Saving the Florida Scrub Ecosystem:
Science and Serendipity

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Abstract

The Florida scrub, ranked as the 15th most endangered ecosystem in the nation, with one of the highest densities of rare, endemic species in the world, came perilously close to extirpation. One of the finest examples of this habitat, the ancient scrub of the Lake Wales Ridge in central Florida, has been rescued from oblivion largely by the strong partnership forged between an internationally recognized not-for-profit research institution, Archbold Biological Station, and the global conservation organization, The Nature Conservancy. Scientists and conservationists, drawing from decades of research, designed an ambitious plan to save the scrub. This drove a massive investment in land acquisition, more than $100M, by public agencies, particularly the state of Florida. The area of protected scrub has tripled, and the risk of extinction for many species has been reduced. The Lake Wales Ridge Ecosystem Working Group, an enduring alliance of scientists and conservation partners from 13 agencies and nonprofits coalesced and, over the last 20 years, provided the social capital and land management skills to sustain this conservation program. The challenge is to maintain conservation momentum in the decades ahead.

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Saving the Florida Scrub Ecosystem: Science and Serendipity

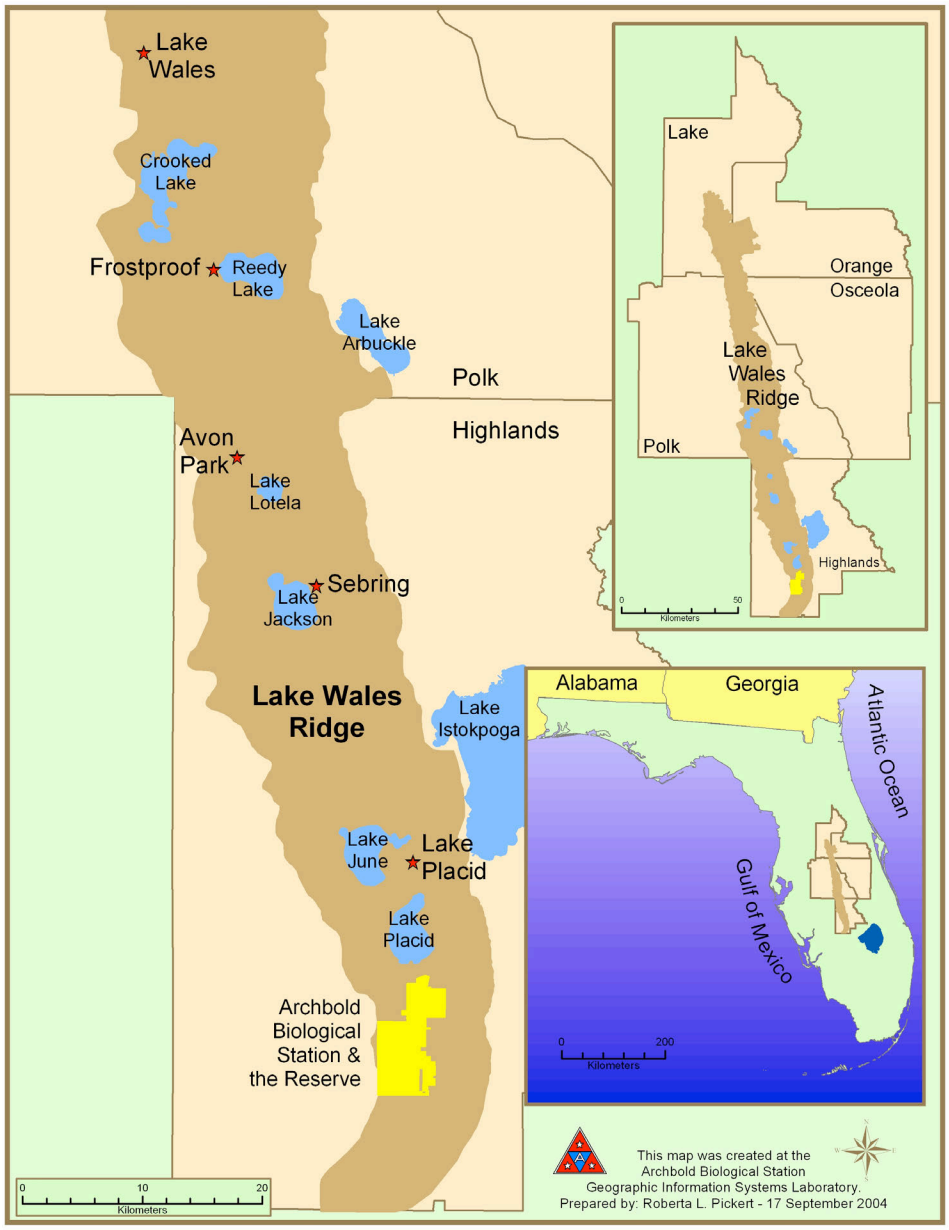
Introduction

This is the story of saving 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 (the 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 not-for-profit research institution, Archbold Biological Station (Archbold), and the global conservation organization, The Nature Conservancy (TNC). By the 1980s high demand for dry, sandy soils, first for citrus, then for housing, had so diminished the remaining habitat that the Florida scrub 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-conservation partners has coalesced over the last 20 years, providing the social capital to sustain this conservation juggernaut. How did all this come together in the remote heart of rural south-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 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, resulting in a series of parallel ridges, running north to south, where a unique ecosystem, the Florida scrub, developed and persists. The 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 the ocean, to the east and west (figure 1), occupying an area of 116 miles north–south by 5 to10 miles east–west (Weekley et al 2008). Rising 100 to 300 feet above sea level, it runs like the sandy backbone of central Florida. With its unique ecosystem and distinct geography, the Ridge is a cohesive, identifiable landscape for conservation action.

