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Regulatory Methodology and Unmitigated Wetland Loss in Southwest Florida

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by

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DEDICATION

This thesis is dedicated to my mother, Nancy Black, who helped cultivate my love of the environment and showed me that with hard work comes great satisfaction. As a unique, successful, independent woman, she has been a role model for me throughout my life. I also dedicate this thesis to my husband, Josh, who encouraged and supported me throughout the process of pursuing a master's degree while working full time and having a newborn. Thirdly, I dedicate this thesis to my godmother, Devri Smith, who arrived in Tampa during the last month of my thesis work to help me with my newborn baby and household chores so that I could complete this research on time for a summer graduation. Lastly, I dedicate this thesis to my beautiful newborn daughter, Claire, who I hope will be able to experience and appreciate nature as I did growing up. May she be inspired to make a difference, and may she accomplish her own goals as I am accomplishing mine.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This research used Geographical Information System (GIS) data to estimate the acreage of wetland loss due to small-scale activities (taking into account exempt, permitted, and unauthorized activities) in the Southwest District of the Department of Environmental Protection (DEP) between 2006 and 2011 and compared that net loss with the unmitigated wetland net loss that DEP documented during that time for authorized activities and violations that were discovered. The comparison allowed an estimation of the extent of undocumented small-scale unmitigated wetland loss that occurred during those six years. DEP records show that 88% of non-compliance cases remain unresolved, and the net loss of wetlands that was documented by DEP is 28.66 acres. The change in acreage of DEP-regulated wetlands (and wetlands on agricultural parcels) as determined by GIS analysis is 1,250 acres gained. However, evidence shows that some of the water features categorized as wetlands in the GIS interface are reservoirs which may not be providing the functions necessary to mitigate for wetland loss. Evidence also shows that many small-scale wetland alterations were not detected by remote sensing, indicating that there is a great level of uncertainty in the GIS interpretation. Consequently, achievement of the No Net Loss goal in Florida cannot be determined using documented alterations, nor can it be determined by use of medium-high resolution aerial imagery. The analysis can be extrapolated to the rest of Florida, where State wetland protection regulations are constant.

CHAPTER 1: INTRODUCTION

1.1 Motivation, Objectives, and Hypothesis

As this thesis will compare the spatiotemporal relationships between small-scale non-mitigated development and degradation of wetlands in Southwest Florida, an overview of the value of wetlands will first be provided. Wetlands play a vital role in providing flood control, water quality improvement through natural filtration, and valuable habitat. Of the 20.32 million acres of wetlands that historically covered Florida (Dahl et. al, 1991), the state has lost approximately ten million acres of wetlands within the last 200 years (University of Florida, 2006). Development has caused a significant increase in the amount of impervious surface area in Florida, reducing the amount of water that can percolate through the soil and back into the aquifer (Brody et. al, 2007[2]). Impacts of wetland alterations have included flooding, impaired water quality, forest fires, and loss in biodiversity (USDOI & USFWS, 2005).

Wetlands filter contaminants which would otherwise degrade surface waters and potentially pose a health threat to wildlife and humans (Mitsch & Gosselink, 2007). One of the major sources of water pollution is stormwater runoff, which can contain oils, greases, pathogens, heavy metals, nutrients, fertilizers, and pesticides. Some of these discharges are toxic at low concentrations, while others promote eutrophication and growth of nuisance vegetation and algae which may lead to dead zones (USDOI & USFWS, 2005). Many of these contaminants are attached to sediment particles. A study by Arias et. al (2013), for instance, showed that although stormwater treatment systems are designed for a particular sediment removal efficiency, the system in a residential catchment in Gainesville, Florida proved to be significantly

less efficient at removing sediments than the estimated design. This supports a need for improvements to the stormwater treatment approach in Florida (Arias et. al, 2013).

Wetlands are essential for collecting and storing excess stormwater runoff, which protects upland areas from flooding. They allow aquifer recharge through infiltration, and coastal wetlands absorb energy from waves, protecting Florida's shorelines from erosion (USDOI & USFWS, 2005). Many wetland-reliant species support Florida's commercial fishing, tourism, and recreation industries (USDOI & USFWS, 2005). Wetlands protect the value of waterfront property, both in the manner mentioned above (providing flood protection and habitat) but also by providing the aesthetic component that makes the properties more valuable than their counterparts. Alterations to wetlands and other surface waters can impact hydrology of adjacent properties, causing pollution, erosion, sedimentation, flooding, or drought (USDOI & USFWS, 2005).

Although many aspects of wetland regulation in Florida have been extensively researched and discussed in articles such as Levrel et al. (2017), Pittman & Waite (2009), and Staff & Losses (2001), the overall goal of this thesis is to provide insight into certain aspects for which data and analysis on wetland loss have not yet been provided. Previous research on wetland loss has addressed mitigation (Goldberg & Reiss, 2016), ecological implications (Stelk et al. (2017), wetland function (Brody et al., 2007[1]), and political constraints (Pittman & Waite, 2009). Most research regarding wetland loss in Florida appears to focus on large development sites permitted by the Water Management Districts or the U.S. Army Corps of Engineers, and tends to analyze the effectiveness of mitigation. However, small-scale development (the types of properties that are regulated by the Florida Department of Environmental Protection (DEP)) is excluded in most research, as well as projects for which wetland impacts were authorized without requiring

mitigation. The term “small-scale” will be described in Section 1.3. Additionally, previous research tends to delve into the permitting aspect of wetland regulation more than the enforcement aspect.

This thesis focuses on the types of activities that are not addressed in previous research: DEP-regulated activities (typically small-scale) that resulted in wetland loss but did not require mitigation, with an emphasis on unauthorized activities while still addressing authorized activities. Mitigation is a term used to describe efforts to offset wetland degradation, and will be discussed in further detail in Section 1.2. Certain types of wetland alteration do not require compensatory mitigation, a concept that will be discussed in Section 1.4. This research will determine how far DEP-jurisdictional properties (usually single-family properties that are not part of a larger community) in the Southwest District of DEP have been from the No Net Loss of wetlands goal between 2006 and 2011, and will assess the major barriers to achieving that goal. The ***objectives*** of this thesis are to:

1. Determine the number of small-scale unmitigated wetland violations that were discovered per county per year between 2006 and 2011 in the Southwest District, the percentage of cases unresolved, and the net acreage of wetland loss documented by DEP.
2. Estimate the acreage of small-scale unmitigated wetland loss in the region between 2006 and 2011 using aerial imagery data provided by the Southwest Florida Water Management District, and compare loss by county.
3. Compare the documented acreage of small-scale unmitigated wetland loss with the estimation of loss by aerial interpretation of the region in order to evaluate the approximate amount of small-scale unmitigated wetland loss that is undocumented. Use

the information collected to analyze the effectiveness of regulatory methodology in Florida in achieving the No Net Loss goal, specifically for small-scale activities.

The analyses within this thesis are limited to the DEP's Southwest District, shown in Figure 1.1, because the population growth and urbanization trends in this region are comparable to the rest of the state, and because this region contains counties that are both delegated and non-delegated to conduct Environmental Resource Permitting on behalf of the State. The term "delegated" means that these county governments are authorized to conduct State regulatory activities using State regulations and procedures; therefore, in delegated counties the State of Florida does not conduct the delegated activities. The Southwest District of DEP includes Citrus, Hernando, Pasco, Hillsborough, Pinellas, Polk, Manatee, and Hardee counties. In the Southwest District of DEP, the only county delegated to conduct Environmental Resource Permitting on behalf of the State is Hillsborough County. Southwest Florida contains a large variety of land use types including urban, suburban, rural, coastal, inland, and agricultural areas, so this region was selected with the hope that the results are applicable to the rest of the state.

The timeframe of 2006-2011 was chosen because the Land Use Land Cover Geographic Information System (GIS) layers provided by the Southwest Florida Water Management District were collected during that time frame, and will allow a good comparison between acreage of wetlands lost as measured using photo-interpreted delineations from aerial imagery to assess land cover change, with acreage of wetlands lost as documented by the DEP. The time period will allow an analysis of the effectiveness of the enforcement aspect of the Environmental Resource Permitting program, which since 1995 has been the statewide regulatory program which guides permitting and enforcement of wetland alteration.

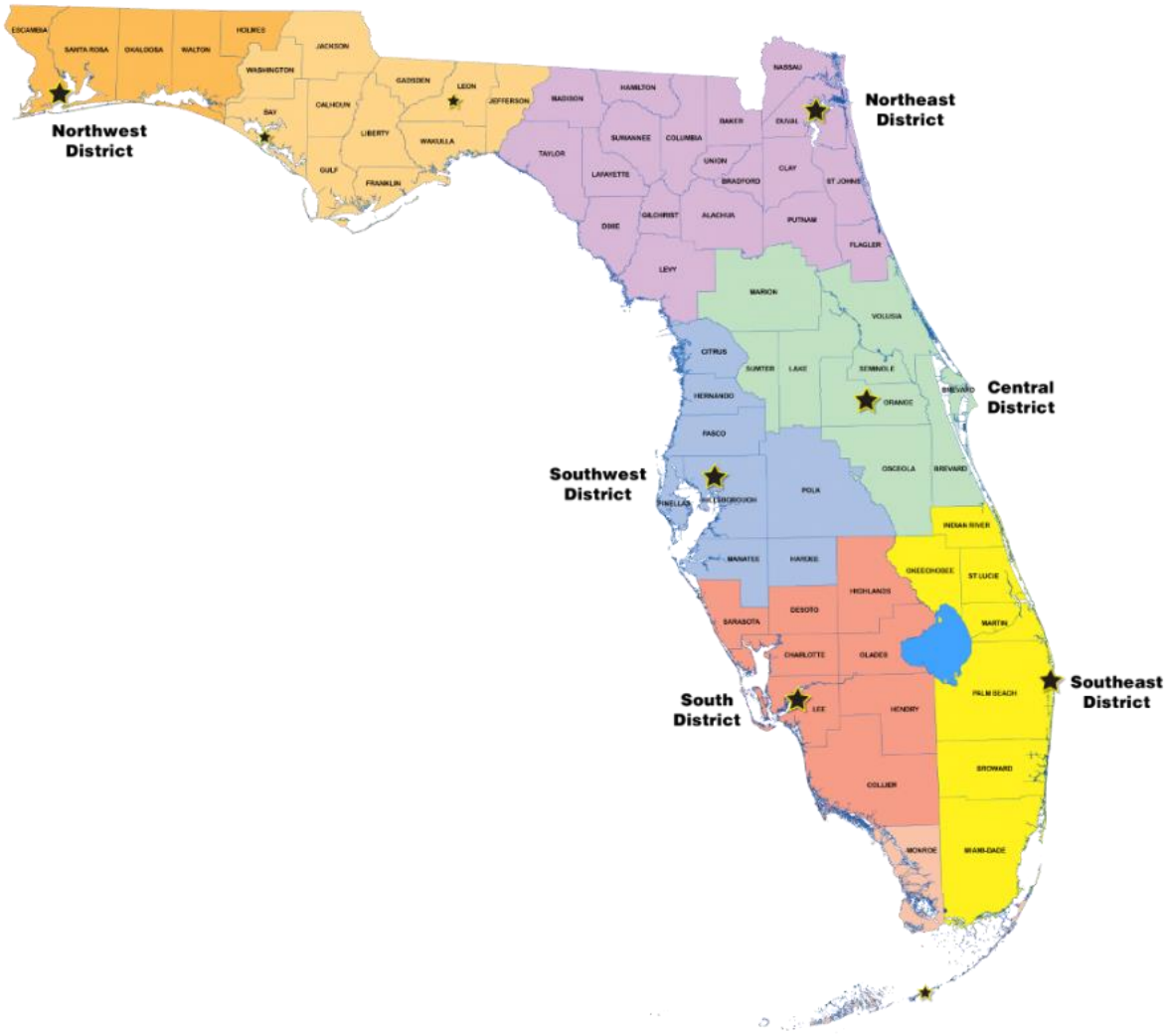

Figure 1.1 Boundary Map of DEP Southwest District. The boundary is represented by the light blue area (not including the blue depiction of Lake Okeechobee). This image is in the Public Domain (Florida Department of Environmental Protection, 2018[1]).

These data will include an assessment of wetland habitat alterations caused by violations discovered. Aerial interpretation will be conducted by overlaying existing GIS layers to show wetland loss and eliminating areas where wetlands are jurisdictional to the Water Management Districts, in order to estimate the total wetland loss due to DEP-jurisdictional and agricultural development activities (taking into account both authorized/exempt and unauthorized activities) and comparing that net loss with the unmitigated wetland loss that DEP has on file for permitted

activities and violations that have been discovered. That will allow an estimation of the extent of untracked wetland losses that are occurring versus the losses that are being documented by regulatory agencies through the permitting and compliance/enforcement programs, and will be further analyzed by county. These data will allow an assessment of the permitting and enforcement of wetland alteration activities relating to small-scale development and how that has affected the No Net Loss goal. The types of wetlands that this research focused on account for approximately 80% of all wetlands in the District, as found through the analyses in this thesis (discussed in Section 4.2).

In discussing types of authorized unmitigated wetland alteration, rules such as the agriculture/silviculture exemption and the general permit for minor works in isolated wetlands will be addressed; these are types of activities that do not require mitigation to compensate for wetland loss. All of this information will be used to analyze the effectiveness of wetlands permitting according to the state regulations and how that has affected the No Net Loss goal. Lastly, this thesis will provide a comparison between Hillsborough County (the county delegated to carry out state wetland regulations) versus the seven non-delegated counties in order to determine where more wetland loss is occurring.

This information will support the analysis of how regulatory methodology is affecting the No Net Loss goal. The final analysis will determine how far small-scale non-mitigated development in the Southwest District has been from the No Net Loss of wetlands goal between 2006 and 2011, and will assess the major barriers to achieving that goal. The ***hypothesis*** of this research is that the region has experienced more of a net loss of wetlands due to small-scale activities than state records indicate, and that the delegated county experienced less small-scale unmitigated wetland loss than non-delegated counties.

1.2 Background of the No Net Loss Goal

The No Net Loss of wetlands goal was established in 1989 under the President George H.W. Bush administration, after being recommended at the National Wetlands Policy Forum in 1987 (USEPA, 2017[1]). The goal intends mitigation activities to compensate for any wetlands lost to permitted activities, and intends that wetlands are not lost due to unpermitted activities, which should lead to zero overall net loss of wetlands in the United States. The Clean Water Act (CWA) was intended to be the mechanism for meeting this goal. The CWA was enacted in 1972 as a national regulatory standard for the protection of the nation's waters. Section 404 of the CWA regulates the dredging and filling of wetlands and other surface waters. It requires that a permit is obtained before any dredging or filling activities occur in waters of the United States, unless the activity is exempt from permitting or unless the receiving waters would be significantly degraded (USEPA, 2017[1]). Therefore, applicants must show that steps have been taken to minimize or avoid impacts to wetlands and other surface waters before requesting authorization to dredge or fill.

