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Introduction

Most Florida Scrub-Jay *(Aphelocoma coerulescens)* populations are vulnerable to extinction because of habitat destruction, degradation, or fragmentation (Fitzpatrick et al. 1991, Woolfenden and Fitzpatrick 1991, Root 1998, Breininger et al. 1999a, Toland 2000, Stith 1999). Brevard County Environmentally Endangered Lands Program (EELs), St. Johns River Water Management District (SJRWMD), and Florida Department of Environmental Protection (FDEP) provide much potential habitat in east central Florida. Additional purchases are being proposed but money for land acquisition and mitigation must be used where it will have the greatest effect. Nearly all potential reserves require restoration and adaptive management (Swain et al. 1995, Boyle 1996, Breininger et al. 1999a). Much must be learned about restoring Florida Scrub-Jay habitat that has been subject to soil disturbances, fire suppression, and habitat fragmentation. A few prescribed fires generally do not readily restore habitat conditions where reproductive success equals or exceeds mortality (Schmalzer et al. 1994, Breininger et al. 1996b, Schmalzer and Boyle 1998, Duncan et al. 1999, Breininger and Carter 2003).

Species densities are not always indicative of habitats suitable for population persistence because species can be abundant where the habitat cannot sustain their population without immigration (Lidicker 1975, Van Horne 1983, Garshelis 2000). Abundance can actually be a misleading indicator of habitat quality (Van Horne 1983, Hanski 1999). Time lags in population responses can mask the consequences of habitat change for long periods (Pulliam 1988, Howe et al. 1991, Nagelkerke 2002). Monitoring without being able to distinguish survival and dispersal can fail to reveal a serious problem until it's too late to recover the population (Howe et al. 1991, Pulliam and Danielson 1991, Pulliam et al. 1992, Pulliam 1996). It is not possible to measure Florida Scrub-Jay survival and dispersal without colorbanding.

Additional descriptions of scrub, geography, and plant ecology specific to the Atlantic Coast are provided elsewhere (e.g., Schmalzer and Hinkle 1992 a, b; Schmalzer et al. 2001). Additional ecological relationships between Florida Scrub-Jays and habitat, specific to the Atlantic coast, are described elsewhere (Breininger and Schmalzer 1990; Breininger and Smith 1992; Breininger et al. 1991a, 1995, 1998). The Brevard County Natural Resources Department (2002) provides a history of Florida Scrub-Jay data collection on the mainland. Toland (2000) describes how conserving Scrub-Jays involves conserving open space and the quality of life.

A regional comprehensive plan specific to Florida Scrub-Jays has only been implemented in Indian River County (Smith Environmental Services 1999). The U.S. Fish and Wildlife funded Brevard County to develop a Habitat Conservation Plan a decade ago to conserve Florida Scrub-Jays and to minimize regulatory burdens (Swain et al. 1995). Although Brevard County chose not to implement a plan, it was regarded as an important case study internationally and was widely used by the U. S. Fish and Wildlife Service, many conservation acquisition organizations, and businesses for planning and project implementations (Noss et al. 1997). Because the plan was not implemented, the cost and uncertainties for thousands of individual projects is cascading upwards as competition for land that is not already developed increases and as recovery options decrease.

2.0 Objectives

The objectives of this empirical study were to:

h) quantify habitat and describe population structure,
i) provide data to prioritize mitigation and land acquisition strategies,
j) quantify habitat-specific demography (e.g., juvenile production, yearling production, breeder survival, helper survival)
k) quantify dispersal (site tenacity, pair bond fidelity, delayed breeding characteristics, dispersal distances, population exchanges among habitat fragments),
l) evaluate habitat quality identify habitat restoration and management needs,
m) quantify the colonization of restored and uninhabited habitat,
n) identify inventory criteria that identify habitat conditions where potential breeder production equals or exceeds breeder mortality.

Caption 2.0. Optimal scrub includes shrub-dominated landscapes that have many scrub oaks and open sandy areas with few trees.

