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Translating Science into Conservation Action
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CONSERVATION CATALYSTS

The Academy as Nature's Agent

Edited by JAMES N. LEVITT

Saving the Florida Scrub Ecosystem: Translating Science into Conservation Action

Hilary M. Swain and Patricia A. Martin

This is the story of the endeavor to save the Florida scrub, ranked as the 15th most endangered ecosystem in the nation (Noss and Peters 1995). Our focus is on the scrub habitat of the Lake Wales Ridge in central Florida and its associated threatened and endangered plants and animals. This scrub ecosystem came perilously close to extirpation, but has been rescued from oblivion largely by the catalytic partnership forged between an internationally recognized nonprofit research institution, Archbold Biological Station, and the global conservation organization The Nature Conservancy (TNC). By the 1980s, high demand for dry, sandy soils—first for citrus and then for housing—had so diminished the Florida scrub that the remaining habitat was declared globally imperiled (Florida Natural Areas Inventory 1990). Scientists and conservationists rallied to save the scrub. A massive investment by public agencies and nonprofit organizations has tripled the area of protected scrub and reduced the risk of extinction for many species. A broad and enduring alliance of science and conservation partners has coalesced over the last 20 years, providing the social capital to sustain this conservation juggernaut. How did all these efforts come together in the remote heart of rural central Florida? Who were the key people? When were the turning points? Which opportunities were seized or missed? And what are the threats and challenges that must be overcome to maintain success into the future?

THE LAKE WALES RIDGE: A UNIQUE LOCATION AND BIOLOGICAL HISTORY

The ancient sand of the Florida scrub was formed millions of years ago as the southern Appalachian mountains eroded. Rivers carried the quartz sand to the sea, and coastal currents transported the sand south, creating dune islands. Sea levels have risen and fallen many times, with changing



FIGURE 4.1. Location of the Lake Wales Ridge in Florida.
 Source: Map used with permission from Archbold Biological Station.

climate and the advance and retreat of global ice sheets. When sea level was low, the shallow margins of the Gulf of Mexico emerged as part of Florida; when sea level was high, much of Florida was isolated or underwater. Whenever the oceans receded, new coastal sand dunes formed, re-

sulting in a series of parallel ridges, running north to south, where a unique ecosystem, the Florida scrub, developed and persists. The Lake Wales Ridge, the largest and oldest of these scrub ridges in central Florida, has stood above sea level for more than a million years (White 1970, McCarten and Moy 1995). Today it lies about 80 miles from both the Atlantic Ocean to the east and the Gulf of Mexico to the west (figure 4.1), occupying an area of 116 miles north to south by 5 to 10 miles east to west (Weekley et al. 2008). Rising 100 to 300 feet above sea level, it is the sandy backbone of central Florida. With its unique ecosystem and distinct geography, the Ridge is a cohesive, identifiable landscape for conservation action.

Millions of years ago, the higher, drier lands of Florida were connected biologically to the terrain of the U.S. West and desert Southwest that extends as far as California and Mexico; as a result, many plants and animals in these disjunct arid ecosystems are near relatives—the Florida scrub-jay (*Aphelocoma coerulescens*) and other scrub-jays found in the west (*Aphelocoma californica* for example), as well as Florida ziziphus (*Ziziphus celata*) and Parry's jujube (*Ziziphus parryi*). Like oceanic islands, the ancient scrub ridges were intermittently isolated by the sea or surrounded by wetlands inhospitable to scrub plants and animals, favoring the rapid evolution of distinct races and species. With strong selection pressures for adaptations to hot wet summers, cool dry winters, droughty nutrient-poor sandy soils, and frequent wildfires, a unique collection of plants and animals evolved in the Florida scrub (Myers 1990, Menges 1998). Given this biogeographical history, it is no surprise that the Florida scrub of the central ridges is rich in endemics, many found nowhere else in the world (Muller et al. 1989). It is a biodiversity hotspot for rare endemic species that would rank comparably with other familiar global hotspots such as the Caribbean Islands (Turner et al. 2006a).

BUILDING THE KNOWLEDGE BASE FOR SCIENCE AND CONSERVATION

The unique flora and fauna of the Florida scrub drew ardent interest from early naturalists and explorers. In the first half of the 20th century, the botanist John Kunkel Small (Austin et al. 1987) and the entomologist Theodore Hubbell (1932) argued for the importance of the scrub habitat. Over the same timespan, chance brought three wealthy philanthropists with an interest in science and conservation to the Ridge. John

A. Roebing II, Richard Archbold, and Edward Bok established the tradition of science and land conservation that would eventually lead to the first efforts to protect the Ridge.

In 1941, wealthy industrialist John A. Roebing gifted his 1,058-acre Red Hill Estate at the southern end of the Ridge to aviator, explorer, and patron of science Richard Archbold (1907–1976), who founded the Archbold Biological Station on the property and lived on site for the next 37 years. The station hosted a veritable who's who of mid-century ecologists; thousands of plants, insects, birds, and mammals were studied, collected, and preserved, building the knowledge of the Florida scrub's biodiversity. James Layne became Archbold's research director in 1967, setting a vision for long-term studies and environmental monitoring. Thomas Eisner, visiting professor from Cornell University, pioneered the field of chemical ecology at Archbold and served as the ecosystem's prominent spokesman for science and conservation on the national stage. He later wrote, "The Archbold Station was to become my primary natural laboratory, and is to this day my favorite outdoor haunt. It is where I made most of my discoveries and where I feel most at home as a naturalist. I fell in love with the Florida scrub on my very first trip in 1958, and have remained in love with that unique habitat ever since, acutely aware of its threatened status" (Eisner 2003, 80). Richard Archbold died in 1976, leaving the land, buildings, and his personal fortune to the nonprofit Archbold Expeditions to continue the station's research, conservation, and education programs.

The station's research programs continue to this day. The study of the Florida scrub-jay initiated at Archbold in 1969 by Glen Woolfenden and now led by Reed Bowman, is the longest-running continuous bird population study in North America. To date, scrub-jay research at Archbold has produced nearly 200 scientific publications, including Woolfenden and John Fitzpatrick's classic book on the subject (Woolfenden and Fitzpatrick 1984). Archbold ornithologists spearheaded conservation planning to save this threatened species, and their work has served as a model for bird conservation projects worldwide. A succession of plant ecologists working at Archbold, from Leonard Brass in the 1940s to Eric Menges now, has produced detailed descriptions of the scrub plant community and its dependence on fire (Abrahamson 1984a, Myers 1990, Menges 1998). Working at Archbold under contract from U.S. Fish and Wildlife Service, Ann Johnson (1981) produced the first systematic inventory of endemic scrub plants at 38 sites on the Ridge. Eric Menges

has published widely on the population biology of rare scrub plants, especially in relation to fire, creating detailed, long-term datasets that inform science and guide management and recovery (Menges and Kohfeldt 1995). His research has vital implications for plant conservation studies in fire-driven ecosystems around the world. Mark Deyrup, once described as the “Hubble telescope of the insect world,” (Eisner 2001) has personally added more than 150,000 specimens of arthropods to the Archbold natural history collection and published descriptions of 12 new arthropod species from the Ridge in the last 30 years, reminding us that no biodiversity inventory is ever complete. He is the epitome of the naturalist with an engaging style that captivates the public, giving them an appreciation for science and conservation (Deyrup and Eisner 1993).

Described recently by Carlton Ward as the “Smithsonian of the Scrub” (Ward 2011), Archbold, with its geographic focus on the Ridge, has forged and promoted a strong interdisciplinary approach to the scrub ecosystem. The Archbold Board of Trustees, committed to the seamless coupling of rigorous inquiry and effective conservation, has appointed two recent directors, John Fitzpatrick (1987–1995) and Hilary Swain (1995–present), with a passion for both pursuits. Archbold supports a staff of 50, hosts thousands of visiting scientists and students annually, and has provided training for more than 460 research interns since 1968. The generosity and vision established by founder Richard Archbold (Morse 2000), nurtured by his sister Frances Archbold Hufty (who served as chairman of the board from 1976 to 2010), and sustained by the family members who continue to serve on the board, has enabled Archbold to become the scientific powerhouse behind conservation on the Ridge.

Other academics in the state have also made important contributions to scrub conservation. Richard Wunderlin at the University of South Florida (USF) has prepared status reports of endemic scrub plants and compiled numerous herbarium records for scrub species. Henry Mushinsky and Earl McCoy, also at USF, contributed to system-wide understanding of herptile communities (Mushinsky and McCoy 1991). Jack Stout at the University of Central Florida and researchers at Kennedy Space Center—notably Ross Hinkle, Paul Schmalzer, and Dave Breining—have published many papers making important contributions to our understanding of northern and coastal Florida scrubs.

Florida Natural Areas Inventory (FNAI), the state heritage program established by TNC in 1981, built critical databases for the Florida

scrub. In 1983, TNC and FNAI contracted with Gary Schultz at the University of Florida to survey 55 scrub sites (Cooper and Schultz 1984). FNAI continues to systematically track the status of scrub species and protected areas (Schultz et al. 1999). Kris Delaney, a botanist from Avon Park, found and described several new species of scrub plants on the Ridge, including the Avon Park harebells (*Crotalaria avonensis*) in 1989 and the Highlands County goldenaster (*Chrysopsis highlandsensis*) in 2002. And independent consultant Steve Christman recorded many astute observations and site records.

A second research facility was founded on the Ridge in 1986 when Bok Tower Gardens joined the Center for Plant Conservation, an organization of botanical institutions committed to conserving plant species. Curator of Endangered Plants Susan Wallace at Bok Tower Gardens established their endangered plant species program using propagation techniques, reintroductions of plants into the wild, and a collection of both seeds and cuttings (Wallace and McMahon 1988).

However, despite this rich history of study and widespread academic recognition of its conservation value, the Florida scrub was almost lost.

SCRUB ON THE RIDGE SUCCUMBS TO A LITANY OF ASSAULTS

Too dry for most crops and too poor for cattle ranching, the Ridge's scrub habitat remained more or less intact until the early 20th century, when successive losses to logging, citrus, mining, and real estate all but wiped it off the face of Florida.