Compensatory mitigation is required for unavoidable impacts. This means that any wetlands lost must be replaced with restored wetlands, created wetlands, enhanced wetlands, or preserved existing wetlands. The following activities are exempt from permitting under Section 404 of the CWA: farming, ranching, and silviculture activities, maintenance of drainage ditches, construction and maintenance of irrigation ditches, construction and maintenance of farm or stock ponds, construction and maintenance of farm and forest roads, and maintenance of structures such as dams, dikes, and levees (USEPA, 2017[1]).

1.3 Regulatory Authority in Florida

The agency responsible for carrying out the permitting and enforcement of Section 404 nationwide is U.S. Army Corps of Engineers (USACE), a federal agency. However, in the state of Florida, three agencies share the responsibility of regulating wetland alterations – the USACE, the Florida Department of Environmental Protection (DEP), and the Water Management Districts (WMDs). These agencies have a complex operating framework which allows regulatory jurisdiction over all wetlands and surface waters, but not typically by all three agencies simultaneously. DEP is a state agency which, among many other responsibilities, must regulate activities in, on, or over surface waters and certain activities in uplands (non-wetland areas) that affect hydrology due to stormwater runoff. The WMDs, which regulate similar activities, are a combination of five districts belonging to a single agency governed by state regulations and managed by a governing board appointed by the governor in four-year terms.

The state is divided into Northwest Florida Water Management District (NWFWMD), the St. Johns River Water Management District (SJRWMD), the Southwest Florida Water Management District (SWFWMD), the South Florida Water Management District (SFWMD), and the Suwannee River Water Management District (SRWMD). This thesis will be using GIS data collected by SWFWMD, and it is important to note that the geographical range of the Southwest District of DEP and that of SWFWMD are slightly different. DEP uses county lines as district boundaries, whereas SWFWMD extends further south than Manatee County, further north than Citrus County, and does not include the southeast portion of Polk County, as shown in Figure 1.2.

Figure 1.2 Boundary Map of SWFWMD. This image is in the Public Domain (Southwest Florida Water Management District, 2018).

While the USACE is governed by federal regulations, DEP and the WMDs are governed by state regulations, which can be more or less stringent depending on the section. For instance, the USACE is more stringent when it comes to activities that could impact listed species, such as manatees, bald eagles, or Johnson's seagrass. However, under Sections 301 and 502 of the Clean Water Act, only dredging or filling "waters of the United States" is prohibited unless authorized

by a USACE permit pursuant to Section 404. It is important to note that jurisdictional "waters of the U.S." are interpreted to not include geographically isolated wetlands, and are instead interpreted to include waters that are navigable or waters that are directly connected to a navigable water. Therefore, the state regulations used by DEP and the WMDs are arguably more stringent when it comes to dredging and filling wetlands. If the state agencies were not responsible for regulating isolated wetlands, much of Florida's wetlands would be non-jurisdictional to a regulatory agency and many dredging and filling activities would remain unregulated, as is the case in certain other states. USACE jurisdiction is depicted in Figure 1.3.

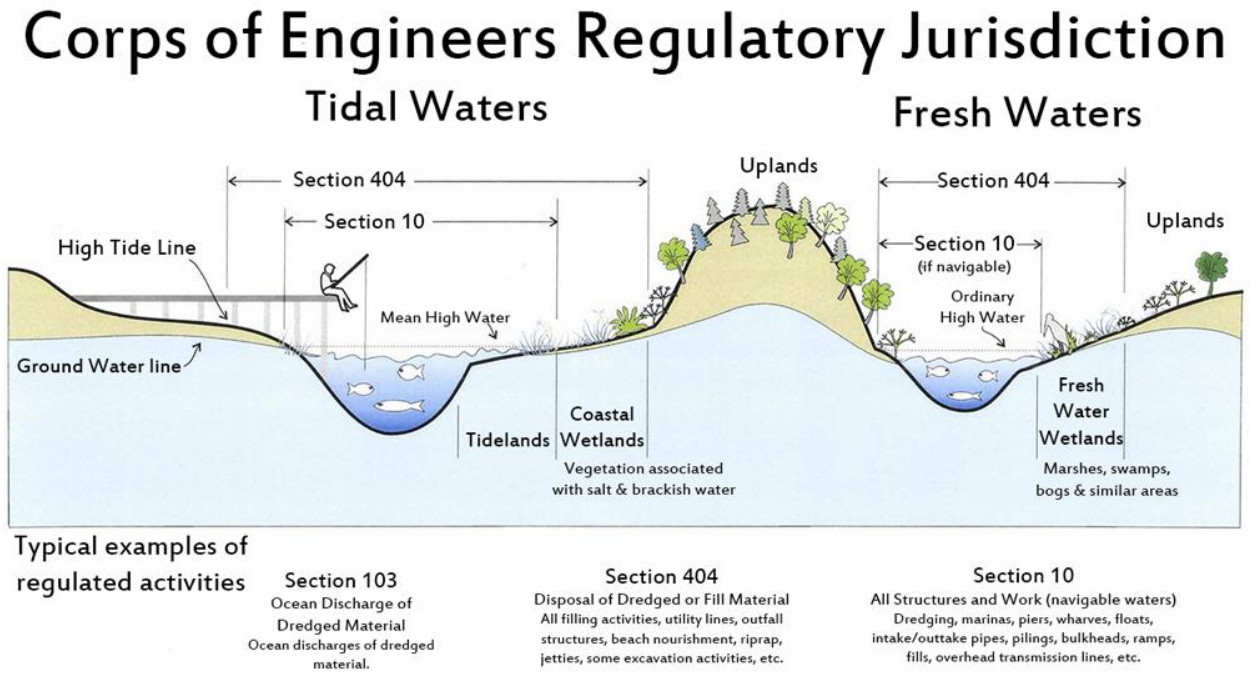

Figure 1.3 USACE Regulatory Jurisdiction. This image is in the Public Domain (USACE, 2018).

Better protection of geographically isolated wetlands has been shown to be imperative nationwide, outlined by sources such as Cohen et al. (2016) and Creed et al. (2017). According to Cohen et al. (2016), these types of ecosystems are hydrologically and biochemically

connected via groundwater despite the lack of permanent surface water connections. Isolated wetlands provide landscape functions such as flow generation, nutrient and sediment retention, biodiversity support, and habitat networks – but despite preferential loss of this type of landscape through development, legal protections remain weak nationwide (Cohen et al., 2016). Creed et al. (2017) asserts that impermanent wetlands outside of floodplains are particularly vulnerable to destruction, and that scientific evidence compels enhanced protection of these freshwater systems. As shown in Figure 1.3, USACE currently does not have jurisdiction to regulate dredging and filling activities in isolated wetlands under Section 10 of the Rivers and Harbors Act of 1899 (USACE, 2018). A recent approach to protecting geographically isolated wetlands was introduced in 2015 through the Clean Water Rule, which aimed to include these types of ecosystems in the jurisdictional scope for federally protected waters (Creed et al., 2017). However, this proposed changed has not yet been passed.

DEP and the WMDs have an operating agreement that basically allows DEP to regulate smaller projects (typically single-family) while the WMDs regulate larger projects (usually commercial) and agricultural activities. The operating agreement will be described in more detail later in this section. In general, DEP and the WMDs do not both regulate the same activity at the same time, but rather split the responsibilities. This means that if a permit is required from DEP, it is generally not required by the WMDs for that activity (with some exceptions). Both DEP and the WMDs operate simultaneously with USACE; that is, if an activity is jurisdictional to USACE, it is generally also jurisdictional to either DEP or the appropriate WMD and must be permitted by two entities. A major exception to this is the State Programmatic General Permit Five (SPGP V) agreement. The SPGP V agreement allows DEP and the WMDs to issue permits for certain common activities on behalf of the USACE so long as the activity meets all SPGP V

criteria. This agreement has allowed for a more streamlined process for the permittee, as only one application and one permit are required instead of two. However, only 10% of these self-certified activities are inspected, and of those about 50% end up being in compliance (Martin, 2013). This implies that only 10% of violations are discovered and pursued by the State.

The WMDs regulate activities in, on, or over wetlands and other surface waters on the following types of properties: a system of one or more parcels of land where a parcel contains or is proposed to contain more than one single-family dwelling unit, a system of four or more contiguous parcels of land under single ownership where each parcel contains or is proposed to contain only one single-family dwelling unit, and a system of three or less contiguous parcels of land under single ownership where the residential unit is only an incidental part of a parcel that is otherwise used for agricultural activities. DEP regulates activities that result in alterations to wetlands or surface waters on properties that do not meet those three criteria, which generally means single-family parcels that are not part of a larger community. Although single-family parcels are the most common type of property where DEP-regulated wetland alterations take place, other types of properties that DEP regulates with respect to management of surface waters include: solid waste facilities, hazardous waste facilities, water/wastewater treatment facilities, water reuse sites, certain types of mines, a system of three or less contiguous parcels of land under single ownership (which can include industrial sites), communication lines, pipelines, docking facilities, and shore protection (including sites where commercial development already exists) (SWFWMD and DEP, 2007). In addition to the three regulatory agencies discussed thus far, certain Florida counties are delegated regulatory authority by DEP to carry out permitting, compliance, and enforcement activities on behalf of DEP. For instance, Hillsborough County has an operating agreement with DEP that allows it to regulate almost all state wetland regulations in

the county, with a few exceptions. Hillsborough County also has its own, often more stringent, county wetland regulations that are incorporated into any permitting or enforcement conducted by the county. For all non-delegated counties, there may be separate county wetland regulations, but the permittee must also apply for state and federal authorization in addition to county authorization. Readers may wonder why the Environmental Protection Agency (EPA) has not been mentioned, as that is often the most well-known agency when it comes to environmental regulation. The EPA is generally not involved in regulatory activities in Florida pertaining to wetlands. They only become involved in the largest and most contentious cases.

1.4 Environmental Resource Permit Program

Since a brief overview of jurisdictional agencies has been provided, and because the major federal law regarding wetland protection has been covered, the state regulations for wetland regulation will now be discussed. In order to develop a comprehensive plan to protect water quantity and quality, the state developed the Environmental Resource Program (ERP), which is a regulatory program managed by the Florida Department of Environmental Protection (DEP) and the Water Management Districts (WMDs). The Environmental Resource Permit regulatory program (ERP) went into effect in 1995 and applies to all activities that involve the alteration of surface waters (wetlands are considered surface waters), including activities not in wetlands that might generate runoff (South Florida Water Management District and St. John's River Water Management District, 2013). The program is also referred to as SWERP (Statewide Environmental Resource Permit Program). The main type of activity within this program is referred to as Dredge and Fill (D/F). The program is regulated pursuant to Part IV of chapter 373, Florida Statutes (F.S.), with corresponding detailed regulations in chapter 62-330 of the

Florida Administrative Code (F.A.C.). The ERP rule is continuously amended in order to streamline permitting and enforcement and promote statewide consistency.

Chapter 62-330, F.A.C. is one of the main chapters used for the ERP program and corresponds with chapter 373 F.S., but gives more detail and provides further depth in each section. The ERP program requires that a permit is issued for nonexempt activities that are in, on, or over wetlands or other surface waters, activities that result in over 4,000 square feet of impervious and semi-pervious surface area subject to vehicular traffic or over 9,000 square feet of impervious or semi-impervious surface area, projects of more than one acre, activities that impound over 40 acre-feet of water, or activities that are part of a larger common plan of development (section 62-330.020, F.A.C.). There are three types of permits – general, individual, and conceptual. Permits for mitigation banks are authorized under an individual or conceptual permit, and must meet criteria in chapter 62-342, F.A.C. General permits are meant for activities that cause minimal impacts to water resources. There are 42 types of general permits. Individual permits are used for activities that do not meet general permit criteria, and conceptual permits are available for large master plans such as phased projects.

Conditions for issuance of a permit include reasonable assurance that the activities will not cause adverse water quality impacts, flooding, impacts to surface water storage and conveyance, impacts to wildlife, or impacts to water resources (62-330.301, F.A.C.). Exemptions are activities that do not require a permit. These are listed in chapters 403.813, F.S., 373.406 F.A.C., 403.9321, F.S., 62-330.051 F.A.C., and 62-340.700, F.A.C. The ERP rule is also thoroughly outlined in the Applicant's Handbook Volumes I and II. These handbooks contain almost the same information, but the sections are laid out in an order that is more "customer friendly" with further detail in the definitions section. The main benefit of the Applicant's

Handbook Volume I is to provide definitions of the terms used in ERP rules, such as definitions for “dock”, “canal”, “seawall”, etc. This handbook is used extensively in order to clarify what certain terms mean that are found in chapter 62-330, F.A.C. (Florida Department of Environmental Protection and Florida Water Management Districts, 2013). The Applicant’s Handbook Volume II is specific to stormwater management systems.

1.5 Wetland Determination and Classification

A major problem in Florida is that the public is largely uneducated when it comes to recognizing wetlands. Many people believe that wetlands are areas inundated with water, but do not understand that a wetland can also be an area that appears completely dry. The State of Florida defines wetlands in section 373.019 (17) of the Florida Statutes and section 62-340.200 (19) of the Florida Administrative Code as:

> "those areas that are inundated or saturated by surface water or ground water at a frequency and a duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soils. Soils present in wetlands generally are classified as hydric or alluvial, or possess characteristics that are associated with reducing soil conditions. The prevalent vegetation in wetlands generally consists of facultative or obligate hydrophytic macrophytes that are typically adapted to areas having soil conditions described above. These species, due to morphological, physiological, or reproductive adaptations, have the ability to grow, reproduce or persist in aquatic environments or anaerobic soil conditions".

Because a wetland is always considered a surface water feature, and not all surface waters are wetlands, the regulated areas discussed herein are referred to as “wetlands and other surface waters”.

The state's method for determining the boundaries of a wetland (referred to as "wetland delineation") is found in section 62-340.300, F.A.C. This method involves identifying indicators that show the influence of water, such as plant species, soil characteristics, water stains, or plant adaptations. Using these indicators, an experienced professional can delineate (draw a line) between wetlands and uplands. Although the State of Florida uses Florida-specific methods, the USACE uses a slightly different method for determining wetland boundaries, and the EPA has its own ideas for scientifically defensible wetland assessment methods as well (Stein et. al, 2009). However, according to a study by Stein et. al (2009), the debate over various methods should be refocused on a discussion of institutional structure and implementation of the methods. Although state and federal methods vary slightly, they are all designed to evaluate the ecological conditions of wetlands using observable indicators and to express the conditions in a manner that informs proper wetland management (Stein et. al, 2009).