3.0 Theoretical Approach

The methods used for mapping habitat potential and approaches for quantifying habitat specific demography rely on long-term studies by our colleagues at Archbold Biological Station and ourselves at Kennedy Space Center. Much of what was first known about Florida Scrub-Jay sociobiology resulted from >30 years of study in a large tract of optimal habitat at Archbold Biological Station (Woolfenden and Fitzpatrick 1984, 1991, 1996). Later studies revealed that patterns of sociobiology, demography, and dispersal varied greatly among and within landscapes (Breininger et al. 1995, 1996a, 1998; Thaxton and Hingtgen 1996, Stevens and Young 2002; Bowman unpublished).

Our approach greatly relies on studies that have shown that source-sink dynamics apply to Florida Scrub-Jay populations within individual landscapes (Mumme et al. 2000, Breininger and Oddy 2001, Breininger et al. 2003). Sources are net exporters of individuals and have births that exceed deaths; sinks are net importers and have deaths that exceed births (Pulliam 1988). Although source-sink dynamics usually consider population dynamics among subpopulations (Hanski 1999), they theoretically occur within complex, heterogeneous landscapes (Howe et al. 1991, Rodenhouse et al. 1997).

We use "territory quality transitions," to compliment traditional ideas of source-sink dynamics (Breininger and Carter 2003). Traditional ideas focus on organisms physically moving from source to sink patches. However, shifting habitat quality and slight shifts in territory boundaries can cause individual territories to cycle between habitat quality states where reproduction exceeds mortality and where mortality exceeds reproductive success. We use "territory quality transitions" to describe the process of individual territories varying in quality temporally, which can allow optimal territories to "export" individuals to sinks without organisms actually relocating to territories. Because Florida Scrub-Jays routinely disperse from optimal territories into many types of sink territories, there is much potential to simply partition a landscape into potential territories and then determine the proportion of optimal territories needed to offset demographic losses in sinks. Our study focuses on quantifying the habitat-specific demographic data that is essential for applying source-sink theory (Pulliam et al. 1992). It is unrealistic for every territory to be optimal so that most managed landscapes probably will have a source-and-sink population structure.

There are limits to source-sink applications. For example, Florida Scrub-Jays do not always disperse into all types of marginal habitat (Woolfenden and Fitzpatrick 1984, Fitzpatrick and Woolfenden 1986). Furthermore source-sink ideas may collapse as one scales up to the metapopulation. For example, other investigators have reported that exchanges between conservation reserves and suburban territories tend to be one-way only: from suburbs to reserves (Thaxton and Hingtgen 1996; Bowman unpublished). Therefore empirical data is needed to quantify how Florida Scrub-Jays respond to habitat fragmentation. Landscape fragmentation by humans has many species biology effects that are described using ideas about metapopulation theory (Stith et al. 1996). But despite the eminence of metapopulation theory, there are little data and modeling has proceeded well ahead of empirical data (Doak and Mills 1994, Breininger et al. 2002). A number of metapopulation models might apply to Florida Scrub-Jay metapopulations (e.g., Kareiva 1990, McPeek and Holt 1992, Stith et al. 1996; Harrison and Taylor 1997, Stith 1999, Doncaster et al. 1997, Diffendorfer 1998).

Our approach focuses on how to maximize the viability within reserves because Florida Scrub-Jays have poor dispersal abilities so that maintaining subpopulation viability is probably the key to maintaining metapopulation viability (Drechsler and Wissel 1998). Populations in many landscapes are too small to withstand environmental stochasticity, catastrophes, inbreeding, and changing environments so that patches must be linked. Most Florida Scrub-Jay populations will probably not persist because they occur in urban and suburban landscapes (Stith et al. 1996, Breininger 1999, Stith 1999, Bowman unpublished). Many large expanses of scrub are unoccupied or are below carrying capacity because of the reduction in the fire regime (Swain et al. 1995, Stith 1999). These large scrub landscapes have the greatest probabilities for population persistence if restored and re-colonized (Stith 1999). Florida Scrub-Jays that reside in suburbs are possible colonists into restored areas (Breininger et al. 1999a, Breininger 1999, Bowman unpublished). However males have lower dispersal tendencies and seldom move among habitat fragments (Breininger 1999). Generally, empirical studies focus on situations where animals settle and live at moderate or high population densities so that little is known about habitat selection when habitats are unsaturated (Greene and Stamps 2001). Habitat quality and many of the common ideas about habitat selection might be poor predictors of dispersal into restored areas that are far below carrying capacity (Greene and Stamps 2001). Therefore, we not only investigate demographic responses to habitat restoration but we also investigate recolonization and dispersal among subpopulations that vary in size, arrangement, and quality.