Figure 1: Location of Archbold Biological Station on the southern end of the Lake Wales Ridge, in Florida. Courtesy of Archbold Expeditions.



Millions of years ago the higher, drier lands of Florida were connected biologically to the west and desert southwest, extending as far as California and Mexico, with the result that many plants and animals in these disjunct arid ecosystems, a continent apart, share nearest relatives. Consider scrub-jays, and plants such as Jujube (*Ziziphus* spp.). 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), and a biodiversity hotspot for rare endemic species that ranks comparably with other, more familiar, global hotspots (Turner et al 2006a).

Building the Knowledge Base for Science and Conservation

The unique flora and fauna of the Florida scrub was a magnet to early naturalists and explorers. Writings in the first half of the twentieth century, such as those by the botanist John Kunkel Small (Austin et al, 1987) and entomologist Theodore Hubell (1932), all argued for the importance of the scrub on the Ridge. Serendipity further set the stage for research and conservation regionally, for chance brought three wealthy philanthropists with an interest in science and conservation to the Ridge in the first half of the last century. John A. Roebling II, Richard Archbold, and Edward Bok established the tradition of science and land conservation that would eventually lead to the protection of the Ridge.

In 1941, John A. Roebling, wealthy industrialist, gifted his 1,058-acre Red Hill Estate at the southern end of the Ridge, to Richard Archbold, aviator, explorer and patron of science. Here Richard Archbold (1907–1976) founded the Archbold Biological Station, living on-site for the next 37 years, and hosting a veritable who's who of midcentury ecologists. Thousands of plants, insects, birds and mammals were studied, collected, and preserved, building the biodiversity knowledge of the Florida scrub. James Layne became Archbold's Research Director in 1967, setting a vision for long-term research and environmental monitoring. He was a leader in early conservation. Thomas Eisner, visiting professor from Cornell University, pioneered the field of chemical ecology at Archbold. He combined a scientific and conservation vision for the Florida scrub, and served as the ecosystem's prominent spokesman on the national stage, writing later (Eisner 2003), "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." Richard Archbold died in 1976, but left the land, buildings, and his personal fortune to Archbold Expeditions, to continue the Station's research, conservation and education programs.

Archbold research continues to this day. The study of the Florida Scrub-jay *Aphelocoma coerulescens* started at Archbold in 1969 by Glen Woolfenden, is now led by Reed Bowman, is the longest-running bird population study in North America. Woolfenden's classic book on Florida Scrub-jays (Woolfenden and Fitzpatrick 1984), together with 173 other scientific publications to date stemming from studies of scrub jays at Archbold, is a remarkable conservation reference. Archbold ornithologists spearheaded conservation planning to save this threatened species, serving as a model for bird conservation 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 it's dependency on fire (e.g. 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 guide management and recovery (e.g. Menges and Kohfeldt, 1995). His research serves as a model for plant conservation studies in fire-driven ecosystems around the world. Mark Deyrup, once described as the "Hubbell telescope of the insect world"[1] has added more than 100,000 specimens of scrub arthropods to the Archbold collection, and published descriptions of 11 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 (e.g. Deyrup and Eisner, 1993).

Described recently as the "Smithsonian of the Scrub"[2], Archbold has created a regional culture integrating science and conservation. The geographic focus of Archbold's mission on the Ridge has resulted in a strong interdisciplinary approach to the scrub ecosystem. The Archbold Board, committed to the seamless coupling between science and effective conservation, appointed two directors, John Fitzpatrick (1987–1995) and Hilary Swain (1995–present), with a passion for both. Archbold supports a staff of 50, hosts thousands of visiting scientists and students annually, and has provided training for more than 300 research interns in the last 20 years. The generosity and vision established by founder Richard Archbold (Morse 2000), nurtured by his sister Frances Archbold Hufty (Chairman of the Board from 1976 to 2010), and sustained by the family who continue to serve on the Board, enabled Archbold to become the scientific powerhouse behind conservation on the Ridge.

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

Florida's Natural Areas Inventory (FNAI), the state heritage program established TNC in 1981, built critical databases for the Florida scrub. In 1983 TNC and FNAI contracted with Gary Schultz, 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 (e.g. Schultz et al 1999).

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. Susan Wallace established their endangered plant species program using propagation techniques, reintroductions of plants into the wild, and a collection of plant material, both seeds and cuttings (Wallace and McMahon 1988).

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[1] Thomas Eisner, in litt. January 19, 2001.
[2] Carlton Ward, keynote speech, Frances Archbold Hufty Learning Center, Dec. 2, 2011.

Despite this rich scientific history and widespread academic recognition of conservation value, the Florida scrub was, nonetheless, almost lost to both science and conservation.

Scrub on the Ridge Succumbs to a Litany of Assaults

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

Timber

During 1920–21 Consolidated Land Company hired A.E. Little to conduct and 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; by the 1950s nearly all the virgin timber was logged.

