HISTORICAL ECOLOGY OF THE SPLIT OAK FOREST IN EAST CENTRAL FLORIDA

by

Valerie Christine Anderson

A Thesis Presented to the
FACULTY OF THE USC GRADUATE SCHOOL
UNIVERSITY OF SOUTHERN CALIFORNIA
In Partial Fulfillment of the
Requirements for the Degree
MASTER OF SCIENCE
(GEOGRAPHIC INFORMATION SCIENCE AND TECHNOLOGY)

December 2015

DEDICATION

I dedicate this thesis and all of the work it represents to Jessica Sullivan, whose calming influence kept me typing, and my grandmother, Doris Poe Anderson, who funded it all.

ACKNOWLEDGEMENTS

I appreciate all of the great advice and assistance provided by my chair, Dr. Wilson. I would like to thank my dad, Ronald Anderson, for visiting me often and taking me out to lunch. I'm grateful to my committee members, Dr. Travis Longcore and Dr. Darren Ruddell for their time, guidance, and overall good humor.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CIR	Color Infra-Red
CLC	Cooperative Land Cover
DOQQ	Digital Orthophoto Quarter Quadrangle
EPA	US EPA
FDOT	Florida Department of Transportation
FFWCC	Florida Fish and Wildlife Conservation Commission
FGS	Florida Geological Survey
FLUCCS	Florida Land Use and Cover Classification System
FNAI	Florida Natural Areas Inventory
FOSS	Free and Open Source Software
GDAL	Geospatial Data Abstraction Library
GIMP	GNU Image Manipulation Program
LABINS	Florida Land Boundary Information System
GLO	General Land Office
MFL	Minimum Flows and Levels
NLCD	National Land Cover Database
NRCS	US Natural Resources Conservation Service
NWI	US National Wetlands Inventory
PLSS	Public Land Survey System
QGIS	Quantum GIS
RMSE	Root Mean Square Error
SAF	Society of American Foresters

SCS	USDA Soil Conservation Service
SFWMD	South Florida Water Management District
SRM	Society for Range Management
TMDL	Total Maximum Daily Load
US	United States
USDA	US Department of Agriculture
USGS	US Geological Survey

ABSTRACT

Restoration and management of ecologically important sites depend on an understanding of reference conditions and the ability of people to return the site to those historic conditions. Historical ecology research sifts through the data about a site to be able to offer restoration options to land managers. This project demonstrates transitions in natural communities of a protected area in East Central Florida: Split Oak Forest. Natural communities are defined based on the General Land Office (GLO) survey maps and notes and applied to historical black and white aerial photos, modern digital orthophotos, and high resolution satellite imagery.

Because of the channelization of the Kissimmee River and the subsequent draining of the Everglades from 1883 onward, Split Oak, like other areas whose surroundings have been drained, cannot be returned to the conditions at the time of the GLO survey. Thus, a detailed time series of eight snapshots over 171 years will be valuable to land managers and restoration ecologists working in sites that share the hydrologically-modified Northern Everglades watershed with Split Oak.

Natural community descriptions gleaned from the surveyors maps and notes and their application to current land cover are a potential backbone to future historical ecology in the southeast. Seasonally re-hydrating drained wetlands is a priority in this watershed, and is supported by cost-share funding from the State of Florida. This research affirms that most grassy wetlands on the site have transitioned to upland communities. Most of the remaining marshes have been invaded by woody plants and swamps extended their boundaries. Sandhill was used for orange (*Citrus x sinensis*) culture and, along with scrub and flat pine, transitioned to hammock.

CHAPTER 1: INTRODUCTION

Landscapes are affected by human habitation and development. Florida experienced a boom in population during the 20th century and the state's native landscapes were subsequently altered. Today, land managers attempt to restore or maintain undeveloped areas to a benchmark historical condition. These historical reference conditions define the goals of restoration and management. Reference conditions are selected by researchers or land managers by date or an amalgamation of dates, often limited by documentary sources of land cover data. James M. Darcy wrote about the changes that Florida was undergoing as Hamilton Disston’s massive ditch-and-drain ‘land reclamation’ project worked its way around the state:

> “The extensive saw grasses, the dread of Government Surveyors along the [Kissimmee] valley […] are entirely disappearing from the prairies” - *Minutes, vol. 3* November 5, 1884

There are available documentary sources of data for Florida's native communities beginning with European contact in the 15th Century (Harisse 1892; Cantino 1502), though the most ecologically useful data comes later, in the 18th and 19th Centuries. The earliest explorers and maps describe the coast quite well but fail in speculating about the interior. M. John Hawkins reported evidence of unicorns in 1564 (Sparke 1906, 127) and Pedro Menéndez de Avilés wrote about inland mountain ranges during his travels from 1565 to 1570 (Barrientos 1965, 25). Tristán de Luna y Arellano walked in Florida’s interior in the 1560s, it seems that he went north from the outpost Santa Maria, on the panhandle near the present-day city of Pensacola, away from the project site (Campbell 1892; Hudson et al. 1989).

William Bartram walked and rode parts of Florida from 1774 to 1777. The US Geological Survey (USGS) divides much of its new land into sections via the Public Land

Survey (PLS) system, starting in Florida in 1844. Flights to collect aerial photos were commissioned by the US Department of Agriculture (USDA) starting in 1934 in the Pacific Northwest and with the earliest photographs of Florida captured in 1939. Black and white aerials were flown over Split Oak Forest, the study area, in Central Florida in 1944, 1947, 1951, 1954, 1969, 1980, and 1984. Soil surveys were undertaken across parts of the study area in 1922, 1960, 1976, 1989, and 2011. Figure 1 shows the location of the site.

The site is a publicly-accessible county-owned mitigation bank. It covers, and is owned by two counties: Orange and Osceola. It has been called Split Oak Forest, Split Oak Mitigation Park, and Split Oak Forest and Wildlife and Environmental Area. It is named after a 200 year old live oak (*Quercus virginiana*) was split down the middle many years ago and survived.

1.1 Research Questions

The goal of this project is to track natural community change over nearly two centuries using spatial data of varying quality. The three research questions that were addressed in this project are:

1. What natural communities can be identified for the GLO Survey, the five years of black and white aerial photography, and the three years of modern satellite images?
2. How has the character of the site changed over time?
3. What is the spatial pattern of the change in land cover?

The resulting georeferenced maps, aerial photos and historical land cover will be of interest to the managers of the site. The land cover change analysis results will be useful to land managers and researchers from further afar whose sites are bordered by development as well.

1.2 Description of the Study Area

The site is located in central Florida, 14.4 km southwest of Orlando International Airport. It consists of 718 contiguous hectares that straddle Orange and Osceola Counties, as shown in Figure 1. The site covers Township 25S Range 31E Section 3 and ¾ of the SE ¼ of Section 2.

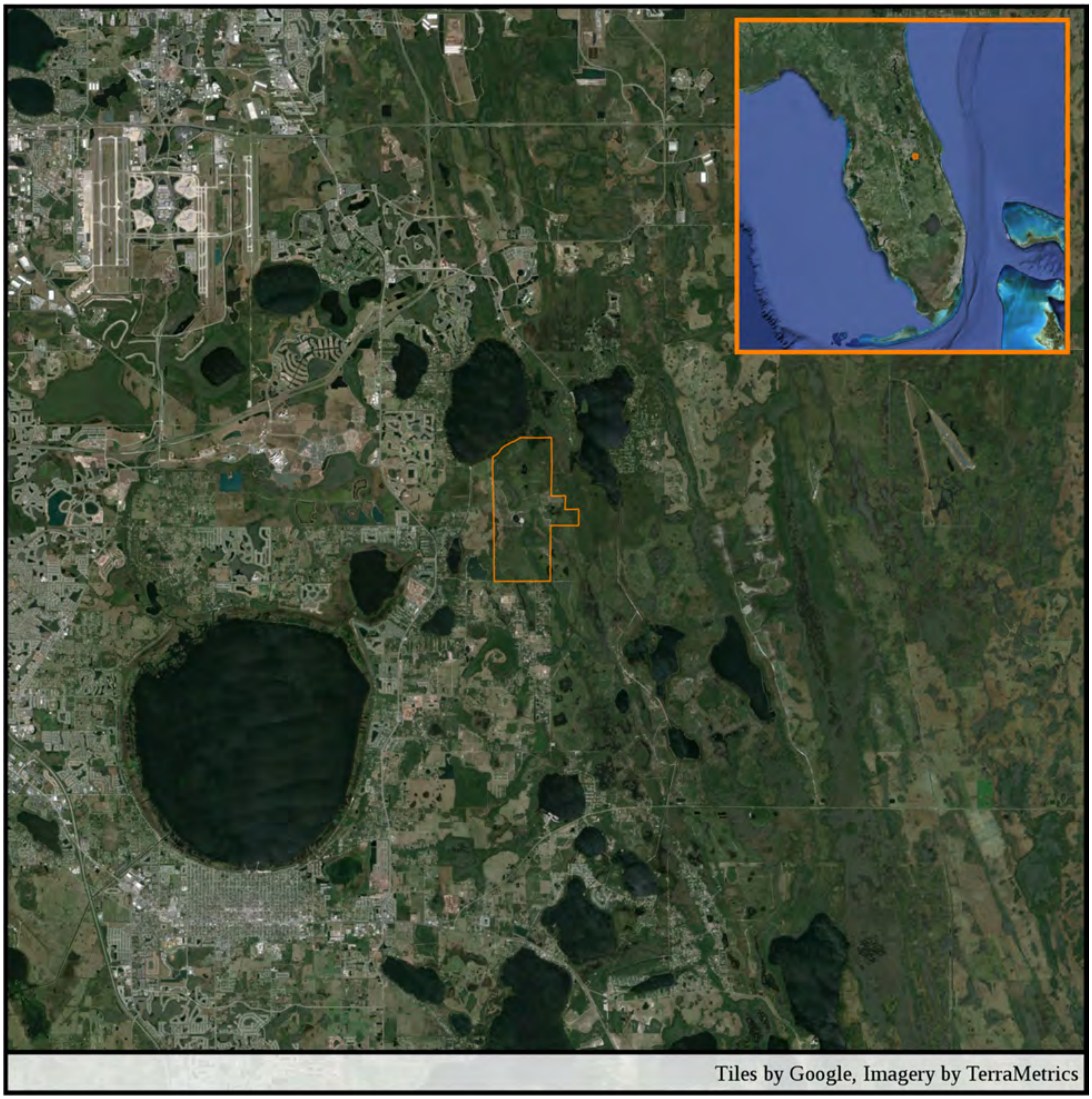


Figure 1 Map showing the Split Oak Forest study site in central Florida, southeast of Orlando and just east of the booming Lake Nona area

1.2.1 Hydrology

The site's hydrology is worth discussing because the levels of water in wetlands and ponds in Florida are often linked with the depth to groundwater. Groundwater in this region is supported by the Floridan aquifer, which underlies much of the Southeastern US and is pumped for agriculture, industry, and housing. Before much of Florida's water was diverted into ditches and canals, it moved over the land in a manner called sheetflow. Historically, broad, shallow sheets of water flowed slowly across the surface of the flatwoods, vegetated wetlands, and swamps; Buckingham Smith, in his report to the US Senate, describes sheetflow across the Everglades: "The water is pure and limpid, and almost imperceptibly moves, not in partial currents, but, as it seems, in a mass, silently and slowly southward." (Smith and Breese 1848, p. 24)

The site is bounded on the north by Lake Hart, a 750 ha tannic lake that is connected through Lake Ajay to East Lake Tohopekaliga by the South Florida Water Management District's (SFWMD) C-29 canal. The site is hydrologically connected to Lake Mary Jane, a 400 ha tannic lake to the northeast that is itself connected to a string of smaller lakes via SFWMD's C-30 canal. That water eventually reaches the Kissimmee River (USFWS 2013). Some of the maps that have been created to show Lake Okeechobee's watershed omit Lakes Ajay, Hart, and Mary Jane (Lodge 2005, p. 106). The three lakes are included in SFWMD's Kissimmee Basic planning area (VanArman et al. 1998). A correct watershed delineation for Lake Okeechobee is very significant because the lake is so large and shallow that direct evapotranspiration from the lake and its littoral zone exceeds on-lake rainfall. The lake is dependent on its watershed (Lodge 2005). Lakes Mary Jane and Hart, the two water bodies that touch the boundaries of Split Oak are the northernmost water bodies that contribute to Lake Okeechobee. Figure 2 shows the hydrological connection between Lake Okeechobee and Lake Hart. The canals and wetlands that drain the Split Oak are also shown.

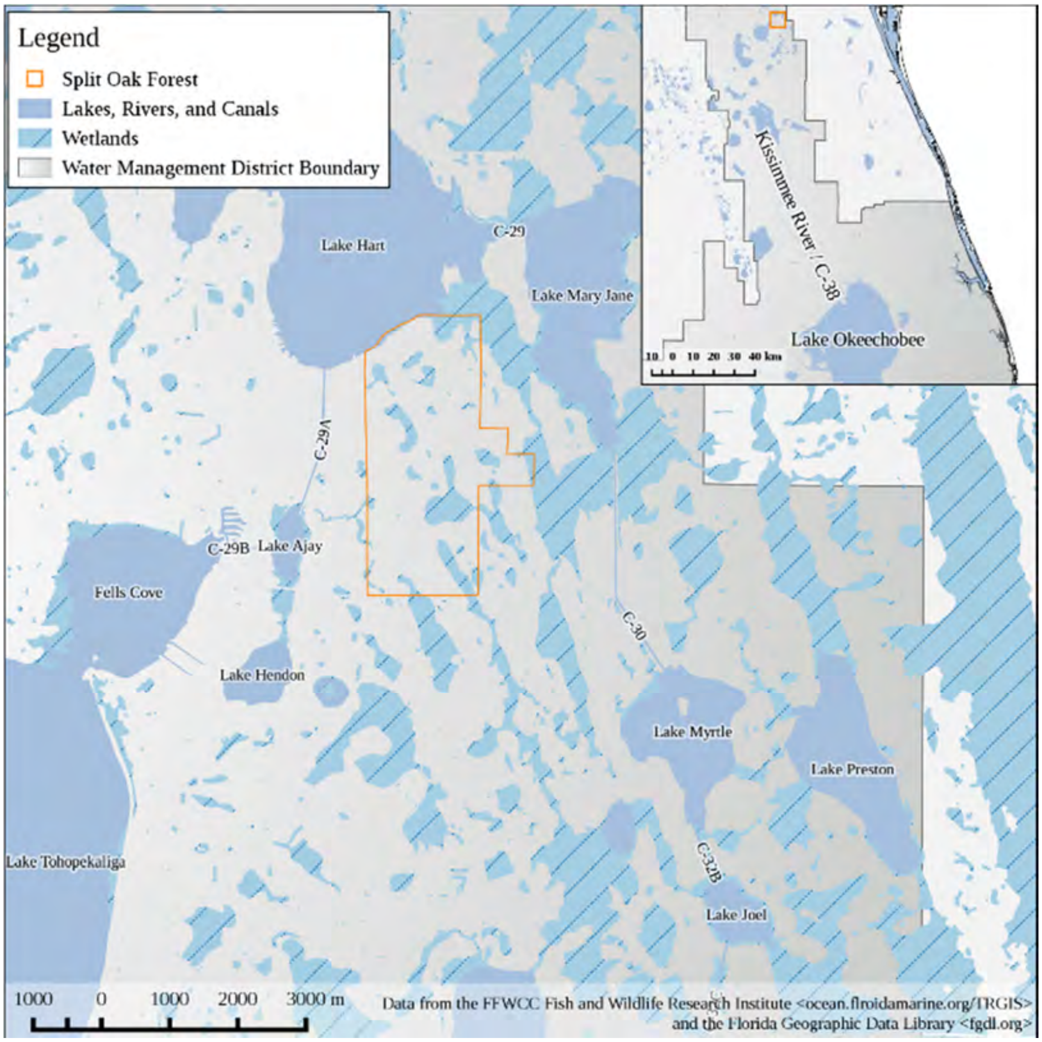


Figure 2 Map showing major hydrologic features, the inset shows how the site it hydrologically connected to Lake Okeechobee

The canal that connects East Lake Tohopekaliga and Lake Tohopekaliga is called the C-31 St. Cloud Canal. It was the third canal built by Hamilton Disston in his massive drainage and development project. The St. Cloud Canal was finished in 1883 and the canals draining Lakes Mary Jane and Hart were completed a few years later (VanArman et al. 1998, 260). This lowered the water levels in the lakes and dried peripheral wetlands. James M. Dancy reported to the State of Florida that Lake Tohopekaliga dropped 4.5' below historic lows (McIntosh, Jr. 1904, 243) for example. East Lake Tohopekaliga was said to have dropped 7' after the canals were finished (Beauchamp 1986, 29). By 1891, it was possible to sail from Lake Mary Jane to the Gulf of Mexico via the Kissimmee River and Lake Okeechobee (Beauchamp 1986, 20).

1.3 Motivation

One application of the project's results will be to inform local residents about their area's history and bolster the efforts of the Osceola County Historical Society. Florida's ecosystems have been modified extensively since European contact, most drastically since the drainage campaign of the late 19th and 20th centuries. Many Floridians are not aware if the protected areas around them reflect how Florida used to look. They also don't understand what the loss of these natural communities mean in terms of vertebrate and invertebrate wildlife, water quality and quantity, and aesthetics. Florida, like much of the remainder of the American Sun Belt, is a state of recent migrants (Frey 2014). The population prior to statehood in 1845 was estimated at 34,730. By 1880 it had reached 267,351 (Secretary of the Treasury 1881). Florida is now the third most populous state, with 19,893,297 people (U.S. Census Bureau 2015). This project shows and quantifies the natural community change within a relatively small, but well-known and heavily visited protected area.

Florida-based historical ecology is discussed at length in 2.3, but a few motivating examples will be mentioned here. Historic land cover/vegetation research is often done. Amy Cohen, for example, digitized John Harshberger's 1913 "Phytogeographic Map of South Florida", which covers an area from about 27º 30' N to the first few Keys. This coverage starts ~90 km south of Split Oak (Cohen 2009). Brean Duncan and Paul Schmalzer have published several articles that use historical aerial photography, 1913 soil maps, city fire insurance maps, and 1900s transportation maps to model 1920s land cover on Cape Canaveral (Duncan et al. 1999; Duncan, Larson, and Schmalzer 2000). The project site has even been the subject of some limited historical ecology: Jacobs and Prenger (2007) constructed a single historical land cover map using the modern Florida Natural Areas Inventory (FNAI) classification system, relying on the 1844 survey notes by Whitner and 1947 aerial photographs.

Many researchers have tried to estimate the historical extent of longleaf pine (*Pinus palustris*) forests. Longleaf pine forests used to cover the southeast from Texas to Southern Virginia and have been greatly reduced in number and geographic extent (Boyer 1990). Van Lear et al. (2005) provide a very good overview of the longleaf pine ecosystem and broadly describe its historical ecology. Walker (2000) performed ecological, archaeological and oral-historic research focusing on pine flatwoods near Ft. Myers on the southwestern coast of Florida. The 'flat pine' natural community identified in this project is the same as longleaf pine flatwoods. Flat pine is how all of the hydrological varieties of pine flatwoods (xeric, hydric, and mesic) are referred to in the 1844 and 1848 GLO surveyor's notes.

Since this thesis project was limited in its resources and time, it focuses on a small area that has the potential to attract substantial attention. Split Oak is located within the Orlando metropolitan area, and in the middle of the rapidly growing, upscale Lake Nona community. It is the nearest hiking to Lake Nona and is popular with geocachers, boy scouts, trail runners, and horseback riders (Belson 2013). Historical research on Split Oak is valuable not only for the potential exposure but because it is one of the few protected areas in the vicinity. Deseret Ranch, Split Oak's neighbor, has been attempting get approval to develop a new city within a few miles of the preserve (Anonymous 2014; Spear 2014).

Restoration and management of publicly-owned lands are drivers for historical ecological research. The State of Florida owns and manages large areas of conservation land. Its acquisition program started early, in 1972, and was strong for many years (Farr and Brock 2006; Finnell Jr. 1973). It has declined since 2006 due to the political environment in the Florida capitol (Wyland 2015; Khahaifa 2012; Dunkelberger 2014). Much of Florida’s public land is not open to recreation, such as the Kennedy Space Center and 21 U.S. military bases (Anderson 2015). Some of these properties remain in native or semi-native vegetation and are managed as such. The powerful water management districts also manage and occasionally restore land. Before oranges, cattle were Florida's predominant agricultural product (Yarlett 1985) and consequently, even today a 2,000 acre ranch is common in central Florida. Ranches have been purchased for restoration/preservation by nonprofits and corporations such as the Audubon Society, The Nature Conservancy, and Forever Florida.

1.4 Thesis Organization

The remainder of this thesis is organized into four chapters: Chapter 2 – Related Work; Chapter 3 - Methodology; Chapter 4 - Results; and Chapter 5 - Discussion and Conclusions. The next chapter will contextualize the project, exploring related work on land cover change analysis, natural communities, and historical ecology. The third chapter, Methodology, addresses the data used for this project by describing its acquisition, quality, and handling. The plant communities defined for this project are described briefly in Methodology, their full descriptions are provided in Appendix A. The second and final part of Chapter 3 describes the methods that were used to analyze change on the site. Chapter 4, Results groups the results by change periods. This chapter explains the transition in communities for each year and explores overarching ecological themes over the 171 years. Chapter 5, Discussion and Conclusions reports on the most significant takeaways from the project, reflects on the use of open source software, and proposes project extensions and further work.

CHAPTER 2: RELATED WORK

As a land cover identification and analysis project, this thesis draws chiefly from the land cover change and historical ecology fields. Land cover mapping is a mature discipline. Current research focuses on automatic classification of satellite remotely sensed imagery in order to understand climate change, identify the cause of land cover changes, and model landscape-scale events such as fire and human development.

Land cover is sometimes lumped in with land use, as in the USGS's National Land Cover Database (NLCD) (Homer, Fry, and Barnes 2012). This and similar systems are not intended for measuring fine-grained ecological change. Because of this, this project will consider land cover units at the ecological community scale. Ecological communities that have been minimally impacted by humans are called natural communities by the FNAI and others (e.g. Whittaker 1962; Garland and Thompson 2011; California Natural Resources Agency 2009; University of New Mexico Libraries 2015).

2.1 Land Cover Change Analysis using Historical Imagery

Historical aerial imagery is often the most spatially continuous record available of historical land cover and vegetation (Barnes 1989; Torri et al. 2013; Guariguata 1990; Simpson et al. 1994; Ross, O'Brien, and Sternberg 1994; Bakker, van den Berg, and Speleers 1994). However, they are difficult to use in land cover change analysis because the flight and camera information are often unavailable and the photos must be registered to a coordinate system to be useful (Grip, Grip, and Morrison 2000). Some researchers have explored automatic and semi-automatic stitching and registration (Jao, Chu, and Tseng 2014; Necsoiu et al. 2013; Yu, Zhang, and Holden 2008; Yang and Gao 2009; Li 2010; Xu, Zhang, and Li 2014). Some automatic registration and stitching is available in GRASS 7, ERDAS Imagine, and ArcGIS 10.1 (GRASS Development Team et al. 2014; Neteler et al. 2005; ERDAS, Inc. 2008; Esri, Inc. 2012). This project did not employ any form of automatic image registration or stitching. The focus was on small-scale changes in the landscape, and the task of registering the images manually was manageable.

Historical imagery is greyscale, and photo interpreters of the time responded to this limitation by delineating boundaries between land cover or vegetation types (Kadmon and Harari-Kremer 1999). When this delineation is done by hand, it is extremely time consuming and limits the analysis to smaller spaces (Scanlan and Archer 1991; Callaway and Davis 1993; Frelich and Reich 1995; Skinner 1995). Some researchers have avoided this arbitrary and labor-intensive process by analyzing the historical imagery for texture (Hudak and Wessman 1998, 2001). Awwad (2003) composited the singleband images that were the results of textural analysis into multiband images. He then subjected those images to automatic classification.

Vegetation survey plots, photo points, and other systematically collected data about natural communities are often only available for areas that have been managed for conservation. Locals that were old enough to remember the landscape of the time of the study may be able to guide historical land cover delineation. Ellis et al. (2006) employed local people trained in photointerpretation to field-validate land cover maps from 1950 to 2001.

2.2 Natural Communities

A natural community is a system of organisms, their physical environment, and natural processes that impact them (Clements 1916; Garland and Thompson 2011). A natural community is defined by its plant species, and thus is useful as a more specific addition to standard land cover classification systems. No two sites have the exact same composition of flora, but this does not preclude organizing individual plants into associations or assemblages (Gleason 1917). GLO Survey maps and notes are the most complete of the old documentary sources of data for the site. These surveyors were not naturalists and described only six land cover categories: pine, marsh, swamp, pond, lake, and bay gall. They also judged the site for agricultural productivity, calling most of the site “third rate”. Fortunately, two surveying teams visited the site, the first in 1844 to mark out the township perimeter and the second in 1848 to delineate the sections. Whitner, the township surveyor, described the vegetation in greater detail than Loring, the section surveyor.

Natural communities that were not mentioned in the first survey map and accompanying notes for PLSS Sections 34, 35, or 36 but are present in later years and needed to be described in a manner appropriate for the survey-level natural community description. The original communities were described as bay gall, marsh, and flat pine. Between 1848 and 1944, some of the Samsula and Sanibel muck underlying the flat pine community was removed and spoil piles were deposited. In the land cover literature, the common identifier of communities resulting from human activity is ‘cultural’. An additional descriptor is appended to ‘cultural’ describing the type of community that developed because of human influence. Community definitions are discussed in depth in Chapter 3.

A soil survey from the early twentieth century is available for the portion of the site that is in Orange County. The idea of correlating soils data with land cover is very attractive and has been tried many times in Florida. The surveys themselves list common plants found on each soil. The *"26 Ecological Communities of Florida"* report provides a table that matches each 1960s-era soil type to one or more ecological communities (USDA SCS 1981, A–1). The Society for Range

Management (SRM) and the NRCS tried to correlate the modern soil map units with updated ecological sites, but they never finished the Ecological Site Descriptions (SRM 2014 Orlando Planning Committee 2014; SRM 2011). Most recently, the NRCS has created forage suitability groups that are associated with one or more modern soil map units (Williams 2012).

In 1922 each soil was assigned a general vegetation description that is consistent across Orange County. Peat is associated with sawgrass, Leon with palmetto flatwoods, longleaf pine, and runner oak, and Portsmouth with broomsedge.

The numeric codes that would have been filled in for the survey-data-scale natural community categories in the Florida Land Use and Cover Classification System (FLUCCS) are shown in Table 1.

Table 1 FLUCCS Code – Natural Community Crosswalk

Name	FLUCCS Number
Flat Pine	1300
Cultural – Spoil	1877
Marsh	21212
Baygall	2231
Pine and Cypress Swamp	2242
Cultural - Palustrine	2400
Cultural - Lacustrine	3200
no data	0

2.3 Historical Ecology

Historical ecology is an emerging field and active area of research that combines ecology and historical geography to study lost historic ecosystems. The field is practical as well as theoretical; historical ecology is often funded in order for a restoration project to have reference conditions. Because North America had an historical exploration/settlement period that was short and well documented relative to that of other continents, proposed historical ecology methods have been well documented, for example in *The Historical Ecology Handbook* (Egan and Howell 2005). Though all of the related work in this section focuses on North America, this does not discount the extensive work that many researchers have conducted on other continents. McGovern et al. (2007), for example, did a beautiful job investigating the historical ecology of Iceland starting in the Viking era.

In my opinion, existing historical data is underutilized in land management. Fortunately, historical ecology is an active area of research. Longcore and colleagues have authored many articles on the historical ecology of southern California, frequently providing concrete recommendations for restoration (Dark et al. 2011; Stein et al. 2007, 2010; Beller et al. 2011; Jacobs, Stein, and Longcore 2011; Longcore and Rich 1998; Mattoni and Longcore 1997; Mattoni et al. 1997). The list of important historical ecology projects is long, though some of note are the now-defunct USGS Land Use History of North America (Bliss et al. 2012) and the entire Chesapeake Bay restoration project (Chesapeake Bay Program 2015).

The field is not concentrating solely on the vegetation of terrestrial landscapes, scholars have also looked into individual aquatic species (McClenachan 2009a; Ermgassen et al. 2012) and entire intertidal ecosystems (Wares and Cunningham 2001). Modeling historical biomass is an emerging trend, with Ermgassen et al. (2012) looking at wild oysters and Rosenberg et al. (2005) investigating cod. The majority of the following related work will discuss only landscape historical ecology.

Data that supports historic ecological research can be divided into two broad categories: prehistoric/natural and historic/documentary (Bromley 1935; Swetnam, Allen, and Betancourt 1999). Fossil trees and plants, charcoal, coral layers, animal deposits/structures, ice cores, and fossil pollen are examples of natural archives. Early travelers’, early surveyors’ and early settlers’ records along with historical written maps, local histories, weather records, insurance maps, historical aerials and vegetation surveys exemplify documentary archives.

Edmonds (2005) further sorts documentary evidence into eight additional categories: (1) classic early explorations; (2) the Jesuit Relations; (3) travelers’ accounts; (4) Native American sources; (5) official US government expeditions; (6) local histories; (7) census schedules; and (8) early scientific investigations. The Jesuit Relations are not spatially relevant and no Native American sources or early scientific investigations are readily available for this site. Natural community descriptions for this project are correlated with travelers’ accounts and the GLO Survey, an official US government expedition, provides the earliest fine-grained spatial data for this project. Local history is tapped to explain settlement patterns and densities, as well as to verify dates and events described in contemporary sources.

Researchers trying to perform historic ecological work on travelers’ records do so because often these records are absolutely the earliest written observations about their area of study. The downside is that the traveler is often a casual observer without a set course or a reason to rigorously sample the vegetation. Frost (2000) used the written observations of George Washington in 1753 and William Byrd in 1728 to reconstruct historical fire regimes and vegetation patterns in the Dismal Swamp region of North Carolina. As Frost (2000, 293) points out, “most of the valuable ecological information available from first settlement to the end of the Colonial Era is provided by nonscientists”.

The natural community accounts created for this project are backed up by travelers, botanists, and other observers both before and after the GLO Survey. While none of the individuals listed in any of the communities' '*Historical Descriptions*' are known to have traversed the project site, their descriptions of nearby landscapes reinforce the classifications.

The present day conditions of the natural communities present on the project site are products of indigenous human actions and a complex cascade of events and conditions that began at European contact with and subsequent settlement of Florida. It is debates whether Juan Ponce de Léon was the first European to step on the peninsula or not (Smith and Gottlob 1994; Cantino 1502). His arrival in 1513 heralded cattle grazing, hog rooting, 16urpentining, timbering, fire suppression, and landscape fragmentation (Davis 1932; Myers 1990). All of the historical observations of communities that occur on the project site were made over 250 years after the first somewhat-accurate map of the Florida peninsula, *Carta del Cantino,* was published. These observations must then show landscapes that are at least somewhat altered from their pre-contact conditions. Even when a landscape was observed by a European at first contact, it is presumptuous to assume that his description is of a pristine ecosystem unaltered by people: The indigenous population of the southeastern US was organized into complex, armed chiefdoms with densely populated towns (Smith 1987).

The US Government was very active in financing rail beds and waging war in the 20th century. These surveys and records are often very useful to historical ecologists, but were not available for this part of Florida (Edmonds 2005). However, land survey data was available and provides the earliest data set for the project at hand.

Land surveys of North America come in three varieties: (1) irregular metes and bounds surveys; (2) regular private land surveys; and (3) regular public land surveys (Wang 2005). The purpose of these surveys was not to accurately sample the vegetation, they were commissioned to enable private and public land transactions. Despite this limitation, much historical ecology research has been based on these old surveys, and contemporary researchers like Black and Abrams (2001), Bourdo (1956), Delcourt and Delcourt (1996), Iverson and Risser (1987), Kronenfeld and Wang (2007), Manies et al. (2001), Manies and Mladenhoff (2000), Mladenhoff, et al. (2002), Wang (2005), Wang (2008), Kronenfeld and Wang (2008), and Wang and Larsen (2006) have critically assessed old surveys for inaccuracies, biases, and suitability for reconstructing pre-settlement vegetation.

Metes and bounds surveys of colonial states contain the earliest systematic vegetation descriptions in North America (Bourdo 1956). Loeb (1987) compared trees listed in colonial metes and bounds surveys with the fossil pollen record and estimated historical tree abundance. However, as Florida was not one of the first colonies, the first surveys conducted in central Florida were, to the best of my knowledge, the official GLO surveys.

The GLO Surveys were the result of an act of Congress in 1785, starting with Ohio. The survey program was intended to promote settlement by making land sales and land grants easier. The townships were intended to be exactly six miles on a side such that they could be divided into 36 one square mile sections. These parameters did not always become reality, so many townships are irregular. The corner posts as originally marked remain official (Avery 1967).

Researchers have quantified tree density change using GLO surveys (Nelson, Redmond, and Sparks 1995), but other researchers argue that absolute density cannot be accurately obtained from the section line and corner post data (Almendinger 1996; Grimm 1984). Old surveys of all three types have been used successfully for comparing the relative structure of ecosystems (Schulte and Barnes 1996; Whitney and DeCant 2005) and for listing tree species and their relative abundance (Lutz 1930; Spurr 1951; Thompson et al. 2013). The number of studies, in addition to the studies already cited, using the GLO surveys for historical ecology work is staggering: Dick-Peddie (1955) in Iowa, Fralish et al. (1991) in Illinois, Fritschle (2008) in California, Sears (1925) in Ohio, and Stearns in (1949) Wisconsin are but a few of the notable examples of such work.

Researchers like Fagin and Hoagland (2011), He et al. (2006), Larsen et al. (2015), Puric-Mladenovic (2003), and Tulowiecki (2014) and have used bearing tree and/or line description data from the GLO survey to create species distribution models.

2.3.1 Historical ecology in the Southeastern US

The 49,104 km^2 of managed conservation land and water has driven historical ecological research in Florida. This includes research that supports the restoration of the Everglades. Bousquin et al. (2005) conducted the most comprehensive study of historical ecology on the Kissimmee River, which indirectly drains the study area and flows into Lake Okeechobee. Other work has included studies examining urban lakes (Brenner et al. 1995), the loss of trophy fish (McClenachan 2009b), and the dry prairies and grasslands of the American Southeast (Noss 2013).

Cowell (1995) examined the unique pre-GLO ‘land-lottery’ surveys commissioned by the State of Georgia to estimate pre-settlement tree abundance in the Piedmont region of Georgia. Clewell (2011) used a British Colonial road map (Purcell 1778) reconstructed by Boyd (1938), GLO Surveys (Clements 1824; Smith 1874; Henderson 1878; May 1825), a census report on Florida cotton production (Smith 1884), and two vegetation surveys (Harper 1914, 1915) to describe forest succession on previously-farmed land. The report on cotton production is part of a series within the US Census that assesses various soil types and vegetation associations for their suitability as cotton land. These land cover and soil observations and correlated with this projects' natural community descriptions in Appendix A.

Historical documentary data sources that describe the flora and fauna of Florida can be valuable, depending on their location, extent of travel, the individual's familiarity with Florida, and the person's botanical knowledge.

Bernard Romans, a marine surveyor for the British crown and private companies, surveyed Florida's coast from 1766-1772 (Romans 1776). He walked across the state from Tampa Bay to St. Augustine after a shipwreck in 1769, collecting plant parts and seeds and recording detailed notes (Braund 2007). He later published *A Concise Natural History of East and West Florida* to capitalize on the success of his well-received maps (Phillips 1924).

William Hayne Simmons, touring Florida in 1821 just after it was acquired from the Spanish, said that the Florida scrub is a concealed desert that is not fit enough for browsing cattle (1822). He traveled between St. Augustine and the Alachua prairie (now Gainesville). Marjorie Kinnan Rawlings wrote fiction set in the scrubby lands between the Ocklawaha and St. John's rivers. Her stories described vast swaths of flammable vegetation growing on what appeared to be beach sand interspersed with islands of pine and hardwoods (Rawlings 1933, 1938). These natural communities are now known as scrub and sandhill, respectively.

George V. Nash, a botanist, recorded some general information about the landscape of North and North Central Florida from Tampa to Orlando to Titusville to Jacksonville to Tallahassee. His articles focus on the botanical descriptions of plants, but they still describe the landscapes in some detail (Nash 1895, 1896). Botanical works such as *Flora of the Southern*

United States (Chapman 1897) list plants by family and their short descriptions of the plants' locations and habitats can be useful for confirming other historical sources' species identification.

Action from the state government has funded some historical ecology research using similar data as was used for this project. As background, the State of Florida has a program that designates "special" water bodies as either *impaired* (really polluted) or *outstanding* (having some historical or ecological significance). The State only requires itself to develop standards for how much nutrient and other pollution can enter a that body of water, and how much water a lake should have or a spring should put out if that water body is on one of the two lists. These standards are called the total maximum daily load (TMDL) and the minimum flows and levels (MFL), respectively (Migliaccio, Li, and Obreza 2014). The State has long resisted (via lawsuits and congressional legislation) numerical criteria for water quality, insisting that Florida is different and the narrative standard listed in Florida Administrative Code, Ch. 62-302.530 is sufficient (National Research Council 2012; EPA 2014; Flowers and Charles 2012; MacCurdy 2011). For example, Florida Senator Mark Rubio wrote "Florida has one of the most aggressive water-quality protection programs in the nation, implemented by the people who know our state best, and it's time EPA stop bullying us into accepting another Washington-contrived mandate that would devastate job creation" (Rubio (2012). To support the development of TMDLs and MFLs for some of these very special waters, Bukata and Kolasa (2005) generated historical land cover and hydrography data for the Peace Creek and Lake Wales Ride Basins using GLO survey maps and notes, 1927 soils data, and military maps.

2.3.2 History of the Area

First, we'll discuss the political boundaries of the area in the 19th and 20th centuries. Lack of knowledge of the interior of Florida did not prevent Colonel Robert Butler from dividing Florida into two counties in 1821: Escambia and St. John's (Gannon 2013). St. John's County included all land south of the Suwannee River, including the project site (Young 1826). The counties were divided again in 1824 and Mosquito/Musquito County was created (Gannon 2013; Searcy 1829; Hinton 1832; Drayton 1827). It lasted until 1845, when it was carved up into Orange and Brevard, with the project site in Brevard. Osceola County was established in 1887, taken out of Orange County and Brevard (Cody and Cody 1987, 4). That action brings us into the present with the site being split between Orange and Osceola Counties. At the time that Osceola County was created it had 815 residents (Beauchamp 1986, 45).

The closest town to Split Oak is the unincorporated Narcoossee. English Army retirees settled the towns of Narcoossee and Runnymede starting in 1883. Both towns were colonies of England. Runnymede had a Polo Club, lawn bowling, tennis, horse racing, an ostrich farm, croquet, a library, afternoon tea, and evening dances. Runnymede attracted Kissimmee residents and tourists who took the St. Cloud & Sugar Belt Railroad to these parties. Narcoossee's population dwindled after a drought in 1908 followed 'The Great Freeze' of 1984-5 and it has never incorporated (Beauchamp 1986, 35).

Between 1910 and 1920 Orange and Osceola Counties together grew 9%. While the rest of Florida experiences a boom and bust from 1920 to 1925, the 1930 census reports combined growth of 123% for the counties: There was a rash of development from 1925-1927, creating the Hendon Park neighborhood in Narcoossee. A category 4 hurricane hit the state in 1926 and a category 5 hurricane killed thousands of people in 1928, Wall Street crashed in 1929, and the two counties still grew 33% between 1930 and 40. World War II took many lives but the counties still grew 58% over the next ten years. The two counties have together sustained at least 30% growth over every ten years since 1950. The societal trend of suburbs and exurbs has not excluded central Florida. The intestinal-shaped developments are visible on the modern aerial in Figure 1.

The rabid development around the site is another motivator for this research. Areas that were previously managed as natural areas and rangeland are quickly being replaced by subdivisions, dollar stores, and gas stations. Education is key to cultivating appreciation for ecology and fostering responsible environmental behavior (Bogner 1998).

CHAPTER 3: METHODOLOGY

The main goal of this project was to quantify the changes in Split Oak's natural communities over time. To do this, natural communities were defined to the level of detail available in the GLO Surveys. These community definitions were then applied to the imagery captured in later years so that the historical data could be compared with modern data. This chapter describes the data and methodology used for this research. The first section describes the data used in this project, including its quality, sources, and how it was processed. The second section describes the natural community definitions that were used and how these were applied to the various data sources that were used, and the final section describes the methodology that was developed and deployed to conduct the change analysis.

3.1 Data

The various data sources used for this thesis project brought a variety of strengths and weaknesses to the work at hand because of the information that was included and could be gathered from each source and because of the quality of the information that was associated with each of these data sources and the information that was extracted and used to prepare the change analysis described in Sections 3.2 and 3.3.

3.1.1 Acquisition

The survey plats were acquired by township from the GLO and the Florida Land Boundary Information System (LABINS) website (http://www.labins.org). The aerial photos were acquired from the University of Florida Digital Collections website (http://www.ufdc.ufl.edu). Flights were conducted on varying numbers of tiles each year, as cameras and flying height varied. The 1995 Digital Orthophoto Quarter Quadrangle (DOQQ) and the 2011 High Resolution

Orthoimagery were acquired from the USGS's EarthExplorer website (http://earthexplorer.usgs.gov). Soil surveys completed by the U.S. Soil Conservation Service (SCS) and its successor, the Natural Resource Conservation Service (NRCS) in 1960, 1979, 1989, and 2011 were acquired from at the NRCS website (http://nrcs.usda.gov). Only a few paper copies remain of the 1922 soil survey and this map was digitized for this thesis project from a copy at the NRCS State Office in Gainesville, FL. Table 2 summarizes the data used.

3.1.2 Quality

The spatial data was used either as a main data source, primary, or as a supporting data source, secondary, and the quality varied as documented below.

3.1.2.1 GLO Survey

The GLO Survey contains information in four basic formats: (1) survey plat maps; (2) township summaries; (3) corner boundary tree bearing and distance; and (4) line descriptions (Whitney 1986). The survey maps' land cover description and labeling are minimal. The maps indicate six distinct natural community classes for the project area: (1) flat pine; (2) marsh; (3) swamp; (4) pond; (5) lake; and (6) bay gall. They are also consistently symbolized, but unfortunately not consistently applied (even within the same surveying team). The line descriptions found in the surveyor's notes describe the vegetation in more detail than the map. In addition to the bearing tree positions, directions, names, and diameters the notes contained descriptions of "any thing in the township worthy of particular notice […] and […] a general notice or description of the township in the aggregate, as it regards the face of the country, soil, timber, &c". The surveyors were also instructed to record the local names of any "rivers, creeks, smaller streams, lakes, swamps, prairies, hills, mountains, or other natural objects" (Conway 1842, 327).

Table 2 Data source and quality information

Name	Year	1°/2°	Format	% Coverage	Source	Scale	Resolution
T.XXV.S R.XXXIE. & T.XXVI.S_R.XXX.E. by Whitner	1844	Primary	Map in JPEG2000 and Handwritten Notes	100	glorecords.blm.gov	1:31,680	1 px:1.82m
FL.TXXIVS. R.XXXIE & FL.TXXVS. R.XXXIE by Loring	1848	Primary	Map in JPEG2000 and Handwritten Notes	100	glorecords.blm.gov	1:31,680	1 px:1.81m
Soil survey of Orange County, Florida	1922	Secondary	print book - digitized	64.5	NRCS State Office	1:63,360	1 px:11.06 m
Flight 4C & Flight 5C	1944	Primary	JPEG2000	100	ufdc.ufl.edu	1:20,000	1 px:1.83 m
Flight 6D	1947	Primary	JPEG2000	100	ufdc.ufl.edu	1:20,000	1 px:0.86 m
Flight 4H	1951	Primary	JPEG2000	100	ufdc.ufl.edu	?	1 px:0.95 m
Soil Survey Orange County Florida	1960	Secondary	PDF & print book	64.5	Orange County Public Library (OCPL)	?	1 px:11 m
Flight 1LL	1969	Primary	JPEG2000	100	ufdc.ufl.edu	1:40,000	1px:1.77m
Soil Survey of Osceola County Area Florida	1979	Secondary	PDF & print book	35.5	OCPL	?	?
Flight 180	1980	Primary	JPEG2000	100	ufdc.ufl.edu	1:40,000	1 px:1.77 m
Soil Survey of Orange County, Florida	1989	Secondary	PDF & print book	64.5	OCPL	?	?
DOQQ	1995	Primary	GeoTIFF	100	earthexplorer.usgs.gov	1:12,000	1 px:1 m
Split Oak Mitigation Park Plant Community Type Mapping Analysis Results	2007	Primary	PDF	100	myfwc.com	?	?
CLC v1.1	2010	Secondary	vector digital data - shp	100	fgdl.org	1:5,000	?
High Resolution Orthoimage	2011	Primary	GeoTIFF	100	earthexplorer.usgs.gov	1:15,000	1 px:1 m
CLC v2.3	2012	Secondary	vector digital data - shp	100	fnai.org	1:5,000	?
CLC v3	2014	Secondary	vector digital data - shp	100	myfwc.com	1:5,000	?
Soil Survey - Orange County	2015	Secondary	vector digital data - shp	64.5	gdg.sc.egov.usda.gov	1:12,000	?
Soil Survey - Osceola County	2015	Secondary	vector digital data - shp	35.5	gdg.sc.egov.usda.gov	1:12,000	?