This study began in Brevard County until we discovered large expanses of occupied habitat in Indian River County that had not been previously identified. These areas were purchased as part of the St. Sebastian River State Buffer Reserve (Sebastian Buffer Reserve). We expanded our studies into Indian River County because it became clear that a significant portion of the metapopulation overlapped with Indian River County. The Sebastian Area-Wide Florida Scrub-Jay Habitat Conservation Plan (Sebastian HCP) provided additional information in Indian River County (Smith Environmental Services 1999). Much information summarized in the Sebastian HCP resulted from previous colorbanding studies by Toland (unpublished).

This reported is organized into three major sections. The first describes habitat and population structure. The second focuses on the demography and dispersal of color-banded Florida Scrub-Jays residing in mainland metapopulations. A minor section updates a previous study of an isolated metapopulation on Brevard’s outer barrier island (Breininger 1999). The final major section addresses recovery and management. A literature cited section ends the report.

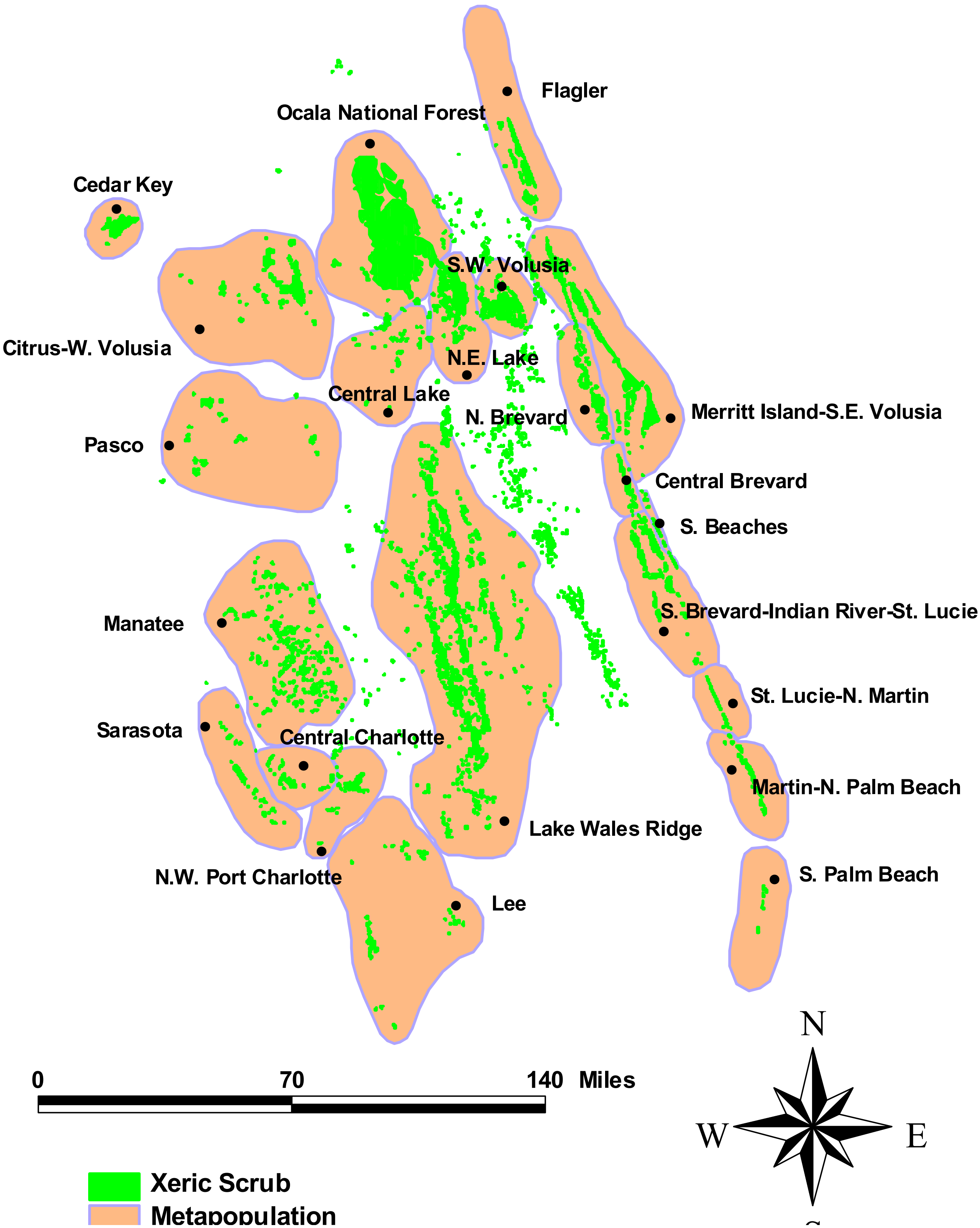
Caption 3. Florida Scrub-Jays near the time of fledging.

