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silviculture

Sand Pine and Florida Scrub-Jays—An Example of Integrated Adaptive Management in a Rare Ecosystem

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Within the environment of semitropical central Florida emerges a confluence of two management needs between sand pine (*Pinus clausa*) and the Florida scrub-jay (*Aphelocoma coerulescens*). Each is a unique species adapted to extremely xeric scrub sites and commonly found on the Ocala National Forest. Since the 1940s, sand pine has been successfully regenerated after timber harvest within the constraints of managing for a low-value product on a poor site. In 1987, the Florida scrub-jay was designated federally threatened, and a recovery plan was developed in 1990 by the US Fish and Wildlife Service (USFWS). Managers on the Ocala National Forest began to adapt sand pine management to accommodate habitat needs of the Florida scrub-jay. In recent years, scrub-jay habitat statewide has declined further and as the USFWS develops a revision to the 1990 Recovery Plan, National Forest managers are evaluating new management schemes to best provide scrub-jay habitat yet still manage sand pine.

Keywords: sand pine, Florida scrub-jay, silviculture, recovery, Ocala National Forest

Within the smallest ecoregion in North America known as "scrub," silviculturists and wildlife biologists have worked together over the past 30 years to develop a successful strategy that benefits and perpetuates two endemic species, the sand pine (*Pinus clausa*) and the Florida scrub-jay (*Aphelocoma coerulescens*). Located in the semitropical area of central Florida, sand pine (SAF Forest Cover type 69) silvics and Florida scrub-jay biology are both unique stories. However, the overall story of using careful scientific study and monitoring to feed a synergetic collaboration between resource managers and cooperation with an informed public is commonly seen throughout the natural resource profession.

The Setting

The Ocala National Forest (ONF) was established as a national forest in 1908 (Figure 1) . At that time the National Forest was only about half the current size and was typed 98% sand pine scrub. Unlike most eastern national forests, the original ONF had never been logged or farmed (Hill 1916) as the land was extremely droughty with sandy soils and sand pine, the primary forest cover, had no known commercial use at the time. W.F. Hill, an early forester on the ONF, described the agricultural value of the newly created National Forest by stating that "this 'Great Scrub' area can safely and rightfully be said to contain no agricultural value whatever, either present or potential" (Hill 1916).

The ONF today has approximately 220,000 of its total 383,000 acres classified as the sand pine scrub natural community (Florida Natural Areas Inventory 2010). This ecosystem occurs atop ancient sand ridges that are remnants of Plio-Pleistocene shorelines (Myers 1990), and the ONF contains the world's largest unbroken expanse of sand pine scrub habitat. The ONF is located in north-central Florida where climate is semitropical. Although rainfall averages slightly greater than 50 in./year (National Oceanic and Atmospheric Administration 2015), the droughty, infertile soils underlying the scrub do not allow plants time to use nutrients from these relatively high rainfall levels. Many scrub plants exhibit adaptations such as waxy leaves and extensive belowground root systems more often seen in desert regions. Soils of the scrub have no or very low proportions of clay, silt, and organic matter (Heuberger et al. 1996), causing their low fertility.

Sand Pine

Commercial sand pine harvesting started in the 1940s, and the ONF currently harvests about 2,500 to 3,000 acres of sand pine per year. Besides being a pine that

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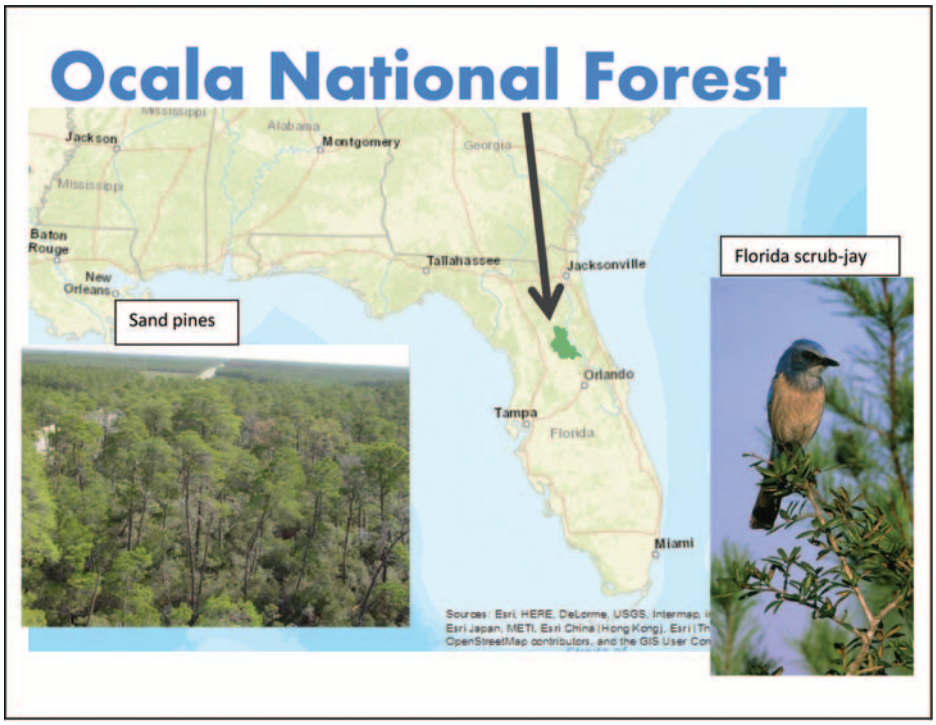

