. Northeast Coastal Genetic Unit Focal Landscape.

North Central Genetic Unit Focal Landscape (Genetic Unit D)

The **North Central Genetic Unit Focal Landscape** consists of four core areas (D-1, D-2, D-4, and D-6) and three support areas (D-10, D-12, and D-17). The northern boundary of the focal landscape is the northern limit of Ocala National Forest (ONF) along the Ocklawaha River, and extends southeasterly through Seminole State Forest (core and support areas) terminating at Rock Springs Run State Park (support area). This focal landscape is absolutely vital for persistence and recovery of the Florida Scrub-Jay. With roughly 91,465 ha (226,000 ac) of scrub habitat in ONF alone, this landscape has the largest carrying capacity remaining within the species' range, and – if management priorities were to dictate such – could be managed to support more Florida Scrub-Jays than in all of the other focal landscapes combined (Figure B5).

Acreage in Conservation: 241,995 ac (97%)
Additional Acreage Proposed: 6,439 ac
Total Focal Landscape Acreage: 248,434 ac

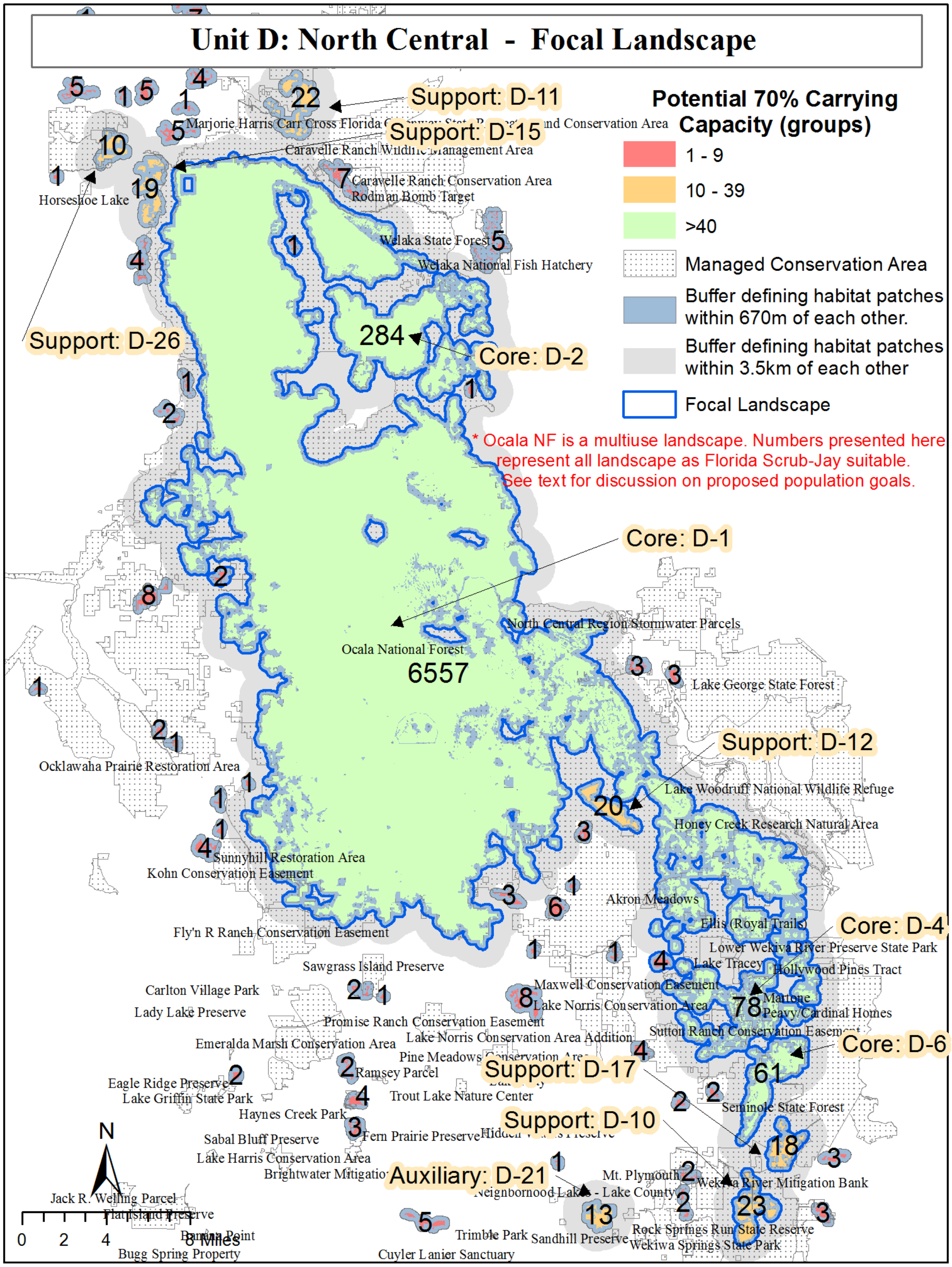

Figure B5. North Central Genetic Unit Focal Landscape.

Southwest Inland Genetic Unit Focal Landscape (Genetic Unit F)

The **Southwest Inland Genetic Unit Focal Landscape** is located in eastern Manatee County in the vicinity of Duette Preserve. Three core areas (F-1, F-2, and F-3), three support areas (F-7, F-8, and F-9), and one auxiliary area (F-4) compose the focal landscape. Manatee County's Duette Preserve along with Mosaic's Wellfield Conservation Scrub Site (core areas and support area) contains roughly 1,497 ha (3,700 ac) of scrub habitat. Northwest of this expanse is a series of small scrub patches (Gilley Creek) that loosely connect several larger public conservation lands (Little Manatee River South Fork Tract, Moody Branch Wildlife and Environmental Area, and Beker State Park) at the northern terminus of the focal landscape (auxiliary area). Southeast of Duette Preserve is scrub habitat that potentially could support large populations (core area and support areas); however, all of these lands are in remote, private ownership precluding our knowledge of current occupancy or habitat conditions. Contacting these private landowners with incentives to raise the possibility that they might contribute to conserving scrub and Florida Scrub-Jays is a high priority for this focal landscape (Figure B6).

Acreage in Conservation:	**5,483 ac (60%)**
Additional Acreage Proposed:	**3,637 ac**
Total Focal Landscape Acreage:	**9,120 ac**