4.0 Habitat and Population Status of the Florida Scrub-Jay along Central Florida's Atlantic Coast.

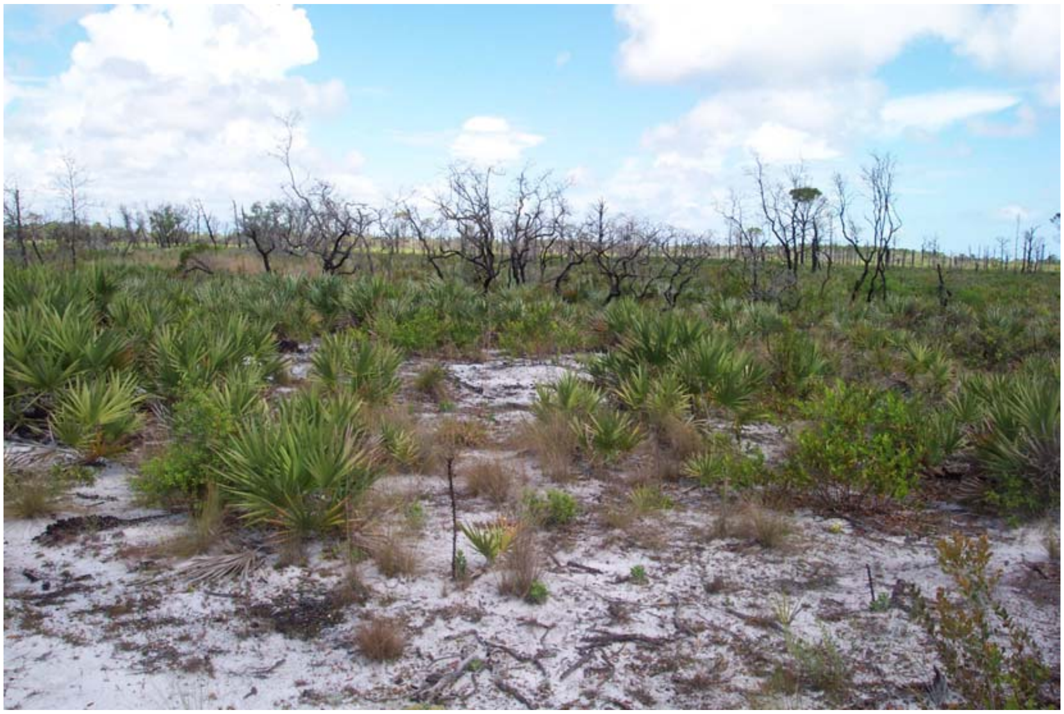
The study focuses on metapopulations on Florida's mainland that occur in Brevard County and Indian River County (Figure 1). These include the North Brevard, Central Brevard, and South Brevard-Indian River-N. St. Lucie metapopulation (Stith 1999). The North Brevard metapopulation is the 7th largest metapopulation in the range and Central Brevard is the 10th largest. The South Brevard-Indian River-N. St. Lucie metapopulation is the 4th largest metapopulation in the range and the largest on the mainland of the Atlantic Coast.