Figure 1. Location of the ONF in north-central Florida. (Photos by Janet Hinchee 2003 and John Puschock 2003.)

occurs almost entirely in Florida (Brendemuehl 1990), sand pine is also a species uniquely adapted to the harsh environment of the scrub. A fast-growing tree in its early years, young sand pines produce cones as early as 5 years old (Brendemuehl 1990). The Ocala geographic race (var. clausa) of sand pine produces an abundant cone crop every year but most cones are serotinous and are retained unopened on the tree until a high heat event such as fire occurs (Brendemuehl 1990). Cones may also open when lying on the ground after a timber harvest when heating from the soil surface is high enough to open them, except in the winter months. Sand pine is relatively short-lived, and root disease, heartrot, and windthrow restrict the age of a sand pine to usually less than 65 years. With such early cone production and the serotinous nature of cones being tied to a high heat event, natural regeneration of sand pine occurs after almost every wildfire event (Cooper 1959). Fire in the sand pine scrub is infrequent by southeastern US standards, occurring every 20–60 years. These infrequent fires burn with high intensity, usually as crown fires, killing most sand pines on the site while burning back all other vegetation to ground level. A recently burned scrub site is a blackened landscape of stems, ash, and bare ground. By reducing vegetative competition back to ground level, consuming surface litter, and exposing bare mineral soil, a fire creates an ideal site for seed to germinate. This perfect seedbed catches up to 1 million sand pine seeds per acre (Cooper 1959) from the now-opened sand pine cones as it literally "rains seeds" for several weeks after the wildfire. Vigorous, dense stands of sand pine are the typical result of a wildfire, but it is not a management choice for regeneration as all timber is burned up and the high-intensity wildfires pose tremendous risks to human life, homes, and property.

In lieu of damaging wildfire, artificial regeneration techniques were developed, although on the surface these techniques look like a version of "Sand Pine Silviculture for Dummies":

Step 1: Harvest by clearcut
Step 2: Prepare site with rolling drum choppers
Step 3: Direct seed
Step 4: Watch it grow for 35–55 years
Step 5: Repeat Step 1

The economics of sand pine as a timber product drives this fairly simple silviculture system. The characteristic crooked, branchy appearance of sand pines growing on infertile, sandy soils limits the uses of the wood to the pulpwood market. Although pulpwood may be harvested on industrial lands when trees are 15–25 years old, sand pine is not harvested until around age 35–55, which is considered a relatively long growth period compared to those of other southern pine species. The longer it takes to grow a relatively low-value product, in this case pulpwood, the lower the reforestation costs need to be for the economics to be profitable or in the case of national forests, for harvesting costs not to exceed costs of reforestation. Seeding is used to reforest sand pine on the ONF because it is much cheaper than planting. Seeding, however, requires a clean seedbed, making site preparation not only a critical step but also the most expensive step. The most cost-effective method is using large tractors to pull rolling drum choppers, which are large metal drums with longitudinally mounted blades. This site preparation

Management and Policy Implications

1. Collaboration between resource managers was a key element in developing a management plan that has multiple resource objectives and treatments. In this case, resource managers representing wildlife biology, fire management, timber management, and silviculture were the interdisciplinary team that developed the new management plan.
2. Understanding the past resource management history of the ONF was important in developing a new plan so that successful activities and treatments were retained in the new plan and unsuccessful activities and treatments were not repeated.
3. By informing and consulting with the public all along the way to project development, the final plan was better accepted and fewer negative comments during the formal public involvement process were received.
4. Federal and state biologists monitored scrub-jay populations beginning shortly after the species was federally listed as threatened in 1987 and provided important data to evaluate past treatments and propose new ones.
5. In the past, resource managers developed one timber management plan that attempted to modify treatments and techniques to provide habitat needs for multiple species. However, as we honestly evaluated the current needs of Florida scrub-jays and the effects on habitat from past timber management, we needed to separate the management plan into different areas to best manage for scrub-jays.