According to section 62-340.200(19), F.A.C., Florida wetlands generally include swamps, marshes, cypress domes and strands, bayheads, sloughs, wet prairies, riverine swamps and marshes, bogs, tidal marshes, hydric seepage slopes, mangrove swamps, and other similar areas. The EPA separates wetlands into four main types – marshes, swamps, bogs, and fens (USEPA, 2017[2]). Marshes, both tidal and non-tidal, are nutrient-rich wetlands that support a variety of emergent soft-stemmed vegetation including reeds and grasses, while swamps are defined by their highly organic soils and ability to support woody plants. Swamps and marshes make up most of the wetlands in Florida. Bogs are more commonly found in northern climates and are characterized by spongy peat deposits, acidic waters and a floor covered by a thick carpet of sphagnum moss. Bogs receive all or most of their water from precipitation rather than from runoff, groundwater or streams. As a result, bogs are low in the nutrients needed for plant

growth, a condition that is enhanced by acid forming peat mosses. Fens, which are a northern hemisphere phenomenon requiring low temperatures and short growing seasons, are peat-forming wetlands that receive nutrients from sources other than precipitation (usually from upslope sources and from groundwater movement). Fens, which are often covered by grasses, sedges, and rushes, have less peat, are less acidic, and have higher nutrient levels than bogs (USEPA, 2017[2]). In comparison, the Florida Natural Areas Inventory (2010) classifies wetlands in Florida based on community type, and separates them into three main categories: freshwater non-forested, freshwater forested, and marine/estuarine. Table 1.1 outlines these wetland communities as they are classified specific to Florida, which does not include fens. All of these types of wetlands are included in the assessment of wetland loss which will be examined in this thesis.

Table 1.1 Wetland Classification in Florida. (Florida Natural Areas Inventory, 2010)

Freshwater Non-forested	Freshwater Forested	Marine/Estuarine
Prairies & Bogs: short hydroperiod; dominated by grasses and sedges. • **Seepage Slope:** open, grass-sedge dominated community kept continuously moist by groundwater seepage. • **Wet Prairie:** flat herbaceous community found on continuously wet, but not inundated, soils. • **Marl Prairie:** sparsely vegetated (20-40% cover), graminoid-dominated community found on marl substrates in South Florida. It is seasonally inundated (two to four months). • **Shrub Bog:** dense stands of broadleaved evergreens 1-5 meters tall depending on time since fire, with or without an overstory of scattered pine or bay trees, growing in mucky soil where water is usually less than a foot deep.	**Cypress/Tupelo:** dominated entirely by cypress or tupelo, or these species important in the canopy; long hydroperiod. • **Dome Swamp:** isolated, forested, depression wetland occurring within a fire-maintained community such as mesic flatwoods. Smaller trees grow in the shallower waters of the outer edge, while taller trees grow in the deeper water in the interior of the swamp. • **Basin Swamp:** basin vegetated with hydrophytic trees and shrubs that can withstand an extended hydroperiod. • **Strand Swamp:** shallow, forested, usually elongated depression or channel situated in a trough within a flat limestone plain, and dominated primarily by bald cypress. • **Floodplain Swamp:** closed-canopy forest of hydrophytic	**Salt Marsh:** largely herbaceous community that occurs in the portion of the coastal zone affected by tides and seawater and protected from large waves. **Mangrove Swamp:** dense forest occurring along relatively flat, low wave energy, marine and estuarine shorelines. The dominant plants of mangrove swamp are red, black, and white mangroves and buttonwood. **Keys Tidal Rock Barren:** flat rockland in the supratidal zone with much exposed and eroded limestone and a sparse cover of stunted halophytic herbs and shrubs. The limestone has a white color, and it is inundated by salt water only during the extreme equinoctial high tides.

Table 1.1 (Continued)

	trees occurring on frequently or permanently flooded hydric soils adjacent to stream and river channels and in depressions and oxbows within floodplains. Groundcover is sparse.	
Marshes: long hydroperiod; dominated by grasses, sedges, broadleaf emergents, floating aquatics, or shrubs. • **Depression Marsh:** shallow depression in sand substrate with herbaceous vegetation. Typically occur near fire-maintained communities. • **Basin Marsh:** regularly inundated freshwater herbaceous wetlands that contain submersed, floating-leaved, emergent, and grassy zones from deepest to shallowest portions. • **Coastal Interdunal Swale:** marshes, moist grasslands, dense shrubs, or damp flats in linear depressions formed between successive dune ridges as sandy barrier islands. • **Floodplain Marsh:** community occurring in river floodplains and dominated by herbaceous vegetation and/or shrubs. • **Slough Marsh:** primarily herbaceous community growing in a narrow to broad shallow channel with intermittently flowing water in flat sandy landscapes. • **Glades Marsh:** herbaceous wetland in South Florida, especially in the Everglades basin, that occurs in broad shallow channels or depressions over a substrate of peat or marl that directly overlies limestone. **Slough:** deepest drainageways within swamps and marsh systems. They are broad channels inundated with slow moving or nearly stagnant water.	**Hardwood:** dominated by a mix of hydrophytic hardwood trees; cypress or tupelo may be occasional or infrequent in the canopy; short hydroperiod. • **Baygall:** evergreen forested wetland of bay species situated at the base of a slope or in a depression. Loblolly bay, sweetbay, and/or swamp bay form a tree canopy and are also dominant in the understory. • **Hydric Hammock:** evergreen hardwood and/or palm forest with a variable understory typically dominated by palms and ferns occurring on moist soils, often with limestone very near the surface. • **Bottomland Forest:** deciduous or mixed deciduous/evergreen, closed-canopy forest on terraces and levees within riverine floodplains and in shallow depressions. Typically found between swamps and uplands. **Alluvial Forest:** hardwood forest found in river floodplains on low ridges that are slightly elevated above floodplain swamp and are regularly flooded for a portion of the growing season. The physical environment is greatly influenced by ongoing disturbances created by a fluctuating river bed which is both eroding and depositing substrates.	

CHAPTER 2: LITERATURE REVIEW

As discussed in Chapter 1, most of the literature found regarding wetland loss has focused on mitigation and loss of wetland function relating to large development projects. The following review will provide a summary of the most relevant literature related to the No Net Loss goal in Florida. First, a review pertaining to mitigation of wetland loss on a nationwide scale will be provided, explaining why and how wetland mitigation has been unsuccessful thus far in achieving the No Net Loss goal nationwide. Then, Florida-specific wetland mitigation will be reviewed, outlining the aspects of mitigation protocol that prevent adequate wetland protection in the state. Lastly, a literature review pertaining to enforcement of wetland rules in Florida will be conducted, which will provide an assessment of how regulatory enforcement protocol for the current rules is impacting achievement of the No Net Loss goal and the corresponding impacts to Florida's wetland functions and economy.

2.1 Nationwide Mitigation of Wetland Loss

Staff & Losses (2001) provides a background and evaluation of mitigation carried out through the USACE nationwide between 1993 and 2000. According to this article, by the early 1980s, wetland area in the contiguous U.S. had decreased by approximately 53% of what it had been in the 1780s due to federal policies that encouraged wetland conversion to promote residential, commercial, and agricultural development. Section 404 of the Clean Water Act (established in 1972 and amended in 1977) requires a permit for wetland impacts, as discussed above. The Committee on Mitigating Wetland Losses, established by the National Research Council (NRC), prepared a report to evaluate how well compensatory mitigation under Section

404 is satisfying the “no net loss” objective. The following paragraphs will discuss the findings of this committee; however, it is important to note that this committee was evaluating mitigation on a national scale and only using data from the U.S. Army Corps of Engineers (USACE) (Staff & Losses, 2001).

The NRC committee found that the No Net Loss goal is not being met by the mitigation program for wetland functions, although the rate of wetlands loss nationwide appears to be slowing down. From 1986 to 1997, the estimated annual rate of wetland loss was approximately 23% that of the rate between 1975-1985. The USACE keeps data regarding the permitted fill and compensatory mitigation. Between 1993-2000, approximately 9,712 hectares (24,000 acres) of wetlands were permitted to be filled, and 16,997 hectares (42,000 acres) were required as mitigation annually. Therefore, approximately 1.8 units of wetland were supposed to be gained for every unit lost. This would indicate that the mitigation program resulted in a net gain in wetland area in the U.S. However, the Committee on Mitigating Wetland Losses found that these data were not adequate for determining whether the mitigation actually took place, or the condition of the mitigation areas over time. Additionally, the information not disclose the wetland functions lost due to the permitted activity. Further research suggested that required mitigation projects often never take place after the permit is issued, or fail to meet the permit conditions (Staff & Losses, 2001).

The compliance factor is far more difficult to implement and to track than the permitting factor when it comes to dredging or filling wetlands. Therefore, the committee stated in the report that they were not convinced that the No Net Loss goal is being met, and the degree to which the goal is not being met cannot be determined due to lack of data; especially compliance data. The committee suggests that the USACE should encourage the establishment of watershed

organizations responsible for monitoring wetlands in public ownership or under easement. The committee also suggests that permit decision making should express a strong preference for mitigation near the impact site and for the same wetland type and functions. However, since there is no requirement in rule for on-site and in-kind mitigation, the negotiation that occurs between the permittee (or the consultant representing the permittee) and the regulatory agency often results in authorization of the mitigation that the permittee or consultant is proposing (Staff & Losses, 2001).

Vaissière et al. (2017), found that the mitigation rules, although well-defined, allow significant flexibility. This enables extensive negotiation to occur between permittees and regulatory agencies with regard to ecological-economic viability of mitigation. That information was determined by interviewing Wetland Mitigation Banking stakeholders in Florida in order to identify strategies used during negotiations, such as how they determine service areas, types of credit, and credit release schedules (Vaissière et al., 2017). Because the mitigation rules allow room for negotiation, and because much of the evaluation process is subjective (see Uniform Mitigation Assessment Method in chapter 62-345, F.A.C. for information regarding evaluation of wetlands and how DEP and the WMDs decide the corresponding acceptable extent of mitigation), it may be futile to recommend a "strong preference" for on-site in-kind mitigation. On-site mitigation tends to be more inconvenient for the permittee than the purchase of mitigation credits, due to constraints in acreage, hydrological conditions, and time. On-site mitigation would require long-term monitoring, and the permittee is often either unwilling to take on that responsibility, or agrees to do so but the regulatory agency neglects to follow up with compliance inspections (Staff & Losses, 2001).

The NRC committee suggests that the mitigation sites must become self-sustaining, and offers ten operational guidelines (Staff & Losses, 2001). However, they also conclude that compliance has often not been assured or attained, therefore these guidelines would not be of much use unless the compliance aspect of the wetlands programs in USACE, DEP, and the WMDs were implemented properly. Currently, the permitting side of each agency takes precedence, as the agencies are required by rule to issue or deny permits within specific timeframes. If those timeframes were not met, the activity would automatically be authorized. However, the rules are much less specific when it comes to requiring these agencies to conduct compliance activities. No drastic events occur when an enforcement action takes longer than expected, or when enforcement is not pursued. The timeframes for the compliance/enforcement types of activities are better described as guidelines than rules. Additionally, the public is much more aware of permits being issued and is more prone to supplying pushback on various permitting decisions, whereas in general the public (other than the complainant or the violator, which are stakeholders to be discussed in more detail later) is typically not aware of most enforcement activities, in which case the situation is often dealt with in terms of which entity is creating more pushback. There is language in the State rules that allows DEP and the WMDs (and any counties with ERP delegation) to authorize activities that do not meet rule criteria, using enforcement discretion on a case-by-case basis (see the "de minimis" exemption in section 373.406(6), F.S.). This ambiguity provides a good justification for a spatiotemporal comparison of wetland violations.

The committee found that, in many cases, required mitigation actions were poorly designed or carelessly implemented and did not allow success of the desired plant and animal communities. The committee notes that monitoring is usually not required for more than five

years, and that legal and financial mechanisms for ensuring protection of mitigation sites long-term are often absent. This is a significant barrier to success, as wetland restoration and creation sites seldom achieve functional success or comply with permit requirements within five years. Therefore, the main suggestion of this committee is that the USACE and other regulatory authorities should improve the effectiveness of compliance monitoring. Although staff at the USACE, DEP, and the WMDs would no doubt agree with this recommendation, these agencies appear to be struggling to maintain their current level of oversight with the current budget and staffing constraints in the State of Florida. The committee notes that the USACE and EPA should work with the states to expand state watershed programs in order to fill gaps in the federal wetland program (Staff & Losses, 2001). In Florida, this recommendation seems to be met, as DEP and the WMDs have extensive and specific rules in place to allow regulation of wetland and surface water impacts. Therefore, the mechanism for interagency cooperation and success of the No Net Loss goal in Florida seems to be available, but the implementation of these rules has proven challenging.

2.2 Wetland Mitigation in Florida

Stelk et al. (2017) assessed wetland loss in Florida as part of a study by the Association of State Wetland Managers. The group, which consisted of a variety of environmental professionals, spent three years (2014-2017) identifying the most significant barriers to wetland restoration and determining potential actions in response to those challenges. The main findings relate to mitigation shortcomings, similar to the assessment discussed above by the Committee on Mitigating Wetland Losses. Goldberg & Reiss (2016) assessed the mitigation trends in Northeast Florida between 2006 and 2013. This case study investigated whether the type of mitigation and the type of wetland area impacted by development differ with land use intensity

between 2006-2013 from a review of 522 ERP permits in the Lower St. Johns River Basin (Northeast Florida). Forested wetlands comprised 47-97% of the impacted wetland areas. 29% of permits required on-site mitigation, 27% of permits required the purchase of mitigation bank credits, and 20% of permits required off-site mitigation. 24% of the permits did not require mitigation. Wetland preservation, accounting for 1,977 acres per year on average, exceeded wetland creation, which accounted for only 22 acres per year. This study finds that the "no net loss" policy is not being met as it pertains to mitigation, and that urban development is causing cumulative loss and fragmentation of wetlands despite compensatory mitigation regulations (Goldberg & Reiss, 2016).

Levrel et al. (2017) describes the risks associated with trusting mitigation banking as a method to conserve wetlands in Florida. One of the main problems is the redistribution of ecosystem services as well as the distance between impact locations and compensation sites, which appears to have increased in the last several years. In the last decade, the method for implementing wetland impact mitigation has changed from a mainly permittee-based system (PRM) to a mainly market-based system (MB). PRM requires that a developer compensate wetland impacts by restoring or enhancing a natural wetland near the impacted area. One issue that this method resulted in was lack of effectiveness regarding ecological outcomes, as well as a high rate of non-compliance. MB involves a third party (mitigation banks) that carries out restoration and enhancement of natural areas prior to impacts occurring (Levrel et al., 2017). Brown (2017) analyzed freshwater mitigation sites in Hillsborough County and found that current mitigation practices are failing to compensate for development intensity rates on a landscape scale. The study found that on average, wetland condition decreased by 9% from the time of release to the time of survey, and that freshwater wetlands on average decreased in size

from the originally intended area by approximately 18%. He also found that non-forested wetlands have experienced significantly more permitted impacts per year than forested wetland systems since 1985 (Brown, 2017).