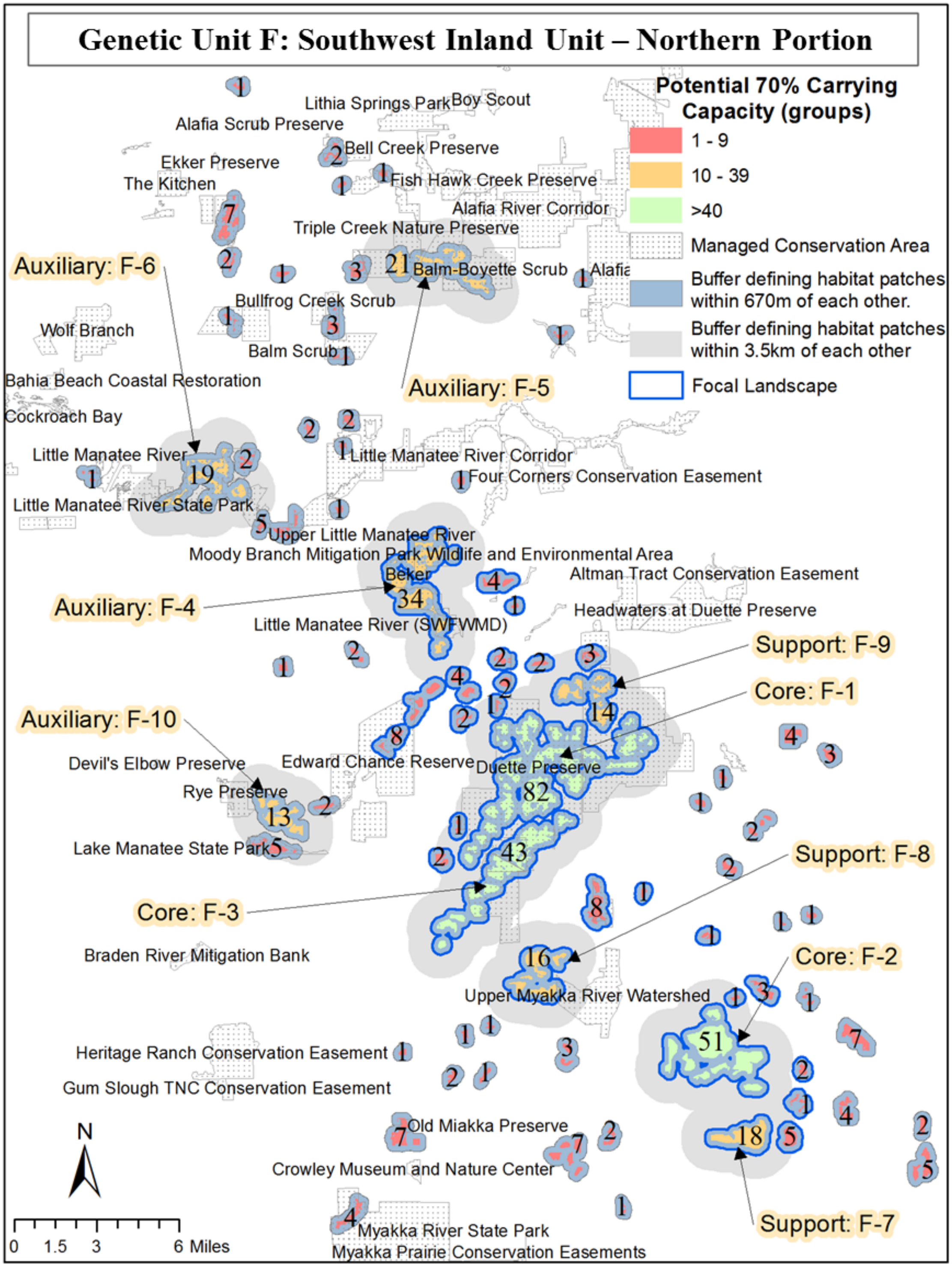

Figure B6. Southwest Inland Genetic Unit Focal Landscape.

Southeast Coastal Genetic Unit Focal Landscape (Genetic Unit I)

With nearly 1,133 ha (2,800 ac), Jonathan Dickinson State Park core area (I-1) has the majority of the contiguous and potential habitat for the **Southeast Coastal Genetic Unit Focal Landscape**. Two support areas (I-3 and I-5) north of Jonathan Dickinson State Park occurring on conservation lands in this focal landscape are the Atlantic Ridge Ecosystem and Seabranch Preserve State Park. Limited opportunities exist outside of the currently protected conservation lands in the genetic unit because this coastal environment is extremely urbanized (Figure B7).

Acreage in Conservation: 3,701 ac (82%)
Additional Acreage Proposed: 827 ac
Total Focal Landscape Acreage: 4,528 ac

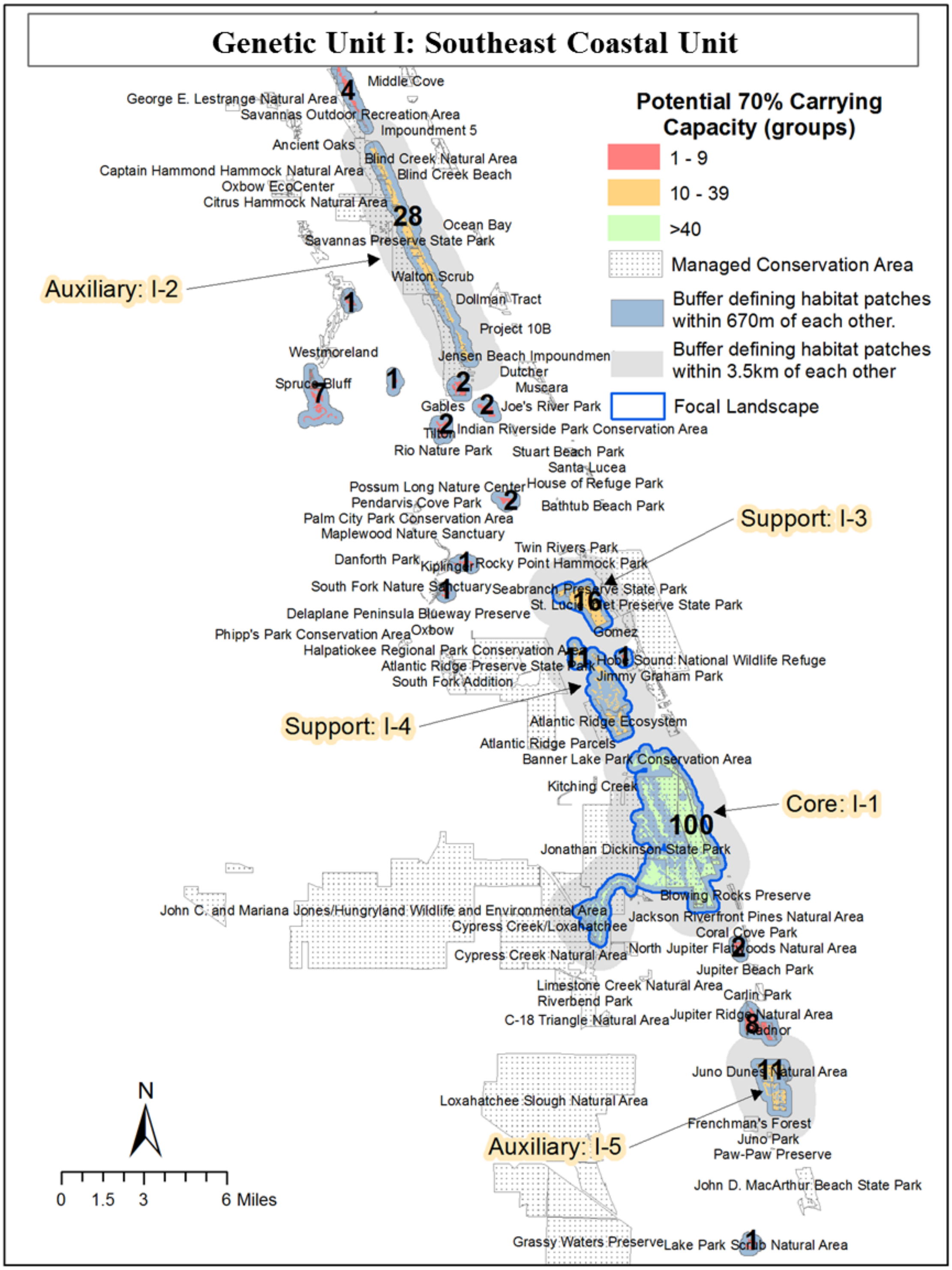

Figure B7. Southeast Coastal Genetic Unit Focal Landscape.

Appendix C – Status Quo

East Coastal Genetic Unit Status Quo (Genetic Unit A)

The long-term viability for the East Coastal Genetic Unit Status Quo option centers around St. Sebastian River State Park (Core: SQA-1) in the southern portion of the genetic unit. The core area is complimented by Micco Scrub Sanctuary (Support: SQA-4). Also occurring in the southern portion of the genetic unit is Malabar Scrub Sanctuary (Auxiliary: SQA-2), which has the potential to be a core area under the focal landscape scenario with additional acquisition between Valkaria Scrub Sanctuary and Jordan Scrub Sanctuary. This small auxiliary area has a high extinction risk because of the limited carrying capacity and fragmented surrounding landscape. In the northern portion of the genetic unit, a prior potential core in the proximity of Buck Lake Conservation Area is also reduced to an auxiliary area (Auxiliary: SQA-5) with very limited potential for viability under this scenario. Two additional populations – Salt Lake Wildlife Management Area (Auxiliary: SQA-10) and Cruikshank Sanctuary/Viera/Capron Ridge Sanctuary (Auxiliary: SQA-9) – remain auxiliary areas with the latter having the greatest viability potential (Figures C1 and C2).

Implementing a status quo for this genetic unit will result with very low representation (potentially one long-term viable population), low resiliency (potential of one population > 40 breeding pairs), and low redundancy (possibly 6 populations; 4 likely short-term).