Timber

During 1920 and 1921, the Consolidated Land Company hired A. E. Little to conduct a timber inventory of its lands throughout Highlands County (Little 1920–1921). He described most trees on scrub soils as “worthless” but documented harvestable pines on Ridge slopes. Logging camps and company towns arrived, and by the 1950s, nearly all the virgin timber on the Ridge had been logged. The remnants of Sherman Mill, one of the original eight logging camps on the Ridge, are preserved on Archbold land.

Oranges

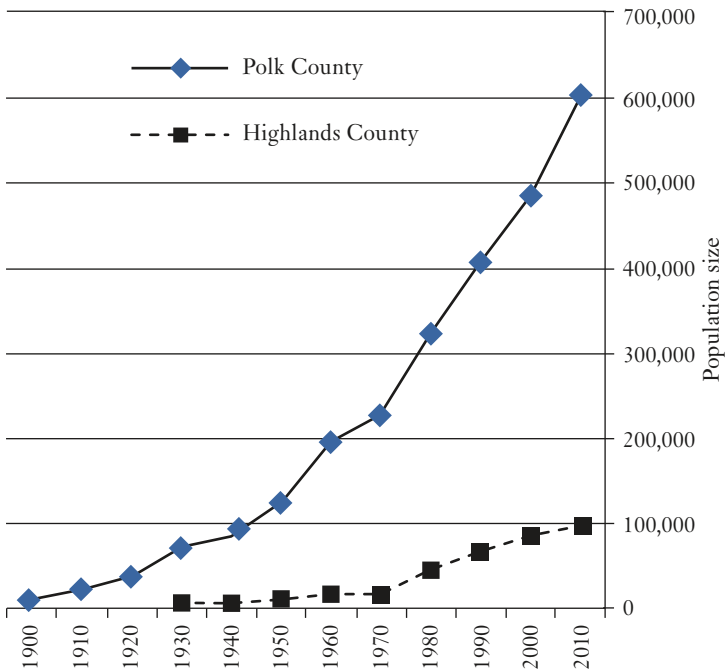
After a series of devastating freezes destroyed orange crops planted north of the Ridge, citrus growers began arriving in the 1920s and 1930s, planted small groves, and founded towns with reassuring names like

Frostproof. Later, these citrus barons, described eloquently in John McPhee's (1966) book *Oranges*, established large groves on the more fertile yellow sands that were often home to sandhill rather than scrub habitat. Initially, the northern half of the Ridge was converted to citrus, with the result that very little scrub or sandhill habitat remains in that area. As late as the mid-1980s, citrus growers were planting large acreages on the white sands and scrub-dominated soils of the southern Ridge.

Development

Some scrub was lost when the resort communities of the 1910s and 1920s—such as Lake Wales, Avon Park, Sebring, and Lake Placid—were built in conjunction with the railroad line. Many of these developments went bankrupt during the Great Depression, and little further population growth ensued until the 1970s, when real estate on the Ridge fell into further cycles of boom and bust development. From 1970 to 2010, Polk County's population trebled to more than 600,000 and that of Highlands County increased fivefold to 100,000 (figure 4.2). High, dry

FIGURE 4.2. Population growth in Polk and Highlands counties (along the Lake Wales Ridge) during the last century.
 Source: Bureau of Economic and Business Research (BEBR), University of Florida.
 Graph used with permission from Archbold Biological Station.



scrubland that had not been converted to citrus became a prime target for development.

Counties permitted huge platted subdivisions up and down the length of the Ridge. As a result, the remaining large areas of scrub were sold worldwide as quarter- and half-acre lots to unsuspecting buyers, often those from overseas or with military backgrounds. The legacy of these ill-conceived planning decisions and disingenuous marketing ploys still haunts modern Ridge conservation. The real estate cycle that reached its zenith from 2004 to 2007 threatened much of the remaining scrub, but the boom collapsed precipitously during the Great Recession in 2008, granting the land a temporary reprieve from further losses.

Sand Mining

In the wake of the rapid development of the 1970s and 1980s, the pockets of coarse quartz sands along the Ridge became attractive to mining companies. Mining, however, was an activity that aroused public concern; in 1988, a public outcry prevented the issuance of a mining permit for approximately 630 acres of a 2,800-acre scrub site northeast of Frostproof and adjacent to TNC's Tiger Creek Preserve. TNC's local attorney explained the potential for environmental impacts at the site as well as the fact that significant sand reserves existed elsewhere, and convinced all five Polk County commissioners to deny the mining request. The state subsequently purchased the land for conservation.

THE RIDGE BECOMES AN EPICENTER FOR THREATENED AND ENDANGERED SPECIES

Researchers have carefully documented the extent of habitat loss and fragmentation on the Ridge, and the number has risen inexorably over the past few decades, from 64 percent lost (Peroni and Abrahamson 1985) to 70 percent (Christman 1988a) to 83 percent (Weekley et al. 2008) (figure 4.3).

Given progressive habitat loss, it was inevitable that scrub plants and animals, notable for endemism and rarity, would be added to state and federal protected species lists (Christman and Judd 1990). The U.S. Fish and Wildlife Service (U.S. FWS) has classified 29 species on the

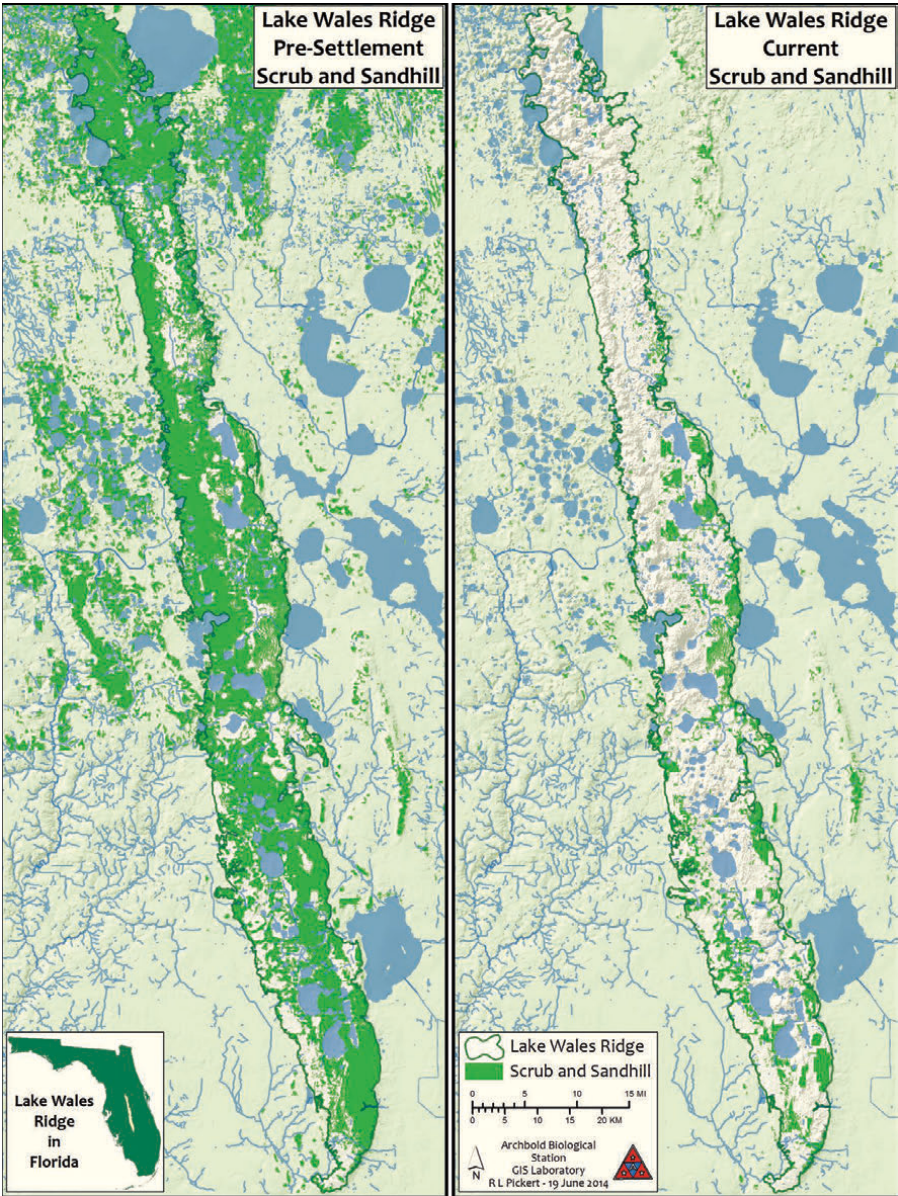


FIGURE 4.3. Extent of loss (83%) of scrub and sandhill habitat on the Lake Wales Ridge from (a) presettlement circa 1900 to (b) 2006.
 Source: Weekley et al 2008. Map used with permission from Archbold Biological Station.

Ridge as endangered or threatened (U.S. FWS 1999). Highlands and Polk counties, which support most remaining scrub habitat, rank among the top 11 counties in the U.S. critical to the protection of endangered species (Dobson et al. 1997, Chaplin et al. 2000). Highlands County is the highest-ranked county in the southeastern U.S. for its number of rare endemic plants (Estill and Cruzan 2001).

A database of imperiled Ridge species assembled by Turner et al. (2006a) records 56 species that either have NatureServe ranks of G3 (globally vulnerable) or higher, or are listed by the U.S. FWS as threatened or endangered. Of these 56 species, a subset of 36 plants and animals are endemic or near endemic to the Ridge (i.e., $\geq 80\%$ of all known occurrences are on the Ridge or are restricted to scrub or sandhill habitats in Florida). Other Ridge species may merit listing; for example, Deyrup and Carrel (2011) surveyed the Ridge for 93 scrub arthropod species that are either endemics or specialists dependent on gopher tortoise (*Gopherus polyphemus*) burrows. Of the 93 species, they note that 25 species of arthropods are not of conservation concern, as they occur on 10 or more Ridge sites. However, 66 species of arthropods are known on fewer than 10 sites, or their status is difficult to ascertain because they are hard to catch.

