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<u>SUMMARY OF TEXT & PURPOSE FOR THE PPG</u>:

This document provides management guidelines for the restoration and management of oak and rosemary scrub habitats in peninsular Florida, defined as the mainland south of an imaginary line from Cedar Key to Jacksonville. These guidelines do not address management of scrub in the panhandle, which differs from that in the peninsular scrub. If followed, these guidelines should benefit most peninsular scrub plant and animal species. Conserving the full suite of species characteristic of scrub requires (1) understanding how a property fits into the regional context for different species and (2) managing for spatial and temporal variability at the local level to create a mosaic of habitat conditions.

In oak scrub, managing in a way that benefits the Florida scrub-jay benefits much of scrub-specialized plants and animals, which require a patchy mosaic of low vegetation and open patches of bare sand. In addition to providing habitat management guidelines targeted at Florida scrub-jays, this document contains species-specific management recommendations for state and federally listed species and species of conservation concern. By managing for heterogeneity at local and regional scales, the habitat needs of the complete suite of scrub species can be met, even though the needs of some species are not perfectly aligned with those of the Florida scrub-jay.

Rosemary scrub contains many endemic species and requires longer fire-return intervals than oak scrub. Many of these species respond positively to fire but can be eliminated if fire is too frequent. Land managers should be mindful of the different fire regimes for rosemary and oak scrubs.

In recent times, most scrub in Florida has experienced fire exclusion or unnaturally rare fire regimes. Restoration of scrub habitats to a condition most beneficial to scrub plants and animals will require re-establishment of the natural fire regime. In some instances, mechanical treatment may be required to restore or maintain scrub. These treatments should be applied in ways that minimize soil disturbance and reduce the possibility of introducing invasive or exotic species. Additionally, these treatments should be followed by fire as soon as is feasible. Although mechanical treatments can mimic some of the structural effects of fire, they are not an ecological substitute for it.

By varying the season, frequency, and spatial extent of burns, land managers can create diverse landscapes, containing a mosaic of habitat types and conditions. This variation will meet the needs of the full suite of scrub species. We recommend that land managers determine when to burn based on vegetation height rather than fixed fire-return intervals because response to fire varies across the peninsula. Maintaining mosaics within sites is also important, and extensive, complete burns should be avoided when possible.

These guidelines are intended to provide information that if implemented will improve the management of scrub to benefit the associated species. Monitoring species' response to the treatments recommended in the guidelines is the only way to determine if these treatments are having the desired effect. We encourage managers to evaluate if management actions are achieving their objectives and to revise management plans based on these evaluations.

FULL TEXT:

INTRODUCTION

The intent of this document is to provide general guidance for the management of wildlife and plants characteristic of scrub habitats in peninsular Florida. Adherence to these guidelines does not constitute an authorization for take of state or federally listed species. Conserving the full suite of species in scrub requires planning at both local and regional levels. At the local level, the first step in scrub management involves identifying species of conservation concern on a property and setting management objectives and strategies based on the needs of those species. When setting objectives, it is important to consider how a given property fits into the larger, regional context for each species of conservation concern. For example, some areas may not be large enough to support viable populations of species like Florida scrub-jays (*Aphelocoma coerulescens*) or eastern indigo snakes (*Drymarchon couperi*) but may play a vital support role by allowing movement among larger sites or providing essential habitat for certain plants. Coordinating with stakeholders also is important when setting local-scale management goals and objectives.

Conserving species in scrub with fire requires varying management actions in both space and time. We use the term "pyrodiversity" to describe this variation (Appendix 1). Maintaining heterogeneity with pyrodiversity provides a bet-hedging strategy to ensure benefits for the maximum number of species (Menges 2007). Spatially, it is important to create a mosaic of habitat conditions either within or among management units. The size of the management unit, species present, and the regional context of a property for those species can determine what type of mosaic is needed. For example, scrub-jays need sufficient cover at the territory scale (approximately 25 acres; see "Using potential scrub-jay territories to guide management" below), and burns that consume all vegetation in a territory can displace scrub-jays (Breininger 2004). The federally endangered lichen *Cladonia perforata* and some other rare plants benefit from burns that leave unburned patches (Appendix 3; Yahr 2000, Menges et al. 2004). Temporal variability (e.g., using a fluctuating rather than a fixed fire-return interval for a management unit) is another important component of managing for scrub species (Menges 2007). Variability can be challenging to achieve. Species experts and land managers should work cooperatively to develop realistic management strategies that acknowledge the current constraints faced by land managers.

These guidelines do not replace local knowledge of other effective management strategies or override management for other rare species or native habitats. Although most species in oak scrub require habitat conditions similar to those that benefit Florida scrub-jays, some species, such as the federally listed sand skink (*Plestiodon reynoldsi*) and fragrant prickly-apple (*Harrisia fragrans*), may require alternative management considerations (Appendices 2 and 3). Given regional variation in scrub habitats, we recommend that land managers discuss management concerns and experiences with other land managers and species experts. Regional working groups provide one forum for addressing these topics with neighboring land managers and other experts. These discussions may be particularly helpful when trying to meet the specific requirements of rare plants and restoring long-unburned scrub.

TYPES OF SCRUB

There are several types of scrub in peninsular Florida, including oak scrub, yellow sand (or oak-hickory) scrub, sand pine scrub, oak-palmetto scrub, and rosemary scrub (Menges 1999, Florida Natural Areas Inventory [FNAI] 2010). Scrub occurs with or without a canopy of sand pines (*Pinus clausa*) or slash pines (*Pinus elliottii*), and this variation can lead to differences in management needs. Scrub can be divided into two broad categories based on the prevalence of oaks or rosemary. Oak scrubs are dominated by one or more species of shrubby oaks, including sand live (*Quercus geminata*), myrtle (*Q. myrtifolia*), Chapman's (*Q. chapmanii*), and scrub oak (*Q. inopina*; Menges 1999). Rosemary scrub is dominated by Florida rosemary (*Ceratiola ericoides*). Key differences between oak scrubs and rosemary scrubs affect management for these distinctive communities. Although coastal and inland oak scrubs also differ from one another, the guidance below accounts for these differences and this document, therefore, does not treat them separately.

OAK SCRUB

The Florida Fish and Wildlife Conservation Commission (FWC) considers the Florida scrub-jay an umbrella species for oak scrub in peninsular Florida because conditions suitable for scrub-jays overlap with the conditions suitable for most oak scrub species, including many species of conservation concern (Appendices 2 and 3). For example, management that creates the low (4 to 5.5 ft), open structure of oak scrub favorable to scrub-jays benefits species including the imperiled Florida scrub lizard (*Sceloporus woodi*; Hokit et al. 1999), the threatened southeastern beach mouse (*Peromyscus polionotus niveiventris*; Suazo et al. 2009; U.S. Fish and Wildlife Service [USFWS], 1989), more than 100 species of arthropod (M. Deyrup, Archbold Biological Station, pers. comm.), and many species of plants (Menges 2007; Appendix 3). This type of management also benefits more widely distributed species such as gopher tortoises (*Gopherus polyphemus*; Diemer 1986, Breininger, et. al 1994, Ashton and Ashton 2008), white-tailed deer (*Odocoileus virginianus*; FWC 2007), wild turkey (*Meleagris gallopavo*; D. Nicholson, FWC, pers. comm., B. Zielinski, National Wild Turkey Federation, pers. comm.), and several declining songbirds (MacAllister and Harper 1998, FWC 2005).

Although the scrub-jay umbrella works at a broad level, no species has management needs that perfectly align with all others. To meet the needs of species that lie at either edge of conditions suitable for scrub-jays, variability in management is necessary. For example, suggested fire-return regimes for scrub lizards, scrub-jays, and sand skinks (*Plestiodon reynoldsi*) overlap, but compared to scrub-jays, scrub lizards benefit from more frequent fire and sand skinks benefit from less (Appendix 2). Managing with pyrodiversity is key to ensuring that management benefits most scrub species.

Because managing with pyrodiversity in a way that benefits scrub-jays also benefits most scrub species, we recommend that managers of oak scrub in peninsular Florida aim to create conditions that meet general requirements for the Florida scrub-jay, in the absence of ecological reasons to do otherwise. The conditions described below replicate what most likely was the historical condition of the landscape and what provided good habitat for most scrub-adapted species.

Using potential scrub-jay territories to guide management

Evaluating management at the scale of a scrub-jay territory (approximately 25 acres) provides a useful method to benefit species that occupy oak scrub. In the absence of other conservation objectives, such as the maintenance of red-cockaded woodpecker (*Picoides borealis*) clusters in some scrubby areas, we recommend managing oak scrub with pyrodiversity in a way that promotes optimal conditions for scrub-jays (Table 1) within potential scrub-jay territories (Appendix 1).

Scrub-jay territories average 25 acres in optimal habitat (Breininger 2004). Creating a grid overlay of 25-acre cells using GIS is a useful way to estimate the number of potential territories a site might support. On a given property, aim to maintain 70% of these cells in optimal condition (Table 1). Vegetation structure in the remaining 30% can be either lower (i.e., average shrub height <4 ft and <1 acre of medium-height shrubs) due to recent management or taller (i.e., average shrub height 5.5 to 8 ft). We recognize that each property has unique conditions and may not be able to achieve this 70% to 30% ratio of optimal and suboptimal vegetation structure due to the size of burn units and other management constraints. However, these recommendations provide the best overall conditions for maintaining the many components of Florida's unique oak-scrub ecosystem.

It is important to consider adjacent natural communities when managing for scrub-jays and other scrub species. In addition to scrub plant communities, optimal scrub-jay territories often include scrubby flatwoods, southern ridge sandhills, prairie, wetland margins, and open mesic flatwoods. Other species associated with oak scrub require both scrub and scrubby flatwoods, and many imperiled scrub species also make use of sandhill communities (Appendix 2 and Appendix 3).