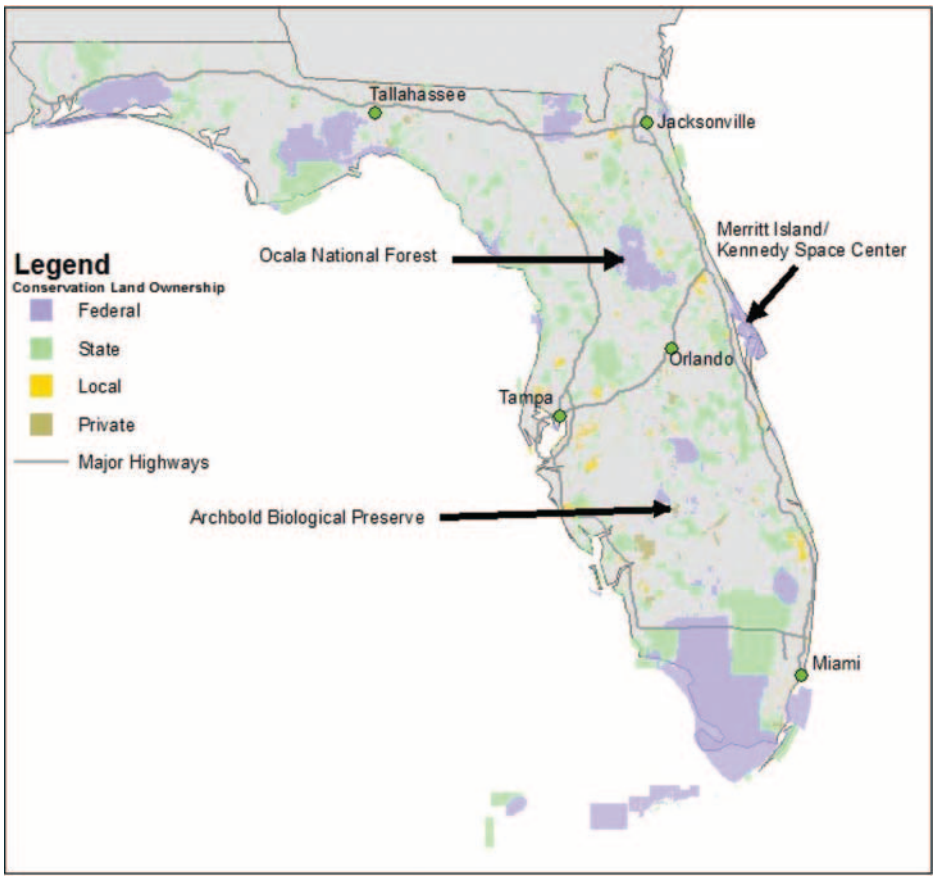

Figure 2. Location of the largest populations of Florida scrub-jays.

method both controls the amount of woody brush that would regenerate after logging and creates bare ground for seedbeds.

History of Sand Pine Management

From 1908 until the 1930s, there was no management or timber harvest in the sand pine forest as there was no use for the wood. In the 1920s, early foresters tried established growth trials (Hill 1916) to see if any other pine would grow in the scrub ecosystem but no species passed the trials. Then in 1932 and 1933, the discovery that useable sulfate pulp could be obtained from sand pine was made (Cooper 1959). US Department of Agriculture (USDA) Forest Service researchers began to develop sustainable harvest systems and regeneration techniques for sand pine, and in 1941 the first commercial timber sale was carried out on the ONF (Cooper 1959). Until 1950, demand for sand pine timber was low (Riebold 1961), and timber harvesting proceeded on a small scale while regeneration studies continued.

These more formal studies of the 1950s culminated in the publication of the booklet, "Sand Pine Regeneration" by Robert Cooper, which laid out sound silvicultural techniques for establishing sand pine regeneration after harvesting. Timber harvesting accelerated in the 1960s and clearcuts in the 1966 Timber Management Plan called for cutting units 320–640 acres in size (Dubow 1966). The Multiple Use Act of 1960 required the Forest Service to manage for other resources besides timber, including wildlife. White-tailed deer was the primary wildlife species considered. Although large clearcuts of the 1960s and early 1970s were considered acceptable for deer habitat, by the late 1970s, concerns about deer habitat reduced clearcut size down to 20–100 acres (O'Keefe 1978).

In 1987, when the Florida scrub-jay, a scrub endemic, was listed as a federally threatened species (US Fish and Wildlife Service [USFWS] 1990), sand pine management was reexamined for impacts on that species and wildlife habitat coordination changed from deer, a species that thrived on small openings with lots of edge, to scrub-jays, an early successional species that required large blocky openings. Consequently, the sand pine management system of the prior 30 years needed significant changes with the shift in wildlife management focus.

Florida Scrub-Jays

The Florida scrub-jay is endemic to Florida and restricted to the scrub ecosystems found on ancient sand ridges along the center of the state and maritime scrubs on the coast. The Florida scrub-jay is similar in size and shape to the more common blue jay but has a different color pattern and lacks a crest (Figure 1). Florida scrub-jays exhibit cooperative breeding, a social system in which a breeding pair is assisted in rearing young by offspring in previous seasons (i.e., "helpers"). The presence of helpers improves fledgling success (Mumme 1992). Major populations (>100 groups) only exist on the ONF, the coastal scrubs of Merritt Island/Kennedy Space Center, and the Archbold Biological Station in south-central Florida (Figure 2). The majority of research done on Florida scrub-jay biology has originated from the latter two populations, where long-term (20+ years) studies have been conducted.