Figure 3 shows the East-West boundary between Townships 24 and 25 South. Township 24S has a pond and a bay gall mapped on Sections 31 and 32 in “FL.TXXIVS. R.XXXIE” (Loring 1848a) but the adjoining Sections 6 and 5 in “FL.TXXVS. R.XXXIE” (Loring 1848b) do not show these features, even though it is unlikely they were both cut off neatly at the township line. This illustrates some inconsistencies present in the GLO Survey. Chapter 5 addresses the consequences of surveyors failing to record every distinct community on a section line. These two maps are the versions that were acquired from the GLO archive, rather than the LABINS website. Take note of the lack of continuity of marsh and baygall features that cross the township line in Figure 3.

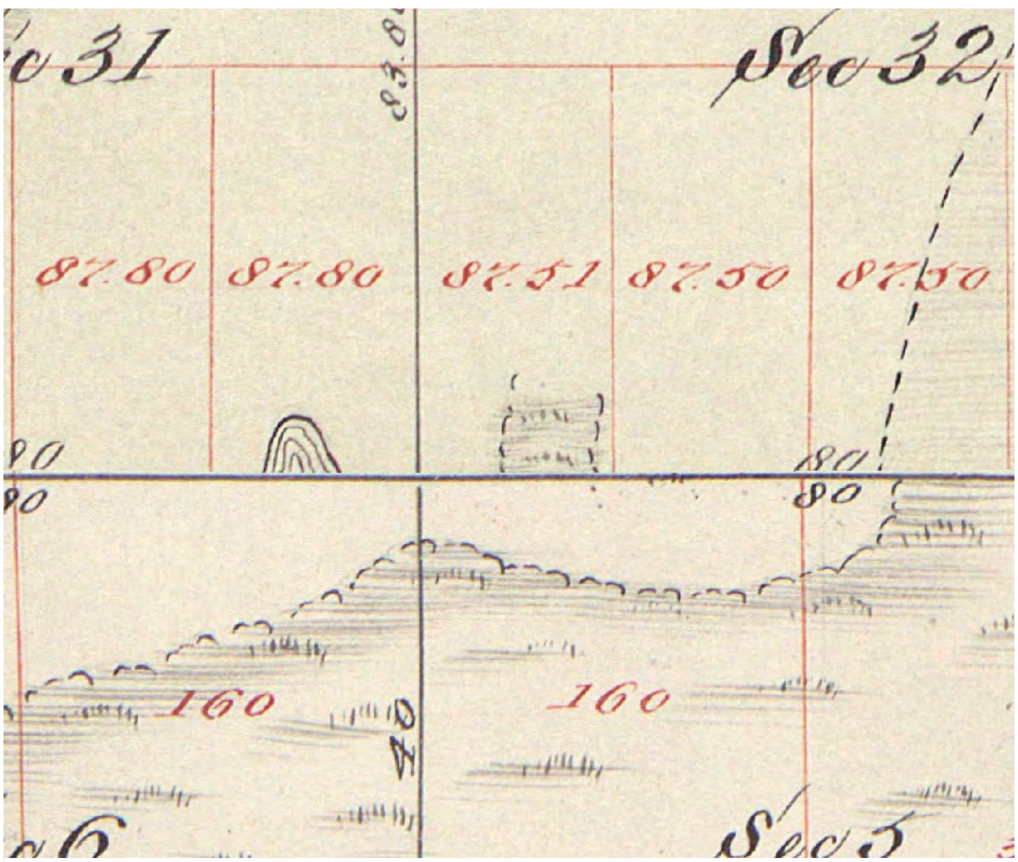


Figure 3 The East-West boundary between townships 24 and 25 shows how inconsistent the GLO survey maps can be even within the same team

3.1.2.2 Soil Surveys

Soil classification and nomenclature has changed over time as well. This includes the soil types that are present within Split Oak, so the way the soils have been named and classified within the area has changed over time. The 1920 soil survey that covered the portion of the forest in Orange County listed five different soil types. The next year the area was surveyed the classifications had changed so that the same land was assigned to 14 different soil types with only one name in common. The next survey of the area was conducted in 1989 and the 14 were condensed and reassigned to 11 distinct soil types, with three names in common between the two years. There were some changes in classification between the 1989 and the present soil map; however, these changes did not affect the study area. The present soil map is updated continuously at http://websoilsurvey.nrcs.usda.gov and one can download layers and associated data at http://gdg.sc.egov.usda.gov. Most of the soil updates were completed in 2011. Table 3 lists the soils for each year on the site, note how the classification system changes.

3.1.2.3 Aerial Photography

The aerial photos were flown by contractors Robinson Aerial and Harry Tubis, Inc. Research into the availability of camera calibration reports returned information about the manufacturer of the camera for each flight, the lens number(s), and the fit symbol(s) (Luchansky 2015a, b). This information was not sufficient to perform orthorectification on the aerial photos. The aerials vary in image quality and environmental parameters, including tilt, brightness, and date of return. The 1944 and 1947 aerials were flown closer to the ground and have significantly higher resolution with fewer visual imperfections.

Table 3 Soil names on Split Oak from 1922-Present

1922	1960			1989				Present			
Name	*Name*	*Type*	*Phase*	*Name*	*Type*	*Hydrology*	*Topography*	*Name*	*Type*	*Hydrology*	*Topography*
Portsmouth fine sand	Rutledge	fine sand		Basinger	fine sand	depres-sional		Basinger	fine sand	depres-sional	
Norfolk fine sand	Lakeland	fine sand	very gently sloping	Candler	fine sand		0-5% slope	Candler	fine sand		0-5% slope
Peaty muck / Peat	Everglades	mucky peat	shallow	Hontoon	muck			Hontoon	muck		
	Brighton		shallow								
			moderately deep								
			very deep								
Portsmouth fine sand / Leon fine sand	Immokalee	fine sand		Immokalee	fine sand			Immoka-lee	fine sand		
Portsmouth fine sand / Peat	Ona	fine sand		Ona	fine sand			Ona	fine sand		
Leon fine sand	Pomello	fine sand		Pomello	fine sand		0-5% slope	Pomello	fine sand		0-5% slope
Peaty muck / Peat	Rutledge	mucky fine sand		Sanibel	muck			Sanibel	muck		
Peaty muck / Peat	Everglades	mucky peat	shallow	Samsula	muck			Samsula	muck		
Leon fine sand	Leon	fine sand		Smyrna	fine sand			Smyrna	fine sand		
Plummer fine sand	Plummer	fine sand		St. John's	fine sand			St. John's	fine sand		
Norfolk fine sand	Blanton	fine sand	level low	Zolfo	fine sand			Zolfo	fine sand		
name of lake	Water			Water				Water			

3.1.3 Handling

The desktop computer that was used to store and handle all of the data for this project runs Linux. Most of the computer programs and code used for handling the data were available by running a Debian system that tracked 'unstable' with some packages from 'experimental' repositories (Debian Developers 2015a, b). In order to use the Cooperative Land Cover (CLC) data from the Florida Fish and Wildlife Conservation Commission (FFWCC) published as an Esri file geodatabase, it was necessary to convert it to shapefiles. The Geospatial Data Abstraction Library (GDAL) began support file geodatabases in Version 1.11, so QGIS 2.8.2 was used for much of this work and was upgraded from the 'Debian-nightly-release' repository to support GDAL 1.11.2 and geodatabases (Rouault 2015).

The 1944, 1947, 1951, 1969, and 1980 aerial tiles came in JPEG 2000 format lacking spatial information. The study area was entirely covered by the tiles each year. Prior to georeferencing, each tile was clipped to remove text and lens error and brightness/contrast were manually changed in the GNU Image Manipulation Program (GIMP) 2.8.14. Each image was then georeferenced to the 1995 DOQQ using the Georeferencer plugin in QGIS 2.8.2. The USGS 7.5 minute series Narcoossee Quarter Quadrangle from 1953 was used as a reference. Table 3 shows the Root Mean Square Errors (RMSE) for each tile after it was transformed with QGIS's polynomial 3 algorithm.

Table 4 Root Mean Square Errors computed for each flight tile

Month	Day	Year	Flight	Aerial Contractor	Camera Make	Camera Size	Lens Number	Tile Numbers	Avg. RMSE
February	8	1944	5C	Robinson Aerial	Park		757405	25	11.4658
April	21	1947	6D	Harry Tubis				139, 140	4.78
July	6	1951	4H	Robinson Aerial	Mark Hurd		761445	83	3.58
December	18	1969	1LL	Park Aerial Surveys		6"		37	3.66724
December	12	1980	180	G.R.W. Aerial Surveys		6"		57	2.8572

The survey maps also came in JPEG 2000 format lacking spatial information. Two survey maps cover the study area. Each image was clipped and rotated in GIMP. The image was georeferenced using the Thin Plate Spline algorithm, which corrects local deformities and is well-suited for low-quality images (Zitová and Flusser 2003). The preprocessing methods are shown visually in Figure 4.

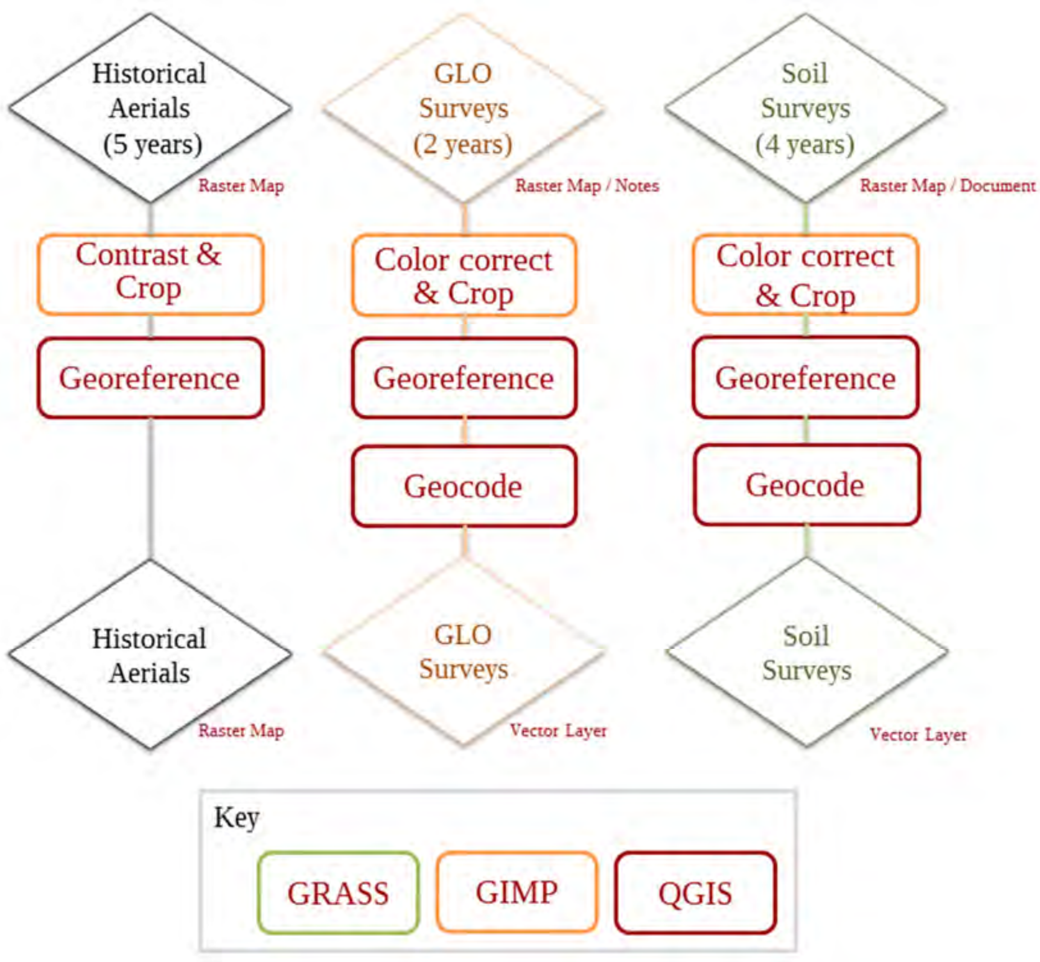


Figure 4 Flowchart describing how the data was prepared for analysis

3.2 Natural Communities

In order to understand the changes in plant communities and land cover over time, the site must be divided into units that are applicable to each data source from 1844-2015 regardless of format or quality. To do this, the many spatial data sources in Table 2 were curated for this project. Figure 5 shows how these data were used to support the natural community delineations for each year.

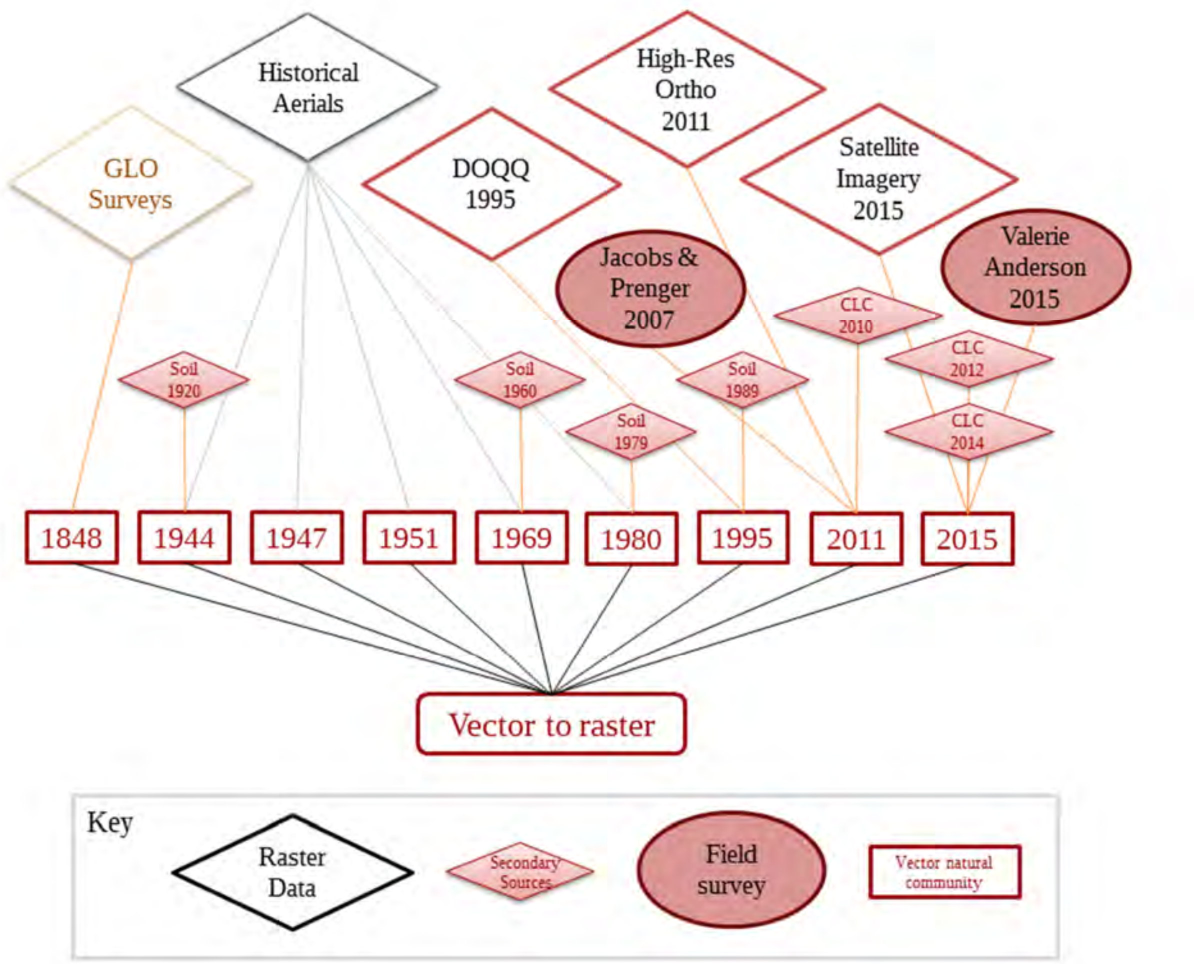


Figure 5 Flowchart describing how each data set applies to the Split Oak's natural community map for each year

3.2.1 Definitions

The definitions are supported by soils maps. The oldest soils map of the site comes with basic vegetation descriptions. Fortunately, researchers working elsewhere in Florida who were using that era of soil descriptions made the effort to correlate soil type with natural communities. Laessle (1942), working in Welaka, approximately 100 km NNE of the site was the main source and Harper's (1915) map and vegetation descriptions provided additional verification. Over the course of 171 years, the site was home to 11 communities, eight of them naturally occurring and three of them directly existing due to human activity: flat pine, scrub, sandhill, hammock, lake, marsh, swamp, bay gall, cultural-spoil, cultural-palustrine, and cultural-lacustrine.

3.2.2 Applying the Definition to the GLO Survey

Two surveying teams visited the site, the first in 1844 to delineate the township perimeter and the second in 1848 to delineate the sections. Whitner, the township surveyor, described the vegetation in detail in his notes. Land cover information from the two team's maps and notes were recorded in QGIS. Figure 6 shows the measuring tool and the map in QGIS overlaid with the line spatialite layer holding the descriptions. The information on the map corresponds to the digitized notes reproduced in Figure 7.

The left column in Figure 7 records the distance from the SW corner. This distance is in the unit 'four pole chains' which is 66 feet (Conway 1842). The SW corner of the section is not shown in Figure 6 so that the labels are legible. The numbers in Figure 6 on the section line are the distance in chains from the SW corner and the labels for the line are Whitner's descriptions in the second column. Notice that not every line segment is labeled with a description. Whitner's survey notes do not indicate land cover for the entire township line, leaving some gaps. Fortunately, the map and the notes later penned by Fred R. Loring fill these in as flat pine.

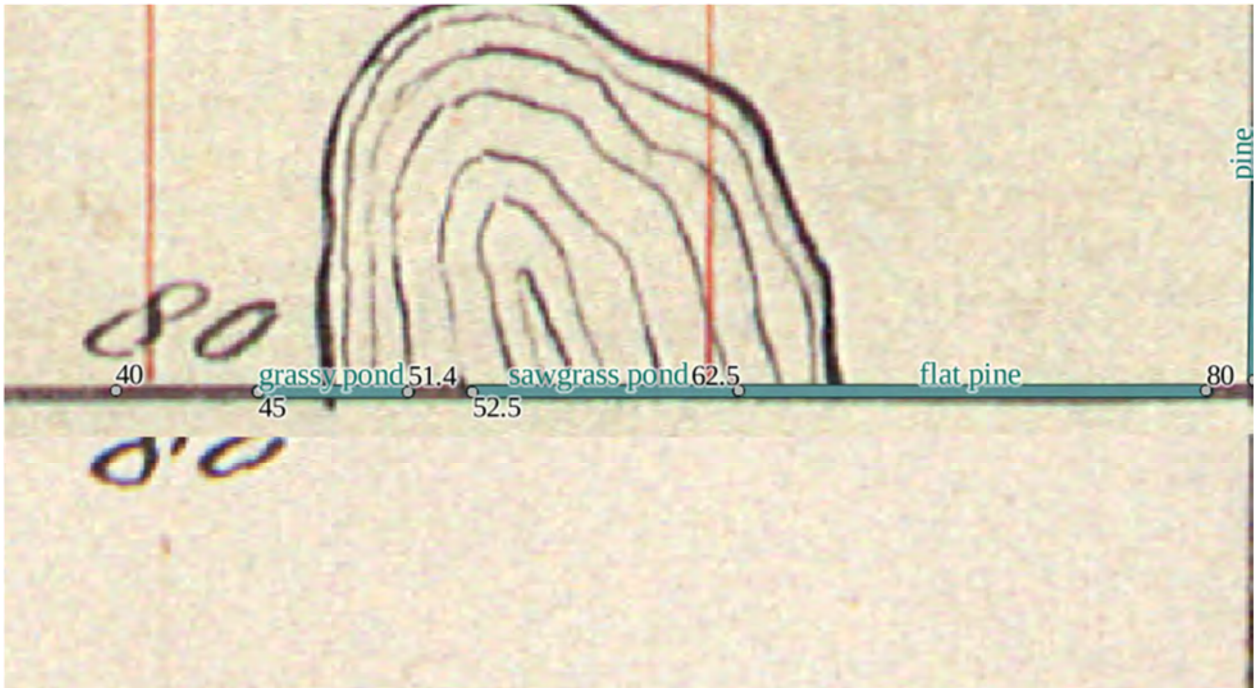
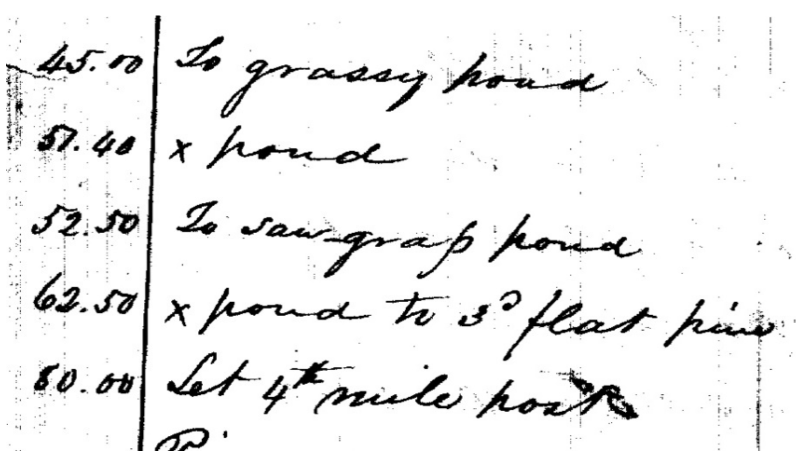


Figure 6 Example of recording GLO survey map and note information



45.00	To grassy pond
51.40	x pond
52.50	To saw-grass pond
62.50	x pond to 3d flat pine
80.00	Set 4th mile post

Figure 7 A clip of page 420 of Volume 125 of the GLO Survey notes written by Benjamin F. Whitner, Jr.

3.2.3 Applying the Definition to Historical Aerials

In order to maintain consistency in the application of the natural community definitions it was necessary to understand what these natural communities looked like on historical aerials. Figure 8 is a time series of images showing the south middle of the study area, which in 1848 was marsh and bay gall, and in 1944 onward was flatwoods and (a different) marsh.

Figure 9 shows the natural community estimate derived from the map and notes. There are three distinct natural communities (1) pine flatwoods (3rd rate) (2) bay gall, and (3) marsh. The three community types are all referred to by different names within and between the three surveying teams: (1) is called pine and flat pine, (2) everyone agrees on Bay Gall, and (3) is called sawgrass, large marsh, and grassy marsh & islands of pine, cypress, and myrtle.

3.2.4 Applying the Definition to Modern Satellite Imagery

The SFWMD's Photointerpretation Key (Cameron et al. 2011) has analogs to every natural community description listed in Appendix A. They provide details about how each community shows up in color infrared and natural color. Each natural community description in Appendix A has an '*Identification and Photointerpretation*' section to describe what methods were most effective in identifying the communities.

3.3 Change Analysis

Finally, the natural community delineations for each year were converted from vector to raster format, and imported into GRASS, where they were analyzed. Figure 10 shows the process used for each natural community layer.

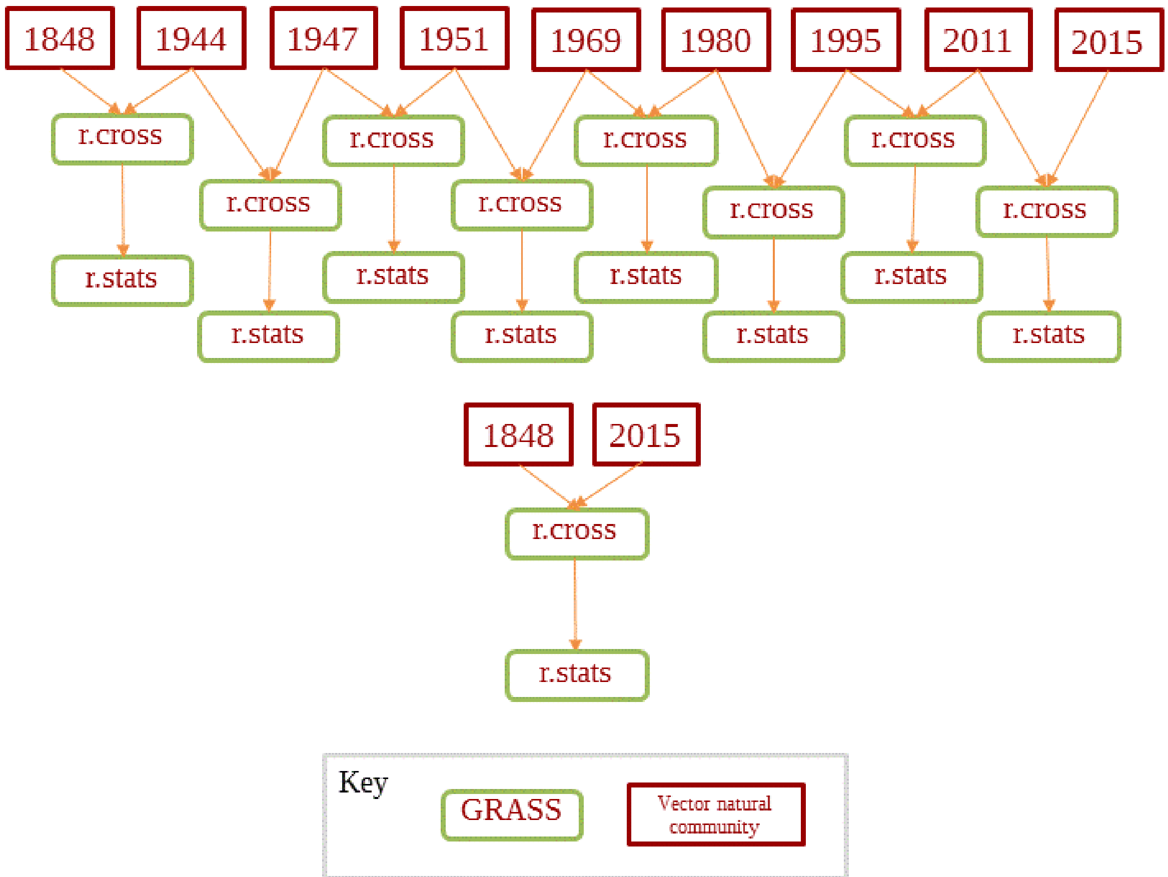


Figure 8 GRASS analysis flowchart for each natural community layer

CHAPTER 4: RESULTS

The results were prepared and compiled as a series of change analyses spanning 10 time periods. The primary results, themselves, consist of pairs of vector maps, overlaid on images for the same year in those years for which such images were available, plus two side-by-side raster change maps, a table showing the community designations cross-tabulated by year, a histogram showing net change and net change as a percent of initial area by community, and a table summarizing the changes by period. The commentaries provided for each period summarize the major trends evident from these materials and introduces additional maps and photographs to help describe and/or validate the interpretations offered in this chapter.

The changes experienced by the site sit in the greater context of world history. Some events very clearly affected the extent and distribution of natural communities on Split Oak Forest. The entirety of the change on the site was not explainable only using the existing data, the data generated for and analyses used in this project. In general, the site lost a majority of its marsh to a variety of other communities, swamp replaced marshes in depressions and floodplains, baygall persisted, and the most xeric sites transitioned to and from hammock.

The site lost 90% of its marsh area between 1844 and 2015. About half of that loss (167 ha) occurred between 1844 and 1944. The site ended up with only 30 ha of marsh in 2015. This does not equal a 90% loss in wetland, the gain in swamp and manmade wetland slightly offset the loss. The net wetland loss between 1844 and 2015 was 215 ha, or 60%. Two wetlands were excavated, ostensibly for the muck soil underneath – this resulted in manmade wetland (cultural – palustrine), manmade lakes (cultural – lacustrine) and spoil piles (cultural – spoil) that transition to disturbed areas (cultural – ruderal). The large marsh on the south west boundary of the site was cleared and transitioned into pasture (cultural – ruderal) once dry. The loss of these marshes is particularly poignant because they were not directly drained, unlike many of the other marshes in the area. The effect of draining Lakes Mary Jane and Hart had a negative impact on Lake Hart's peripheral wetlands. Some of the areas of marsh might be over- or under-represented in the 1884 map, as discussed next.

The inaccuracies within the GLO survey have been well documented in the literature and were discussed in Section 2.3. Because many of the critiques were aimed at methodology using bearing and line trees to ascertain tree species relative abundance, density, and timber quality, I thought that the notes and maps would be suitable for reconstructing the natural communities of the time. With the addition of the information from the 1920s soil map covering the north half of the site, I feel that the 1844 map for some of this area is fairly accurate. However, the surveyors completely missed Bonnet Pond (in the northeast corner). They also failed to map the swamp in the southeast corner and the sandhill across the township line, despite being recorded in the notes. The Loring team says they walked through what is now the not-insubstantial Lake Mary Jane. In addition to the lapses in community recordkeeping, the sections are not square.

The swamp is the southeast corner was the only recoded swamp on the site in 1848, though the survey team declined to include it on the map so that it would be possible for me to map it. Since 1944, swamps expanded at their edges and developed from both depression/basin marshes and floodplain/strand marshes. Some depression/basin marshes persisted,

The net change in baygall was difficult to quantify across the years, since the large baygall that rings the large swamp in the east-center of the site was either non-existent or missed by the surveyors in 1944. Nearly all of the baygall ringing Lake Hart transitioned to flat pine between 1844 and 1944. Descriptive names for some sites on Split Oak are in Figure 9.

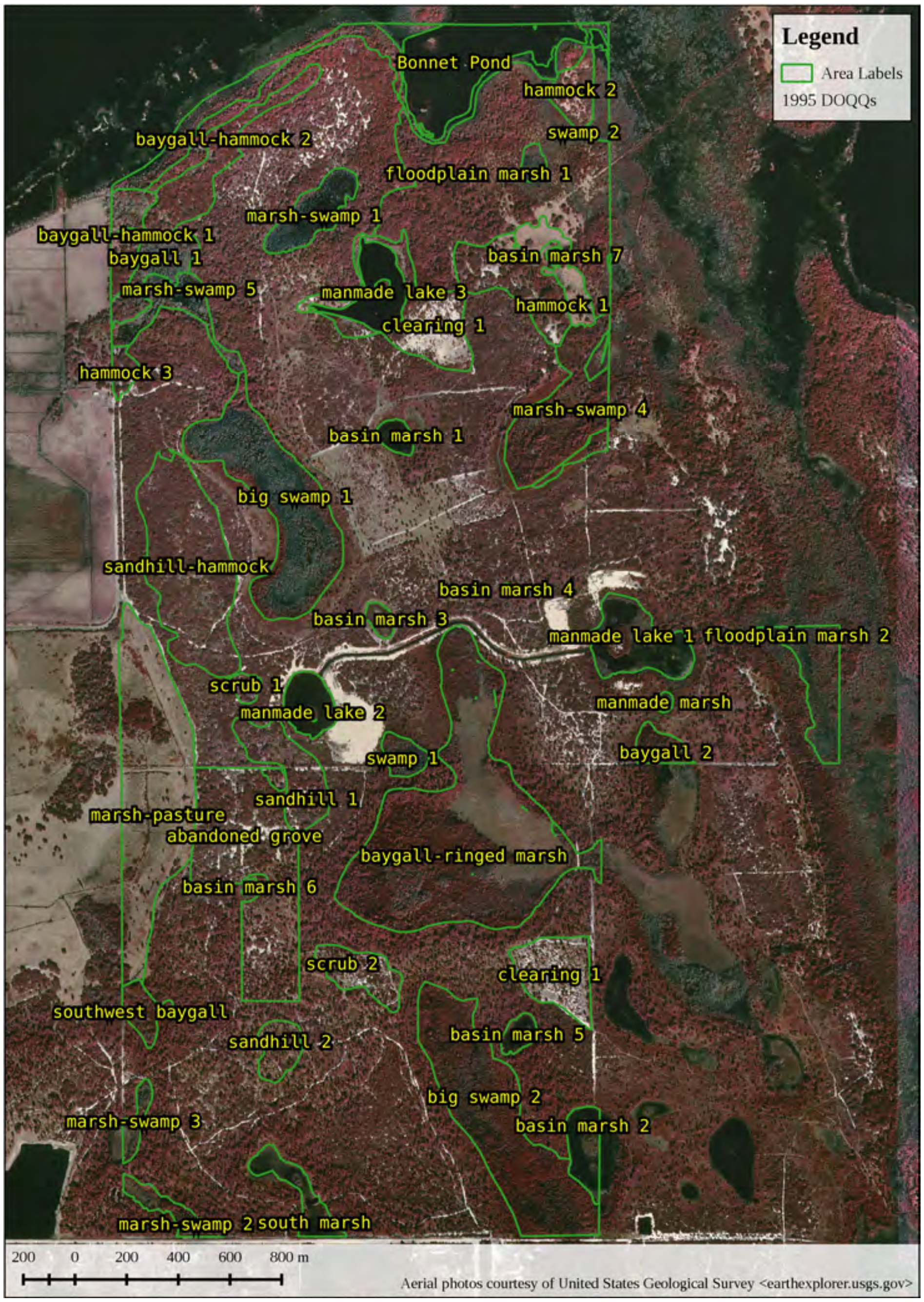


Figure 9 Split Oak communities labeled with descriptive names

The driest sites, sandhill and scrub, tend to just transition back and forth to and from hammock. Certainly the specific species abundances and densities change over the years but these changes are not discernible on aerial imagery. Changes will be easier to describe if some of the areas on the site have names. To this end, Figure 9 is a map of the site with relevant areas labeled for ease of reference.

4.1 The First Century: 1844 to 1944

The most striking result of the GLO survey delineation, seen in Figure 10, is that neither hammocks, scrubs, nor Lake Mary Jane were observed. The namesake of the forest, a 200 year old live oak (*Quercus virginiana*) that is split down the middle has been growing in the same place since before 1815 on an area that the surveyor's map called marsh. Live oaks are able to grow to full size if an area is sheltered from fire and not inundated. These conditions usually lead to the community transitioning from sandhill or scrub into a hammock. This casts doubt upon the accuracy of their descriptions, especially where the team would have to be carrying a heavy chain through sawgrass marshes.

The extent of the sandhill, labeled sandhill – hammock on Figure 9, in the 1844 map is verified by the Norfolk fine sand in the 1922 soil survey. The sandhill, a natural community situated on very well drained soils, was partially converted to orange grove starting at the township line and somehow became divided into two sandhills both with a reduced extent. Obviously, the surveyor's delineations are smoothed, curvy generalizations, and the shape of the northern portion of the sandhill could have resembled its shape on the 1944 aerial.

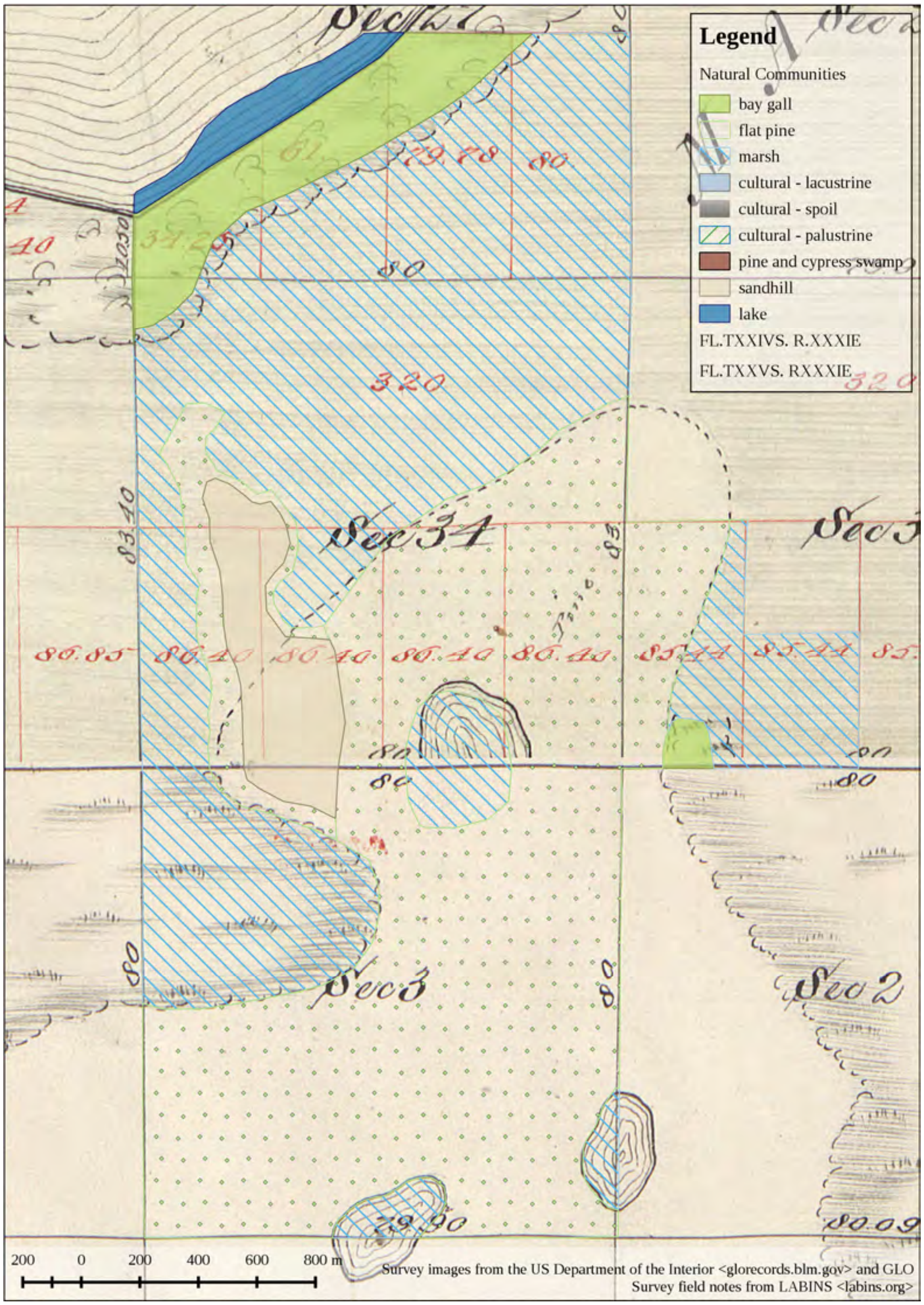


Figure 10 Natural Community map for the GLO Survey, 1844-1848

An additional inconsistency with the GLO survey is the large marsh crossing the township line that can be seen in Figure 10. In 1844 it is symbolized on the map as stopping at the township line. That is unlikely, there is nothing to cut a marsh off in a straight line there today and there were no roads, ditches, or fences there in 1844. Florida, for example, was the last state to enact a law to fence rangeland (Florida Legislature 1949).

Figure 11 is a photo taken 2015-08-16 just after crossing the man-made embankment over the narrowest part of the baygall abutting the eastern boundary. The inset to the photo shows its location and direction on the 1944 aerial. A view of the marsh is blocked by pines (*Pinus* spp.), bays (*Gordonia lasianthus, Persea palustris,* and *Magnolia virginiana*), and wax myrtles (*Myrica cerifera*).

Figure 11 View looking southwest through baygall into the baygall-ringed marsh, sawgrass (*Cladium jamaicense*) in foreground

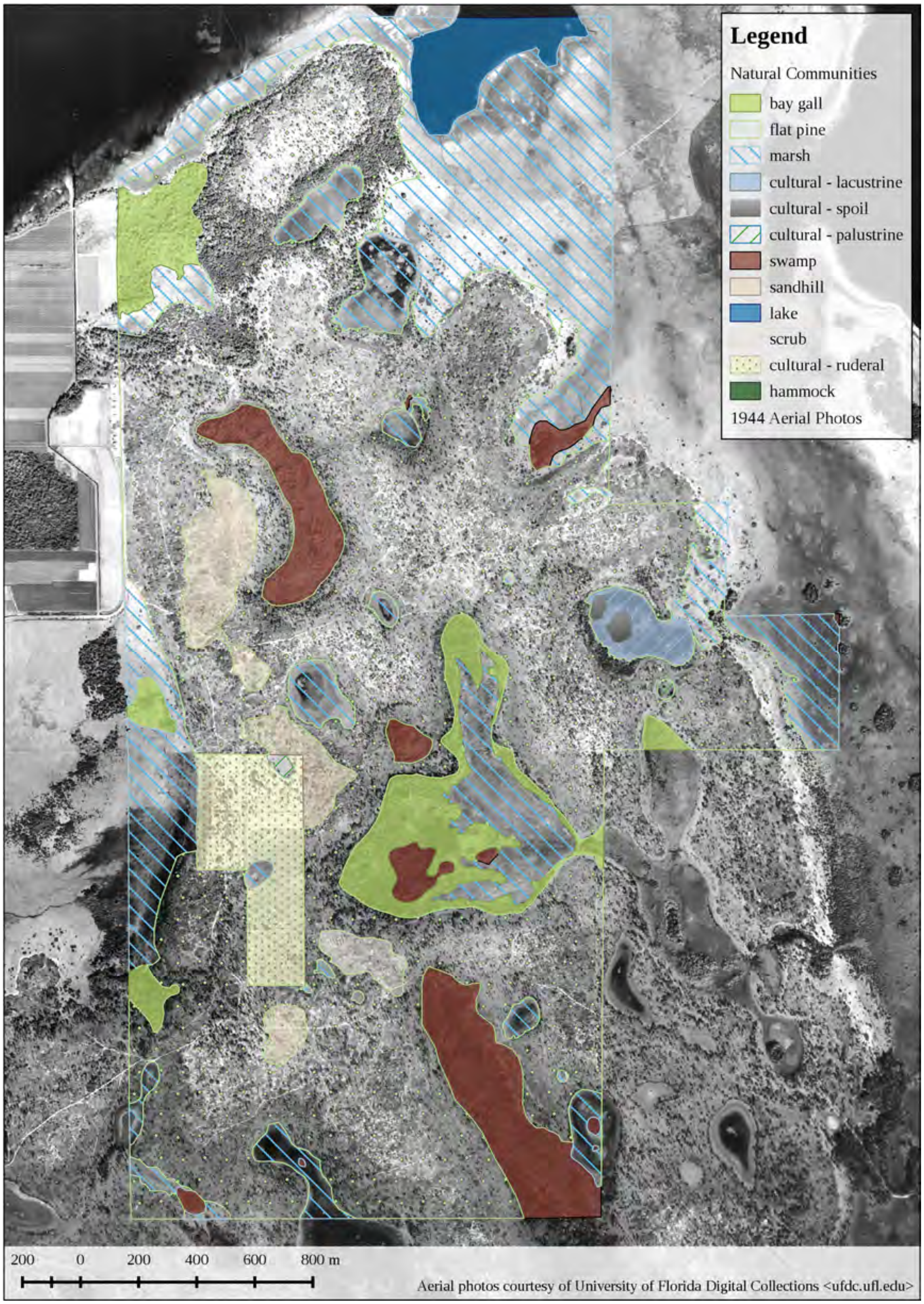


Figure 12 Natural Community map, 1944

The notes did not indicate how far the marsh extended past the township line and early soil data is not available south of the line. The marsh in 1944 is quite large (16 ha) and ringed by a baygall (Figure 12). It is not clear whether this marsh extended to the section line as it does now – the survey team did not report it if it did. If the marsh did, in fact, extend this far down in 1844 in a similar shape and was also surrounded by baygall, the loss of bay gall and marsh would be even more severe between 1844 and 1944. As is, the loss in baygall is due primarily to the retreat of the lake and the transition of that community into flat pine. Some additional baygall either developed after 1844 or was not reported by the surveyors.

Two very significant swamps, the 12 ha “big swamp 1” and the 21 ha “big swamp 2” were not recorded on the survey map; the latter is adjacent to a recorded wetland. Bonnet Pond also developed by 1944. Previously recorded as partly marsh, partly baygall, it became an area of open water still connected to Lake Hart by 1944. The complete cross and binary change maps reproduced in Figures 13 and 14 show visually just how much changed over the course of this first century. Table 6 shows the results presented in Figure 16 in numbers, such that the areas reported in the diagonal cells from the top left to the bottom right can be followed to see the persistence of each community and the areal estimates reported in other cells record the changes from 1844 to 1944.

The total change, gain and loss along with the net change for each community are summarized in Table 7 and the net change is visualized as a histogram in Figure 15. For context, the net change as a percentage of the total area of each community in 1844 is indicated and labeled as an orange circle in the appropriate histogram bar.