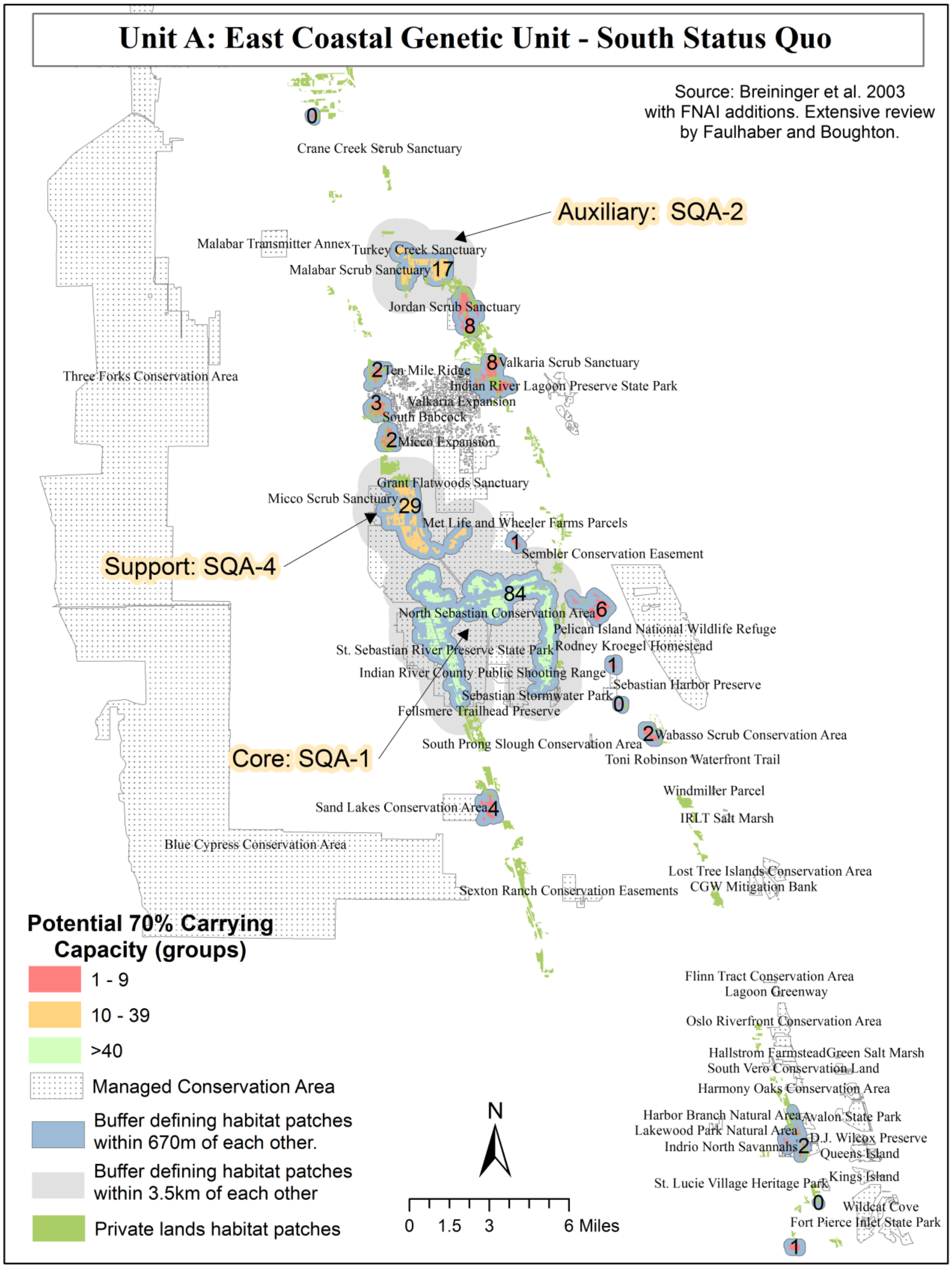

Figure C1. East Coastal Genetic Unit South Status Quo.

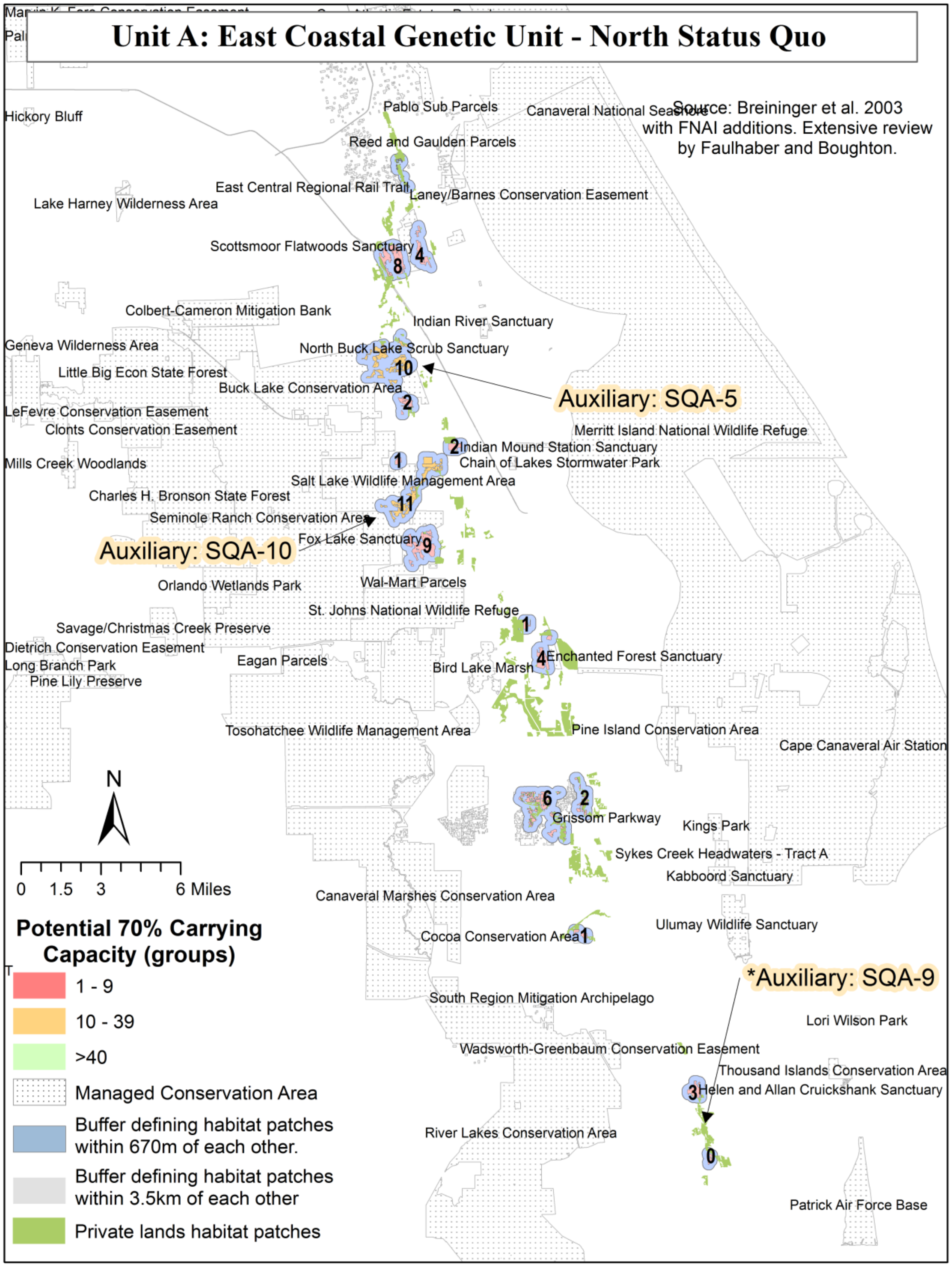

Figure C2. East Coastal Genetic Unit North Status Quo.

Lake Wales Ridge Genetic Unit Status Quo (Genetic Unit B)

The Lake Wales Ridge Genetic Unit Status Quo scenario will result in 22 fragmented local populations. Fifty percent of these populations will likely not be assured long-term viability (11 auxiliary areas). The southern portion of the genetic unit's stronghold will occur around Archbold Biological Station (Core: SQB-1) and Lake Wales Ridge Wildlife and Environmental Areas - Highlands Ridge and Henscratch (Core: SQB-3). The latter core is assisted by a potentially large support area (Support: SQB -7) consisting of additional Lake Wales Ridge Wildlife and Environmental Areas - Lake Wales Ridge Wildlife and Environmental Areas Royce Ranch and Highlands Park Estates. The northern portion of the genetic unit's future viability clusters around Lake Wales Ridge State Forest (Core: SQB-4). East of the state forest is Avon Park Air Force Range (Core: SQB-2a, Core:SQB-2b, Support: SQB-18) and to its north is an additional parcel of the state forest and Tiger Creek (Support: SQB-11). Two additional isolated core areas also occur in this portion of the genetic unit; Catfish Creek (Core: SQB-5) to the north of Tiger Creek and Lake Wales Ridge Wildlife and Environmental Area - Carter Creek (Core: SQB-9) to the south of the state forest core area (Figures C3 and C4).

The status quo scenario for this genetic unit would be high for representation (potentially 11 long-term viable populations), high for resiliency (potential of seven populations > 40 breeding pairs), and high for redundancy (possibly 22 populations; 11 likely short-term).