The regulatory agencies assign mitigation "credits" based on an assessment of the ecological gains of the project. The Compensatory Mitigation Rule standardized the system nationally in 2008. This led to an increase from 35% to 50% in the use of the mitigation banking system in 2014 (Levrel et al., 2017). The benefits of this system are that regulators have better control due to fewer stakeholders responsible for implementation, that large-scale restorations are typically more successful than smaller dispersed projects, and that ecological gains would occur even if the offset project is not completed. There are several problems associated with this trend, however. There is a risk that this method facilitates rather than limits development projects. There is also a risk that wetlands will be privatized, commoditized, and homogenized. Also, due to the distance between developed sites and corresponding mitigation sites, there appears to be special redistribution of benefits delivered by wetlands. This trend may mean that regulatory agencies are protecting the market more than the environment (Levrel et al., 2017).

Rains et al. (2013), provided a background of wetland loss in Tampa Bay and used Geographic Information System (GIS) layers to identify areas where wetland restoration or preservation should be used to accomplish watershed goals. Apparently, one-third of the wetlands in the Tampa Bay Watershed (Figure 2.1) were lost between the 1950s and 2007, and Florida experienced a loss of almost half of its wetlands between 1845 and the late 1990s (Dahl, 2005). On average, that trend has improved nationally between 1998 and 2009, as it appears that the wetland area in the coterminous U.S. has remained somewhat constant according to available data (Dahl 2006, 2011). However, coastal watersheds along the Atlantic and Gulf of Mexico

coasts have continued to experience a loss of wetlands during this timeframe, where approximately 64,247 acres were lost annually between 1998 and 2004. Losses were especially apparent in the Tampa Bay area (Stedman & Dahl, 2008). Many of the wetland gains that have occurred can be attributed to regulatory programs. However, these gains are often out-of-kind mitigation, meaning that natural wetlands are replaced with open-water ponds in urban settings. This results in a loss of wetland functions (National Academy of Sciences, 2001; Turner et al., 2001). Compensatory mitigation efforts should be approached with watershed coordination in mind, as recommended by federal regulatory guidance. The Tampa Bay Watershed takes this guidance seriously, and pursues a federal-state-local-private partnership to provide framework for connecting existing mitigation programs with freshwater wetland conservation and restoration priorities (PBS&J, 2010; Rains, et. al., 2013).

The study by Rains et. al. (2013) was developed in order to provide the necessary information and tools to assist these efforts though the development of a geodatabase. This geodatabase can be used to "estimate the area of freshwater wetlands lost since the 1950s, the area of the remaining freshwater wetlands, the condition of remaining freshwater wetlands, hydrological connectivity between remaining freshwater wetlands and Tampa Bay, and the potential locations where future opportunities might exist for the conservation of freshwater wetlands" (Rains et. al., 2013). The information can be used to determine where conservation strategies, such as creation, restoration, and preservation may be most appropriate or desirable. The study found that wetland losses, though widely distributed, were principally concentrated in the northeastern and eastern portions of the watershed. Wetland loss in the urban areas was not detected since these losses generally occurred prior to 1950. Wetland gains were mostly

concentrated in the eastern portion of the watershed, and were associated with phosphate mining (Rains et. al., 2013).

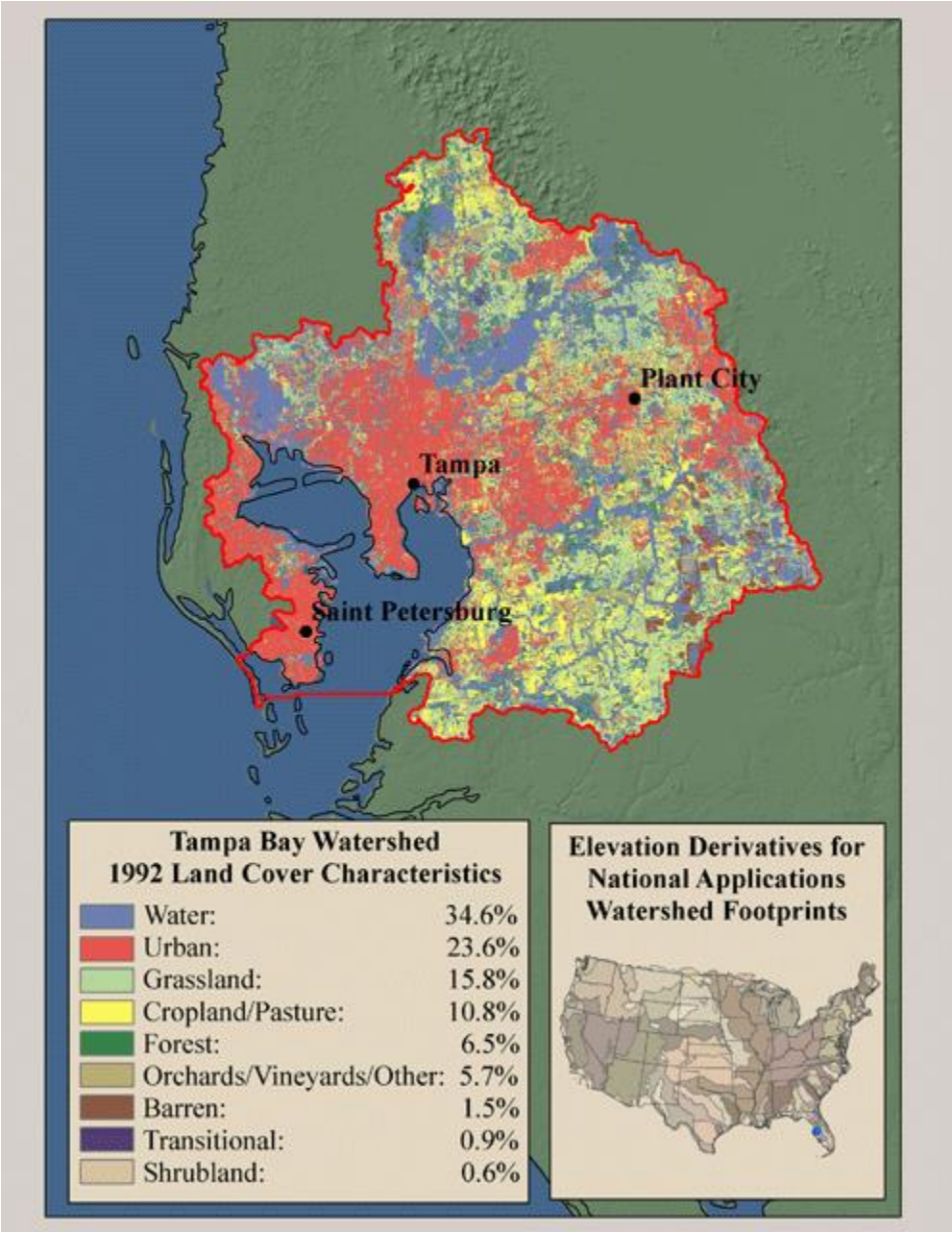

Figure 2.1 Map of the Tampa Bay Watershed. This image is in the Public Domain (USGS, 2008).

Part of the loss of wetlands that the Tampa Bay Watershed has experienced, aside from dredge/fill activities, was due to groundwater withdrawals which lowered the water table and caused many wetlands to dry up and convert to upland communities (Rains et. al., 2013). Until the mid-1990s, the only source of domestic water supply in this watershed was groundwater, during which time withdrawals accounted for approximately 192 million gallons per day (Tampa Bay Water, 2012). Since that time, the water suppliers in the watershed began a regionally coordinated effort to optimize water supply and distribution using not only ground water, but also surface water, including water from the Hillsborough River and desalinated water from the Gulf of Mexico, which resulted in groundwater withdrawals being reduced to 90 million gallons per day, a 53% reduction (Tampa Bay Water, 2012).

Despite the wetland losses described up to this point, wetlands still cover over 14% of the Tampa Bay Watershed (Rains et al., 2013). This study identified 64,000 acres of wetlands that seem to be appropriate for preservation. High concentrations are located on the Hillsborough River and Cypress Creek. The study identified 90,240 acres of wetlands that seem appropriate for restoration. The authors note that watershed approaches to mitigation can be difficult to implement due to sociopolitical constraints. This is largely due to the broad spectrum of stakeholders involved, such as a population exceeding four million people, resource and regulatory agencies, six counties, numerous local municipalities, and of course private companies. Therefore, the greatest challenge to coordinating a watershed approach is facilitating communication and cooperation between stakeholders (Rains et. al., 2013).

While Rains et. al. (2013) noted the barriers to a watershed approach to mitigation, Pittman & Waite (2009) examined the relationship between unsuccessful mitigation practices and diminishing wetlands in Florida. Interviews were conducted with past and present staff from

various government agencies, lobbyists, and citizens. The authors assessed development projects throughout the time period of statehood in 1845 to 2007. The authors found that decisions are most strongly influenced by politicians, developers, and the Army Corps of Engineers (Pittman & Waite, 2009). The authors discussed the struggle that the USACE experiences in reviewing permit applications in a timely manner and in such a way that wetlands are being protected. Between 1999 and 2003, only one of approximately 12,000 permits was denied by the Corps. Between 1990 and 2003, while the federal policy mandated No Net Loss of wetlands, at least 84,000 acres of wetlands were lost due to development. The No Net Loss policy was designed to eliminate further loss of wetlands, and the authors claim that this goal, in most cases, has failed. There are many ways for developers to find loopholes in the policy, allowing them to skimp on the required mitigation. According to this book, the leading cause for failure of the No Net Loss policy is failure to implement sufficient mitigation. When mitigation is not executed properly, it often results in more harm than good. Another major factor is that the first plan of action when designing a development plan is to minimize and avoid wetland impacts; however, projects frequently use preservation as mitigation even though preservations are meant to be used as a last resort (Pittman & Waite, 2009).

USACE is known in the environmental permitting world for taking the longest out of any agency to process a permit application, according to Pittman & Waite (2009). “Developers often cut corners so that the project would be approved, knowing that the Corps did not have enough resources of fully perform an assessment of the area to be developed, and politicians aided the process by making deals and encouraging the speediness of permit approvals” (Pittman & Waite, 2009). The authors provide insight into potential ways to improve regulation so as to actually achieve the No Net Loss goal, through practices such as imposing more stringent rules. This idea

of stringent regulation and implementation of enforcement has been proven successful by many county governments in Florida. One of their ideas is to set a threshold at which point no more wetlands will be allowed to be destroyed. The authors also advocate a system that has better communication with the public that emphasizes conservation and restoration. The authors recommend a scale that will force developers who seek larger areas to pay more for a permit than developers with smaller projects. Currently, all permit applications start at the same price regardless of the size of the project. In addition, they propose that preservation acreage should not be counted as if it were new acreage that was previously nonexistent (similar to mitigation), and that legal and financial penalties should be imposed for developers who submit falsified information in applications (Pittman & Waite, 2009).

2.3 Enforcement and Impacts in Florida

Since a background of ERP permitting effectiveness through mitigation has been provided, this section will focus on the other aspect of regulation – enforcement – as well as the effect that wetland degradation has had on Florida's economy. Brody & Highfield (2005) addressed the deviations in Florida wetland development between permitted plans and subsequent development activity. Local municipalities identify regions designated for future development in order to reduce adverse environmental impacts, in response to a statewide comprehensive planning mandate. Research revealed that it is difficult for regulatory agencies to monitor large development projects due to the nature of their timeframes. Long term monitoring often becomes forgotten due to high turnover rates at regulatory agencies and lack of sufficient staffing to address old projects. Priority is given to new projects, and therefore the final outcome of ten to twenty-year development activities frequently remains unanalyzed as it relates to wetland impacts (Brody & Highfield, 2005). This inability to for state and federal agencies to

conduct monitoring activities could be mitigated by local municipality delegation. For instance, Pinellas County adopted a program, called Penny for Pinellas, which uses a one-cent sales tax to fund preserves and habitat management as well as land acquisition; this helped improve the quality of Tampa Bay (Brody & Highfield, 2005).

One major impetus for conformance with permit conditions is a penalty system designated for failure to comply, which motivates developers to conform to the permitted plan (Brody & Highfield, 2005). In the study, only 10% of projects that were non-compliant were imposed penalties; this trend appears to cause increased non-compliance over time. The result indicates that if there are consequences for not adhering to regulations, developers are more likely to take permit conditions more seriously. Regular self-monitoring is important for keeping projects on track. Periodic assessment can assist planners in reducing loss of ecosystem structure and function. As part of the state mandate, all jurisdictions are required to submit a monitoring report every seven years. This document evaluates progress and determines if any changes should be made. However, if state employees are not analyzing these reports, the process is missing an important aspect (Brody & Highfield, 2005).

Brody et al. (2007[1]) examined the relationship between wetland alteration and flooding of coastal watersheds in Florida over the course of twelve years. The authors assess permits that were issued under Section 404 of the Clean Water Act and correlate the number of permits with the degree of flooding. Results indicate that state and federal permits that allowed wetland alterations correlated with increased flooding events in coastal watersheds (Brody et al., 2007[1]). According to an article by Brody et al. (2007[2]), which builds upon the information in the above-discussed paper, the current permitting process indirectly encourages development in flood zones. Their study analyzed 383 non-hurricane flood events in Florida in order to identify how

planning decisions lead to flood-induced property damage due to alteration of natural wetlands. The average number of flooding events per year has increased from 394 annually in the 1960s to 2,444 annually in the 1990s, nationally. Approximately $41.69 million of damage was caused by flooding in the U.S. every year in the 1960s, compared to approximately $378.12 million of damage every year in the 1990s. (Brody et al., 2007[2]). Increasing the impervious surface area in low-lying regions has altered the hydrology to the point that these areas no longer have the capacity to store surface water runoff. Florida suffered approximately $2.5 billion in losses due to flooding between 1990 and 2003, and was ranked the state with the highest risk for flooding in the nation at the time the paper was published (Brody et al., 2007[2]). Increasing the amount of impervious surface in a drainage basin by 10-20% is estimated to double the corresponding runoff. Basins with only 5% wetland area might have 40-60% lower flood peaks than basins that lack wetlands. Peak discharges increased by 300% when the impervious area had increased from 0% to 11% (Brody et al., 2007[2]).

So far, this thesis has provided a background of previous research in order to support the claim that most literature regarding wetland loss in Florida appears to focus on large development projects and tends to analyze the effectiveness of mitigation. This has shown that small-scale development (the types of properties that are regulated by DEP) is excluded in most research, as well as wetland alterations that are authorized without mitigation requirements. Literature also shows that previous research tends to delve into the permitting aspect of wetland regulation more than the enforcement aspect. The next sections of this thesis will focus on small-scale activities that resulted in wetland alteration but did not require mitigation. It will use DEP data and SWFWMD GIS data to compare the documented acreage of small-scale unmitigated wetland loss with the estimation of loss by aerial interpretation of the region in order to evaluate

the approximate amount of small-scale unmitigated wetland loss that is undocumented. The information will be used in order to analyze the effectiveness of regulatory methodology in Florida in achieving the No Net Loss goal.