Optimal Florida scrub-jay habitat

Overview

In optimal scrub-jay habitat, recruitment of young scrub-jays into the population exceeds mortality of adults. Optimal habitat consists of mostly treeless expanses of low shrubs interspersed with bare sandy patches. Oaks and other shrubs are generally low enough that a person approximately 6 feet tall can see across the landscape (Figure 1, Appendix 5). These vegetation characteristics, detailed in Table 1, also benefit a preponderance of oak scrub endemics (both plant and animal) as well as species that occur in scrub but use other habitats. More research is necessary to fine-tune specifics, including suggestions for the maximum number of snags per territory and number and size of tall scrub oak patches. However, management for optimal scrub-jay habitat is likely the best version of Noah's Ark for the complex suite of species found in Florida oak scrub.

Figure 1: Optimal scrub at Savannas Preserve State Park. Note low structure, sandy openings and sparse tree cover (photo by Chris Vandello). See Appendix 5 for more habitat photos.

Vegetation heights

Vegetation height within a territory is one of the most important factors influencing demographic success of scrub-jays (Breininger and Carter 2003, Breininger and Oddy 2004, Breininger et al. 2006). Scrub-jay demographic performance is best when there are sufficient medium-height (4 - 5.5 ft) shrubs to provide cover, nest sites, and acorns (Breininger and Carter 2003). An average shrub height of 4 to 5.5 ft also provides appropriate habitat for the majority of other scrub-adapted species. In areas where the shrub layer averages taller than 5.5 ft, scrub-jay numbers decline (Breininger et al. 1998), and the sandy openings needed by many scrub plant and animal species disappear (Appendix 2 and Appendix 3). When average vegetation height becomes too tall, managers can reduce the height of the shrub layer using fire or a combination of mechanical means and fire. Ideally, all scrub-jay territories will have access to some medium-height scrub, even when portions of their territory have been burned or mechanically treated. Options include treating only a portion of each scrub-jay territory or leaving small patches of 4 to 5.5 ft tall oaks within each territory to provide escape and roosting cover, nesting sites, and acorns. Many other scrub species benefit from untreated patches, and some require the patches (Appendix 3).

Table 1. Optimal and suitable Florida scrub-jay habitat characteristics per territory. Adapted from Breininger (2004), Breininger et al. (1998, 2014) and, Burgman et al. (2001).

Habitat variable	**Optimal habitat for scrub-jays (i.e., recruitment exceeds mortality)**	**Suitable scrub-jay habitat (i.e., scrub-jays can persist, at least for the short-term)**
Vegetation height	Sufficient amount of medium-height (4 - 5.5 ft tall) shrubs are present to provide cover and produce acorns for scrub-jays. Optimal arrangement of shrub heights within each potential territory includes conditions where: • at least 10% of the territory is medium height • most of the vegetation is medium height or shorter • no more than 1 acre of vegetation taller than 5.5 ft per 25 acres is present	Shrub height averages greater than 3.5 ft but less than 8 ft tall
Open ground	10 - 50% bare sand or sparse herbaceous vegetation.	Minimum: At least some bare sand or sparse herbaceous vegetation. Maximum: No more than 75% bare ground. At least 25% of the territory contains shrubs that provide escape cover, nest sites, and acorns.
Overstory (>15 ft tall) density	0 - 1 tree per acre.	0 - 2 trees per acre (D. R. Breininger, InoMedic Health Applications, pers. comm.).
Distance to forest edge	1,000 ft non-forested buffer (0 - 2 trees/acre) between a scrub-jay territory and forest.	At least a 300 ft non-forested buffer (0 - 4 trees/acre) between a scrub-jay territory and forest.

Although the ecological role of taller oak scrub (taller than 5.5 ft) is not well understood, it is likely beneficial to leave a small percentage of taller oak scrub (Table 1) on the landscape (K. Enge, FWC, pers. comm.). Threatened sand skinks and blue-tailed mole skinks (*Plestiodon egregius lividus*) benefit from management that lets the shrub height grow slightly taller than the optimal height for scrub-jays in some areas to allow for the accumulation of litter for foraging and to allow more time for skink populations to recover after a fire (E. D. McCoy and H. R. Mushinsky, University of South Florida, pers. comm.). Black bears also need scattered tall patches for denning and resting sites (W. McCown, FWC, pers. comm.). Additionally, taller oak patches left standing continue to provide acorns, an important food, and may discourage scrub-jays from dispersing after treatment (R. Risch, Florida Forest Service [FFS], pers. comm.). Historical fire shadows (Appendix 1) provide an opportunity to maintain some taller patches on a property.

Open ground

Many scrub plant and animal species depend on maintenance of open areas where sunlight reaches the ground (Appendix 2 and Appendix 3). Optimal scrub-jay habitat contains 10% to 50% open ground with either bare sand or grass ≤6 inches tall (Breininger 2004). Scrub-jays use these open areas to cache acorns and search for insects; individual scrub-jays buried an average of 6,500 to 8,000 acorns during one fall in a study at Archbold Biological Station (DeGange et al. 1989). Scrub-jay nest success is lower in areas with fewer sandy openings (Carter et al. 2011) and highest in areas with 20% to 40% bare sand (R. Risch, FFS, pers. comm.). Other species associated with oak scrub require sandy openings as well. Endemic oak scrub herbs, especially on the Lake Wales Ridge, rely on bare sand patches (Lambert and Menges 1996, Menges et al. 2006), and scrub-lizard abundance is correlated with amount of bare sand (Hokit et al. 1999).

Tree density

Scrub-jays generally avoid heavily forested areas. Most dense stands of pine today occur in areas where they have been planted or fires have been unnaturally excluded for decades. A thick overstory also results in less light reaching the ground, resulting in reduced habitat suitability for most scrub-adapted species (Appendix 2 and Appendix 3). Scrub-jays do best in areas with less than one tree per acre (Breininger 2004), though scrub-jays can tolerate one to two pine trees per acre (D. R. Breininger, pers. comm.). Maintaining the latter density may be helpful in scrub that lacks sandy openings. Limbs cast from pines can create hot spots during fires that may create sandy openings. In areas managed for scrub-jays and other scrub associated species, thinning of dense pine through harvest, frequent burning, and mechanical removal may be necessary to restore oak scrub. Moreover, because scrub-jays incorporate seasonal wetlands and pine flatwoods with sparse pine canopies into their territories, thinning in adjacent non-scrub habitats maximizes available space for scrub-jays.

For scrub-jay territories that occur entirely in non-scrub habitats and for lands within the 1,000 ft buffer (Table 1) that are not classified as scrub, the amount of tree thinning is ultimately at the discretion of the land manager. Managers must weigh the benefits to scrub-jay population survival at a site against other management objectives and the habitat needs of other species in non-scrub areas considered for thinning.

Distance of scrub-jay territory from forest edge

Areas of otherwise suitable habitat within 1,000 ft of a forest may constitute lower quality habitat for Florida scrub-jays (Burgman et al. 2001, D. R. Breininger, pers. comm.). For example, scrub-jay daily nest survival rates showed a declining trend as far as 2,400 feet from dense forests during a 20-year period at a study site on Merritt Island in Brevard County (Carter et al. 2011). Scrub-jays may avoid these 'tree shadows' (Appendix 1) because potential predators such as hawks pose a threat in these areas (Breininger et al. 1995). However, scrub-jays do not appear to avoid areas adjacent to closed canopy sand pine forest in Ocala National Forest, and observations from one region may not be applicable to all others (K. Miller, FWC, pers. comm.). Thinning patches of pinelands to <1 tree per acre within 1000 ft of scrub patches will maintain maximum habitat suitability for scrub-jays (Burgman et al. 2001), though a buffer of at least 300 ft with 1-4 trees/acre would likely have some benefit for scrub-jays (D. R. Breininger, pers. comm.). Such thinning may be warranted on properties that are high priority for scrub-jays or in areas where the long-term persistence of scrub-jays depends on maximizing available habitat for the species. However, we do not recommend this action in all areas of oak scrub, nor do we recommend compromising natural non-scrub habitat for other rare species.

In some cases, the ability of scrub-jays to disperse across a landscape (the 'permeability' of the landscape, Appendix 1) may be enhanced by thinning trees to produce a more open forest (i.e., tree densities prior to fire exclusion). Isolated optimal habitat patches surrounded by dense upland forests may remain unoccupied permanently, especially in areas with few dispersing scrub-jays. We recommend managers view their site's scrub-jay population within a regional context and coordinate with their neighbors to maximize permeability of the upland landscape.

ROSEMARY SCRUB

Scrub dominated by rosemary occupies the most xeric portions of the landscape and occurs as patches, or balds, embedded in oak scrub (Abrahamson et al. 1984, Figure 2.). Rosemary scrub has a more open structure and retains sandy openings longer than oak scrub. These balds are home to many endemic and rare plants that require sandy openings as well as invertebrates that specialize on rosemary shrubs (Hawkes and Menges 1996, Deyrup 2011). Rosemary shrubs can reach heights of nearly 10 ft but are usually below 6 ft in height (Abrahamson et al. 1984, Gibson and Menges 1994). Thus, although not a primary habitat of scrub-jays, rosemary scrub rarely exceeds shrub heights suitable for scrub-jays.

Care should be taken when burning rosemary scrub. Historically, rosemary scrub burned less frequently than oak scrub (Menges 2007). Rosemary shrubs are killed by fire, but fire and other disturbances stimulate the seeds, resulting in recruitment from a persistent seed bank (Johnson 1982). Frequent fire could result in the extirpation of rosemary shrubs, because individuals take 10 years or more to reach maturity (Johnson 1982). A fire return interval of 15-30 years is recommended for rosemary scrub on the Lake Wales Ridge (Menges 2007). When rosemary shrubs are intermixed within a burn unit, plan ignitions in a way that ensures that these rosemary patches do not burn as frequently as the adjacent oak scrub.

Figure 2. Rosemary bald (foreground) at Lake June-in-the-Winter State Park.