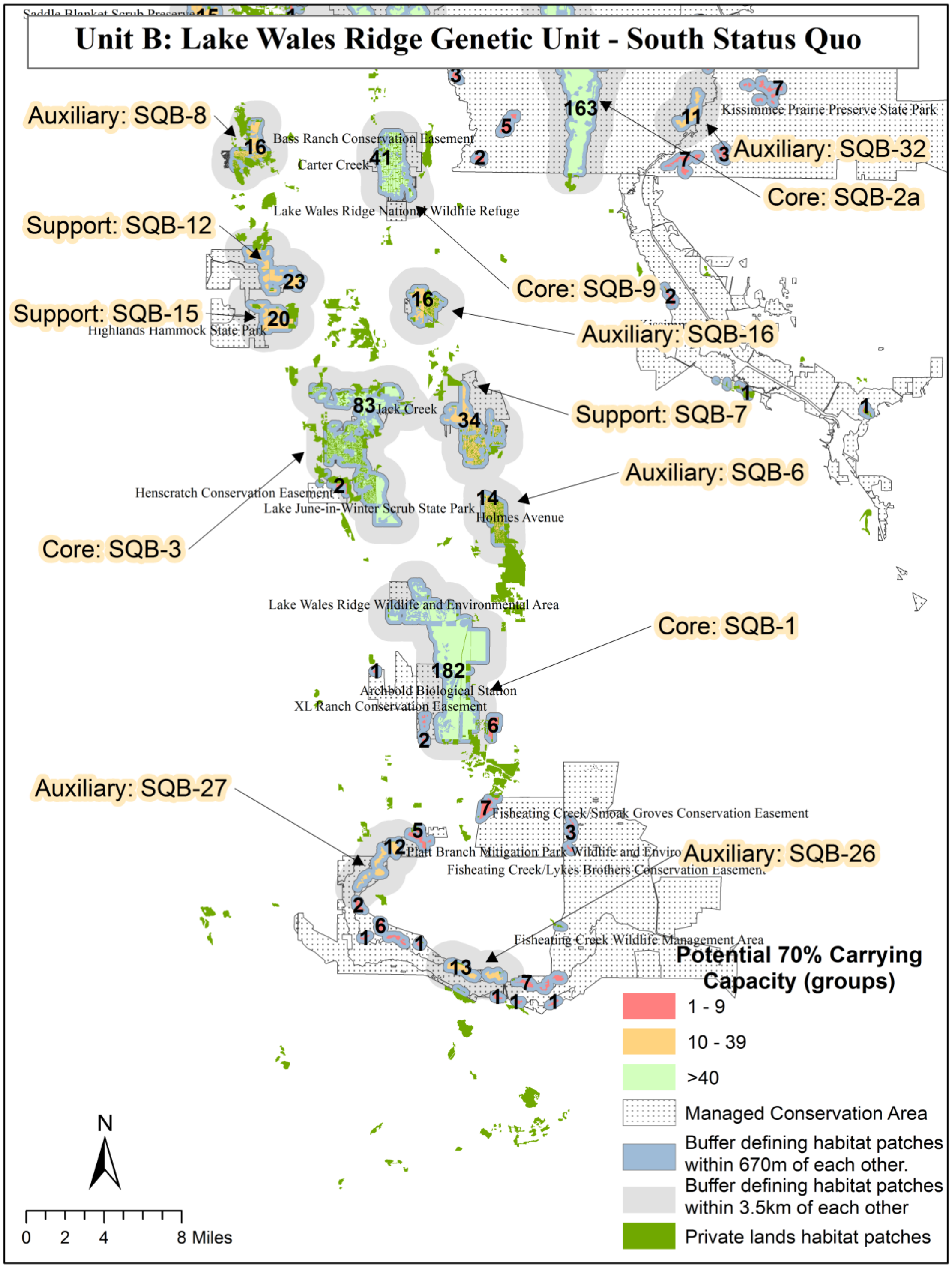

Figure C3. Lake Wales Ridge Genetic Unit South Status Quo.

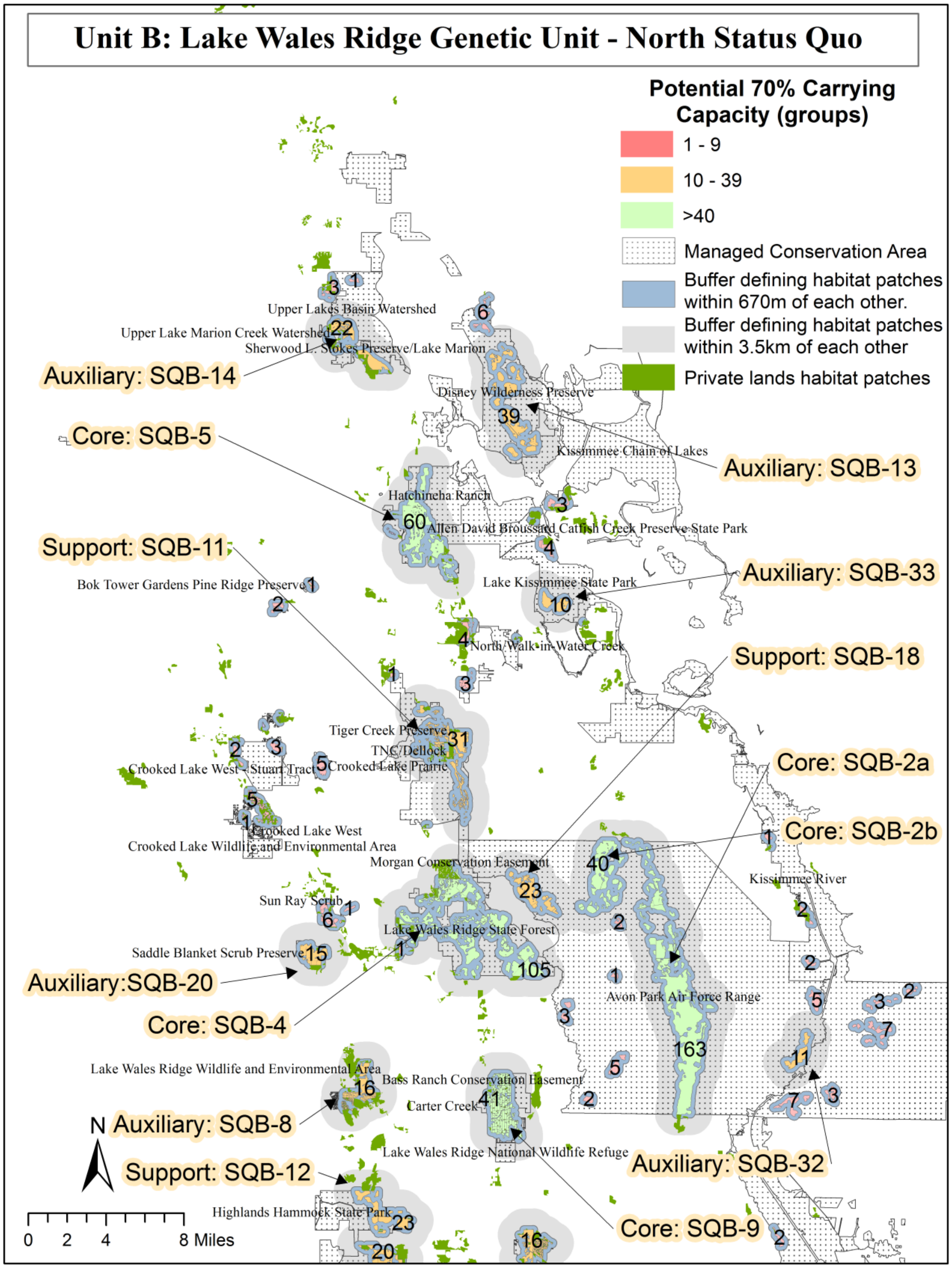

Figure C4. Lake Wales Ridge Genetic Unit North Status Quo.

Northeast Coastal Genetic Unit Status Quo (Genetic Unit C)

The vast majority of the Florida Scrub-Jay habitat in the Northeast Coastal Genetic Unit is currently under federal ownership. The Northeast Coastal Genetic Unit Status Quo option includes Kennedy Space Center's Merritt Island National Wildlife Refuge (Core: SQC-1), Cape Canaveral Air Force Station (Core: SQC-2), and three state owned conservation areas (Auxiliary: SQC-4, Guana River Wildlife Management Area; Auxiliary: SQC-5, Spruce Creek Preserve; Auxiliary: SQC-7, North Peninsula State Park). These areas account for 71% of the potential habitat in the genetic unit (>20,000acres).

The status quo scenario for this genetic unit is moderate for representation, high for resiliency (potentially 2 very large populations), and low to moderate for redundancy (Figure C5).