SURVIVAL OF THE SCRUB HANGS IN THE BALANCE

In 1988, Steve Christman (1988b) wrote an impassioned plea to the science and conservation community that “the ancient and unique scrub community of Florida’s Central Ridges will soon disappear forever.” At the time, only seven Ridge sites were protected; these totaled approximately 30,000 acres but harbored relatively little scrub or sandhill. Archbold had grown from 1,058 acres in 1941 to 3,974 acres in 1988, and was the only protected locality for two plants, Lake Placid scrub balm (*Dicerandra frutescens*) and wedge-leaved button snakeroot (*Eryngium cuneifolium*). Highlands Hammock State Park, gifted earlier to the state by the same Roebing family that donated the land for Archbold, totaled nearly 4,000 acres by 1988 but protected little scrub habitat. Lake Louisa State Park at the north end of the Ridge was established in 1973 after acquisition of nearly 1,800 acres under the state’s Environmentally Endangered Lands program, but it is a fairly disturbed site, with virtually no remaining scrub.

TNC had established a toehold on the Ridge in 1971 with its purchase of Tiger Creek Preserve, the story of which has its roots in a much older preservation effort. In the 1920s, author, publisher, and philanthropist Edward Bok established the 58-acre Mountain Lake Sanctuary, which encompassed a small patch of sandhill as well as gardens and a carillon tower. Bok also fell in love with an area on the eastern slope of the Ridge, although he never purchased the land himself. Decades later, Ken Morrison, director of the sanctuary (now called Bok Tower Gardens), and Bok's son, Cary, who was on TNC's Board of Governors, revived the dream. Morrison and philanthropist George Cooley mounted a grassroots fundraising campaign to purchase the eastern slope property. In 1971, TNC purchased 580 acres, to be called Tiger Creek Preserve; by 1988, it totaled 4,700 acres (now 4,862 acres) of mostly sandhill and forested wetlands. In 1989, TNC also began acquisition of the 829-acre Saddle Blanket Scrub Preserve, an exceptional example of Ridge scrub.

Between 1984 and 1986, the state of Florida, with funding from the Conservation and Recreation Lands (CARL) program, purchased 13,746 acres—the largest public area on the Ridge—that harbored some of the best remaining scrub in central Florida. The area became the Lake Arbuckle State Forest and State Park (later combined and renamed the Lake Wales Ridge State Forest).

Just to the east, off the Ridge, a much larger site of high conservation value was also in public ownership, but not with conservation as its primary mission. While WWII war clouds were gathering, the U.S. government purchased extensive land to provide for air-to-ground bombing training. The modern Avon Park Air Force Range (APAFR) is now 106,110-acres in size, encompassing a small scrub ridge called the Bombing Range Ridge and one of the highest numbers of threatened and endangered species of any Department of Defense (DOD) installation in the country, including several scrub species, though none of the rarest Ridge endemics.

Despite the seven protected sites on the Ridge and the APAFR, it was abundantly clear that the scrub and its associated species were “all going extinct” (Christman 1988b). The regulatory provisions of the Endangered Species Act had made scant headway in meeting recovery plan goals. The state listed only three sites as acquisition priorities: Saddle Blanket, Catfish Creek, and an extension of Highlands Hammock

(Florida Department of Natural Resources 1990). Nearly every site displayed “For Sale” signs; time for action was overdue.

SCIENTISTS RALLY TO SAVE THE SCRUB

In 1985, the Florida Game and Freshwater Fish Commission (FGFWFC)—now the Florida Fish and Wildlife Conservation Commission (FFWCC)—engaged scientist and conservationist Steve Christman to conduct a three-year statewide assessment of scrub plants and animals. In conjunction with Dennis Hardin at FNAI, he used aerial photography to identify more than 250 Ridge scrub and sandhill parcels for survey. His report (Christman 1988a) documented the status of 35 plants and two lizards, combining earlier data with his own survey results. The report crystallized the degree of endangerment for scrub species and provided a rallying call for conservation on the Ridge.

In response to this report and others, a workshop was convened at Archbold on November 29 and 30, 1989, with participants from Archbold, TNC, and federal, state, and local agencies as well as other scientists and conservationists to review potential plans for saving the Ridge ecosystem (Fitzpatrick 2012). Based on data, expert knowledge, and rudimentary mapping, the resultant white paper entitled *Biological Priorities for a Network of Scrub Preserves on the Lake Wales Ridge* (Archbold Biological Station 1989) established the goal of “provid[ing] for the long-term persistence and continued biological health of all species and natural communities native to the upland habitats on the Ridge, and to preserve their original geographic extent.” The report included maps of sites proposed for protection—24 in Highlands County and 25 in Polk County—that had not yet been included in any other land acquisition proposal. Decades of scientific knowledge were distilled into a single document, and the design of a network of conservation sites was proposed. At last, a large, ambitious, and cohesive plan for preserving Ridge habitat had been formulated and was finding an audience.

State Land Acquisition: The Lake Wales Ridge Project

The 1989 Biological Priorities Report was timely. John Fitzpatrick, Archbold director and board member of the Florida chapter of TNC, argued passionately for the supreme importance of protecting the remaining scrub of the Ridge. Emboldened by strong public support for

conservation, John Flicker, then-director of the Florida chapter of TNC, had conceived of a far-reaching strategy for state land acquisition. TNC promoted the cause; recruited allies in other conservation organizations and in state, county, and municipal governments; and formed alliances with supportive legislators (Willson 2012). In 1989, Governor Bob Martinez appointed a commission to examine threats to the future of Florida's environment. The commission recommended that the state sell long-term bonds to fund needed land acquisition rather than relying on the established mechanism of year-to-year collection of documentary stamp taxes (Farr and Brock 2006). (The attraction of the "doc stamp tax," generally levied on documents that transfer an interest in real property, was that it targeted state newcomers and real estate developers as an appropriate source of funds for conservation.) The Florida legislature responded in 1990 with passage of the landmark Preservation 2000 Act, authorizing the sale of \$3 billion in bonds from 1991 to 2000. This was a voluntary seller program with only willing landowners participating. Preservation 2000 (P2000) was a phenomenal success; Florida preserved almost two million acres for conservation and resource-based recreation through the programs it funded (Farr and Brock 2006).

As soon as the P2000 legislation passed, TNC, FNAI, and Archbold jointly submitted the *Lake Wales/Highlands Ridge Ecosystem CARL Project Proposal* to the state for consideration (TNC 1991). Drawing from the 1989 workshop, the authors targeted 21 scrub sites in Highlands and Polk counties to complement existing conservation lands. The proposal incorporated enough sites to protect a complete portfolio of scrub endemics and contain examples of each distinctive mix of scrub microhabitats. The spatial configuration allowed for sufficient sites along the linear north-south axis of the Ridge to protect the full geographic range of species. Multiple tracts connected by smaller habitat islands would serve as stepping stones for better dispersal of species. Other conservation attributes, like the protection of aquifer recharge, were also woven into the plan. The 21 sites encompassed everything from large single ownerships of scrub that had miraculously escaped clearance to the eight so-called megaparcels sites: large areas of scrub that had been subdivided and sold as quarter- and half-acre lots—many to foreign owners—but never developed and still retaining valuable scrub. Involving more than 20,000 lots, the megaparcels sites targeted for state acquisition were

a challenging legacy of earlier flawed planning. No one in real estate would envisage, never mind choose to assemble, such a complex acquisition strategy, except that these were the last, best, and often the only remaining areas of scrub.

After P2000 was launched, TNC convened a statewide planning charrette in 1991 to flesh out details for an acquisition strategy (Wilson 2012). Steve Gatewood led a group of approximately 50 well-known scientists and conservationists from nonprofit organizations and state agencies to determine Florida's areas of greatest need in the field of biodiversity preservation. The Lake Wales Ridge Project ranked among the top priorities at this planning charrette and, over the next two decades, would always rank at or near the top of the state's priority list for land acquisition.

The state contracted with TNC to serve as the acquisition partner and agent for most of the proposed Lake Wales Ridge Project sites. Early purchases included large single ownerships—an 800-acre extension to Highlands Hammock in 1990, the Placid Lakes Scrub (3,188 acres) in 1993, more than 4,000 acres for Allen David Broussard Catfish Creek Preserve State Park (1991 and 1994), the 9,995-acre Walk in the Water Tract (1995 and 1996) that was added to the Lake Wales Ridge State Forest (site of the proposed former sand mine that was refused planning permission), Lake June Scrub (897 acres in 1996), Gould Road (156 acres in 1996), and the major ownership in Silver Lake (2,020 acres). In 1998, TNC decided to retain ownership of the Saddle Blanket site. Bob Burns, Keith Fountain, Richard Hilsenbeck, and Mike Izzarone with TNC's protection department successfully closed many of these deals on behalf of the state. They also started purchasing the megaparcels—a grueling process, as it can be as difficult to purchase a single quarter-acre lot as a 4,000-acre parcel.

In 1999, following a 72 percent vote in favor of Amendment 5, the Florida constitutional revision provision to continue funding conservation land acquisition, the legislature passed a successor program to P2000, the Florida Forever Act. It authorized bonding \$300 million annually for up to 10 years, starting in 2000, and thus land acquisition on the Ridge continued. From 2000 to 2006, Hilary Swain, Archbold's executive director, served as the gubernatorial appointment on the nine-member Acquisition and Restoration Council, with responsibility to recommend acquisitions under Florida Forever as well as oversight of land management on all state-owned lands. Her participation gave the

science community unrivaled access to and insight about the state process of identifying and selecting lands for preservation. Under Florida Forever, TNC made extraordinary progress in purchasing lots on behalf of the state in the megaparcel, managing to close on 5,800 acres, or nearly 14,000 lots (out of a total of approximately 24,500 lots). Several changes were made over the years to the Lake Wales Ridge Project; some megaparcel sites were never started, a few less viable sites were dropped because of encroaching development, and three new sites and many boundary amendments were added. Overall, conservation progress under P2000 and Florida Forever was transformational; 15 of the original 21 sites proposed have been acquired or partially acquired, and 34,926 acres on the Ridge have been purchased (figure 4.4).