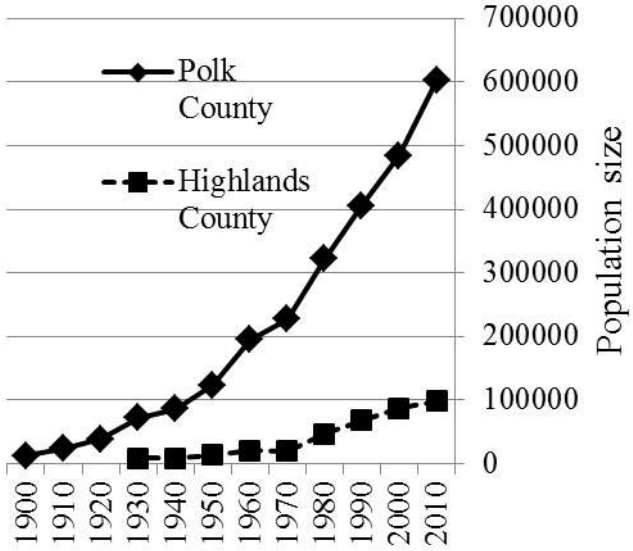
Oranges

In the wake of logging, citrus pioneers arrived in the 1920s and 30s, moving south after earlier devastating freezes, planting small groves and creating Ridge towns with reassuring names like Frostproof. Later, the citrus barons described eloquently in John McPhee's (1966) book *Oranges*, establishing 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—very little scrub or sandhill habitat remains here. Later citrus growers planted on the white sands and scrub habitat-dominated soils of the southern Ridge, including large acreages as late as the mid-1980s.

Development

Some scrub was lost when the resort communities of the 1920s, such as Lake Wales, Avon Park, Sebring, and Lake Placid, were built in conjunction with the railroad line. Many went bankrupt and little further population growth ensued until the 1970s. After then the Ridge was engulfed by typical boom and bust cycles of real estate. 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 2). High, dry scrub land that had not been converted to citrus became a prime target for development.

Figure 2. Population growth along the Ridge in Polk and Highlands Counties during the last century. Courtesy of Archbold Expeditions.



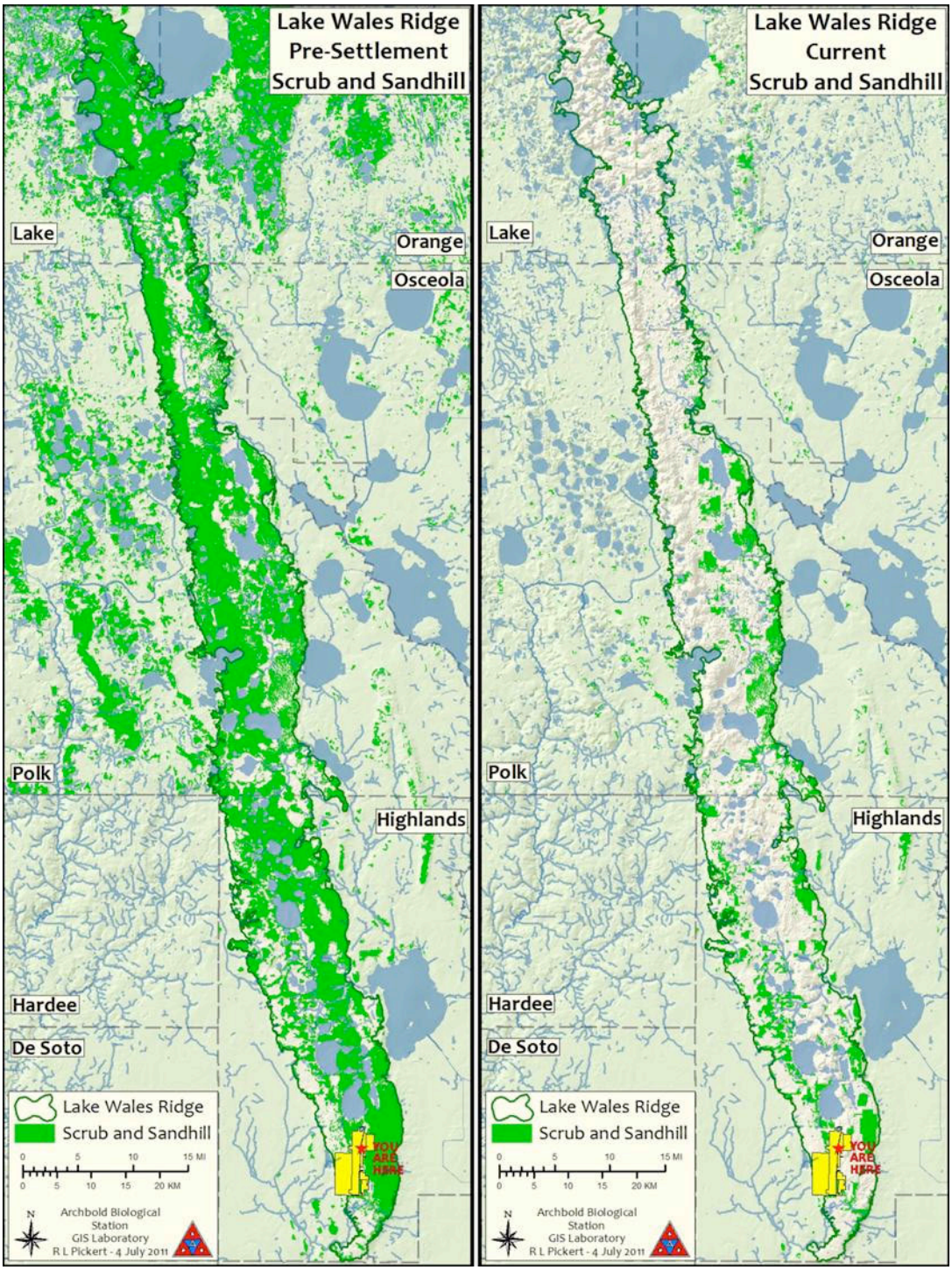
Counties permitted huge platted subdivisions up and down the length of the Ridge, with the result that remaining large areas of scrub were sold world-wide as ¼- and ½-acre lots to unsuspecting buyers, often overseas, or with military backgrounds. The legacy of these ill-conceived planning decisions, and disingenuous marketing ploys, still haunts modern Ridge conservation. The most recent real estate cycle reached its zenith from 2004 to 2007, threatening much of the remaining scrub, but collapsed precipitously in 2008, granting a temporary reprieve from further losses.