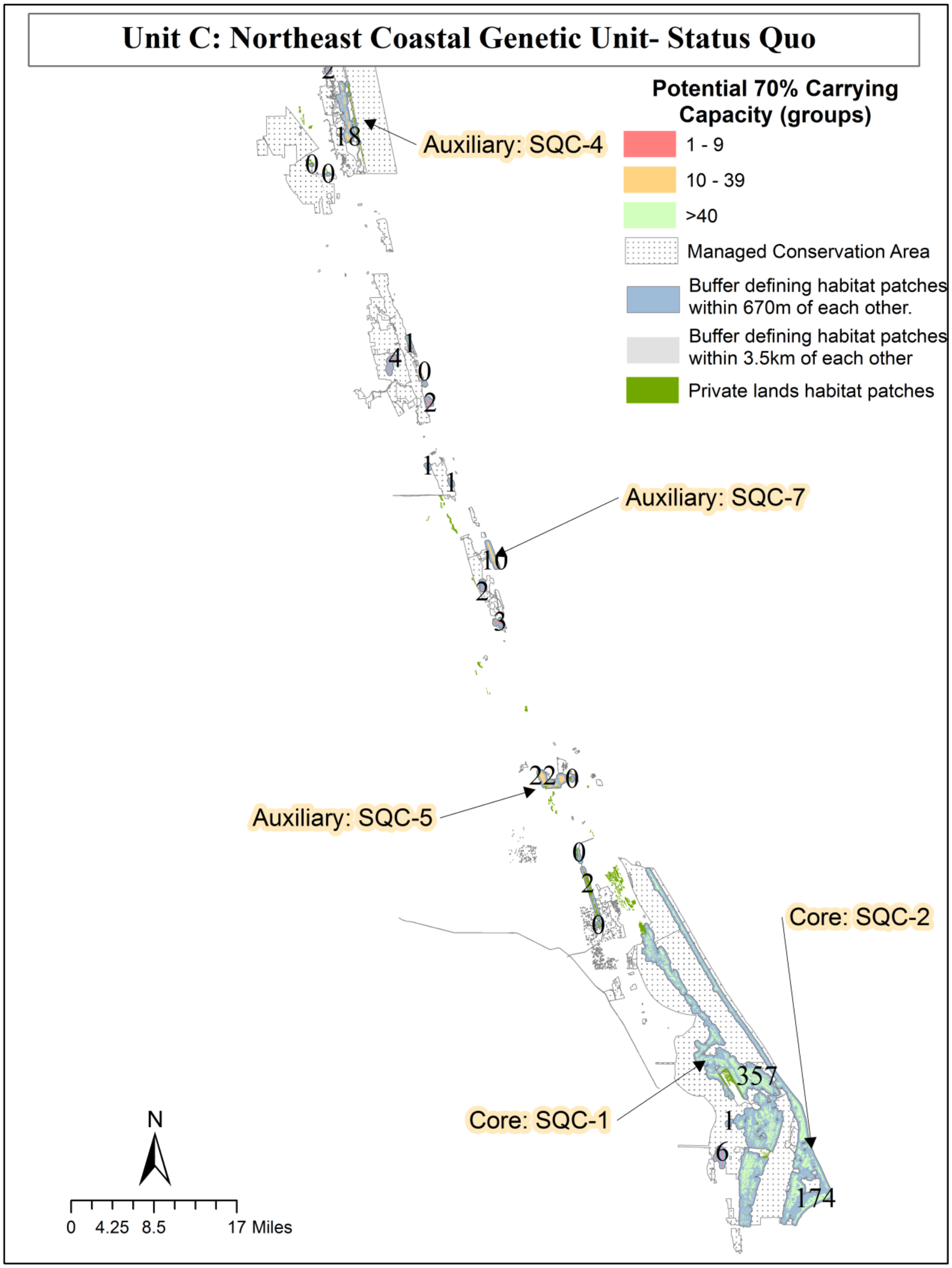

Figure C5. Northeast coastal Genetic Unit Status Quo

North Central Genetic Unit Status Quo (Genetic Unit D)

The North Central Genetic Unit Status Quo four core areas are identical to the focal landscape approach clustering around Ocala National Forest and Seminole State Forest (Core: SQD-1, Core: SQD-2, Core: SQD-4, and Core: SQD-6). The status quo identifies six support areas. They include the three support areas (Support: SQD-10, Support: SQD-12, and Support: SQD-17) from the focal landscape concept plus an additional three support areas (Support: SQD-11, Support: SQD-15, and Support: SQD-26). The three former are associated with the core areas of Ocala National and Seminole State Forests, and the latter three occur in the south western portion of the genetic unit by Starkey Wilderness Preserve. Nine auxiliary areas are also included in the status quo scenario (Auxiliary: SQD-5, Auxiliary: SQD-8, Auxiliary: SQD-9, Auxiliary: SQD-13, Auxiliary: SQD-17, Auxiliary: SQD-20, Auxiliary: SQD-23 Auxiliary: SQD- 25, and Auxiliary: SQD-28).

The status quo scenario for North Central Genetic Unit is high for representation, resiliency, and redundancy (C6 and C7).