In the same timeframe, Archbold itself raised private funding, expanding to nearly 9,000 acres, and now lies nestled within a contiguous network of state- and federally-protected conservation lands totaling 53,000 acres.

State acquisition brought five major new players to the table for scrub conservation on the Ridge, contributing tremendous knowledge and greatly expanding capacity. Three agencies—Florida Department of Environmental Protection (FL DEP), Florida Forest Service (FFS, formerly the Florida Division of Forestry), and FFWCC—assumed management responsibility for state land acquisitions. The South Florida and Southwest Florida Water Management Districts (SFWMD and SWFWMD) also purchased and managed sites, with their major acquisitions being Horse Creek (1,325 acres) and Henscratch/Jack Creek (1,309 acres) respectively.

Following the financial crises of 2008, funding for the Florida Forever program and state for acquisition stalled. Few acres have been acquired since then. The Ridge was among 14 state conservation sites still targeted, although funds could only purchase a very small number of the 24,237 acres remaining, most of which are lots in the megaparcel sites.

Establishing the Federal Lake Wales Ridge National Wildlife Refuge

In response to the large number of federally listed species in jeopardy, the federal government joined the state government in land acquisition on the Ridge. In 1993, the U.S. FWS proposed establishment of the Lake Wales Ridge National Wildlife Refuge (U.S. FWS 1993); its goal was to enhance the recovery of four listed vertebrates as well as 26 listed or list-candidate plants. FWS employee Dave Martin took a passionate

interest in protecting Ridge plants, describing them as a national “treasure trove of biodiversity” (Martin 1993, 3). Although the refuge—the first designated to protect endangered plants—was authorized by Congress in 1994, little money was allocated for acquisition. Of the 19,630 acres proposed, only four tracts were acquired, although the state eventually purchased some proposed sites. The U.S. FWS now owns and manages a total of 1,843 acres on the Ridge, including Flamingo Villas (1,039 acres), Carter Creek South (626 acres), Snell Creek (Lake Marion) (139 acres), and Lake McLeod (38 acres) (figure 4.4).

Local Government Becomes Engaged: Polk County

Much of the Ridge’s biodiversity resides in two counties: Polk and Highlands. Of the two, Polk is larger and more urban. Thanks to a grassroots effort in 1994, a majority of voters in Polk County voted to increase their ad valorem taxes for the purchase of environmentally sensitive land. This county program attracted matching state funds to leverage its dollars, purchasing four Ridge sites that totaled 804 acres (figure 4.6). In 2008, a few local Highlands County champions also thought about mounting a local ballot, but times were tough, and the measure never made the ballot.

SCIENTIFIC EVALUATION: STATE OF THE SCRUB

Through a combination of nonprofit, local, state, and federal efforts, more than \$100 million has been spent for land acquisition on the Ridge in the last 25 years, and more than 104,000 acres of land—including approximately half the remaining native xeric upland habitat—has been set aside for preservation. The conservation community, appalled at what has been lost, remains somewhat amazed at what has been saved. But is it enough? Prompted by the question “to what extent has acquisition on the Ridge made a difference for conservation?” Hilary Swain at Archbold partnered with Dave Wilcove and Will Turner from Princeton University to complete the first scientific assessment of the success of land acquisition in reducing threats to rare and endemic Ridge species. Their *State of the Scrub* report (Turner et al. 2006a) synthesized existing data on 36 of the rare and endemic species on the Ridge. The analyses indicated that conservation efforts had contributed greatly to protecting imperiled plants and animals. Using a quantitative approach (figure 4.5), they showed that conservation purchases since 1988 had

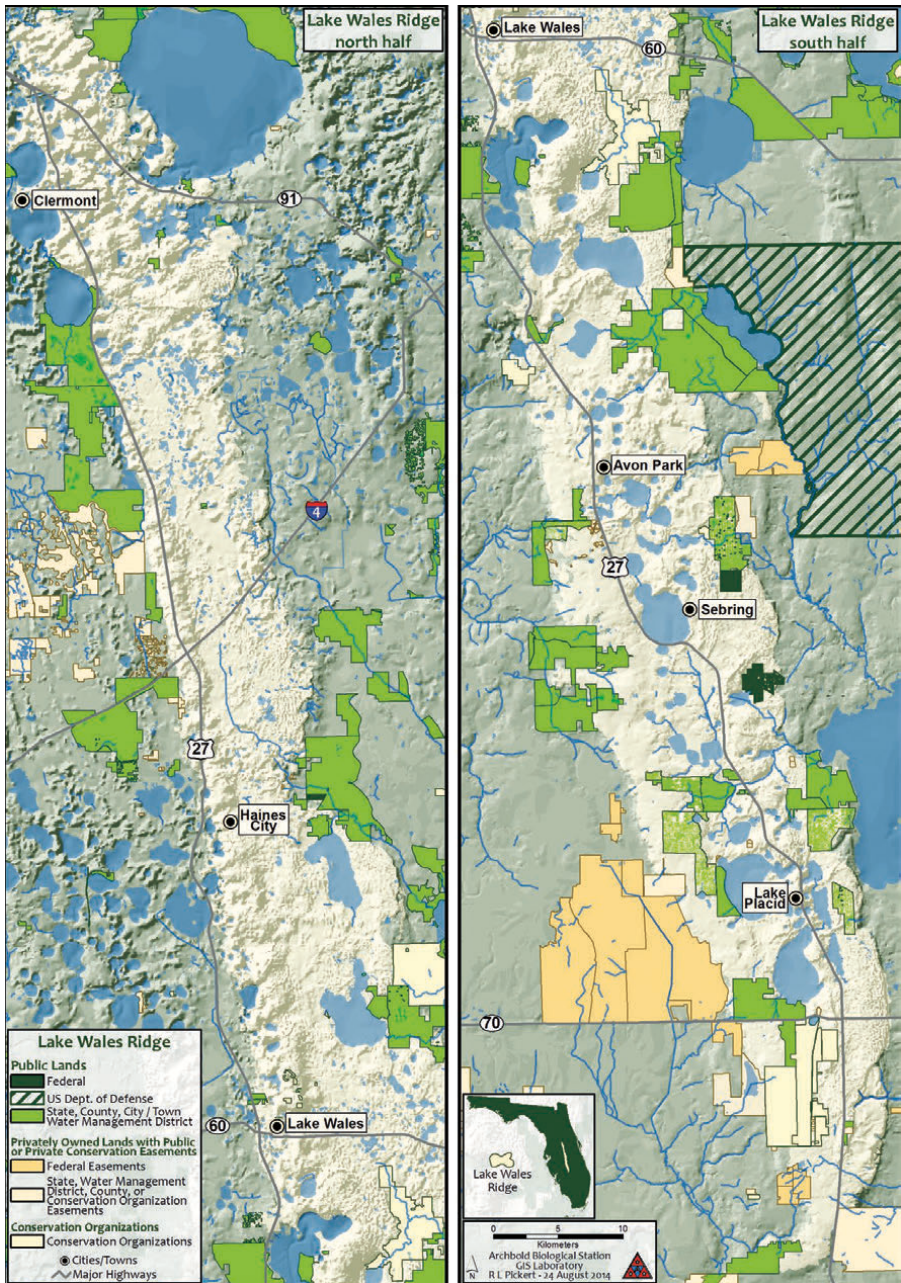


FIGURE 4.4. Land acquisition and easement purchases by federal, state, and local agencies and conservation organizations on the Lake Wales Ridge and surrounding lands.

Source: FNAI and Roberta Pickert, Archbold GIS Laboratory. Map used with permission from Archbold Biological Station.

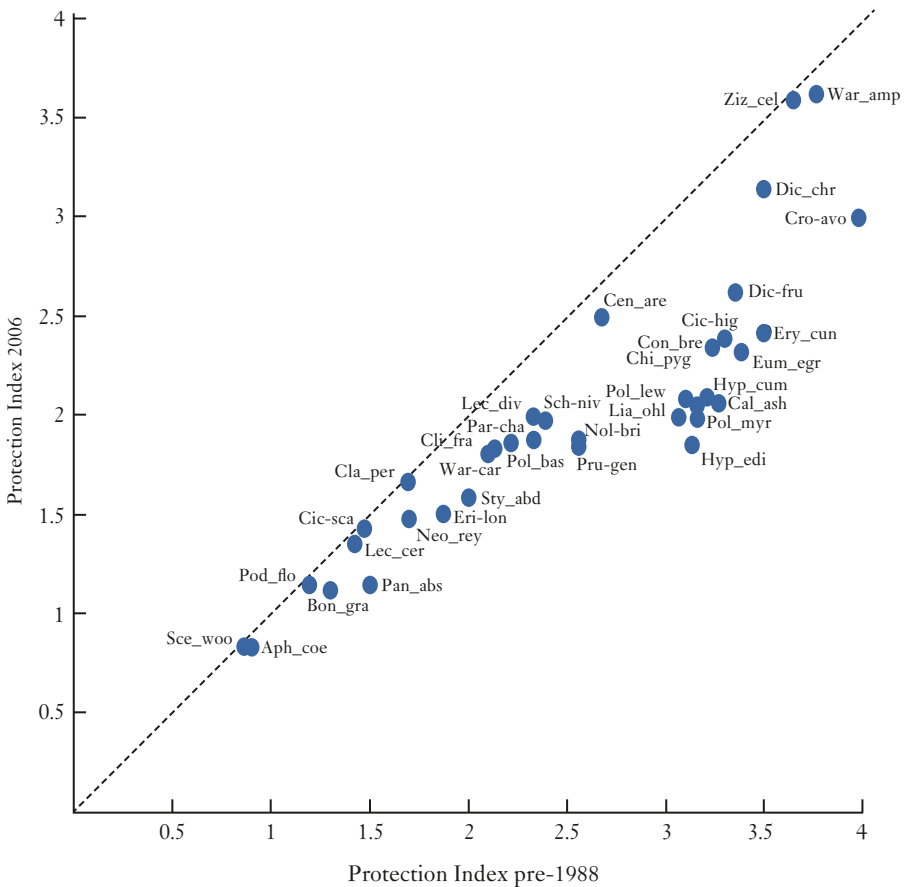


FIGURE 4.5. Improvement in the conservation status of 36 rare scrub plants and animals on the Lake Wales Ridge as a result of land acquisition between 1988 and 2006, as measured by a protection index (very low = 4 to high = 0.5) that integrates the number of populations of a species that are protected, area occupied, and geographic range (based on Figure 7 in Turner et al. 2006a). The status of species lying below the line is improved.