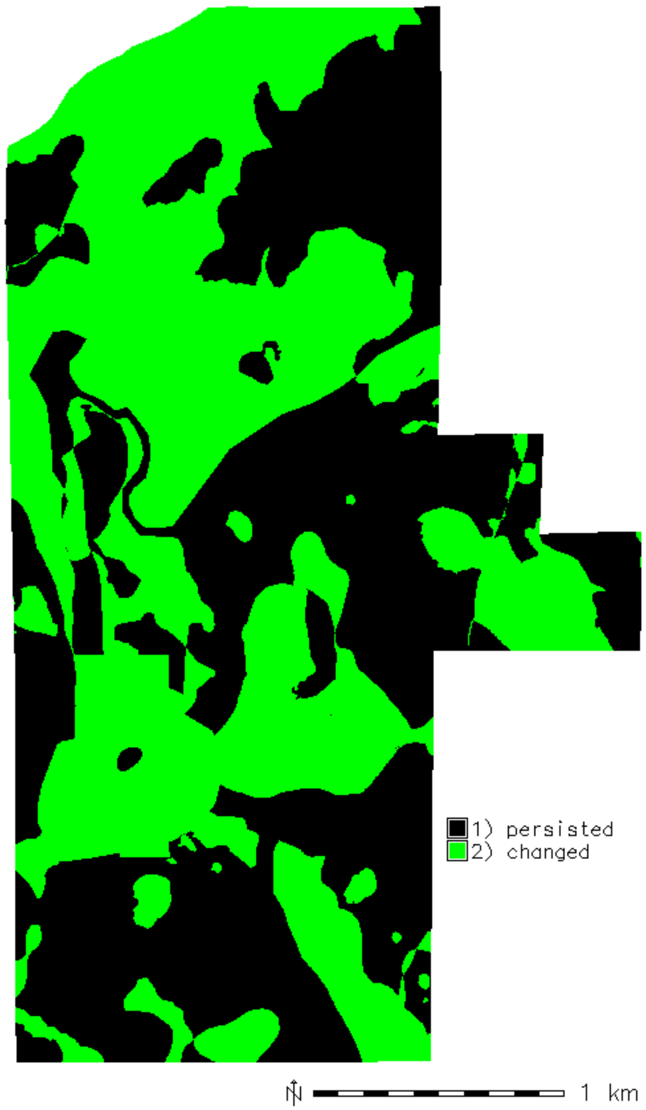


Figure 13 Binary change raster, 1844-1944

Figure 14 Complete cross raster, 1844-1944

Table 5 Cross tabulation matrix, 1844-1944, in hectares

1944	ham-mock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palus-trine	lake	c – lacus-trine	marsh	Total 1844	Loss
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212		
1844														
1120														0.00
1210														0.00
1240		8.48	3.66	12.54	1.65				0.45			2.56	29.33	25.67
1300		6.20	4.33	224.88	3.46	1.05	18.53	26.03			4.01	26.67	315.15	90.27
1800														0.00
1877														0.00
2231				20.54			10.39			4.72		3.51	39.17	28.77
2242														0.00
2400														0.00
3100				4.23			0.08					6.33	10.64	10.64
3200														0.00
21212		0.67	0.17	158.99	15.98		7.62	14.16	0.33	7.72	1.38	115.76	322.78	207.02
Total 1944	0.00	3.68	19.83	421.18	21.10	1.05	26.63	40.19	0.78	12.44	5.39	154.84		
Gain	0.00	3.68	16.16	196.31	21.10	1.05	16.24	40.19	0.78	12.44	5.39	39.08		

Table 6 Summary of change between 1844 and 1944, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	0.00	0.00	0.00	0.00	0.00
1210	scrub	3.68	0.00	3.68	0.00	3.68
1240	sandhill	16.16	25.67	41.83	32.32	-9.51
1300	flat pine	196.31	90.27	286.58	180.54	106.03
1800	cultural – ruderal	21.10	0.00	21.10	0.00	21.10
1877	cultural – spoil	1.05	0.00	1.05	0.00	1.05
2231	baygall	16.24	28.77	45.01	32.48	-12.53
2242	swamp	40.19	0.00	40.19	0.00	40.19
2400	cultural – palustrine	0.78	0.00	0.78	0.00	0.78
3100	lake	12.44	10.64	23.07	21.27	1.80
3200	cultural – lacustrine	5.39	0.00	5.39	0.00	5.39
21212	marsh	39.08	207.02	246.10	78.16	-167.94
	total	352.41	362.37	357.39	172.39	

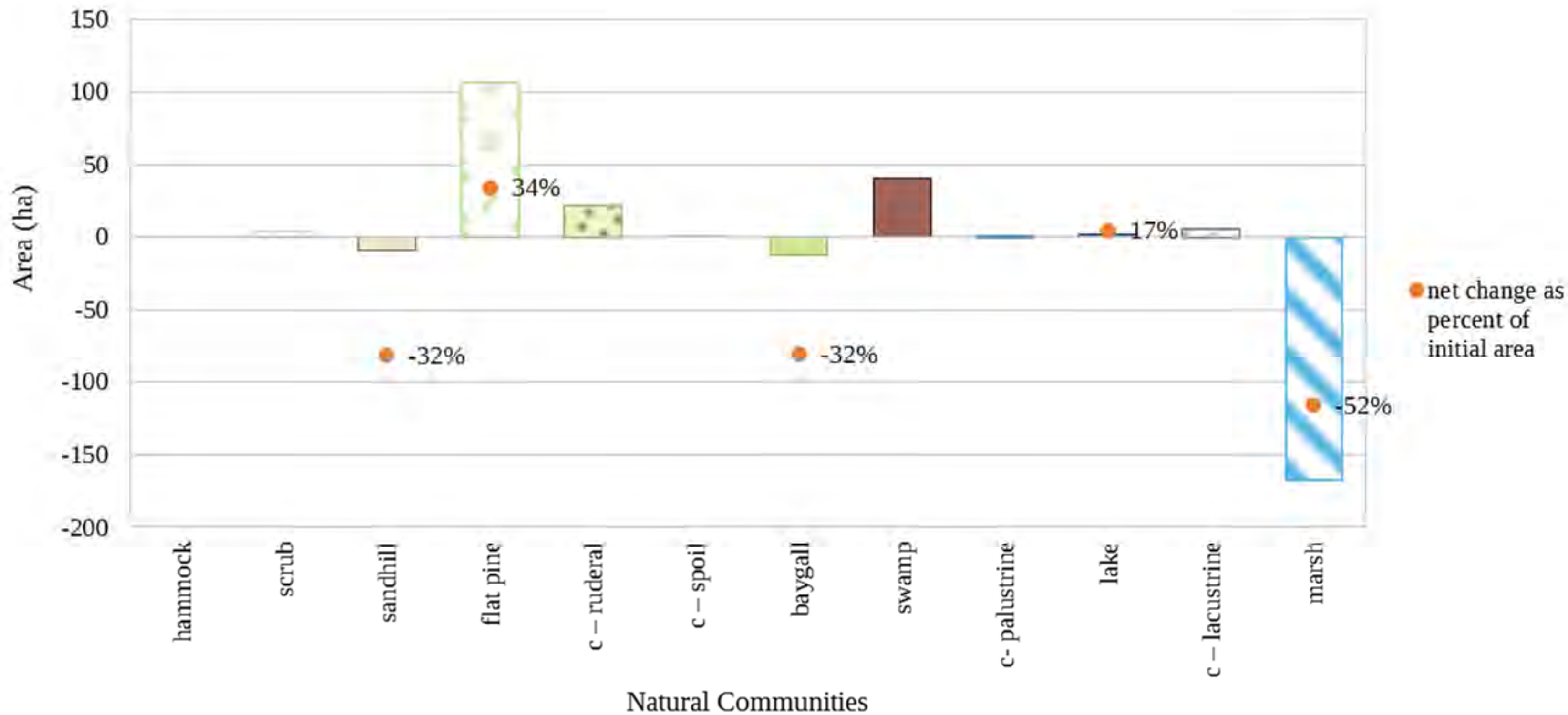


Figure 15 Histogram displaying net (ha) and percent natural community change from 1844 to 1944

To illustrate the differences along the shore of Lake Hart, Figure 16 places the two data sources at the same zoom levels adjacent to each other. In 1844, the baygall rings the lake between 250 and 480 m from the shore. In 1944, the lake had receded and the baygall had transitioned to flat pine. The highly reflective area in the center of the image is a dry flat pine, and south of it a two marshes persisted in a depression, marsh: swamp 1 and manmade lake 2.

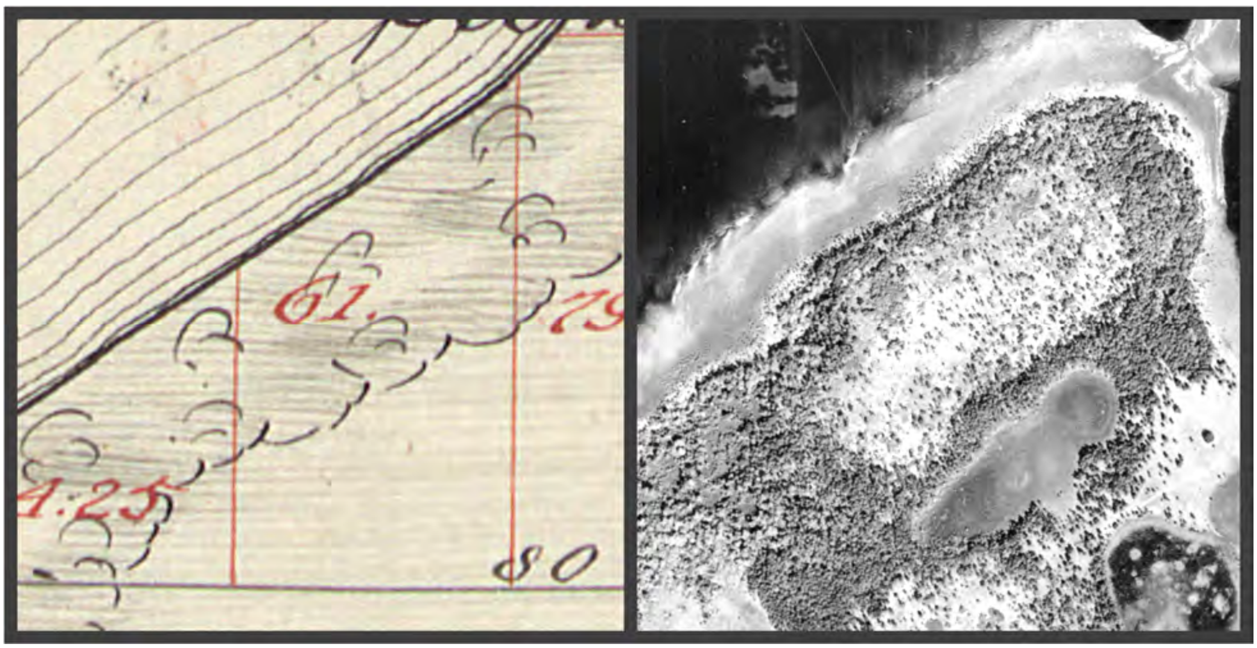


Figure 16 The same location, 1844 on the left, 1944 on the right; the center symbology in the survey map is baygall

4.2 The Mid-1940s: 1944 to 1947

The changes between 1944 and 1947 were minimal. The natural community map for 1947 reproduced in Figure 18 is largely unchanged from the 1944 map (Figure 12). This interpretation was confirmed by the small changes shown in Figures 19 and 20 (the complete and binary change maps) and the small numbers reported for the off-diagonal cells in Table 8. The smattering of change pixels in Figures 18 and 19 were compiled by manual photointerpretation.

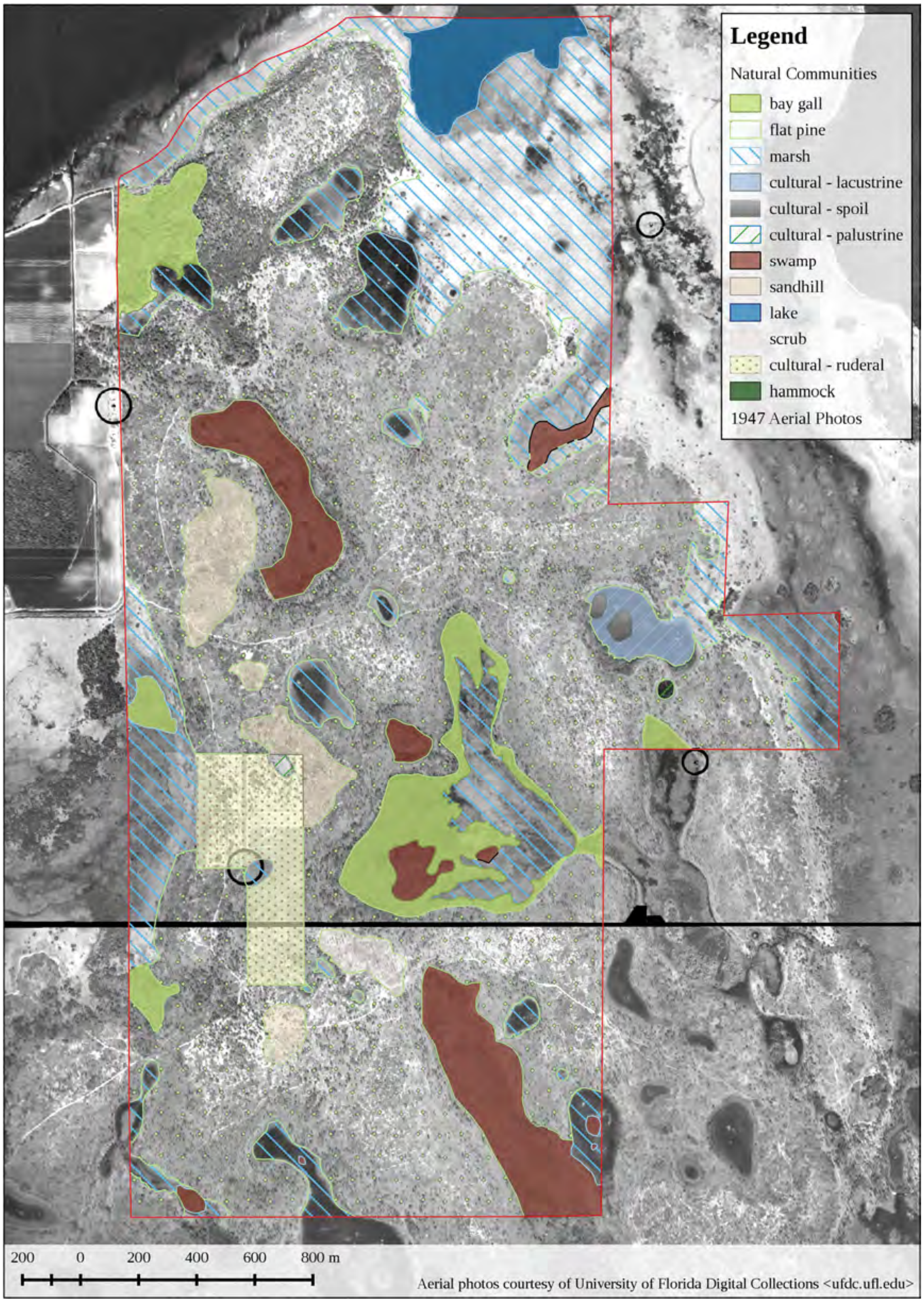


Figure 17 Natural communities, 1947

In addition, it seems from Figure 18 that 1947 was a wetter year than 1944. The photos were taken in January and April, respectively, which are both dry months in central Florida (UF/IFAS Extension Agents 2015). "Big swamp 1" expanded slightly at the expense of the lower lake level exposed marsh recorded in 1944. The existence of Bonnet Pond and Lake Mary Jane are peculiar because neither are mentioned in the survey maps and notes. Researching the history of Lake Mary Jane and Bonnet Pond were outside of the scope of this project; however, the survey notes for the section lines that cross Lake Mary Jane talk only of marshes and baygalls, not a lake. The lake does not appear on maps from 1871-1882 (US War Department Corps of Engineers 1856; Asher & Adams 1871; Elliott 1888), but is on an 1890 map of Orange County (Fries 1890), named Lake Fries. Bonnet Pond and Lake Hart are a few feet higher today than they were in 1947 (Figure 17): the photo reproduced in Figure 18, for example, was taken on a viewing platform over several feet of water.

As the histogram in Figure 21 shows, the largest magnitude change came from a decrease in marsh, though it was a small percentage of the prior year's area, just over 1.2 ha. The binary change map in Figure 20 shows that the changes were isolated to the shore of Lake Hart, expansion of big swamp 1, and some additional swamp formation in marsh – swamp 4.

Figure 18 View of Bonnet Pond from the pier, 2015-02-06, courtesy of Marty Fries

Bonnet Pond is particularly interesting because the GLO surveyors recorded marsh in its location and it is (August 2015) connected to both Lake Hart and Lake Mary Jane by small ditches. It is shallow, marshy pond whose water level as fluctuated over the last 71 years.

Figure 19 Complete cross raster, 1944-1947

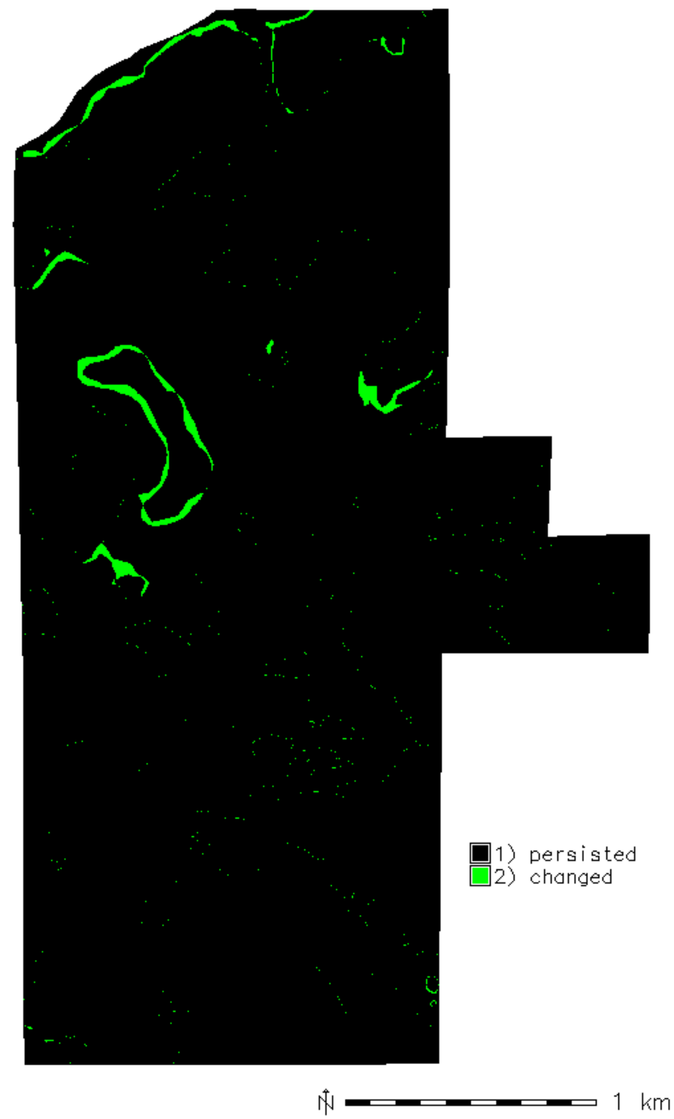


Figure 20 Binary change raster, 1944-1947

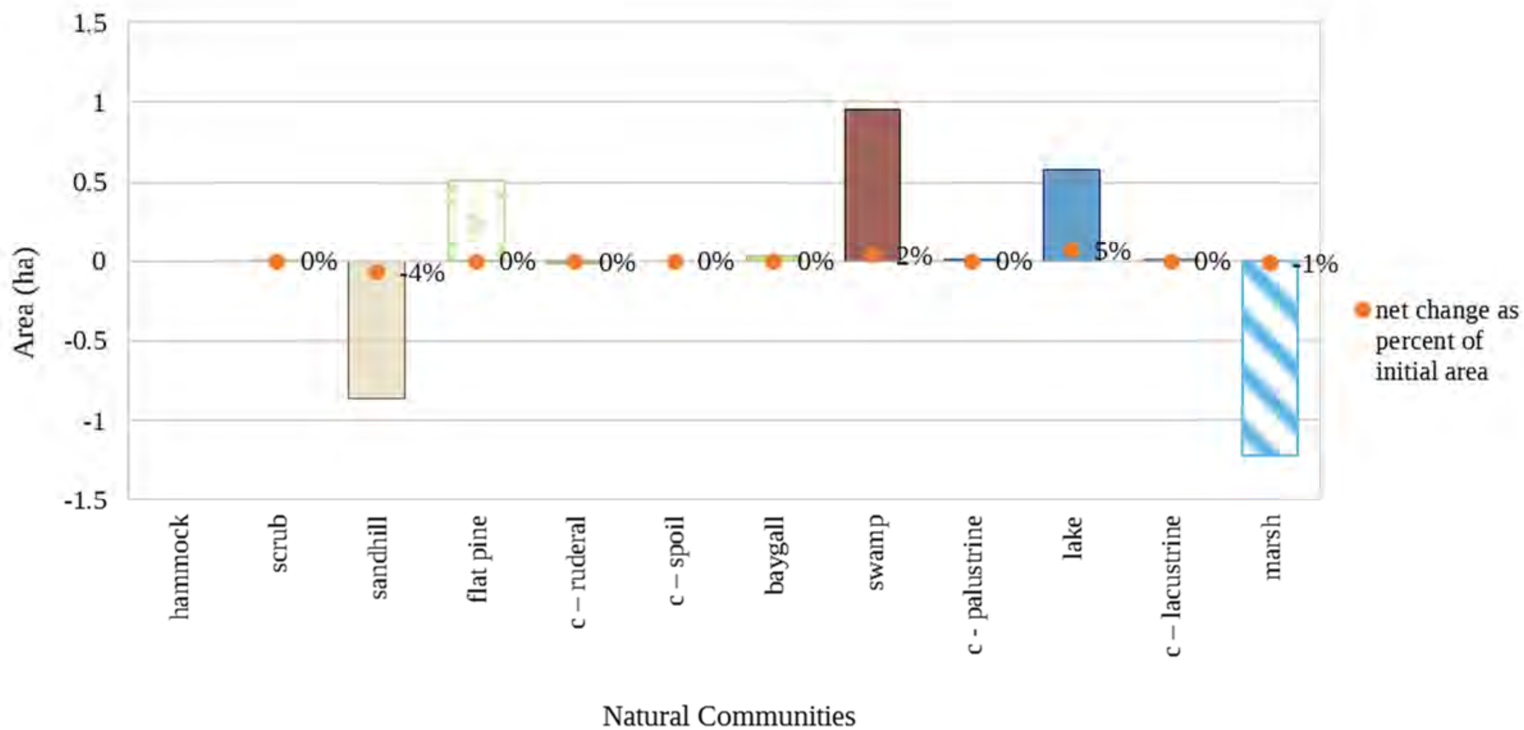


Figure 21 Histogram displaying net (ha) and percent natural community change from 1944 to 1947

Table 7 Cross-tabulation matrix for 1944-1947, in hectares

	1947												Total 1944
	ham-mock	scrub	sandhill	flat pine	c- rude-ral	c - spoil	baygall	swamp	c – palus-trine	lake	c – lacus-trine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1944													
1120													0.00
1210		3.67		0.01									3.68
1240			18.89	0.93	0.00				0.00				19.83
1300		0.02	0.07	416.99	0.01	0.00	0.08	2.57	0.00		0.02	1.39	421.18
1800			0.00	0.03	21.07				0.00			0.00	21.10
1877				0.00		1.04					0.01		1.05
2231				0.08			36.46	0.02				0.07	36.63
2242			0.00	1.41			0.02	38.46				0.29	40.19
2400				0.00	0.00				0.77				0.78
3100										12.38		0.05	12.44
3200				0.02		0.01					5.36	0.00	5.39
21212				2.20	0.01		0.11	0.09		0.62	0.00	151.77	154.84
Total 1947		3.68	18.96	421.69	21.09	1.05	36.66	41.14	0.78	13.01	5.39	153.63	

Table 8 Summary of change from 1944 to 1947, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	0.00	0.00	0.00	0.00	0.00
1210	scrub	0.02	0.01	0.03	0.03	0.00
1240	sandhill	0.07	0.93	1.00	0.14	-0.86
1300	flat pine	4.70	4.20	8.90	8.39	0.51
1800	cultural – ruderal	0.02	0.04	0.05	0.04	-0.02
1877	cultural – spoil	0.01	0.01	0.01	0.01	0.00
2231	baygall	0.20	0.17	0.38	0.35	0.03
2242	swamp	2.68	1.73	4.40	3.45	0.95
2400	cultural – palustrine	0.01	0.01	0.02	0.02	0.00
3100	lake	0.63	0.06	0.69	0.11	0.57
3200	cultural – lacustrine	0.03	0.03	0.05	0.05	0.00
21212	marsh	1.86	3.08	4.94	3.72	-1.22
	total	10.23	10.26	10.24	8.16	

The comparison photo below shows Bonnet Pond in 1944 and 1947. It does seem as though 1947 was wetter. If, however, the mechanisms that hydrated a marsh sufficiently enough to produce a lake were functioning between 1888 and 1890, perhaps similar mechanisms were functioning between 1944 and 1947.

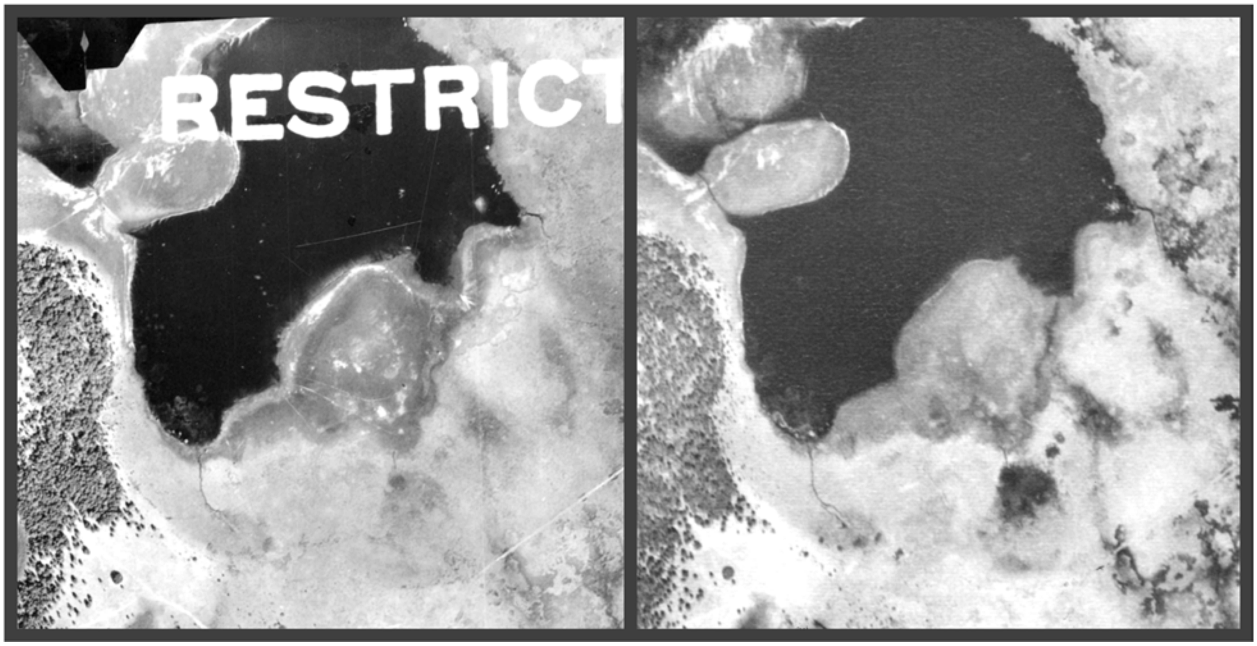


Figure 22 Bonnet Pond in 1944 on the left, 1947 on the right; 1947 appears to have been wetter.

4.3 The Late-1940s: 1947 to 1951

Change was minimal over this five year period. Marsh lost around the same percentage as over the last series and swamps expanded slightly. The map of the communities in 1951 is shown in Figure 24.

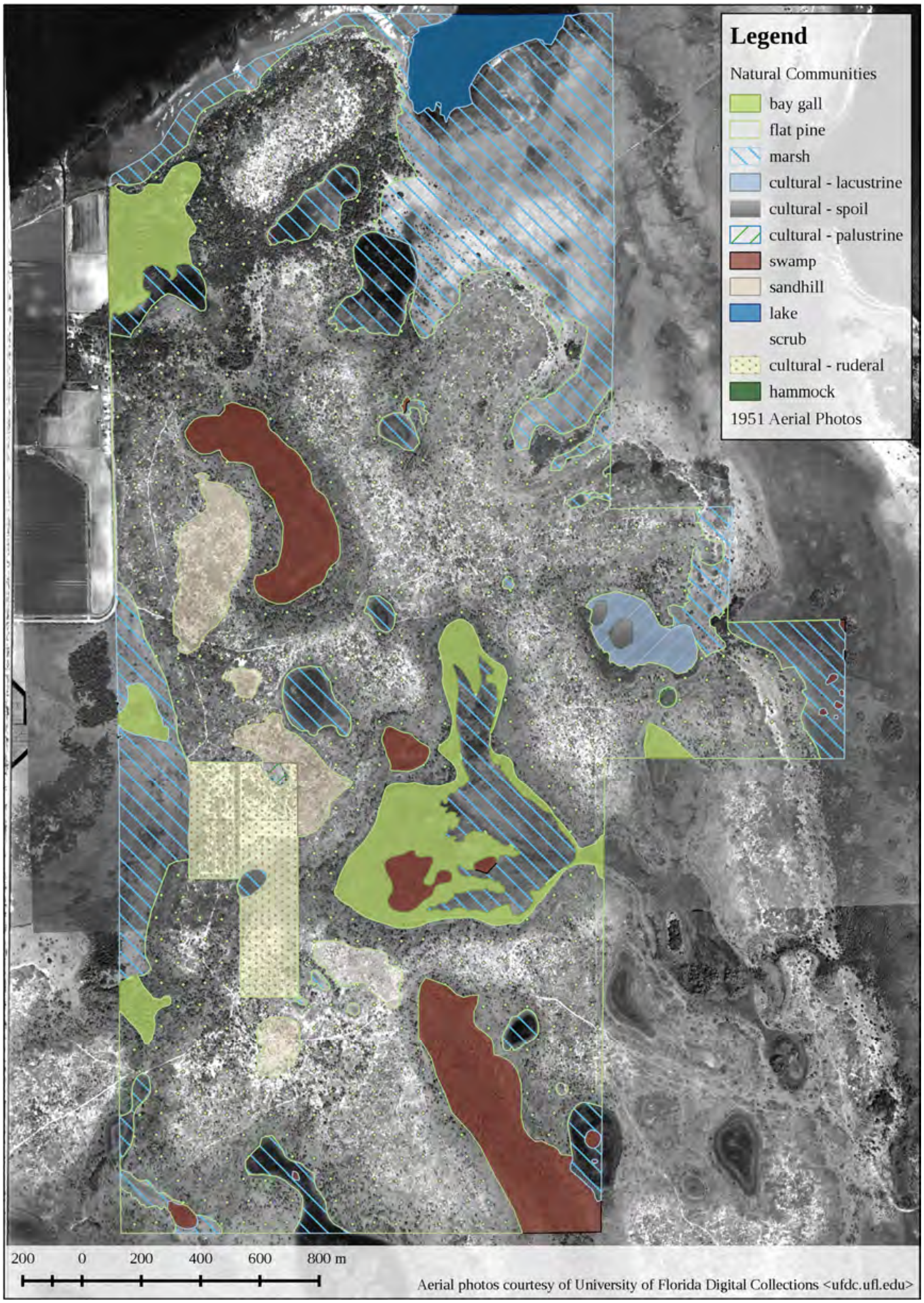


Figure 23 Natural Communities, 1951

Figure 25 shows a contemporary view of the manmade lake and marsh in the east-center of the site. The manmade lake is discussed in Section 4.1 and its associated spoil areas are not news in 1947, but the spoil areas in the center are beginning to regenerate and often form modified versions of the existing ecosystem, like this spoil pile with slash pine and willow.

Figure 24 Manmade lake in the east-center of the property. Slash pines (*P. elliottii*), vines, and willows (*Salix caroliniana*) growing on a small spoil mound block the view

The old grove is also regenerating, and will eventually become hammock and flatwoods, but until it fills in significantly (by 1969) it remains cultural – ruderal. As the binary change raster (Figure 26) illustrates, the loss of lake was pretty significant, 24% of its 1947 area. The totality of the changes can be viewed on the complete cross map of Figure 27 The summary of changes is listed in Table 10 and is illustrated in the histogram in Figure 28. The slow expansion of the “bug swamp 1” is illustrated well by the side-by-side aerials in Figure 29.

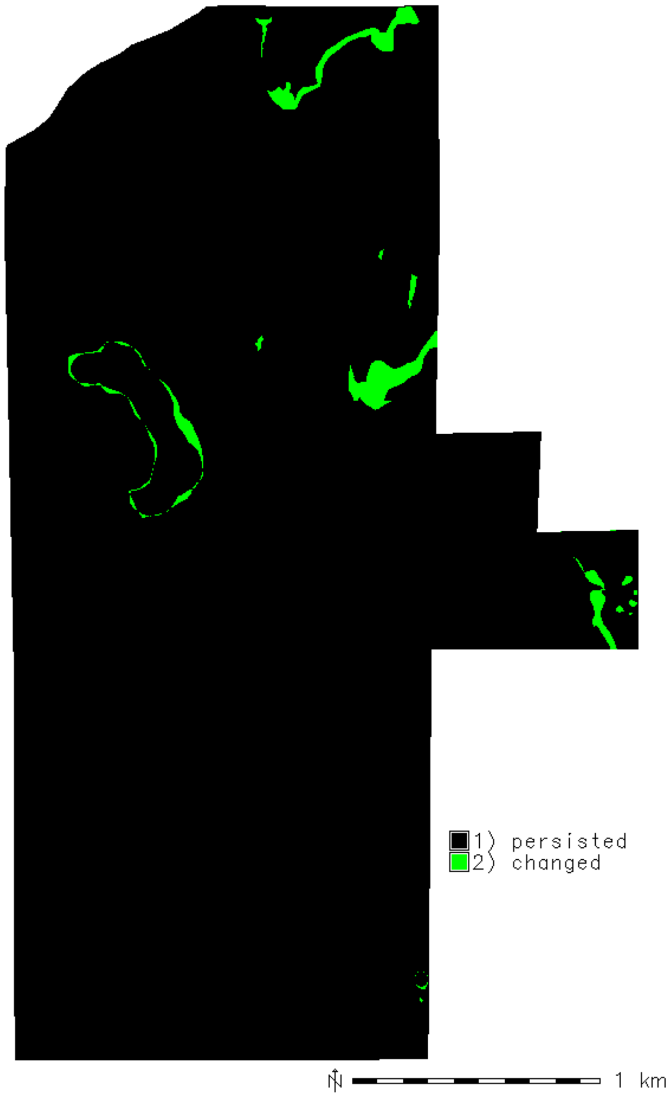


Figure 25 Binary change raster, 1947-1951

Figure 26 Complete cross raster, 1947-1951

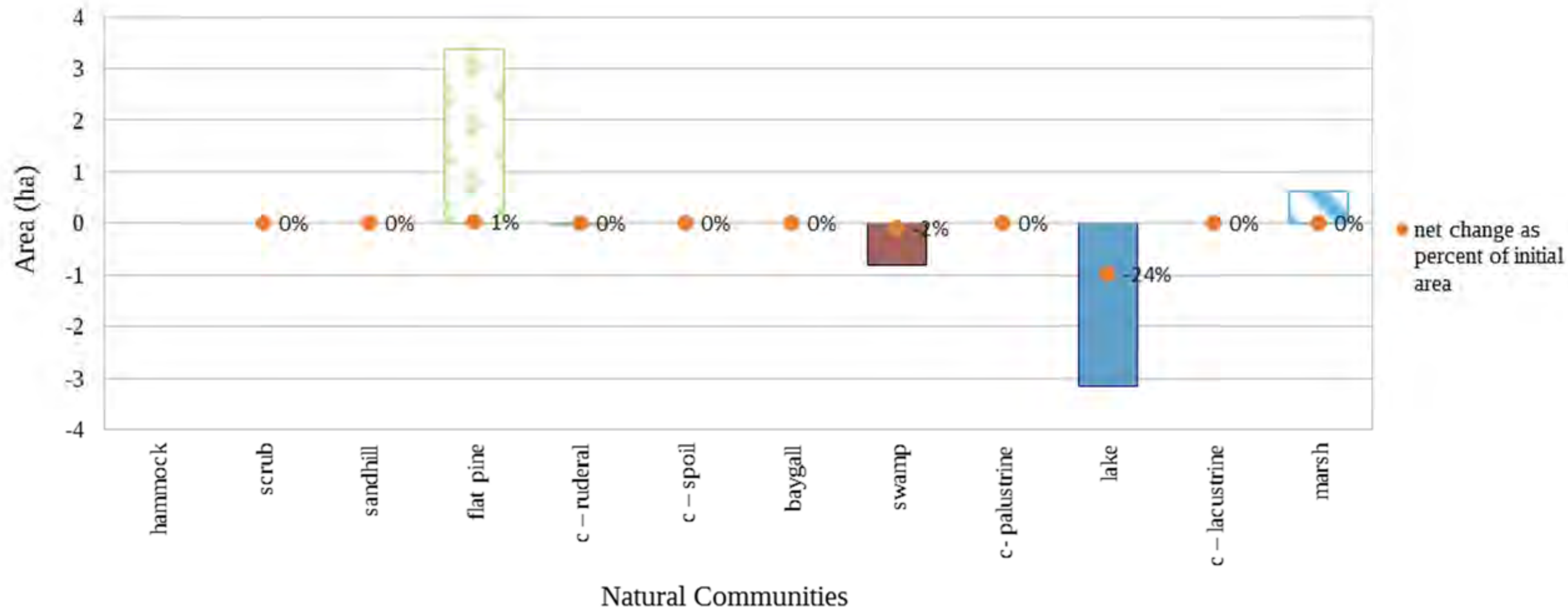


Figure 27 Histogram displaying net (ha) and percent natural community change from 1947 to 1951

Table 9 Cross-tabulation matrix, 1947-1951, in hectares

	1951												Total 1947
	hammock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palustrine	lake	c – lacustrine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1947													
1120													
1210		3.68											3.68
1240			18.96										18.96
1300				419.98				1.66				0.05	421.69
1800					21.09								21.09
1877						1.05							1.05
2231							36.66						36.66
2242				2.68				38.40				0.06	41.14
2400									0.78				0.78
3100										9.85		3.16	13.01
3200											5.39		5.39
21212				2.39				0.27				150.97	153.63
Total 1951		3.68	18.96	425.06	21.09	1.05	36.66	40.33	0.78	9.85	5.39	154.24	

Table 10 Summary of changes, 1947-1951, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	0.00	0.00	0.00	0.00	0.00
1210	scrub	0.00	0.00	0.00	0.00	0.00
1240	sandhill	0.00	0.00	0.00	0.00	0.00
1300	flat pine	5.08	1.71	6.78	3.41	3.37
1800	cultural – ruderal	0.00	21.04	21.04	0.00	0.00
1877	cultural – spoil	0.00	0.00	0.00	0.00	0.00
2231	baygall	0.00	0.00	0.00	0.00	0.00
2242	swamp	1.92	0.53	2.46	1.07	-0.82
2400	cultural – palustrine	0.00	0.00	0.00	0.00	0.00
3100	lake	0.00	3.16	3.16	0.00	-3.16
3200	cultural – lacustrine	0.00	0.00	0.00	0.00	0.00
21212	marsh	3.27	1.68	4.95	3.37	0.61
	total	10.27	28.13	19.20	3.92	

The comparison photo in Figure 28 focuses on the expansion of “big swamp 1”. The swamp’s hydrologic boundary does not seem to be expanding, yet its edges are becoming denser with what appears to be cypress and pine.

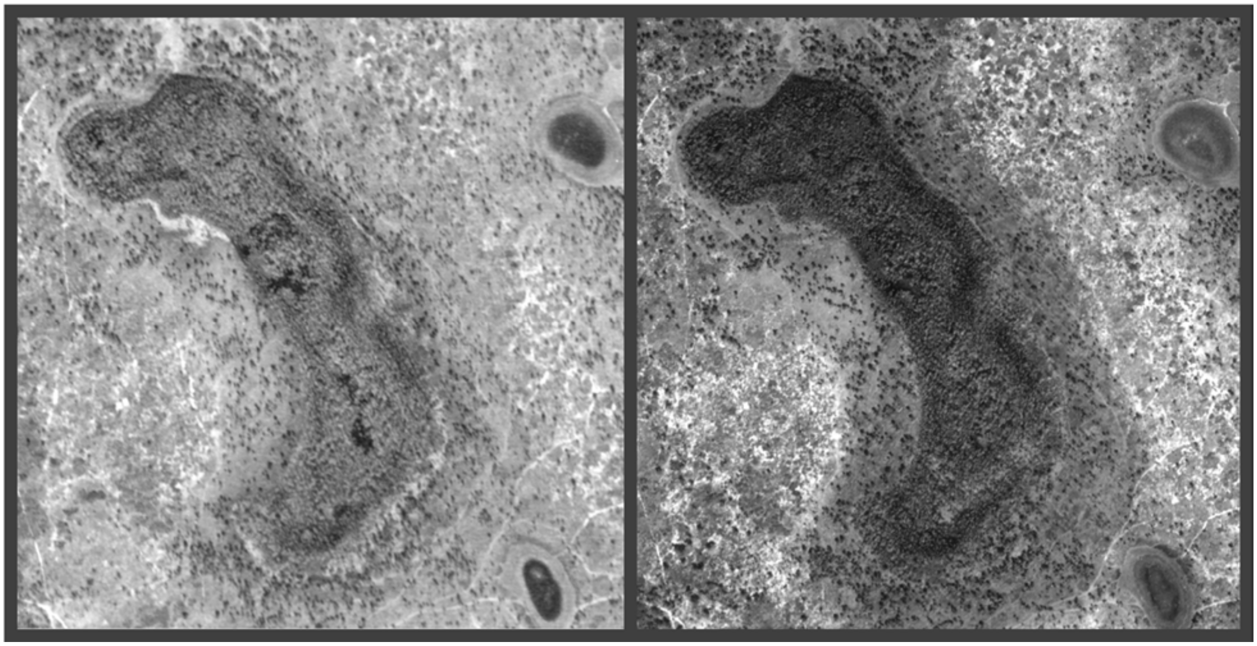


Figure 28 The same location, 1947 on the left, 1951 on the right; notice the edges of the swamp, “big swamp 1”expand

4.4 The Fifties and Sixties: 1951 to 1969

Between these years “floodplain marsh 1” almost completely transitioned to other communities. Figures 29 and 30 give you a general sense of the extent of the changes over the time period. Figure 31 shows how low spots were spared and the “big swamp 1” expanded a little more. The canopy closed almost completely in what was previously the large sandhill, making it a nearly 10 ha hammock. There remains some sandhill at the northern tip of the hammock. In the years since it was purchased for conservation site managers have conducted very hot burns in the area to kill the oaks. Marsh and swamp change significantly during this time period.

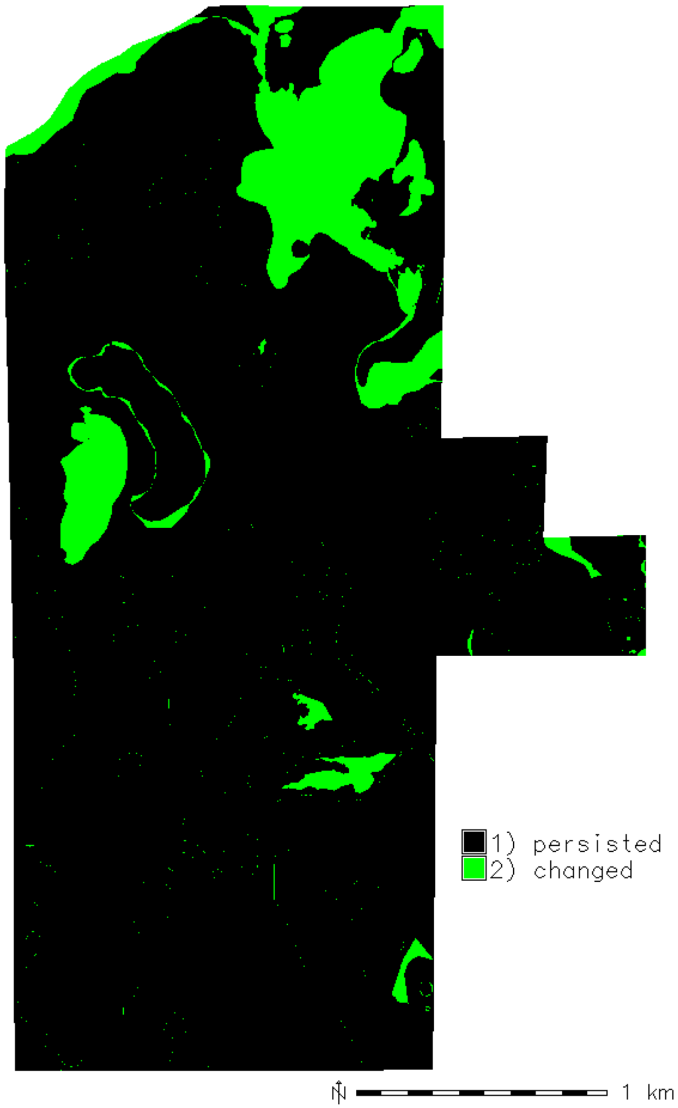


Figure 29 Binary change raster, 1951-1969

Figure 30 Complete change raster, 1951-1969

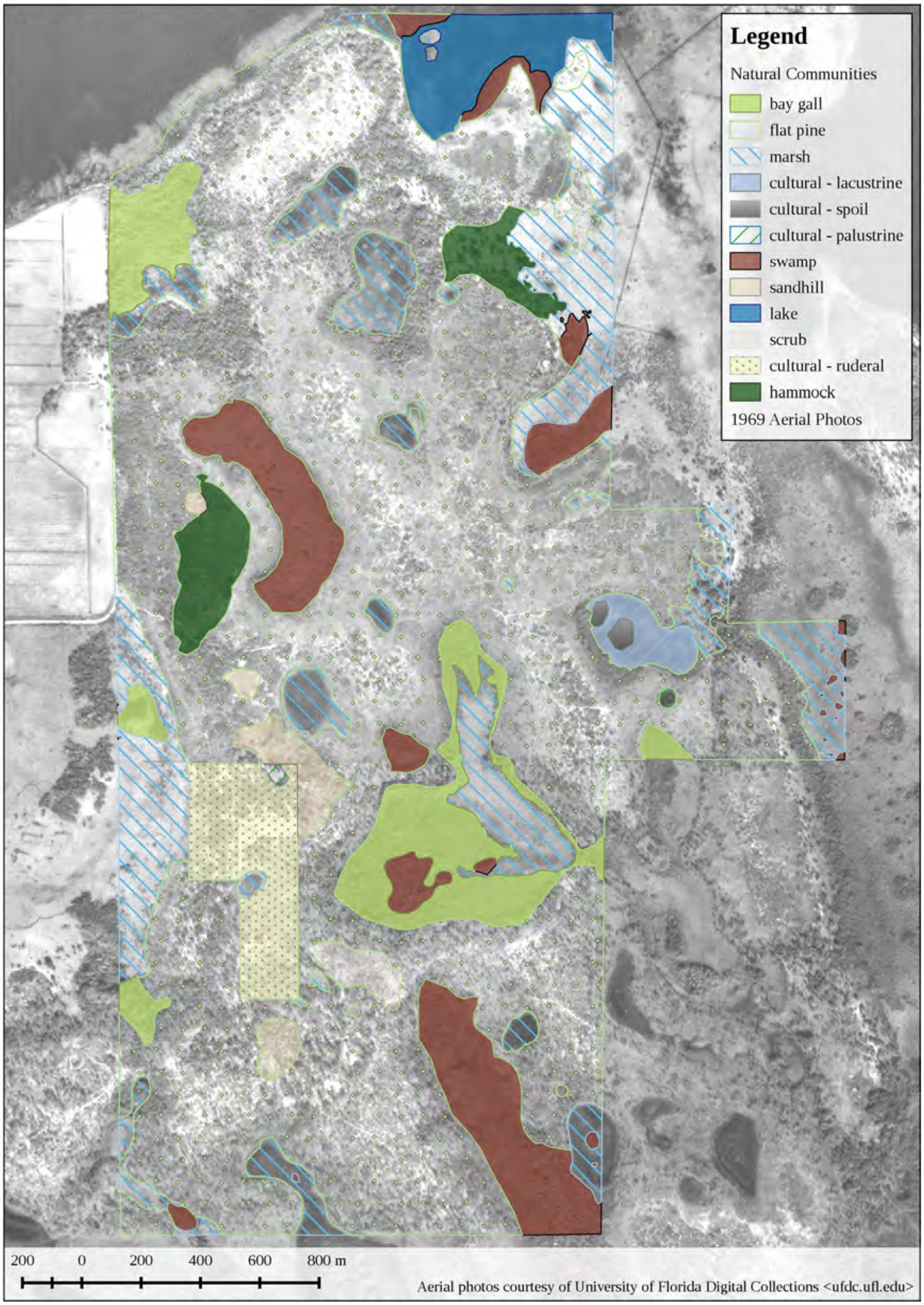


Figure 31 Natural community map, 1969

Figure 33 is a modern view of the far south marsh that crosses the site's border and the section line, "south marsh". The photo was taken from the road that runs along the section line. The marsh is still grassy, but it is cut off hydrologically by an earthen dam that can be seen in 1995 (Figure 43). Much of the rest of the marsh has transitioned to swamp since 1969.