Sand Mining

With development, the pockets of coarse quartz sands along the Ridge became attractive to mining companies. Mining was one activity that aroused public concern; a conservation highlight was the public outcry that prevented one mining permit in 1988, for approximately 630 acres of a 2,800-acre scrub site northeast of Frostproof, adjacent to TNC's Tiger Creek Preserve. TNC's local attorney explained the potential for environmental impacts together with the fact that significant sand reserves existed elsewhere, and convinced all five Polk County commissioners to deny the mining request. Holding ground here allowed the subsequent purchase of this land by the state for conservation.

The extent of habitat loss and fragmentation on the Ridge, largely a result of conversion to citrus and development, was documented repeatedly by the science community; 64 percent lost (Peroni and Abrahamson, 1985), 70 percent (Christman 1988a), and 83 percent (Weekley et al. 2008) (figure 3).

Figure 3. Extent of loss (83%) of scrub and sandhill habitat on the Lake Wales Ridge from (a) pre-settlement; to (b) current (based on Weekley et al. 2008). Courtesy of Archbold Expeditions.



The Ridge Becomes an Epicenter for Threatened and Endangered Species

With 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). Twenty-nine species on the Ridge are classified as federally Endangered or Threatened by the U.S. Fish and Wildlife Service U.S. FWS (U.S. FWS 1999). Highlands and Polk counties, which support most remaining scrub habitat, rank among the top 11 counties in the U.S.A 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.A for 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 this suite of 56 species, a subset of 36 plants and animals are endemic or near-endemic to the Ridge (i.e. ≥80% of all known occurrences on LWR) or are restricted to scrub or sandhill habitats in Florida. Other Ridge species may merit listing; for example Deyrup and Carrel (2011) recently surveyed the Ridge for 91 scrub arthropod species that are either endemics or specialists dependent on Gopher Tortoise *Gopherus polyphemus* burrows. Of the 91 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 are known on fewer than 10 sites, or their status is difficult to ascertain as they are hard to catch.

Survival of the Scrub Hangs in the Balance

In 1988 Steve Christman (1988b) wrote an impassioned plea to the conservation community that "the ancient and unique scrub community of Florida's Central Ridges will soon disappear forever." On the Ridge there were only seven sites protected, totaling approximately 30,000 acres, but harboring relatively little scrub or sandhill. Archbold had grown from 1,058 acres in 1941 to 3,974 acres in 1988, 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 to the state by the same Roebling family that donated the land for Archbold, totaled nearly 4,000 acres but had little scrub. 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 their purchase of Tiger Creek Preserve. That story dates back to the 1920s. Author, publisher, and philanthropist Edward Bok established the Mountain Lake Sanctuary, protecting 58 acres, including 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 could never conserve the land. Decades later Ken Morrison, director of the Sanctuary (now called Bok Tower Gardens), and Bok's son, Cary, who was on the Board of Governors of TNC, revived the dream. Morrison and another philanthropist George Cooley mounted a grassroots fundraising campaign to purchase the property. In 1971 TNC purchased 580 acres, to be called Tiger Creek Preserve; by 1988 it totaled 4,700 acres, mostly sandhill and

forested wetlands. In 1989 TNC also started acquisition of the 829-acre Saddle Blanket Scrub, an exceptional example of Ridge scrub.

Between 1984 and 1986 the state, with funding from the Conservation and Recreation Lands CARL program, purchased 13,746 acres, the largest public area on the Ridge harboring some of the best remaining scrub in Central Florida. The area became the Lake Arbuckle State Forest and State Park (later combined and renamed 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 106,110 acres to provide for air to ground bombing training. The modern Avon Park Air Force Range APAFR, which encompasses a small scrub ridge called the Bombing Range Ridge, has one of the highest numbers of threatened and endangered species of any Department of Defense DOD installation in the country, including several scrub species although 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 little contribution towards meeting recovery plan goals. Only three sites were listed as acquisition priorities by the state; Saddle Blanket, Catfish Creek, and an extension of Highlands Hammock (FL 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), funded scientist-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 scrub and sandhill parcels on the Ridge for survey. His report (Christman 1988a) was a turning point in Ridge conservation. He combined field surveys with earlier data to document the occurrences of 35 plants and two lizards. The report crystallized the degree of endangerment for scrub species; it became a rallying call for conservation on the Ridge.

In response to this report and many earlier surveys, together with deep alarm about the prognosis for the survival of the scrub, a conference was convened at Archbold on 29–30 November 1989. Participants included 6 from TNC, 5 Archbold, 11 state and federal agencies, and 9 other scientists and conservationists. Attendees recall a riveting workshop[3] using data, expert knowledge, and rudimentary mapping, to produce a white paper entitled "Biological Priorities for a Network of Scrub Preserves on the Lake Wales Ridge" (Archbold Biological Station 1989). The goal was "to provide 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

[3] John Fitzpatrick, pers. comm. email April 5, 2012.

original geographic extent". The report included maps for 24 sites proposed for Highlands County and 25 for 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 constructed. At last, after all the despondency, the scientists and conservationists created a large, ambitious plan for saving the Ridge ecosystem.