Source: Archbold Biological Station. (Mammals: *Podomys floridanus*; Birds: *Aphelocoma coerulescens*; Reptiles: *Eumeces egregius lividus*, *Neoseps reynoldsi*, *Sceloporus woodi*; Arthropods: *Cicindela highlandensis*, *Cicindela scabrosa*; Plants: *Bonamia grandiflora*, *Calamintha ashei*, *Centrosema arenicola*, *Chionanthus pygmaeus*, *Cladonia perforata*, *Clitoria fragrans*, *Conradina brevifolia*, *Crotalaria avonensis*, *Dicerandra christmanii*, *Dicerandra frutescens*, *Eriogonum longifolium* var *gnaphalifolium*, *Eryngium cuneifolium*, *Hypericum cumulicola*, *Hypericum edisonianum*, *Lechea cernua*, *Lechea divaricata*, *Liatris ohlingeriae*, *Nolina brittoniana*, *Panicum abscissum*, *Paronychia chartacea* ssp *chartacea*, *Polygala lewtonii*, *Polygonella basiramia*, *Polygonella myriophylla*, *Prunus geniculata*, *Schizachyrium niveum*, *Stylisma abdita*, *Warea amplexifolia*, *Warea carteri*, *Ziziphus celata*.)

reduced extinction risk by increasing the proportion of sites at which species are protected and the protected area over which species occur, and by maintaining their geographic range.

Despite this success, most scrub species are likely to remain at risk of extinction primarily because even the most optimistic acquisition scenarios will protect little more than 7 percent of the original Ridge habitats, most having already been destroyed. Turner et al. (2006b) used a reserve-design algorithm to determine which remaining sites should be high priorities for future protection based on their biological value and cost-effectiveness, and then estimated the incremental effectiveness of the reserve network likely to result from planned future acquisitions. They noted that—however successful future acquisition efforts may be—virtually all scrub species will depend upon active management, especially prescribed fire, for their long-term persistence.

AN INCREASING ROLE FOR SCIENCE IN CONSERVATION LAND MANAGEMENT

Recognizing that fire management is critical, TNC and Archbold started to address the management needs of the patchwork of conservation lands and the coordination required among twelve managing agencies (two federal, five state, two county, and three nonprofit). Science was to play a key role in land management planning and implementation. Building the social capital to achieve management coordination was critical for a conservation landscape with multiple sites and multiple agencies.

In 1991, anticipating the long-term need for a collaborative land management approach, TNC called for the creation of a working group for the original agencies managing land around Lake Arbuckle. This group included TNC, the Florida Division of Forestry (now the Florida Forest Service), the Florida Department of Natural Resources (now the Florida Department of Environmental Protection), the Florida Game and Freshwater Fish Commission (now the Florida Fish and Wildlife Conservation Commission), the Avon Park Bombing Range (now Avon Park Air Force Range), Polk County Parks and Recreation, and Polk County Water Resources Division. Soon the geographic scope was expanded, and Archbold was invited to join.

First established as the Greater Arbuckle Working Group, the association is now called the Lake Wales Ridge Ecosystem Working Group

(LWREWG). An interagency steering committee and five subcommittees (invasive species, rare species, GIS, fire, and education) provide the framework for all the partners managing land along the Ridge to work collaboratively. Presentations by scientists at quarterly meetings ensure exposure to current research and management practices. Joint projects and problem-solving allow managers to be more effective and efficient. The institutional brokering mitigates some of the effects of fragmentation.

More than twenty years later, the LWREWG is still going strong. Virtually every land manager participates, as well as nearly all scientists working in the scrub ecosystem. Meetings usually have 50 to 70 attendees, bringing many knowledgeable and innovative agency and scientist minds to the conservation process. The LWREWG has allowed scientists and agencies to share information and resources, to develop a shared vision, and to foster accord between the aims of research and conservation. Research directly translates into conservation action and conservation needs define new research questions. With no charter, bylaws, government oversight, votes, or any kind of formal structuring, the LWREWG has exhibited surprising resiliency, although it is not an advocacy organization. The far-sighted vision of a nonthreatening forum for exchange of information has proven to be a powerful force in conservation. The success of the LWREWG inspired the state to create working groups in other regions and project areas.

Fire as a Vital Tool for Land Management

Although the Ridge conservation community achieved considerable success in land acquisition and the LWREWG established an important forum for collaboration, fire management continued to lag behind. The species-rich xeric upland communities depend on periodic fires to maintain habitat. If the conservation community was going to save this ecosystem, it had to implement fire management more successfully. An initial field assessment conducted by TNC in 1994 revealed that 75 percent of a subset of 18 Ridge scrub sites proposed for acquisition were badly overgrown and at risk of losing their endemic species due to fire exclusion (Huffman 1994).

Decades of research had documented the critical role of fire in the scrub habitat. Warren Abrahamson's widely cited papers on the role of fire in scrub (Abrahamson 1984a, 1984b) represented a paradigm shift

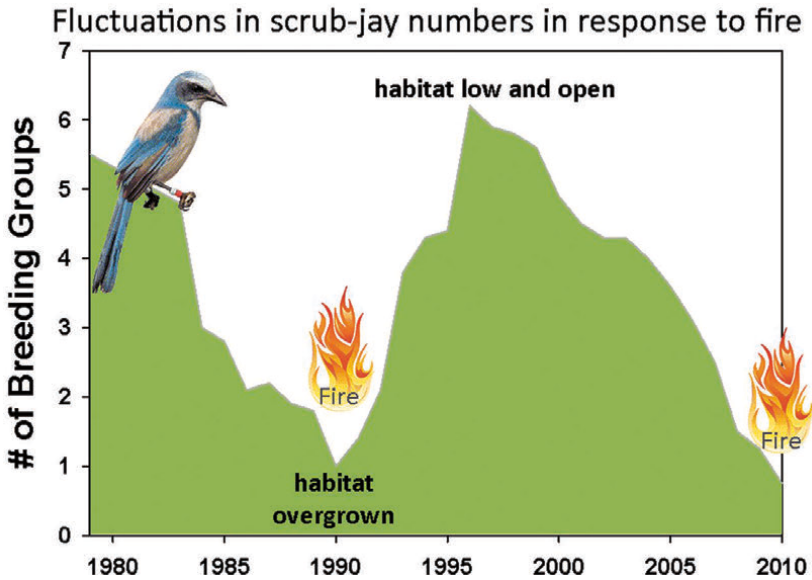


FIGURE 4.6. The number of Florida scrub-jay groups in relation to time since fire in burn unit 50 at Archbold Biological Station.

Source: Figure by Reed Bowman. Used with permission from Archbold Biological Station.

for both the science and the conservation communities in Florida and nationally. Numerous Florida scrub-jay studies at Archbold confirmed the essential role of fire in creating low, open habitat for this threatened species (figure 4.6).

Guided by research findings, prescribed burns were used after 1979 to mimic fire's natural cycles on Archbold's globally threatened preserve (Main and Menges 1997). Ron Myers, who conducted the early burns at Archbold, went on to a career promoting fire management nationally for TNC. In parallel with Archbold's research-driven approach to fire management, Steve Morrison, TNC's first employee on the Ridge, was experimenting with prescribed fire at the Tiger Creek Preserve and reached many of the same conclusions.

By 1999, despite decades of successful management by TNC and Archbold on their own sites, the partners were deeply concerned that, of 31 Ridge sites in conservation ownership, 19 had not received any fire management since they were purchased (Huffman 1999). Mary Huffman, chair of the LWREWG fire committee, convened a meeting to ask partners to identify the biggest barriers to getting fires completed. This

inquiry revealed that managers were hampered largely by a shortage of staff on days when the weather was conducive for burning; adding crew members with accompanying equipment might tip the balance. TNC secured partial funding to provide an innovative approach to increasing fire management: a roving crew initially called the Florida Scrub-Jay Fire Strike Team.

The area burned by the team has increased annually from about 1,000 acres in 2001 to more than 20,000 acres in 2012. Thirteen managing agencies rely on the group, which has evolved into the Central Florida Ecosystem Restoration Team. An excellent example of public-private partnerships and interagency cooperation, the team has become a model for other regions. Despite significant progress, a recent Archbold analysis by Boughton and Bowman (2011) has revealed that Florida scrub-jay populations have declined by as much as 25 percent from 1992–1993 to 2009–2010 on protected public lands statewide. The current number of scrub-jays is less than 50 percent of the estimated carrying capacity on public lands, and the decline is largely attributable to a lack of fire. Obviously much remains to be done.

Another Conundrum: Management of Invasive Species

Invasive plants on the Ridge like cogon grass (*Imperata cylindrica*), Natal grass (*Rhynchelytrum repens*), and Old World climbing fern (*Lygodium microphyllum*) as well as feral hogs (*Sus scrofa*) require constant attention. TNC was able to expand the LWREWG to treat priority invasive species, including those on private lands adjacent to conservation sites. The LWREWG invasives subcommittee became a management springboard to develop Cooperative Invasive Species Management Areas statewide. This collaborative approach has facilitated strategies such as aerial surveys to understand the scope of the threat, and created a forum for exchanging information on effective responses and early detection.