APPROACHES TO SCRUB MANAGEMENT

FIRE

Historically, scrub land covers were maintained in conditions suitable for scrub associate species by low frequency, high-intensity fires that occurred under extreme burning conditions such as the high wind, low humidity, and low fuel moisture (Myers 1990) characteristic of the transition into Florida's rainy season. Repeated applications of lower intensity fires (such as many winter burns) may not achieve the same ecological function as a more natural burn regime. However, low-intensity fires are better than no fire. When weather conditions prohibit a planned transition season burn, it may be beneficial to conduct a winter burn rather than waiting for optimal conditions during subsequent growing seasons. We recommend that managers choose the seasonality of a burn based on the specific objectives for that burn. For example, lower intensity fires may be helpful in creating habitat mosaics within burn units. Varying the season, frequency, and spatial extent of burns helps to create diverse landscapes that benefit many species. Many current conservation lands had a long history of fire suppression prior to acquisition, and restoration of these sites may necessitate mechanical treatment and winter burns before it can be maintained with growing season fire. While mechanical treatments do not have the same ecological effect as fire (Weekley et al. 2008, Suazo et al. 2009, Menges and Gordon 2010), they can be used as a precursor to allow for the safe application of fire.

We recommend that managers use vegetation height to determine when to burn. To maintain a low, open scrub structure, fires must be frequent enough to keep average shrub height generally below 5.5 ft, but leave vegetation heights variable enough to allow continuous acorn production within a scrub-jay territory and provide refugia for other scrub species. Scrub oaks generally begin producing acorns three years after being top-killed by a burn (Fitzpatrick et al. 1991), but this may vary among oak species and sites. Allowing prescribed fires in adjacent flatwoods or sandhills or other habitats to burn into scrub may achieve this desired mosaic (Appendix 1) if fires burn into the scrub far enough to create openings and low vegetation, but not so severely that all vegetation at optimal height is lost (Breininger et al. 2002). However, if a site is severely fire-suppressed and unsuitable for most scrub-associate species, managers may wish to use extensive 'restoration' burns (Appendix 1) to restore the entire area as quickly as possible.

We do not recommend a fixed prescribed fire return interval because of the high degree of variation in scrub types and site conditions, including an individual site's burn history. For example, fire return intervals between 8 and 15 years have been recommended as optimal for maintaining Florida scrub-jay populations in *Quercus inopina*-dominated scrub (Woolfenden and Fitzpatrick 1996), but an 8 to 15-year fire return interval may be too long for some areas in central Florida's Atlantic coast, where openings in scrub disappear within 3 to 5 years (Schmalzer and Hinkle 1992, Breininger et al. 2002, Schmalzer 2003). Menges (2007) recommended a 5 to 12-year fire return interval for oak-hickory scrubs for scrub plants. By contrast, rosemary scrub has a minimum fire return interval of 15 years (Menges 2007). Some species associated with rosemary scrub, such as Florida rosemary and some invertebrates, respond poorly to frequent fire. Therefore, patches of rosemary scrub may need special consideration during management activities. Even when burned infrequently, rosemary scrub maintains the low structure optimal for scrub-jays.

Scrubby flatwoods burn more readily than scrub and may recover more quickly because of a higher vegetation density (USFWS 1999). Long unburned scrubby flatwoods may re-sprout with vigor and require more frequent burning in the initial stages of restoration to maintain optimal conditions (Schmalzer and Hinkle 1992, Schmalzer et al. 1999, Schmalzer and Adrian 2001).

Burning occupied scrub-jay habitat

The strategy for burning in occupied scrub-jay habitat depends on the size of the area and how many occupied territories it contains. If the property is large and contains many occupied territories, an entire territory may be burned at once. On smaller properties with limited habitat, care should be taken to avoid burning entire territories at once. Conducting a mosaic burn in an occupied territory should ensure that some optimal habitat remains for resident scrub-jays. However, in some instances, it may be logistically desirable, necessary, or unavoidable to burn entire territories that are occupied. Ideally, in these instances, adjacent management units should offer suitable habitat to which birds can relocate. Private landowners managing scrub in conjunction with federal cost-share programs should consult and comply with the USFWS-NRCS Interagency Consultation Matrix.

MECHANICAL TREATMENTS

Although the goal of management should be to restore fire to scrub habitats, mechanical treatments (Appendix 4) prior to burning may be useful to speed up restoration, create ignition strips, manage fuel loads to maintain prescribed fire safety, or maintain vegetation height in areas where fire is not possible. However, mechanical treatments do not provide an ecological substitute for fire and should be followed by prescribed fire if possible (Weekley et al. 2008, Suazo et al. 2009, Menges and Gordon 2010). Mechanical treatments are usually more expensive than burning alone and often involve heavy equipment that may result in soil disturbance and ecological damage such as harming fossorial animals and introducing exotic plant material. If mechanical treatments use heavy equipment to prepare a site for fire, we recommend management techniques and operating methods that minimize soil disturbance and foster mosaic burns. The use of 'sloppy' (Appendix 1) methods of treatment produces an uneven and more natural landscape after fire (J. Hinchee, U. S. Forest Service, pers. comm., K. Enge, pers. comm.). Alternatively, treating strips through a unit may achieve a more complete but still mosaic burn. If the goal is to create the desired safety conditions for a burn, it may be sufficient to mechanically treat only the perimeter of a unit (Doren et al. 1987). These methods can reduce the potential negative impacts of mechanical treatments while providing enhanced opportunity to control prescribed burns.

Mechanical equipment and tools that have minimal soil disturbance are preferable. Examples of those types of equipment include chainsaws, track vehicles, and single-pass empty roller drums. An empty roller drum pulled by a tracked vehicle in a single pass method will push vegetation down instead of digging into the soil. Empty drums may not sufficiently push shrubs down under all conditions, and the need to reduce the height of the shrubs must be balanced with the need to minimize soil disturbance. Some managers use a Brontosaurus mower to reduce the height of the scrub with minimal impacts at ground level. The use of tracked vehicles usually results in less soil disturbance than using vehicles of a similar weight that have tires (S. M. Nagid, City of Gainesville Nature Operations Division, pers. comm.). However, some managers report less soil disturbance when using wheeled vehicles (S. Green, Southwest Florida Water Management District, pers. comm.). Regardless of vehicle type, reducing turns and avoiding extreme maneuvers helps to minimize soil disturbance.

Effects of mechanical treatments on lichens, soil crusts, and many focal species have not been adequately studied. If gopher tortoises are present, mark and avoid burrows during mechanical treatments where possible, and consider treating areas during winter, when animals are most likely to be underground and out of harm's way, then follow up with a spring/summer burn. In occupied scrub-jay habitat, avoid treating areas with active nests until nesting is complete. Consider the effects on rare plants and other localized special features in the mechanical treatment footprint, and apply treatments at times of year that generate the desired results.

Managers using mechanical treatments have reported the possibility that these treatments caused infestations of invasive plants, such as Natal grass (*Melinis repens*) and torpedo grass (*Panicum repens*). These infestations may result from neighboring exotic plant populations spreading into areas with disturbed soil created by mechanical methods (E. Egensteiner, Florida Park Service, pers. comm., K. Main, Archbold Biological Station, pers. comm.), from creation of fire lines, or from seed brought in on equipment. To minimize the chance of spreading invasive seeds, wash equipment (or ensure contractors have washed equipment) before and after each use. Treatment of nuisance and exotic vegetation within a manager's control surrounding the area prior to mechanical restoration may reduce the possibility of windblown seeds dispersing into the restoration area. Managers are encouraged to contact FWC's Invasive Plant Management staff for assistance with invasive exotics.

While mechanical treatments are often a useful step in the process to restore vegetation, these areas should still be burned, preferably less than three months following treatment. This is especially true for mechanical treatments that leave mulch on the ground. Beyond six months, the mulch layer starts breaking down and the increasing shrub height retards wind and creates shade, all of which decrease the flammability. Mechanically treated scrub may not carry fire well after more than a year without a follow-up burn (S. Morrison, The Nature Conservancy, pers. comm., Weekley et al. 2008). Timely application of fire after mechanical treatment is also important for plants. If seedlings emerging after mechanical treatment are consumed by fire it acts as a "1-2 punch to their demographics" (D. Bender, USFWS, pers. comm.). Finally, there is no ecological substitute for fire – it is essential for the maintenance of plant species richness in scrub habitat and likely has other benefits as well (Williges et al. 2006, Weekley et al. 2008, Menges and Gordon 2010). Mechanical treatments are best used sparingly, preferably only initially to start the prescribed burning cycle or as one component of the burn process.

ADAPTIVE MANAGEMENT

Use of these guidelines should help managers improve the structure of scrub on a given property, thereby benefiting scrub associated plants and animals. However, only by monitoring the responses of native and rare species will a manager know if the treatments are beneficial. Habitat management is the first step in the stewardship of Florida's scrub resources; monitoring of target species provides feedback to land managers about the success of management actions. Evaluating outcomes against objectives and revising management plans based on these evaluations is critical to improving habitat management.

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Appendix 1: Terminology used in this paper

Fire shadow: An area that remains unburned for long periods of time while the surrounding landscape is burned, usually because of fire behavior associated with a landscape feature, such as a wetland.
Mosaic burn: A burn that results in a landscape of variable burn intensities and vegetation heights, with some patches left unburned.
Permeability: Used to describe the degree to which an organism may pass through a landscape.
Pyrodiversity: The temporal and spatial variation of fire on a landscape that results in fires of appropriate intensities and burn areas and maintains optimal habitat requirement for a large variety of species. Managers increase pyrodiversity by varying seasonal ignition times, time since fire, and methods of ignition while conducting mosaic burns.
Tree curtains: Heavily forested landscapes surrounding more open habitats. Tree curtains may decrease landscape permeability and provide cover for predators such as raptors.
Tree shadow: An area of reduced survival or reproductive success adjacent to a forested area in otherwise suitable habitat. Alternatively, an area of otherwise suitable habitat that remains unoccupied due to proximity to a forest edge.
Scrub-jay territory: The area defended by a scrub-jay family group. Scrub-jay family groups defend areas that average 25 acres, but the size of any one territory is highly variable and depends on site characteristics and each individual territory's history. In areas with a low density of scrub-jays, individual scrub-jay families may defend very large areas.
'Sloppy' treatment: A means of mechanically treating an area in which some small patches are left untreated to give the resulting landscape a diversity of shrub heights. Sometimes referred to as the sloppy chop if a roller chopper is involved.
Restoration burn: An intense, complete burn across the entire area of unoccupied habitat, or of occupied habitat provided there is ample optimal unoccupied habitat nearby. A restoration burn is often necessary in long unburned areas.
Umbrella species: A species whose habitat requirements are also requirements of a wide range of other species; managing for an umbrella species will create habitat conditions that will also benefit many other species.