Suitable Florida scrub-jay habitat is generally characterized by shrub layer heights ranging from 1 to 3 m (3.2–9.8 ft.) tall, numerous patches of open bare ground, and low levels (<20% cover) of pine cover (Woolfenden and Fitzpatrick 1984, Fitzpatrick et al. 1991). Scattered patches of bare ground are an important habitat component providing areas to cache acorns and hunt lizards and other small prey (USFWS 1990). Tall, dense scrub lacking the characteristics described above are associated with decreased fledgling survival, yearling production, and Florida scrub-jay densities (Woolfenden and Fitzpatrick 1984, Breininger et al. 1998). On the ONF, a shrub height of 3 m roughly translates to stands 12 years of age or younger. Scrub oaks, like sand pines, are early fruit producers and start producing acorns, an important scrub-jay food, as early as 2–3 years of age. Sand pines less than 12 feet high are tolerated by scrub-jays in very low densities, but higher densities can lower habitat quality. Florida scrub-jays prefer a minimum of edge along occupied openings, a minimum of snags within their openings as taller trees hide hawks which prey on scrub-jays, and sand pine cover at less than 20% (Breininger et al. 1995). As the shrub layer (including oaks and pines) approaches 10 feet in height, scrub-jays may persist for short periods but often move on to neighboring suitable habitat as soon as it becomes available. In general, scrub-

jays persist in early successional scrub communities that are relatively large or in close proximity to other scrub communities. Thus, high-quality or optimal habitat will be in early succession and either large in size or close to adjacent young scrub habitat patches (USFWS 1990).

Historically, the infrequent lightning-generated fires on the landscape were the mechanism that created new scrub-jay habitat. Though the natural occurrence of fires varied from 5 to 60 years statewide, the Ocala scrub probably burned on the less frequent side, every 20 to 60 years. In today's managed forests, new habitat is created by prescribed fires, mechanical treatments, or by timber harvesting.

The most recent surveys for Florida scrub-jays on the ONF were conducted in 2012–2014 and yielded estimates of 1,100-1,250 groups, which translates into approximately 2,530–2,875 individuals if an average observed group size of 2.3 birds per group is extrapolated to the entire population (Miller et al. 2015). These surveys were conducted entirely within an area that was managed for sand pine timber. The Florida scrub-jay population on the ONF has not been as thoroughly surveyed as the other two major populations because of the vast amount of potential habitat present and the infeasibility of conducting statistically robust surveys.

Recovery Plan—Part 1, 1990

The Florida scrub-jay was listed as threatened by the USFWS in 1987 in response to habitat degradation and habitat fragmentation across Florida. Habitat loss from development and habitat degradation from fire suppression caused an estimated 50% decline in the Florida scrub-jay population over the last century (USFWS 1990). As part of the Endangered Species Act, each species has an associated recovery plan. Recovery plans are nonregulatory documents that "delineate reasonable actions which are believed to be required to recover and/or protect the species" (USFWS 1990).

Under the Endangered Species Act of 1973, the Forest Service on the ONF must ensure that no activities are jeopardizing the continued survival of the Florida scrub-jay as a species. The ONF sand pine timber program was reviewed, and the USFWS acknowledged that the regular timber harvesting of the sand pine management program created new scrub-jay habitat every year and replaced habitat that was becoming unsuitable. USFWS recognized timber harvesting as a management strategy and the first Recovery Plan listed periodic timber harvest and regeneration of sand pine as an accepted management practice (USFWS 1990). When the National Forests in Florida prepared a new Land and Resource Management Plan, also known as a Forest Plan, in the late 1990s, sand pine management was modified to better combine scrub-jay habitat with sand pine management. Modifications included increasing the maximum size of clearcuts to 160 and 320 acres, emphasizing prescribed burning after harvesting, and implementing scrub-jay monitoring plans. After the new Forest Plan was implemented in 1999, the management goal in most of the scrub was to produce pine pulpwood under conditions that balance efficient timber production practices with practices that promote the growth and perpetuation of species native to the Big Scrub area within the ONF (USDA Forest Service 1999).

The 1999 Forest Plan for ONF set an objective that 45,000–55,000 acres of 3- to 15-year-old sand pine scrub would be available as potential habitat for scrub-jays in any given year. To accomplish this objective, the Forest Plan set a harvesting goal of 4,000 acres/year to meet the scrub-jay habitat objective (USDA Forest Service 1999). The approach was to create scrub-jay habitat through an aggressive timber sale program using silviculture techniques that would also produce the vegetative characteristics associated with higher Florida scrub-jay habitat quality in other scrub ecosystems. The goal of the plan was to harvest enough sand pine annually to produce enough early successional scrub to support a stable population of Florida scrub-jays.

Within this overall goal, additional modifications were made as timber managers and wildlife biologists worked together and scrub-jay monitoring was implemented. As a result of local manager collaboration:

- Clearcuts were designed with minimum edge.
- Clearcuts were planned adjacent to existing occupied habitat to shorten dispersal distances for scrub-jays leaving degrading habitat.
- Habitat variability within forest stands was increased by leaving numerous small areas untreated by rolling drum choppers during site preparation activities.
- Seeding was changed from broadcast seeding to spot seeding to reduce the frequency of overstocked sand pine stands. Overstocked stands shortened the length of time that scrub stands were occupied by scrub-jays.