Coordinating Recovery Planning with the U.S. Fish and Wildlife Service and Others

Over the last 30 years, scientists at Archbold and elsewhere have contributed to the development of at least 13 U.S. FWS recovery plans for federally listed scrub species, one for 11 scrub plants (expanded later to 20 plants; U.S. FWS 1995) and others for indigo snakes, sand skinks, blue-

tailed mole skinks, and the Florida scrub-jay. This planning culminated in the creation of the comprehensive South Florida Multi-Species Recovery Plan, which includes scrub plant species (U.S. FWS 1999).

In partnership with the Cornell Laboratory of Ornithology, Archbold completed complex analyses of population viability, landscape connectivity, genetic structuring, reintroductions, habitat restoration, and habitat conservation plans for the Florida scrub-jay. These studies brought massive scientific firepower to bear on conservation of the species.

Carl Weekley at Archbold, in partnership with TNC, Bok Tower Gardens, and federal and state agencies, has spearheaded the recovery of *Ziziphus celata*, an extremely rare and genetically depauperate Ridge plant once thought to have been extirpated but now listed as endangered (Weekley et al. 2012). This work involves extensive surveys for new locations, basic ecology, genetics research, plant propagation, and successful reintroductions. For at least six other Ridge scrub plants, scientific assistance for translocation and/or propagation may be necessary to ensure their survival (Turner et al. 2006a).

Adaptation and Mitigation for Climate Change

Florida's climate exhibits high seasonal and annual variability, and many scrub species have marked correlations with variability in rainfall, temperature, and cycles such as El Niño–La Niña and the Atlantic Multi-decadal Oscillation. To date, we do not have equivocal evidence of responses to long-term climate change in scrub habitats on the Ridge. Climate data at Archbold, like many rural southeastern sites, do not exhibit marked increases in temperatures or changes in rainfall or fire frequency. Von Holle et al. (2010) detected temperature-induced shifts statewide in Florida plant phenology, documenting a trend for delayed seasonal flowering among plants in rural Florida. The climate change adaptation strategy on the Ridge is to focus on continually improving management to ensure that habitat is maintained in optimal condition.

LARGE LANDSCAPES: THINKING AT THE SCALE OF A BEAR

After the Ridge reserve network was established, management organized, and species-specific recovery underway, another threat loomed. The initial reserve network was envisioned within a matrix of agriculture,

but by the mid-2000s, a new wave of habitat conversion was turning agricultural land over to development. Former citrus groves and the rural lands bordering the Ridge, much of it used for low-intensity cattle ranching, became a focus of increasing development pressure. Five developments large enough to be categorized as having regional impact were proposed for Highlands County. The alarming *Florida 2060* report showed that Polk and Highlands counties were poised for large landscape-level change (Zwick and Carr 2006). Two major toll roads were proposed that could forever change the character of the region. It became clear that science and conservation partners needed to propose connections and buffer conservation lands to create a functional landscape, allowing the movement of species among sites and limiting encroachment in order to facilitate fire management. The types of land use surrounding conservation areas play a critical role in our ability to preserve their conservation value over time.

In the face of these new challenges, the partners brought in landscape ecologist Tom Hoctor from the University of Florida to develop a spatial analysis of land use on the Ridge. The resulting analysis relied on a collaborative study on the travel patterns of the Florida black bear (*Ursus americanus floridanus*) in Highlands and Glades counties by the University of Kentucky and Archbold (Ulrey 2007, Guthrie 2012) as well as the statewide modeling by Hoctor. The resulting Greater Ridge Conservation Planning Tool (TNC et al. 2007) can be used to give planners guidance about where Ridge communities could continue to grow while simultaneously emphasizing the need to preserve a functional landscape that allows for the movement of wildlife, the continuing application of prescribed fire, the protection of watersheds, and the preservation of rare species. This project in turn served as the springboard for further spatial analyses, including conservation corridor mapping for Highlands County (Swain et al. 2009), a regional Heartland 2060 analysis in conjunction with FNAI (Hoctor et al. 2010), and a regional corridor analysis under the state's Cooperative Conservation Blueprint (FFWCC 2010).

Land managers planning controlled burns are significantly constrained by the proximity of smoke-sensitive land uses such as major highways, airports, and hospitals. The team thus developed a GIS-based tool as a guide for land use planning around conservation lands (Pace-Aldana 2009). The Florida Department of Transportation is consider-

ing adoption of this smoke-buffering tool statewide, and the data are being used for local and regional planning.

Facing similar concerns about encroaching development and the incompatibility of growth with military missions, the Department of Defense initiated a joint land use study around APAFR in 2010 (figure 4.7) (APAFR 2010). The purpose of the study was to work collaboratively with local governments to develop compatible land use plans and land development regulations. The use of conservation funding to protect this military site from encroachment using conservation funding has attracted new sources of federal support for planning and conservation, such as a conservation buffer program that includes a portion of the Ridge under the DoD's National Readiness and Environmental Protection Initiative.

THE CHALLENGES OF ENGAGING THE PUBLIC

Scientists and professional conservationists have always been intrigued by the scrub ecosystem; they consider the Florida scrub as one of the most interesting and unusual of habitats, supporting plants and animals that are an almost Dr. Seuss-like collection of delightful oddities (Wilcove 1999). But unlike the grandeur of mountains and canyons, or the verdant luxuriousness of forests and riverine meadows, the Florida scrub has never been a captivating landscape to the novice or public eye. Public opinion nowadays differs little from that offered 80 years ago by the ecologist Maurice Mulvania (1931, 528).

The vegetation is mostly dwarfed, gnarled and crooked, and presents a tangled scraggly aspect. It . . . display[s] the misery through which it has passed and is passing in its solution of life's grim riddle. Here live the rosemary (*Ceratiola ericoides*), spruce-pine (*Pinus clausa*), poor grub (*Xolisma ferruginea*), and their associates rooted in a bed of silica, to which the term soil is but remotely applicable. Here the sun sheds its glare and takes a toll of the unfit.

Saving this ecosystem has never involved much public grassroots conservation effort. Instead, the scrub's survival has depended mostly on a determined cadre of scientists and professional conservationists who marshaled incontrovertible conservation arguments. Few public champions emerged. This state of affairs may be because most of the remaining

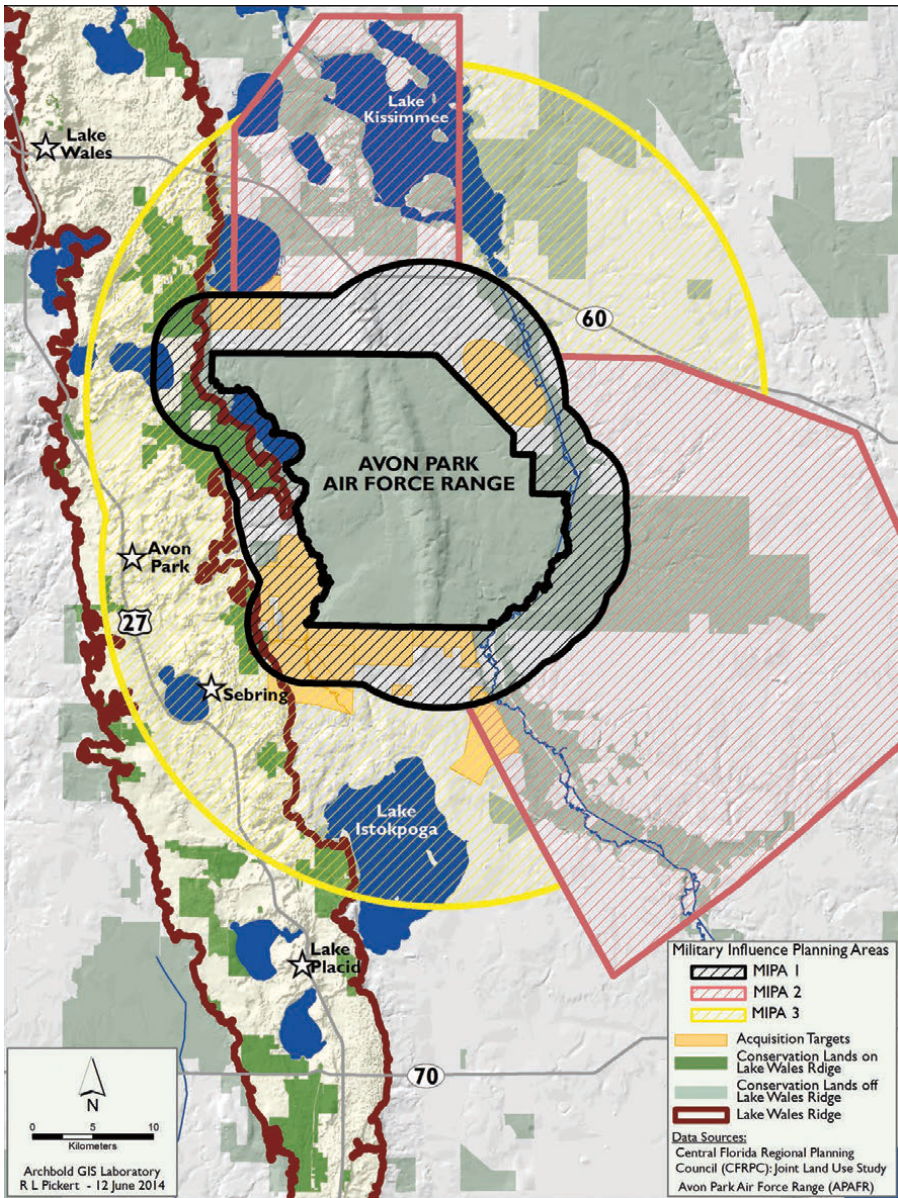


FIGURE 4.7. The location of existing conservation lands on the Lake Wales Ridge and potential land acquisitions targeted to reduce conflicts within the Military Influence Planning Areas (MIPA) around the Avon Park Air Force Range. MIPA 1: 3-mile buffer with moderate noise risk plus low-level flights; MIPA 2: low noise risk plus low-level flights; MIPA 3: low noise risk.