The nearby Merritt Island-S.E. Volusia metapopulation is the largest along the Atlantic coast and occurs mostly on the barrier islands (Merritt Island and Cape Canaveral). Nearly all of this population occurs on Kennedy Space Center and Cape Canaveral Air Force Station. Congress established that primary purpose of these properties was to support the nation's space and military programs. Lands not directly being used by these programs are managed as Merritt Island National Wildlife Refuge and Canaveral National Seashore. Mechanisms exist to remove habitat from conservation when necessary to support the primary purpose of these properties. The commercialization of the space program has also led to a proposed investment by the State of Florida to extensively develop this area as the Nation's spaceport (http://www.yourspaceport.com/). The low topography of the barrier island populations and proximity to the Atlantic Ocean makes them vulnerable to hurricanes and changes in sea level (Breininger et al. 1996b, 1999a). Consequently, conservation cannot only rely on the federal properties to conserve Florida Scrub-Jay populations in east central Florida.

Figure 1. Florida Scrub-Jay Metapopulations (Stith 1999).



Caption 4. Extensively burned short scrub a few months after fire. These areas are temporarily unoccupied or are population sinks before becoming optimal.



It is has almost always been assumed that Florida Scrub-Jay populations are restricted to xeric oak scrub on well-drained soils (Woolfenden and Fitzpatrick 1984, 1991, 1996) and so conservation focuses almost entirely on this habitat (e.g., Swain et al. 1995, Stith et al. 1996, Root 1998, Stith 1999). Florida Scrub-Jays on Merritt Island often occur in pine flatwoods on poorly-drained soils (Breininger et al. 1991aa, 1995), and long-term studies identified that these Florida Scrub-Jays can have reproductive success that exceed mortality depending on the arrangements of shrub height (Breininger and Oddy 2001). We mapped Florida Scrub-Jay habitat using new criteria because we found that existing scrub maps did not explain the existing distribution of Florida Scrub-Jays. We mapped scrub from Volusia County south to Wabasso on the Atlantic Coastal Ridge and State Route 60 on the Ten Mile Ridge. We then reevaluated metapopulation structure.

4.1 Methods

Habitat Mapping and Modeling. Habitats features needed to evaluate habitat suitability and their associated uncertainties are described in detail elsewhere (e.g., Duncan et al. 1995, Breininger et al. 1998, Burgman et al. 2001). Here, we map habitat quality in broader categories and at less resolution than our previous NASA studies because the geographical extent precluded detailed mapping and we wanted to develop and test procedures that were more practical for land managers and planners to implement. These approaches have been successfully used to describe source-sink dynamics on Merritt Island (Breininger and Oddy 2001, Breininger and Carter 2003).

We obtained high resolution (1 meter) digital orthophoto quads (DOQs) for 1994 and 1999. The DOQs are available across the species range and provide consistent, convenient, high quality templates for managing and displaying spatial data using readily available software (e.g., ArcView) on most hardware and software platforms. Using the DOQs as templates provides a mechanism to view thematic layers with digital photography as a background and facilitates the development of techniques that can be used at scrub sites. All habitat maps were registered to DOQs. All Geographical Information Analyses (GIS) procedures used ARC/INFO files, and none were performed at survey level accuracy. Boundaries between different features were usually mapped within 1-10 meters of the actual location but could occasionally be 30 meters from the actual boundary. Our target minimum mapping unit was 0.4 ha (1 acre) but we often distinguished smaller features that were readily identified. We also viewed imagery from 1943 to evaluate habitat potential. Habitat potential was important to consider because many of today's forests were scrub and flatwoods that could be restored (Duncan et al. 1999). Historical aerial photography is also available across the species range.