Although USFWS was comfortable with the Forest's timber harvesting program as the primary method of maintaining scrub-jays on the ONF, they requested that the forest managers consider setting aside some areas where scrub-jays would be the management focus. In these "Scrub-Jay Management Areas," timber harvest could be used to set back succession, but sand pine could not be purposely regenerated. Fire and/or mechanical treatments could be used for subsequent treatments when the scrub has grown too tall and dense. In the initial Forest Plan, just one 1,870-acre unit was designated.

Later amendments to the Forest Plan expanded scrub-jay management by adding a second Scrub-Jay Management Area of 1,000 acres. In the timber-managed scrub, maximum clearcut size was increased to 800 acres. Finally, based on monitoring data, the defined age range in which scrub habitat was considered suitable for Florida scrub-jays was shortened to 3–12 years of age from the previous 3- to 15-year age range.

Recovery Plan—Part 2, 2015

Beginning in 2014 and 2015, the Florida scrub-jay Recovery Plan was reexamined by the USFWS. Part of the process was to look at the current status of the scrub-jay in Florida, assess the importance of the ONF's scrub-jay habitat to the statewide habitat distribution, and evaluate the effects of sand pine management since 1990 on scrub-jay habitat. The USFWS estimated the total number of scrub-jays to be between 7,757 and 9,382, similar to numbers reported in 1986 (USFWS 1990). Approximately one-third of the groups reported in 2015 were attributed to the ONF. Aside from the other two major populations described above, much of the remaining scrub-jay populations statewide were small in number and isolated from each other. Extinction models suggest that scrub-jay populations beginning at a level of 100 groups were robust enough to survive potential catastrophes and poor habitat quality (Breininger et al. 1999). An unpublished 2011 statewide assessment of scrub-jays on managed lands found only three populations in Florida had over 100 groups (the ONF was not part of this assessment). In the surveys discussed above, the ONF population was conservatively estimated to have 1,100 groups, highlighting the importance of the ONF's population to the recovery of the species. Studies have

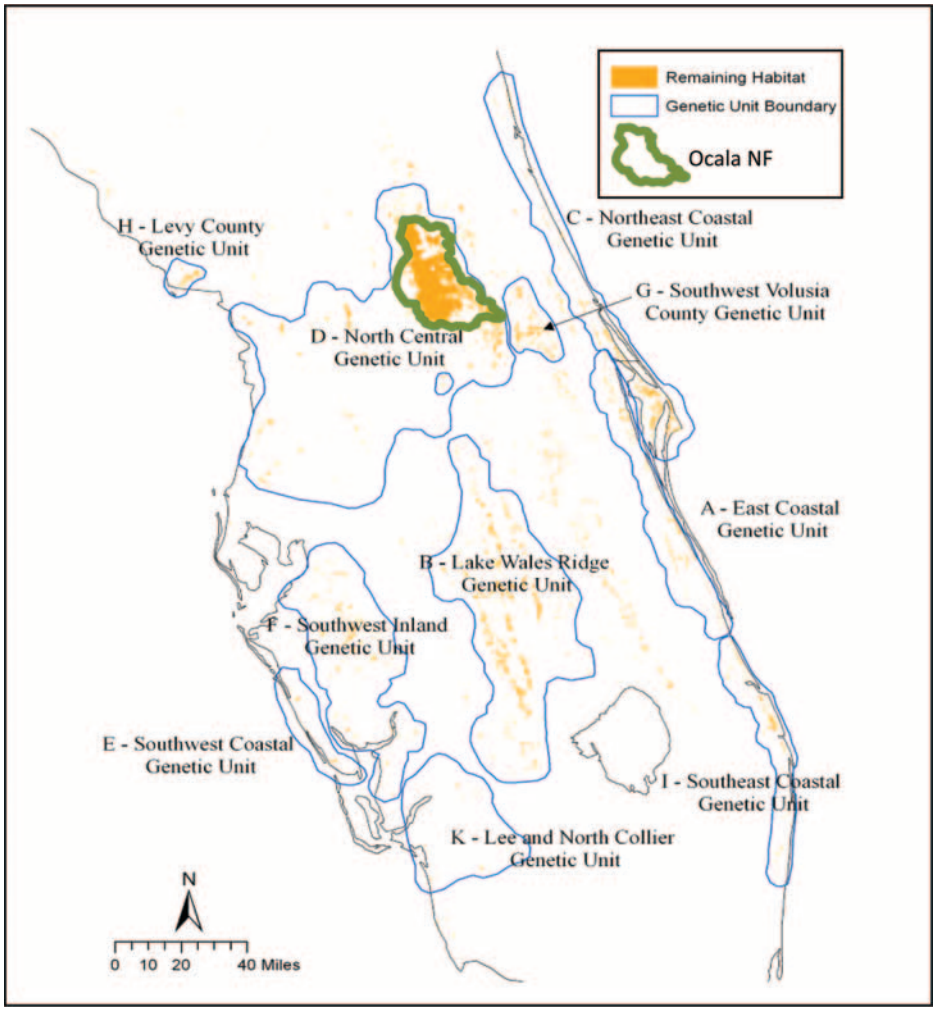

Figure 3. Map showing remaining scrub-jay habitat by genetic units. The amount of remaining habitat on the ONF illustrates the importance of the national forest to scrub-jay populations in Florida. (Adapted from Coulon et al. and Stith 1999.)