State Land Acquisition: The Lake Wales Ridge Project

The "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 scrubs of the Ridge. John Flicker, then Director of the Florida Chapter of TNC and senior TNC staff, emboldened by strong public support for conservation, had conceived of a far-reaching strategy for state land acquisition. They built the case, recruiting allies in other conservation organizations, in state, county and municipal governments, and formed alliances with supportive legislators[4]. In 1989, Governor Bob Martinez appointed a Commission to examine threats to the future of Florida's environment. They recommended 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, generally levied on documents that transfer an interest in real property, was that it targeted newcomers to the state 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 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, Archbold and FNAI together submitted the "Lake Wales/Highlands Ridge Ecosystem CARL Project Proposal" to the state for consideration (TNC, 1991). Drawing from the workshop in 1989, they targeted 21 scrub sites in Highlands and Polk counties to complement existing conservation lands. This proposal included enough sites to protect a complete portfolio of scrub endemics and encompass examples of each distinctive mix of scrub microhabitats. The spatial configuration included sufficient sites along the linear north–south axis of the Ridge to protect the full geographic range of species. It proposed multiple tracts, connected by smaller habitat islands, to serve as dispersal stepping stones. Other conservation attributes like the protection of aquifer recharge were added. The 21 sites encompassed everything from large single ownerships of scrub that had miraculously escaped clearance for citrus and development, to the eight so-called megaparcel sites, large areas of scrub that had been subdivided and sold as ¼- and ½-acre lots, many to foreign owners, but never developed and still with valuable scrub. Involving more than 20,000 lots, the megaparcel sites targeted for state acquisition were a challenging legacy of earlier flawed planning. No one in real estate would ever envisage, never mind assemble such a complex acquisition strategy, but these were the last, best, remaining areas of scrub.

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[4] George Wilson, pers. comm. email April 5, 2012.

After P2000 was launched, a statewide planning charrette was convened by TNC in 1991 to flesh-out details for an acquisition strategy[5]. Steve Gatewood led a group of approximately 50 well-known scientists, and conservationists from nonprofit organizations and state agencies, to determine the highest priorities for a brighter future for Florida's biodiversity. The Lake Wales Ridge Project ranked among the top priorities at this planning charrette and, over the next two decades, subsequently always ranked at the top, or close to the top, of the state's priority list for acquisition list. The biological importance was irrefutable; under any assessment the Ridge always rose to the top.

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), added to the 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 Saddle Blanket Scrub. Bob Burns and Keith Fountain with TNC's protection department successfully closed many of these deals. They also started purchasing the megaparcel lots; this proved a grueling process as it can be as hard to purchase a single ¼-acre lot, as a 4,000-acre parcel but, by the end of P2000, they had purchased 9,248 acres out of a total 20,201 acres in the megaparcel category.

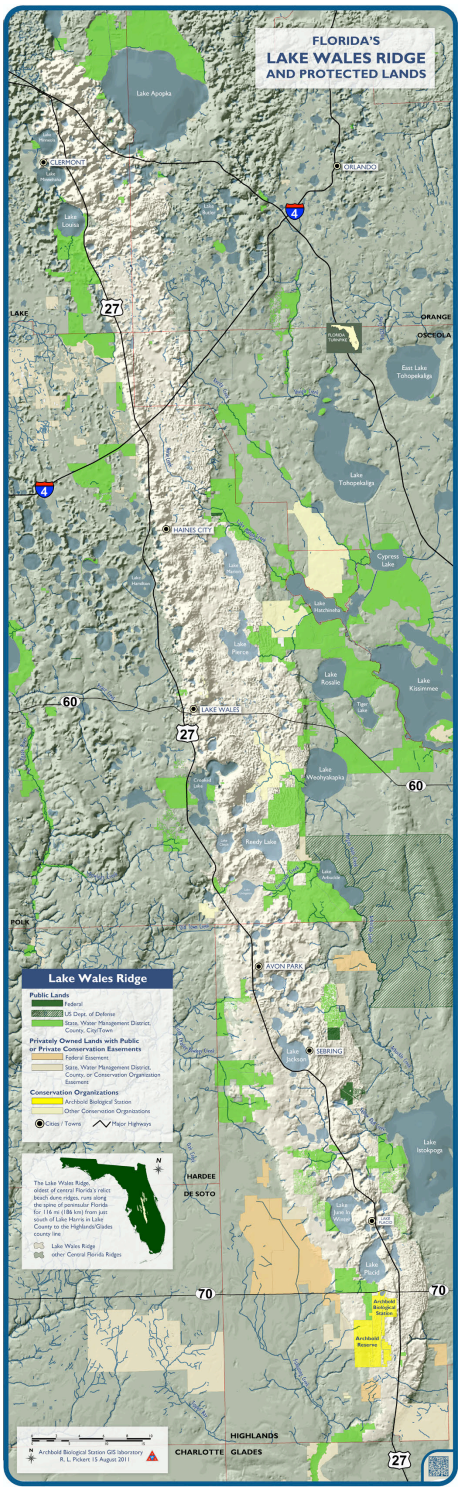
In 1999, following a 72 percent vote in favor of Amendment 5, the Florida constitutional revision provision to continue funding conservation land acquisition, the Legislature passed a successor program to P2000, the Florida Forever Act. It authorized bonding $300 million annually for up to 10 years, starting in 2000. Land acquisition on the Ridge continued. From 2000 to 2006 Hilary Swain, Archbold's executive director, served as gubernatorial appointment on the 9-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. This gave the science community unrivalled access, insight, and participation in the state process. Under Florida Forever TNC made extraordinary progress in purchasing lots in the megaparcels, managing to close on 5,800 acres, nearly 14,000 lots (out of a total 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). But in 2008, following the financial meltdown in Florida, the state ceased to fund Florida Forever and acquisition stalled. Few acres have been acquired since that time. The Governor's proposed 2013 budget has $8.4M for Florida Forever, targeted at 14 conservation projects statewide including the Lake Wales Ridge Ecosystem, although this

[5] George Wilson. pers. comm. April 5, 2012.

will purchase only a small portion of the 24,237 acres remaining in the project (FL DEP 2012), most of which are lots in the megaparcel sites.