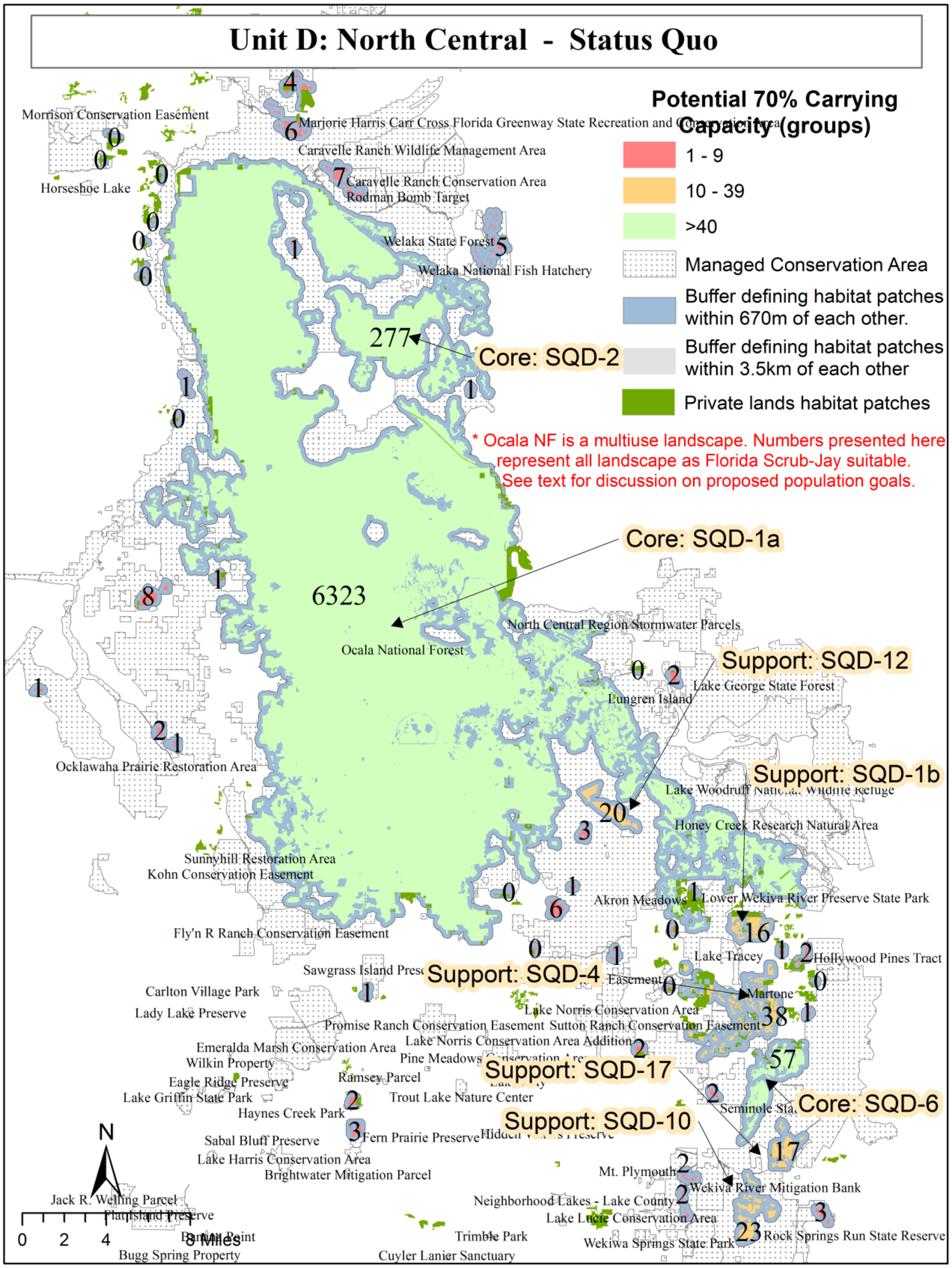

Figure C6. North central Genetic Unit Ocala National Forest Status Quo

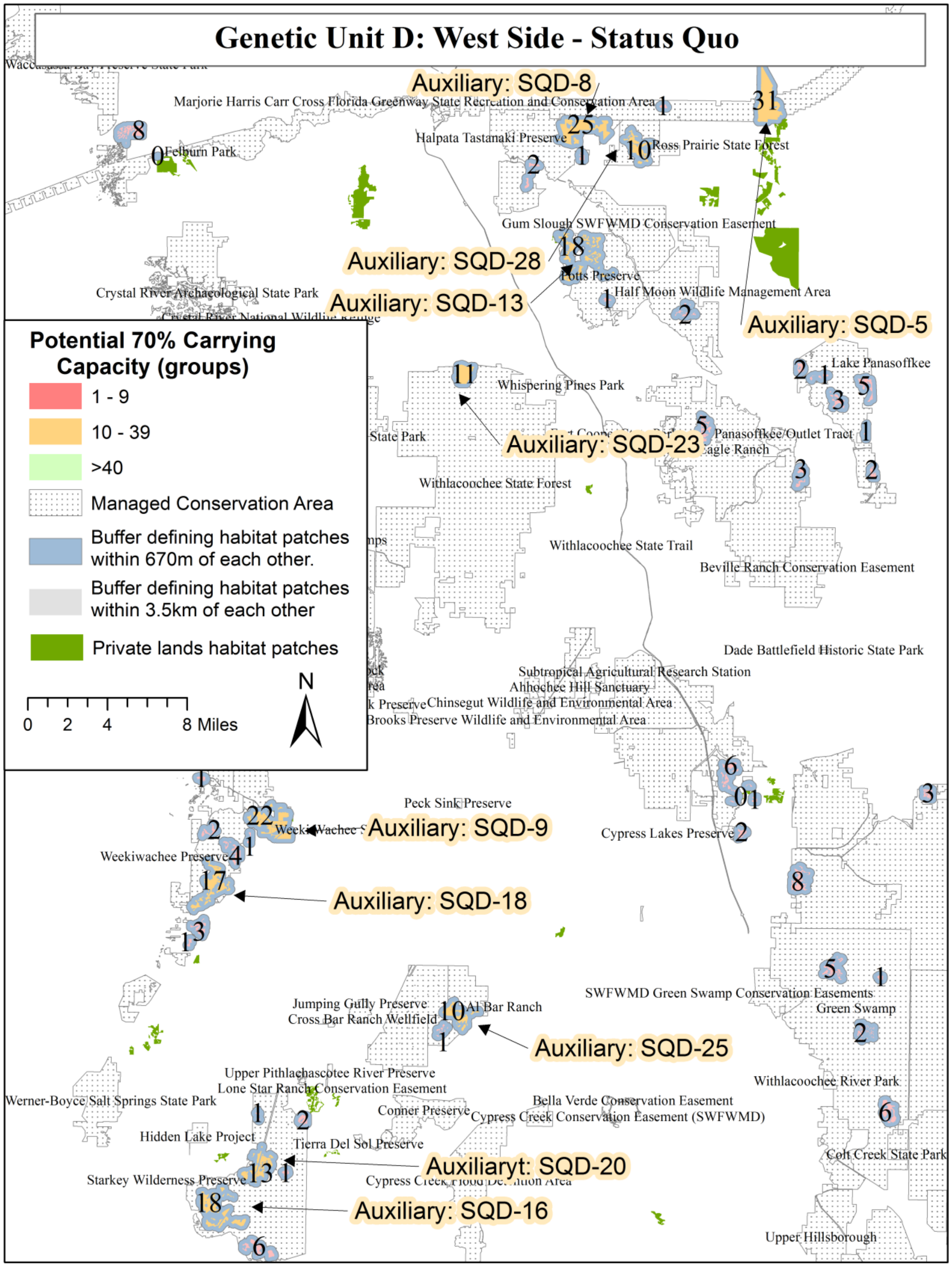

Figure C7. North Central Genetic Unit West Side Status Quo

Southwest Coastal Genetic Unit Status Quo (Genetic Unit E)

The Southwest Coastal Genetic Unit Status Quo consists of Oscar Scherer State Park (Auxiliary SQE-2). Very limited opportunities exist for this genetic unit as the landscape is extremely fragmented and the remaining habitat has small potential carrying capacities.

This genetic unit has low representation, resiliency, and redundancy (Figure C8).

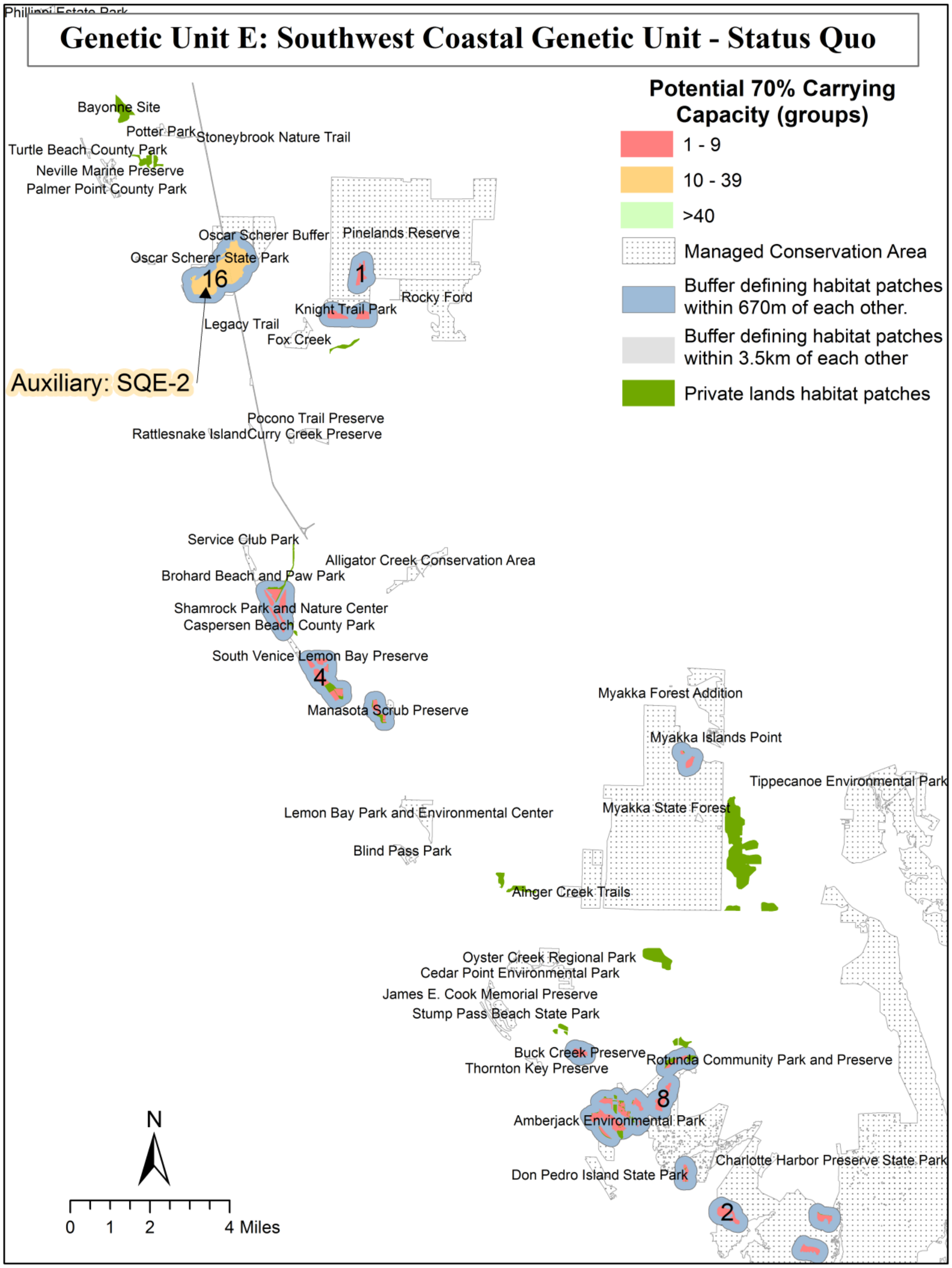

Figure C8. Southwest Coastal Genetic Unit Status Quo

Southwest Inland Genetic Unit Status Quo (Genetic Unit F)

The Southwest Inland Genetic Unit Status Quo scenario will be reduced from three potential core areas from the previous scenarios to one potential core area. Duette Preserve (Core:SQF-1) and the associated Support: SQF-3 (Mosaic Wellfield and Edward Chance Preserve) will remain the anchor for this genetic unit. Although Moody Branch Wildlife and Environmental Area (Auxiliary: SQF-4) is technically isolated per the mapping conventions from the core and support areas, numerous small scrub patches still support movement between the local populations. The remaining auxiliary areas (SQF-5 and SQF-6) are isolated and no longer have any genetic exchange with other local populations within the metapopulation.

The status quo scenario for the Southwest Inland Genetic Unit is low for representation, moderate for resiliency, and low for redundancy (Figure C9).