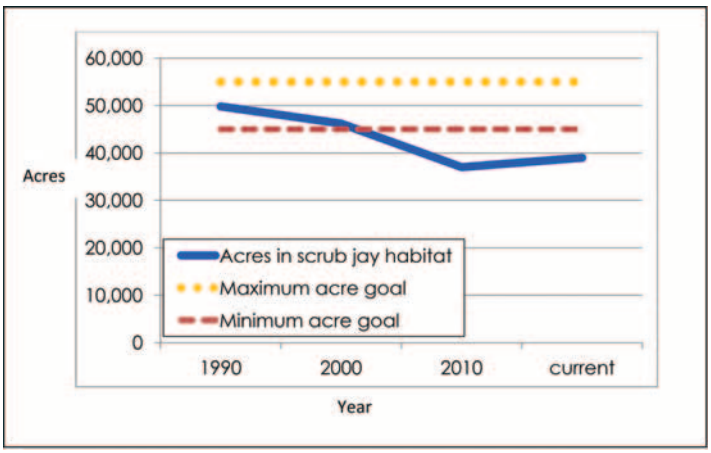

Figure 4. Estimated habitat (acres) for Florida scrub-jay (FSJ) 1990–2015 on the ONF compared to targets (minimum and maximum) set in the 1999 Forest Plan. (Graph source: Janet Hinchee, 2015.)

mapped genetic units or metapopulations established through study of scrub-jay DNA and by spatial models based on dispersal probabilities across the landscape (Figure 3).

As indicated in Figure 3, the amount of potential habitat on the ONF also represents a significant portion of potential scrub-jay habitat statewide. The ONF's status as federal property eliminates the potential for loss by real estate development, and, therefore, the ONF represents most of the future potential in addition to being a significant part of the currently existing populations of scrub-jays.

As the USFWS and the Scrub-jay Recovery Team evaluated past (since 1990) management activities on the ONF, it was clear many changes made have improved scrub-jay habitat, whereas other goals seemed unfulfilled. The improvements were as follows:

1. Fewer overly dense (>1,000 per acre) sand pine stands within the 3- to 12-year age range, resulting from changes to the sand pine seeding operation.
2. Timber harvesting and subsequent sand pine regeneration still provided oak cover at a level associated with scrub-jay habitat suitability in the sand pine understory.
3. Modifications to the rolling drum chopping technique, the standard site preparation method, yielded vegetative conditions associated with higher scrub-jay habitat quality. These chopping modifications are now being used on other public land being managed for Florida scrub-jays.

However, problems in scrub-jay management on the ONF still existed, including shortfalls in habitat creation through sand pine harvest. For several years, the Forest Service was not meeting the annual harvesting goals stated in the 1999 Forest Plan that were directly related to the scrub-jay habitat goal. The graph in Figure 4 shows how this deficit has progressed (Figure 4). Consolidation of timber programs on the ONF and decreased funding for the timber sale program resulted in decreased staffing and lowered capacity to carry out the Forest Plan goals with regard to acres of sand pine harvested per year.

Besides this shortfall in habitat quantity, habitat quality concerns were present as well. Stands seeded with sand pine yielded young stands with overly dense (≥1,000 per acre) sand pine, which, in turn, yielded stand conditions typically identified as poor for the scrub-jay. High sand pine seedling densities shade out oaks at an earlier age, reducing the amount of time a stand is suitable scrub-jay habitat after harvesting. A stand is typically suitable for scrub-jays at 3 to 12 years of age, but if the sand pine stand is overly dense, it can become unsuitable at 9–10 years of age. As stated previously, the economics of managing a low-value product on poor sites dictates that reforestation costs