Our ARC/INFO coverage's included the following attributes: (1) habitat type, (2) tree cover, (3) height, and (4) presence/absence of openings among scrub oaks. Habitat types included: scrub, ruderal grass, marsh, permanent forest, disturbed grass/shrubland, water, human cultural features, and unsuitable pasture (Table 1). Scrub included: oak scrub (> 50 % scrub oak cover), palmetto-oak scrub (5 – 49 % scrub oak cover), and palmetto scrub (< 5 % scrub oak cover; Table 2). Permanent forest included pine and hardwood forests that were present in 1943 or scrub that became forest and existed as disjunct landscape areas that did not justify restoration to scrub. Forests within disjunct landscapes comprised sites that probably would not be within a Scrub-Jay reserve and areas that probably would not be important to connect reserves. Forested scrub, which became forest by 1994 because of fire suppression and habitat fragmentation, could become suitable to Florida Scrub-Jays after restoration. Forested scrub was classified as scrub and not forest in the habitat layer and included areas with pine and oak canopies. Tree density classes included: savanna (< 15 % tree cover), woodland (15 - 65% tree cover), and forest (> 65% tree cover). Height mapping classes (Table 3) included: (1) short scrub (< 120 cm tall), (2) a mosaic of short (< 120 cm tall) and optimal scrub (120 - 170 cm tall), and (3) tall scrub (> 170 cm tall) which could have included all tall scrub and mixture of tall scrub and other height classes.

For 1994 habitat conditions, we aggregated scrub into potential reserve units (PRUs) comparable to "critical habitat polygons" used by Stith (1999) by excluding habitat fragments categorized as "suburban territories". PRUs were areas of oak or palmetto-oak that were contiguous or connected by mesic flatwoods or swale marshes that were large enough to support >1 Florida Scrub-Jay territory. We overlaid PRU boundaries on 1999 DOQs to digitize habitat destroyed by humans. We used the area of oak and palmetto-oak destroyed by humans between 1994 and 1999 to estimate the rate of habitat loss within PRUs.

Table 1. Definitions of habitat mapping categories.

Habitat type	Description
Scrub	Oak scrub and palmetto-lyonia with or without a interlocking tree canopy; potentially suitable Scrub-Jay habitat that includes areas forested today but were scrub in the 1943 landscape.
Ruderal grass	Bahia grass or open sandy areas with sparse vegetation <15 cm tall.
Marsh	Wetlands dominated by herbaceous vegetation.
Forest	Dense tree canopy not restorable to Scrub-Jay habitat; hammocks, swamps, and scrub with a dense tree canopy that are not adjacent to a potential reserve; native hammocks and swamps.
Disturbed grass/shrubland	Human disturbed areas with shrubs and grass such as pasture land that could be suitable.
Water	Lakes, ponds, and lagoon waters.
Human cultural features	Roads, buildings, and surrounding ruderal grass.
Unsuitable pasture	Pasture with no shrubs; trees sometimes present.

Table 2. Definitions of Florida Scrub-Jay habitat quality features within scrub polygons.

Feature	Description	Habitat Quality
Oak cover:		
Oak scrub	Scrub with > 50 % oak cover.	Optimal
Palmetto-oak	Palmetto-lyonia with 5 – 49 % oak cover.	Suboptimal
Palmetto	Palmetto-lyonia without oaks (< 5% oak cover).	Suboptimal
Open space:		
Present	Mosaic of open sandy areas among oaks.	Optimal
Absent	Continuous shrubs or dense grass > 15 cm tall	Suboptimal
Tree cover:		
Savanna	0 – 15 % tree canopy cover.	Optimal
Woodland	16 – 65 % tree canopy cover.	Suboptimal
Forest	> 65 % tree canopy cover.	Suboptimal
Height categories:		
Short	Large areas (> 10 ha) completely burned (< 120 cm tall) within the last 3 - 5 years.	Suboptimal
Optimal mosaic	Patches of scrub oaks at optimal height (120 – 170 cm) without patches of tall scrub (> 170 cm) greater than 0.4 ha.	Optimal
Tall	Tall scrub or a mosaic of other height categories that include tall scrub patches > 0.4 ha.	Suboptimal

Note: Tall scrub was distinguished into all tall and tall mix within territories that were subject to detailed demographic investigations.

Caption 5. Restored, occupied, optimal scrub that was an unoccupied sand pine forest 5 years previously because of fire suppression.