CHAPTER 3: METHODS

Data collected are from the period of January 1, 2006 through December 30, 2011 in the eight counties of the Southwest District of DEP (refer to Figure 1.1). This timeframe was chosen because the most recent Land Use Land Cover GIS layers provided by the Southwest Florida Water Management District were collected during that time frame. The Southwest District was chosen because the population growth and urbanization trends in this region are comparable to the rest of the state, and because this region contains counties that are both delegated and non-delegated to conduct Environmental Resource Permitting on behalf of the State. Although the location of the analysis is representative of the rest of Florida, the timeframe contained a severe economic downturn which may cause the data to not be representative of the current state of the economy and subsequent development activities. Development was constrained between 2008 and 2011 due to the recession. Presumably, there should be more dredging and filling activities occurring today than there were during the timeframe being studied, as Florida's economy gradually began to recover between 2012 and the present.

In order to collect compliance and enforcement data, access to the Environmental Resource Program Compliance and Enforcement (ERPce) database used by DEP staff was needed. Only DEP employees have login credentials for this database, therefore the general public does not have direct access to the data. However, data collected by the State of Florida agencies are public record as required by the Sunshine Law (Chapter 286, F.S.), so in theory any person could request and obtain specific information for a processing fee. The data from ERPce can be seen (with credentials) at the following website: https://fldep.dep.state.fl.us/erpce_rep.

The law requires DEP to maintain records of wetland alterations, but does not specify the use of this particular database nor the manner in which data should be recorded. Therefore, data found in ERPce may not be a complete compilation of records, although it is the only location where full documentation of ERP activities can be expected.

3.1 Compliance/Enforcement Data Collection Procedure

First, data were collected pertaining to the various activities that have been conducted by the DEP ERP compliance/enforcement program specific to Dredge and Fill violations. These data were found at the website listed in the previous section by clicking “Office Reports”, then navigating to “Recent Activities Completed Summary Search” (the Office field should be filled with “SWD”, and the Program Area field should be filled with “Dredge and Fill”). This shows how many various enforcement documents were issued, and how many cases were closed. Some violations are discovered during inspections of permitted activities, and some violations are discovered after a complaint is received by the District.

Complaints result from concerned citizens informing the District that they believe another party has performed an unauthorized activity. The number of complaints compared to the amount of wetland loss is expected to be small, and these data will provide evidence of how complaints correlate to amount of wetland loss. Information regarding violations is available for four sub-program areas: Dredge and Fill (DF), Mangrove Alteration (MA), State Lands (SL), and Stormwater (RO). All of these sub-programs are regulated under the Environmental Resource Program, but this thesis will focus on Dredge and Fill activities because those are the bulk of ERP work (85%), and because those activities are the largest cause of permanent wetland degradation according to the data analyzed in this thesis.

Next, the Dredge and Fill complaint information for the Southwest District is found by clicking “County Reports”, then navigating to “Complaint Search Results” for the Program Area “Dredge and Fill”. These data show the total number of such complaints as well as the information about the county and the date at which each complaint was initiated. The data pertaining to resolved and unresolved Dredge and Fill violations is found by clicking “Program Area Reports” and navigating to “Program Area Reasons for Out of Compliance”. When the Outcome field is “Both SOC and MOC” (significant out-of-compliance and minor out-of-compliance) and the OOC Status is “Both Resolved and Outstanding”, the Report Summary shows the number of outstanding and resolved violations, as well as the reason for the violation (for example, “filling in wetlands without a permit”).

The summary that shows this resolved/unresolved violation information includes a few counties that are no longer jurisdictional to the Southwest District, such as Sumter, Marion, and Sarasota. The data for those counties was neglected when the list is analyzed and manually separated based on county and year. There is a dropdown option in the Office field called “EPC Hillsborough County – SWHC”. It seemed intuitive to search this office because Hillsborough County is the one county within the Southwest District that has jurisdiction to regulate the ERP program, and their activities are supposed to be entered in ERPce. However, their activities are entered under the “SWD” office, so a separate query is not necessary to account for EPCHC activities. Note that “resolved” does not necessarily mean that restoration was required, only that the project was closed (closure could occur after collecting a fine). After collecting the data for the time period of this thesis, a few more recent years are also reviewed in order to evaluate what trend might be occurring. This information is collected simply by changing the dates in the query described above.

Wetland type and acreage impacted by Dredge and Fill activities (both authorized and unauthorized) can be seen by clicking “District Reports”, then clicking “ERPCE: Habitat Alterations”. This summary is called the Habitat Alterations Report. Authorized wetland type and acreage for various projects are determined when a permitting staff member of DEP visits a site to verify proposed alterations noted in an application. Unauthorized wetland type and acreage are determined when a compliance/enforcement staff member of DEP visits a site to document a violation. In order to view the acres of each habitat type being impacted during the time period being analyzed, the Project Type should be queried using “Enforcement”, “Complaint”, and “Compliance” separately. This will show alterations caused by permitted activities, violations resulting from non-compliance with permit conditions, and violations discovered through complaints.

By clicking on one of the numbers highlighted in blue (shown in Figure 3.1), the screen will show all the projects that contributed to that particular type of impact (shown in Figure 3.2). In order to analyze the data appropriately, the alterations due to gains (mitigation such as bank credits, creation, preservation, restoration, or enhancement) must be calculated separately from the alterations due to losses (permanent impacts due to dredging and filling). This must be done manually, as there is no query to separate gains from losses; the “grand total” shown after the initial query is the addition of the gains and the losses, which is gross alterations of habitat rather than net alteration (the “net loss” is the goal of this research). The queries described in this thesis were performed in April of 2018.

A screenshot of the Wetland Forested Mixed section of the alterations report is provided in Figure 3.1. However, this does not represent all wetland types. The other habitat types listed in the report are shown in Table 3.1. This thesis will not delve into the alterations per habitat type,

as the goal is to determine the net loss of wetlands as a whole. Additionally, these numbers will be compared to the GIS analysis in Section 4.2, which groups all wetland types together. However, it should be noted that No Net Loss numbers are often skewed by changes in wetland type, as well as increases in the number of artificial wetland features (Schmidt et. al, 2017).

Table 3.1 List of Habitat Types Shown in the Habitat Alterations Report (Florida Department of Environmental Protection, 2018[3]).

Habitat Types	
Wetlands	Wetland Forested Mixed
Wetland Hardwood Forests	Vegetated and Non-Forested Wetlands
Wet Prairies	Saltwater Marshes
Bay Swamps	Herbaceous (seasonally Inundated)
Bays and Estuaries	Inland Ponds and Sloughs
Beaches Other than Swimming Beaches	Intermittent Ponds
Cypress	Lakes
Cypress Palm	Mangrove Swamps
Freshwater Marshes	Mixed Wetland Hardwoods
Ditched and Otherwise Channelized Streams	Natural Streams
Herbaceous	Improved Pastures
Oyster Bars	Seagrasses
Non-vegetated	Shorelines
Tidal Flats	Stream and Lake Swamps (Bottomland)
Streams and Waterways	Submergent and Aquatic Vegetation
Upland Forests	Urban Built-up
Willow/Elderberry	Water
Borrow Ponds	Australian Pine
Coastal Scrub	Ditch (Man-Made)
Ditch Cut through Uplands	Ditch Through a Wetland

WETLAND FORESTED MIXED	
Descriptor	**Acreage Affected**
AMS4 - ACTUAL MITIGATION ON-SITE: ENHANCEMENT OF WETLANDS	0.1
AMS6 - ACTUAL MITIGATION ON-SITE: PRESERVATION OF WETLANDS	0.1
AMS8 - ACTUAL MITIGATION ON-SITE: RESTORATION OF WETLANDS	1.79
API2 - ACTUAL PERMANENT IMPACTS TO WETLANDS: DREDGE	1.15
API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	2.65
ATI1 - ACTUAL TEMPORARY IMPACTS TO WETLANDS: CLEARING	2.2
ATI3 - ACTUAL TEMPORARY IMPACTS TO WETLANDS: FILL	0.257
ATI5 - ACTUAL TEMPORARY IMPACTS TO WETLANDS: NOT DEFINED	0.1
Subtotal	**8.347**

Figure 3.1 Habitat Alterations Report: Wetlands Forested Mixed Section. Actual Enforcement Alterations (Florida Department of Environmental Protection, 2018[3]).

WETLAND FORESTED MIXED				
Project Id	**Descriptor**	**Acreage Affected**	**Acreage Status**	**Preserved**
305645	API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	0.25	ACTUAL	NO
309031	API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	0.61	ACTUAL	NO
309862	API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	0.5	ACTUAL	NO
322226	API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	0.47	ACTUAL	NO
329582	API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	0.72	ACTUAL	NO
330351	API3 - ACTUAL PERMANENT IMPACTS TO WETLANDS: FILL	0.1	ACTUAL	NO

Figure 3.2 Projects Affecting the Habitat Alterations Report . Example of a list of all projects that contributed to the affected acreage of the "Wetlands Forested Mixed" section of the Habitat Alterations Report by clicking on a specific Descriptor, such as "API3 – Actual Permanent Impacts to Wetlands: Fill" (see Figure 3.1, the purple acreage of 2.65 was clicked to get this screen). (Florida Department of Environmental Protection, 2018[3])

3.2 GIS Data

In order to determine wetland loss by aerial interpretation of the region, ArcGIS software (Redlands, CA) (specifically Esri ArcGlobe 10.4) was used to compare wetland acreage in 2006 versus 2011. The analysis was designed to determine wetland loss due to non-mitigated small-scale activities in this region in order to fill in a gap of research caused by heavy focus by others on wetland loss due to mitigation practices used on large projects. This timeframe was used because the most recent GIS data available are from the years 2006 and 2011. The Southwest District of DEP was used because it comprises a variety of land uses (agricultural, urban, coastal, rural, wetland, and upland for example) which are representative of other Florida regions.

Because the ERP rules are enforced the same way throughout the state, the results of this research could be extrapolated to the rest of Florida. The files containing county boundaries for the GIS analysis were downloaded from a publicly available page on the web (SWFWMD, 2003). The layer is labeled as District Counties (only eight of these counties will be used in the analysis). This layer was developed using the Legal Descriptions on USGS Topographic Maps, and its positional accuracy is estimated to be +/- 43 feet. One limitation of this boundary is that many areas of County Legal Descriptions use the MHWL as a boundary, which can change over time. The shoreline used in this layer was obtained from 1995 records.

The SWFWMD Land Use Land Cover (LULC) layers that were downloaded onto the ArcGIS software were found at SWFWMD (2007), SWFWMD (2012), and SWFWMD (2017). These layers contain Florida Land Use, Cover, and Classification System (FLUCCS) profiles of various habitat types. The habitats are labeled with FLUCCS codes. The following FLUCCS codes were used for the analysis, representing all types of wetlands and other surface waters: Lakes(5200), bays and estuaries (5400), mangrove swamps (6120), cypress (6210), wetland forested (6300), freshwater marsh (6410), saltwater marsh (6420), emergent aquatic (6440), streams and water (5100), wet prairies (6430), stream and lake (6150), intermittent pond (6530), and salt flats (6600).

The following information applies to both the 2006 and 2011 LULC files: Photointerpretation and visual inspection were performed at a scale of 1:8,000. Data is estimated to be precise within 33.3 feet. Land use and land cover boundaries are not always well defined, but it is expected that data acreage should be accurate due to the use of the following sources: 1984, 1990, and 1994/1995 color infrared aerial photography, National Wetlands Inventory maps (1:24,000), and Natural Resources Conservation Service (NRCS) county soil surveys. The

National Wetlands Inventory consists of wetland GIS files developed by the U.S. Fish and Wildlife Service using a similar combination of techniques as was used by SWFMWD. These ancillary data sources were used to ensure proper delineation of land features, and any features that could not be reliably interpreted were field verified. A minimum mapping unit of 0.5 acres for wetlands and 5.0 acres for uplands was required during development of these files. No statistical accuracy verifications were done, and it is estimated that classification accuracies are between 80% - 90%. In addition to the metadata described in this paragraph, the 2011 LULC layer also required a minimum mapping unit of 2.5 acres for irrigated agricultural areas, and 1.0 acre for upland areas within an irrigated agricultural area (SWFWMD, 2012). Changes between wetland types and surface waters were not considered losses in this research – the purpose was to determine how regulatory methodology is accounting for loss of wetlands and other surface waters as a whole, as the ERP rules specifically protect wetlands and other surface waters and generally treat the two concepts as the same thing.

In order to analyze only the wetlands that are not jurisdictional to SWFWMD, all areas that contain SWFWMD ERP permits must be removed from the map using the Environmental Resource Permits layer (found at SWFWMD (2017)). This layer was clipped from the area of analysis in order for the results to include only DEP-jurisdictional areas. The layer was created by SWFWMD staff using the following procedures: Project Activity Areas were created by sketching the project activities for each permit using a customized GIS tool. Visual inspection of the linework at a scale of 1:8,000, was used to verify the positional placement of the linework. Data is estimated to be precise within 33.3 feet. According to the metadata found at the SWFWMD (2017) website, the process is as follows: “the permittee provides their best estimate of the boundary using the WMIS online permit application tools. This results in either a parcel

boundary from the property appraiser's data, the existing permit boundary, a sketch made using the WMIS sketch tool, or a site plan that the reviewer can reference. The District review staff check the information provided by the applicant, then send a sketch to GIS editors, who then review the data submitted by the reviewers and adjust it as necessary to obtain the best possible boundary. In doing so the editor consults parcel data, legal descriptions, aerial imagery, and other available sources" (SWFWMD, 2017).

In order to see the difference in wetland and surface water acreages between 2006 and 2011 within the specified boundary while excluding areas that contain SWFWMD ERP permits, the modified District boundary was intersected with the LULC layers in order to calculate wetland loss within the District including areas waterward of the Mean High Water Line (MHWL). Then, the District Counties layer was intersected with the LULC layers in order to calculate wetland loss per county. However, the county lines in many areas exclude regions waterward of the MHWL, so these numbers exclude any changes in wetlands that may have occurred waterward of the Mean High Water Line. The 2006 result was compared with the 2011 result in order to obtain the difference in acreage of non-SWFWMD-jurisdictional wetlands and surface waters within the Southwest District of DEP during that timeframe. Change was identified as: Gain (2006 wetland not present, but 2011 wetland was present), Loss (2006 wetland was present, but 2011 wetland not present), Type Change (wetland present in 2006 and 2011 but different FLUCCS code), and No Change (FLUCCS code the same in 2006 and 2011).