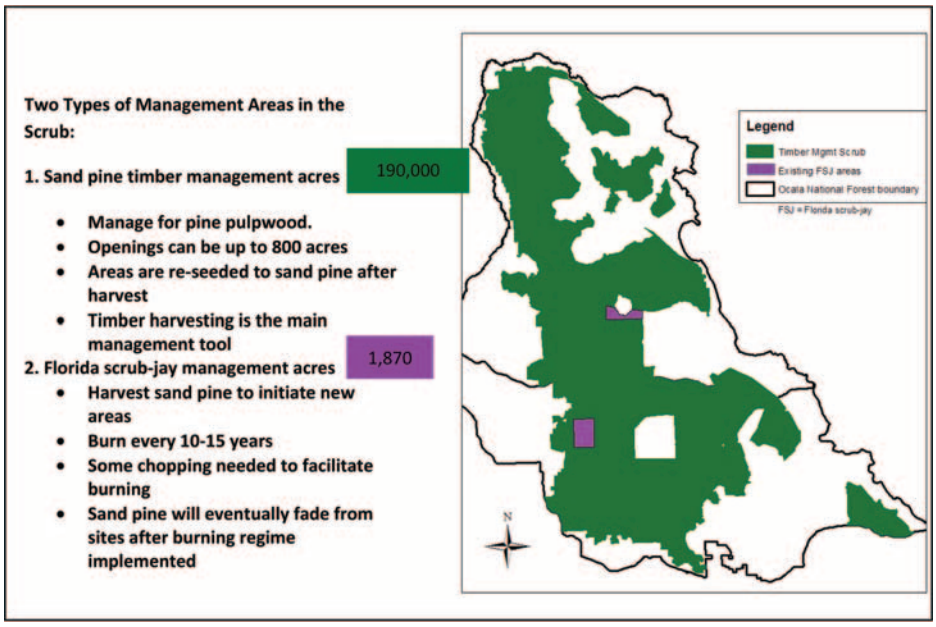

Figure 5. The present allocation of scrub acres to the two different management areas and a brief summary of how each area is managed. (Source: USDA Forest Service Management Area Dataset 2015.)

be kept low, and seeding (versus planting) is essential to keeping costs low. However, control of the number of established seedlings per acre is difficult because the eventual seedlings per acre on a seeded site is heavily influenced by weather occurring after seeding (particularly abundant late winter or spring rain), which can be highly variable and therefore can yield highly variable sand pine densities from year to year. To minimize the chances of seeding failure, stocking rates are set slightly high, and thus in 3 or 4 years out of 10, the stocking will be higher than desired relative to scrub-jay habitat. The shift from broadcast seeding to spot seeding in the early 1990s certainly improved the situation, but in years with abundant late winter/spring rainfall, the result is almost always overly dense stands. High numbers of sand pines shade out the oaks at an earlier age, reducing the amount of time a stand is suitable scrub-jay habitat after harvesting.

Another habitat quality problem noted is the lack of prescribed burning to treat stands after harvest both in timber management areas and in the scrub-jay management areas.

Overall, the informal evaluation of sand pine management on the ONF and its effect on scrub-jay habitat yielded several conclusions. First, the ONF possesses a Florida scrub-jay population with a high probability of persistence. Second, improvements in habitat quality have been made by modifying sand pine silviculture treatments. However, in light of the continued decline of Florida scrub-jays in the rest of the state and the subsequent increased importance of the ONF population to the future of the species, a new approach was needed to better address the management of the Florida scrub-jay population on the ONF.

Through an interdisciplinary team representing timber management, silviculture, wildlife biology, and fire management, the Forest Service has proposed to significantly increase the number of scrub acres being managed as scrub-jay management areas. The present allocation is 190,000 acres managed for sand pine timber and 1,870 acres managed for scrub-jays (Figure 5). Although sand pine timber areas also are managed for scrub-jays and provide some proportion of their habitat, scrub-jay areas do not provide sand pine for timber purposes, although stands may be harvested if sand pine is present. The proposed reallocation of acres between the two management areas changes acres from sand pine timber management to scrub-jay management, increasing scrub-jay management areas from 1,870 acres to about 48,000 acres (Figure 6).

New scrub-jay management areas were selected by first redefining what characteristics make the best scrub-jay management areas. The scrub-jay biologist recommended areas to be at least 1,000 acres in size and include areas that represent variations of scrub that occur on the ONF. For example, ONF has both "white sand" scrub and "yellow sand" scrub described as distinctly different soil types and occupying somewhat different parts of the landscape. Proposed new scrub-jay areas represent both soil variations. Fire managers recommended that the areas have characteristics that would enhance the ability to prescribe burn them regularly and in a cost-effective manner. Consequently, new areas are blocky in shape, bounded by existing firebreaks, and not adjacent to primary highways. Scrub-jay areas, both proposed and existing, would be harvested for operable sand pine and then mechanically treated and/or prescribe burned as needed to create suitable scrub-jay habitat. As habitat becomes unsuitable (i.e., when average scrub height approaches 10 feet), areas would be primarily treated with fire although some mechanical treatment may be needed to facilitate the burning or, in a few cases, substitute for burning where smoke management issues or urban interface problems preclude burning.

After designating proposed areas, silviculture and timber staff developed a model using reasonable harvest levels to simulate the effect on scrub-jay habitat during and after implementation. A projected implementation plan to not only meet but also exceed scrub-jay habitat goals from the 1999 Forest Plan was modeled and confirmed (Table 1). Habitat quality should also be increased as reduction of sand pines and increased burning would eliminate the two major habitat quality problems of the past 25 years. The final result of the proposal would hopefully be a corresponding increase in the scrub-jay population on the ONF. The process of drafting the proposed changes on the ONF (through a Forest Plan amendment) and the new Florida scrub-jay Recovery Plan is ongoing at the time of the drafting of this document.