Figure 32 A shot of the marsh that crossed the south boundary, "south marsh", 2015-08-27

The histogram in Figure 34 shows that again, marsh and swamp change significantly: marsh lost a third of its area and swamp gained 21% of its area. The lake's gains, while not much in terms of area, amounted to 56% of its 1951 extent. The raw area for the cross between the two years can be seen in Table 11 and a summary of the changes can be seen in Table 12.

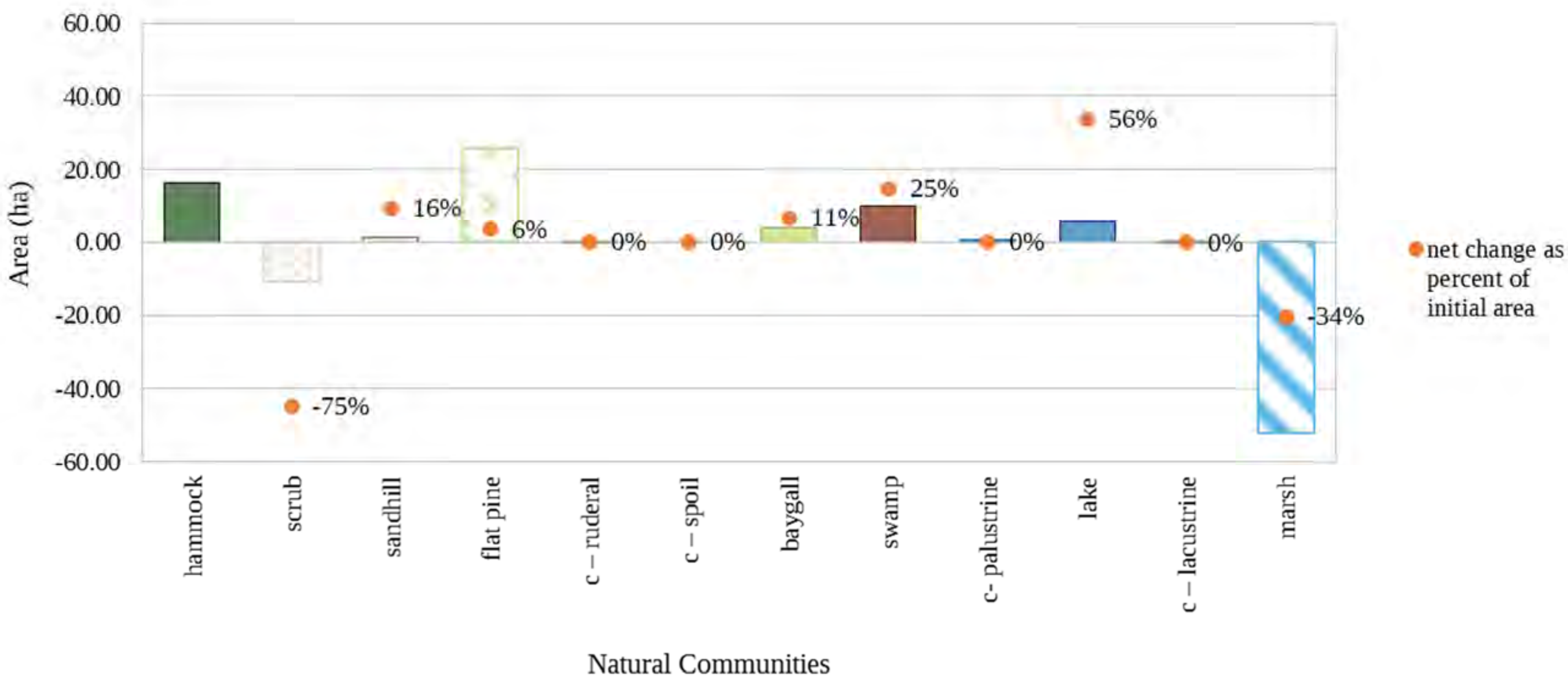


Figure 33 Histogram displaying net (ha) and percent natural community change from 1951 to 1969

Table 11 Cross-tabulation matrix, 1951-1969, in hectares

	1969												Total 1951
	ham-mock	scrub	sandhill	flat pine	c- rude-ral	c - spoil	baygall	swamp	c – palus-trine	lake	c – lacus-trine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1951													
1120													
1210		3.67		0.01									14.48
1240	9.61		8.97	0.38	0.00				0.00				8.16
1300	1.74	0.01	0.47	415.33	0.02	0.00	0.16	5.19	0.00		0.01	2.06	425.06
1800			0.00	0.02	21.05				0.00			0.01	21.09
1877				0.00		1.04					0.01		1.05
2231				0.06			36.55	0.01				0.03	36.66
2242				0.38			0.01	39.86				0.06	40.33
2400			0.00	0.00	0.00				0.77				0.78
3100								0.00		9.37		0.47	9.85
3200						0.01				0.01	5.37	0.00	5.39
21212	5.06			34.53	0.01		4.03	5.18		6.02	0.00	99.33	154.24
Total 1969	16.42	3.68	9.44	450.80	21.08	1.05	40.77	50.25	0.78	15.40	5.38	102.02	

Table 12 Summary of changes from 1951-1969, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	16.42	0.00	16.42	0.00	16.42
1210	scrub	0.01	10.81	10.82	0.02	-10.80
1240	sandhill	0.47	0.00	0.47	0.00	1.28
1300	flat pine	35.46	9.73	45.19	19.45	25.74
1800	cultural – ruderal	0.03	0.04	0.07	0.06	0.00
1877	cultural – spoil	0.01	0.01	0.01	0.01	0.00
2231	baygall	4.22	0.12	4.34	0.23	4.10
2242	swamp	10.39	0.46	10.85	0.93	9.92
2400	cultural – palustrine	0.01	0.01	0.01	0.01	0.00
3100	lake	6.03	0.47	6.50	0.95	5.56
3200	cultural – lacustrine	0.02	0.02	0.04	0.04	0.00
21212	marsh	2.69	54.90	57.59	5.38	-52.21
	total	75.75	76.56	76.16	13.54	

Since the major loss between these two photos was a great deal of marsh, Figure 32 compares floodplain marsh 1 between 1951 and 1969. Trees have established over the 18 years in the former marsh.

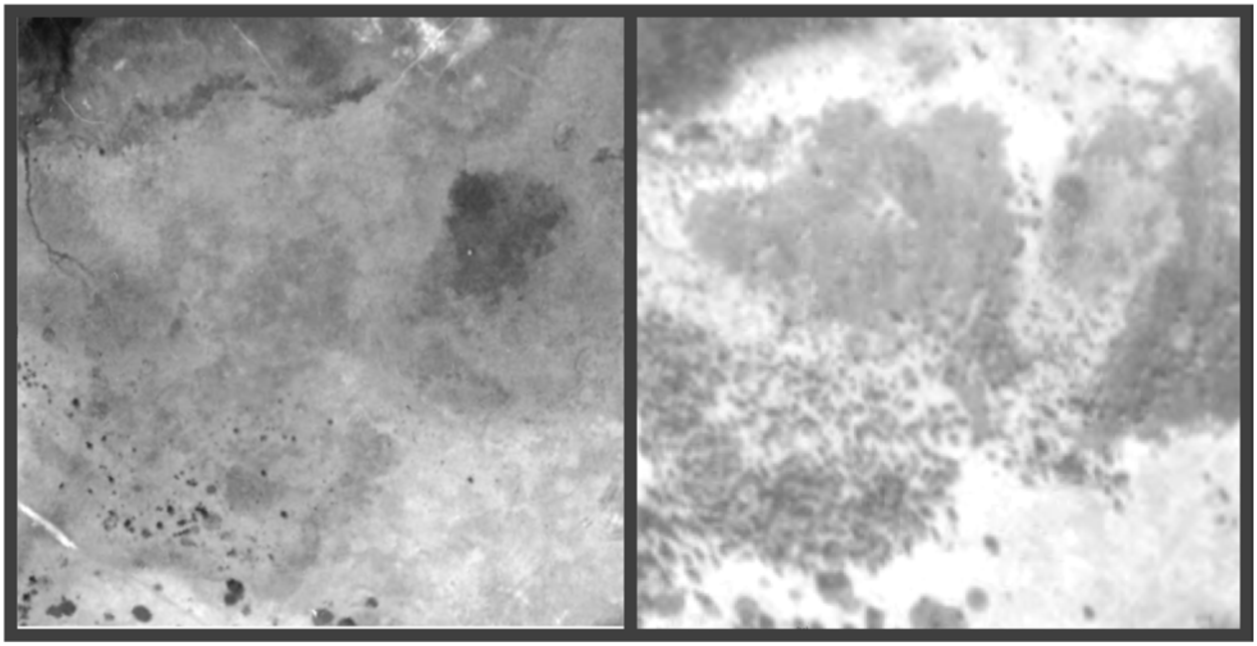


Figure 34 The same location, 1951 on the left, 1969 on the right; notice the pine trees growing in the former marsh

4.5 The Seventies: 1969 to 1980

The site changed a great deal in these 11 years. The swamps continued to expand at the expense of marsh and flat pine and the property owners did a great deal of land clearing, creating 45 ha of cultural – ruderal from marsh, flat pine, and scrub. They also dug another shallow marsh, half of which was later dug out further to make a manmade lake, drying the other half to transition to uplands. The photo point in Figure 36 shows what the partially-recovered marsh looks like in August of 2015.

Figure 35 “Marsh-pasture” area that has been partially restored, 2015-08-16

Looking below at the vector map in Figure 37, the human activities are very obvious – large areas are cleared and excavated. Also note the change in Bonnet Pond’s shape, the development of “hammock 1” and the expansion of “big swamp 1”. Figure 38, the binary change map, displays the transitions in bright green and Figure 39 shows every category created by the cross. Tables 13 and 14 show the areas that persisted and transitioned over the 11 years and Figure 40 shows the changes visually as a histogram.

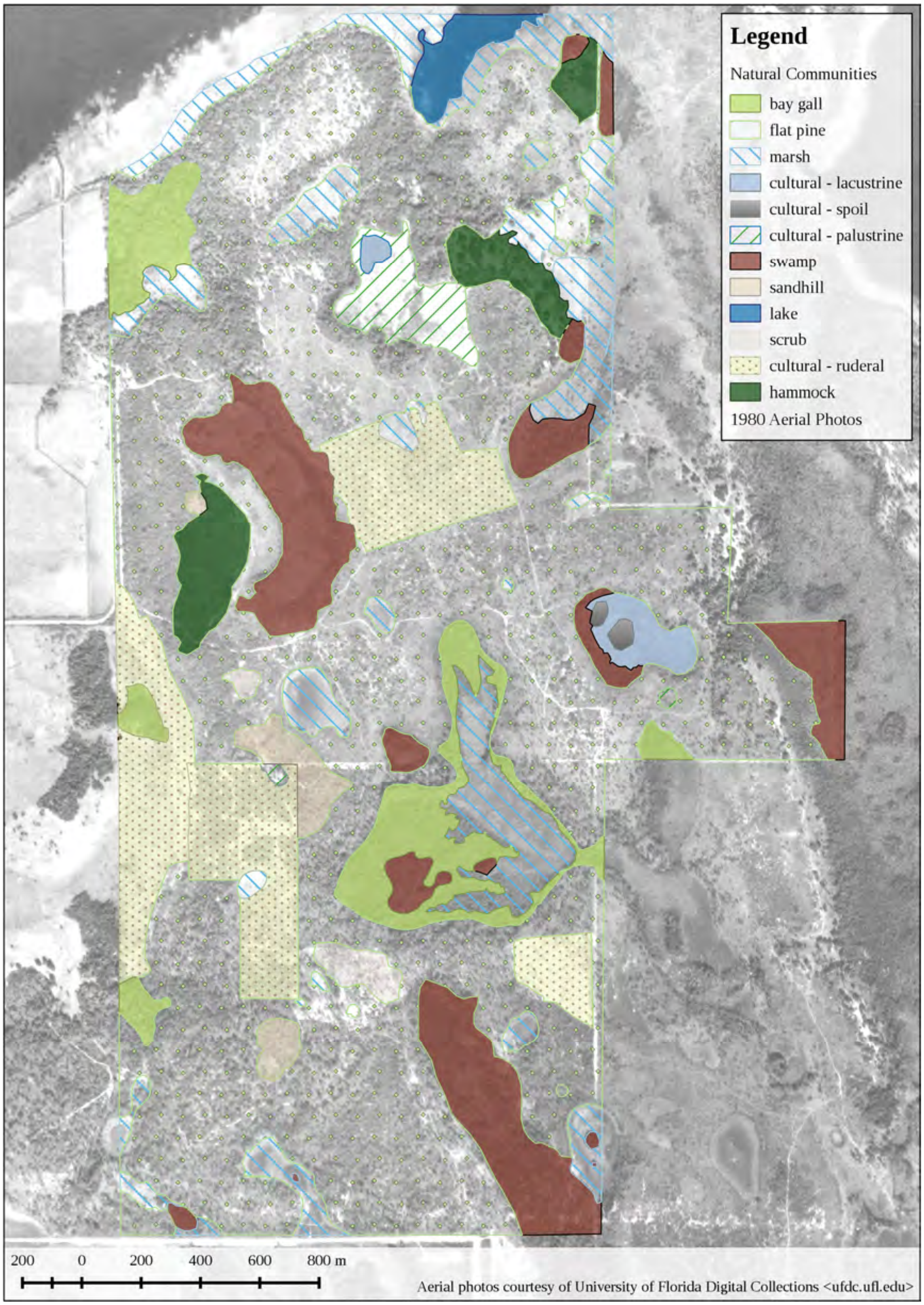


Figure 36 Natural Community map for 1980

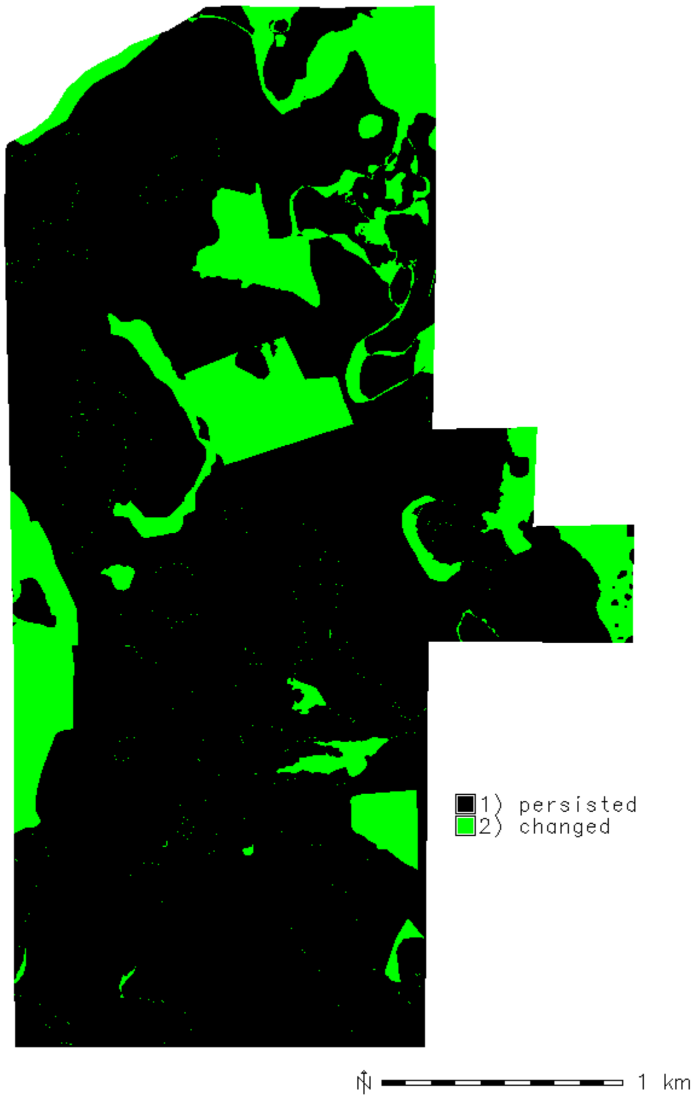


Figure 37 Binary change raster, 1969-1980

Figure 38 Complete change raster, 1969-1980

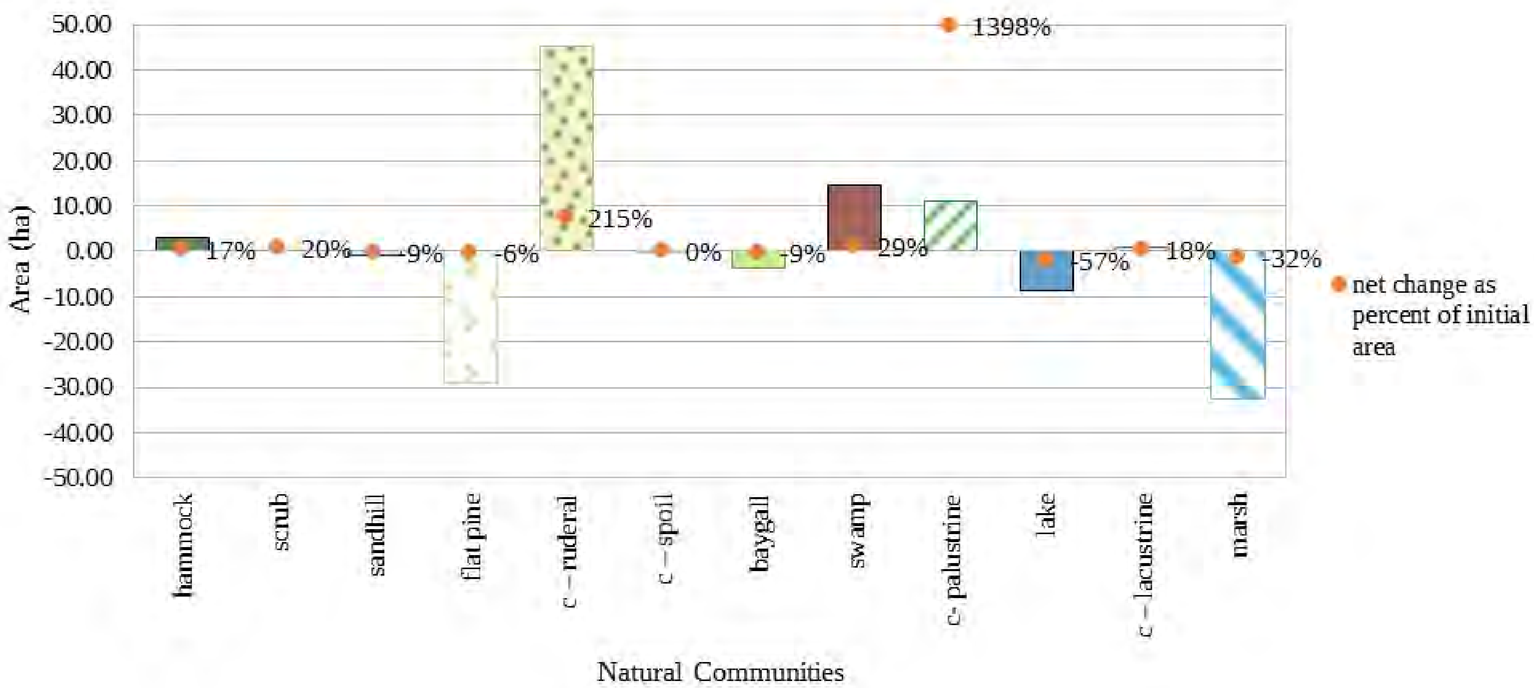


Figure 39 Histogram displaying net (ha) and percent natural community change from 1969 to 1980

Table 13 Cross-tabulation matrix, 1969-1980, in hectares

	1980												Total 1969
	hammock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palustrine	lake	c – lacustrine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1969													
1120	14.60		0.00	1.47					0.00			0.35	16.42
1210		3.56		0.12									3.68
1240	0.00	0.83	8.58	0.02	0.00				0.00				9.44
1300	1.32	0.01	0.02	402.57	26.57	0.00	0.21	9.81	5.17		0.01	5.06	450.80
1800			0.00	0.02	21.06				0.00			0.00	21.08
1877						1.04		0.00			0.01		1.05
2231				0.06	0.01		36.65	0.01				4.02	40.77
2242	0.05			2.33	0.00		0.01	45.66				2.18	50.25
2400			0.00	0.00	0.00				0.77				0.78
3100	0.08			1.76				0.27		6.40	0.03	6.86	15.40
3200				0.01		0.01		0.01			5.37		5.38
21212	3.18			13.22	18.77		0.03	8.96	5.74	0.24	0.95	50.89	102.02
Total 1980	19.22	4.40	8.61	421.65	66.41	1.05	36.92	64.73	11.68	6.64	6.36	69.41	

Table 14 Summary of changes, 1969-1980, in hectares

1120	hammock	4.62	1.82	6.44	3.63	2.81
1210	scrub	0.84	0.12	0.96	0.24	0.72
1240	sandhill	0.03	0.86	0.89	0.06	-0.83
1300	flat pine	19.09	48.23	67.32	38.18	-29.14
1800	cultural – ruderal	45.35	0.03	45.38	0.05	45.33
1877	cultural – spoil	0.01	0.01	0.01	0.01	0.00
2231	baygall	0.27	4.11	4.38	0.53	-3.85
2242	swamp	19.07	4.59	23.66	9.18	14.48
2400	cultural – palustrine	10.91	0.01	10.91	0.01	10.90
3100	lake	0.24	9.00	9.24	0.48	-8.77
3200	cultural – lacustrine	1.00	0.02	1.02	0.04	0.98
21212	marsh	18.52	51.13	69.66	37.05	-32.61
	total	119.94	119.93	119.93	44.73	

The comparison photos in Figure 41 also shows the change in *marsh-pasture*, the marsh that crossed the western border of the site. At the time the whole property was owned by William Crowder. It appears that he had been transitioning the area to pasture since the 1950s, as the water receded due to the ditching to the west. This year was the first that there was enough cleared and dry that I felt comfortable calling it cultural – ruderal, though the marsh was impacted before 1980.

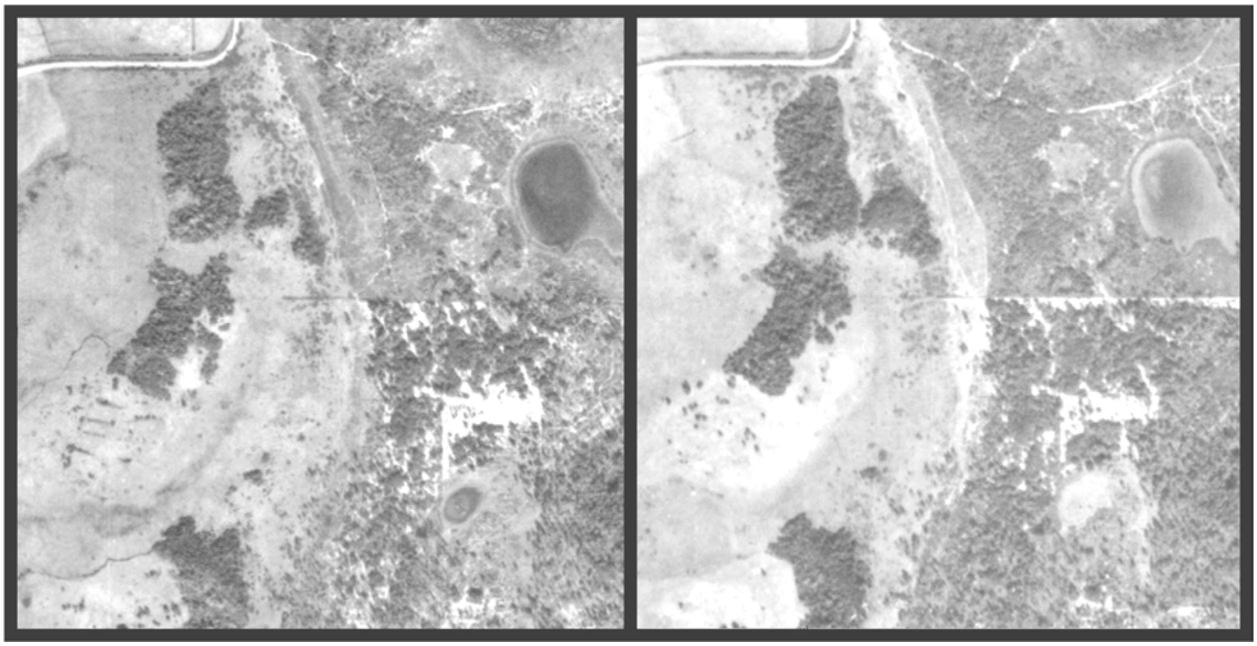


Figure 40 The marsh crossing the eastern border, 1969 on the left and 1980 on the right

4.6 The Eighties and Early 1990s: 1980 to 1995

Between 1980 and 1995 the property was sold to a group of LLCs and trusts who were preparing to develop it. Even more land clearing and digging occurred over these 15 years than the last 11. The photo point below in Figure 41 is of the most recently dug lake on the property, "manmade lake 2", also shown in the comparison photo later in this section. The aerial photo comparison follows in Figure 42. From a look at Figure 43, the vector map, it is obvious that marsh and swamp again lead the change in net area. The digging of the new pond almost triples the existing cultural – lacustrine area. Figures 44 and 45, the cross rasters, show the new hammocks along the shore of Lake Hart. Tables 15 and 17 show the details of the numerical change. Figure 45 displays the changes over the 11 years in a histogram.

Figure 41 "Manmade lake 2", an easy walk from the site entrance. Photo taken 2015-08-16

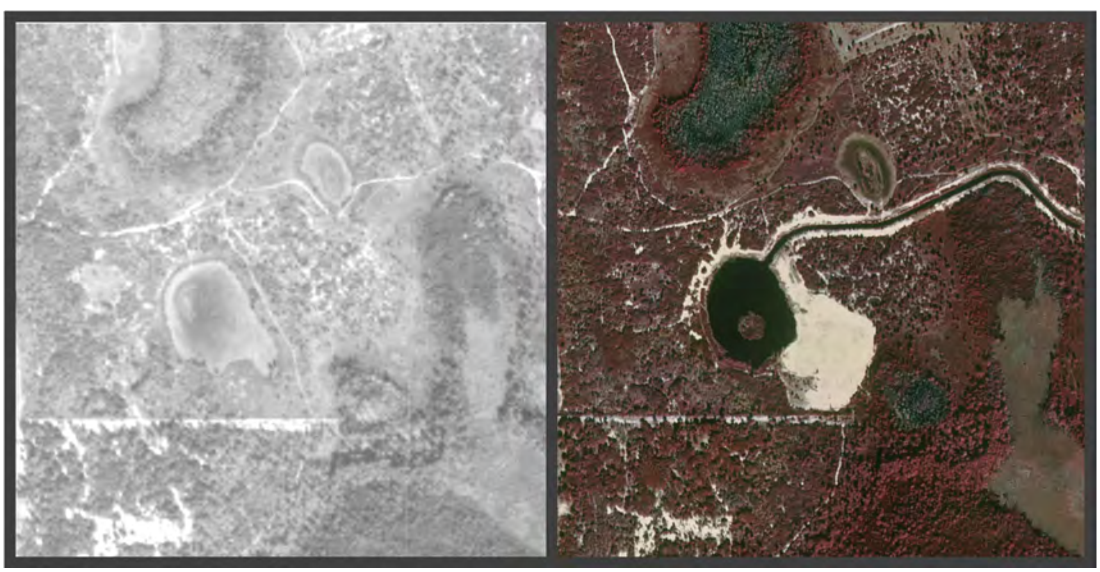


Figure 42 Photos showing "manmade lake 2" dug in the 1980s out of a marsh

Figure 43 Natural Community map for 1995

Figure 44 Binary change raster, 1980-1995

Figure 45 Complete change raster, 1980-1995

Table 15 Cross tabulation matrix, 1980-1995, in hectares

	1980 hammock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palustrine	lake	c – lacustrine	marsh	Total 1980
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1969													
1120	8.78	9.36		1.09	0.00								19.22
1210		4.19		0.21									4.40
1240			6.78	1.83									8.61
1300	5.70		0.27	383.37	12.38	3.01	7.09	5.99	0.33	0.40	1.34	1.35	421.65
1800			0.83	25.27	40.21							0.10	66.41
1877					0.31	0.55		0.06	0.07		0.06		1.05
2231	4.17			0.61		0.02	32.12						36.92
2242	0.02			6.05	1.17	0.22		57.09	0.04		0.14		64.73
2400			0.02	0.97	7.22				0.33		3.14		11.68
3100										6.63		0.01	6.64
3200				0.12	0.14	0.06		0.12	3.32		2.61		6.36
21212	0.69			10.30	4.59	0.25	4.61	10.19		6.21	2.82	29.74	69.41
Total 1995	19.37	13.82	8.05	429.80	66.02	4.11	43.82	73.45	4.09	13.24	10.11	31.20	

Table 16 Summary of changes, 1980-1995, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	10.59	10.45	21.04	20.89	0.15
1210	scrub	9.63	0.21	9.84	0.42	9.42
1240	sandhill	1.27	1.83	3.10	2.54	-0.56
1300	flat pine	46.44	38.29	84.73	76.58	8.15
1800	cultural – ruderal	25.82	26.20	52.02	51.64	-0.39
1877	cultural – spoil	3.56	0.50	4.06	1.00	3.06
2231	baygall	11.70	4.80	16.51	9.60	6.90
2242	swamp	16.36	7.64	24.00	15.28	8.72
2400	cultural – palustrine	3.76	11.35	15.11	7.52	-7.59
3100	lake	6.62	0.01	6.63	0.02	6.60
3200	cultural – lacustrine	7.50	3.76	11.26	7.51	3.75
21212	marsh	1.46	39.68	41.14	2.93	-38.21
	total	144.71	144.71	144.71	97.96	

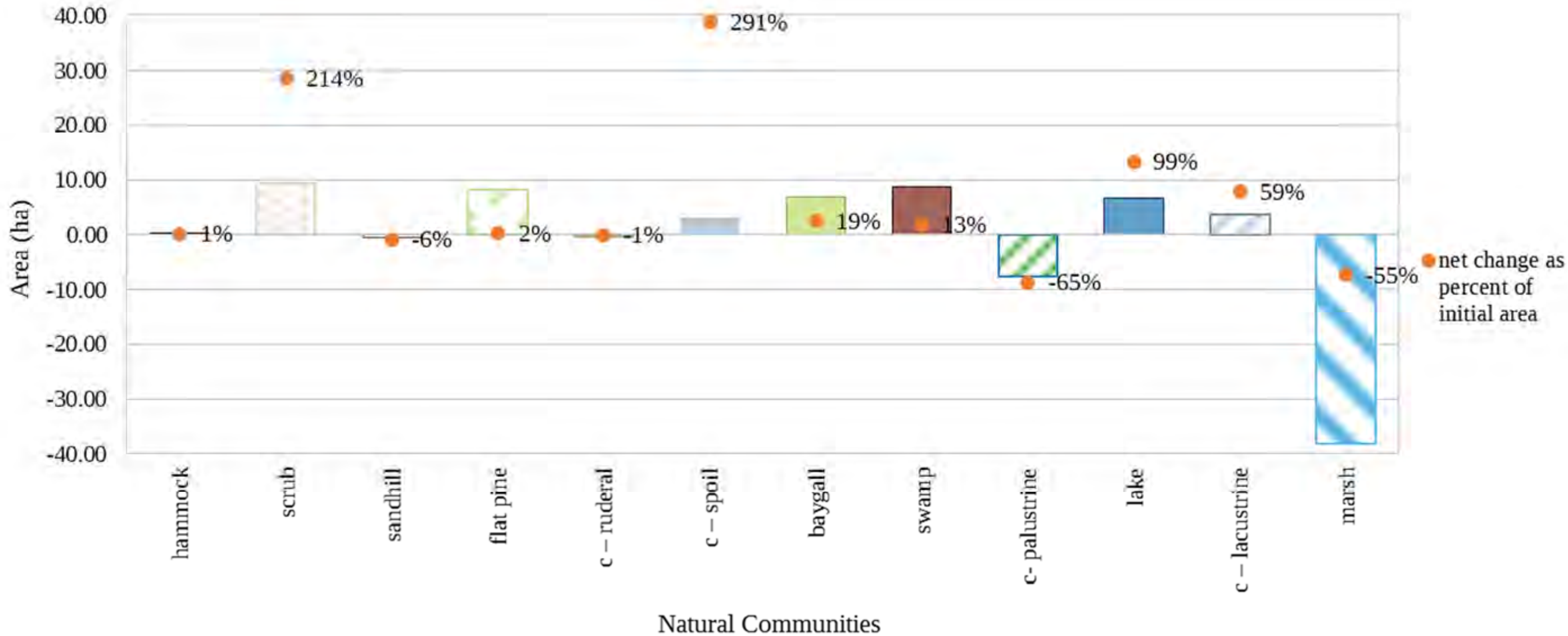


Figure 46 Histogram displaying net (ha) and percent natural community change from 1980 to 1995

4.7 The New Millennium: 1995 to 2011

The site was purchased jointly by Osceola and Orange counties in 1994, and so almost all of the changes seen from 1995 to 2011 are ecologically positive. Figure 47 shows what the spoil areas surrounding the canal looked like in August 2015. There are mature scrub oaks (*Q. inopina*) on the dry areas and willows and bays on the edges of the water. Today, the canal is used as a firebreak and water source for prescribed fire and the spoil as walking paths.

The comparison graphic, Figure 48, focuses on the area round “hammock 1”. Figure 49 is a vector map of the communities in 2011. Figures 50 and 51 show the total cross and the binary change, respectively. The histogram, Figure 52 demonstrates that most of the wetland loss had ceased by 1995 and does not continue. Swamps expand less when prescribed fire is allowed to creep into the edges; FFWCC has been allowing fire into the edges of the swamps during prescribed fires. This being the case, most of the change during these 11 years was flat pine gaining area by recovering old cut-over sites. Again, Tables 17 and 18 give a good summary of the exact numerical changes.

Figure 47 Photo of the canal dug between the two manmade lakes, taken 2015-08-16

Figure 48 "Hammock 1" and an area just north of it is, as of August 2015, horse trailer parking and is kept mowed; this series show how quickly pines can regenerate on a disturbed site

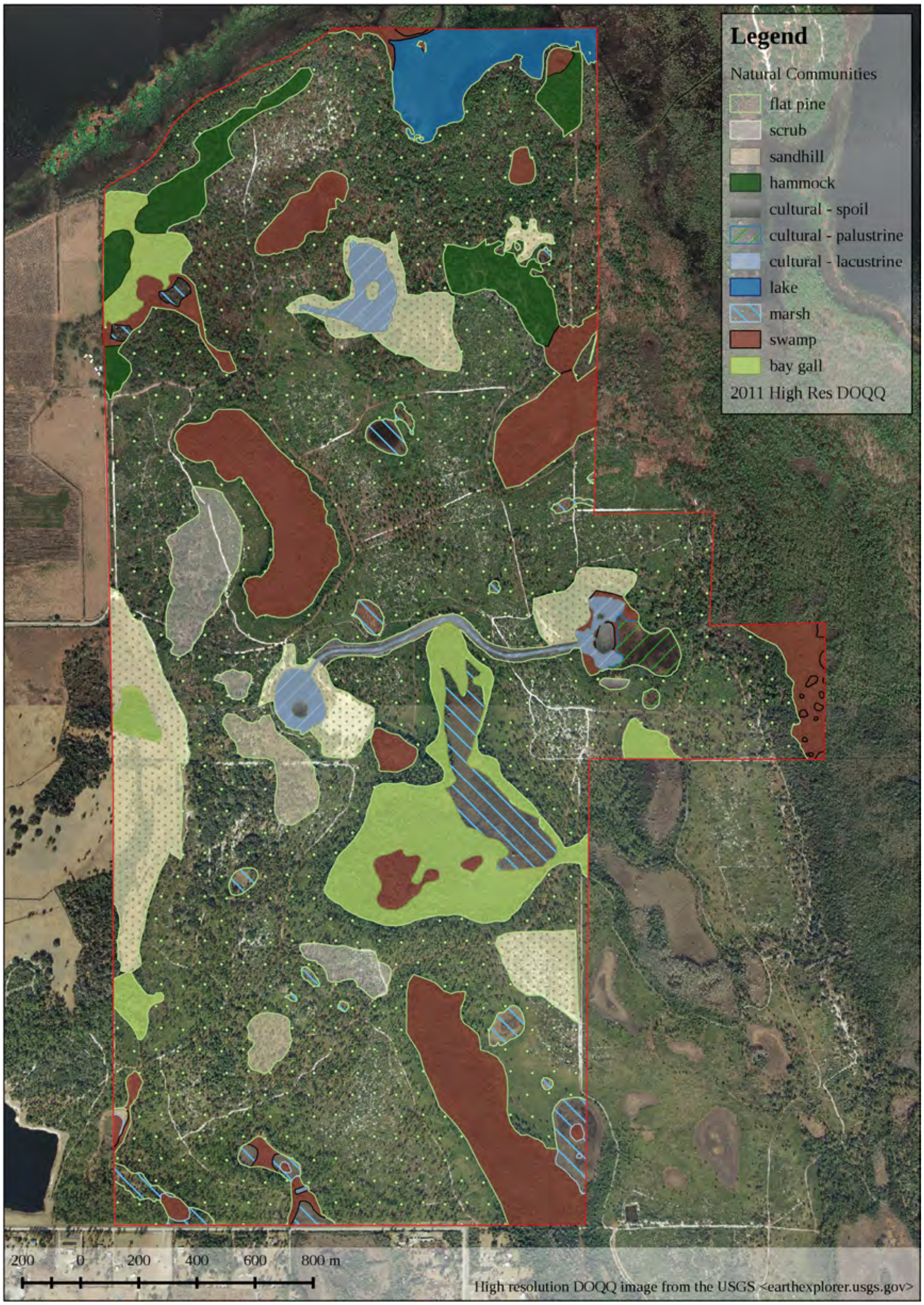


Figure 49 Natural Community map for 2011

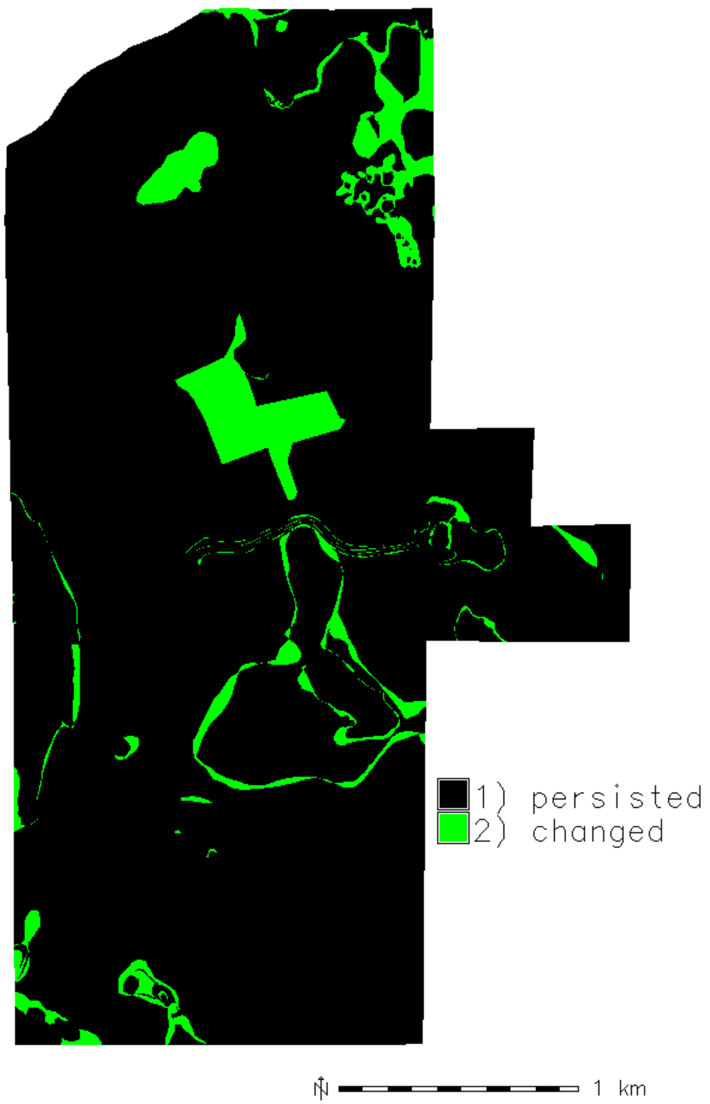


Figure 50 Binary change raster, 1995-2011

Figure 51 Complete cross raster, 1995-2011

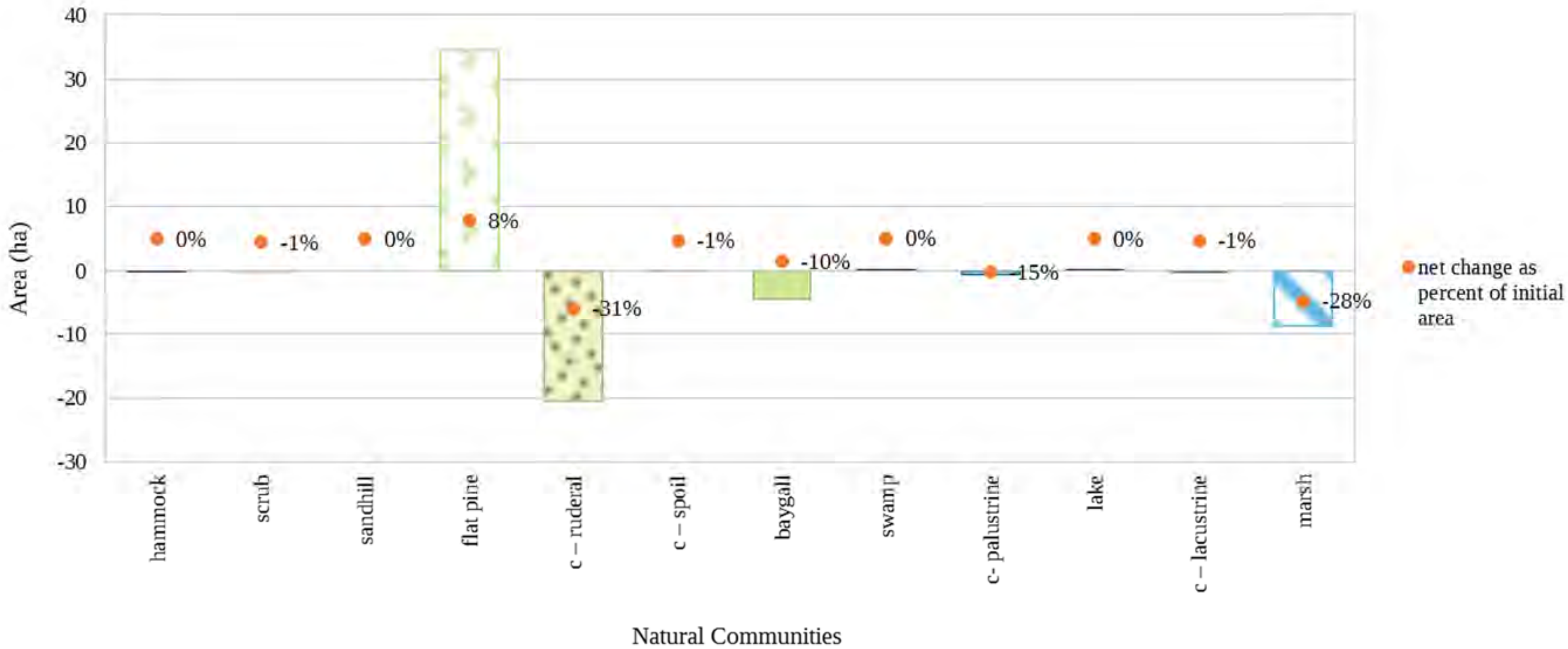


Figure 52 Histogram displaying net (ha) and percent natural community change from 1995 to 2011

Table 17 Cross tabulation matrix, 1995-2011, in hectares

2011	hammock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palustrine	lake	c – lacustrine	marsh	Total 1995
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1995													
1120	19.36			0.01									19.37
1210		13.61		0.21									13.82
1240			8.05										8.05
1300				426.40	0.38	0.20	0.67	1.52	0.10	0.00	0.00	0.54	429.80
1800				20.78	45.12			0.02			0.00	0.10	66.02
1877				0.23		3.74	0.02				0.12		4.11
2231				6.46		0.01	37.32					0.04	43.82
2242				7.41	0.00			64.73			0.03	1.28	73.45
2400				0.16				0.55	3.35		0.04		4.09
3100				0.15				0.01		13.09			13.24
3200				0.00		0.14		0.10	0.03		9.84		10.11
21212				2.50			1.37	6.60		0.16		20.56	31.20
Total 2011	19.36	13.61	8.05	464.30	45.50	4.08	39.38	73.53	3.48	13.25	10.03	22.51	

Table 18 Summary of changes, 1995-2011, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	0.00	0.01	0.01	0.00	-0.01
1210	scrub	0.00	0.21	0.21	0.00	-0.21
1240	sandhill	0.00	0.00	0.00	0.00	0.00
1300	flat pine	37.91	3.41	41.31	6.81	34.50
1800	cultural – ruderal	0.38	20.90	21.28	0.76	-20.52
1877	cultural – spoil	0.34	0.37	0.71	0.68	-0.03
2231	baygall	2.06	6.50	8.57	4.13	-4.44
2242	swamp	8.80	8.72	17.52	17.44	0.08
2400	cultural – palustrine	0.13	0.74	0.88	0.27	-0.61
3100	lake	0.16	0.16	0.32	0.31	0.00
3200	cultural – lacustrine	0.19	0.27	0.46	0.38	-0.08
21212	marsh	1.96	10.64	12.60	3.91	-8.68
	total	51.93	51.93	51.93	17.35	

4.8 Recent History: 2011 to 2015

Figure 54 is centered on a rare (for this area) bluejack oak (*Quercus incana*) among the remnant sandhill patch in the south-center of the site. It has an understory that is more saw palmetto than wiregrass but it is still recruiting turkey oaks. The comparison photo for these four years is reproduced in Figure 54. The “marsh-pasture” has been managed as a dry prairie because the drainage is offsite and is not under the managers’ control.