An example of what is meant by "small-scale unmitigated wetland loss" is shown in Figure 3.3. A coastal herbaceous wetland on a single-family residential property in Manatee County is shown before and after the vegetation was removed and fill material was placed on site. This activity was recorded as a "fill violation" but was documented as "unresolved" in

ERPce. However, rather than the GIS interface showing a change in habitat type due to the unauthorized filling activity, the corresponding FLUCCS code is shown as “residential high density” both before and after the activity took place. This shows that the GIS data used in this research does not recognize all wetlands. In this particular case, the layer shows a “bays and estuaries” habitat on the open water next to the “residential high density”, leaving out the wetland buffer zone in between. The area impacted was approximately 0.21 acres, but this discrepancy suggests that there may be many acres of wetlands that separate open water from residential areas which are not represented by the GIS data.

Figure 3.3 Example of Violation Excluded in GIS Data. Aerial imagery in the top two quadrants was obtained using Google Earth Pro, and depicts a wetland violation that was not resolved according to FDEP (2018[3]). The LULC images in the lower two quadrants were obtained from SWFWMD (2007) and (2012) and show that the area was not classified as a wetland before or after the violation. These images are in the Public Domain.

CHAPTER 4: RESULTS AND DISCUSSION

4.1 Analysis of Compliance/Enforcement Data

Now that data have been collected regarding both authorized and unauthorized activities, the analysis will begin with unauthorized activities. There were 2,481 total complaints received by the DEP Southwest District Environmental Resource Program during 2006-2011. Of these, 2,118 were Dredge and Fill complaints, 66 of them were Stormwater, 281 were Mangrove Alteration, and 16 were State Lands. These are the only four sub-program areas that were logged in the complaint database for this timeframe. These data show that Dredge and Fill cases comprised 85% of complaints received by the Environmental Resource Program at the Southwest District of DEP during that timeframe. Because some complaints result in immediate closure due to lack of a violation, the data discussed in the following section focus on non-compliance cases only.

4.1.1 Non-Compliance Data

In order to provide background information regarding non-compliance Dredge and Fill cases, this thesis reviews enforcement documentation on file between 1/1/2006 and 12/30/2011. During this time period, 236 Non-Compliance Letters were issued, 273 Warning Letters were issued, 50 Notices of Violation were issued, 136 Draft Consent Orders were issued, and 108 Consent Orders were Executed. Of the 684 cases that were Closed by the District, 158 sites were Closed Without Enforcement.

Those enforcement documents are listed in order of escalation of the case. The Non-Compliance Letters are also referred to as an “offer of compliance assistance”. If the violation is

not resolved with a Non-Compliance Letter, then a Warning Letter is issued, and then a Notice of Violation if the violation still hasn't been resolved (if a violation is particularly egregious, a Warning Letter is issued without a preceding Non-Compliance Letter). A Consent Order is a legal document signed by the violator and the Department which agrees on a resolution (involving a fine and sometimes restoration). The case is closed when a resolution has been reached; this could be voluntary restoration or completion of the activities agreed upon in a Consent Order. Of the 2,118 Dredge and Fill complaints that were received by the SWD office, only 32% of them were closed – with or without enforcement actions. This means that 68% of Dredge and Fill complaints received were not closed. When a complaint is not closed, this implies that the investigation of the alleged violation was not completed. An implication of these data is that the following enforcement data are incomplete.

After searching ERPce Reports for the violations in all four sub-program areas of the Environmental Resource Program, the summary shows that there were 214 total non-compliance cases; 166 are outstanding (unresolved) and 48 were resolved. Focusing on Dredge and Fill cases only, the database shows that of 133 total non-compliance cases, 118 are outstanding and 15 have been resolved. A view of this screen is shown in Figure 4.1. After discarding the data for Sumter, Marion, and Sarasota Counties (which was SWD jurisdiction during part of that timeframe but are now the responsibility of other districts), the Southwest District documented 102 outstanding Dredge and Fill non-compliance cases and 14 resolved. As stated earlier, "resolved" does not always mean that restoration was required; many cases result in penalties paid.

Report Summary

Office	OOC Reason (Violation)	Outstanding	Resolved	Total
SWD	CONSTRUCTION W/O PERMIT (UNAUTHORIZED ACTIVITY INCLUDING SF DOCKS	41	7	48
SWD	DREDGING OF WETLANDS W/O PERMIT	15	0	15
SWD	DREDGING WITHOUT A PERMIT	2	3	5
SWD	FILL IN WETLANDS W/O PERMIT	50	2	52
SWD	FILLING WITHOUT A PERMIT	3	1	4
SWD	GENERAL PERMIT CONDITION VIOLATION	1	0	1
SWD	Mangrove Violation	1	0	1
SWD	SPECIFIC CONDITION: LACK OF BMPS VIOLATION	1	0	1
SWD	SPECIFIC PERMIT CONDITION VIOLATION	3	2	5
SWD	STORMWATER VIOLATION	1	0	1
	TOTALS:	**118**	**15**	**133**

Figure 4.1 Summary of Dredging and Filling Violations. Violations listed under Dredge and Fill projects between 1/1/2006 and 12/30/2011, as shown in ERPce (Florida Department of Environmental Protection, 2018[3]).

After manually going through the report totals in order to separate violations by year and by county, ERPce shows the resolved and unresolved violations which are depicted in Table 4.1. The years 2010 and 2011 experienced a significant drop in violations discovered, possibly a result of the recession during that time. Polk, Pinellas, Citrus, and Pasco counties had the most unresolved Dredge and Fill violations, respectively. These counties represent a diverse group of primary land use – Polk being heavy in agriculture, Pinellas being highly urbanized, Citrus being fairly rural, and Pasco having substantial new urban development. A comparison is shown in Figures 4.2 and 4.3. GIS analysis in Section 4.2 will determine whether aerial interpretation of wetland loss corresponds with regulatory documentation as it pertains to which counties experienced the most alteration.

Table 4.1 Resolved and Unresolved Dredging and Filling Violations (Florida Department of Environmental Protection, 2018[3]).

	2006	2007	2008	2009	2010	2011	TOTAL
Pasco Resolved	2	0	0	0	0	0	2
Pasco Unresolved	4	3	4	2	0	1	14
Pinellas Resolved	3	1	0	2	0	0	6
Pinellas Unresolved	1	2	5	12	0	0	20
Hillsborough Resolved	0	0	0	0	0	0	0
Hillsborough Unresolved	3	4	2	1	0	0	10
Polk Resolved	0	0	0	0	0	0	0
Polk Unresolved	6	13	3	4	0	1	27
Manatee Resolved	1	0	0	0	0	0	1
Manatee Unresolved	0	4	3	3	0	0	10
Citrus Resolved	1	1	0	0	2	1	5
Citrus Unresolved	3	8	2	3	0	0	16
Hernando Resolved	0	0	0	0	0	0	0
Hernando Unresolved	1	3	0	1	0	0	5
Hardee	0	0	0	0	0	0	0
TOTAL	**25**	**39**	**19**	**28**	**2**	**3**	**116**

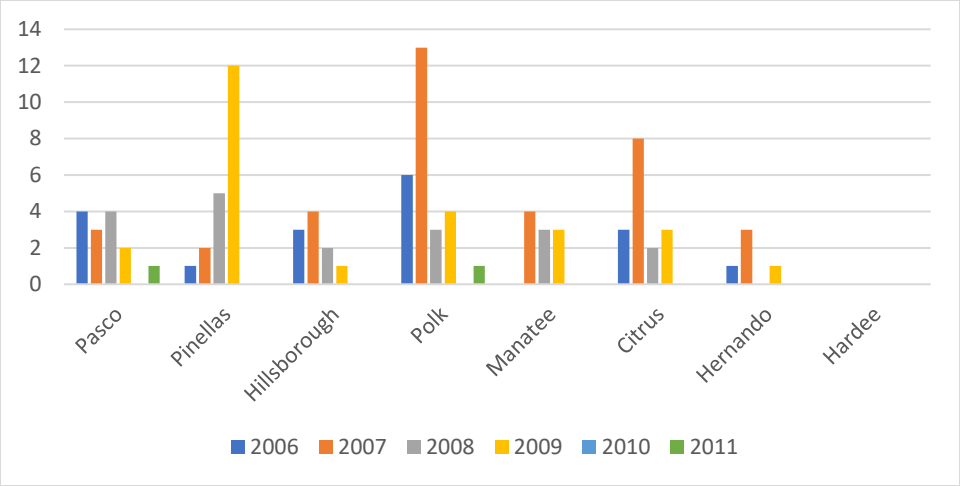

Figure 4.2 Unresolved Dredge and Fill Violations, 2006-2011 (Florida Department of Environmental Protection, 2018[3]).

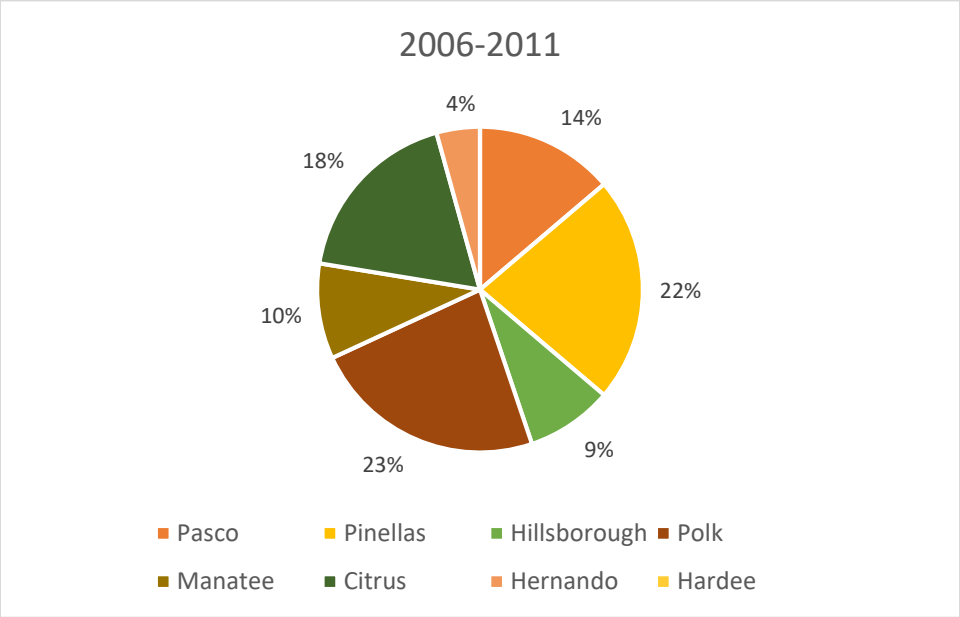

Figure 4.3 Distribution of Dredge and Fill Violations per County between 2006-2011 (Florida Department of Environmental Protection, 2018[3]).

To get an idea of how those numbers compare with recent regulatory activity, the year 2016 is analyzed as well. There were a total of 10 outstanding and 30 resolved Dredge and Fill cases in 2016. Polk County had five resolved and three unresolved violations, Pasco had eight resolved and two unresolved, Hillsborough had one unresolved, Citrus had seven resolved,

Hernando had three resolved, Pinellas had three resolved and two unresolved, and Manatee had four resolved and one unresolved. Hardee did not have any non-compliance Dredge and Fill cases in 2016. The corresponding percentages are shown in Figure 4.4. Since the average year between 2006 and 2011 experienced 19.3 non-compliance Dredge and Fill cases, and there were such cases in 2016, it appears that there were 207% more violations in 2016 than there were during the average year between 2006-2011.

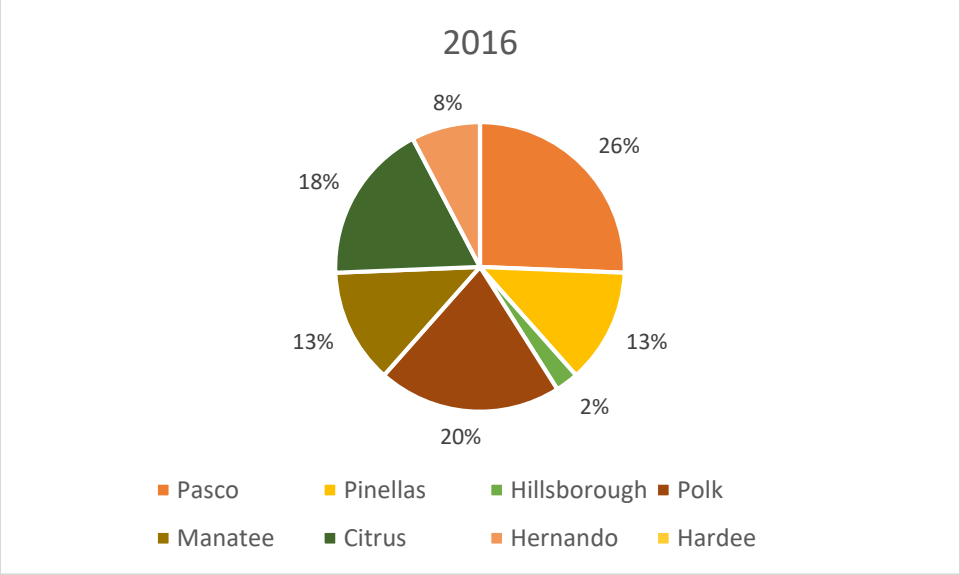

Figure 4.4 Distribution of Dredge and Fill Violations per County in 2016 (Florida Department of Environmental Protection, 2018[3]).

A major issue that was discovered during this research is the lack of proper data entry on behalf of Hillsborough County Environmental Protection Commission (HCEPC). Of the eight counties in the Southwest District, Hillsborough is the only one that regulates wetlands on behalf of the state and enters their data into ERPce. Ten Dredge and Fill violations are shown in the period of six years, and none of them are documented as being resolved. It is unlikely that none of the violations were resolved. Additionally, it is unlikely that there was only one violation in 2016 (a year which was on average 207% more non-compliant than 2006-2011), which again is

documented as being unresolved. It appears that the enforcement project data were not entered appropriately, and the major difference in data entry between DEP and HCEPC is that each ERP staff member at DEP enters their own project information, whereas there is one data entry person at HCEPC who is responsible for updating everyone's projects. DEP does not audit the activities of the jurisdictional counties such as Hillsborough, and HCEPC is required by the Operating Agreement to enter their data into ERPce using the State's methods. Based on the data discussed in this section, it is possible that HCEPC staff are not properly trained and updated on data entry methodology. This implies that the data on file for delegated counties in Florida may not be accurate.