Appendix 2: Recommendations for scrub animals beyond the Florida scrub-jay umbrella

KEY

Listing Status: FE = Federally Endangered, FT = Federally Threatened, SE = State Endangered, ST = State Threatened, SSC = State Species of Special Concern, FNAI S3 = vulnerable or locally rare, DL = Delisted

Habitat: IS = interior scrub, CS = coastal scrub, SF = scrubby flatwoods, SH = sandhill

Oak or Rosemary? O = oak scrub, R = rosemary scrub

FSJ: Florida scrub-jay

Species (Common Name)	Listing status	Habitat	Oak or Rosemary scrub?	Optimal fire return interval

Response to fire and fire exclusion. Response to mechanical treatments. Co-occur w/FSJs? Under FSJ management umbrella? Management recommendations beyond the scrub-jay umbrella

References

AMPHIBIANS:

Lithobates capito (Gopher frog)	FNAI S3	IS, CS, SH, other	O, R	Unknown; likely similar to gopher tortoise.

Potentially vulnerable to fire when dispersing from and migrating to breeding ponds. Gopher tortoise burrows are critical for sheltering, and gopher tortoises benefit from periodic fire and abandon long-unburned areas. Gopher frogs appear to avoid long-unburned areas that have become overgrown with hardwoods. Treatments that benefit gopher tortoises will benefit this species. Gopher frogs shelter in burrows during the day. Mark and avoid gopher tortoise burrows. Co-occur with FSJs and under FSJ umbrella.

Russell et al. 1999, Roznik et al. 2009, Florida Fish and Wildlife Conservation Commission 2013a

Notophthalmus perstriatus (Striped newt)	FNAI S2	SH, SF, IS, CS, other	O	Unknown

More information is needed about the habitat requirements and ecology of striped newts in scrub. Extensive fires in scrub are likely to be detrimental. Mechanical treatments presumably could result in mortality of terrestrial adults. More information is needed about the habitat requirements, ecology, and management needs of striped newts in scrub. It is possible that a patchy mosaic of different aged scrub may help newts persist. Wetland edges with extensive areas of grasses may provide important habitat for efts and terrestrial adults in ponds embedded in scrub. Found more often in sandhill than in scrub. Scrub may be marginal or unsuitable habitat for terrestrial adults. Breeding by paedomorphs, rather than returning adults, is hypothesized to keep populations extant in some ponds surrounded by scrub.

Enge 2011, K. M. Enge, pers. comm.

REPTILES:

Plestiodon egregius lividus (Blue-tailed mole skink)	FT	IS, SH	O, R	Unknown; perhaps on the order of 20 years.

Response to fire possibly like sand skinks. Thought to reach highest densities in long-unburned sites. Minimize soil compaction, which could lead to mortality. Co-occur with FSJs, especially when managed for some patches at the longer return to provide habitat. Allowing time for the development of a litter layer will maximize population density and will allow more time for skink populations to recover after a fire. Restricted to Highlands and Polk counties, the portion of Osceola county on the Lake Wales ridge.

Ashton and Knipps 2011, E. D. McCoy and H. R. Mushinsky, pers. comm.

Crotalus adamanteus (Eastern diamondback rattlesnake)	FNAI S3	IS, CS, SF, SH, other	O	Unknown

Rarely killed by fires, individuals seek shelter from fires in gopher tortoise burrows and other burrows or holes. Prefer open-canopy, fire-maintained habitats. Fire exclusion leads to dense, closed-canopy habitat unsuitable for this species. Co-occur with FSJs and under the FSJ umbrella. Primarily associated with pinelands, but can be found in scrub and scrubby flatwoods.

Martin and Means 2000

Drymarchon corais couperi (Eastern indigo snake)	FT	IS, CS, SH, other	O, R	Unknown; likely similar to gopher tortoise.

Retreat into burrows to escape fires. Unlikely to be found in mature sand pine stands. Gopher tortoise burrows are important for sheltering and foraging, and gopher tortoises benefit from periodic fire and abandon long-unburned areas. Scrub restoration is likely to benefit gopher tortoises and thus indigo snakes. There is a possibility of direct mortality from equipment. Co-occur with FSJs and under the FSJ umbrella, but indigo snakes require a mosaic of habitat types, including both uplands and wetlands.

Layne and Steiner 1996, U.S. Fish and Wildlife Service 1999a, Stevenson et al. 2010, Hyslop et al. 2011, P. E. Moler, pers. comm.

Pituophis melanoleucus mugitus (Florida pine snake)	ST	CS, IS, SH	O	Unknown, but likely similar to gopher tortoise.

Prefer open, fire-maintained habitat. Sometimes shelter in the burrows of the gopher tortoise, which benefits from periodic fire. Will use xeric hammocks, but closed canopy forests may not provide suitable habitat. Mechanical treatments can improve habitat conditions. Treatments are unlikely to result in direct mortality because spends most of its time under-ground. Avoid heavy soil disturbance. Co-occur with FSJs and under FSJ umbrella.

Franz 1992, Hipes et al. 2001, Florida Fish and Wildlife Conservation Commission 2013b, P. E. Moler, pers. comm. Woolfenden and Fitzpatrick 1984, 1996, Fitzpatrick et al. 1991, Breininger and Carter 2003, Breininger 2004, Breininger et al. 2013

Gopherus polyphemus (Gopher tortoise)	ST	IS, CS, SH, other	O, R	Variable in scrub, 3-8 years in scrubby flatwoods.

Fire is critical to maintaining suitable habitat. Fire stimulates growth of important forage plants and facilitates open, sunny areas needed for proper egg incubation. Tortoises abandon areas that are long-unburned. Those that persist in long-unburned areas do so in open areas such as roadsides and fire lanes. Mechanical treatments followed by fire can restore habitat. Avoid known burrows, and minimize heavy equipment use in areas with high burrow densities. Consider treating areas during winter, when tortoises are more likely to be under-ground. Co-occur with FSJs and under FSJ umbrella.

Diemer and Moler 1982, Diemer 1986, Breininger et al. 1994, Ashton et al. 2008, Florida Fish and Wildlife Conservation Commission 2012

Plestiodon reynoldsi (Sand skink)	FT	IS, SH	O, R	Unknown, perhaps on the order of 20 years.

Abundance is lower in recently-burned areas, as skinks move to find better habitat conditions. Mortality from fire is thought to be low, but instances of significant fire mortality have been recorded. Frequent fires can reduce genetic variation. Reach highest densities in long-unburned sites. Minimize soil compaction, which could lead to mortality. Co-occur with FSJs. Allowing time for the development of a litter layer will maximize population density and will allow more time for skink populations to recover after a fire. Occurs on the Lake Wales, Winter Haven, and Mount Dora ridges.

Schrey et al. 2010, Ashton and Knipps 2011, McCoy et al. 2013, E. D. McCoy, pers. comm., H. R. Mushinsky, pers. comm., P. E. Moler, pers. comm.

Sceloporus woodi (Scrub lizard)	FNAI S3	IS, CS	O, R	Perhaps <7-9 years in sand pine scrub.

Prefers open, sandy areas, and may occur at higher densities in early-successional scrub. Decrease as the canopy closes and sandy openings disappear. Treatments that promote open, sandy areas could benefit this species. Co-occur with FSJs and under FSJ umbrella. Scrub lizards have poor dispersal and benefit from large, contiguous stands of early-successional scrub.

Greenberg et al. 1994, Tiebout III and Anderson 1997, 2001, Hokit et al. 1999, Hokit and Branch 2003, McCoy et al. 2013

Stilosoma extenuatum (Short-tailed snake)	ST	IS, CS, SH	O	Unknown

Found in both fire-maintained and fire-suppressed areas. One of the species' primary prey, the Peninsula crowned snake (*Tantilla relicta*), tends to be more abundant in open scrub. Minimize soil compaction, which could lead to incidental mortality. Found in some residential areas, so possibly tolerant of some disturbance. Mostly fossorial, little known about habitat requirements.

Campbell and Christman 1982, Campbell 1992, Greenberg et al. 1994, Florida Fish and Wildlife Conservation Commission 2013c, P. Moler, pers. comm.

BIRDS:

Falco sparverius paulus (Southeastern American kestrel)	ST	IS, CS, SF, SH	O	Unknown

Fire maintains the low, open conditions and sparse tree cover needed by the species. Mechanical treatments, followed by fire, can create the low, open conditions needed by kestrels. Co-occur with FSJs, but need suitable cavity trees or nest boxes and scattered perch sites. Leaving snags and scattered pines on the landscape would benefit kestrels and other cavity nesting birds. Primarily associated with sandhill but can be found in scrub and scrubby flatwoods.

Hoffman and Collopy 1988, Stys 1993, Florida Fish and Wildlife Conservation Commission 2013d

MAMMALS:

Ursus americanus floridanus (Florida black bear)	FNAI S3	IS, SF, SH, other	O	Unknown

Burning in winter can result in neo-natal mortality in areas used by bears for denning. Fires need to be infrequent enough to allow for adequate mast production. Black bears use mid- and late successional scrub more often than early successional scrub. However, periodically burned, intermediate sized oaks provide greatest acorn mast production. Mechanical treatments in winter can result in neo-natal mortality in areas used by bears for denning. Treatments need to be infrequent enough to allow for adequate mast production. Co-occur with FSJs. Require a mosaic of different natural communities and a mosaic of successional stages, with some patches of tall, dense vegetation for den security. Ensuring habitat diversity and adequate mast production is important.

Maehr and Brady 1984, Maehr et al. 2001, Abrahamson and Layne 2002, McCown et al. 2004, Ulrey 2008

Podomys floridanus (Florida mouse)	FNAI S3	IS, CS, SF, SH	O, R	Unknown

Populations are highest in early-successional stages of scrub. Seek shelter in gopher tortoise burrows during fire. May use adjacent natural communities as refugia immediately after fire until vegetation recovers enough to provide cover and food. Populations decline in the absence of fire as the habitat becomes denser and the microhabitat more mesic. Mechanical treatments can restore the open conditions needed by Florida mice. Care should be taken to avoid gopher tortoise burrows. Co-occur with FSJs and under FSJ umbrella. In addition to vegetation structure, diversity of groundcover, abundance of masting species, and density or abundance of gopher tortoise burrows are thought to be important to the species. Able to persist longer in unburned scrub than scrub-jays. Often use gopher tortoise burrows.