The vector map from 2015 is reproduced in Figure 56. From the vector maps reproduced in Figures 49 and 55 and Tables 19 and 20 you can see that it lost area to many communities, though it only lost 8% of its existing area. The binary change map in Figure 56 indicates that hammock gained a lot of acreage, mostly from continual scrub transition and a little pine. Figure 57 uses the same color scheme as all of the full cross maps to show the area and percentage change for each community.

As mentioned in Section 4.7, the “marsh-pasture” is being managed as a dry prairie. As such, it would have a lower density of saw palmetto and be dominated by herbaceous species. To that end, the FFWCC has been roller chopping that area to control the saw palmetto and seeding appropriate native grasses and forbs. While some bahia grass (*Paspalum notatum*) remains, the site seems to be functioning as intended.

Figure 53 Individual bluejack oak (*Q. incana*) along a walking path in center-south sandhill patch, 2015-08-16, to demonstrate that not everything changes

Figure 54 Photos showing the clearing of an area adjacent to "marsh-pasture"

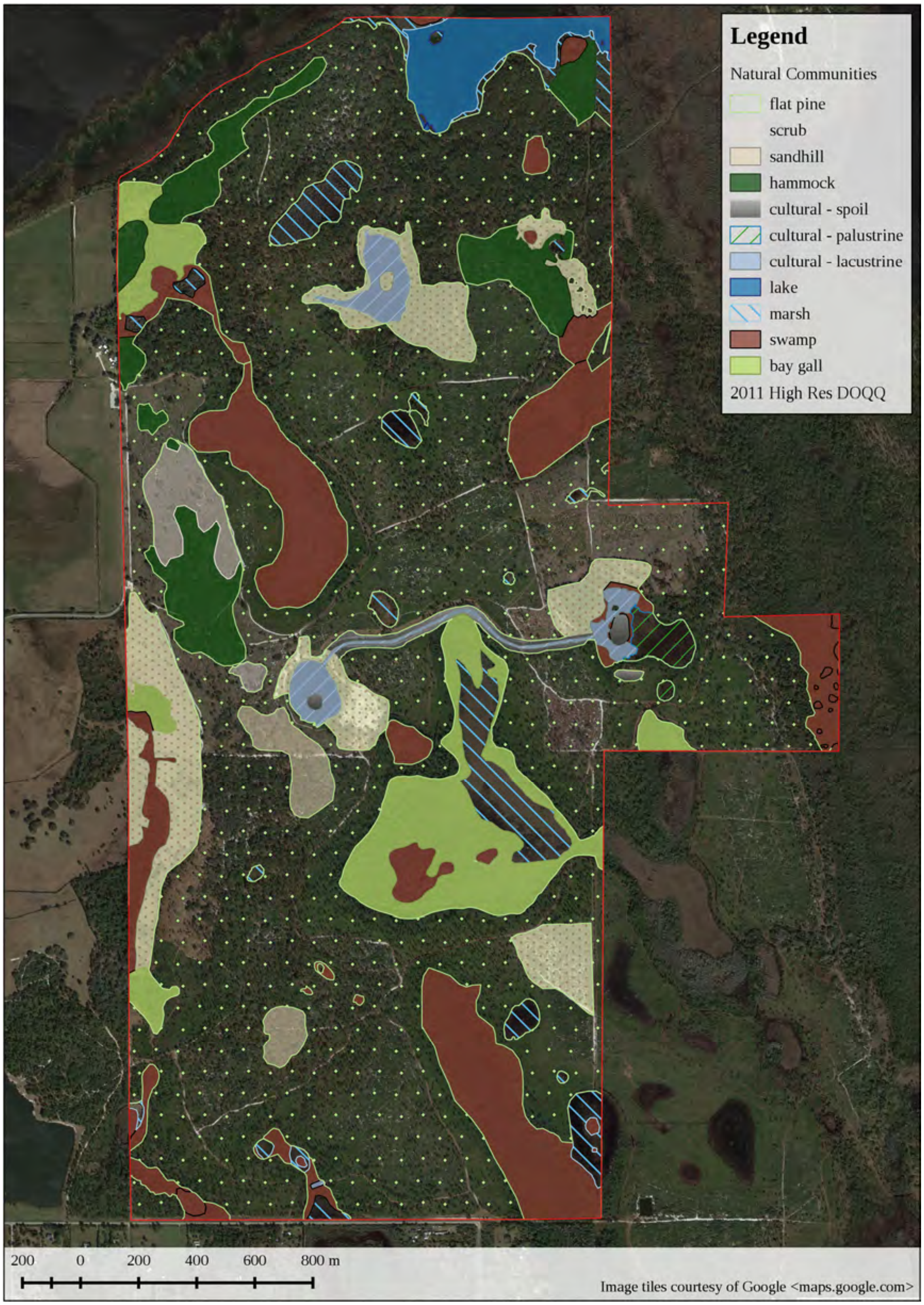


Figure 55 Natural Community map, 2015

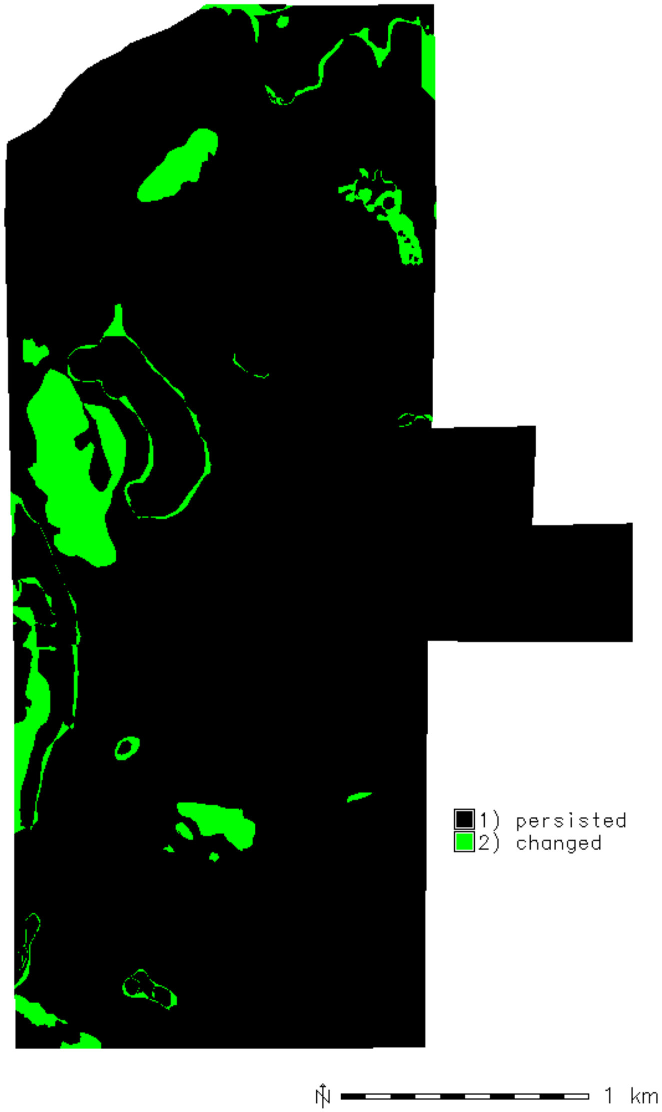


Figure 56 Binary change raster, 2011-2015

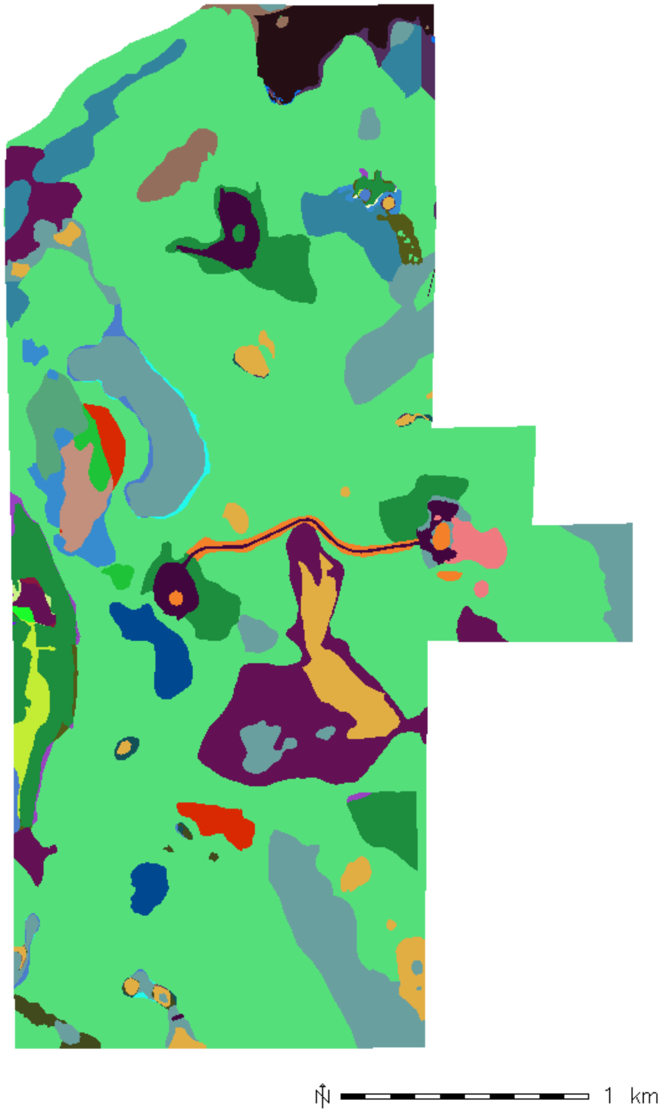


Figure 57 Complete cross raster, 2011-2015

Table 19 Cross tabulation matrix, 2011-2015, in hectares

2015													Total 2011
	ham-mock	scrub	sandhill	flat pine	c- rude-ral	c - spoil	baygall	swamp	c – palus-trine	lake	c – lacus-trine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
2011													
1120	19.36												19.36
1210	5.28	2.76		5.57									13.61
1240			8.05										8.05
1300	6.18	5.58		444.69	2.33			2.56		0.15		2.82	464.30
1800	0.08			1.34	39.77		0.25	4.06					45.50
1877						4.08							4.08
2231					0.19		38.82	0.37					39.38
2242				1.26	0.01		0.01	66.92		0.01		5.32	73.53
2400									3.48				3.48
3100				0.00						13.09		0.16	13.25
3200											10.03		10.03
21212	0.01			0.81				2.15				19.55	22.51
Total 2015	30.90	8.34	8.05	453.66	42.30	4.08	39.08	76.06	3.48	13.24	10.03	27.85	

Table 20 Summary of changes, 2011-2015, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	11.55	0.00	11.55	0.00	11.55
1210	scrub	5.58	10.85	16.43	11.15	-5.27
1240	sandhill	0.00	0.00	0.00	0.00	0.00
1300	flat pine	8.97	19.61	28.59	17.95	-10.64
1800	cultural – ruderal	2.53	5.73	8.26	5.06	-3.20
1877	cultural – spoil	0.00	0.00	0.00	0.00	0.00
2231	baygall	0.26	0.56	0.83	0.53	-0.30
2242	swamp	9.14	6.61	15.75	13.21	2.53
2400	cultural – palustrine	0.00	0.00	0.00	0.00	0.00
3100	lake	0.16	0.16	0.32	0.31	0.00
3200	cultural – lacustrine	0.00	0.00	0.00	0.00	0.00
21212	marsh	8.30	2.97	11.27	5.93	5.33
	total	46.49	46.49	46.49	27.07	

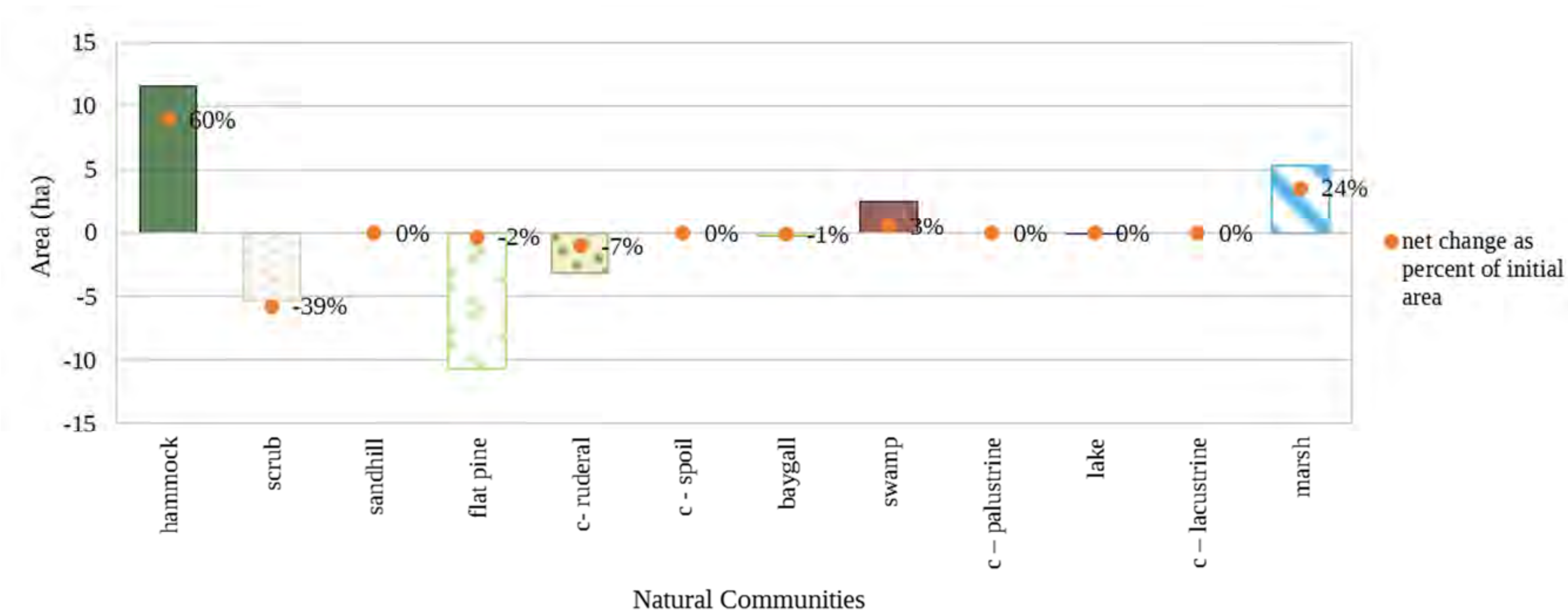


Figure 58 Histogram displaying net (ha) and percent natural community change from 2011 to 2015

4.9 The Full 171 Years: 1844 to 2015

These next two sections compare total change for the site. This section compares the survey data to the latest available imagery. As discussed in Section 4.1, the GLO survey natural community map has a low level of accuracy. Crosses between this map and others will not result in highly accurate quantities of change. Table 21, row 21212, illustrates how marsh transitioned into all but two of the communities. Not every transition was one-sided. The column "swamp" in Table 22 illustrates that flat pine readily transitions to and from other communities (almost 210 ha of total swap over the 171 years), and Table 21, row 1300, shows that it has transitioned to every category except lake and transitioned from sandhill, baygall, lake, and marsh.

One area of change that was not as drastic as the transition might imply is "sandhill 1". This area was recorded in 1844 and persisted until 1969 when it transitioned to hammock. Despite the heavy leaf litter, longleaf pine seedlings germinated and emerged in the former sandhill shown in the modern photo Figure 60. The overstory is turkey oak with a midstory of saw palmetto and runner oak. If this project was able to define communities in a more nuanced way, this area might be more apt to be named 'turkey oak hammock' or 'sandhill hammock'. The current managers have successfully transitioned the area back from a thick hammock, as seen on the 1980 (Figure 37) and 1995 (Figure 43) aerial images. The hammock shown in the August 2015 photo below has a low-density turkey oak canopy and sparse wiregrass understory. As of that date it had not been burned in several years but patches around it have been and are now sandhill.

Figure 59 The understory of the "sandhill 2" that turned into a hammock

The binary change map in Figure 60 gives us the impression that the entire north three-quarters of the property changed. The northern part of the property was identified as mostly marsh bordering a lake that was drained at least 4' in depth (but probably 7' or more). This is not unreasonable. Taking into consideration that the surveyors may not have accurately identified all of the upland areas, a map of this time period modified to accommodate the presence of the hammock where the site's namesake oak lived at the time of the survey would show a bastion of persistence across time. The following two maps, Figures 60 and 61, show the complete changes spatially between 1944 and 2015.

Figure 60 Binary change raster, 1844-2015

Figure 61 Complete cross raster, 1844-2015

Table 21 Cross tabulation matrix, 1844-2015, in hectares

	2015												Total 1844
	hammock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palustrine	lake	c – lacustrine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1844													
1120													
1210													
1240	3.75	3.76	4.20	14.21	0.98	0.25				2.18			29.33
1300	4.66	2.48	3.79	210.25	14.67	3.83	24.03	33.47	1.74	3.58		12.65	315.15
1800													
1877													
2231	6.88			18.73			6.61	0.83		5.29		0.83	39.17
2242													
2400													
3100	1.62			8.47			0.28					0.27	10.64
3200													
21212	14.00	2.10	0.06	201.99	26.65		8.16	39.96	1.74	12.22		15.91	322.78
Total 2015	30.90	8.34	8.05	453.66	42.30	4.08	39.08	76.06	3.48	13.24	10.03	27.85	

Table 22 Summary of changes, 1844-2015, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	30.90	0.00	30.90	0.00	30.90
1210	scrub	8.34	0.00	8.34	0.00	8.34
1240	sandhill	3.85	25.13	28.98	7.69	-21.28
1300	flat pine	243.41	104.90	348.31	209.80	138.51
1800	cultural – ruderal	42.30	0.00	42.30	0.00	42.30
1877	cultural – spoil	4.08	0.00	4.08	0.00	4.08
2231	baygall	32.47	32.55	65.02	64.94	-0.09
2242	swamp	76.06	0.00	76.06	0.00	76.06
2400	cultural – palustrine	3.48	0.00	3.48	0.00	3.48
3100	lake	13.24	10.64	23.88	21.27	2.61
3200	cultural – lacustrine	10.03	0.00	10.03	0.00	10.03
21212	marsh	11.93	306.87	318.80	23.87	-294.94
	total	480.10	480.09	480.10	163.79	

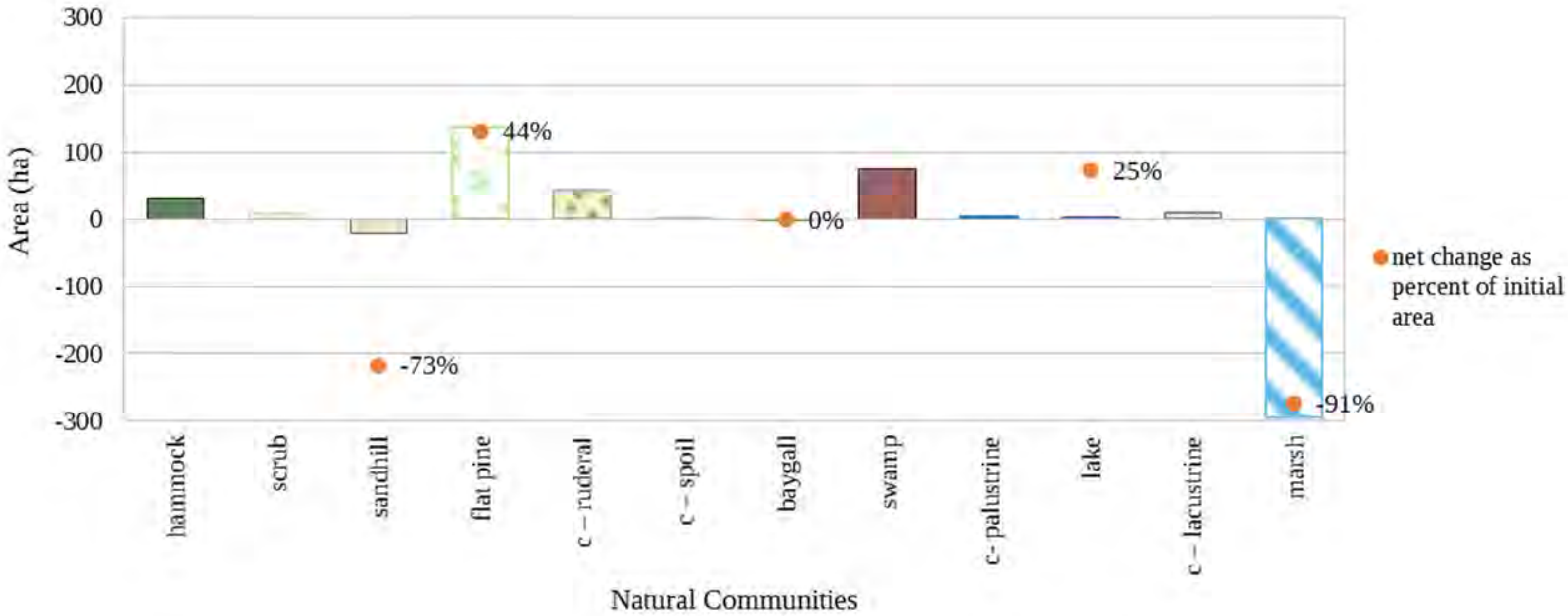


Figure 62 Histogram displaying net (ha) and percent natural community change from 1844 to 2015

Since “marsh 3” was mapped as two disjunct areas on the GLO survey and should have been in the path of the Loring team, it is unclear if the entire marsh was extant in the 1840s. Marsh 3 is particularly interesting because the site managers use it as an example of a healthy sawgrass marsh, and have built a pier out into the marsh so visitors can view it. The Loring team omitting Marsh 3 could be completely accounted for by their disinterest in walking into the section from the section lines; meaning the marsh boundaries to the east and north could be arcs drawn as assumptions. However, the marsh crosses the east boundary.

Perhaps the team was getting tired. On the 1944 aerial (Figure 12), two marsh crossings are visible, one at the section line and another 36 m to the east. Presently, there is an embankment that the walking path on the west crosses (that I was standing on when I took the photo in Figure 11) that is very obviously and abruptly at a higher elevation from the adjacent baygall. The vegetation on this area has no invasive plant species, indicating it was not established with equipment exposed to invasive plant propagules (Gordon and Thomas 1997). This, combined with lack of evidence of earthmoving activity there, suggests that the crossing was initially established before 1944. However, the path seems to have been widened and solidified in 1995, perhaps masking my ability to accurately speculate about the time the embankment was established and whether or not it had an effect on the marsh/baygall. The offending area is shown in the comparison image in Figure 64.

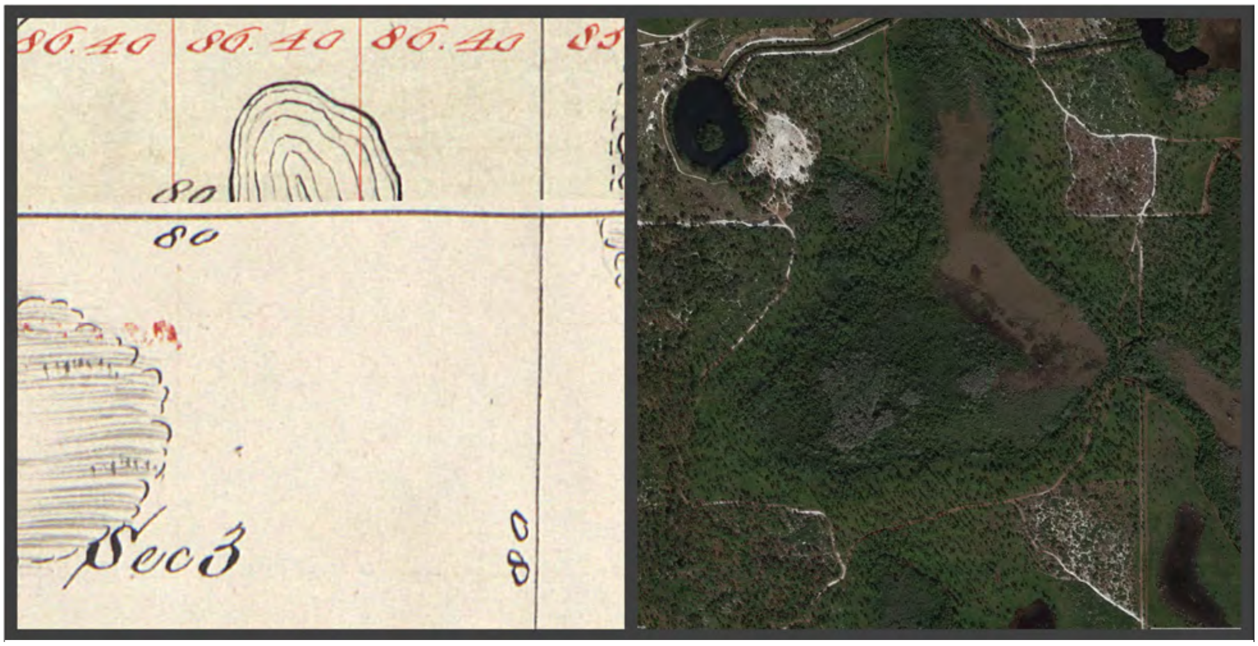


Figure 63 The "baygall-ringed marsh", seen (or not) in 1844 on the left and 2015 on the right.

The failure to map the "big swamp 2" could be due to the fact that the south and east boundaries were covered by the Loring team, who were less thorough than Whitner, the notes indicate that the southeast corner was set with all pines as bearing trees. It is hard to imagine the team slogging through and setting a corner in a thick pond cypress (*Taxodium ascendens*) swamp covered in low knees. Further, the Bay & Cypress span 9.9 chains (~200 m) in the south border notes (Loring 1848c, 148:211) but are not listed in the east border notes (1848c, 148:208). The northern tip of this swamp is shown Figure 64.

4.10 The 71 Years of Photography: 1944 to 2015

In contrast to the previous section, this section compares data of similar sources, therefore the cross data is more likely to represent actual historical change. Unfortunately, 1944 was not that long ago relative to how long people have been impacting this particular site. Still, there has been a great deal of change, and not all of it has been due to direct human action. The "big swamp 2" in the southeast corner of the site from Figure 64 is a good example of persistence; it has been the same size and shape since 1944. The northern tip of that swamp is shown in Figure 65.

Figure 64 Northern tip of "big swamp 2" 2015-08-27

Other swamps, like "big swamp 1", have expanded significantly. And even other swamps have come into existence by taking over marshes, as is the case for "floodplain marsh 2". This wetland drains the east side of the site very slowly to the southeast to Holopaw and then southeast again eventually to Lake Kissimmee. Its flow is partially restricted by a utility line easement north of US Highway 192 and then again by the highway itself. Not all of the marshes in this strand have transitioned to swamp. Figure 65, the binary change map, shows that once an area loses marsh, the marsh does not regenerate. Once the water left the northeast and southwest corners via what are now C-29 and C-30 in the 1880s, the large marshes did not persist. Smaller disconnected wetlands persisted, some for the whole 71 years. Figure 65, as well as every other complete cross map in the results section, shows in pale green the amount of flat pine that persisted.

Flat pine is described in depth in Appendix A, but suffice it to say that it does not really have a default community to transition to. If fire is suppressed for 50 or more years in flat pine, it becomes extremely dense, tall, and the catastrophic fire hazard is increased. It is a very different looking community that does not have a different name. Flat pine that is dry and has an oak understory can transition to hammock. If it is drained, it does not transition to another community, but its species composition changes. If it is flooded, it will transition into a marsh or a swamp, depending on the degree; that did not happen here (the ~1 hectare was due to manual photointerpretation error).

Figure 65 Binary change raster, 1944-2015

Figure 66 Complete cross raster, 1944-2015

What does happen to flat pine, though, can be seen in Tables 23 and 24. It lost to almost every category. Why? Flat pine to swamp occurs by swamp expansion via increased edge cypress recruitment, very dry flatwoods can be difficult to distinguish from scrub and changes in local climate can push a community one way or the other, and all of the cultural impacts are direct human impacts. As Pontius et al. (2004) would point out, the largest category is the one that is most likely to change.

The transition from herbaceous marshes to swamps is very obvious when comparing the photos side-by-side, as Figure 67 does.

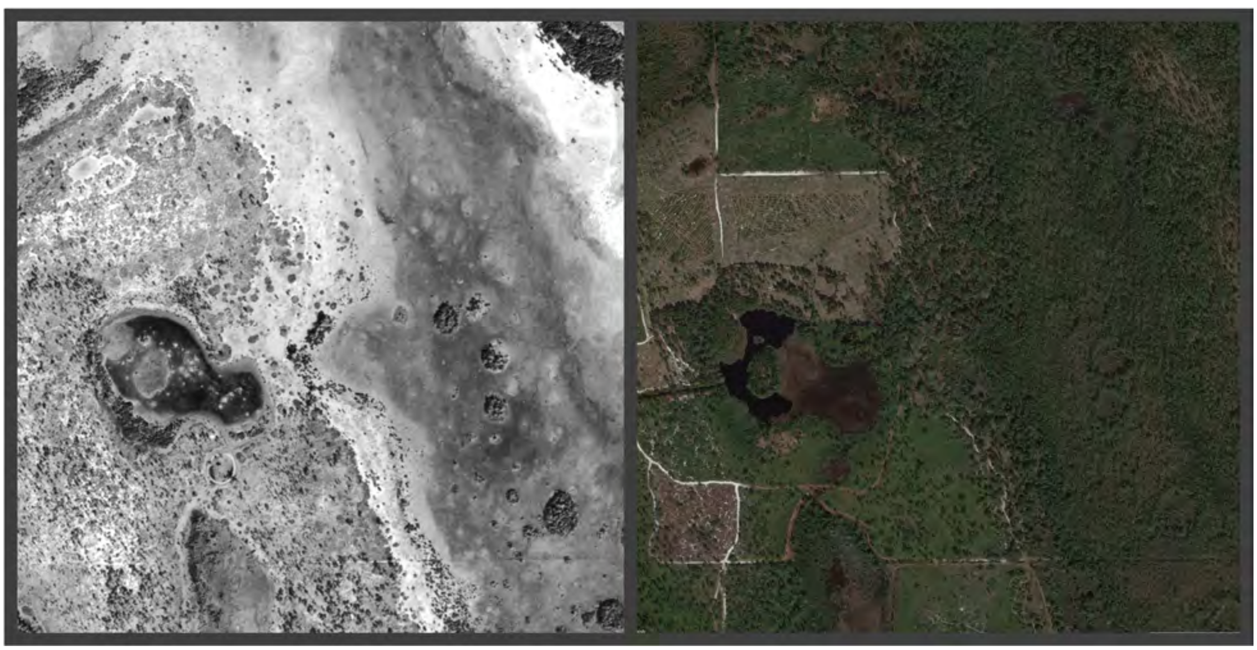


Figure 67 Two photos are of "floodplain marsh 2", chosen to highlight the drastic change in the character of the floodplain marsh

Figure 68 shows a histogram indicating the net change and percent change for each category from 1944 to 2015.

Table 23 Cross tabulation matrix, 1944-2015, in hectares

	2015												Total 1944
	hammock	scrub	sandhill	flat pine	c- ruderal	c - spoil	baygall	swamp	c – palustrine	lake	c – lacustrine	marsh	
	1120	1210	1240	1300	1800	1877	2231	2242	2400	3100	3200	21212	
1944													
1120													0.00
1210	6.05	2.75		6.55									15.34
1240			6.78	1.38									8.16
1300	11.82	5.59	0.42	366.55	20.00	3.22	1.15	9.66	0.08	0.00	1.55	1.15	421.19
1800			0.83	19.86	0.40								21.09
1877					0.31	0.55		0.17	0.00		0.02		1.05
2231	4.17			0.26	0.19		31.64	0.37					36.63
2242				0.07	0.01		0.01	40.02				0.06	40.19
2400			0.02	0.43					0.33				0.78
3100				0.19				0.01		11.57		0.67	12.44
3200				0.08	0.13	0.06		0.44	3.07		1.61		5.39
21212	8.86			58.30	21.26	0.25	6.28	23.59		1.67	6.85	27.77	154.83
Total 2015	30.90	8.34	8.05	453.66	42.30	4.08	39.08	74.25	3.48	13.24	10.03	29.66	

Table 24 Summary of changes, 1944-2015, in hectares

nc number	nc name	gain	loss	total change	swap	net change
1120	hammock	30.90	0.00	30.90	0.00	30.90
1210	scrub	5.59	12.60	18.19	11.19	-7.00
1240	sandhill	1.27	1.38	2.65	2.54	-0.11
1300	flat pine	87.12	54.64	141.76	109.28	32.48
1800	cultural – ruderal	41.91	20.69	62.59	41.38	21.22
1877	cultural – spoil	3.53	0.50	4.02	1.00	3.03
2231	baygall	7.44	4.99	12.43	9.98	2.45
2242	swamp	34.23	0.16	34.39	0.33	34.07
2400	cultural – palus-trine	3.15	0.78	3.93	1.56	2.70
3100	lake	1.67	0.87	2.54	1.74	0.80
3200	cultural – lacus-trine	8.42	3.77	12.19	7.55	4.64
21212	marsh	1.89	127.06	128.95	3.78	-125.17
	total	227.11	227.44	227.28	95.16	

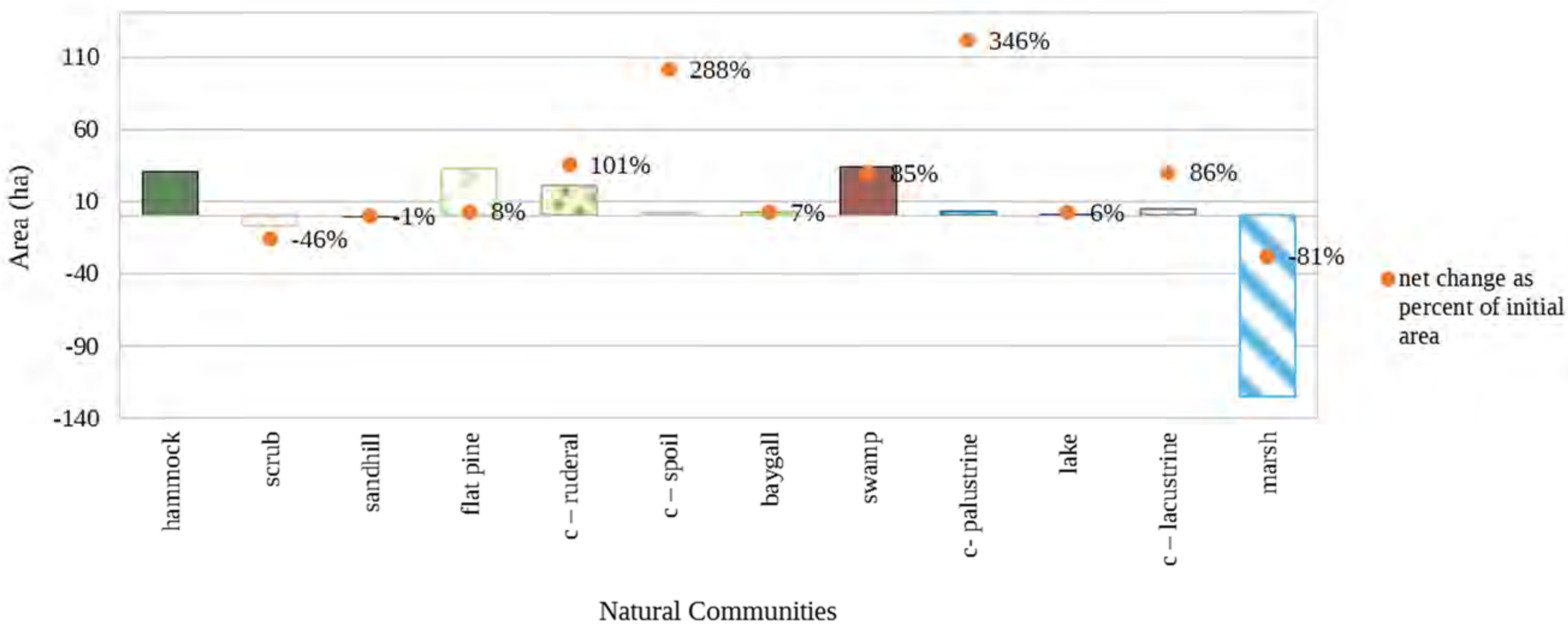


Figure 68 Histogram displaying net (ha) and percent natural community change from 1944 to 2015

CHAPTER 5: DISCUSSION AND CONCLUSIONS

It is clear that marsh lost the most area to almost every other community. Direct human impacts, particularly soil extraction and land clearing, were a significant part of the overall change in the property. Overall, the site became much drier, most likely because of the draining of the area 40 years after the GLO survey. In the second century, a ditch was dug on the property and manmade lakes further dried the property. Swamps expand and marshes transitioned into scrub-shrub wetlands, which are categorized in this project's methodology as swamps. Hardwoods became more prevalent on the site in general. As is standard for Florida, the well-drained sandhill in the southwest center of the property was partially razed for a citrus grove after 1844, yet it was abandoned long enough before 1944 for mature oak trees to have grown there. Prior to 1944, enough muck was removed to create a lake in the east center of the site.

The expansion of the swamp at the expense of flatwoods is initially counterintuitive, as a swamp's existence is dependent on its soil being inundated for some significant part of the year. However, a swamp in an agricultural area may appear to be expanding despite a lower groundwater level and an altered hydrological regime because bald cypress (*Taxodium distichum*) recruitment is higher at the edges of a swamp (McCauley 2011) and second-growth bald cypress growth is faster under less-frequent flooding (Dicke and Toliver 1990). Additionally, the first cutover of old-growth cypress was completed by the 1940s and acreage began to rebound starting in the 1950s as second-growth trees re-established (Conner and Toliver 1990).

With the hammock containing the site's namesake as an exception, all of the hammocks on the site developed after 1951. The composition of hammocks is hypothesized to be governed by the recurring natural disturbances of fires and tropical storms (Platt and Schwartz 1990). Between 1852 and 1909 there were one tropical depression, three tropical storms, one category one hurricane, and two category two hurricanes whose eyes' passed within 20 km of the centroid of the site. Since 1959 two tropical depressions have passed within the same distance (Table 25) (NOAA 2015).

Table 25 Tropical Storms passing within 20 km of the centroid of Split Oak

Year	Month	Name	Type
1852	September	n/a	TS
1858	September	n/a	TS
1859	October	n/a	H1
1871	August	n/a	H2
1880	August	n/a	H2
1897	September	n/a	TS
1909	August	n/a	TD
1959	June	n/a	TD
1968	June	Brenda	TD

TS=tropical storm TD=tropical depression H=hurricane #=category

The site has undergone very significant changes since the first spatial data was collected on it in 1844. Almost all of the marsh that was connected to Lake Hart and (what is now) Lake Mary Jane's natural sheetflow outlets south has disappeared. Residual marshes remain in some depressions, though their lower water levels leave them prone to invasion by woody vegetation. Individual

Each step of the process was exposed to the potential of error. The GLO survey plats and the 1944-1980 aerial photos were originally paper and were digitized with undisclosed methodologies. The GLO survey distances were measured with chains, which could kink, and by people, who could get tired and/or forget to write something down. The notes themselves could be mis-numbered, the many diagrams correlating page numbers with section lines could be wrong, and the handwriting is difficult to read. Digitization methods for the notes are also not disclosed and result in jagged, high-contrast black and white images. Despite repeated requests for flight information with multiple potentially-involved US agencies, I could not obtain lens, tilt, and flying height for any of the flights and only the dates and contractors were available for some of the flights.

After obtaining the flight tiles, I attempted to correct for tilt and lens error with basic image processing in GIMP, which could exaggerate or hide parts of the landscape in the photo. The tiles were georeferenced in reverse-chronological order; I hoped to be able to visually identify as many landmarks as possible. However, I did not have existing correctly-georeferenced ground points for any of the years prior to 1995. The GLO survey plats were georeferenced to the existing Public Land Survey System layer based on the original GLO Survey (Florida Resources and Environmental Analysis Center 2003), but this too, was manual and could introduce some error. RMSE values in meters for each flight and GLO map are shown in Table 5.

I investigated methods like textural analysis that might give credence to some of my delineations, but the published methodology was skimpy and the skills required to use and validate the processes is beyond my ability. So, the natural communities are supported by visual information, modern classifications and field surveys, historical observations, and the probability that a community would transition to another.

In creating the cross-tabulation and summary tables, data was manually copied and pasted, cell by cell, from the r.report text files to a programmed libreoffice '.ods' which was then transferred to Excel 365 on the Windows 7 laptop used in writing this document. This was a lengthy process that required attention to detail. Any uncaught error would be propagated through to the tables and histograms and then on through to the analysis.

The spatial processing for this project was performed with free and open source software (FOSS). This presented both opportunities and limitations. I had been running GNU/Linux for two years when I began to work on this project. I had minimal experience with QGIS, none with GRASS, and none with the bash shell. Focusing on FOSS allowed me to develop skills in working with spatial data that the comfort of Esri's products would dull. I also learned basic shell scripting to automate processing and learned to compile programs from source.

The time saved in using a dedicated purpose-built desktop for the data processing allowed time to troubleshoot the many problems that accompany running software with no paid support. FOSS often has an enthusiastic user and developer community and support is not hard to come by if you are willing to search for the answer and become familiar with Stack Exchange.

FOSS has downsides. When developers are not necessarily being paid to work on bugs, sometimes crashing and bad behavior is not explainable or fixable. In pursuit of new release software, I broke from my stable Debian 7 installation to add the 'sid' and eventually the 'experimental' repositories. This proved to be a poor decision and broke my GRASS dependencies, and downgrading in Debian is a professional endeavor. I backed-up my data and did a full reinstall/ upgrade to the newly stable Debian 8 while deadlines loomed.

Some of the work I did would have been unnecessary if running ArcMap on Windows. For example, the CLC data was in geodatabase format and some practice with GDAL's command-line tools was necessary to translate it into shapefiles. While ArcMap does freeze and crash occasionally, it beats QGIS for stability. I have a still-unresolved problem in QGIS with vector data and crashing that remains unexplained. FOSS was appropriate for this project's timeline and data needs.

A natural extension to this project would be to make the data modified and created for this project publicly available in an online database as in Dark et al. (2011). I am friends with people who have georeferenced historical aerials in other parts of Florida who have expressed interest in uploading their images. The natural community data created for this project could be used to model historic fire frequency as in Duncan and Schmalzer (2004). It could also be used to quantify the impact of past management practices as in Duncan et al. (1999). If historical fire frequency data is available or modeled it could be combined with the community data to model the impact of anthropogenic edges on the site, as La Puma did (2011, 2013). These community data could also be used to estimate historical water levels (current data goes back to 1960) and thus correlate historical wetlands extents, drainage, and groundwater pumping. The community data could be used to estimate historical habitat suitability for various currently threatened and endangered species like the red cockaded woodpecker (*Picoides borealis*), the Florida panther (*Puma concolor coryi*), and the Florida grasshopper sparrow (*Ammodramus savannarum*). Herbacous wetland change on this site could be compared to similarly situated sites that are not adjacent to a drained lake and/or sites whose wetlands have been directly drained. Hammock change could also be compared with sites that have had different spatial and temporal patterns of hurricane strikes.