Figure 4. Land acquisition by federal, state, and local agencies on the Lake Wales Ridge and surrounding lands (Swain and Pickert, unpublished data 2011).



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 Division of Forestry FL DOF, and FFWCC, assumed management responsibility for state land acquisitions. South Florida and Southwest Florida Water Management Districts also purchased and managed sites, with their major acquisitions being Horse Creek (1,325 acres) and Henscratch/Jack Creek (1,309 acres) respectively.

Establishing the 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 13 listed plants, and 13 more plants that were candidates for listing, as well as four listed vertebrates. Dave Martin, U.S.FWS employee, took a passionate interest in protecting Ridge plants describing them as a national "treasure trove of biodiversity" (Martin 1993). The Refuge was authorized by Congress in 1994, the first designated to protect endangered plants. Unfortunately, Congress did not allocate much money and, of 19,630 acres proposed, only four tracts were acquired, although some proposed sites were eventually purchased by the state. 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). The federal government became a presence on the Ridge.

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 valorem taxes for the purchase of environmentally sensitive land. This county program attracted matching state funds to leverage their dollars, purchasing 4 sites, totaling 804 acres on the Ridge (figure 4). In 2008 a few local Highlands County champions also thought about mounting a local ballot; times were tough and the measure never made the ballot.

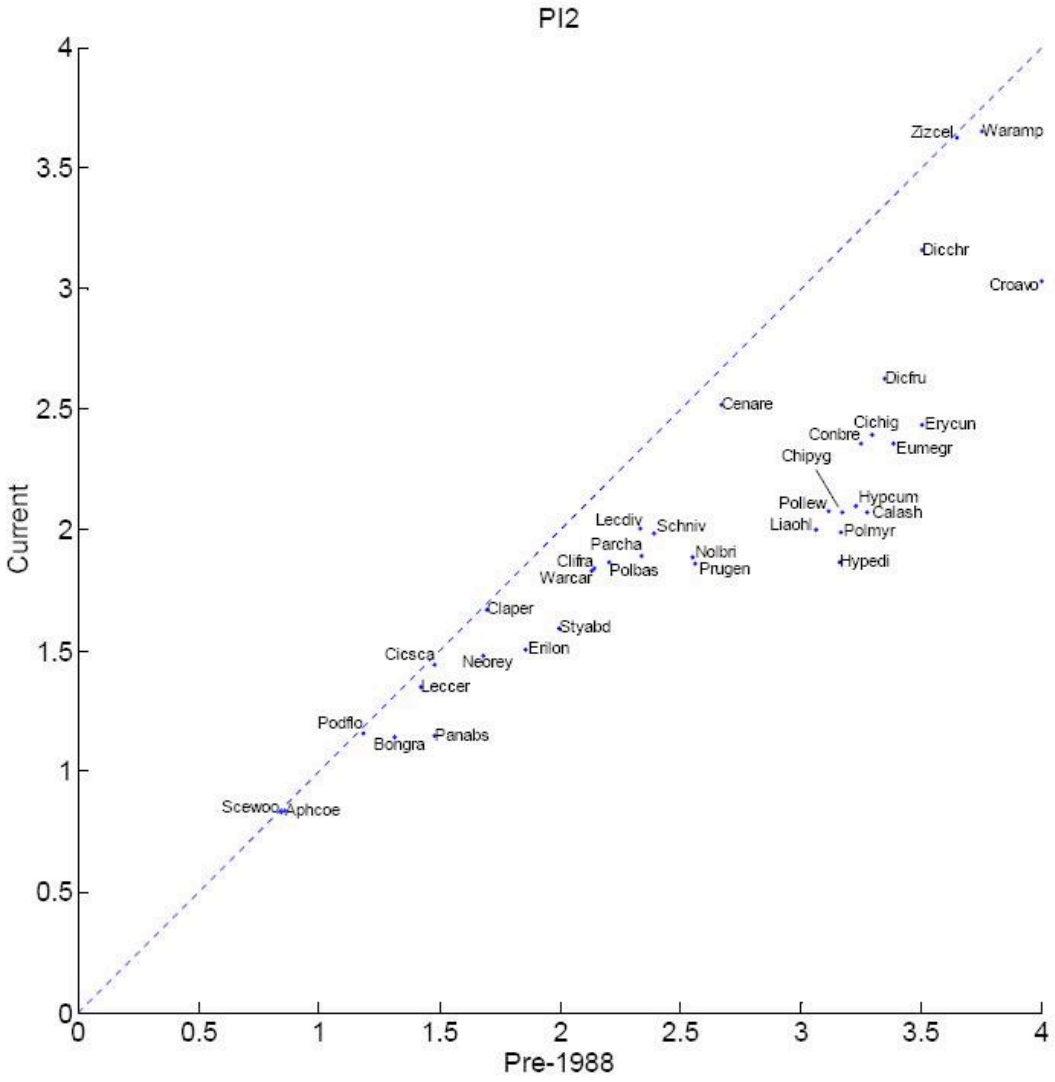
Scientific Evaluation; State of the Scrub

Through a combination of nonprofit, local, state, and federal efforts over $100 million has been spent for land acquisition on the Ridge in the last 25 years. There are more than 104,000 acres of conservation lands on the Ridge, protecting half the remaining native xeric upland habitats. The conservation community, appalled at what had been lost, was somewhat amazed at what had been saved. But is it enough? Prompted by the question "How ***is*** conservation on the Lake Wales Ridge going?" the scientists at Archbold partnered with Dave Wilcove and Will Turner from Princeton University to complete the first scientific assessment of the "State of the Scrub", aimed at evaluating the success of land acquisition in reducing threats.