We became concerned that the areal extent of mapped features might not identify how Florida Scrub-Jays partition a landscape so that we created a potential territory model for the population. Territory boundaries rarely coincide with habitat features, except along open water (Breininger et al. 1995, 1998). This is a particular problem for Florida Scrub-Jays in coastal areas because habitat features are associated with geological process that formed long narrow ridges and swales (Breininger et al. 1991a). Florida Scrub-Jay territories are not long and linear and often cross several ridges and swales (Breininger et al. 1995). Although fires are influenced by vegetation type, fires also generally cross dozens of ridges and swales so that habitat quality variation is also more complex than evident from simple vegetation maps (Breininger et al. 2002). To represent potential population structure, we subdivided the Brevard County and Indian River County into a grid where each cell approximated the size of a territory. We then classified the habitat potential of each grid cell as a binary attribute based on whether or not it was likely to represent the approximate location of a territory in a landscape.

We restricted the potential number territories within a PRU to number expected based on the areal extent of oak and palmetto-oak divided by 10 ha, which we called MIN POP SIZE. For each PRU we began classifying the potential of a grid cell by coding cells as potential territories based on whether the intersected well-drained oak scrub. We used U.S. Department of Agriculture soils maps (Huckle et al. 1974, Wettstein et al. 1984) to define well-drained soils. We added an attribute that defined potential territories as primary, secondary, and tertiary based on scrub oak cover (Breininger and Oddy 2001). We identified primary territories as those that intersected xeric oak scrub (see Breininger and Oddy 2001). We then coded additional cells as potential territories based on whether they intersected oak scrub polygons that were at least 0.4 ha in size but did not occur on well-drained soils; we termed these secondary territories (see Breininger and Oddy 2001). We then identified tertiary territories by finding grids cells that had the most scrub oak cover (excluding primary or secondary territories already identified), until the total number of potential primary, secondary, and tertiary territories equaled MIN POP SIZE. We differentiated secondary and tertiary territories in the potential territory model and not the habitat map because it is difficult to map small patches of oak scrub (< 0.4 ha). It is much easier to classify a grid cell based on particular habitat attributes (i.e. the presence of $\geq$ 0.4 ha of scrub with $\geq$50% scrub oak cover) than to explicitly map scrub oak patches of varying size and scrub oak cover.

Related studies indicate that most primary and secondary territories are occupied when fires are frequent (Breininger and Oddy 2001, Breininger and Carter 2001). Occupancy of potential tertiary territories is usually low (Breininger et al. 1991a) although numbers can fluctuate greatly if there is high immigration (Breininger and Oddy 2001). PRUs might have been able to support more tertiary territories resulting in a larger potential population size than we modeled but occupation of many more additional tertiary territories than we modeled would probably occur only upon the most favorable circumstances. We intend to explore these possibilities further using spatially explicit population models. Florida Scrub-Jay territories also occurred outside the PRUs, especially in Palm Pay and Port St John. We identified cells outside of PRUs as potential territories if they were occupied. We assumed that the 2001-2002 number of suburban territories was the maximum likely and that population would never exceed this upper limit because of rapid urbanization and a long history of fire exclusion.

We also classified potential territories into three categories based on their context to human-dominated landscapes because of potential edge effects (Mumme et al. 2000, Bowman and Woolfenden 2001). “Core” territories were not adjacent to human housing or hard surface roads. “Reserve Edge” territories were within potential reserves and bordered human landscapes, but were not adjacent to hard surface roads. “Suburban territories” occurred within suburban areas or were adjacent to hard surface roads.

To incorporate fire history, we classified potential territories based on their habitat suitability related to tree cover (Table 2) and shrub height (Table 3). The shrub height criteria have been useful for quantifying source-sink dynamics and the progress of restoration (Breininger and Carter 2003). We classified potential territories as protected, proposed but not protected, and unprotected by overlaying grid cells on thematic layers from EELs, Florida Department of Environmental Protection, and The Florida Greenways project.

Table 3. Height classes of potential Florida Scrub-Jay territories.

Height class	Description	Minimum mapping units
Short.	Entire territory was < 120 cm tall.	No patch taller than 120 cm was > 0.13 ha.
Short/optimal mix.	Territory was a mix of short and optimal scrub (120 - 170 cm tall) and had no tall scrub (> 170 cm tall).	At least 1 patch of optimal scrub was > 0.13 ha and at least 1 patch of short scrub was > 0.4 ha. No patch of tall scrub was > 0.4 ha.
Tall mix.	Territory was mix of tall scrub and short and/or optimal scrub.	At least 1 patch of tall scrub was > 0.4 ha. At least 1 patch of short or optimal scrub was > 0.4 ha acre.
Tall.	Entire territory was > 170 cm tall.	No scrub < 170 cm tall was > 0.4 ha.