4.1.2 Habitat Alterations Report

Moving on to the Habitat Alterations Report, the three Project Types will be analyzed individually; Enforcement, Complaint, and Compliance (the fourth type is Criminal Activity, but there are no data under that category). Actual permanent wetland alterations due to Enforcement cases totaled 21.39 acres lost (shown in Table 4.2), while Complaints totaled 0.15 acres lost and 1.21 acres mitigated (a net gain of 1.06 acres), and Compliance totaled 11.61 acres lost and 3.27 acres mitigated (a net loss of 8.33 acres). Note that 91.12 acres were preserved for Compliance projects and is not being included in this analysis, which will be further explained in the following paragraph. The total net loss of wetlands documented for 1/1/2006 through 12/30/2011 (authorized and unauthorized) is 28.66 acres. This number will be compared to GIS interpretation of wetland loss in Section 4.2. These data shows that most wetland impacts due to violations are entered into the database under Enforcement projects rather than being labeled as Complaints. Moving forward, the project type "Complaints" will not be the focus due to the small amount of data recorded under this category.

To get an idea of the permanent gains and losses of wetlands documented per county due to Enforcement projects, the activities listed under Enforcement were analyzed and shown in Table 4.2. It is important to note that although the alterations are labeled as losses (through dredging and filling activities) and gains (through mitigation – whether creation, enhancement, restoration, or preservation), the ratio of loss to gain is not always 1:1. In other words, when a ten-acre wetland is converted to an upland through filling activities, a ten-acre wetland may be created elsewhere as compensation. Alternatively, a 40-acre wetland might be preserved through a conservation easement as compensation, or a twenty-acre wetland might be enhanced or restored, or a combination of any of the above options. That determination is made by permitting staff and is highly dependent on the conditions of each particular site. For instance, the wetland could be pristine and untouched, or it might be highly disturbed and filled with nuisance vegetation. Each habitat is thoroughly evaluated and scored in order to determine appropriate mitigation. This scoring technique is described in the Uniform Mitigation Assessment Method (UMAM) rules, which can be found in Chapter 62-345, F.A.C.

This analysis simplifies these concepts by evaluating gains as creation and restoration while ignoring preservation and enhancement. Creation means establishing wetlands or surface waters in a location that was historically uplands, and restoration means re-establishing wetlands or surface waters in a location that was historically wetlands or surface waters but was at some point degraded by dredging or filling activities. Preservation means conserving existing wetlands to ensure that they are not degraded in the future, and enhancement means improving the condition of existing wetlands (such as by removing exotic vegetation). The simplification of ignoring preservation and enhancement was performed because this research is not focusing on habitat quality or type, but rather water storage capability, and also because it is a more

appropriate way to compare gains and losses as a 1:1 ratio. It is also important to note that dredging projects may result in a wetland being converted to a surface water. Therefore, dredging acreage of DEP data is being shown as a loss in wetlands and other surface waters when, in reality, it may be a change from a wetland to a surface water or a change from a surface water to a deeper surface water. This uncertainty may come into play when DEP data are compared to GIS data. However, since there are significantly more filling projects than dredging projects (approximately 80.4% vs. 19.6%, as discussed in Section 4.1.1), any discrepancies caused by this uncertainty should have minimal impact on the analysis.

Table 4.2 Net Change in Wetland Acreage Due to Enforcement Projects During 2006-2011 (Florida Department of Environmental Protection, 2018[3]).

Change in Wetland Acreage Due to Enforcement Projects between 2006 and 2011			
County	**Change type (acres)**		**Net Change**
Pasco	2.03 Restoration	1.19 Dredge/Fill	+0.84 acres
Pinellas	0.11 Restoration	0.14 Fill	-0.03 acres
Hillsborough	1.13 Restoration	0.58 Dredge/Fill	+0.55 acres
Polk	6.37 Restoration/Creation	8.21 Dredge/Fill	-1.84 acres
Manatee	2.05 Restoration	23.36 Dredge/Fill	-21.31 acres
Citrus	2.27 Restoration	0.95 Dredge/Fill	+1.32 acres
Hernando	0.02 Restoration	0.28 Dredge/Fill	-0.26 acres
Hardee	None	0.66 Dredge/Fill	-0.66 acres

Note that there were more wetland alterations performed than were authorized, as shown when the Acreage Status query changes from “Authorized” to “Actual”, indicating that much of the alterations resulted from unauthorized activities. These numbers do not support the data discussed in Section 4.1.1 regarding unresolved violations per county; rather than Polk, Pinellas, Citrus, and Pasco experiencing the most loss, these data shows Manatee experiencing significantly more wetland loss than any other county in the Southwest District. The reason for this appears to be a lack of data entry, which will be discussed later in reference to Figure 4.5,

which shows that the wetland type and acreage for enforcement projects is left blank in most cases.

There is an option for "ERPCE: Habitat Error" under District Reports. This section is described as listing "projects that have habitat alterations identified without the associated detailed habitat codes and descriptors entered". By clicking this option, an excel file was downloaded which showed 1,156 Dredge and Fill cases between 1/1/2006 and 12/30/2011 that come up under Habitat Error. That is the number of projects where the "habitat alteration" section was toggled "yes", but where the habitat type and/or acreage was not specified (as shown in Figure 4.5). This means that there are at least 1,156 altered wetland habitats for which data are not included in the Habitat Alterations Report. This may correlate with the 2,118 complaints received of which only 32% were closed. This could also correlate to the fact that there are only 78 dredging and filling violations on file (a "violation" is recorded when an enforcement project is created and an "activity" is added to the project). If a "violation" is not added to the activities of a project, the non-compliance will not show up in the non-compliance report.

To summarize, although some data are available to show the wetland type and acreage that was altered due to violations, it appears that the data on file are incomplete. When a violation is found, that information should be recorded in the project that is created for that site. Looking at the screenshot in Figure 4.5, the fields in the lower right quadrant should be filled in with the total acreage of dredged and filled material as well as the reference wetland. However, it appears that the typical project leaves these fields blank. Documenting all wetland alteration information for enforcement projects in ERPce is essential if the state hopes to use these data to determine whether the No Net Loss goal is being met. Although there does not appear to be a State regulation requiring specific methods to be used in record-keeping, this database is the only

location where this type of information is stored. Therefore, other than by using ERPce records, there is no way to determine the acreage and type of wetland alteration for DEP-jurisdictional properties. It is unclear how extensively ERPce is currently used in order for policy-makers to estimate success or failure of the No Net Loss Goal in Florida, but to neglect these records would be to miss part of the wetland loss "equation".

When restoration is not required and the violation becomes authorized after fines are paid, the loss of wetlands is not documented as it would be if the property owner had been approved for a permit before any activity was conducted. DEP does not issue after-the-fact permits for the Environmental Resource Program; therefore, the authorization of activities after they have been performed does not contribute to the Habitat Alterations Report unless the data are entered under the enforcement project. The lack of cases closed, violations documented, and acreage recorded implies that the state has a very limited knowledge of the actual amount of wetland loss occurring due to discovered violations (let alone undiscovered violations).

After gathering enough data to determine that the Habitat Alterations Report is an unreliable way to calculate wetland loss in the time frame being researched, it is interesting to note whether habitat information is still not being consistently documented. For the years 2016 and 2017, no habitat alteration has been documented for enforcement projects. In 2015, only 0.17 acres were recorded as the grand total (all alterations; gains and losses added together). Only 0.78 acres were recorded in 2014, only 2.49 acres recorded in 2013, and 4.13 acres recorded in 2012. Compare these numbers to the 98.75 acres of actual wetland alterations shown for the period of 2006-2011 (an average of 16.5 acres per year). The point is, data entry appears to have dwindled since the time period being researched in this thesis, as the number of complaints received by the district per year has remained constant; there were 2,156 Dredge and Fill

complaints in the six years between 2012 and 2017 as compared to 2,118 in the six years between 2006 and 2011.

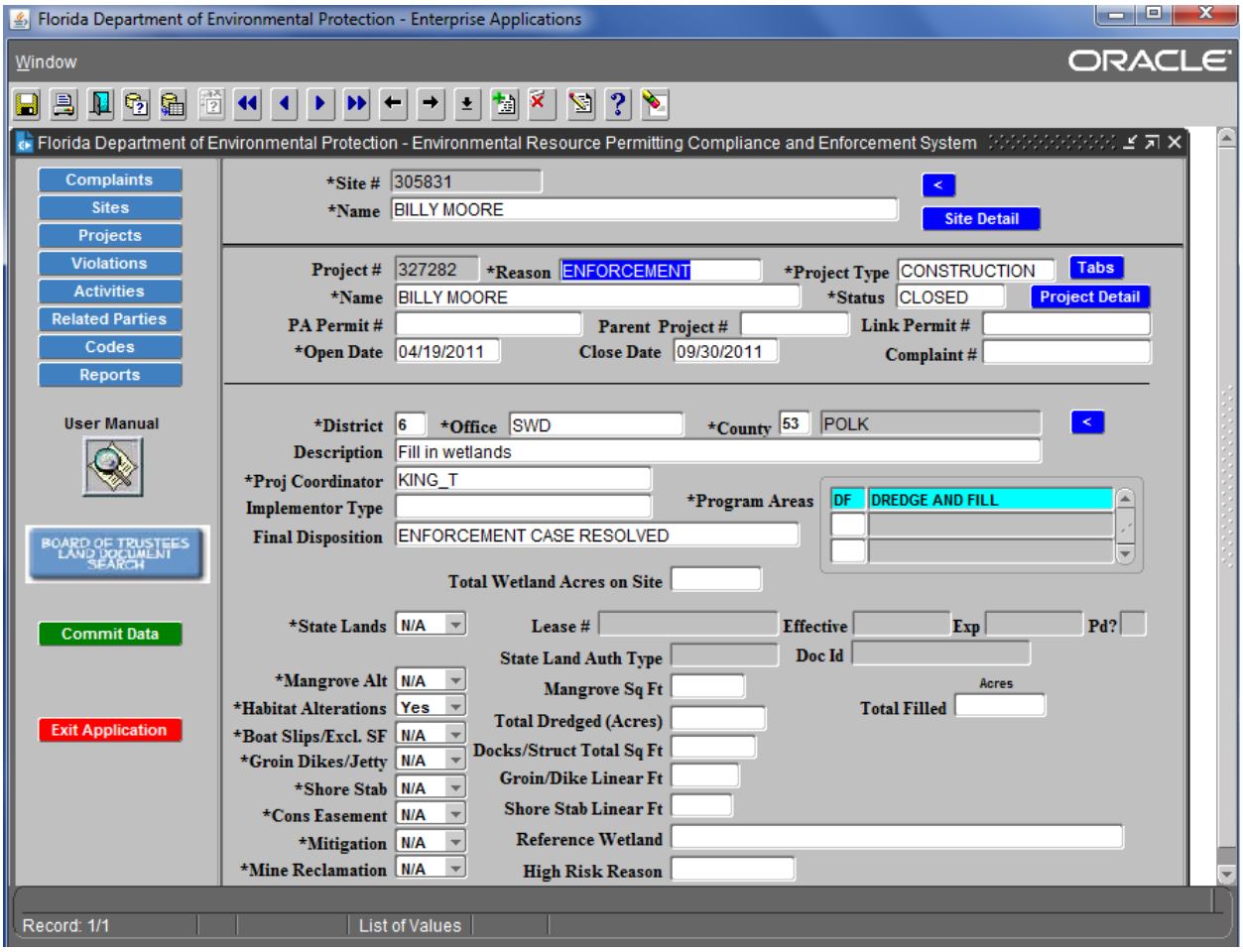

Figure 4.5 Example of an Incomplete Project in ERPce. Notice that wetland type and acreage are not recorded, and that "Habitat Alterations" is toggled "Yes" (Florida Department of Environmental Protection, 2018[3]).

4.2 Analysis of GIS Data

After performing all the steps listed in Section 3.2, the total acreage of DEP-regulated wetlands in 2011 can be determined, which is 859,333 acres. The 2006 area shows a total of 858,083 acres. The total difference in DEP-regulated wetlands between 2006 and 2011 is 1,250 acres gained, as shown in Figure 4.7. This represents a 0.15% gain in non-SWFWMD-regulated

wetlands. This number can be compared to the 28.66 acres of wetland loss that was shown in the Habitat Alterations Report of ERPce in Section 4.1. This indicates that DEP was unable to document wetland gain. It is possible that there were artificial surface waters created during 2006-2011 that were not considered to be mitigation of wetland loss, such as stormwater detention and retention ponds that do not provide wetland functions. It is unclear how these types of waters contribute to wetland studies through aerial interpretation, but a few possibilities will be discussed in Section 4.2.1.

4.2.1 Small-Scale Wetland Gain in the Southwest District

Wetlands jurisdictional to DEP in 2011 accounted for approximately 80% of the total wetlands in the region. That same year, 208,865 acres of wetlands were jurisdictional to SWFWMD; approximately 20% of wetlands in the region. Most literature focuses on the larger projects regulated by SWFWMD, but this shows that wetland loss due to small-scale projects has the potential to result in even more impacts than large-scale projects. However, in this study, the change in wetland coverage on small-scale properties accounted for only a 0.12% gain in total wetlands. This number is somewhat insignificant with regard to overall wetland change, indicating that other research may be appropriate in its focus on wetlands and surface waters affected by large-scale commercial projects (which accounted for a 0.23% gain in total wetlands, even though SWFWMD projects only accounted for 20% of total wetland area). One aspect of permitting that was expected to contribute to small-scale wetland loss is the general permit for minor works in isolated wetlands. The permit criteria is found in section 62-330.475 F.A.C., and allows minor unmitigated impacts to isolated wetlands as long as certain criteria are met. That type of permit could potentially result in many cases of unmitigated wetland loss. However, only 12 such permits were issued between 2006-2011 according to the Environmental Resource

Program Permit Application (ERPpa) database, so it is not surprising that these activities appear to have not contributed to significant wetland losses in the region.

Figure 4.6 shows the total wetland and surface water change in the Southwest District of DEP between 2006 and 2011, including SWFWMD-jurisdictional wetlands. Subtracting acreage lost from acreage gained, the net change in overall wetlands is 3,730 acres gained (shown in Table 4.3). It appears that most of the loss that occurred was inland rather than coastal. Figure 4.8 shows the wetland and surface water change in the Southwest District of DEP on SWFWMD-jurisdictional properties alone (excluding some agricultural parcels). The "type change" areas indicate wetlands or surface waters that were converted from one habitat type to another, such as a lake changing to a freshwater emergent wetland. While the DEP-regulated areas experienced 23,139 acres of type change, the SWFWMD-regulated areas experienced 15,606 acres of type change (shown in Table 4.3). Most of the type changes occurred inland rather than in coastal areas, as depicted in Figure 4.6.

Table 4.3 Change in Wetland Acreage in DEP-jurisdictional and SWFWMD-jurisdictional Areas Between 2006 and 2011. Determined by GIS analysis.