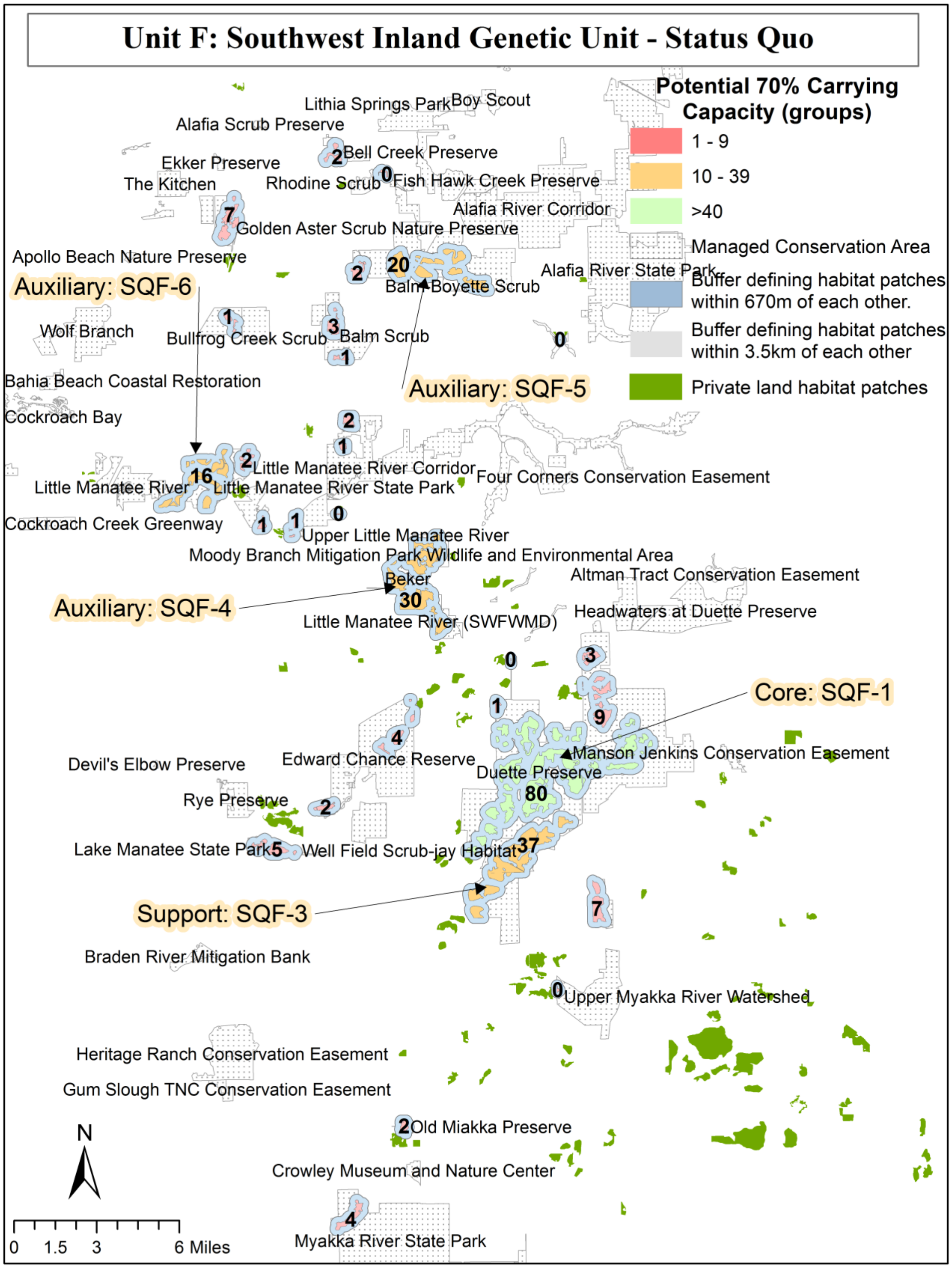

Figure C9. Southwest Inland Genetic Unit North Status Quo

Southwest Volusia County Genetic Unit Status Quo (Genetic Unit G)

Blue Spring State Park (Auxiliary: SQG-2) and Lake Monroe Conservation Area (Auxiliary: SQG-4) are the only potential opportunities for the Southwest Volusia County Genetic Unit Status Quo approach. Long-term population persistence under this scenario is quite grim. The existing conservation lands are small and isolated. Coupled with high development pressure throughout the genetic unit, the status quo strategy would almost certainly result in a high extinction probability.

The Southwest Volusia County Genetic Unit Status Quo option would be low for representation, resiliency, and redundancy (Figure C10).

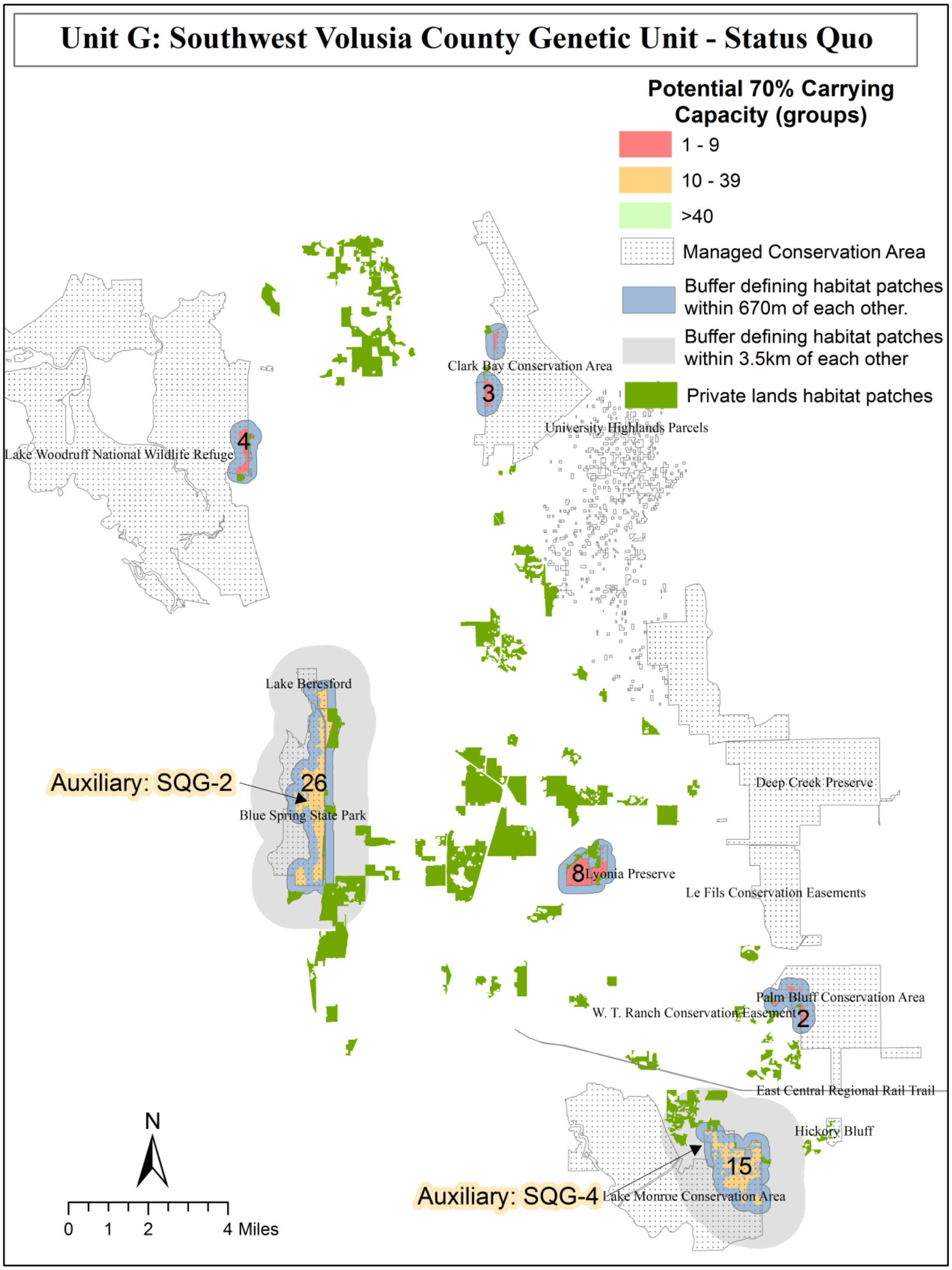

Figure C10. Southwest Volusia County Genetic Unit Status Quo

Levy County Genetic Unit Status Quo (Genetic Unit H)

Having only one small auxiliary area (Cedar Key Scrub State Reserve, Auxiliary: SQH-1) for the entire genetic unit, the Levy County Genetic Unit Status Quo scenario will result in extirpation near-term. Currently, this auxiliary area is not occupied.

Under this scenario, the Levy County Genetic Unit will remain low for representation, resiliency, and redundancy (Figure C11).