Adapted from Breininger and Carter (2003).

Florida Scrub-Jay population surveys and analyses. We regularly surveyed areas within the 1992 polygons (Stith et al. 1996) and other known locations of jays to identify dispersals of colorbanded jays from the regularly censused demographic study areas (Chapter 5.0). In South Brevard County, surveys additional to the demographic study tracts were performed at least 1x per year since 1998. In other areas of Brevard County, these surveys were performed at least 1x per year between 2000 and 2002. Indian River County initiated a Sebastian Area-Wide Habitat Conservation Plan (Sebastian HCP) that provided habitat studies and Florida Scrub-Jay surveys (Smith Environmental Services 1999). Much of the demography data used to prepare the Sebastian HCP resulted from almost a decade of colorbanding by Toland (unpublished). Brevard County Natural Resource Management Office (2002) began new surveys to update the Scrub-Jay database. We also exchanged data with many environmental consultants and agency personnel. These exchanges provide additional opportunities to find new jay locations and dispersals given that large numbers of environmental assessments are being performed. The few areas not surveyed included some areas north of the Buck Lake Conservation Area, scrub west of Fox Lake, scrub north of the Micco Scrub Reserve, the Atlantic Coastal Ridge south of the Wabasso Scrub Sanctuary and the Ten Mile Ridge south of Sebastian Buffer Reserve. We estimated that the areas surveyed during 2000-2002 approached 85% of the potential territories.

We compared 1992 data (Swain et al. 1995, Stith et al. 1996, Root 1998) with 2002 data within areas that we described as “potential territory clusters” rather than the 1992 polygons because habitats changed since 1992 and the 1992 polygons did not represent any defined population structure. We described potential territory clusters as areas of contiguous suitable habitat occupied by Florida Scrub-Jays. The approach to define potential territory clusters began using the 1992 habitat polygons and subsequent locations of known territories and then extended outward into suitable habitat even if habitat occupancy was unknown. Suitable habitat included suitable oak and palmetto-oak scrub within open landscapes that lacked interlocking tree canopies. We assumed that suitable habitat was better for defining potential population structure than "occupied habitat" because it is difficult to define occupied habitat in fragmented landscapes during brief intervals of time (i.e., months) and because territory boundaries frequently change. Contiguity referred to suitable oak and palmetto oak patches not greater than 2 territory widths but connected by suitable matrix habitat. Suitable matrix included palmetto-lyonia, maintained grass, open sand, and marshes. These are often defended by Florida Scrub-Jays and occur within territory boundaries (Breininger et al. 1995, 1998). Potential territory clusters were generally comparable to polygons used to identify territories during the 1992 surveys (Swain et al. 1995, Stith et al. 1996, Root 1998) except that many previous polygons were combined because of their close proximity. We performed most of the 1992 surveys and knew that their boundaries did not represent population structure but represented boundaries associated with sampling logistics.

To describe potential subpopulation and population structure, we used 3 conservation protection scenarios that ranged from most favorable to least favorable. The middle scenario that probably best represented existing structure was produced by buffering territory cluster boundaries by 2.9 km to define separate subpopulations (Stith et al. 1996). We used a 6.0 km buffer from territory cluster boundaries to identify potential metapopulations (Stith et al. 1996). This slightly differs from Stith et al. (1996) because we did not use actual territory approximations. We argue, however, that territories are not stable because of habitat and population dynamics and it is difficult to define exact territory boundaries in areas below carrying capacity. The most favorable scenario used the same buffers to define subpopulations and metapopulations except that buffers were applied to PRUs and not territory clusters. This scenario assumed that most PRUs would be protected and restored and that jays would have re-colonized several fragments that were no longer occupied. The least favorable assumed that the only PRUs that would be protected would be those that already have some habitat already acquired for conservation. It also assumes that all remaining habitat would be destroyed because of current rapid urbanization. We believed all scenarios were plausible.