Source: Central Florida Regional Planning Council. Map used with permission from Archbold Biological Station.

scrub on the Ridge is located in a part of Florida that is still relatively rural, where residents are sensitive to any perceived infringement on property rights, elected officials are loath to bypass any “development opportunity,” and out-of-state retirees have no sense of place or awareness of the area’s history.

Despite these challenges, the partners have made a concerted effort to build a conservation constituency. At the outset, the conservation organizations realized the importance of educating the public. Since 1990, Archbold’s K–12 education program has hosted more than 40,000 local schoolchildren at the station and produced an award-winning science curricula based on scrub ecology that is used throughout the state. Archbold’s new learning center, opened in 2012, invites the public to explore the scrub and learn about the Ridge. In 2008, Polk County joined with the SWFWMD to create a visitor center just off the Ridge at Circle B Bar. The Center attracts 20,000 visitors annually and offers a variety of environmental education programs. In addition, Highlands Hammock State Park can host 2,000 to 3,000 visitors daily, and many other Ridge sites provide hiking trails and host the public in small visitor centers.

While the reserve network was being assembled, TNC staff tried to get the public involved in caring for the sites to increase awareness about the ecology of the Ridge and develop support for the newly acquired public lands. In 1995, TNC created an interagency volunteer program called Ridge Rangers, engaging citizens in on-the-ground conservation work for nearly all the managing agencies on the Ridge. In 2002, TNC transferred the program to the FFWCC to provide a more stable funding source. The program now has 128 members who volunteer nearly 5,000 hours annually (Parken 2012).

Building on the pioneering work of the Cornell Laboratory of Ornithology in the area of citizen science, TNC and Archbold created a targeted program called Jay Watch that enlisted local residents to monitor the scrub’s flagship umbrella species. Scrub-jays are an indicator of scrub habitat condition because the range of optimal conditions for jays is also good for many other rare scrub species (Breininger et al. 2006). The beauty of this approach was that while the public usually hates smoke and fire, they almost instantly fall in love with scrub-jays. Demographic data on scrub-jays are collected annually, and biennial vegetation monitoring tracks habitat condition in relation to scrub-jay presence.

Archbold scientists then evaluate and analyze the data collected. This monitoring informs prescribed fire planning for maintenance of good quality scrub. Jay Watch began surveys on public conservation lands along the Ridge and has since expanded to cover 73 sites in 19 counties, with the assistance of more than 200 volunteers. Now managed by Florida Audubon with scientific support from Archbold, the program has become the baseline scrub-jay monitoring standard for state lands managed by the DEP and FFWCC.

Additional efforts to generate support for conservation over the years have included informing and working with international, national, state, and local media outlets to produce hundreds of articles; creating numerous print and audiovisual materials, among them the 19-minute DVD produced by Bill Kurtis called *Islands in Time* as well as a companion print piece called *Florida's Ancient Islands*, working with artists such as printmaker Mollie Doctrow, creator of *Spirit of the Scrub* and the Wildflower Wayside Shrine Trail; and producing numerous site-specific publications as well as interpretive signage.

SECURING THE FUTURE OF THE FLORIDA SCRUB

Progress to date made in saving the scrub could be viewed as one of North America's great conservation success stories, although it has probably not received the national recognition it deserves. Scientists and conservationists have been working together to save this system for more than 25 years. There has been great strength in focusing a broad ecological research program on the large landscape of the Ridge; always opportunistic, this partnership has taken advantage of every chance. Although all conservation projects have their idiosyncrasies, this one provides the world with many innovative models of science leading to conservation action. Broad impacts with global relevance include work in the areas of fire management, endangered species planning, management planning for scrub habitats, land management working groups, training in hands-on conservation science for the next generation of ecologists, management strike teams, and public science platforms for conservation.

Despite the conservation successes, it is still not enough to have trebled the acreage of protected habitat on the Ridge. The community continues to prioritize remaining scrublands for purchase, but it is harder to finish an acquisition program than to start one. The big, sexy

land deals have largely been completed, and it's mostly multiple small challenges that remain. The science community and professional conservationists have to support and pressure the public agencies to persevere with purchases. When the state legislature failed to fund Florida Forever in 2008, they set a depressing tone for acquisition for the next few years. Now TNC, Archbold, and other partners are cultivating new sources of funding. This is an acquisition marathon, and the conservation community can't afford to stall.

In addition to the need for continued engagement in land acquisition and protection, there are pressing demands for scientific input into improved land management, particularly prescribed fire. Although the threat to state and federally listed species has decreased, most need perennial conservation management to survive. Maintaining the 20-year-old LWREWG is vital, as is support for the Central Florida Ecosystem Restoration Team. Money for management has become scarce; funders are attracted to creating new programs, not sustaining ongoing efforts. TNC and Archbold have engaged new partners to administer Ridge-wide programs for the public, including Florida Audubon and FFWCC for Jay Watch and FFWCC for Ridge Rangers. But land managers have more land and fewer resources.

Success in conservation is never a single step; it is always a long journey. At the heart of this particular success story is the rich biodiversity of the Ridge; the ecosystem garnered attention because it is so important to save, and we knew that because of a wealth of earlier science. This story illustrates how conservation success increases demands on scientists' time, as they are asked to provide more input at every incremental step of the conservation journey. Every new step adds to the continuing burdens of earlier steps. But scientists must protect enough of their time to continue the fundamental research and inventory that increases knowledge and justifies conservation.

Although scientists have served as catalysts for conservation, conservation has been a wonderful crucible for science. There is a tight coupling between research and conservation: fundamental and applied research feeds directly into conservation planning; conservation action stems from research findings; conservation needs define new research questions and activities; inventory and monitoring is structured to benefit science; taking advantage of well-planned land management activities creates experimental research opportunities; and adding new conservation sites

has greatly expanded the scope and scale of research projects. Conservation has been an avenue to research success; institutions like Archbold that focus on a regional ecosystem have the reward of providing answers to real conservation problems while also advancing general ecological knowledge. Conservation solutions based on sound research have been favored, based on pressure on state and federal agencies to conserve the environment. Local and regional facilities have had the advantage when it comes to grants, based on their history of research focus and enriched by long-term data accumulation. Research findings have led to general goodwill and public support locally.

However we take into account the benefits of conservation-driven research, scientists and conservationists are spread very thin. The Ridge needs a wider base of public support and enthusiasm to prevent institutional fatigue from setting in. Investments to move from a largely professional-driven conservation program to building grassroots public support will be essential. There is a daunting need for people to engage in local planning decisions that directly affect conservation outcomes. We need marketing to increase public awareness of how the Ridge conservation areas provide clean water, enhance their quality of life, give local communities their sense of place, and hold the secrets of sustainability for future generations. The challenge remains to find a way to convey E.O. Wilson's (2000, x) exhortation that:

To Americans who know natural history, and their numbers are certain to grow with each passing generation, Nevada's Ash Meadows and Florida's Lake Wales scrubland are sacred landmarks, the equivalent of Independence Hall and Gettysburg of original America.

REFERENCES

- Abrahamson, W. G. 1984a. "Species Responses to Fire on the Florida Lake Wales Ridge." *American Journal of Botany* 71:35–42.
- . 1984b. "Post-Fire Recovery of Florida Lake Wales Ridge Vegetation." *American Journal of Botany* 71:9–21.
- Archbold Biological Station. 1989. *Biological Priorities for a Network of Scrub Preserves on the Lake Wales Ridge*. Lake Placid, FL: Archbold Biological Station.
- Austin, D. F., A. F. Cholewa, R. B. Lassiter, and B. F. Hansen. 1987. *The Florida of John Kunkel Small: His Species and Types, Collecting Localities, Bibliography and Selected Reprinted Works*. Volume 18: 3. Bronx: New York Botanical Garden Press.

- Avon Park Air Force Range. 2010. *Avon Park Air Force Range Joint Land Use Study*. Prepared by Tetra Tech, Inc., Miller Legg, and Central Florida Regional Planning Council. Avon Park, FL: Avon Park Air Force Range.
- Boughton, R. K., and R. Bowman. 2011. *State-Wide Assessment of Florida Scrub-Jays on Managed Areas: A Comparison of Current Populations to the Result of the 1992–93 Survey*. Venus, FL: Archbold Biological Station.
- Breining, D. R., B. Toland, D. M. Oddy, and M. L. Legare. 2006. “Landcover Characterizations and Florida Scrub-Jay (*Aphelocoma coerulescens*) Population Dynamics.” *Biological Conservation* 128:169–181.
- Chaplin, S. J., R. A. Gerrard, H. M. Watson, L. L. Master, and S. R. Flack. 2000. “The Geography of Imperilment: Targeting Conservation Toward Critical Biodiversity Areas.” In *Precious Heritage: The Status of Biodiversity in the United States*, ed. B. A. Stein, L. S. Kutner, and J. S. Adams, 159–200. New York, NY: Oxford University Press.
- Christman, S. P. 1988a. *Endemism and Florida’s Interior Sand Pine Scrub*. Florida Game and Freshwater Fish Commission Nongame Wildlife Section. Report GFC-84–101. Tallahassee: Florida Game and Freshwater Fish Commission.
- . 1988b. “Preserving Florida Scrub.” Unpublished manuscript. 1988.
- Christman, S. P., and W. S. Judd. 1990. “Notes on Plants Endemic to Florida Scrub.” *Florida Scientist* 33:52–73.
- Cooper, S. T., and G. E. Schultz. 1984. “Endangered Plant Species of the Central Florida Ridge, Polk and Highlands Counties.” Paper presented at the Florida Academy of Sciences 1984 Annual Meeting. Abstract in *Florida Scientist* 74: Supplement 1.
- Deyrup, M., and J. E. Carrel. 2011. *Conservation Status and Management of Lake Wales Ridge Arthropods Restricted to Scrub Habitat*. Final Report, Project T-15-D, on Lake Wales Ridge Scrub Arthropods to the Florida Fish and Wildlife Conservation Commission. Venus, FL: Archbold Biological Station.
- Deyrup, M., and T. Eisner. 1993. “A Last Stand in the Sand.” *Natural History* 102:42–47.
- Dobson, A. P., J. P. Rodriguez, W. M. Roberts, and D. S. Wilcove. 1997. “Geographic Distribution of Endangered Species in the United States.” *Science* 275:550–553.
- Eisner, T. 2001. Personal communication, January 19.
- Eisner, T. 2003. *For Love of Insects*. Cambridge, MA: Belknap Press of Harvard University Press.
- Estill, J. C., and M. Cruzan. 2001. “Phytogeography of Rare Plant Species Endemic to the Southeastern United States.” *Castanea* 66:3–23.
- Farr, J. A., and O. G. Brock. 2006. “Florida’s Landmark Programs for Conservation and Recreation Land Acquisition.” *Sustain: The Kentucky Institute for the Environment and Sustainable Development* 14:35–44.
- Fitzpatrick, J. 2012. Personal communication, April 5.
- Florida Department of Environmental Protection. 2012. *Florida Forever Five-Year Plan*, April 2012. Tallahassee: Florida Department of Environmental Protection.