Jones and Franz 1990, Layne 1990, 1992, Jones and Layne 1993, DePue 2005, Silva-Lugo 2008, Florida Fish and Wildlife Conservation Commission 2013e

Peromyscus polionotus niveiventris (Southeastern beach mouse)	FT	CS, other	O	Unknown

Significantly more abundant in burned scrub. Respond positively to mechanically treated areas. Co-occur with FSJs. Occupy coastal dunes, but also found in adjacent scrub.

Suazo et al. 2009

ARTHROPODS:

Various Scrub specialist arthropods	NA	IS	O, R	Generally the same as the recommended fire return interval for the natural communities in which they are found (e.g., 5-20 years in oak scrub, 15-30 years in rosemary scrub).

All scrub specialist arthropods require fire to maintain suitable habitat conditions. Unknown response to mechanical treatments, but may suffer if soil is compacted. Thus, minimize soil compaction. Care should be taken when managing rosemary scrub, because frequent fire can result in the extirpation of Florida rosemary (*Ceratiola ericoides*), an important plant for some scrub specialist arthropods.

Deyrup 2011, M. Deyrup, pers. comm., E. Bauer USFWS pers.comm.

Appendix 3. Recommendations for scrub plants beyond the Florida scrub-jay umbrella

KEY

Listing Status: FE = Federally Endangered, FT = Federally Threatened, SE = State Endangered, ST = State Threatened, DL=Delisted
Habitat: IS = interior scrub, CS = coastal scrub, SF = scrubby flatwoods, SH = sandhill
O = oak scrub, **R** = rosemary scrub
FSJ: Florida scrub-jay
FSJ Umbrella: Management for Florida scrub-jay

Species (Common Name)	Listing status	Habitat	Oak or rosemary scrub?	Optimal fire return interval

Response to fire and fire exclusion. Response to mechanical treatments. Co-occur w/FSJs? Under FSJ management umbrella? Management recommendations beyond the scrub-jay umbrella

References

Asclepias curtissii (Curtiss' milkweed)	SE	IS, CS, SF	O	Can tolerate a range of fire return intervals.

Re-sprouts after fire. Co-occurs with FSJs and under the FSJ umbrella. One individual was observed flowering 6 months after a fire.

Putz and Minno 1995, E. S. Menges, pers. comm.

Asimina tetramera (Four-petal pawpaw)	FE	CS, SF	O, R	10-40 years

Resprouts after fire. Fire stimulates growth, removes fungal growth, promotes flowering and fruiting, and invites pollinators into long-unburned habitat. Can persist for decades without fire, but flowering decreases with time since fire. Re-sprouts after mechanical treatment. Prefers open sand, thus mechanical treatments should be followed by fire to remove duff and litter. Frequent mowing can result in extirpation. Co-occurs with FSJ and under FSJ umbrella. Season of fire may influence the amount of flowering and seed production.

Kral 1983, Carrington 1999, U.S. Fish and Wildlife Service 1999b, 2009a, Cox 2006, A.C. Cox, pers. comm.

Bonamia grandiflora (Florida bonamia)	FT	IS, SH	O, R	Sandhill fire return intervals (2-8 years)

Re-sprouts after fire. Fire stimulates flowering, seed production and germination. Clonal stem production is greatest the first year after fire, then declines. Seed production is greatest during the second season after fire. Fire causes turnover of seed bank. Declines in absence of fire. In sand pine scrub, persists in a variety of successional stages, but flowers profusely only in the open, sunny conditions of early-successional scrub and sparsely if at all in later successional stages. Re-sprouts after mechanical treatments. If treated while flowering, reproductive season is lost. Mow after seed-set or before leaf-out. Co-occurs with FSJ and under FSJ umbrella, but probably does best under more frequent fire. Grows in disturbed areas as well as sandy openings from fire. Maintains seed bank of dormant seeds. Fire not thought to be needed for germination.

Hartnett and Richardson 1989, U.S. Fish and Wildlife Service 1999c, E. S. Menges, pers. comm.

Calamintha ashei (Ashe's savory)	ST	IS, CS, SF, SH	O, R	Unknown; needs periodic fire to avoid overtopping by shrubs.

Killed by fire, but strong post-fire seedling establishment. Requires open, sandy patches. Probably declines after several decades without fire. Co-occurs with FSJ and under FSJ umbrella. Potentially allelopathic.

Hessl and Spackman 1995, Carrington 1999, Menges et al. 1999, E. S. Menges, pers. comm.

Ceratiola ericoides (Florida rosemary)	None	IS, CS	R	15-30 years

Killed by fire. Seedlings recruit from a persistent seed bank. Populations show slow recovery after fire, with slightly increasing local abundance for first 10 years and relatively stable numbers thereafter. Frequent fire could extirpate local populations. Plants may lose productivity and begin partial dieback after 20 years, but some individuals can survive more than 50 years. Vulnerable to root disturbance, but may survive some mechanical disturbances such as logging. Co-occurs with FSJs but frequent fire could result in extirpation of rosemary populations. Fire return intervals of 15-30 years are recommended to ensure persistence. Plants take 10-15 years to reach sexual maturity, with peak seed production between 20 and 30 years post-fire.

Johnson 1982, Gibson and Menges 1994, Menges 2007, n.d., E.S. Menges, pers. comm.

Chamaesyce cumulicola (Sand-dune spurge)	SE	IS, CS	O	Unknown

Relies on open sandy areas, which were maintained historically by either fire or, in the case of some coastal scrub, storms. Co-occurs with FSJ. Possesses a substantial tap root, suggesting that it probably re-sprouts following fire.

P. A. Schmalzer, pers. comm.

Chionanthus pygmaeus (Pygmy fringe-tree)	FE	IS, SH	O	No strong requirements

Re-sprouts after fire. Fire may reduce competition from neighboring plants. Frequent fire may suppress fruiting. Can persist in long-unburned sites. Mortality has been observed when fire was reintroduced into long-unburned areas with high fuel load. Re-sprouts from mowing, which encourages root and shoot production. Does not usually co-occur with FSJ; species is common along creek banks or transitional zones between upland and lower wet areas and in sand-hill sites that are xeric and burned often. Species can persist in long-unburned conditions but the fire frequency that it can tolerate is has not been documented.

Kral 1983, Stout 1990, U.S. Fish and Wildlife Service 1999d, E. S. Menges, pers. comm., J. J. Navarra, pers. comm., I. J. Stout, pers. comm.

Chrysopsis floridana (Florida golden-aster)	FE	IS, CS, SF, SH	O, R	Frequent fire (1 -10 years) in sandhill or transitional areas and every 10 or more years in scrub.

Can re-sprout after fire. Fire increases flowering but does not affect seed germination or seedling survival. Fire increases flowering but does not affect seed germination or seedling survival. May benefit from low intensity disturbance, but frequent or high intensity disturbance can result in extirpation. Co-occurs with FSJ and under FSJ umbrella. It is best to burn in late spring and summer, when seeds have been dispersed and plants are in rosette stage.

U.S. Fish and Wildlife Service 1988, 1999e, 2009b, Lambert and Menges 1996, T. Mecklenborg, pers. comm.

Chrysopsis highlandsensis (Highlands golden-aster)	SE	IS, SF	O, R	Unknown

Most plants killed by fire. Post-fire recruitment is variable. Species declines with fire exclusion. Does well in areas that have been disturbed by machines or grazing. Co-occurs with FSJ and under FSJ umbrella. May respond to soil disturbances.

Menges and Weekley 2005, M. R. Jenkins, pers. comm., E. S. Menges, pers. comm.

Cladonia perforata (Florida perforate; reindeer lichen)	FE	IS, CS	R, O	Perhaps two decades+ based on distribution.

Killed by fire. Recolonization is thought to be slow, and it is possible that frequent fires can result in extirpation, though this is unproven. Requires infrequent, periodic fires to maintain open, sandy areas. In absence of fire, buildup of heavy fuel loads could lead to extirpation when fires occur. Buildup of fuel from mechanical treatment could lead to extirpation when fires occur. May respond negatively to some mechanical treatments, though mechanical treatment may result in dispersal of the species via vegetative fragmentation. Co-occurs with FSJ and under FSJ umbrella, but unburned refugia are important for this species. Patchy fires can create a mosaic of microhabitats. When restoring long-unburned scrub, individuals can easily be hand-picked or gently swept into a dustpan, moved temporarily, and returned following fire. Temporarily translocated pieces >8 mm had high survival rates (>75%). Seek translocation assistance from USFWS or other individuals with experience translocating this species. Monitoring is recommended post translocation. Vegetative fragmentation of the thallus may be the only means of reproduction. Recolonization is slow. Historically, individuals perhaps windblown into newly burned areas from adjacent unburned areas, but now land managers may have to facilitate this process due to loss and fragmentation of scrub. In southeast Florida, found in oak scrub and sometimes in swales between tufts of grasses under sparse pine canopy in drier pine flatwoods.

Buckley and Hendrickson 1988, Florida Natural Areas Inventory 2000a, Yahr 2000, E.S. Menges, pers. comm., J.A. Moore, pers. comm., J.J. Navarra, pers. comm.

Clitoria fragrans (Pigeon-wing)	FT	SH, IS	O	2-8 years

Benefits from frequent fire in sandhill vegetation. Blooms profusely in response to fire. Species will persist in long-unburned locations, but reproduction declines or ceases. Co-occurs with FSJ and under FSJ umbrella. Found primarily in yellow sand areas, where vegetation grows faster than white sand scrub and needs more frequent fire to maintain sandy openings. Primarily occurs in sandhill. Note that the scrub-jay umbrella does not apply to sandhill.

U.S. Fish and Wildlife Service 1999f, E.S. Menges, pers. comm., J.J. Navarra, pers. comm.