Turner et al (2006a,b) synthesized existing data on 36 of the rare and endemic species on the Ridge. Their analyses indicated that conservation efforts had contributed greatly to protecting

imperiled species. Using a quantitative approach (figure 5) they showed that conservation purchases since 1988 had reduced extinction risk by increasing: (i) the proportion of sites (occurrences) at which species are protected; (ii) the protected area over which species occurred; and (iii) maintaining their geographic range.

Figure 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 current (2006). The protection index (1, at risk, 4, secure) is based on Red Data book criteria, integrating the number of populations protected, area occupied, and geographic range. Values to the right of the line represent improvements in status, as measured by increases in protection index. Based on Turner et al 2006a. Courtesy of Archbold Expeditions.



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

acquisition based on their biological value and cost-effectiveness. They estimated the incremental effectiveness of the reserve network likely to result from planned future acquisitions. They also noted that, however successful future acquisition, 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

TNC and Archbold knew that effective land management by local, state and federal agencies was paramount for newly acquired scrub. As if the challenges of implementing extensive fire management are not enough, the multiple funding sources for Ridge acquisition means that land management on the resulting patchwork of conservation lands has to be coordinated among thirteen managing agencies (two federal, five state, two county, three nonprofit). The role of science became as much about science-based land management as about acquisition, and about building the social capital to achieve management coordination across a large 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 included TNC, Florida DOF—now Florida Forest Service (FL FS), Florida Department of Natural Resources—now FL DEP, FGFWFC—now FFWCC, Avon Park Bombing Range—now Avon Park Air Force Range (APAFR), Polk County Parks and Recreation, and Polk County Water Resources Division (Polk County). Soon the geographic scope was expanded and Archbold was invited to join. Representatives created a powerful assemblage of scientists and land managers. This organizational collaborative, established in 1991 as the Greater Arbuckle Working Group, 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 fragmentation effects.

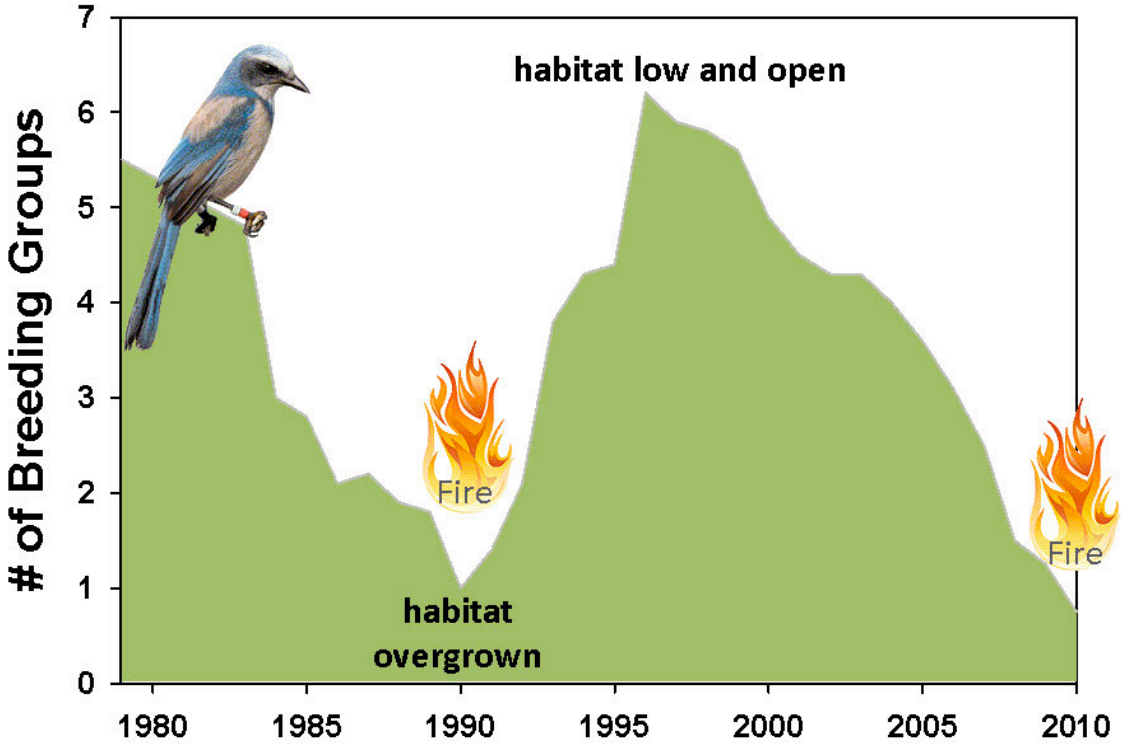
Twenty years later the LWREWG is still going strong. Virtually every land manager participates, as well as nearly all scientists working in the scrub ecosystem. Meetings usually have 50 to 70 attendees, bringing many knowledgeable and innovative agency and scientist minds to the conservation process. The LWREWG has allowed scientists and agencies to share information, resources, and develop a shared vision. It enables a catalytic coupling between research and conservation; research directly feeds 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 non-threatening 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 of the state.

Fire Management

Although the Ridge conservation community celebrated successes in land acquisition, and the LWREWG established an important forum for collaboration, fire management continued to lag behind. It was frustrating. 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 do more than buy it. 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. Warren Abrahamson's widely cited papers on the role of fire in scrub (e.g. Abrahamson 1984a,b) were a paradigm shift 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 6).

Figure 6. The number of Florida Scrub-jays groups in relation to time since fire in one burn unit at Archbold Biological Station (Reed Bowman, unpublished data).



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). 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 Tiger Creek, and reached many of the same conclusions. Ron Myers, who conducted the early burns at Archbold, went onto a career promoting fire management nationally for TNC.