REFERENCES

Abrahamson, Warren G., and David C. Hartnett. 1990. “Pine Flatwoods and Dry Prairies.” In *Ecosystems of Florida*, edited by Ronald L. Myers and John J. Ewel, 103–49. Orlando: University Press of Florida.

Almendinger, John C. 1996. *Minnesota’s Bearing Tree Database*. St. Paul, MN, USA: Minn. Department of Natural Resources. http://files.dnr.state.mn.us/eco/nhnrp/brgtree.pdf.

Anderson, Daniel. 2015. “Florida Military Bases.” *Military Bases*. http://militarybases.com/florida/.

Anonymous. 2014. “North Ranch Sector Plan - Long-Term Master Plan.” Osceola County Government. http://www.osceola.org/core/fileparse.php/2731/urlt/140820_FullPlan.pdf.

Asher & Adams. 1871. “Asher & Adams Florida, 1871.” Atlas. New York, NY: Asher & Adams. University of South Florida Libraries. http://digital.lib.usf.edu/SFS0024582/00001.

Avery, T. Eugene. 1967. *Forest Measurements*. The American Forestry Series 2. New York: McGraw-Hill Book Company.

Awwad, Waleed Abdulaziz. 2003. “Land Cover Mapping: A Comparison between Manual Digitizing and Automated Classification of Black and White Historical Aerial Photography.” Master of Science, Gainesville, FL, USA: University of Florida. http://web.pdx.edu/~nauna/awwad_w.pdf.

Bakker, Steven A., Nanja J. van den Berg, and Barbara P. Speleers. 1994. “Vegetation Transitions of Floating Wetlands in a Complex of Turbaries between 1937 and 1989 as Determined from Aerial Photographs with GIS.” *Vegetatio* 114 (2): 161–67.

Barnes, William J. 1989. “A Case History of Vegetation Changes on the Meridean Islands of West-Central Wisconsin, USA.” *Biological Conservation* 49 (1): 1–16. doi:10.1016/0006-3207(89)90109-2.

Barrientos, Bartolomé. 1965. *Pedro Menéndez de Avilés, Founder of Florida*. Translated by Anthony Kerrigan. Gainesville, FL, USA: University of Florida Press.

Bartram, William. 1791. *Travels Through North & South Carolina, Georgia, East & West Florida, the Cherokee Country, the Extensive Territories of the Muscogulges, or Creek Confederacy, and the Country of the Chactaws; Containing An Account of the Soil and Natural Productions of Those Regions, Together with Observations on the Manners of the Indians. Embellished with Copper-Plates.* Philadelphia: James & Johnson. http://docsouth.unc.edu/nc/bartram/menu.html.

Beauchamp, Catherine W. 1986. *Look What’s Happened in Osceola County*. Kissimmee, FL, USA: The Osceola County Arts and Culture Center.

Beller, Erin E., Robin M. Grossinger, M. N. Salomon, Shawna J. Dark, Eric D. Stein, Bruce K. Orr, Peter W. Downs, et al. 2011. “Historical Ecology of the Lower Santa Clara River, Ventura River, and Oxnard Plain: An Analysis of Terrestrial, Riverine, and Coastal Habitats.” SFEI Publication 641. A Report of SFEI’s Historical Ecology Program. Oakland, CA, USA: San Francisco Estuary Institute. http://www.sfei.org/projects/VenturaHE.

Belson, Shane. 2013. “Split Oak Mapping Project,” November 1.

Black, Bryan A., and Marc D. Abrams. 2001. “Influences of Native Americans and Surveyor Biases on Metes and Bounds Witness-Tree Distribution.” *Ecology* 82 (9): 2574–86.

doi:10.1890/0012-9658(2001)082[2574:IONAAS]2.0.CO;2.
Bliss, Norman P., Patrick J. Comer, Rex C. Crawford, Jonathan M. Friedman, Robert B. McMilan, Evan Peacock, and Bonnie W. Styles. 2012. “LUHNA Homepage.” Government. *USGS*. December. http://landcover.usgs.gov/luhna/.
Bogner, Franz X. 1998. “The Influence of Short-Term Outdoor Ecology Education on Long-Term Variables of Environmental Perspective.” *The Journal of Environmental Education* 29 (4): 17–29. doi:10.1080/00958969809599124.
Bourdo, Eric A., Jr. 1956. “A Review of the General Land Office Survey and of Its Use in Quantitative Studies of Former Forests.” *Ecology* 37 (4): 754–68. doi:10.2307/1933067.
Bousquin, Stephen G., David H. Anderson, Gary E. Williams, and David J. Colangelo. 2005. “Establishing a Baseline: Pre-Restoration Studies of the Channelized Kissimmee River.” Technical Publication ERA 432. Kissimmee River Restoration Studies. West Palm Beach, FL, USA: South Florida Water Management District. http://www.researchgate.net/profile/Gary_Williams11/publication/264489030_Establishing_a_baseline_pre-restoration_studies_of_the_channelized_Kissimmee_River/links/5460c3ae0cf295b5616377f0.pdf.
Boyd, Mark F. 1938. “A Map of the Road from Pensacola to St. Augustine, 1778.” *The Florida Historical Quarterly* 17 (1): 15–23.
Boyer, W.D. 1990. “Pinus Palustris Mill.” In *Silvics Manual*, edited by Russell M. Burns and Barbara H. Honkala, 2 - Hardwoods:877. Washington, DC, USA: U.S. Dept. of Agriculture, Forest Service. http://www.na.fs.fed.us/pubs/silvics_manual/Volume_1/pinus/palustris.htm.
Braund, Kathryn. 2007. “Bernard Romans.” *Encyclopedia of Alabama*. Auburn, AL: Alabama Humanities Foundation. http://www.encyclopediaofalabama.org/article/h-1074.
Brenner, Mark, Michael W. Binford, and Edward S. Deevey. 1990. “Lakes.” In *Ecosystems of Florida*, edited by Ronald L. Myers and John J. Ewel, 364–91. Orlando: University Press of Florida.
Brenner, Mark, Thomas J. Whitmore, Jason H. Curtis, and Claire L. Schelske. 1995. “Historical Ecology of a Hypereutrophic Florida Lake.” *Lake and Reservoir Management* 11 (3): 255–71. doi:10.1080/07438149509354207.
Bromley, Stanley W. 1935. “The Original Forest Types of Southern New England.” *Ecological Monographs* 5 (1): 61–89. doi:10.2307/1943098.
Bukata, B. J., and Keith Kolasa. 2005. “Generating Predevelopment Land Cover Datasets for Two Florida Basins.” In *2005 Esri International User Conference Proceedings*. San Diego, California, US: Esri, Inc. http://proceedings.esri.com/library/userconf/proc05/papers/pap1791.pdf.
California Natural Resources Agency. 2009. “Protocols for Surveying and Evaluating Impacts to Special Status Native Plant Populations and Natural Communities.” State of California. http://drecp.orgwww.drecp.org/sitingcases/genesis_solar/documents/exhibits-406-424/Genesis_Staff_Exhibit_408.pdf.
Callaway, Ragan M., and Frank W. Davis. 1993. “Vegetation Dynamics, Fire, and the Physical Environment in Coastal Central California.” *Ecology* 74 (5): 1567–78. doi:10.2307/1940084.

Cameron, James, Kurt Saari, Kuang-Yao Lee, Jennifer Barnes, Jim Kramp, Cindy Bowes, and Gary Krasovetz. 2011. “2009 SFWMD Photointerpretation Key.” South Florida Water Management District. https://www.mapwise.com/maps/florida/docs/2009_PI-Key.pdf.

Campbell, Richard L. 1892. *Historical Sketches of Colonial Florida*. Bicentennial Floridiana Facsimile. Gainesville, FL, USA: The University Presses of Florida.

Cantino, Alberto. 1502. “Carta del Cantino.” Latitude chart/portolan chart. Modena, Italy: Biblioteca Estense. http://bibliotecaestense.beniculturali.it/.

Casey, William P., and Katherine C. Ewel. 2006. “Patterns of Succession in Forested Depressional Wetlands in North Florida, Usa.” *Wetlands* 26 (1): 147–60. doi:10.1672/0277-5212(2006)26[147:POSIFD]2.0.CO;2.

Chapman, Alvan Wentworth. 1897. *Flora of the Southern United States: Containing an Abridged Description of the Flowering Plants and Ferns of Tennessee, North and South Carolina, Georgia, Alabama, Mississippi, and Florida: Arranged according to the Natural System*. Cambridge, Mass: Cambridge botanical supply company. http://archive.org/details/floraofsouthe00chap.

Chesapeake Bay Program. 2015. “A Watershed Partnership - Chesapeake Bay Program.” 2015-08. Accessed August 25. http://www.chesapeakebay.net/.

Clements, Benjamin. 1824. “Meridean North from Tallahassee.” Survey Plat. Tallahassee, FL, USA: United States Department of the Interior. Surveys - General Land Office Records. http://www.glorecords.blm.gov/details/survey/default.aspx?dm_id=8457&sid=ccqsotok.n3w&surveyDetailsTabIndex=1#surveyDetailsTabIndex=0.

Clements, Frederic E. 1916. *Plant Succession - an Analysis of the Development of Vegetation*. 242. Washington, DC, USA: Carnegie Institution of Washington. http://hdl.handle.net/2027/nyp.33433010842403.

Clewell, Andre. 2011. “Forest Succession After 43 Years Without Disturbance on Ex-Arable Land, Northern Florida.” *Castanea* 76 (4): 386–94.

Cody, Aldus Morill, and Robert S. Cody. 1987. *Osceola County: The First 100 Years*. Kissimmee, FL, USA: Osceola County Historical Society.

Cohen, Amy. 2009. *Historic South Florida Vegetation Map*. JPEG. amy-cohen.com. http://www.amy-cohen.com/images/LandClass.jpg.

Conner, William H., and John R. Toliver. 1990. “Long-Term Trends in the Bald-Cypress (Taxodium Distichum) Resource in Louisiana (U.S.A.).” *Forest Ecology and Management* 33: 543–57. doi:http://dx.doi.org/10.1016/0378-1127(90)90217-Y.

Conway, Valentine Y. 1842. “General Instructions to Deputy Surveyors.” In *Florida Instructions of 1842*, 321–28. Tallahassee, FL, USA: Office of the Surveyor General.

Cowardin, Lewis M., Virginia Carter, Francis C. Golet, and Edward T. LaRoe. 1979. “Classification of Wetlands and Deepwater Habitats of the United States.” FWS/OBS 19/31. Washington, DC, USA: US Fish and Wildlife Service. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.364.379&rep=rep1&type=pdf.

Cowell, C. Mark. 1995. “Presettlement Piedmont Forests: Patterns of Composition and Disturbance in Central Georgia.” *Annals of the Association of American Geographers* 85 (1): 65–83. doi:10.1111/j.1467-8306.1995.tb01795.x.

Dark, Shawna J., Eric D. Stein, Danielle Bram, J. Oscuna, Joeseph Monteferante, Travis Longcore, Robin Grossinger, and Erin Beller. 2011. “Historical Ecology of the Ballona

Creek Watershed." 671. Southern California Coastal Water Research Project. Los Angeles, California, USA. ftp://ftp.sccwrp.org/pub/download/DOCUMENTS/TechnicalReports/671_BallonaHistoricalEcology_ES.pdf.

Davis, John H. 1967. "General Map of Natural Vegetation of Florida." Paper. Circular. Gainesville, FL, USA: Agricultural Experiment Stations, Institute of Food and Agricultural Sciences, University of Florida. http://128.227.24.32:8080/ImageServer/imageserver?res=4&viewwidth=1536&viewheight=1536&rotation=0&filename=UF\00\00\05\05\00001\UF00000505.jp2.

Davis, T. Frederick. 1932. "The Record of Ponce de Leon's Discovery of Florida, 1513." *The Florida Historical Society Quarterly* 11 (1): 5–15.

Debian Developers. 2015a. "Software Packages in 'Experimental.'" Software Repository. *Packages*. June 3. https://packages.debian.org/experimental/allpackages.

———. 2015b. "Software Packages in 'Sid.'" Software Repository. *Packages*. June 3. https://packages.debian.org/sid/allpackages.

Deevey, Edward S., Jr. 1988. "Estimation of Downward Leakage from Florida Lakes." *Limnology and Oceanography* 33 (6): 1308–20.

Delcourt, Hazel R., and Paul A. Delcourt. 1996. "Presettlement Landscape Heterogeneity: Evaluating Grain of Resolution Using General Land Office Survey Data." *Landscape Ecology* 11 (6): 363–81.

Dicke, Stephen G., and John R. Toliver. 1990. "Growth and Development of Bald-Cypress/water-Tupelo Stands under Continuous versus Seasonal Flooding." *Forest Ecology and Management* 33–34: 523–30. doi:http://dx.doi.org/10.1016/0378-1127(90)90215-W.

Dick-Peddie, William Alexander. 1955. "Presettlement Forest Types in Iowa." Ph.D., Ames, IA, USA: Iowa State College.

Doolittle, James A., and Gregg Schellentrager. 1989. *Soil Survey of Orange County, Florida*. http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/florida/orangeFL1989/orangeFL1989.pdf.

Drayton, Joseph. 1827. "Geographical, Statistical, and Historical Map of Florida, 1827." Paper. Philadelphia: Careya and Lea. Florida Studies Center Gallery. http://scholarcommons.usf.edu/flstud_gallery/2168/.

Duncan, Brean W., Shannon Boyle, David R. Breininger, and Paul A. Schmalzer. 1999. "Coupling Past Management Practice and Historic Landscape Change on John F. Kennedy Space Center, Florida." *Landscape Ecology* 14 (3): 291–309. doi:10.1023/A:1008029831187.

Duncan, Brean W., V. L. Larson, and P. A. Schmalzer. 2000. "Modeling Historic Landcover: An Evaluation of Two Methodologies for Producing Baseline Reference Data." *Natural Areas Journal* 20 (4): 308–16.

Duncan, Brean W., and Paul A. Schmalzer. 2004. "Anthropogenic Influences on Potential Fire Spread in a Pyrogenic Ecosystem of Florida, USA." *Landscape Ecology* 19 (2): 153–65. doi:10.1023/B:LAND.0000021714.97148.ac.

Dunkelberger, Lloyd. 2014. "Florida Forever Program: Land Conservation Funds Rising." Newspaper. *The Ledger*. June 22.

http://www.theledger.com/article/20140622/NEWS/140629820.
Dunn, J.E., Mark Baldwin, and Charles N. Mooney. 1922. *Soil Survey of Orange County, Florida*. Edited by W. Edward Hearn. Washington, DC, USA: Government Printing Office.
Edmonds, Michael. 2005. “The Pleasures and Pitfalls of Written Records.” In *The Historical Ecology Handbook*, edited by Dave Egan and Evelyn A. Howell, 73–99. Washington, DC: Island Press.
Egan, Dave, and Evelyn A. Howell, eds. 2005. *The Historical Ecology Handbook*. Washington, DC: Island Press.
Elliott, D. H. 1888. “A New Sectional Map of Florida Issued by the Land Department of the South Florida R. R. Co. and the Plant Investment Co.” Paper. Sanford: Plant Investment Company. https://www.loc.gov/item/98688458/.
Ellis, Erle C., Hongqing Wang, Hong Sheng Xiao, Kui Peng, Xin Ping Liu, Shou Cheng Li, Hua Ouyang, Xu Cheng, and Lin Zhang Yang. 2006. “Measuring Long-Term Ecological Changes in Densely Populated Landscapes Using Current and Historical High Resolution Imagery.” *Remote Sensing of Environment* 100 (4): 457–73. doi:10.1016/j.rse.2005.11.002.
EPA. 2014. “Nutrients Water Quality Standards for the State of Florida.” Government. *Water: Regulatory Information*. September 25. http://water.epa.gov/lawsregs/rulesregs/florida-index.cfm.
ERDAS, Inc. 2008. *IMAGINE AutoSync User’s Guide*. Norcross, GA, USA: ERDAS, Inc. http://faculty.une.edu/cas/szeeman/rs/docs/AutoSync.pdf.
Ermgassen, Philine S. E. Zu, Mark D. Spalding, Brady Blake, Loren D. Coen, Brett Dumbauld, Steve Geiger, Jonathan H. Grabowski, et al. 2012. “Historical Ecology with Real Numbers: Past and Present Extent and Biomass of an Imperilled Estuarine Habitat.” *Proceedings of the Royal Society of London B: Biological Sciences* 279 (1742): 3393–3400. doi:10.1098/rspb.2012.0313.
Esri, Inc. 2012. *Automatic Georeferencing in ArcGIS 10.1*. Flash. Redlands, CA, USA: ArcGIS Video. http://video.arcgis.com/watch/1553/automatic-georeferencing-in-arcgis-101.
Ewel, Katherine C. 1990. “Swamps.” In *Ecosystems of Florida*, edited by Ronald L. Myers and John J. Ewel, 281–323. Orlando: University Press of Florida.
Eyre, F.H., ed. 1980. *Forest Cover Types of the United States and Canada*. Washington, DC, USA: Society of American Foresters.
Fagin, Todd D., and Bruce W. Hoagland. 2011. “Patterns from the Past: Modeling Public Land Survey Witness Tree Distributions with Weights-of-Evidence - Springer.” *Plant Ecology* 212 (2): 207–17. doi:10.1007/s11258-010-9815-9.
Farr, James A., and O. Greg Brock. 2006. “Florida’s Landmark Programs for Conservation and Recreation Land Acquisition.” Government. *Florida Department of Environmental Protection*. May. http://www.dep.state.fl.us/lands/AcqHistory.htm.
FDOT Surveying and Mapping Office. 1999. *Florida Land Use, Cover, and Forms Classification System*. Third. Tallahassee, FL, USA: State of Florida Department of Transportation. http://www.dot.state.fl.us/surveyingandmapping/documentsandpubs/fluccmanual1999.pdf.

FFWCC. 2015. “Special-Use Bear Permit.” Government. *Limited Entry / Quota Hunts*. August 10. http://myfwc.com/license/limited-entry-hunts/general-info/bear-permit/.
Finnell Jr., Gilbert L. 1973. “Saving Paradise: The Florida Environmental Land and Water Management Act of 1972.” *Urban Law Annual*, Journal of Urban and Contemporary Law, 1973 (1): 103.
Florida Resources and Environmental Analysis Center. 2003. “Florda Public Land Survey System - Section Level - Statewide.” Vector digital data. Gainesville, FL, USA: Florida Geographic Data Library. ftp://ftp.fgdl.org/pub/state/plss.zip.
Flowers, Wayne E., and James E. Charles. 2012. “Numeric Nutrient Water Quality Criteria: Lessons from Florida.” *Natural Resources & Environment* 26 (3). http://www.llw-law.com/files/pdfs/NNC_ABA_Journal_Article_00085057.PDF.
FNAI. 1990. *Guide to the Natural Communities of Florida*. Florida Department of Natural Resources. http://www.fnai.org/PDF/Natural_Communities_Guide.pdf.
———. 2010. *Guide to the Natural Communities of Florida*. 2010 edition. Tallahassee, FL, USA: Florida Natural Areas Inventory. http://fnai.fsu.edu/PDF/AA_Introduction.pdf.
Fralish, James S., Fred B. Crooks, Jim L. Chambers, and Francis M. Harty. 1991. “Comparison of Presettlement, Second-Growth and Old-Growth Forest on Six Site Types in the Illinois Shawnee Hills.” *American Midland Naturalist* 125 (2): 294. doi:10.2307/2426234.
Frelich, Lee E., and Peter B. Reich. 1995. “Spatial Patterns and Succession in a Minnesota Southern-Boreal Forest.” *Ecological Monographs* 65 (3): 325–46. doi:10.2307/2937063.
Frey, William H. 2014. “Sun Belt Migration Revives as Florida Overtakes New York.” The Brookings Institution. *The Avenue / Rethinking Metropolitan America*. December 30. http://www.brookings.edu/blogs/the-avenue/posts/2014/12/30-sun-belt-migration-florida-new-york-frey.
Fries, J. O. 1890. “Map of Orange County, Florida.” Map. Philadelphia, PA: E. W. Smith & Co. Map Publishers. https://www.loc.gov/item/2012592407/.
Fritschle, Joy A. 2008. “Reconstructing Historic Ecotones Using the Public Land Survey: The Lost Prairies of Redwood National Park.” *Annals of the Association of American Geographers* 98 (1): 24–39. doi:10.1080/00045600701734018.
Frost, III, Cecil Carlysle. 2000. “Studies in Landscape Fire Ecology and Presettlement Vegetation of the Southeastern United States.” Ph.D., Chapel Hill, NC, USA: The University of North Carolina at Chapel Hill. http://search.proquest.com/docview/304607683?accountid=10920.
Gannon, Michael, ed. 2013. *The History of Florida*. Gainesville: University Press of Florida.
Garber, A. P. 1877. “Botanical Rambles in East Florida.” *Botanical Gazette* 2 (3): 70–72.
Garland, Amanda, and Elizabeth Thompson. 2011. “Natural Community.” *The Encyclopedia of Earth*. http://www.eoearth.org/view/article/154786/.
Gilbert, Terry, and Beth Stys. 2004. “Descriptions of Vegetation and Land Cover Types Mapped Using Landsat Imagery.” Florida Fish and Wildlife Conservation Commission. http://etd.fcla.edu/UF/UFE0016045/george_a.pdf.
Gleason, Henry Allan. 1917. “The Structure and Development of the Plant Association.” *Bulletin of the Torrey Botanical Club* 44 (10): 463–81. doi:10.2307/2479596.
Gordon, Doria R., and Kevin P. Thomas. 1997. “Florida’s Invasion by Nonindigenous Plants: History, Screening, and Regulation.” In *Strangers in Paradise: Impact And Management*

Of Nonindigenous Species In Florida, by Daniel Simberloff, Donald C. Schmitz, and Tom C. Brown, 21–38. Island Press.
GRASS Development Team, Ivan Michelazzi, Luca Miori, and Markus Metz. 2014. "I.points.auto." Software Documentation. *GRASS GIS 7.0.1svn Reference Manual*. April 10. http://grass.osgeo.org/grass70/manuals/addons/i.points.auto.html.
Grimm, Eric C. 1984. "Fire and Other Factors Controlling the Big Woods Vegetation of Minnesota in the Mid-Nineteenth Century." *Ecological Monographs* 54 (3): pp. 291–311.
Grip, Wayne M., Randall W. Grip, and Robert D. Morrison. 2000. "Application of Aerial Photography and Photogrammetry in Environmental Forensic Investigations." *Environmental Forensics* 1 (3): 121–29. doi:10.1006/enfo.2000.0014.
Gruver, Bradley J., and Caly Murphy. 2013. "Florida's Threatened and Endangered Species." Florida Fish and Wildlife Conservation Commission. FWCC Media. http://myfwc.com/media/1515251/threatened_endangered_species.pdf.
Guariguata, Manuel R. 1990. "Landslide Disturbance and Forest Regeneration in the Upper Luquillo Mountains of Puerto Rico." *Journal of Ecology* 78 (3): 814–32. doi:10.2307/2260901.
Harisse, Henry. 1892. *The Discovery of North America - a Critical, Documentary, and Historic Investigation*. London, UK: Henry Stevens and Son.
Harper, Roland M. 1905. "'Hammock,' 'Hommock' or 'Hummock'?" *Science,* New Series, 22 (561): 400–402.
———. 1914. "Geography and Vegetation of Northern Florida." In *Florida Geological Survey - Sixth Annual Report*, by Elias Howard Sellards, 266–79. Tallahassee, FL, USA: The State Geological Survey. http://ufdcimages.uflib.ufl.edu/UF/00/00/00/01/00006/VID00006.pdf.
———. 1915. "Vegetation Types." In *Florida Geological Survey - Seventh Annual Report*, by Elias Howard Sellards, 135–88. Tallahassee: The State Geological Survey. http://ufdc.ufl.edu/UF00000001/00007.
———. 1921. "Geography of Central Florida." In *Florida Geological Survey - Thirteenth Annual Report*, by Herman Gunter, 13:71–307. Tallahassee: The State Geological Survey.
Harshberger, John W. 1914. "The Vegetation of South Florida South of 27° 30´ North, Exclusive of the Florida Keys." *Transactions of the Wagner Free Institute of Science* 7 (3): 50–189.
He, Hong S., Daniel C. Dey, Xiuli Fan, Mevin B. Hooten, John M. Kabrick, Christopher K. Wikle, and Zhaofei Fan. 2006. "Mapping Pre-European Settlement Vegetation at Fine Resolutions Using a Hierarchical Bayesian Model and GIS." *Plant Ecology* 191 (1): 85–94. doi:10.1007/s11258-006-9216-2.
Henderson, John A. 1878. "Township No. 3 N Range No. 1 E Meridian." Tallahassee, FL, USA: US Department of the Interior.
Henshall, James Alexander. 1884. *Camping and Cruising in Florida*. Cincinatti: Robert Clarke & Co. http://archive.org/details/campingandcruis01hensgoog.
Hinton, Isaac Taylor. 1832. "Map of the State of Florida." Paper. An Atlas of the United States of North America, Corrected to the Present Period, Accompanied by a Condensed View of the History & Geography of Each State Compiled from the Latest Official Documents. London: I.T. Hinton & Simpkin & Marshall. http://www.library.ufl.edu/spec/pkyonge/dismap/hin1832.html.

Homer, Collin H., Joyce A. Fry, and Christopher A. Barnes. 2012. "The National Land Cover Database." *US Geological Survey Fact Sheet* 3020 (4). http://pubs.usgs.gov/fs/2012/3020/.

Hudak, Andrew T., and Carol A. Wessman. 1998. "Textural Analysis of Historical Aerial Photography to Characterize Woody Plant Encroachment in South African Savanna." *Remote Sensing of Environment* 66 (3): 317–30. doi:10.1016/S0034-4257(98)00078-9.

———. 2001. "Textural Analysis of High Resolution Imagery to Quantify Bush Encroachment in Madikwe Game Reserve, South Africa, 1955-1996." *International Journal of Remote Sensing* 22 (14): 2731–40. doi:10.1080/01431160119030.

Hudson, Charles, Marvin T. Smith, Chester B. DePratter, and Emilia Kelley. 1989. "THE TRISTÁN DE LUNA EXPEDITION, 1559-1561." *Southeastern Archaeology* 8 (1): 31–45.

Iverson, Louis R., and Paul G. Risser. 1987. "Analyzing Long-Term Changes in Vegetation with Geographic Information System and Remotely Sensed Data." *Advanced Space Research* 7 (11): 183–94.

Jacobs, David K., Eric D. Stein, and Travis Longcore. 2011. "Classification of California Estuaries Based on Natural Closure Patterns: Templates for Restoration and Management." Technical Publication 619.a. Los Angeles, CA, USA: Southern California Coastal Water Research Project. http://sawpa.org/documents/ClassificationofCaliforniaEstuariesBasedonNaturalClosurePatternsTemplatesforRestorationandMa.pdf.

Jacobs, Kori, and Joseph Prenger. 2007. "Split Oak Mitigation Park Plant Community Type Mapping Analysis Results." Florida Natural Areas Inventory. http://myfwc.com/media/121476/Split_Oak_NC_Mapping_Report.pdf.

Jao, Fang-Ju, Hone-Jay Chu, and Yi-Hsing Tseng. 2014. "Historical Image Registration and Land-Use Land-Cover Change Analysis." *Environments* 1 (2): 181–89. doi:10.3390/environments1020181.

Kadmon, Ronen, and Ruthie Harari-Kremer. 1999. "Studying Long-Term Vegetation Dynamics Using Digital Processing of Historical Aerial Photographs." *Remote Sensing of Environment* 68 (2): 164–76. doi:10.1016/S0034-4257(98)00109-6.

Kawula, Robert. 2014. "Florida Land Cover Classification System." Final SWG T-13. Tallahassee, FL, USA: Florida Fish and Wildlife Conservation Commission. http://myfwc.com/media/2815396/LandCoverClassification-2014.pdf.

Khahaifa, Avido. 2012. "State Leaders Must Act to Save Ailing Springs, Rivers." Newspaper. *The Orlando Sentinel*. December 23. http://articles.orlandosentinel.com/2012-12-23/news/os-ed-declining-rivers-122312-20121221_1_septic-tanks-florida-forever-rivers.

Kronenfeld, Barry J., and Yi-Chen Wang. 2007. "Accounting for Surveyor Inconsistency and Bias in Estimation of Tree Density from Presettlement Land Survey Records." *Canadian Journal of Forest Research* 37 (11): 2365–79. doi:10.1139/X07-068.

Kuchler, August Wilhelm. 1964. *Potential Natural Vegetation of the Conterminous United States - Manual to Accompany the Map*. American Geographical Society of New York. Special Publication ; No. 36. New York: American Geographical Society.

Kurtz, Herman. 1942. "Florida Dunes and Scrub, Vegetation and Geology." Edited by S. E. Rice and Herman Gunter. *Florida Geological Survey Bulletin* 23: 1–154.

Kushlan, James A. 1990. “Marshes.” In *Ecosystems of Florida*, edited by Ronald L. Myers and John J. Ewel, 324–63. Orlando: University Press of Florida.

Laessle, Albert Middleton. 1942. *The Plant Communities of the Welaka Area - With Special Reference to Correlations Between Soils and Vegeational Succession*. Vol. 4. 4 vols. University of Florida Biological Series 1. Gainesville, FL, USA: The University of Florida. https://babel.hathitrust.org/shcgi/pt?id=mdp.39015006928538;view=1up;seq=1.

Laessle, Albert Middleton, and Carl D. Monk. 1961. “Some Live Oak Forests of Northeastern Florida.” *Quarterly Journal of the Florida Academy of Sciences* 24 (1): 39–55.

Landman, George B., and Eric S. Menges. 1999. “Dynamics of Woody Bayhead Invasion into Seasonal Ponds in South Central Florida.” *Castanea*, 130–37.

La Puma, Inga P. 2011. “Fire in the Pines:A Landscape Perspective of Human-Induced Ecological Change in the Pinelands of New Jersey.” Portable Document Format, Rutgers University, New Brunswick, NJ, USA, November 17. http://climatechange.rutgers.edu/docman-list/education/119-ingalapumapresentation.

La Puma, Inga P., Richard G. Lathrop, Jr, and Nicholas S. Keuler. 2013. “A Large-Scale Fire Suppression Edge-Effect on Forest Composition in the New Jersey Pinelands.” *Landscape Ecology* 28 (9): 1815–27. doi:10.1007/s10980-013-9924-7.

Larsen, Chris P. S., Stephen J. Tulowiecki, Yi-Chen Wang, and Andrew B. Trgovac. 2015. “Predicting Historic Forest Composition Using Species Lists in Presettlement Land Survey Records, Western New York.” Edited by Martin Hermy. *Applied Vegetation Science* 18 (3): 481–92. doi:10.1111/avsc.12165.

Leighty, Ralph George. 1960. *Soil Survey Orange County Florida*. Soil Conservation Service. https://babel.hathitrust.org/shcgi/imgsrv/download/pdf?id=pst.000012569250;marker=6eae8797718c89bdbb3ebba00d15287f.

Li, Deren. 2010. “Remotely Sensed Images and GIS Data Fusion for Automatic Change Detection.” *International Journal of Image and Data Fusion* 1 (1): 99–108. doi:10.1080/19479830903562074.

Lodge, Thomas E. 2005. *The Everglades Handbook: Understanding the Ecosystem*. Second. Boca Raton, FL, USA: CRC Press. http://www.crcpress.com/product/isbn/9781439802625.

Loeb, Robert E. 1987. “Pre-European Settlement Forest Composition in East New Jersey and Southeastern New York.” *American Midland Naturalist* 118 (2): 414. doi:10.2307/2425798.

Loftin, Cynthia Smith. 1998. “Assessing Pattern and Processes of Landscape Change in Okeefenokee Swamp, Georgia.” Doctor of Philosophy, Gainesville, FL, USA: University of Florida. Internet Archive. https://ia801004.us.archive.org/13/items/assessingpattern00loft/assessingpattern00loft.pdf.

Longcore, Travis, and Catherine Rich. 1998. “419 Acres: UCLA’s Natural History. 1. Land Use, 2. Biological Homogenization, 3. Island Biogeography.” Poster presented at the California’s Biodiversity Crisis: The Loss of Nature in an Urbanizing World, Los Angeles, CA, USA, October. http://urbanwildlands.org/Resources/419acres.pdf.

Loring, Fred R. 1848a. “FL.TXXIVS. R.XXXIE.” Survey Plat. St. Augustine, FL, USA: US Department of the Interior. Surveys - General Land Office Records.

http://www.glorecords.blm.gov/ConvertedImages/FL290240S0310E00001.JP2.
———. 1848b. “FL.TXXVS. R.XXXIE.” Survey Plat. St. Augustine, FL, USA: US Department of the Interior. Surveys - General Land Office Records. http://www.glorecords.blm.gov/ConvertedImages/FL290250S0310E00001.JP2.
———. 1848c. *FL.TXXVS. R.XXXIE*. Vol. 148. St. Augustine, FL, USA: US Department of the Interior. www.labins.org.
Luchansky, Gerald. 2015a. “Calibration Information,” March 19.
———. 2015b. “Camera Calibration for Orange Co.and Osceola Co.,Fla.(15-36489/JL),” June 24.
Lutz, H. J. 1930. “Original Forest Composition in Northwestern Pennsylvania as Indicated by Early Land Survey Notes.” *Journal of Forestry* 28 (8): 1098–1103.
MacCurdy, Meline. 2011. “EPA Faces Lawsuits Challenging Potentially Far-Reaching Rule Setting Numeric Nutrient Criteria in Florida Waters.” Attorney. *Marten Law*. February 10. http://www.martenlaw.com/newsletter/20110210-florida-water-nutrient-criteria.
Manies, Kristen L., and David J. Mladenoff. 2000. “Testing Methods to Produce Landscape-Scale Presettlement Vegetation Maps from the US Public Land Survey Records.” *Landscape Ecology* 15 (8): 741–54.
Manies, Kristen L, David J Mladenoff, and Erik V Nordheim. 2001. “Assessing Large-Scale Surveyor Variability in the Historic Forest Data of the Original U.S. Public Land Survey.” *Canadian Journal of Forest Research* 31 (10): 1719–30. doi:10.1139/x01-108.
Mattoni, Rudi, and Travis R. Longcore. 1997. “The Los Angeles Coastal Prairie, a Vanished Community.” *Crossosoma* 23 (2): 71–102.
Mattoni, Rudi, Travis R. Longcore, Jeremiah George, and Catherine Rich. 1997. “Down Memory Lane: The Los Angeles Coastal Prairie and Its Vernal Pools.” Poster presented at the 2nd Interface Between Ecology and Land Development in California, Occidental College, Los Angeles, CA, USA, April 19. http://urbanwildlands.org/prairie.html.
Mattoon, Wilbur R. 1967. *Common Forest Trees of Florida - How to Know Them*. Florida Forestry Association.
May, Leroy. 1825. “Township III Range I North & East.” Survey Plat. Tallahassee, FL, USA: US Department of the Interior. http://www.glorecords.blm.gov/ConvertedImages/FL290030N0010E00001.JP2.
McCauley, Lisa A. 2011. “THE EFFECTS OF URBANIZATION ON CYPRESS (TAXODIUM DISTICHUM) IN CENTRAL FLORIDA.” Doctor of Philosophy, Orlando: University of Central Florida. ResearchGate. http://www.researchgate.net/publication/242147381_The_effects_of_urbanization_on_pond_cypress_%28Taxodium_distichum_var._imbricarium_%28Nutt.%29_Croom%29_in_central_Florida.
McClenachan, Loren. 2009a. “Historical Declines of Goliath Grouper Populations in South Florida, USA.” *Endangered Species Research* 7 (3): 175–81.
———. 2009b. “Documenting Loss of Large Trophy Fish from the Florida Keys with Historical Photographs.” *Conservation Biology* 23 (3): 636–43. doi:10.1111/j.1523-1739.2008.01152.x.
McGovern, Thomas H., Orri Vésteinsson, Adolf Friđriksson, Mike Church, Ian Lawson, Ian A. Simpson, Arni Einarsson, et al. 2007. “Landscapes of Settlement in Northern Iceland:

Historical Ecology of Human Impact and Climate Fluctuation on the Millennial Scale." *American Anthropologist* 109 (1): 27–51. doi:10.1525/aa.2007.109.1.27.
McIntosh, Jr., William M. 1904. *Minutes, Vol. 3*. 39 vols. Tallahassee, FL, USA: I.E. Hilson, State Printer of Florida. http://digitalcollections.fiu.edu/iif/volumes/volume3/FI06013203_body.pdf.
Migliaccio, Kati W., Yuncong Li, and Thomas A. Obreza. 2014. "ABE 381/AE431: Evolution of Water Quality Regulations in the United States and Florida." UF/IFAS Extension. EDIS. http://edis.ifas.ufl.edu/ae431.
Mladenoff, David J, Sally E. Dahir, Erik V Nordheim, Lisa A. Schulte, and Glenn G. Guntenspergen. 2002. "Narrowing Historical Uncertainty: Probabilistic Classification of Ambiguously Identified Tree Species in Historical Forest Survey Data." *Ecosystems* 5 (6): 539–53. doi:10.1007/s10021-002-0167-8.
Myers, Ronald L. 1985. "Fire and the Dynamic Relationship between Florida Sandhill and Sand Pine Scrub Vegetation." *Bulletin of the Torrey Botanical Club* 112 (3): 241–52. doi:10.2307/2996539.
———. 1990. "Scrub and High Pine." In *Ecosystems of Florida*, edited by Ronald L. Myers and John J. Ewel, 150–93. Orlando: University Press of Florida.
Myers, Ronald L., and John J. Ewel, eds. 1990. *Ecosystems of Florida*. Orlando: University Press of Florida.
Nash, George Valentine. 1895. "Notes on Some Florida Plants." *Bulletin of the Torrey Botanical Club* 22 (4): 141–61. doi:10.2307/2477851.
———. 1896. "Notes on Some Florida Plants.-II." *Bulletin of the Torrey Botanical Club* 23 (3): 95–108. doi:10.2307/2478121.
National Plant Data Team. 2015. "Plants Profile for Quercus Marilandica (blackjack Oak)." USDA NRCS. Plants Database. http://plants.usda.gov/core/profile?symbol=QUMA3.
National Research Council. 2012. "Review of the EPA's Economic Analysis of Final Water Quality Standards for Nutrients for Lakes and Flowing Waters in Florida." Expert Consensus Report. Washington, DC, USA: The National Academy of Sciences. http://dels.nas.edu/resources/static-assets/materials-based-on-reports/reports-in-brief/EPA-Econ-Analysis-Florida-Final.pdf.
Necsoiu, Marius, Cynthia L. Dinwiddie, Gary R. Walter, Amy Larsen, and Stuart A. Stothoff. 2013. "Multi-Temporal Image Analysis of Historical Aerial Photographs and Recent Satellite Imagery Reveals Evolution of Water Body Surface Area and Polygonal Terrain Morphology in Kobuk Valley National Park, Alaska." *Environmental Research Letters* 8 (2): 025007.
Nelson, John C., Anjela Redmond, and Richard E. Sparks. 1995. "Impacts of Settlement on Floodplain Vegetation at the Confluence of the Illinois and Mississippi Rivers." *Transaction of the Illinois State Academy of Science* 87 (3 & 4): 117–33.
Neteler, Markus, Daniel Grasso, Ivan Michelazzi, Luca Miori, Stefano Merler, and Cesare Furlanello. 2005. "An Integrated Toolbox for Image Registration, Fusion and Classification." *Int J Geoinformatics* 1: 51–61.
NOAA. 2015. "Historical Hurrican Tracks." Government. *Hurricanes*. August 9. http://coast.noaa.gov/hurricanes/?redirect=301ocm.
Noss, Reed F. 2013. *Forgotten Grasslands of the South*. Washington, DC, USA: Island

Press/Center for Resource Economics. http://link.springer.com/chapter/10.5822/978-1-61091-225-9_5.
Peroni, Patricia A., and Warren G. Abrahamson. 1986. "Succession in Florida Sandridge Vegetation: A Retrospective Study." *Florida Scientist* 49: 176–91.
Phillips, Philip Lee. 1924. *Notes on the Life and Works of Bernard Romans*. Publication of the Florida Historical Society 2. Deland, FL, USA: Florida Historical Society. https://babel.hathitrust.org/shcgi/imgsrv/download/pdf?id=mdp.39015039795284;marker=fdd7329f94dc95180263d2efcbaa1717.
Platt, William J., and Mark W. Schwartz. 1990. "Temperate Hardwood Forests." In *Ecosystems of Florida*, edited by Ronald L. Myers and John J. Ewel, 194–229. Orlando: University Press of Florida.
Pontius, Robert G., Emily Shusas, and Menzie McEachern. 2004. "Detecting Important Categorical Land Changes While Accounting for Persistence." *Agriculture, Ecosystems & Environment*, From pattern to process: Landscape Fragmentation and the analysis of land use/land cover change, 101 (2–3): 251–68. doi:10.1016/j.agee.2003.09.008.
Purcell, Joseph. 1778. "A Map of the Road from Pensacola in West Florida to St. Augustine in East Florida. From, a ,Survey Made by Order of the Late Hon. Col. John Stuart, Esq. His Majesty's Superintendent of Indian Affairs, Southern District in 1778." Paper. London: Public Records Office.
Puric-Mladenovic, Danijela. 2003. "Predictive Vegetation Modeling for Forest Conservation and Management in Settled Landscapes." Ph.D., Canada: University of Toronto (Canada). http://search.proquest.com/docview/305255827/abstract/5F6E7AB37A44C39PQ/1?accountid=10920.
Rawlings, Marjorie Kinnan. 1933. *South Moon Under*. New York, NY, USA: Scribner's Sons. http://ufdc.ufl.edu/UF00055164.
———. 1938. *The Yearling*. New York, NY, USA: Grosset & Dunlap.
Readle, Elmer L. 1979. *Soil Survey of Osceola County Area Florida*. USDA Soil Conservation Service. http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/florida/FL097/0/Osceola.pdf.
Romans, Bernard. 1776. *A Concise Natural History of East and West Florida*. New York: R. Aitken. http://ufdc.ufl.edu/l/UF00000163.
Rosenberg, Andrew A., W Jeffrey Bolster, Karen E. Alexander, William B. Leavenworth, Andrew B. Cooper, and Matthew G. McKenzie. 2005. "The History of Ocean Resources: Modeling Cod Biomass Using Historical Records." *Frontiers in Ecology and the Environment* 3 (2): 78–84. doi:10.1890/1540-9295(2005)003[0078:THOORM]2.0.CO;2.
Ross, Michael S., Joseph J. O'Brien, and Leonel da Silveira Lobo Sternberg. 1994. "Sea-Level Rise and the Reduction in Pine Forests in the Florida Keys." *Ecological Applications* 4 (1): 144–56. doi:10.2307/1942124.
Rouault, Even. 2015. *OpenFileGDB*. Cross-platform. Python. Paris, France: Spatialys. http://www.gdal.org/drv_openfilegdb.html.
Royse, David. 2011. "Florida Fish and Wildlife Approves Delisting of Black Bear, Other Species." News. *Sunshine State News*. June 8. http://www.sunshinestatenews.com/story/florida-fish-and-wildlife-approves-delisting-black-bear-other-species.

Rubio, Marco. 2012. “Rubio Introduces Legislation to Stop EPA’s Regulatory Interference in Florida.” Senator. *Press Releases*. February 16. http://www.rubio.senate.gov/public/index.cfm/press-releases?ID=51ae32b3-c4d5-49c6-9f57-2b4129dc6f28.

Scanlan, J. C., and Steve Archer. 1991. “Simulated Dynamics of Succession in a North American Subtropical Prosopis Savanna.” *Journal of Vegetation Science* 2 (5): 625–34. doi:10.2307/3236173.

Schulte, Lisa A., and William J. Barnes. 1996. “Presettlement Vegetation of the Lower Chippewa River Valley.” *Michigan Botanist* 35 (1): 19–38.

Searcy, I. G. 1829. “Map of Florida : Constructed Principally from Authentic Documents in the Land Office at Tallahassee /.” Map. Tallahassee & Baltimore: I. G. Searcy & F. Lucas Sr. https://www.loc.gov/item/2005625323/.

Sears, Paul Bigelow. 1925. “The Natural Vegetation of Ohio.” *Ohio Journal of Science* 25 (3): 139–49.

Secretary of the Treasury. 1881. “Statistical Abstract of the United States - 1800.” Government Printing Office. http://www2.census.gov/prod2/statcomp/documents/1880-01.pdf.

Simmons, William Hayne. 1822. *Notices of East Florida, with an Account of the Seminole Nation of Indians*. Bicentennial Floridiana Facsimile. Gainesville, FL, USA: University Press of Florida. http://ufdc.ufl.edu/l/AM00000176.

Simpson, John W., Ralph E. J. Boerner, Michael N. DeMers, Leslie A. Berns, Francisco J. Artigas, and Alejandra Silva. 1994. “Forty-Eight Years of Landscape Change on Two Contiguous Ohio Landscapes.” *Landscape Ecology* 9 (4): 261–70. doi:10.1007/BF00129237.

Skinner, Carl N. 1995. “Change in Spatial Characteristics of Forest Openings in the Klamath Mountains of Northwestern California, USA.” *Landscape Ecology* 10 (4): 219–28. doi:10.1007/BF00129256.