Conclusion

Staff on the ONF and from the USFWS and the public are encouraged that the plan to increase scrub-jay management areas on the ONF will potentially help in recovery of the population of Florida scrub-jays. Besides scrub-jays, sand pine, another unique and tenacious scrub species, will continue to be managed and perpetuated on the ONF. The sand

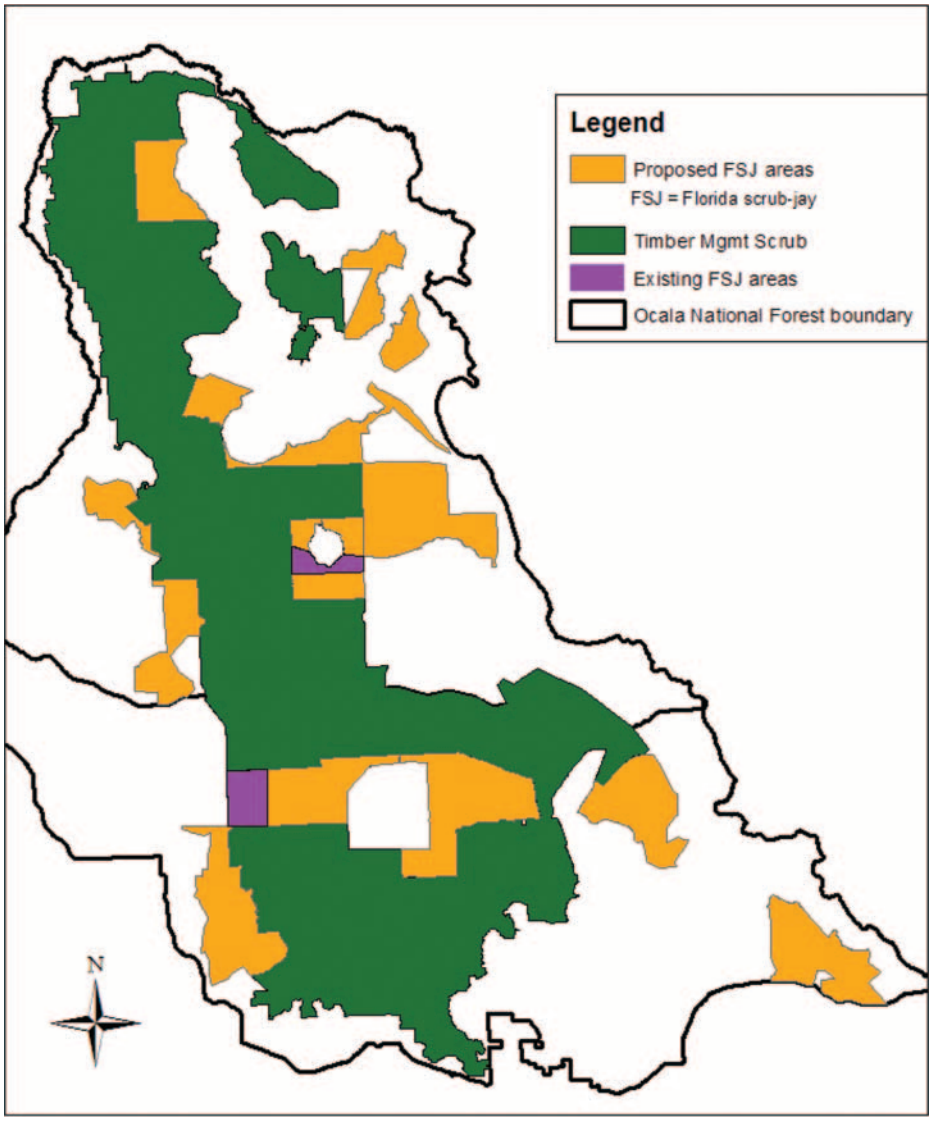

Figure 6. Map of ONF showing the management area allocated to timber versus area managed for scrub-jays, both existing and planned. Florida Scrub-Jay (FSJ) Management Areas would increase from 1,870 acres to about 48,000 acres.

Table 1
Results over time of implementing the new proposal on the acres of total potential scrub-jay habitat.

Time into project	Scrub jay habitat in: Scrub-jay management areas	Sand pine timber management areas	Bonus areas[a]	Total potential scrub jay habitat
	(acres)			
Current	6,000	20,500	13,000	39,500
Year 8	23,500	20,000	12,000	55,500
Year 15	41,700	20,000	12,000	73,700
After full implementation	48,000	20,000	12,000	80,000 potentially; 68,000 conservatively

[a] Bonus areas are areas with management goals other than scrub jays that are still providing significant scrub jay habitat. Examples are the Juniper Wilderness Area, the Navy Bombing Range, and scenic areas.

pine story is a classic silviculture success story as current and past methods of management are adapted to meet new objectives.

This requires the following:
- To work with other resource disciplines
- To practice adaptive management
- To closely monitor our new management schemes

In practicing silviculture, the silvics of the trees stays the same but the ever-changing, increasingly complex management environment of today makes the practice of silviculture truly a blend of the science of silvics and the art of balancing management objectives.

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