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). Huffman, chair of the LWREWG fire committee, convened a meeting to ask partners what were the biggest barriers to getting fire done. This 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 team 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 team. The team evolved into the Central Florida Ecosystem Restoration Team. An excellent example of public-private partnerships and interagency cooperation, it 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. This is less than 50 percent of the estimated carrying capacity on public lands, and 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

Over the last 30 years Archbold and other scientists contributed towards 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), others for Indigo Snakes, Sand Skinks, Blue-tailed Mole Skinks and Florida Scrub-jay. Planning culminated in the massive South Florida Multi-Species Recovery Plan which includes scrub plants species (U.S. FWS 1999). Writing recovery plans has drawn extensively on scientist input. For example Archbold, in partnership with the Cornell Laboratory of Ornithology, completed complex analyses for; population viability, landscape connectivity, genetic structuring, reintroductions, habitat restoration, and habitat conservation plans for the Florida Scrub-jay. This brought massive scientific firepower to bear on conservation of this threatened species, unique to Florida. Similarly, Carl Weekley at Archbold, in partnership with TNC, Bok Tower Gardens, and other 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 and Menges 2006). This work involves extensive surveys for new locations, basic ecology, research in genetics, 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).

Large Landscapes: Thinking at the Scale of a Bear

After the Ridge reserve network was established, management started, and species-specific recovery underway, another threat loomed larger, again a turning point in conservation. The initial reserve network was envisioned within a matrix of agriculture, but by the mid-2000s a new wave of habitat conversion was occurring from agriculture to development. Former citrus groves and the rural lands bordering the Ridge, much of it low intensity cattle ranching, became an increasing foci of development pressure. Five developments large enough to be categorized as of regional impact, were proposed for Highlands County. The alarming Florida 2060 report showed 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 to facilitate fire management.

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 Florida Black Bear *Ursus americanus floridanus* in Highlands and Glades counties by the University of Kentucky and Archbold (Ulrey 2007, Guthrie 2012), and the statewide modeling by Hoctor.

The Greater Ridge Conservation Planning Tool (TNC et al. 2007) took a science-based approach that gave guidance as to 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 preservation of rare species. The type of land uses surrounding conservation areas plays a critical role in our ability to preserve their conservation value over time. This 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 2010), and a regional corridor analysis under the state's Cooperative Conservation Blueprint (FFWCC 2010). Land managers cannot burn or put smoke onto adjoining areas if they are next to incompatible land uses like major highways, some commercial developments, airports and other sensitive zoning. So the team developed a GIS-based tool as a guide for land use planning around conservation lands (Pace-Aldana 2009). The Florida Department of Transportation is considering adopting 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, in 2010 the Department of Defense initiated a Joint Land Use Study around APAFR (figure 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. Protecting 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

which includes a large portion of the Ridge under the U.S. DOD national Readiness and Environmental Protection Initiative.

Figure 7. The location of protected areas on the Lake Wales Ridge in relation to targeted zones designed to reduce encroachment on military operations and flight paths around the Avon Park Air Force Range (Avon Park Air Force Range, 2010)

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 Nino-La Nina 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. Monitoring data at Archbold, like many rural southeastern sites, do not exhibit marked increases in temperatures, or changes in rainfall, or fire frequencies. Von Holle et al (2010) recently detected temperature-induced shifts statewide in Florida plant phenology; but documented a trend for delayed seasonal flowering among plants in Florida. The climate adaptation strategy on the Ridge is to focus on continually improving management to ensure habitat is maintained in optimal condition.

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 weird of plant associations, 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 Mulvania (1931).

> 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 rosemany (*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 been dependent mostly on a determined cadre of scientists and professional conservationists who marshaled incontrovertible conservation arguments. Few public champions emerged. This may be because most of the remaining 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 history or sense of place.

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 at Circle B Bar. The Center attracts 20,000 visitors annually and offers a variety of environmental education program. In addition, Highlands Hammock State Park can host 2,000–3,000 visitors daily, and many other Ridge sites provide hiking trails and host the public in small visitor centers.

While the reserve network was being put together, 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 the Conservancy 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, the Conservancy transferred the program to the

FFWCC to provide more stable funding source. The program now has 128 members who volunteer nearly 5,000 hours annually[6].

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 to monitor the scrub's flagship umbrella species, the threatened Florida Scrub-jay. 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 (e.g. Breininger et al. 2006). The beauty of this approach was that while the public usually hate smoke and fire, they almost instantly fall in love with scrub-jays. Demographic data on scrub-jays are collected annually. Biennial vegetation monitoring tracks habitat condition in relation to scrub-jay presence. Archbold scientists evaluate and analyze the scientific 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. Jay Watch has become the baseline scrub-jay monitoring standard for state lands managed by the FL DEP and FFWCC.

Additional efforts to generate support for conservation over the years included scientists working with international, national, state and local media outlets resulting in hundreds of articles; creating numerous print and audio visual materials including 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 Mollie Doctrow's *Spirit of the Scrub* and her *Wayside Wildflower Shrines*; 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; 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 scrub lands for purchase,

[6] Bill Parken, FFWCC, pers comm. April 5 2012.

but it is harder to finish an acquisition program than to start. The big, sexy land deals have been largely completed and it's mostly 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 but the conservation community can't afford to "hit the wall".

In addition to the need for continued engagement in land acquisition and protection, there are pressing demands for scientist 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 scare; funders are attracted to 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 a scientist's time, as they are asked to provide more catalytic 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 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 pay-off 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, 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 set 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 admonition 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.[7]

[7] Edward O. Wilson. Forward in Precious Heritage, The Status of Biodiversity in the United States , The Nature Conservancy and Association for Biodiversity Information, 2000.

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