Smith, Buckingham, and Sidney Breese. 1848. “To Authorize Draining of Everglades in Florida, Etc.” Senate Report 242. Washington, DC, USA: United States Senate. FI07020101. Everglades Online. http://everglades.fiu.edu/archive/FI07020101_final.pdf.

Smith, Charles F. 1874. “The Watson, McNeil, and Orr&Whitner Lines.” Survey Plat. Tallahassee, FL, USA: US Department of the Interior.

Smith, E. A. 1884. “Report on the Cotton Production of the State of Florida with an Account of the General Features of the State.” In *10th Census of the United States*. Vol. 6. Washington, DC, USA: General Printing Office.

Smith, Eugene Allen. 1884. “Report on the Cotton Production of the State of Florida, with an Account of the General Agricultural Features of the State.” In *Report on Cotton Production in the United States; Also Enbracing Agriculture and Physico-Geographical Descriptions of Several Cotton States and of California - Part II: Eastern Gulf, Atlantic, and Pacific States*, 6:175–214. 1880 United States Census 10. Washington, DC: General Printing Office. http://www2.census.gov/prod2/decennial/documents/1880a_v6-04.pdf.

Smith, Hale G., and Marc Gottlob. 1994. “Spanish-Indian Relationships: Synoptic Hisotry and Archaeological Evidence, 1500-1763.” In *Tacachale: Essays on the Indians of Florida and Southeastern Georgia during the Historic Period*, edited by Jerald T. Milanich and Samuel Proctor. Florida Museum of Natural History: Ripley P. Bullen Series 7.

Gainesville, FL, USA: University Press of Florida.
Smith, Marvin T. 1987. *Archaeology of Aboriginal Culture Change in the Interior Southeast: Depopulation during the Early Historic Period*. Florida Museum of Natural History: Ripley P. Bullen Series 9. Gainesville: University Press of Florida.
Snedaker, Samuel C., and Ariel E. Lugo, eds. 1972. *Ecology of the Ocala National Forest*. Atlanta, GA: USFS.
Sparke, John. 1906. "The Voyage Made by M. John Hawkins Esquire, 1565." In *Early English and French Voyages, Chirfly from Haklyut, 1534-1608*, edited by Henry S. Burrage, 113–32. New York, NY, USA: Charles Scribner's Sons. http://www.americanjourneys.org/pdf/AJ-030.pdf.
Spear, Kevin. 2014. "Osceola, Deseret Plan for Metropolis near OIA." Newspaper. *The Orlando Sentinel*. August 19. http://articles.orlandosentinel.com/2014-08-19/news/os-deseret-osceola-massive-city-20140819_1_deseret-ranches-erik-jacobsen-central-florida.
Spurr, Stephen H. 1951. "George Washington, Surveyor and Ecological Observer." *Ecology* 32 (3): 544–49. doi:10.2307/1931731.
SRM. 2011. "ESD Florida Workshop - Registration Opens Monday, September 26, 2011!" Professional Organization. *Society for Range Management Blog*. September 22. http://srmoutreach.blogspot.com/2011/09/esd-florida-workshop-registration-opens.html.
SRM 2014 Orlando Planning Committee. 2014. "Program." Professional Organization. *The Society for Range Management*. April 25. http://rangelands.org/orlando2014/program_at_a_glance.html.
Stearns, Forest W. 1949. "Ninety Years Change in a Northern Hardwood Forest in Wisconsin." *Ecology* 30 (3): 350–58. doi:10.2307/1932615.
Stearns, Robert Edwards Carter. 1869. "Rambles in Florida - Part II." *The American Naturalist* 3 (7): 349–56.
Stein, Eric D., Shawna J. Dark, Travis R. Longcore, Robin M. Grossinger, Nicholas Hall, and Michael Beland. 2010. "Historical Ecology as a Tool for Assessing Landscape Change and Informing Wetland Restoration Priorities." *Wetlands* 30 (3): 589–601.
Stein, Eric D., Shawna J. Dark, Travis R. Longcore, Nicholas Hall, Michael Beland, Robin M. Grossinger, Jason Casanova, and Martha Sutula. 2007. "Historical Ecology and Landscape Change of the San Gabriel River and Floodplain." SCCWRP Technical Report 499. Los Angeles, California, USA: Southern California Coastal Water Research Project. http://greenvisions.usc.edu/documents/SGRreport.pdf.
Swetnam, Thomas W., Craig D. Allen, and Julio L. Betancourt. 1999. "Applied Historical Ecology: Using the Past to Manage for the Future." *Ecological Applications* 9 (4): 1189–1206. doi:10.1890/1051-0761(1999)009[1189:AHEUTP]2.0.CO;2.
Thompson, Jonathan R., Dunbar N. Carpenter, Charles V. Cogbill, and David R. Foster. 2013. "Four Centuries of Change in Northeastern United States Forests." *PLoS ONE* 8 (9): e72540. doi:10.1371/journal.pone.0072540.
Torri, D., E. Santi, M. Marignani, M. Rossi, L. Borselli, and S. Maccherini. 2013. "The Recurring Cycles of Biancana Badlands: Erosion, Vegetation and Human Impact." *CATENA*, Updating Badlands Research, 106 (July): 22–30. doi:10.1016/j.catena.2012.07.001.
Tulowiecki, Stephen J. 2014. "Using Vegetation Data within Presettlement Land Survey Records

for Species Distribution Modeling: A Tale of Two Datasets." *Ecological Modelling* 291 (November): 109–20. doi:10.1016/j.ecolmodel.2014.07.025.
UF/IFAS Extension Agents. 2015. *FAWN Archive Data*. Eng. Florida Automated Weather Network. ftp://agrofawn-prod01.osg.ufl.edu/fawnpub/data/.
University of New Mexico Libraries. 2015. "The Natural Heritage Network." Public University. *New Mexico Conservation Information System*. https://nhnm.unm.edu/about/network.
U.S. Census Bureau. 2015. "Florida QuickFacts." Government. *State & County QuickFacts*. http://quickfacts.census.gov/qfd/states/12000.html.
USDA SCS. 1981. *26 Ecological Communities of Florida*. Fort Worth, TX, USA: US Department of Agriculture. http://ufdc.ufl.edu/UF00000110/00001/1j.
USFWS. 2013. *USFWS National Wetlands Inventory - Florida*. Cross-platform. Vector digital data. Classification of Wetlands and Deepwater Habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31. Washington, DC, USA: U.S. Fish and Wildlife Service, Division of Habitat and Resource Conservation. http://www.fws.gov/wetlands/Data/Data-Download.html.
———. 2015. "Listed Species Believed to or Known to Occur in Florida." Government. *Environmental Conservation Online System*. February 13. http://ecos.fws.gov/tess_public/reports/species-listed-by-state-report?state=FL&status=listed.
US War Department Corps of Engineers. 1856. "Map of the State of Florida." Map. https://www.loc.gov/item/2006628339/.
VanArman, Joel, Winnie Park, Patti Nicholas, Patricia Strayer, Agnes McLean, Barry Rosen, and Jim Gross. 1998. "South Florida Water Management District." In *Water Resources Atlas of Florida*, edited by Edward A. Fernald and Elizabeth D. Purdum, Second, 260–84. Tallahassee, FL, USA: Institute of Science and Public Affairs, Florida State University.
Van Lear, David H., W.D. Carroll, P.R. Kapeluck, and Rhett Johnson. 2005. "History and Restoration of the Longleaf Pine-Grassland Ecosystem: Implications for Species at Risk." *Forest Ecology and Management* 211 (1-2): 150–65. doi:10.1016/j.foreco.2005.02.014.
Vignoles, Charles Blacker. 1823. *Observations on the Floridas*. New York: E. Bliss & E. White. https://openlibrary.org/books/OL23366324M/Observations_upon_the_Floridas.
Wade, Dale, John J. Ewel, and Ronald Hofstetter. 1980. "Fire In South Florida Ecosystems." General Technical Report SE-17. Asheville, NC: US Department of Agriculture, Southeastern Forest Experiment Station. Southeastern Research Station Publications. http://www.srs.fs.usda.gov/pubs/gtr/gtr_se017.pdf.
Walker, Karen. 2000. "Historical Ecology of the Southeastern Longleaf and Slash Pine Flatwoods: A Southwest Florida Perspective." *Journal of Ethnobiology* 20 (2): 269–99.
Wang, Yi-Chen. 2005. "Presettlement Land Survey Records of Vegetation: Geographic Characteristics, Quality and Modes of Analysis." *Progress in Physical Geography* 29 (4): 568–98. doi:10.1191/0309133305pp463ra.
Wang, Yi-Chen, Barry J. Kronenfeld, and Chris P.S. Larsen. 2008. "Spatial Distribution of Forest Landscape Change in Western New York from Presettlement to the Present." *Canadian Journal of Forest Research* 39 (1): 76–88. doi:10.1139/X08-161.
Wang, Yi-Chen, and Chris P. S. Larsen. 2006. "Do Coarse Resolution U.S. Presettlement Land

Survey Records Adequately Represent the Spatial Pattern of Individual Tree Species?” *Landscape Ecology* 21 (7): 1003–17. doi:10.1007/s10980-005-6221-0.
Wares, John P., and Clifford W. Cunningham. 2001. “Phylogeography and Historical Ecology of the North Atlantic Intertidal.” *Evolution* 55 (12): 2455–69. doi:10.1111/j.0014-3820.2001.tb00760.x.
Wells, Bertram Whittier, and Ivan Vaughan Detweiler Shunk. 1931. “The Vegetation and Habitat Factors of the Coarser Sands of the North Carolina Coastal Plain: An Ecological Study.” *Ecological Monographs* 1 (4): 465–520. doi:10.2307/1943080.
Wharton, C. H., H. T. Odum, Katherine C. Ewel, M. Duever, A. Lugo, R. Boyt, J. Bartholomew, et al. 1977. “Forested Wetlands of Florida - Their Management and Use.” Final. University of Florida, Gainesville: Center for Wetlands - Phelps Lab.
Whitney, Gordon G. 1986. “Relation of Michigan’s Presettlement Pine Forests to Substrate and Disturbance History.” *Ecology* 67 (6): 1548–59. doi:10.2307/1939085.
Whitney, Gordon G., and J. DeCant. 2005. “Government Land Office Survey and Other Early Land Surveys.” In *The Historical Ecology Handbook - A Restorationist’s Guide To Reference Ecosystems*, edited by Dave Egan and Evelyn A. Howell, 2nd ed., 147–72. The Science and Practice of Ecological Restoration Series. Covelo, CA, USA: Island Press.
Whitney, Milton. 1898. “A Preliminary Report on The Soils of Florida.” Division of Soils S. 15. Washington: General Printing Office.
Whittaker, Robert H. 1962. “Classification of Natural Communities.” *Botanical Review* 28 (1): 1–239.
Williams, M.J. 2012. “General Information about Forage Suitability Groups.” USDA NRCS Florida. Section 2. Field Office Technical Guide. http://efotg.sc.egov.usda.gov/references/public/FL/READ_First_How_to_find_your_FSG_description.pdf.
Wunderlin, R.P., and B.F. Hansen. 2008. *Atlas of Florida Vascular Plants*. University of South Florida, Tampa: Institute for Systematic Botany. http://www.florida.plantatlas.usf.edu/Plant.aspx?id=991.
Wyland, Scott. 2015. “Scott Gutted Florida Forever in Recession, When Prices Were Lowest.” Newspaper. *TCPalm*. February 18. http://www.tcpalm.com/franchise/indian-river-lagoon/mobile-scott-gutted-florida-forever-in-recession-when-prices-were-lowest_08610106.
Xu, Qizhi, Yun Zhang, and Bo Li. 2014. “Improved SIFT Match for Optical Satellite Images Registration by Size Classification of Blob-like Structures.” *Remote Sensing Letters* 5 (5): 451–60. doi:10.1080/2150704X.2014.917774.
Yang, Ying, and Xin Gao. 2009. “Remote Sensing Image Registration via Active Contour Model.” *AEU - International Journal of Electronics and Communications* 63 (4): 227–34. doi:10.1016/j.aeue.2008.01.003.
Yarlett, Lewis L. 1985. “History of the Florida Cattle Industry.” *Rangelands Archives* 7 (5): 205–7.
Young, J. H. 1826. “Map of Florida According to the Latest Authorities.” Paper. Philadelphia: A. Finley. Publication of Archival Library & Museum Materials - State University Libraries of Florida. http://www.raremaps.com/gallery/detail/34173/Map_of_Florida_According_to_the_Lates

t_Authorities/Finley.html.
Yu, Le, Dengrong Zhang, and Eun-Jung Holden. 2008. “A Fast and Fully Automatic Registration Approach Based on Point Features for Multi-Source Remote-Sensing Images.” *Computers & Geosciences* 34 (7): 838–48. doi:10.1016/j.cageo.2007.10.005.
Zitová, Barbara, and Jan Flusser. 2003. “Image Registration Methods: A Survey.” *Image and Vision Computing* 21 (11): 977–1000. doi:10.1016/S0262-8856(03)00137-9.

APPENDIX A: NATURAL COMMUNITY DESCRIPTIONS

The full natural community definitions below were created for this project as vegetation descriptions that are applicable to observations made beginning with government surveyors in 1844 through time to modern ecosystem taxonomies created using vegetation sampling and satellite imagery. Most sources for each natural community are listed in their respective classification schemes table. Federally threatened and endangered species listing status was obtained using the USFWS's listing database (2015) and is indicated in the species tables as a superscript "federal threatened" and "federal endangered" next to the common name. If the species isn't federally listed but Florida has assigned it a status it will have one of the following labels: "state concern" for Species of Special Concern and "state threatened" for state-designated threatened (Gruver and Murphy 2013). Identification and photointerpretation are based on SFWMD's Photointerpretation Key (Cameron et al. 2011) and personal plant identification and photointerpretation experience. The correlation between natural communities and their soils are backed up by Laessle (1942), Harper (1914; 1915), Dunn et al. (1922), Leighty (1960), Readle et al. (1979), SCS (1981), and Doolittle and Schellentrager (1989).

Not every square meter of the site is covered with natural vegetation, or even vegetation at all. The lake category catches all open water except that which was dug out by man, which is called cultural – lacustrine. The areas where man dumped the spoil from digging a new lake or wetland are called cultural – spoil. The areas that were dug out but are covered with emergent aquatic vegetation rather than open water are called cultural – palustrine. The upland areas whose vegetation was removed or otherwise significantly adversely affected by man and not yet recovered are called cultural – ruderal.

Hammock (1120)

Synonyms:

Hardwood forest, oak hammock, hummock, hommock, hardwood hammock

Summary:

Hammocks in central Florida are hardwood forests limited to bands and clumps in fire-restricted areas, historically slopes between sandhills and lakes.

Historical Descriptions:

Bernard Romans (1776, 17): “The hammock land ſo called from its appearing in tufts among the lofty pines; ſome ſmall ſpots of this kind, if ſeen at a diſtance, have a very romantick appearance; the large parcels of it often divide ſwamps, creeks, or rivers from the pine land, this is indeed its moſt common situation;”

William Bartram (1791, 117): “this grand sweep of high forests encircles, as I apprehend, at least twenty miles of these green fields, interspersed with hommocks or islets of evergreen trees, where the sovereign Magnolia and lordly Palm stand conspicuous.”

James A. Henshall (1884, 25): “ hamak[1] | [1] The orthography of this word varies greatly. I prefer this form of it, as it is, no doubt, of Indian derivation. It is variously spelled hammock, hommock, and hummock. In Florida it denotes land covered with hard-wood timber, in contradistinction to pine land.”

Roland M. Harper (1905, 401): “It is used for quite a variety of conditions, but from all the evidence obtainable it may be defined broadly as a limited area, with comparatively dry soil (at least never inundated, and thus distinguished from a swamp), containing a large proportion of trees other than pines, and located in a region where 'prairies,' marshes or open pine forests predominate. Topographically a hammock may be either a slight elevation, or a depression, or a slope, and its soil may be sandy, clayey or rocky. The soil is usually rather rich, and the trees growing in it are usually mostly evergreens though there is probably no one tree which characterizes all hammocks - and they usually grow so close together as to shade the ground and allow the formation of humus, which is almost wanting in adjacent areas.”

John W. Harshberger (1914, 118): “A hammock from the standpoint of the physiognomy of the vegetation is a group of hardwood trees, shrubs, vines, terrestrial and epiphytic herbs scattered as islands about the country, usually in a rather deep soil, rich in humus, or vegetable matter, and more retentive of water than the adjacent pineland.”

Albert Laessle and Carl Monk (1961, 54): "On the inland areas, live oak stands may be encountered on sandhill sites, on better drained pine flatwoods areas, scrub sites, and fringing lakes, streams, and sinkholes."

Dominant Flora:

Overstory of live oak (*Q. virginiana*), turkey oak (*Q. laevis*), laurel oak (*Q. haemispherica*), white ash (*Fraxinus americana*), pines (*P. palustris, P. elliottii, P. taeda, P. glabra*) and sweetgum (*Liquidambar styraciflua*). Midstory includes American holly (*Ilex opaca*), winged elm (*Ulmus alata*), cabbage palm (*Sabal palmetto*), and basswood (*Tilia americana*). Understory of Virginia creeper (*Parthenocissus quinquefolia)*, woodsgrass (*Oplismenus hirtellus*), and other shade-tolerant low-growing grasses and sedges.

Soils:

1922 (Orange) –
1960 (Orange) –
1979 (Osceola) –
1989 (Orange) –
2011/Present (Orange) –
2011/Present (Osceola) –

Succession:

Hammocks may emerge out of long unburned scrubby flat pine, scrub, sandhill, and even mesic or hydric flat pine. A hammock burned over catastrophically may transition into any of the aforementioned communities if the underground oak roots are killed to prevent resprouting.

Identification and Photointerpretation:

Hammocks appear heterogeneous on both CIR and natural color imagery. The pines or cypress in the canopy appear fluffy and brick red on CIR. Hardwoods have large round crowns that appear textured and will show bright red on CIR or a variety of greens on natural color. Though historical extent of hammocks has been limited to strips between sandhills and lakes where they have been sheltered by fire they can be found on modern imagery anywhere that hydrology and fire allow.

Classification Schemes:

Scheme	**Source**	**Top-Level**	**Mid-Level**	**Low-Level**	**Community Name**
US Census	(E. A. Smith 1884)		Long-Leaf Pine Region	Hammock lands	High hammocks
FGS	(Harper 1914)			Middle Florida Hammock Belt	upland oak woods

					hammocks
Harshberger	(Harshberger 1914)				High Hammock Formation
FGS	(Harper 1915)				red oak woods
					sandy hammocks
					high hammocks
Laessle	(Laessle 1942)		Hammock Communities	Xeric Hammock	*Quercus virginiana* [Live Oak] Association
				Mesic Hammock	*Magnolia grandiflora* [Southern magnolia]-*Ilex opaca* [American holly] Association
				Hydric Hammock	*Quercus nigra* [water oak]-*Liquidambar* [*L. styraciflua* sweetgum]-*Sabal palmetto* [cabbage palm] Association
Kuchler	(Kuchler 1964)				Southern Mixed Forest
Davis	(Davis 1967)				Mixed Hardwoods and Pines
					Hardwood Forests
SAF	(Eyre 1980)				Shortleaf pine - Oak
SCS	(USDA SCS 1981)				Upland Hardwood Hammocks
					Oak Hammocks
Myers and Ewel	(Myers and Ewel 1990)	Upland Ecosystems	Upland Forest		Temperate Hardwood Forests
FNAI	(FNAI 1990)	Terrestrial	Xeric Uplands		Xeric Hammock
			Mesic Uplands		Upland Hardwood Forest
					Upland Mixed Forest
			Mesic Flatlands		Mesic Hammock
		Palustrine	Wet Flatlands		Hydric Hammock
FLUCCS	(FDOT Surveying and Mapping Office 1999)		Upland Forests		Beech-Magnolia
					Hardwood-Conifer Mixed
					Mixed Hardwoods

FFWCC	(Gilbert and Stys 2004)		Mesic Uplands		Mixed Hardwood-Pine Forests
					Hardwood Hammocks and Forests
					Cabbage Palm-Live Oak Hammock
FNAI	(FNAI 2010)		Pine Flatwoods and Dry Prairie		Mesic Flatwoods
					Wet Flatwoods
					Scrubby Flatwoods
SFWMD	(Cameron et al. 2011)		Upland Non-Forested		Herbaceous – Dry Prairie
			Upland Forests	Upland Coniferous Forests	Pine Flatwoods
					Pine – Mesic Oak
FLCCS	(Kawula 2014)	Uplands	Terrestrial	Pine Flatwoods and Dry Prairie	Dry Flatwoods
					Mesic Flatwoods
					Scrubby Flatwoods
					Dry Prairie
					Palmetto Prairie

Flora:

Common Name	**Botanical name**
red oak	*Quercus falcata*
live oak	*Q. virginiana*
sand live oak	*Q. geminata*
laurel oak	*Q. laurifolia*
water oak	*Q. nigra*
Southern magnolia	*Magnolia grandiflora*
longleaf pine	*Pinus palustris*
slash pine	*P. elliotii* var. *elliottii*
loblolly pine	*P. taeda*

spruce pine	*P. clausa*
sweetgum	*Liquidambar styraciflua*
white ash	*Fraxinus americana*
red bay	*Persea borbonia*
pignut hickory	*Carya glara*
mulberry	*Morus rubra*
American olive	*Osmanthus americana*
American holly	*Ilex opaca*
Dahoon holly	*I. cassine*
red cedar	*Juniperus virginiana*
Michaux's hawthorne	*Crataegus michauxii*
Hercules-club	*Zanthoxylum clava-herculis*
sparkleberry	*Vaccinium arboreum*
wax myrtle	*Myrica cerifera*
winged sumac	*Rhus copallinum*
saw palmetto	*Serenoa repens*
sabal palm	*Sabal palmetto*
scrub palmetto	*Sabal etonia*
black haw	*Viburnum rufidulum*
Virginia creeper	*Parthenocissus quinquefolia*
American beautyberry	*Callicarpa americana*
Carolina laurelcherry	*Prunus caroliniana*
Devil's walking stick	*Aralia spinosa*
greenbriar	*Smilax* spp.
yellow jessamine	*Gelsemium sempervirens*

tillandsia	*Tillandsia* spp.
wiregrass	*Aristida stricta*

Fauna:

Hardwood hammocks are used by the same mammals that are present in flat pine, with the exclusion of species that are hampered by the presence of a closed canopy, like the bobwhite quail and the crested caracara, or by places for predatory birds to perch, like the Florida scrub jay.

Common Name	**Zoological name**
bobcat	*Lynx rufus*
armadillo	*Dasypus novemcinctus*
Eastern cottontail rabbit	*Sylvagus floridanus*
gray fox	*Urocyon cinereoargenteus*
opossum	*Didelphis virginiana*
white-tailed deer	*Odocoileus virginianus*
raccoon	*Procyon lotor*
Florida black bear	*Ursus americanus floridanus*
Florida panther [federal endangered]	*Felix concolor coryi*
cotton rat	*Sigmodon hispidus*
cotton mouse	*Peromyscus gossypinus*
bald eagle	*Haliaeeutus leucocephalus*
Bachman's sparrow [federal threatened]	*Aimophila aestivalis*
pileated woodpecker	*Drycopus pileatus*
red bellied woodpecker	*Melanerpes carolinus*
eastern diamondback rattlesnake	*Crotalus adamanteus*
eastern indigo snake [federal endangered]	*Drymarchon couperi*

pygmy rattlesnake	*Sisturis miliarius*
box turtle	*Terrapine carolina*
Kirtland's warbler [federal endangered]	*Dendroica kirtlandii*
ovenbird	*Seiurus aurocapillus*
solitary vireo	*Vireo solitarus*
black-whiskered vireo	*V. atiloquus*
white-eyed vireo	*V. griseus*
grey kingbird	*Tyrannus dominicensis*
white-crowned pidgeon [federal threatened]	*Columba leucocephala*
great crested flycatcher	*Myiarchus crinitus*
cardinal	*Cardinalis cardinalis*
pine warbler	*Dendroica pinus*
Carolina wren	*Thryothorus ludovicianus*
Florida mastiff bat	*Eumops glaucinus floridanus*
Schaus swallowtail butterfly	*Heraclides aristodemus ponceanus*

Scrub (1210)

Synonyms: scrub, rosemary scrub, sand pine scrub, barren sand hills

Summary: Scrub is a collection of xeric plant associations situated on excessively drained sands. Sand pine, oaks, scrub rosemary, and saw palmetto are diagnostic. Scrub supports many xeric animal species and is used by many others. It undergoes stand-replacing fires every 10-50 years.

Historical descriptions:

Bernard Romans (1776, 35): "In my journey by land from the Bay of Tampe acroſs the Peninſula to St. Auguſtine, I croſſed twenty three mile ſrom eaſt to weſt of miſerable barren ſand hills, the grain of the land is very ſmall and ferrugineous ; theſe hills riſe a conſiderable height ; on them is ſome growth of very ſmall pines, and a very humble kind of oak grows ſo thick, that with the addition of ſome wythes and other plants, to me utterly unknown, they render it abſolutely impenetrable."

William Bartram (1791, 163–4) on an area near Salt Springs, now in the Ocala National Forest (60 km NW of Split Oak): "we behold an endless wild desert, the upper stratum of the earth of which is a fine white sand, with small pebbles, and at some distance appears entirely covered with low trees and shrubs of various kinds, and of equal heighth, as dwarf Sweet Bay (Laurus borbonia) [classified as facultative wetland, Bartram's correct identification of red bay is possible, *Persea borbonia*, more likely silk bay, *P. borbonia* var. *humilis*] Olea Americana [American olive, *Osmanthus americanus*], Morus rubra [red mulberry], Myrica cerifera [wax myrtle], Ptelea [common hoptree, *Ptelea trifoliata*], Æsculus pavia [red buckeye], Quercus Ilex [evergreen oak native to the Mediterranean, instead probably myrtle oak, *Q. myrtifolia*] Q. glandifer [perhaps Chapman's oak, which has large acorns, *Q. chapmanii*], Q. maritima foliis obcunciformibus obsolete tribobis minoribus [laurel oak, *Q. laurifolia*], Q. pumila [running oak], Rhamnus frangula [Carolina buckthorn, *Rhamnus caroliniana*], Halesia diptera, & Tetraptera [two-wing silverbell], Cassine [Dahoon holly, *Ilex cassine*], Ilex aquifolium [European holly, incorrectly identified, probably American holly *I. opaca*], Callicarpa Johnsonia [American beautyberry, *C. americana*], Erythryna corallodendrum [coral bean, *E. herbacea*], Hibiscus spinifex [gingerbush, *Pavonia spinifex*], Zanthoxilon [any of five native species of the genus *Zanthoxylum*], Hopea tinctoria [common sweetleaf, *Symplocos tinctoria*], Sideroxilum [any of the eleven native bullys of the genus *Sideroxylon*], with a multitude of other shrubs, many of which are new to me, and some of them admirably beautiful and singular. One of them particularly engaged my notice, which, from its fructification I take to be a species of Cacalia [garberia, *Garberia heterophylla*]. It is an evergreen shrub, about six or eight feet high."

Charles Vignoles (1823, 77, 89): "The *scrub* lands have been particularly described before in page 68 : they vary but very little in their general appearance wherever found […] These scrubs and undulating grounds, consist of a sand of a very small and ferruginous grain, producing an infinite variety of dwarf oaks and a number of parasitical plants ; where the land swells to a considerable elevation, there is generally to be seen a growth of small spruce pines, most of which however seem to die, after springing up to the height of twenty or thirty feet. The wythes and other creeping shrubs which interweave with the humble species of oaks, renders a passage very difficult."

William H. Simmons (1822, 34): "nothing could be more sterile than the soils; and these tracts are, in fact, concealed deserts, as they […] afford nothing that is fit, even for the browsing of cattle. The growth upon these places, form its tough and stunted character, forms a complete live fence, which, probably, would never have been penetrated through, but by the Indians, who made the present trail, for the purpose of hunting bear."

George V. Nash (1895, 144): "The scrub flora is entirely different from that of the high pine land, hardly a single plant being common to both ; in fact these two floras are natural enemies and appear to be constantly fighting each other."

Marjorie K. Rawlings (Rawlings 1933, 2): "The growth repelled all human living. The soil was a tawny sand, from whose parched infertility there reared, indifferent to water, so dense a growth of scrub pine-the Southern spruce-that the effect of the massed thin trunks was of a limitless, canopied stockade. It seemed impenetrable, for a man-high growth of scrub oak [*Q. inoptina*], myrtle [*Myrica cerifera*], sparkleberry [*Vaccinium arboretum*], and ti-ti [*Cyrilla racemiflora*] filled the interstices."

Herman Kurtz (1942, 9): "a special plea for the conservation of scrubs seems superfluous. Remoteness from and disrelation to salt water surf as well as undesirability for cultivation constitutes ample protection."

Dominant Flora: Several xeric oak species (*Q. chapmanii*, *Q. geminata*, *Q. inopina*, and *Q. myrtifolia*), sand pine (*P. serotina*), and Florida rosemary (*Ceratiola* ericoides) are most of the overstory and midstory. The understory is often a mixture of rare plants, saw palmetto (*Serenoa repens*), and grasses.

Soils: The soils look like beach sand, are well drained, often white, and have minimal organic matter. Large and small patches of bare soil abound.

1922 – St. Lucie fine sand (Sf)
1960 – Pomello fine sand (Pc),
1979 – Pomello fine sand, 0 to 5 percent slopes (34)
1989 – Pomello fine sand, 0 to 5 percent slopes (34)

Succession: Sand pine scrubs that have their fire return intervals lengthened grade more smoothly into high pine and eventually both communities will transition into xeric hardwood forest (Myers 1985), which in this classification system is merged into scrub. Some scrubs, like those dominated by Florida rosemary, can self-maintain without fire for centuries via windthrow, natural shrub mortality, and animal trails, though perhaps with a different vegetation distribution. Sandhill may transition to scrub if its fire return interval is lengthened.

Identification and Photointerpretation: Since the light-colored soil is often exposed, that can be seen on aerial photos. Sand pines have a variety of fungal root infections, their dark, wilty crowns can separate them from longleaf and slash pines. The overstory varies from extremely dense to absent. The rolling topography is usually visible on CIR and true color photos. The boundaries between scrub and other upland (flat pine and sandhill) are distinct.

Classification Schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
U. S. Census	(E. A. Smith 1884)		Long-leaf pine region	Hummock lands	High hummocks
FGS	(Harper 1914)			Peninsular lake region	Scrub
Harshberger	(Harshberger 1914)				Sand-pine Formation (Rosemary Scrub)
FGS	(Harper 1915)				The Scrub
Laessle	(Laessle 1942)		Non-Hammock Communities of Well Drained Soils	The Scrub	St. Lucie Scrub: *Pinus clausa-Quercus* spp. Association
Kuchler	(Kuchler 1964)				Southern Mixed Forest
Davis	(Davis 1967)				Sand Pine, *Pinus clausa*, Scrub Forests
SAF	(Eyre 1980)				Sand pine
					Longleaf pine – scrub oak
					Southern scrub oak
SCS	(USDA SCS 1981)				Sand pine scrub
Myers and Ewel	(Myers and Ewel 1990)			Scrub and High Pine	Scrub
FNAI	(FNAI 1990)	Terrestrial	Xeric Uplands		Scrub
FLUCCS	(FDOT Surveying and Mapping Office 1999)		Upland Forests	Upland Coniferous Forests	Sand Pine
					Xeric Oak
				Upland Hardwood Forests	Sand Live Oak
					Upland Scrub, Pine and Hardwoods
FFWCC	(Gilbert and Stys 2004)		Xeric Uplands		Xeric Oak Scrub
					Sand Pine Scrub
FNAI	(FNAI 2010)		High Pine and Scrub	Scrub	Rosemary Scrub

					Sand Pine Scrub
SFWMD	(Cameron et al. 2011)		Upland Forests	Upland Coniferous Forests	Sand Pine
FLCCS	(Kawula 2014)	Uplands	Terrestrial	High Pine and Scrub	Scrub
					Oak Scrub
					Rosemary Scrub
					Sand Pine Scrub

Flora:

Common Name	**Botanical Name**
sand pine	*Pinus clausa*
sand live oak	*Quercus geminata*
myrtle oak	*Q. myrtifolia*
scrub oak	*Q. inopina*
Chapman oak	*Q. chapmanii*
Florida rosemary	*Ceratiola ericoides*
rusty lyonia	*Lyonia ferruginea*
saw palmetto	*Serenoa repens*
scrub palmetto	*Sabal etonia*
scrub hickory	*Carya floridana*
pygmy fringetree [T&E]	*Chionanthus pygmaeus*
scrub plum [T&E]	*Prunus geninculata*
gopher apple	*Licania michauxii*
beak rush	*Rhynchospora megalocarpa*
milk pea	*Galactia* spp.
Florida bluestem	*Andropogon floridanus*
hemlock witchgrass	*Dichanthelium portoricense*

British soldier moss	*Cladonia leporina*
prostrate cup lichen	*C. prostrata*
Evan’s reindeer lichen	*C. evansii*
reindeer lichen	*C. subtenuis*
American holly	*Ilex opaca*
scrub holly	*I. opaca* var. *arenicola*
silk bay	*Persea borbonia* var. *humilis*
garberia	*Garberia heterphylla*
Feay’s palafox	*Palafoxia feayi*
sparkleberry/farkleberry	*Vaccinium arboretum*
Curtiss’ milkweed	*Asclepias curtisii*

Fauna: Most animal species that use scrub aren’t endemic there, but there’s a fair number of species that are adapted to xeric habitats.

Common Name	**Zoological name**
gopher tortoise [federal threatened]	*Gopherus polyphemus*
pocket gopher	*Geomys pinetis*
Florida sand skink [federal threatened]	*Neoseps renoldsi*
blue-tailed mole skink [state threatened]	*Eumeces egregius lividus*
Florida mouse	*Podomys floridanus*
Florida scrub jay [federal threatened]	*Aphelocoma coerulescens*
Florida scrub lizard [federal under review]	*Sceloporus woodi*
common nighthawk	*Chordeiles minor*
common ground dove	*Columbina passerina*
northern bobwhite	*Colinus virginianus*

loggerhead shrike	*Lanius ludovicanus*
palm warbler	*Dendroica palmarum*
flying squirrel	*Glaucomys volans*
red bellied woodpecker	*Melanerpes carolinus*
downy woodpecker	*Picoides pubescens*
hairy woodpecker	*P. villosus*
great crested flycatcher	*Myiarchus crinitus*
blue jay	*Cyanocitta cristata*
Carolina wren	*Thryothorus ludovicianus*
pine warbler	*Dendroica pinus*
Eastern screech owl	*Otus asio*

<u>Sandhill (1240)</u>

Synonyms:

black jack ridge, sandhill, ridge sandhill, high pine, high pine land, pine barrens, pine ridge lands

Summary:

Rolling hills with a sparse canopy of pine and oak, a diverse midstory and an understory dominated by wiregrass and silkgrass. Low intensity fire returns frequently to the sandhill and there is little organic matter accumulation. Rain is the sandhill's main water source. Black jack oak (*Quercus marilandica*) are common throughout the United States, however no individuals have been vouchered within 150 miles from the site (National Plant Data Team 2015; Wunderlin and Hansen 2008) and no ecosystems containing that species currently exists on the site. Sand post oak (*Q. margaretta*) and post oak (*Q. stellate*) are easily misidentified as black jack oak. Black jack could also be misnamed but correctly identified blue jack oak (*Q. incana*). Some references (Myers 1990, 183; Mattoon 1967, 36) assert that blackjack was the former name of turkey oak (*Q. laevis*). *Q. marilandica* is present on sandhill starting in the panhandle of Florida and north.

Historical descriptions:

Bernard Romans (1776, 15–16): "the pine land […] conſiſts of a grey, or white ſand […] ; it produces a great variety of ſrubs or plants, the principal produce from whence it derives its name is the *pinus foliis longiffimis ex una theca ternis*. […] It is on this kind of land, that immenſe flocks of cattle are maintained, although the moſt natural graſs on this foil is of a very harſh nature, and the cattle not at all fond of it, it is known by the name of wire graſs; […] the woods are frequently fired, and at different ſeaſons, in order to have a ſucceſſion of young graſs. […] Some high pine hills are ſo covered with two or three varieties of the *quercus* or oak ſo as to make an underwood to the lofty pines; and a ſpecies of dwarf cheſnut is often found here."

William Bartram (1791, 173, 303, 386): "The Pine groves passed, we immediately find ourselves on the entrance of the expansive airy Pine forests, on parallel chains of low swelling mounds, called the Sand Hills, their ascent so easy, as to be almost imperceptible to the progressive traveller, yet at a distant view, before us in some degree exhibit the appearance of the mountainous swell of the ocean immediately after a tempest; but yet, as we approach them, they insensibly disappear, and seem to be lost, and we should be ready to conclude […] After breakfasting, having each of us a Siminole horse completely equipped, we sat off: the ride was agreeable and variously entertaining; we kept no road or pathway constantly, but as Indian hunting tracks, by chance suited our course, through high, open Pine forests, green lawns and flowery savannas in youthful verdure and gaity, having been lately burnt, but now overrun with a green enamelled carpet. […] We halted at *noon* […] on the acclivity of a high swelling ridge planted with open airy groves of the superb terebenthine Pines, glittering rills playing beneath, and pellucid brooks meandering through an expansive green savanna, their banks ornamented with coppices of blooming aromatic shrubs and plants perfuming the air.

William Simmons (1822, 35): “Beyond the scrub, a region of high rolling pine land occurs, […] it is often mingled with the black-jack ; and the soil, when it is turned up, (as is frequently is in heaps, by a reptile, here called the salamander,) exhibits a yellow appearance”

Charles Vignoles (1823, 77, 89): “Another kind of land, are the ridges of white sand covered with the small black or post oak, commonly called black jacks. These are sometimes so thick as to exclude the pines, and when this is the case there is scarcely any grass found on the sand hills […] The oak and hickory lands produce almost exclusively those two kinds of forest trees, with occasionally gigantic pines : the under-brush is generally composed of sucker saplings of the oak and hickory ; this description of land is generally disposed on the exterior edges of the high hammocks, and separate them from the pine lands. The black oak is the species most general here ; the soil a rich deep yellow sandy loam.”

A. P. Garber (1877, 72): “On this elevated or salamander land, where these vigilant miners display wonderful activity in the construction of a great number of diminutive mounts, I added to my list *Helianthemum Carolinianum*, Mx. [Carolina frostweed], *Stipulicida setacea,* Mx. [pineland scalypink], *Polugala grandiflora*, Walt. [showy milkwort], *Rhynchosia tomentosa*, var. *monophylla*, T. & G. [now *Rhynchosia reniformis* DC., dollarleaf], and *Desmodium triflorum* [threeflower ticktreefoil].”

Milton Whitney (1898, 8): “It is a very light, rather coarse, sandy soil. […] The characteristic growth is the long-leaf pine. The trees are sparsely set and often of quite large size. There is very little undergrowth, and a wagon or carriage can be driven through the forest in almost any direction. There is generally a good growth of grass, and these lands are very extensively used for grazing. […] The country is generally rolling, with differences of elevation of from 25 to 50 feet.”

Roland Harper (1915, 146): “On the vegetation map three types of high pine land are distinguished, namely, open pine woods, pine with black-jack oak, and pine with turkey oak; but the herbaceous vegetation of all these types is so similar that it did not seem worth while to make three separate lists.”

Bertram Wells and Ivan Shunk (1931, 467): “To one who travels in the coastal plain of the Southeastern United States, one of the most distinctive vegetation-habitat complexes is that of the erect, tenuous-bladed wire grass (Aristida stricta) in scattered tussocks on the dry loose sand hills and ridges. If trees are present they will in the most xeric areas be the long leaf pine (*Pinus palustris* and the turkey oak (*Quercus Catesbaci*). On the more favorable sites, black jack oak (*Q. Marylandica*), blue jack oak (*Q. brevifolia*), or the scrub post oak (*Q. Margaretta*).”

Dominant flora:

longleaf pine (*Pinus palustris*), turkey oak (*Quercus geminata*), bluejack oak (*Q. incana*), sand post oak (*Q. margaretta*), and wiregrass (*Aristida stricta* var. *beyrichiana*)

Soils:

Rolling to undulating areas with a gray fine sand overlaying a grey or yellow fine sand that extends below three feet. The soil is excessively drained, highly permeable, and low in nutrients. The soil pH ranges from highly acidic to neutral.

1922 (Orange) – Norfolk fine sand (Ns)
1960 (Orange) – Lakeland fine sand, very gently sloping (Lb)
1979 (Osceola) – Candler fine sand, 0 to 5 percent slopes (7), Tavares fine sand, 0 to 5 percent slopes (44)
1989 (Orange) – Candler fine sand, 0 to 5 percent slopes (4), Tavares fine sand, 0 to 5 percent slopes (46) Zolfo fine sand (54)
2011/Present (Orange) – Candler fine sand, 0 to 5 percent slopes (4), Zolfo fine sand (54)
2011/Present (Osceola) – Candler sand, 0 to 5 percent slopes (7), Tavares fine sand, 0 to 5 percent slopes (44)

Succession:

Sandhill requires a fire return interval between one to ten years with short flame lengths to persist. Longer return intervals allows sand live oaks to create nonflammable clonal domes and for turkey oak, bluejack oak, and/or sand post oak seedlings to reach an age at which they can tolerate fire. An oak-dominated sandhill is visited less frequently by fire and other hardwoods like black cherry (*Prunus serotina*), scrub hickory (*Carya floridana*), persimmon *(Diospyros virginiana*), and sassafras (*Sassafras albidum*) are able to thrive. An increased fire return interval also diminishes the reproductive capability of wiregrass, it rarely flowers any other time except soon after a growing-season burn or other defoliation (such as by grazing or mowing).

Identification and Photointerpretation:

Sandhill is the upland cousin of flat pine and is situated on deep, well drained sands within flat pine. On the landscape, it transitions abruptly into scrub and grades slowly into hammocks. Sandhill is characterized by sparse and irregular vegetation overstory closure above 25%. The midstory is a textured blue-green, usually visible through the pine overstory. The sand is usually visible through the canopy. Bright green grasses may be visible, depending on the site's history. Sometimes remnant sandhill exists within a pasture (Cameron et al. 2011).

Classification Schemes:

Scheme	**Source**	**Top-Level**	**Mid-Level**	**Low-Level**	**Community Name**

US Census	(E. A. Smith 1884)			The Oak, Hickory, and Pine Upland Region	The brown loam lands, with oak and hickory and short-leaf pine
					The long-leaf pine ridge lands
				Long-Leaf Pine Region	Rolling pine lands
FGS	(Harper 1914)			East Florida flatwoods	High pine land
				Bellair sand region	Sandhill
Harshberger	(Harshberger 1914)				Long-leaf Pine
FGS	(Harper 1915)			Rolling pine lands	Open pine
					Pine with black jack undergrowth
					Pine with turkey oak undergrowth
Laessle	(Laessle 1942)		Non-Hammock Communities of Well Drained Soils	The Sandhills	The *Pinus australis* [*P. palustris*]-*Quercus laevis* Association
					The *Pinus australis* [*P. palustris*]-*Quercus cinerea* Association
Kuchler	(Kuchler 1964)				Southern Mixed Forest
Davis	(Davis 1967)				Forests of Longleaf Pine and Xerophytic Oaks
SAF	(Eyre 1980)				Longleaf Pine & Scrub Oak
SCS	(USDA SCS 1981)				Longleaf Pine Turkey Oak Hills
Myers and Ewel	(Myers and Ewel 1990)				High Pine
FNAI	(FNAI 1990)	Terrestrial		Xeric Uplands	Sandhill
FLUCCS	(FDOT Surveying and Mapping Office 1999)			Upland Forests	Longleaf Pine & Xeric Oak
FFWCC	(Gilbert and Stys 2004)			Xeric Uplands	Sandhill
FNAI	(FNAI 2010)			High Pine and Scrub	Sandhill
SFWMD	(Cameron et al. 2011)	Upland Forests		Upland Coniferous Forests	Longleaf Pine & Xeric Oak
FLCCS	(Kawula 2014)	Terrestrial		High Pine and Scrub	Sandhill

Flora:

Common Name	**Botanical Name**
longleaf pine	*Pinus palustris*
wiregrass	*Aristida stricta* var. *beyrichiana*
turkey oak	*Quercus laevis*
bluejack oak	*Q. incana*
sand live oak	*Q. geminata*
sand post oak	*Q. margarettae*
saw palmetto	*Serenoa repens*
sparkleberry	*Vaccinium arboreum*
dwarf huckleberry	*Gaylussacia dumosa*
prickleypear cactus	*Opuntia humifusa*
gopher apple	*Licania michauxii*
earleaf greenbriar	*Smilax auriculata*
pineywoods dropseed	*Sporobolus junceus*
lopsided indiangrass	*Sorhastrum secundum*
bluestems	*Andropogon* spp.
three-awns	*Aristida* spp.
little bluestem	*Schizachyrium scoparium*
bracken fern	*Pteridium aquilinum*
narrowleaf silkgrass	*Pityopsis graminifolia*
blazing stars	*Liatris* spp.
coastalplain honeycomb head	*Balduinia angustifolia*
sweet goldenrod	*Solidago odora*
sidebeak pencilflower	*Stylosanthes biflora*
sensitive briar	*Mimosa quadrivalvis* var. *angustata*

summer farewell	*Dalea pinnata*
spurred butterfly pea	*Centrosema virginianum*

Fauna:

Sandhill shares animal species with many other vegetation communities. Some of these species are specifically adapted to dry habitats with scrub and drier flat pine, such as Gopher tortoises (*Gopherus polyphemus*), pocket gophers (*Geomys pinetis*), and the Florida sand skink (*Neoseps renoldsi*). These species plus the Florida mouse (*Podomys floridanus*), the endangered Sherman's fox squirrel (*Sciurus niger shermani*), the Florida sandhill crane (*Grus canadensis pratensis*) and red-cockaded woodpecker (*Picoides borealis*) characterize sandhill fauna.