Conradina brevifolia (Short-leaved rosemary; false rosemary)	FE	IS	O	Variable

Killed by fire but recruits from seed bank. Dramatic increases in plant density the second year after fire, with continued increases through 5 years post-fire. Persists in gaps in long-unburned (50+ years) scrub. Persists in sites that receive log and log-and-burn treatments. Can re-sprout if some live tissue remains following mowing or chain-sawing, though high mortality rate has been observed when mowed along some trails. Flowering is delayed or absent within one year of mowing. Co-occurs with FSJ and under FSJ umbrella. Anecdotal evidence suggests this species can persist under a frequent fire regime.

Slapcinsky et al. 2010, Proenza 2012, Weekley et al. 2013, J.J. Navarra, pers. comm.

Conradina etonia (Scrub rosemary)	FE	IS	O	Unknown

Killed by fire but returns from seed. Most Conradina species are fire adapted, and persistence is generally dependent on disturbance. Occurs in sandy openings and disappears with heavy accumulation of leaf litter in the absence of fire. Re-sprouts and germinates after mowing and logging. Co-occurs with FSJ and under FSJ umbrella.

U.S. Fish and Wildlife Service 2007a, Edwards et al. 2009, M.R. Jenkins, pers. comm.

Conradina grandiflora (Large-flowered rosemary)	ST	CS, SF	O	Variable

Killed by fire but returns from seed. Most Conradina species are fire adapted, and persistence is generally dependent on disturbance. Observed to persist in some areas under a sand pine canopy or in oak scrub that has not burned recently. However, observed to flower profusely when the sand pine canopy was removed by a hurricane. Co-occurs with FSJ.

Edwards et al. 2009, P.A. Schmalzer, pers. comm.

Crotalaria avonensis (Avon Park harebells)	FE	IS, SF, SH	R, O	Recommended fire return interval for the natural communities in which it is found, but can decline earlier in scrubby flatwoods.

Flowering increases two years after fire. Can re-sprout after low intensity fire. Mortality increases with increased shade. Declines in scrubby flatwoods that remain unburned for more than eight years. Plant re-sprouts after mowing, similar to the response after fire. Survival after mowing is similar to survival after fire. Co-occurs with FSJ and under FSJ umbrella, but may require more frequent fire in some habitats. Introduction and population augmentation are necessary to conserve the species. The USFWS recommends surveys whenever these species will be affected.

The Nature Conservancy Lake Wales Ridge Program 1999a, U.S. Fish and Wildlife Service 1999g, 2007b, Slapcinsky et al. 2010, M.R. Jenkins, pers. comm., E.S. Menges, pers. comm.

Dicerandra christmanii (Garrett's mint)	FE	IS, SH	O	No direct data on response to fire.

Data from *congener D. frutescens* suggests 6-12 year fire return interval (6-21 at most). *Congener D. frutescens* killed by fire but comes back strong from seed bank. Seed bank has peak input around 3-10 years postfire; frequent fire can deplete the seed bank. Sensitive to canopy cover and disappears with shade. Absence of fire will result in population declines and a decline in the seed bank. Members of the genus suffer mortality from mechanical disturbance. However, occasional disturbance along fire lanes and roads provides habitat, especially in long-unburned areas. Co-occurs with FSJ and under FSJ umbrella. Introductions and population augmentations are required. Found primarily in yellow sand scrub, which grows faster than white sand scrub and needs more frequent fire to maintain sandy openings. The USFWS recommends surveys whenever these species will be affected. Seed dispersal is poor, so unlikely to recolonize if no populations are nearby. Note that the scrub-jay umbrella does not apply to individuals in sandhill.

Menges and Weekley 1999, Menges et al. 1999, U.S. Fish and Wildlife Service 2009c, A.F. Johnson, cited as pers. comm. in Hessl and Spackman 1995, E.S. Menges, pers. comm.

Dicerandra cornutissima (Robin's mint)	FE	IS, SF, SH	O, R	Unknown

Killed by fire, but recovers from seed. May require fire to maintain open habitat. Will ultimately be shaded out in the absence of fire. Suffers mortality from mechanical treatments, but treatments can provide sandy openings that the species will colonize. Co-occurs with FSJ and under FSJ umbrella.

Kral 1983, M.R. Jenkins, pers. comm.

Dicerandra frutescens (Lloyd's mint)	FE	IS	O	Models suggest 6–12 years (6-21 at most)

Killed by fire but comes back strongly from seed bank. Population growth rate highest shortly after fire and declines steeply thereafter. Occupancy decreases with litter depth, litter cover, and shade. Can persist in some long-unburned areas, but populations generally decline in the absence of fire. Populations likely to become extirpated in 30-70 years without fire. Clearing the area 1 m around individual plants had positive, though marginal, effect on germination. Co-occurs with FSJ and under the FSJ umbrella. Found primarily in yellow sand scrub, which grows faster than white sand scrub and needs more frequent fire to maintain sandy openings.

Kral 1983, Pavlovic 1994, Menges and Weekley 1999, Menges et al. 2006, E.S. Menges, pers. comm.

Dicerandra immaculata (Olga's mint; Lakela's mint)	FE	CS, SH	O	Unknown

Fire (or other disturbance) is required to maintain this species' specific microhabitat needs. Killed by fire, and a hot burn may damage seed bank. Needs patchy burns to prevent mortality of all adults; probably recolonizes areas (especially long-unburned areas) from seeds of existing, unburned plants. Disappears with heavy leaf litter. Populations suffer without regular management. Long unburned areas may have no seed bank as seeds may not remain viable for >1-2 years. Needs re-introduction or augmentation once management occurs. Suffers mortality from mechanical treatments, but treatments can provide sandy openings that the species will colonize. Gaps in the canopy are also critical for the species. Co-occurs with FSJ and under FSJ umbrella. Spring/summer burn probably best to avoid reproduction and seed drop (Oct-Jan).

Kral 1983, Stout et al. 1998, U.S. Fish and Wildlife Service 2008, C. Peterson, pers. comm.

Dicerandra thinicola (Titusville balm)	SE	CS	O	Unknown, likely similar to members of the genus

Killed by fire but comes back strong from the seed bank. Declines with fire suppression, although not as sensitive as other Dicerandra species. Suffers mortality, but can colonize after certain mechanical treatments. Co-occurs with FSJ and under umbrella. Probably will need to be introduced to additional sites. Found primarily in yellow sand scrub, which grows faster than white sand scrub and needs more frequent fire to maintain sandy openings.

M.R. Jenkins, pers. comm., E.S. Menges, pers. comm.

Eriogonum longifolium var gnaphifolium (Scrub buckwheat)	FT	SH, IS	O	Adapted to sandhill fire return intervals (2-8 years) but can persist under scrub fire return intervals (e.g. 5-20 years).

Re-sprouts and flowers profusely after fire, resulting in addition to seed bank and seedling recruitment in the years following fire. Able to persist in some long-unburned locations (>30 yrs), but declines as open spaces disappear. Accumulation of litter inhibits seedling establishment. Mechanical methods that remove the tops from plants stimulate re-sprouting and flowering, but thatch from treatments is likely to inhibit seedling recruitment. Co-occurs with FSJ and under FSJ umbrella. Found primarily in yellow sand areas, where vegetation grows faster than white sand scrub and needs more frequent fire to maintain sandy openings. Primarily occurs in sandhill. Note that the scrub-jay umbrella does not apply to sandhill.

Carrington 1999, McConnell and Menges 2002, Satterthwaite et al. 2002, E.S. Menges, pers. comm., J.J. Navarra, pers. comm.

Eryngium cuneifolium (Scrub eryngium)	FE	IS	R	15 years or less

Dependent on open habitat maintained by fire. Often killed by fire, but can recolonize areas via both re-sprouting and seedling recruitment. Germination increases following fire, but re-sprouting is rare. Shrubs encroach on open patches in the absence of fire, resulting in dramatic decreases in survival, growth, and fecundity. Encroachment by lichens also decreases survival and fecundity. Extinction time of 25-35 years reported in absence of fire. Occupies fire lanes and other disturbed areas. Suffers mortality from mechanical treatments, but they can provide sandy openings that the species will colonize. Co-occurs with FSJ, but is a specialist in rosemary scrub, which is not primary scrub-jay habitat.

Menges and Weekley 1999, Quintana-Ascencio and Menges 2000, Menges and Quintana-Ascencio 2004, U.S. Fish and Wildlife Service 2010a, Stephens et al. 2012, E.S. Menges, pers. comm.

Euphorbia rosescens (Scrub spurge)	SE	IS	O, R	Unknown

Can re-sprout after fire. Not found in sites from which fire has been excluded. Probably can survive due to deep rooting. Co-occurs with FSJ, probably under FSJ umbrella. Limited seed production is an issue, but there are currently no recommendations.

E.S. Menges, pers. comm.

Garberia heterophylla (Garberia)	ST	IS, SF, SH	O, R	Re-sprouts and flowers after fire; strong post-fire seedling establishment.

Can be shaded out by canopy vegetation. Re-sprouts after mowing. Co-occurs with FSJ and under FSJ umbrella.

Carrington 1999, M.R. Jenkins, pers. comm.

Harrisia fragrans (Fragrant prickly-apple)	FE	CS, SF, other	O, R	Unknown, but 50-100 year, like that of xeric hammocks, is probably the most frequent the species can endure.

Very sensitive to intense radiant heat; individual plants killed by fire. Fire does not promote recruitment. Individual plants reportedly intolerant of shade. However, at small sizes, do best with partial shade and can desiccate in full sun. Can cope with full sun once over 2 ft tall. More flowering and fruit production in open habitat. Mechanical treatments can result in mortality when plants are cut or covered by cut material. However, cut segments roughly >4 inches have been observed to survive and re-root. Co-occurs with FSJ. Protect individuals when burning or mowing, but burn surrounding habitats in a mosaic. For cactus adjacent to the burn zone perimeter, use hand lines to protect individuals, and attempt to burn-out around the cactus prior to lighting prescribed fires. For cactus in interior of zone, reduce fuel loading around cacti before burning. Avoid clearing xeric hammocks where the species occurs. Bradley and Hines (2007) do not believe that this species was historically associated with sand pine scrub. Transplanted individuals observed to start new roots within 2-3 months and grew well with regular watering.