- Florida Department of Natural Resources and the Land Acquisition Advisory Council. 1990. *Annual Report of the Conservation and Recreation Lands Program*. Tallahassee: Florida Department of Natural Resources.
- Florida Fish and Wildlife Conservation Commission. 2010. *Cooperative Conservation Blueprint: 2010 Status Report*. Tallahassee: Florida Fish and Wildlife Conservation Commission.
- Florida Natural Areas Inventory. 1990. *Guide to the Natural Communities of Florida*. Tallahassee: Florida Department of Natural Resources.
- Guthrie, J. M. 2012. *Modeling Movement Behavior and Road-Crossing Behavior in the Black Bear of South-Central Florida*. Master's thesis, University of Kentucky, Lexington.
- Hector, T. S., M. O'Brien, and J. B. Oetting. 2010. *Heartland Ecological Assessment Report*. Babson Park, FL: The Nature Conservancy.
- Hubell, T. H. 1932. *A Revision of the Puer Group of the North American Genus Melanopus with Remarks on the Taxonomic Value of the Concealed Male Genitalia of Cyrtachanthacrinae (Orthoptera, Acrididae)*. Miscellaneous publications of the University of Michigan Museum of Zoology 23:1–64.
- Huffman, M. R. 1994. *Discussion Paper: The Urgent Need for Fire Management to Save the Florida Scrub-Jay*. Lake Wales, FL: The Nature Conservancy.
- . 1999. *A Fire Strike Team to Save the Florida Scrub-Jay*. Lake Wales, FL: The Nature Conservancy.
- Johnson, A. F. 1981. "Scrub Endemics of the Central Ridge, Florida." Unpublished report prepared for the U.S. Fish and Wildlife Service, Jacksonville, FL.
- Little, A. E. 1920–1921. Timber Cruise Reports for Sections of Highlands County for the Consolidated Land Company. Available at Archbold Biological Station, Venus, FL.
- Main, K. N., and E. S. Menges. 1997. *Archbold Biological Station: Station Fire Management Plan*. Land Management Publication 97-1. Venus, FL: Archbold Biological Station.
- Martin, D. 1993. "The Lake Wales Ridge National Wildlife Refuge: Preserving a Treasure Trove of Biodiversity." *Endangered Species Technical Bulletin* 18 (4): 3–4.
- McCarten, L., and W. S. Moy. 1995. *Geologic Map of Sarasota and Arcadia, Florida: 30- × 60-Minute Quadrangles*. U.S. Geological Survey Open File Report 95-261. Reston, VA: U.S. Geological Survey.
- McPhee, J. 1966. *Oranges*. New York, NY: Farrar, Straus and Giroux.
- Menges, E. S. 1998. "Ecology and Conservation of Florida Scrub." In *Savannas, Barrens, and Rock Outcrop Plant Communities of North America*, ed. R. C. Anderson, J. S. Fralish, and J. Baskin, 7–22. Cambridge, U.K.: Cambridge University Press.
- Menges, E. S., and N. Kohfeldt. 1995. "Life History Strategies of Florida Scrub Plants in Relation to Fire." *Bulletin of the Torrey Botanical Club* 122:282–297.
- Morse, R. A. 2000. *Richard Archbold and the Archbold Biological Station*. Gainesville: University of Florida Press.
- Muller, J. W., E. D. Hardin, D. R. Jackson, S. E. Gatewood, and N. Claire. 1989. *Summary Report on the Vascular Plants, Animals and Plant Communities Endemic to*

- Florida. Nongame Wildlife Program Technical Report No. 7. Tallahassee: Florida Game and Freshwater Fish Commission.
- Mulvania, M. 1931. "Ecological Survey of a Florida Scrub." *Ecology* 12:528–540.
- Mushinsky, H. R., and E. D. McCoy. 1991. *Vertebrate Species Composition of Selected Scrub Islands on the Lake Wales Ridge of Central Florida*. Report NG87-149. Tallahassee: Florida Game and Freshwater Fish Commission, Nongame Wildlife Program.
- Myers, R. L. 1990. "Scrub and High Pine." In *Ecosystems of Florida*, ed. R. L. Myers and J. J. Ewel, 150–193. Orlando: University of Central Florida Press.
- Noss, R. F., and R. L. Peters. 1995. *Endangered Ecosystems: A Status Report on America's Vanishing Habitat and Wildlife*. Washington, DC: Defenders of Wildlife.
- Pace-Aldana, B. 2009. "A GIS Data Layer for Guiding Development Compatible with Fire Management of Neighboring Conservation Sites." In *Proceedings of the 24th Tall Timbers Fire Ecology Conference: The Future of Fire: Public Awareness, Health, and Safety*, ed. K. M. Robertson, R. E. Masters, and K. E. M. Galley. Tallahassee, FL: Tall Timbers Research Station.
- Parken, W. 2012. Personal communication, April 5. Florida Fish and Wildlife Conservation Commission.
- Peroni, P. A., and W. G. Abrahamson. 1985. "Vegetation Loss on the Southern Lake Wales Ridge." *Palmetto* 5 (3): 6–7.
- Schultz, G. E., L. G. Chapin, and S. T. Krupenovich. 1999. *Rare Plant Species and High Quality Natural Communities of Twenty-Six CARL Sites in the Lake Wales Ridge Ecosystem*. Final Report. December 1999. Tallahassee: Florida Natural Areas Inventory.
- Swain, H. M., R. L. Pickert, T. S. Hctor, and J. B. Oetting. 2009. *Highlands County Conservation Lands, Connectivity, and Corridor System: Report, Metadata, and Shapefiles*. Venus, FL: Archbold Biological Station.
- Turner, W. R., D. S. Wilcove, and H. M. Swain. 2006a. *State of the Scrub: Conservation Progress, Management Responsibilities, and Land Acquisition Priorities for Imperiled Species of Florida's Lake Wales Ridge*. Venus, FL: Archbold Biological Station.
- . 2006b. "Assessing the Effectiveness of Reserve Acquisition Programs in Protecting Rare and Threatened Species." *Conservation Biology* 20:1657–1669.
- Ulrey, W. A. 2007. "Home Range, Habitat Use, and Food Habits of the Black Bear in South-Central Florida." Master's thesis, University of Kentucky, Lexington.
- U.S. Fish and Wildlife Service. 1993. *Proposed Establishment of Lake Wales Ridge National Wildlife Refuge*. Atlanta, GA: U.S. Fish and Wildlife Service.
- . 1995. *Draft Recovery Plan for Nineteen Florida Scrub and High Pineland Plant Species (Revision and Expansion of Recovery Plan for Eleven Florida Scrub Plant Species Approved January 20, 1990)*. Atlanta, GA: U.S. Fish and Wildlife Service.
- . 1999. *South Florida Multi-Species Recovery Plan*. Atlanta, GA: U.S. Fish and Wildlife Service.
- Von Holle, B., Y. Wei, and D. Nickerson. 2010. "Climatic Variability Leads to Later Seasonal Flowering of Floridian Plants." *PLoS ONE* 5 (7): e11500. doi:10.1371/journal.pone.0011500.

- Wallace, S. R., and L. R. McMahon. 1988. "A Place in the Sun for the Plants." *Garden* (Jan/Feb): 20–23.
- Ward, C. 2011. Keynote speech, Opening ceremony, Frances Archbold Hufty Learning Center, Archbold, December 2.
- Weekley, C. W., E. S. Menges, and R. L. Pickert. 2008. "An Ecological Map of Florida's Lake Wales Ridge: A New Boundary Delineation and an Assessment of Post-Columbian Habitat Loss." *Florida Scientist* 71:45–64.
- Weekley, C. W., S. A. Smith, S. J. Haller-Crate, S. W. McAllister, and E. S. Menges. 2012. *Continuation of Research on the Federally-Listed Lake Wales Ridge Endemic Florida Ziziphus (Ziziphus celata)*. Venus, FL: Archbold Biological Station.
- White, W. A. 1970. *The Geomorphology of the Florida Peninsula*. Volume 51. Tallahassee: Bureau of Geology, Florida Department of Natural Resources.
- Wilcove, D. S. 1999. "A Bounty at the Border." In *The Condor's Shadow: The Loss and Recovery of Wildlife in America*, 170–201. New York, NY: W. H. Freeman and Co.
- Willson, G. 2012. Personal communication, April 5.
- Wilson, E. O. 2000. Foreword. In *Precious Heritage: The Status of Biodiversity in the United States*. New York, NY: Oxford University Press and The Nature Conservancy and Association for Biodiversity Information.
- Woolfenden, G. E., and J. W. Fitzpatrick. 1984. *The Florida Scrub Jay: Demography of a Cooperative-Breeding Bird*. Princeton, NJ: Princeton University Press.
- Zwick, P. D., and M. H. Carr. 2006. *Florida 2060: A Population Distribution Scenario for the State of Florida*. A research project prepared for the 1,000 Friends of Florida. Gainesville: Geoplan Center, University of Florida.

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Cover design by David Drummond

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ISBN 978-1-55844-301-3