Common Name	**Zoological name**
gopher tortoise [federal endangered]	*Gopherus polyphemus*
pocket gopher	*Geomys pinetis*
Florida sand skink [federal endangered]	*Neoseps renoldsi*
Florida mouse	*Podomys floridanus*
Sherman's fox squirrel [state special concern]	*Sciurus niger shermani*
sandhill crane [Federal endangered]	*Grus canadensis pratensis*

Flat Pine (1300)

Synonyms:

flatwoods, pine flatwoods, pine savanna, pine barrens, longleaf pine savanna

Summary:

Flat pine is the most extensive of these natural communities in Florida and it is characterized by flat topography and fine sands underlain by a thin restrictive soil horizon that impedes drainage. Pine flatwoods are maintained by frequent low to moderate intensity fires, and all species in the community are adapted to a 2-4 year fire return interval. This community description catches several flat pine divisions like wet flatwoods, scrubby flatwoods, and cabbage palm flatwoods. Older nomenclatures tended to lump communities rather than split them, for example Harshberger's (1914) "Long-leaf Pine Formation" grouped Flat Pine with Sandhill.

Historical Descriptions:

Bernard Romans (1776, 15–16): "the pine land […] conſiſts of a grey, or white ſand […] ; it produces a great variety of ſrubs or plants, the principal produce from whence it derives its name is the *pinus foliis longiffimis ex una theca ternis*. […] It is on this kind of land, that immenſe flocks of cattle are maintained, although the moſt natural graſs on this foil is of a very harſh nature, and the cattle not at all fond of it, it is known by the name of wire graſs; […] the woods are frequently fired, and at different ſeaſons, in order to have a ſucceſſion of young graſs."

William Bartram (1791, 170): "For the first four or five miles we travelled West-ward, over a perfectly level plain, which appeared before and on each side of us, as a charming green meadow, thinly planted with low spreading Pine trees (*P. palustri*.) [*Pinus palustris*]. The upper stratum of the earth is a fine white chrystaline sand, the very upper surface of which being mixed or incorporated with the ashes of burnt vegetables, renders it of sufficient strength or fertility to clothe itself perfectly, with a very great variety of grasses, herbage and remarkably low shrubs, together with a very dwarf species of Palmetto (*Corypha pumila stipit. serratis*.) [*Sabal minor*, dwarf palmetto]"

Robert E.C. Stearns (1869, 350): "The forest scenery has neither tropical beauty nor the grandeur of the pineries of Maine, Michigan or California, which so impresses the beholder; the prevailing timber is the *Pinus palustris*, or pitch-pine; the trees are hot above medium size and stand many paces apart; hundreds may be seen whose sides are defaced by the rough scars or notches made by the ruthless axes of the pitch gatherers, and some trees have many of these wounds. At one place there is an extensive establishment or the distillation of the spirits of turpentine, which employs several persons; at other points saw-mills may be seen."

John W. Harshberger (1914, 100): "Here Pinus palustris Mill. [longleaf pine] forms pure forest. The trees are draped with festoons of the Spanish moss, Dendropogon (Tillandsia) usneoides (L.) Raf. […] The pineland alternates with hammock-land, branch swamps and cleropyllous scrub with rounded clumps of saw-palmetto. The saw-palmetto, Serenoa serrulata (Michx.) Hook. [*Serenoa repens*] is the prevailing undergrowth in the long-leaf pine formation."

Roland M. Harper (1921, 138): "The principal vegetation types are palmetto flatwoods, prairies of several kinds, cypress ponds, low hammocks, swamps, fresh marshes, and a few patches of scrub. The prairies are several miles wide along the two largest rivers, and those along the Kissimmee (which the writer has not yet had opportunity to explore) are said to have an abundant and varied native fauna and to be great cattle ranges, thus resembling some of the western plains Other and probably different prairies border the lakes near Kissimmee, and there are numerous small wet prairies in shallow depressions."

Dominant Flora:

A scattered longleaf pine (*Pinus palustris*) overstory and a saw palmetto (*Serenoa repens*) understory dominate the community. Gallberry (*Ilex glabra*), wiregrass (*Aristida* spp.), and tarflower (*Befaria racemosa*) round out the most common plants.

Soils:

1922 (Orange) – Leon fine sand (Ls), Plummer fine sand (Pf), Portsmouth fine sand (Ps)
1960 (Orange) – Immokalee fine sand (Ia), Leon fine sand (Lf), Ona fine sand (Oa)
1979 (Osceola) – Immokalee fine sand (20), Myakka fine sand (22), Ona fine sand (27), Smyrna fine sand (42)
1989 (Orange) – Immokalee fine sand (20), Ona fine sand (26), Smyrna fine sand (44)
2011/Present (Orange) – Immokalee fine sand (20), Ona fine sand (26), Smyrna fine sand (44)
2011/Present (Osceola) – Immokalee fine sand (16), Myakka fine sand (22), Ona fine sand (27), Smyrna fine sand (42)

Succession:

Flatwoods is maintained as a community by frequent fire. Individual species abundance is controlled by the season of fire (ie. growing season versus dormant), and, for wetland or facultative wetland plants, the presence or absence of water. The hydroperiod and landscape position of the flat pine controls succession in the absence of fire: A wet flat pine community will increase in swamp hardwoods like red maple, titi, and bays. A scrubby flat pine community will transition very slowly into xeric live oak hammock or scrub. A mesic flat pine community will increase in hardwoods and the saw palmetto is likely to become impenetrable. Gallberry sprouts from the roots and will form thickets with the lyonias. When flat pine are invaded by hardwoods, the new trees may penetrate the spodic horizon, making it more water permeable (Snedaker and Lugo 1972). This would dry the community and alter the hydrology of nearby depressions, making them wetter. Some authors have proposed that this hardwood invasion of flatwoods is a contributing factor in the statewide expansion of bayhead species (Laessle 1942; Abrahamson and Hartnett 1990; Landman and Menges 1999; Peroni and Abrahamson 1986).

Identification and Photointerpretation:

Pine trees are shown as rounded "feathered" medium green canopies which appear brick red on a color infrared photo. Saw palmetto appears as irregularly shaped patches that are pink to pink-red on a color infrared photo. The grassy understory is pale green and rather smoothly textured that is pale pink on color infrared photos.

Classification Schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
US Census	(E. A. Smith 1884)			Long-Leaf Pine Region	Pine flats, or flatwoods
FGS	(Harper 1914)			East Florida flatwoods	Flatwoods
					Low pine land
					Pine lands
				Middle Florida Flatwoods	
Harshberger	(Harshberger 1914)				Long-leaf Pine Formation
					Slash-pine Formation
FGS	(Harper 1915)			Flatwoods	Palmetto flatwoods
					Open flatwoods
FGS	(Harper 1921)			Peninsular Flatwoods- Eatern Division	
Laessle	(Laessle 1942)		Flatwoods communities of poorly drained soils	The Longleaf-Pine Flatwoods	*Pinus australis* [*P. palustris*]-*Artistida stricta* Association
				The Black-Pine and Fetterbush Flatwoods	*Pinus serotina-Desmothamnus* [*Lyonia lucida*] Association
				The Slash-Pine Flatwoods	*Pinus palustris* [*P. elliotii* var. *elliotii*] Association
			Non-hammock communities of well drained soils	The Scrub	Scrubby Flatwoods: *Quercus v. geminata* [*Quercus geminata*]-*Q. myrtifolia-Q. chapmanii* Association
				The Serenoa Association	*Serenoa repens*
					The Slash-Pine Flatwoods
Kuchler	(Kuchler 1964)				Southern Mixed Forest

Davis	(Davis 1967)				Pine Flatwoods
SAF	(Eyre 1980)		Longleaf Pine		Longleaf Pine
					Longleaf Pine – Slash Pine
					Slash Pine
SCS	(USDA SCS 1981)				South Florida Flatwoods
					Cabbage Palm Flatwoods
					North Florida Flatwoods
Myers and Ewel	(Myers and Ewel 1990)	Upland Ecosystems	Pine Flatwoods and Dry Prairies		Pine Flatwoods
					Dry Prairies
					Scrubby Flatwoods
FNAI	(FNAI 1990)	Terrestrial	Mesic Flatlands		Mesic Flatwoods
					Scrubby Flatwoods
		Palustrine	Wet Flatlands		Wet Flatwoods
FLUCCS	(FDOT Surveying and Mapping Office 1999)		Upland Forests		Pine Flatwoods
					Pine – Mesic Oak
					Cabbage Palm
FFWCC	(Gilbert and Stys 2004)		Mesic Uplands		Pinelands
FNAI	(FNAI 2010)		Pine Flatwoods and Dry Prairie		Mesic Flatwoods
					Wet Flatwoods
					Scrubby Flatwoods
SFWMD	(Cameron et al. 2011)		Upland Non-Forested		Herbaceous – Dry Prairie
			Upland Forests	Upland Coniferous Forests	Pine Flatwoods
					Pine – Mesic Oak
FLCCS	(Kawula 2014)	Uplands	Terrestrial	Pine Flatwoods and Dry Prairie	Dry Flatwoods
					Mesic Flatwoods
					Scrubby Flatwoods
					Dry Prairie
					Palmetto Prairie

Flora:

Common Name	**Botanical name**
longleaf pine	*Pinus palustris*
slash pine	*P. elliotii* var. *elliottii*
South Florida slash pine	*P. elliotii* var. *densa*
pond pine	*P. serotina*
saw palmetto	*Serenoa repens*
cabbage palm	*Sabal palmetto*
gallberry	*Ilex glabra*
fetterbush	*Lyonia lucida*
rusty lyonia	*L. ferruginea*
staggerbush	*L. fruticosa*
dwarf huckleberry	*Gaylussacia dumosa*
blueberries	*Vaccinium* spp.
wax myrtle	*Myrica cerifera*
dwarf live oak	*Quercus minima*
runner/running oak	*Q. pumila*
tarflower	*Befaria racemosa*
wiregrass	*Aristida stricta*
bottlebrush three-awn	*A. spiciformis*
arrowfeather	*A. purpurescens*
broomsedge	*Andropogon virginicus*
love grasses	*Eragrostis* spp.
coontie	*Zamia integrifolia pigmaea*

Fauna:

As the most extensive terrestrial ecosystem, flat pine has an extensive animal species list that overlaps significantly with all of the other vegetative communities. The bird population fluctuates throughout the year because of winter migrants. Since the flat pine community covers much of the US Southeast, few species are endemic to Florida.

Common Name	**Zoological name**
bobcat	*Lynx rufus*
armadillo	*Dasypus novemcinctus*
Eastern cottontail rabbit	*Sylvagus floridanus*
gray fox	*Urocyon cinereoargenteus*
opossum	*Didelphis virginiana*
white-tailed deer	*Odocoileus virginianus*
raccoon	*Procyon lotor*
Florida black bear	*Ursus americanus floridanus*[1]
Florida panther [federal endangered]	*Felix concolor coryi*
cotton rat	*Sigmodon hispidus*
cotton mouse	*Peromyscus gossypinus*
bobwhite quail	*Colinus virginianus*
bald eagle	*Haliaeeutus leucocephalus*
crested caracara [T&E]	*Polyborus plancus audubonii*
Bachman's sparrow [T&E]	*Aimophila aestivalis*
pileated woodpecker	*Drycopus pileatus*
red bellied woodpecker	*Melanerpes carolinus*
red cockaded woodpecker [T&E]	*Picoides borealis*
eastern diamondback rattlesnake	*Crotalus adamanteus*

[1] The first Florida black bear hunting permits were sold by the FFWCC in August 2015 (FFWCC 2015). The species was taken off of the threatened list in 2012 (Royse 2011).

eastern indigo snake [T&E]	*Drymarchon couperi*
pygmy rattlesnake	*Sisturis miliarius*
box turtle	*Terrapine carolina*
scrub lizard	*Sceloporus woodi*
sand skink [T&E]	*Neoseps reynoldsi*
pinewoods tree frog	*Hyla femoralis*
flatwoods salamander	*Ambystoma cingulatum*

Cultural – Ruderal (1800)

Synonyms:

Ruderal, pasture, improved pasture, unimproved pasture, clearing, rural open

Summary:

Any disturbed upland area that has been revegetated but not restored to a recognized natural community.

Dominant Flora:

Early successional vegetation, unless managed as a pasture.

Soils:

May be underlain by any soil. Community characteristics depend on the nature of the disturbance and the type of management.

Succession:

A ruderal area may transition to any of the upland communities depending on the soil, hydrological regime, fire frequency, and source of vegetative propagules.

Identification and Photointerpretation:

Cleared and ruderal land may be old spoil piles, tilled areas, cut-over timber, drained marshes, etc. Past photos indicate that the area has been disturbed. Once it's revegetated it is considered cultural-ruderal until it transitions into another community.

Classification Schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Barren Land			Disturbed Land
		Agriculture	Cropland and Pastureland		Improved Pasture
					Unimproved Pastures
					Other Open Lands - Rural
				Tree Crops	Abandoned Groves
FFWCC	(Gilbert and Stys 2004)		Disturbed Communities	Transitional	Shrub and Brushland

					Grassland
					Bare Soil/Clearcut
				Agriculture	Improved Pasture
					Unimproved/Woodland Pasture
SFWMD	(Cameron et al. 2011)	Barren Land			Disturbed Land
		Agriculture	Cropland and Pastureland		Improved Pasture
					Unimproved Pasture
					Other Open Lands - Rural
				Tree Crops	Abandoned Groves
FLCCS	(Kawula 2014)	Uplands	Terrestrial	Cultural-Terrestrial	Mowed grass
					Rural Open
					Cropland/Pasture

Cultural – Spoil (1877)

Synonyms:

Spoil pile, dirt pile

Summary:

Elevated mounds created by human deposition of excavated soil or rocks.

Dominant Flora:

Spoil piles are classified as such only as long as they are barren.

Soils:

May be underlain by any soil. Community characteristics depend on the size of the pile, its materials, and its slope.

Succession:

The piles revegetate to cultural -ruderal, but may transition into another community over time.

Identification and Photointerpretation:

Spoil piles are often near the excavated area and are generally round and always elevated (Cameron et al. 2011).

Classification Schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Barren Land	Disturbed Lands		Spoil Areas
FFWCC	(Gilbert and Stys 2004)		Disturbed Communities	Mining	Extractive
SFWMD	(Cameron et al. 2011)	Barren Land	Disturbed Land		Spoil Areas
FLCCS	(Kawula 2014)	Uplands	Cultural - Terrestrial	Extractive	Spoil Area

Baygall (2231)

Synonyms:

bay gall, bayhead, bay swamp, sweetbay

Summary:

Evergreen forested wetland in a depression. Overstory of Loblolly bay, sweetbay, and/or Swamp bay. Diverse but indicative understory. Acidic peat soil.

Historical Descriptions:

Bernard Romans (1776, 31): "I ſhall next deſcribe the bay and cypreſs galls ; theſe interſect the pine lands, and are ſeldom of any breadth ; the bay galls are properly water courſes, covered with a ſpungy earth mixed with a kind of matted vegetable fibres ; they are ſo very unſtable […] their natural produce is a ſtately tree called loblolly bay, and many different vines, briars, thorny withs […] this ground is ſo replete with vitriolic principles, that the water ſtanding in them is impregnated with acid"

William Bartram (1791, 11, 173, 469): "Towards the evening we made a little party at fishing. We chose a shaded retreat, in a beautiful grove of magnolias, myrtles, and sweet bay trees […] then the path descends to a wet bay-gale; the ground a hard, fine white sand, covered with black slush, which continued above two miles […] several of his servants came home with horse loads of wild pigeons (Columba migratoria) [passenger pigeon, *Ectopistes migratorius*] which it seems that they had collected in a short space of time at a neighboring Bay swamp."

William H. Simmons (1822, 33): "[…] an immense cypress swamp, which presents a novel and picturesque object, from the amazing altitude of the trees, and the almost palpable darkness of its recesses, which, being thickly crowded with bays, has an unusually benighted and even awful appearance."

Charles Vignoles (1823, 76, 91): "The pine lands however are not all of the same elevated character : […] sometimes interspersed with cypress ponds and bay galls. […] While we are on the subject of wooded lowlands it may be observed, that in the pine lands, the early courses of the creeks and streams are through two sorts of channels, *bay galls* and *cypress* galls. The *bay galls* are spongy, boggy, and treacherous to the foot, with a coat of matted vegetable fibres : the loblolly bays spread their roots, and the saw palmetto crawls on the ground, making them altogether unpleasant and even dangerous to cross."

Eugene Allen Smith (1884, 28): "Galls or sour-lands are spongy tracts, where the water continually ooze through the soil and finally collect in streams and pass off. […] These galls are usually covered with titi (*Cliftonia ligustra*) [*Cliftonia monophylla*, buckwheat tree, black titi], loblolly bay, and others, vacciniums and vines."

George V. Nash (1895, 145–6): "The large swamps, lying generally along the low pine land, have a peculiar flora and one quite interesting. These are locally known as "bayheads," so called, I presume, from the large number of bay trees, *Magnolia Virginiana* [sweetbay], that occur in them. The shrubs most prominent are *Pieris nitida* [fetterbush, *Lyonia lucida*] and *Leucothoe racemose* [swamp doghobble, *Eubotrys racemose*]. *Gordonia Lasianthus* [loblolly bay], with its large white showy flowers, occurs in quantity along the margins. It ranges in height from ten to thirty feet, and when in full bloom is a very pretty sight. The plant most common, and which attracts the eye above all others, is the ever prevailing *Smilax laurifolia* [laurel greenbriar]. It climbs and clambers over all the shrubs and bushes, and makes the "bayheads" almost impenetrable."

Dominant Flora:

Swamp bay (*Persea palustris*), sweetbay (*Magnolia virginiana*), and loblolly bay (*Gordonia lasianthus*) with assorted vines.

Soils:

Peat-filled depressions, sometimes on deep sands.

1922 (Orange) – Norfolk fine sand (Ns), Portsmouth fine sand (Pf)
1960 (Orange) – Plummer fine sand (Pb), Rutledge fine sand (Ra), Rutledge mucky fine sand (Rc)
1979 (Osceola) – Hontoon muck (15), Samsula muck (40)
1989 (Orange) – Hontoon muck (19), Samsula muck (40)
2011/Present (Orange) – Hontoon muck (19), Samsula muck (40)
2011/Present (Orange) – Hontoon muck (19), Samsula muck (40)

Succession:

The bay species will spread from their roots and colonize other natural communities if fire does not regularly set them back (Casey and Ewel 2006). If the bay species' roots and the underlying peat are destroyed in a fire, the depression will be recolonized by grassy marsh, tupelo/cypress, or willow (*Salix caroliniana*; (Wade, Ewel, and Hofstetter 1980; Loftin 1998). The conditions that support bay swamps would be strongly modified by drainage canals in or anywhere upslope from them (Wharton et al. 1977).

Identification and Photointerpretation:

Baygalls are always small units on hillsides, in depressions in pine flatwoods, in ravines, or as strips along the edge of creeks. They are characterized by dense vegetation with overstory closure between 67 and 90%. Pines, particularly slash (*Pinus elliottii*) may be interspersed. There is a stippled texture of medium to tall dense trees. This community consistently appears bright scarlet red on Color Infra-Red (CIR) photos and dark green on natural color photos year-round (Cameron et al. 2011).

Classification Schemes:

Scheme	**Source**	**Top-Level**	**Mid-Level**	**Low-Level**	**Community Name**
US Census	(E. A. Smith 1884)		Long-Leaf Pine Region		Low hummocks
			Pitch pine, Treeless, and Alluvial Region	Swamps	Galls or sour lands
FGS	(Harper 1915)				Low Hammocks
Kuchler	(Kuchler 1964)				Southern Mixed Forest
Laessle	(Laessle 1942)		Hydric Communities Dominated by Trees	Bayhead	*Gordonia* [*G. lasianthus*]-*Tamala pubescens* [*Persea palistrus*]-*Magnolia virginiana* Association
Davis	(Davis 1967)				Swamp Forests, mostly of hardwoods
NWI	(Cowardin et al. 1979)		Palustrine	Forested Wetland	Broad-leaved evergreen
SAF	(Eyre 1980)				Sweetbay - Swamp Tupelo - Redbay
					Slash Pine - Hardwood
SCS	(USDA SCS 1981)				Wetland Hardwood Hammocks
Myers and Ewel	(Myers and Ewel 1990)		Swamps	Stillwater swamps	Bay swamp
FNAI	(FNAI 1990)		Palustrine	Seepage Wetlands	Baygall
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Wetlands		Wetland Hardwood Forests	Bay Swamps
FFWCC	(Gilbert and Stys 2004)	Wetlands	Palustrine		Bay Swamp
FNAI	(FNAI 2010)		Freshwater Forested Wetlands	Hardwood	Baygall
SFWMD	(Cameron et al. 2011)	Wetlands		Wetland Hardwood Forests	Bay Swamps
FLCCS	(Kawula 2014)	Wetlands	Palustrine	Freshwater Forested Wetlands	Baygall
					Bay Swamp

Common plant species:

Common Name	Botanical Name
loblolly bay	*Gordonia lasianthus*
sweetbay	*Magnolia virginiana*
swamp bay	*Persea palustris*
loblolly pine	*Pinus taeda*
slash pine	*P. elliottii*
pond pine	*P. serotina*
sweetgum	*Liquidambar styraciflua*
swamp tupelo	*Nyssa sylvatica* var. *biflora*
pond cypress	*Taxodium ascendens*
fetterbush	*Lyonia lucida*
laurel greenbriar	*Smilax laurifolia*
coral greenbriar	*S. walteri*
muscadine grape	*Vitis rotundifolia*
cinnamon fern	*Osmunda cinnamomea*
netted chain fern	*Woodwardia areolata*
Virginia chain fern	*W. virginica*
Sphagnum moss	*Sphagnum* spp.

Fauna: Baygalls provide forage, food, cover, and den/nest sites for most flatwoods animals, so instead of reiterating that here, the list will include the species that use baygalls the most.

Common Name	Zoological name
Florida black bear	*Ursus americanus floridanus*
Florida panther [federal endangered]	*Felix concolor coryi*
Southeastern shrew	*Sorex longirostris*
cotton mouse	*Peromyscus gossypinus*

yellow-rumped warblers	*Dendroica coronata*
pine warblers	*D. pinus*
limpkin	*Aramus guarauna*
white ibis	*Eudocimus albus*
glossy ibis	*Plegadis falcinellus*
wood storks [federal threatened]	*Mycteria americana*
short-tailed hawk	*Buteo brachyurus*
southern bald eagle	*Haliaeetus leucocephalus*
osprey	*Pandion haliaetus*
nonbiting midges	family Chironomidae

Swamp (2242)

Synonyms:

Hydric hammock, forested wetland, low hammock, cypress swamp, cypress dome

Summary:

Forested wetlands in depressions, along flow-ways, or along bodies of water. The soil is saturated and standing water is present much or all of the year.

Historical Descriptions:

Bernard Romans (1776, 27): "Swamps are alſo found of two kinds, river and inland ſwamps, thoſe on the river as eſteemed the moſt valuable, and the more ſo, in they are in the ride way, becauſe then the river water may be at pleaſure let on or kept out, with much leſs labour and expence than in the other kinds."

William Bartram (1791, 93): "After leaving this village, and coasting a considerable cove of the lake, I perceived the river before me much contracted within its late bounds,but still retaining the appearance of a wide and deep river, both coasts bordered, for several miles,with rich deep swamps, well timbered with Cypress, Ash, Elm, Oak, Hiccory, Scarlet Maple, Nyssa aquatic, Nyssa tupelo, Gordonia lasianthus, Corypha palma, Corypha pumila, Laurus Borbonia, &c."

William H. Simmons (1822, 6, 33): "a Cabbage Swamp, or region of low hammock, which might be easily drained and reduced to cultivation […] This district of country […] was terminated by an immense cypress swamp, which presents a novel and picturesque object, from the amazing altitude of the trees, and the almost palpable darkness of its recesses, which, being thickly crowded with bays, has an unusually benighted and even awful appearance."

Charles Vignoles (1823, 90–1): " The word *swamp* is, in the signification now adopted, peculiar to America ; by it is understood a tract of land lying low, but with a sound bottom, covered in rainy seasons and high water with that element. […] The *cypress galls* have firm sandy bottoms, and are only troublesome from the multitude of sprouting knees."

Eugene Allen Smith (1884, 24): "Along the margins of many of the lakes and streams of the longleaf pine regions, and in some of the low swampy areas not connected with any running water or lake, are the low hummocks, with cypress, cabbage palmetto, saw palmetto, hickory, liveoak, water oak, bay, evergreen, etc."

George V. Nash (1895, 108): "PLUCHEA LONGIFOLIA n. sp. (longleaf camphorweed) […] coming in an open swamp just back of Titusville, Brevard Co., No. 2293.In the field the tawny white pappus makes the plant very conspicuous."

Dominant Flora:

Conifers and hardwoods with a significant midstory of bushes and vines. Extensive plant list, please see *Common plants*.

Soils:

Poorly drained, very acidic mineral soils with minimal to several feet of muck accumulation.

1922 (Orange) – Peaty muck (Pm)
1960 (Orange) – Samsula muck (40), Sanibel muck (42)
1979 (Osceola) – Basinger fine sand, depressional (6), Samsula muck (40), Smyrna fine sand (42)
1989 (Orange) – Basinger fine sand, depressional (3), Samsula muck (40), Hontoon muck (19), Sanibel muck (42)
2011/Present (Orange) – Basinger fine sand, depressional (3), Hontoon muck (19), Samsula muck (40), Sanibel muck (42)
2011/Present (Orange) – Basinger fine sand, depressional (6), Hontoon muck (19), Samsula muck (40), Smyrna fine sand (42)

Succession:

The species distribution and diversity in a given swamp is dependent on hydroperiod, fire frequency, and organic matter accumulation (Ewel 1990). Because swamps come in so many varieties, it is not feasible to list each potential succession pathway.

Identification and Photointerpretation:

Swamps occupy low positions in the landscape. Since this community has such a variety of representations, its visibility on imagery is highly variable (Cameron et al. 2011). The characteristic overstory species, bald and pond cypress appear fluffy and gray-gray green on CIR photography.

Classification schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
US Census Bureau	(Eugene Allen Smith 1884)		Pitch pine, Treeless, and Alluvial Region	Swamps	Banks of rivers and lakes
					The pine barrens swamps
FGS	(Harper 1914)			West Florida lime-sink or cypress pond region	cypress pond
FGS	(Harper 1915)			Swamps and Streams	Swamp

				Low Hammocks	low hammock
Harshberger	(Harshberger 1914)				Low hammock
					cypress swamp
Laessle	(Laessle 1942)		Hammock Communities	Hydric Hammock	The *Quercus nigra-Liquidambar* [*L.styraciflua*]-*Sabal palmetto* association
			Hydric Communities Dominated by Trees	River Swamp	The *Taxodium distichum-Nyssa biflora* association
Kuchler	(Kuchler 1964)				Southern Mixed Forest
Davis	(Davis 1967)				Swamp forests, mostly of hardwoods
					Cypress swamp forests
NWI	(Cowardin et al. 1979)		Palustrine	Forested Wetland	Needle-leaved deciduous
			Lacustrine		Needle-leaved evergreen
SCS	(USDA SCS 1981)				Cypress swamp
					Swamp hardwoods
Myers and Ewel	(Myers and Ewel 1990)		Swamps	Stillwater swamps	Cypress pond
					Cypress savanna
					Cypress strand
					Hydric hammock
					Lake fringe swamp
			Temperate Hardwood Forests		Hydric hammock
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Wetlands	Wetland Hardwood Forests		Stream and Lake Swamps
					Inland Ponds and Sloughs
					Mixed Wetland Hardwoods
			Wetland Coniferous Forests		Cypress
					Pond Pine
					Cypress – Pine – Cabbage Palm

					Slash Pine Swamp Forest
			Wetland Forested Mixed		Wetland Scrub
FFWCC	(Gilbert and Stys 2004)	Wetland Plant Communities	Palustrine		Shrub Swamp
					Cypress Swamp
					Cypress/Pine/Cabbage Palm
					Mixed Wetland Forest
					Hardwood Swamp
SFWMD	(Cameron et al. 2011)	Wetland	Wetland Hardwood Forests	Mixed Wetland Hardwoods	Mixed Shrubs
				Cabbage Palm Wetland	
			Wetland Coniferous Forests	Cypress	Cypress Domes/Heads
					Cypress Mixed Hardwoods
				Cypress – Pine – Cabbage Palm	
				Wet Pinelands – Hydric Pine	
			Wetland Forested Mixed		
FLCCS	(Kawula 2014)	Wetlands	Palustrine	Freshwater Forested Wetlands	Cypress/Tupelo
					Dome Swamp
					Stringer Swamp
					Basin Swamp
					Strand Swamp
					Floodplain Swamp
				Other Coniferous Wetlands	Cabbage Palm Hammock
					Mixed Wetland Hardwoods
				Other Wetland Forested Mixed	Cypress/Hardwood Swamps
					Cypress/Pine/Cabbage Palm

Common plant species:

Common Name	**Botanical Name**
bald cypress	*Taxodium distichum*
pond cypress	*T. ascendens*
pond pine	*Pinus serotina*
slash pine	*P. elliottii*
pond pine	*P. serotina*
southern red cedar	*Juniperus silicola*
southern red maple	*Acer rubrum*
pignut hickory	*Carya glabra*
sweetgum	*Liquidambar styracuflua*
loblolly bay	*Gordonia lasianthus*
southern magnolia	*Magnolia grandiflora*
sweet bay	*M. virginiana*
swamp laurel oak	*Quercus laurifolia*
water oak	*Q. nigra*
black tupelo	*Nyssa sylvatica*
water tupelo	*N. aquatica*
Ogeechee lime	*N. ogeche*
sabal palm	*Sabal palmetto*
dwarf palmetto	*S. minor*
buttonbush	*Cephalanthus occidentalis*
sweet pepperbush	*Clethra alnifolia*
gallberries/haws/hollies	*Ilex* spp.
lyonias	*Lyonia* spp.
wax myrtle	*Myrica cerifera*

northern bayberry	*M. heterophylla*
wild coffee	*Psychotria* spp.
elderberry	*Sambucus canadensis*
blueberries	*Vaccinium* spp.
viburnums/haws	*Viburnum* spp.
strangler fig	*Ficus aurea*
yellow jessamine	*Gelsemium sempervirens*
grapes	*Vitis* spp.

Fauna:

The same animal species use swamp as use baygall. Please refer to the Fauna section of Baygall.

Cultural – Palustrine (2400)

Synonyms:

Manmade wetland

Summary:

Herbaceous wetlands that are noted for their fluctuating water levels, frequent fires, and mineral-rich water. Occurring anywhere people dug them out or impounded water for them.

Dominant Flora:

Plant species will vary widely depending on water level, wetland size, connection to other water bodies, and invasive species introduced. Expect plants on the *Common plant species* list in Marsh (21212).

Soils:

May be underlain by muck or sand. If soil was mined the muck or the sand could have been removed. No consistent soils are able to be listed

Succession:

A manmade wetland is subject to the same succession factors as a natural wetland is.

Identification and Photointerpretation:

Manmade wetlands are borrow areas that have filled with water and revegetated with emergent aquatic vegetation. The textures and colors will be similar to Marsh (Cameron et al. 2011).

Classification Schemes:

Scheme	**Source**	**Top-Level**	**Mid-Level**	**Low-Level**	**Community Name**
NWI	(Cowardin et al. 1979)		Lacustrine	Unconsolidated Bottom	Excavated
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Barren Land	Disturbed Land		Spoil Areas
FFWCC	(Gilbert and Stys 2004)		Disturbed Communities	Mining	Extractive
SFWMD	(Cameron et al. 2011)	Barren Land	Disturbed Land		Borrow Areas
FLCCS	(Kawula 2014)	Wetlands		Lacustrine	Cultural - Lacustrine

Lake (3100)

Note: Limnology is a deep and fascinating field and I'm not capable of giving it the treatment it deserves in this section. Since this schema doesn't differentiate between any types of lake, the two open water bodies larger than 0.4 ha were called lakes.

Synonyms:

lake

Summary:

Bodies of open water, usually larger than 0.4 ha, that may have some emergent vegetation in the shallow areas and are often ringed by marshes, swamps, and baygalls.

Dominant Flora:

Lakes in Florida support many species of phytoplankton. Invasive aquatic plants dominate most Florida lakes at present. Hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*) choke many nutrient-laden lakes (and streams and ponds).

Soils:

May be underlain by muck or sand. Sedimentation depends on water fluctuation and nutrient inflows.

1922 (Orange) – Lake name
1960 (Orange) – Water
1979 (Osceola) – Water (99)
1989 (Orange) – Water (99)
2011/Present (Orange) – Water (99)
2011/Present (Osceola) – Water (99)

Succession:

Lakes may form if an outflow is dammed or a low area is shunted water. Lakes recede if drained and could be drained enough that they transition to marshes, swamp, or even an upland community. Lake levels are highly correlated with water levels in artesian well and therefore with the aquifer levels (Deevey 1988; Brenner, Binford, and Deevey 1990).

Identification and Photointerpretation:

Natural lakes have curved shorelines and usually very low reflectance if not eutrophic or hypereutrophic. The natural lakes on the property have all been drained and have control structures. Undrained lakes will show evidence of fluctuating water levels (Cameron et al. 2011).

Cultural – Lacustrine (3200)

Synonyms:

Manmade lake, mine

Summary:

Bodies of open water that were not open water until excavated by people to a depth that prevents emergent aquatic vegetation from growing.

Dominant Flora:

Just like natural lakes, manmade lakes in Florida support many species of phytoplankton. Invasive aquatic plants may dominate manmade lakes. Hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*) choke many nutrient-laden lakes (and streams and ponds).

Soils:

May be underlain by muck or sand. Sedimentation depends on water fluctuation and nutrient inflows.

1922 (Orange) – Lake name
1960 (Orange) – Water
1979 (Osceola) – Water (99)
1989 (Orange) – Water (99)
2011/Present (Orange) – Water (99)
2011/Present (Osceola) – Water (99)

Succession:

Manmade lakes would recede if drained and could be drained enough that they transition to marshes, swamp, or even an upland community. Manmade lake levels correlate with groundwater levels, which are affected by soil type, depth to restrictive layer, local rainfall, and aquifer levels. A shallow manmade lake could sediment and become a manmade wetland (cultural – palustrine).

Identification and Photointerpretation:

Manmade lakes will appear to have straight or blocky shorelines and are often accompanied by dykes, impoundments, control structures, and spoil piles (Cameron et al. 2011).

Classification Schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
NWI	(Cowardin et al. 1979)		Lacustrine	Unconsolidated Bottom	Excavated
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Barren Land	Disturbed Land		Spoil Areas
FFWCC	(Gilbert and Stys 2004)		Disturbed Communities	Mining	Extractive
SFWMD	(Cameron et al. 2011)	Barren Land	Disturbed Land		Borrow Areas
		Water			Reservoirs
FLCCS	(Kawula 2014)	Wetlands		Lacustrine	Cultural - Lacustrine

Marsh (21212)

Synonyms:

Grassy marsh, basin marsh, depression marsh, wet prairie, sawgrass marsh, freshwater marsh, flatwoods marsh, savanna

Summary:

Wetlands dominated by herbaceous plants that are rooted in standing water most of the year. Community is dfor their fluctuating water levels, frequent fires, and mineral-rich water. Occurring anywhere local topography, hydrology, and impermeable soils allow; often on depressions and floodplains.

Historical Descriptions:

Bernard Romans (1776, 30–1): “The marſhes are next to be conſidered, they are of four kinds, two in the ſalt, and two in the ſreſh water ; they are either ſoft or hard, the ſoft marſhes conſiſting of a very wet clay or mud, are as yet of no uſe, without a very great expence to drain them ; the hard ones are made up of a kind of marly clay, which in dry ſeaſons is almoſl burned up, true it is they afford a paſture ſuſſicient to keep any gramenivorous animals in good order; […] The marſhes on freſh water are in every reſpect ſimilar to thoſe on the ſalt, except, that they are not impregnated with the ſaline particles, of which the ſirſt are very replete, therefore the hard ones, with little trouble, are adapted to cultivation; the ſoft ones coſt a conſiderable deal more of expence, to render them fit to anſwer this purpoſe, but when ſo drained as to anſwer this end, they certainly are by no means inferior to any land in this country ; in the lower part of theſe marſhes grows a kind of hitherto undeſcribed grain, of which the weſtern Indians make a great uſe for bread.”

William Bartram (1791, 181): “We now rise a little again, and pass through a narrow Pine forest, when suddenly opens to view, a vastly extensive and sedgy marsh, expanding Southerly like an open fan, seemingly as boundless as the great ocean: our road crossed the head of it, about three hundred yards over, the bottom here, was hard sand, a foot or more under a soft muddy surface”

William H. Simmons (1822, 36): “The Ocklewaha [Ocklawaha river, ~60km NW of the site], runs, for a great part of its course, though a fresh marsh, which is very wide in many places, and would afford fine rice fields, if sufficient embankments can be formed against the inundations of the river.”

Charles B. Vignoles (1823, 91): “The *fresh water marshes* are of two kinds, *hard* and *soft* ; the *hard marsh* is made up of a kind of marly clay whose soil has too much solidity for the water to disunite its particles : and therefore, being also generally higher above the water,may be with little trouble adapted to proper cultivation : the *soft marshes* lie lower and are more subject to overflow and require in the embankments, earth from the high land to make them substantial, and consequently are more expensive in their redemptions ; but this once accomplished they are undoubtedly the most fruitful ; affording in the dry culture means of raising sugar, hemp, corn, cotton, and indigo."

Eugene A. Smith (1884, 28): "On the peninsula, and especially in the lower part, where the limestone is close to the surface and the soil thin, there are large areas of treeless country, called prairies, and, when rather wet, savannahs. Savannas are no more than natural reservoirs, like swamps, except that they are covered with grass and herbs instead of with trees and vines. They are usually founded on clay or marl, but sometimes on hard sand. There are frequently extensive, and form excellent grazing land."

Dominant Flora:

Marshes are dominated by flooding-tolerant herbaceous broadleaf species such as white water lilies (*Nymphaea odorata*), cattails (*Typha* spp.), maidencane (*Panicum hemitomon*), and grasses like sawgrass (*Cladium jamaicense*), muhlygrass (*Muhlenbergia filipes*), and cordgrass (*Spartina bakeri*).

Soils:

Poorly drained mucky soils.

1922 (Orange) – Portsmouth fine sand (Ps), Peat (P), Muck (M)
1960 (Orange) – Everglades mucky peat, shallow (Ec)
1979 (Osceola) – Basinger fine sand, depressional (6), Samsula muck (40), Smyrna fine sand (42)
1989 (Orange) – Basinger fine sand, depressional (3), Samsula muck (40), Hontoon muck (19), Sanibel muck (42)
2011/Present (Orange) – Basinger fine sand, depressional (3), Hontoon muck (19), Samsula muck (40), Sanibel muck (42)
2011/Present (Orange) – Basinger fine sand, depressional (6), Hontoon muck (19), Samsula muck (40), Smyrna fine sand (42)

Succession:

Marsh-adapted herbaceous species are adapted to narrow ranges of hydroperiods and fire frequencies. This leads to seasonal dominance and flowering that is dependent on water level. Long hydroperiod species like sawgrass, pickerelweed, arrowhead, and maidencane diminish when marshes are drained. These species are also very competitive following fire. Drainage and reduction in fire frequency leads to the invasion of wax myrtle, buttonbush, and woody species within ten years (Kushlan 1990). Of course, marshes are not exempt from primary succession due to sedimentation. Their organic soil layers may also be destroyed by smoldering muck fires.

Identification and Photointerpretation:

Marshes occupy low positions on the landscape and are often drained by people. They also usually have lower reflectivity on both CIR and true color photos. Less diverse sawgrass and cattail marshes appear smooth while more diverse assemblages may have heterogeneous textures and colors.

Classification schemes:

Scheme	Source	Top-Level	Mid-Level	Low-Level	Community Name
US Census	(Eugene Allen Smith 1884)		Pitch pine, Treeless, and Alluvial Region	Prairies and savannas	savannas
				Marshes	fresh
FGS	(Harper 1915)			East Florida Flatwoods	Ponds
					Marshes
Harshberger	(Harshberger 1914)				Freshwater Marsh
Laessle	(Laessle 1942)		Flatwoods Communities of Poorly Drained Soils	The Grassy Pond-Margins	The *Spartina bakeri* Association of Pond Margins
					The *Andropogon brachystachys* [*A. brachystachyus*]-*A. capillipes* [*A. virginicus* var. *glaucus*] Association
			Herbaceous Communities of Flatwoods Ponds and Bogs		The *Castalia lekophylla* [*Nymphaea odorata*] Association
					The *Panicum hemitomon* Association
					The *Pontederia lanceoloata* [*Pontederia cordata*] Association
					The *Anchistea* [*Woodwardia virginica*]-*Sphagnum* Association
Kuchler	(Kuchler 1964)				Southern Mixed Forest
Davis	(Davis 1967)				Fresh Water Marshes
NWI	(Cowardin et al. 1979)		Palustrine	Emergent Wetland	Persistent
				Scrub-Shrub Wetland	Broad-leaved deciduous
					Broad leaved evergreen

SCS	(USDA SCS 1981)				Freshwater Marshes and Ponds
					Slough
Myers and Ewel	(Myers and Ewel 1990)	Freshwater Wetlands and Aquatic Ecosystems	Marshes		Water lily
					Submersed
					Cattail
					Flag
					Saw grass
					Wet prairie
FNAI	(FNAI 1990)		Palustrine	Floodplain Wetlands	Slough
				Basin Wetlands	Basin Marsh
					Depression Marsh
FLUCCS	(FDOT Surveying and Mapping Office 1999)	Wetlands		Vegetated Non-Forested Wetlands	Freshwater Marshes
					Wet Prairies
					Emergent Aquatic Vegetation
FFWCC	(Gilbert and Stys 2004)	Wetlands	Palustrine		Freshwater Marsh and Wet Prairie
					Sawgrass Marsh
					Cattail Marsh
FNAI	(FNAI 2010)		Freshwater non-Forested Wetlands	Marshes	Depression Marsh
					Basin Marsh
					Slough Marsh
SFWMD	(Cameron et al. 2011)	Wetlands		Vegetated Non-Forested Wetlands	Freshwater Marshes/Graminoid Prairie-Marsh
FLCCS	(Kawula 2014)	Wetlands	Palustrine	Freshwater Non-Forested Wetlands	Prairies and Bogs
					Wet Prairie
					Marshes – Depression Marsh, Basin Marsh, Slough

Common plant species:

Common Name	**Botanical Name**
white water lily	*Nymphaea odorata*
neverwet	*Orotium aquiaticum*
yellow lotus	*Nelumbo lutea*
naiad	*Najas guadalupensis*
bladderwort	*Urtricularia* spp.
pondweed	*Potamogeton* spp.
cattail	*Typha* spp.
pickerelweed	*Pontederia lanceolata*
arrowhead	*Sagittaria latifolia*
spikerush	*Eleocharis* spp.
maidencane	*Panicum hemitomon*
blue maidencane	*Amphicarpum muhlenbergianum*
fire flag	*Thalia geniculata*
bulrush	*Scirpus* spp.
Tracy's beakrush	*Rynchospora tracyi*
sawgrass	*Cladium jamaicense*
muhlygrass	*Muhlenbergia fillips*
cordgrass	*Spartina bakeri*
torpedograss	*Panicum repens*
smartweed	*Polygonum* spp.
white-topped sedge	*Dichromena colorata*
St. John's wort	*Hypericum fasciculatum*
primrose willow	*Ludwigia repens*

string lily	*Crinum americanum*
cutgrass	*Leersia hexandra*
cutthroat grass	*Panicum abscissum*
rush	*Juncus acuminatus*
rush	*J. effusus*
horsehair sedge	*Eleocharis equisetoides*
swamp hibiscus	*Hibiscus grandiflorus*
redroot	*Lachnanthes caroliniana*
yellow-eyed grass	*Xyris* spp.

Flora:

Common Name	**Zoological name**
white-tailed deer	*Odocoileus virginianus*
Florida panther [federal endangered]	*Felix concolor coryi*
Florida alligator	*Alligator mississipiensis*
green water snake	*Nerodia cyclopion*
swamp snake	*Seminatrix pygaea*
cottonmouth	*Agkistrodon piscivorus*
mud snake	*Kinosternon bauri*
mud turtle	*Sternotherun odoratus*
Florida cooter	*Chrysemys floridana*
chicken turtle	*Deirochelys reticularia*
apple snail	*Pomacea paludosus*
livebearing mosquitofish	*Gambusia affinis*
least killfish	*Heterandria formosa*

golden topminnow	*Fundulus chrysotus*
dollar sunfish	*Lepomis marginatus*
leopard frog	*Rana sphenocephala*
pig frog	*R. grylio*
fire-bellied newt	*Notophthalamus viridescens*
least bittern	*Ixobrychus exilis*
American bittern	*Botaurus lentiginosus*
green-backed heron	*Butorides striatus*
limpkin	*Aramus guarana*
marsh wren	*Cistothorus palustris*
snail kite	*Rostrahamus sociabilis*
wood stork [Federal endangered]	*Mycteria americana*
sandhill cranes [Federal endangered]	*Grus canadensis pratensis*
fulvous whistling duck	*Dendrocygna bicolor*
mottled duck	*Anas fulvigula*
canvasback duck	*Aythya valsineria*
Carolina wren	*Thryothorus ludovicianus*
Cardinal	*Cardinalis cardinalis*
red-shouldered hawk	*Buteo lineatus*