U.S. Fish and Wildlife Service 1999h, 2010b, Bradley et al. 2004, Bradley and Hines 2007, J.A. Moore, pers. comm., C. Vandello, pers. comm.

Hypericum cumulicola (Highlands scrub hypericum)	FE	IS, SF	R, O	It does well under scrub fire regimes (e.g. 5-20 year intervals).

Killed by fire but recruits heavily from dormant seeds in the seed bank. Higher fecundity, survival, establishment, and population growth rates in areas that receive periodic fire. Requires open sandy patches. Above-ground individuals disappear over time in long-unburned sites (e.g., by 24 years after fire). Subsequent mortality in the seed bank results in extirpation. Mortality rates are higher along roads that receive periodic mowing, though populations persist. Co-occurs with FSJ, under FSJ umbrella.

Quintana-Ascencio et al. 1998, 2003, Quintana-Ascencio and Menges 2000, E.S. Menges, pers. comm., J.J. Navarra, pers. comm.

Lechea cernua (Nodding pinweed)	ST	IS, CS, SF	O, R	Not very sensitive to fire return interval

Both re-sprouts and recruits seedlings after fire. Needs gaps in rosemary scrub or scrubby flatwoods, which are created by fire. Has been observed to do well in mowed roadsides. Co-occurs with FSJ, and under FSJ umbrella.

Johnson and Abrahamson 1990, Gordon 1992, Hawkes and Menges 1996, Maliakal-Witt et al. 2005, E.S. Menges, pers. comm., M.R. Jenkins, pers. comm.

Lechea divaricata (Pine pinweed)	SE	CS, SF	O	Unknown

Found in sandy openings, and observed to increase following burning or log and burn treatments. Relies on sandy openings, which disappear in the absence of fire. Has been observed to increase following a log and burn treatment. Co-occurs with FSJ and under FSJ umbrella. FNAI suggests applying prescribed fire to create a mosaic of habitat conditions.

Florida Natural Areas Inventory 2000b, M.R. Jenkins, pers. comm., P.A. Schmalzer, pers. comm.

Lechea lakelae (Lakela's pinweed)	SE	CS	O	Unknown

Restricted to Collier County and possibly Broward County. May be extinct.

Gann et al. 2002

Liatris ohlingerae (Florida blazing star)	FE	IS, SF, SH	O, R	Often found in scrubby flatwoods (5-20year fire return interval) and rosemary scrub (15-30 fire return interval)

Probably maintains healthy populations over this range. Herndon (1999) suggested that a 20-40 year fire return interval may be optimal. Re-sprouts after fire. Does not maintain persistent seed bank. Will persist in long-unburned oak scrub, but oak and pine litter reduce seedling recruitment. Will likely re-sprout if only above-ground plant structures are impacted. Co-occurs with FSJ and under FSJ umbrella.

Herndon 1999, Weekley and Menges 2003, Weekley et al. 2008, E.S. Menges, pers. comm., J.J. Navarra, pers. comm.

Lupinus aridorum (Scrub lupine)	FE	IS, SH	O, R	Unknown

Response to fire not known, but probably like other lupine species. Most likely killed by fire, with regrowth from seed bank. It has been suggested that hot fires will kill plants while a fire that moves rapidly through a sparsely vegetated clearing will spare many plants. Scrub lupine requires open, sandy patches that disappear with lack of fire. Mechanical clearing potentially could create the bare sand and open, sunny conditions required by the species. However, mechanical disturbance to existing populations should be avoided. Does not co-occur but should be covered by the "scrub-jay umbrella" if the species is well established with a strong seed bank, but any management activity around plants should be done in a research context. Hand-weeding or treatment of invasive plants should not occur within 2 ft. Exercise caution when applying management treatments, because invasive plants can fill gaps and inhibit germination of seedlings. No observations of response to prescribed fire or wildfire, though at least one plant was observed germinating after a pile burn.

U.S. Fish and Wildlife Service 1996, 1999i, 2007c, The Nature Conservancy Lake Wales Ridge Program 1999b, J. Rynear, pers. comm., I.J. Stout, pers. comm.

Matelea pubiflora (Sandhill spiny-pod)	SE	SH, IS	O, R	Unknown

Grows vigorously and flowers after fire. Co-occurs with FSJ and under FSJ umbrella.

M. R. Jenkins, pers. comm.

Nolina brittoniana (Britton's beargrass)	FE	IS, SF, SH	O, R	Can probably tolerate a wide range of fire return intervals (e.g. 2-60 years).

Re-sprouts after fire. Generally no significant change in flowering or density following fire, though high intensity fire can cause mortality. Occurs in both scrub and sandhill with a large range of time since fire. May persist and expand in shaded and overgrown sites. Of all the listed vascular plants in scrub and sandhill, probably the most tolerant of vegetation changes in long unburned areas. Co-occurs with FSJ and under FSJ umbrella.

Weekley 1997a, Weekley and Menges 2003, Slapcinsky et al. 2010, E.S. Menges, pers. comm.

Oncidium bahamense (Dancing-lady orchid)	SE	CS	R	Unknown, but the species is found at highest densities in later successional scrub.

Killed by fire, and can persist for long periods without fire, but requires periodic disturbance for recruitment. Mechanical treatments likely to kill individuals. However, marking and mowing around individual plants could benefit the species. Co-occurs with FSJ, rarity requires special management. Mark plants, and do not burn or mow individuals. Reduce fuels near plants to reduce fire intensity in prescribed burns.

M.R. Jenkins, pers. comm.

Paronychia chartacea (Paper-like nailwort)	FT	IS, SF	R	The recommended fire return interval for rosemary scrub (15-30 years) should maintain populations.

Killed by fire, but recruits from soil seed bank. A gap specialist that requires periodic fires to reduce litter and maintain open space. Occurrence and density decrease with time since fire, though can persist for decades without fire in larger gaps. Post-fire response is better than post-mechanical response. Co-occurs with FSJ and under FSJ umbrella.

Menges and Kohfeldt 1995, Schafer et al. 2010, E.S. Menges, pers. comm.

Persea humilis (Scrub bay)	NL	IS, CS, SF	O, R	Unknown

Resprouts after fire. Increases in frequency and abundance with time since fire in scrubby flatwoods. Can persist for decades without fire. Co-occurs with FSJ, probably under FSJ umbrella. Susceptible to laurel wilt. Control of laurel wilt likely to be important.

Menges and Kohfeldt 1995, Hughes et al. 2012, E.S. Menges, pers. comm.

Polygala lewtonii (Lewton's polygala)	FE	SH, IS	O	Should be managed with frequent fires (2-8 years).

Primarily a sandhill species dependent on frequent fires. Often killed by fire, but may re-sprout. Germinates from a persistent soil seed bank. Post-fire cohorts have higher seedling recruitment and survival, earlier flowering, and longer lifespans. Declines rapidly with fire exclusion. Unlikely to persist in long-unburned areas. Co-occurs with FSJ, but is found primarily in sandhill and benefits from more frequent fire compared to scrub-jays. Note that the scrub-jay umbrella does not apply to sandhill.

Weekley and Menges 2012, E. S. Menges, pers. comm., J. J. Navarra pers. comm., C. Peterson, pers. comm.

Polygala smallii (Tiny polygala)	FE	CS, SH	O	Unknown

Fire ecology not well known. Plants usually appear, flower, and then disappear until the next fire or other suitable disturbance. Killed by fire, but returns from the seed bank. The species requires high light levels and open sandy patches without litter accumulation. Co-occurs with FSJ and under FSJ umbrella. FNAI suggests using prescribed fire to create and maintain sandy openings. The seed bank can persist for years.

U.S. Fish and Wildlife Service 1999j, 2010c, Florida Natural Areas Inventory 2000c, M. R. Jenkins, pers. Comm.

Polygonella basiramia (Florida jointweed; wireweed)	FE	IS, SF	R, O	Unknown, but should do fine with a fire return interval of 5-30 years.

Killed by fire, but germination is stimulated by fire or other disturbances that create gaps in vegetation. Lacks a persistent seed bank. Must recruit from outside the burned area or from unburned patches to recolonize after fires. Promoting patchy fires would benefit the species. Requires open patches of bare sand, which can disappear in the absence of fire. Will persist in long-unburned scrub if open gaps remain. Increased following log and log-and-burn treatments. Co-occurs with FSJ and under FSJ umbrella. Promoting patchy fires would benefit the species.

Hawkes and Menges 1995, Quintana-Ascencio and Menges 2000, Boyle et al. 2003, Weekley et al. 2013, E. S. Menges, pers. comm., J. J. Navarra, pers. comm.

Polygonella myriophylla (Small's jointweed)	FE	IS, SH	R, O	Persists over a wide range of fire return intervals (e.g. 10-50 years); abundance decreases with fires that occur too frequently or too infrequently.

Killed by fire but recruits from seeds or clonal growth from plants adjacent to burned areas. Frequent fires will reduce abundance. Can persist in most sites for decades after fire, though abundance decreases over time. Benefits from low-intensity mechanical treatments, and responds well to mowing that occurs above the soil surface. Co-occurs with FSJ and under the FSJ umbrella. Promoting patchy fires would benefit the species.

Weekley and Menges 2003, Quintana-Ascencio et al. 2008, Weekley et al. 2008a, E. S. Menges, pers. comm., J. J. Navarra, pers. comm., P. Quintana-Ascencio, pers. comm.

Prunus geniculata (Scrub plum)	FE	IS, SH	O	Probably optimal to burn every 4-50 years.

Very strong re-sprouter. Rapidly regains pre-burn height and stem number. Fire increases chances of flowering and recruitment. Flowering declines with time since fire, and shade from encroaching shrubs and buildup of litter may inhibit seedling establishment. Can persist without fire for decades, but high mortality rates seen in an area with no fire for 60 years. Will likely re-sprout if only the above-ground stems are impacted. Co-occurs with FSJ and under FSJ umbrella.

Weekley 1997b, Weekley and Menges 2003, Weekley et al. 2010, E.S. Menges, pers. comm., J.J. Navarra, pers. comm.