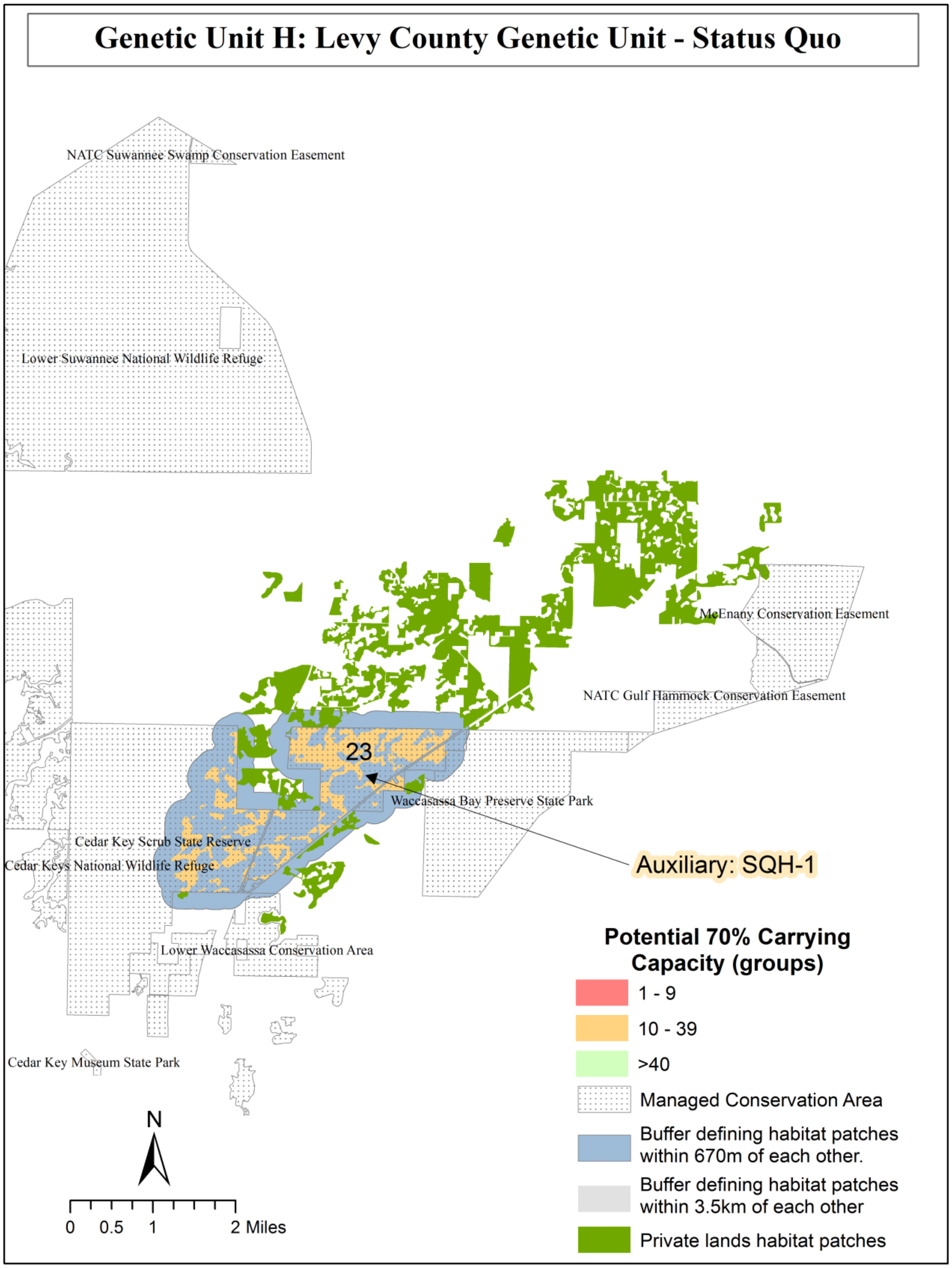

Figure C11. Levy County Genetic Unit Status Quo

Southeast Coastal Genetic Unit Status Quo (Genetic Unit I)

Similar to the northeast coastal genetic unit status quo scenario, a large portion of the potential Florida Scrub-Jay habitat in the Southeast Coastal Genetic Unit Status Quo is currently under public ownership. Jonathan Dickenson State Park (Core: SQI-1) has a relatively high potential carrying capacity. Three additional auxiliary areas also occur in the genetic unit: Savannas Preserve State Park (Auxiliary: SQI-2), Seabranch Preserve State Park (Auxiliary: SQI-3), and Juno Dunes Natural Area (Auxiliary: SQI-5). These areas account for 55% of the potential habitat in the genetic unit.

The status quo scenario for this genetic unit is moderate for moderate representation, moderate resiliency, and low for redundancy (Figure C12).

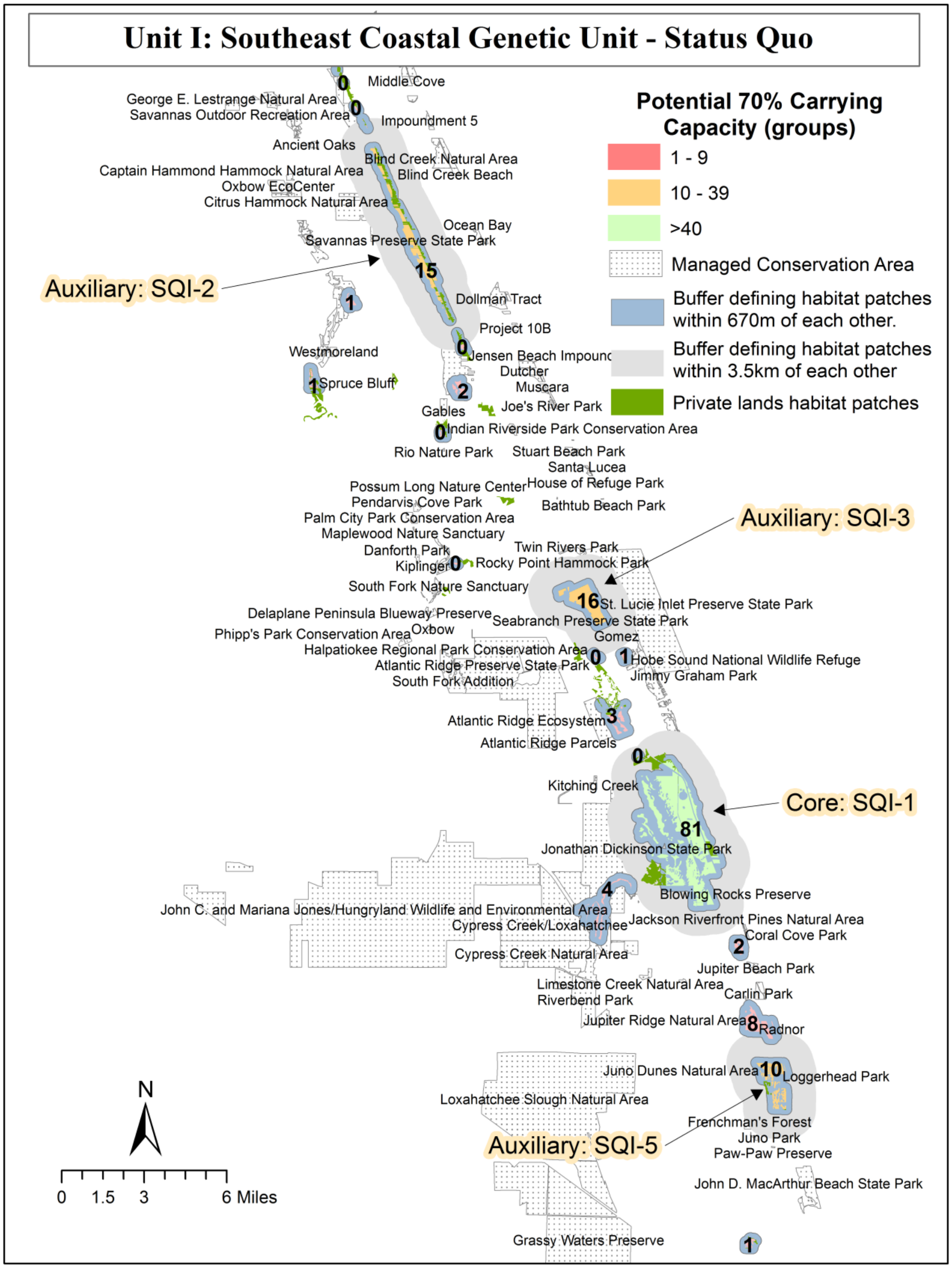

Figure C12. Southeast Coastal Genetic Unit Status Quo.

Lee and North Collier Genetic Unit Status Quo (Genetic Unit K)

The Lee and North Collier Genetic Unit Status Quo scenario identified no core, support, or auxiliary areas. This genetic unit is extremely vulnerable to extirpation regardless of the approach pursue.