Pteroglossaspis ecristata (Non-crested eulophia; giant orchid)	ST	IS, SH, other	O	Unknown

Fire provides sunny openings and reduces competition with woody species. The species appears positively associated with fire. Co-occurs with FSJ and under FSJ umbrella. The species does not always produce above-ground stems every year.

Florida Natural Areas Inventory 2000d, P.A. Schmalzer, pers. comm.

Rhyncospora megaplumosa (Hairy-spikelet beakrush)	SE	SF	N/A	Often found in frequently burned scrubby flatwoods.

Found in frequently burned scrubby flatwoods, and flowers profusely in areas following burning. Grows in sandy, open patches. Probably shaded out when shrub encroachment occurs. Co-occurs with FSJ and under FSJ umbrella.

Bridges and Orzell 2000, Florida Natural Areas Inventory 2012, M. R. Jenkins, pers. comm.

Schizachyrium niveum (Scrub bluestem)	SE	IS	R, O	Unknown

Killed by fire. Recolonizes burned areas via seeds. Recruitment may be uncoupled from fire. Patchy burns probably benefit this species. Grows in sandy, open patches. Observed to disappear with litter accumulation in sandhill. Possibly shaded out when shrub encroachment occurs. Co-occurs with FSJ and under FSJ umbrella. Promoting patchy fires would benefit the species.

Weekley and Menges 2003, E. S. Menges, pers. comm., B. Pace-Aldana, pers. comm.

Stylisma abdita (Scrub stylisma)	SE	IS, SH	Unknown	Unknown

Grows vigorously and flowers after fire. Can persist in the long absence of fire. Seems to prefer open, litter free patches; long intervals without fire would presumably be detrimental. Not often observed in firebreaks or roadsides. Co-occurs with FSJ and under FSJ umbrella. Very little information on this species.

Florida Natural Areas Inventory 2012, M. R. Jenkins, pers. comm., E.S. Menges, pers. comm.

Warea carteri (Carter's warea)	FE	CS, SF, SH, IS	O	Probably every 4-15 years.

Killed by fire, but fire stimulates germination from a persistent seed bank, resulting in a dramatic population increase the first year after fire. Flexible enough to persist in both sandhill and scrubby flatwoods. Relies on fire to reduce competition with shrubs. Some seeds may survive for a decade or longer, but fire exclusion is likely to result in depletion of the seed bank and eventual extirpation. Small, fluctuating populations may persist in mechanically disturbed areas like fire lanes or trails. Co-occurs with FSJ. Note that the scrub-jay umbrella concept does not apply to sandhill. An annual plant with overlapping cohorts due to delayed germination. Population numbers quite variable, but typically show a biennial fluctuation after fires, with dampening of population numbers over time. Patchy fires might dampen population fluctuations.

Menges and Gordon 1996, Evans et al. 2000, Slapcinsky et al. 2010, Quintana-Ascencio et al. 2011, E.S. Menges, pers. comm.

Ziziphus celata (Florida ziziphus)	FE	SH, IS	O	Can probably tolerate a range of fire return intervals from 3-20 years (possibly more).

Probably does best with frequent fire. Strong re-sprouter after fires, and fires can potentially revitalize moribund individuals. Fire also can provide bare patches necessary for recruitment of new shoots, although data are sparse. Shrubs and vines encroach and compete with the species in the absence of fire. Careful hand-removal of weeds and encroaching native shrubs maintains bare patches needed for recruitment of new shoots. Forms dense, multi-stemmed clumps in response to mowing. Does not co-occur, primarily in sandhill, a rarity which requires special management. Note that the scrub-jay umbrella does not apply to sandhill. Extremely rare; thought to be extinct until rediscovered in 1987.

Ziziphus celata Species Account n.d., Weekley and Menges 2008, E.S. Menges, pers. comm.

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Appendix 4: Mechanical methods for vegetation reduction

For all mechanical methods, minimize soil disturbance and opportunities for invasive plant intrusion, and maximize the mosaic burn effect by utilizing 'sloppy' cuts. The goal of all these treatments should be, when possible, to return fire to the landscape ideally less than a year after the mechanical treatment.

Chain Saw: The least damaging method to reduce vegetation that causes minimal soil disturbance and chance of invasion by exotic plants. Trees and/or tall shrubs should be cut at or near ground level to reduce the chance of vehicles getting caught on stumps. Piling felled trees creates hotspots during subsequent burns and can be used to promote openings.

Cutting/ Grinding: Used to reduce shrubs and trees by various methods of cutting, or grinding vegetation. Examples include the Brown Tree Cutter, Gyro-Trac, Kershaw Klearway, Fecon Bull Hog, and Brontosaurus. Using a coarse cut or only cutting the tops of vegetation will reduce the amount of mulch generated and create more desirable conditions for burning. Finer fuels may be hard to burn if they are wet or compacted, or they may burn too severely due to long smoldering time.

Girdling: Can reduce tree density while retaining snags on the landscape. Snags are important for cavity nesting birds, provide sentinel perches for scrub-jays, and dropped limbs create sandy openings after fire.

Roller Chopping: The number of drums, number of passes, and weight of drums will vary between sites, but the most appropriate selection will include only the minimum needed to reduce vegetation height while causing the least amount of soil disturbance. Vehicles towing drums should avoid sharp turns that create rutting.

Root Raking: Causes substantial soil disturbance and should only be used where there are no other vegetative reduction methods available because this technique causes substantial soil disturbance, increases potential for invasive plant infestation, increases chances of killing fossorial animals, and has other negative consequences to the soil.

Timber Harvest: May be a suitable management approach for reducing or eliminating some canopy trees.

Appendix 5. A pictorial companion to the Scrub Management Guidelines

PART 1: TYPES OF SCRUB IN PENINSULAR FLORIDA

1.a. Oak scrub

Oak scrub at Lake Wales Ridge Wildlife and Environmental Area, Lake Placid Scrub Tract, Highlands County. Oak scrub is characterized by shrubby oaks with bare patches of sand interspersed throughout. Photo by Adam Kent.

Oak-palmetto scrub adjacent to the Atlantic Coastal Ridge in Valkaria Scrub Sanctuary, Brevard County. Photo by Craig Faulhaber.

Long-unburned oak scrub often has a sand pine canopy, such as in this sand pine scrub in Ocala National Forest, where sand pines have been intentionally planted. Photo by Craig Faulhaber.

Rosemary scrub on the McJunkin Unit of the Lake Wales Ridge WEA, Highlands County. Rosemary scrub is dominated by Florida rosemary. Photo by Reed Bowman.

PART 2: OPTIMAL HABITAT CONDITIONS FOR FLORIDA SCRUB-JAYS

2.a. Vegetation height in oak scrub

The average vegetation height in this management unit in Ocala National Forest is optimal for scrub-jays, containing enough medium height (4-5.5 ft tall) shrubs to provide cover, acorns, and nest sites. Photo by Craig Faulhaber.

Medium-height oak-palmetto scrub in Valkaria Scrub Sanctuary, Brevard County. Small patches of taller shrubs, like those on the left in the background and on the right in the foreground, provide structural diversity. Mosaic burns can foster such variability on the landscape. Photo by Craig Faulhaber.


A 6-ft tall person can see over much of the habitat in medium-height scrub, such as this scrub on Seminole State Forest in Lake County. Photo by Ralph Risch.


A scrub-jay perches on an oak in medium-height (average shrub height 4-5.5 ft) oak scrub at Archbold Biological Station in Highlands County. Photo by Craig Faulhaber.

The Marjorie Harris Carr Cross Florida Greenway, Marion County, contains a mosaic of vegetation heights, which is important for maintaining scrub-jays. Scrub-jays do poorly if all of the habitat is short, as seen in the foreground of this photo. Complete, extensive treatments over large acreages can displace scrub-jays. Photo courtesy of Sandra Marriffino

Long-unburned scrub, like this area in Marion County, becomes too tall for scrub-jays and lacks the sandy openings needed by scrub lizards, gopher tortoises, and many other scrub species. Photo by Karl Miller.

Maintaining a mosaic of scrub heights on the landscape benefits many species characteristic of scrub. A mosaic can be maintained either among management units or within a management unit. This photo from Archbold Biological Station illustrates both concepts: adjacent management units provide sufficient litter for sand skinks and cover for scrub-jays, and the unburned patches within the burned unit also provide necessary cover. Photo courtesy of Roberta L. Pickert.

Mosaic burns, such as this one at Disney Wilderness Preserve in Osceola County, can create spatial variability within a management unit. Photo by Craig Faulhaber

2.b. Sandy openings

Sandy openings are important for many species characteristic of scrub. In oak scrub, sandy openings usually occur in small patches interspersed throughout the habitat, as in this area in Ocala National Forest, Marion County. Photo by Craig Faulhaber.

This oak scrub on the Ten Mile Ridge at St. Sebastian River Preserve State Park, Indian River County, has many small sandy openings. Optimal scrub-jay habitat usually contains 10-50% bare sand, and sandy openings are critical for many scrub plants. Photo by Craig Faulhaber.

Oak-palmetto scrub on Merritt Island in Brevard County occurs on dunes separated by swale marshes. Note the lack of sandy openings in this photo. The average shrub height is short due to recent application of fire, but the sandy openings have disappeared due to a history of fire exclusion. Restoring sandy openings is a significant challenge for land managers in some coastal areas. Photo by Craig Faulhaber.

2.c. Density of pine trees

Optimal scrub-jay habitat has few pine trees, ideally less than 1 tree per acre in oak scrub, as in this area of Archbold Biological Station in Highlands County. Photo by Adam Kent.

This photograph, taken in 2009, depicts snags resulting from a stand-replacing wildfire in sand pine scrub in 2006 (foreground) and 2009 (background) in the Juniper Prairie Wilderness of the Ocala National Forest. Scrub-jays tolerate snag densities as in the foreground, and the snags provide important habitat for cavity-nesting species like Southeastern American kestrels. Photo by Craig Faulhaber.

Scrub-jays can tolerate 1-2 pine trees per acre, as in this mix of oak-palmetto scrub and flatwoods on Merritt Island, Brevard County. Limbs cast from widely-scattered pine trees may help restore sandy openings during fires in some coastal areas. Photo by Craig Faulhaber.