DEP Jurisdiction		**SWFWMD Jurisdiction**	
Wetland Change	**Acres**	**Wetland Change**	**Acres**
Gain	10,917.25	Gain	20,223.57
Loss	9,667.06	Loss	17,743.54
No Change	825,277.08	No Change	485,851.32
Type Change	23,138.62	Type Change	15,606.33
Net Change	1,250.19 gained	**Net Change**	2,480.03 gained
Net Change (DEP & SWFWMD)		3,730 gained	

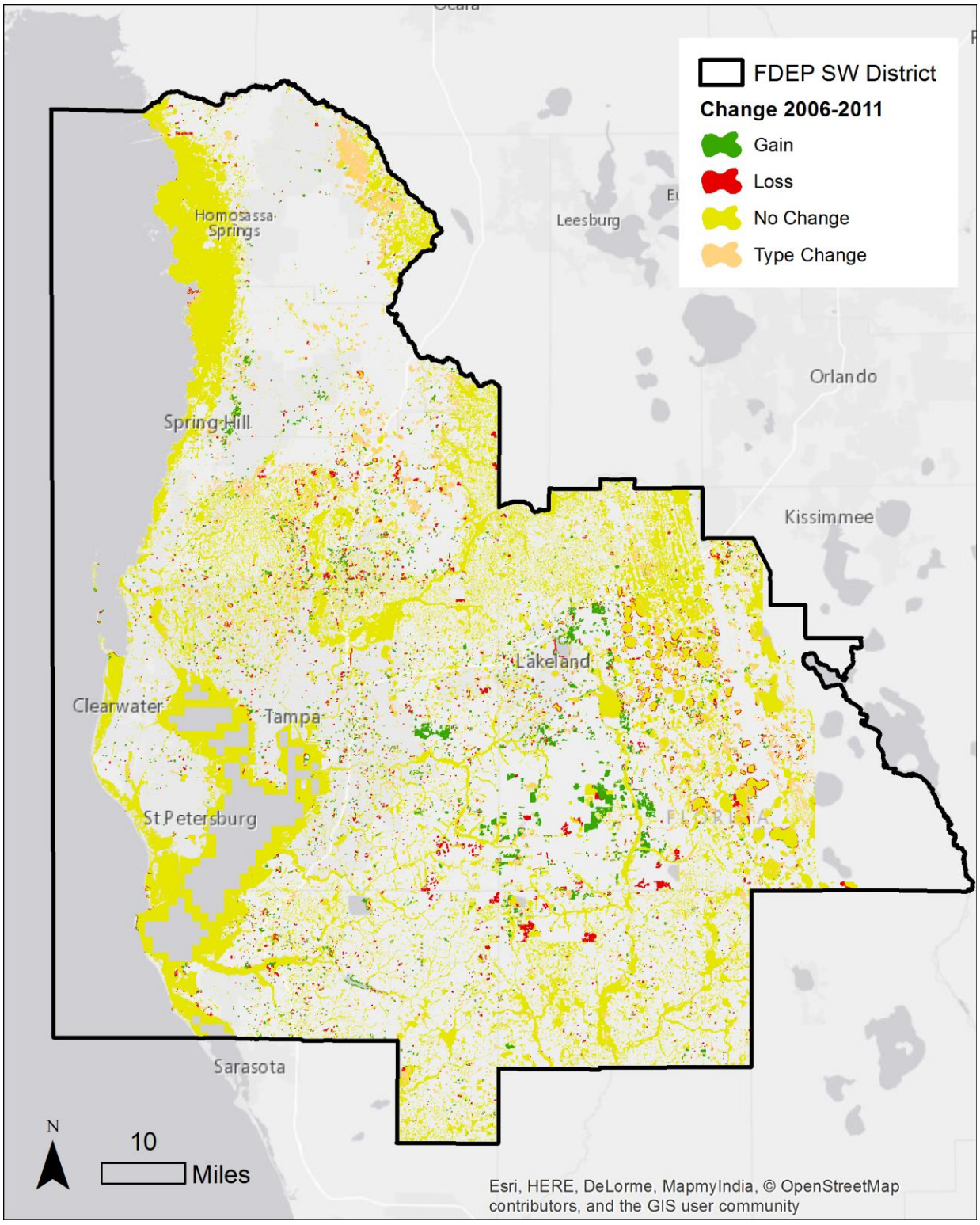

Figure 4.6 All Wetland Change between 2006 and 2011. Determined by GIS analysis.

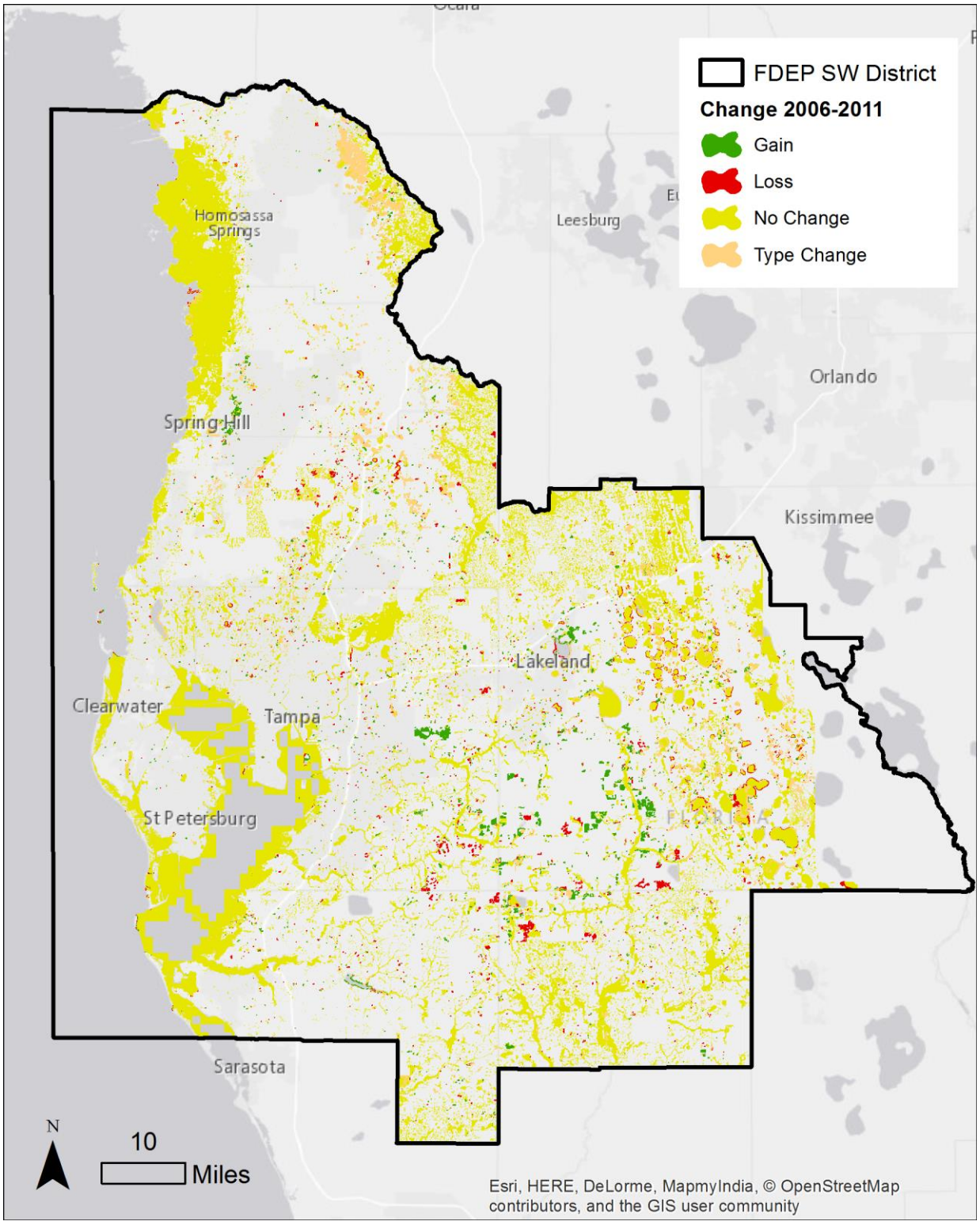

Figure 4.7 DEP-Jurisdictional Wetland Change; 2006-2011. Some agricultural lands are included which are not jurisdictional to DEP. Determined by GIS analysis.

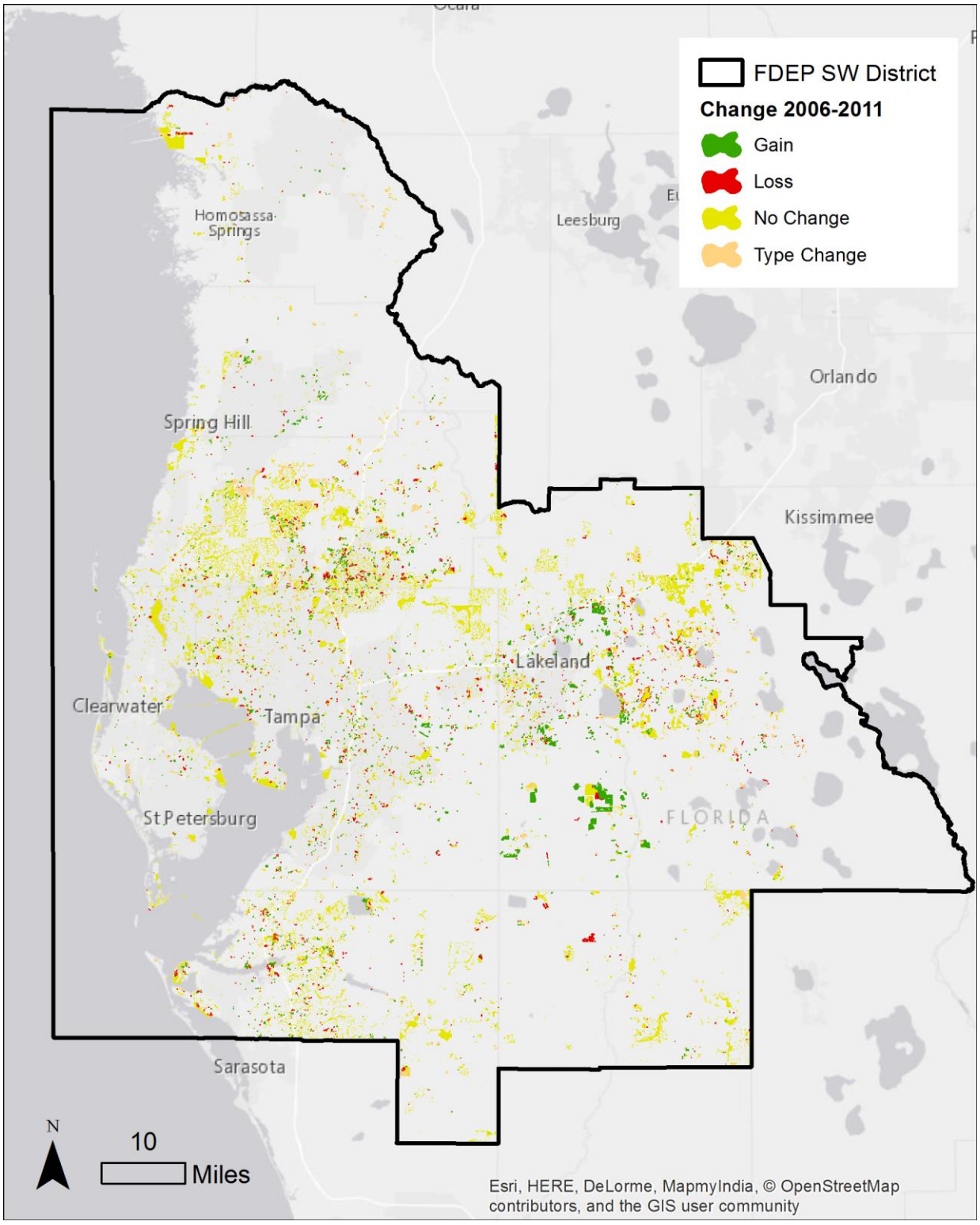

Figure 4.8 SWFWMD-Jurisdictional Wetland Change; 2006-2011. Some agricultural areas are excluded in this analysis. Determined by ArcGIS.

Table 4.4 shows the specific types of DEP-jurisdictional (and agricultural) wetlands and surface water habitats that were gained and lost between 2006 and 2011. Freshwater marshes experienced the most significant net increase in acreage during that time, followed by wet prairies. Freshwater marshes are inundated inland areas dominated by grasses and shrubs rather than trees; wet prairies are similar, but can be either saturated (water table is below the soil surface) or inundated (water is above the soil surface) and are dominated by grasses (Florida Natural Areas Inventory, 2010). Emergent aquatic habitats experienced the most significant net decrease in acreage during 2006-2011, followed by lakes. Emergent aquatic habitats contain plants that are rooted below the water surface with vegetative parts emerging above the water surface, and lakes are bodies of water surrounded by land (Florida Natural Areas Inventory, 2010).

Table 4.4 Change in DEP-jurisdictional Acreage per Type of Surface Water Between 2006 and 2011. Determined by GIS analysis.

Waters Gained (net acres)		**Waters Lost (net acres)**	
bays and estuaries	232.79	streams and water	165.75
mangrove swamps	10.17	lakes	7,387.87
freshwater marsh	14,962.85	stream and lake	2,328.59
wet prairies	4,171.42	cypress	428.96
salt flats	34.43	wetland forested	183.63
		saltwater marsh	214.47
		emergent aquatic	7,398.20
		intermittent pond	54.09
Total Gained	19,411.81	**Total Lost**	18,161.56
	Net Change	1,250.25 acres gained	

Table 4.5 shows more detailed information about habitat changes in DEP-regulated areas in order to determine from what type of change the most significant habitat gains and losses resulted. The habitat types listed in the table include only those which experienced more than

500 acres of change between 2006 and 2011. Of the gains in freshwater marsh habitat, 7,032 acres were created from non-wetlands (47%), while the majority of the remaining gains resulted from conversions of lakes and emergent aquatic habitats. Of the gains in wet prairie habitat, 1,177 acres were created from non-wetlands (28%), while the majority of the remaining gains resulted from conversions of lakes and freshwater marsh. Of the emergent aquatic habitat that were lost, 1,017 acres were converted to non-wetlands (14%), while the majority of the remaining gains resulted from conversions to freshwater marshes and wet prairies. Of the lakes and streams that were lost, 4,122 acres were converted to non-wetlands (42%), while the majority of the remaining gains resulted from conversions to freshwater marshes and wet prairies.

This shows that the major types of wetland and surface water net gains and losses that occurred in DEP-jurisdictional and agricultural areas between 2006 and 2011 were conversion of non-wetlands to freshwater marsh and conversion of lakes to non-wetlands. The term "non-wetlands" refers to any area that is not classified as one of the FLUCCS codes described in Section 3.2. However, a "non-wetland" is not necessarily an upland. Upon inspection of the SWFWMD GIS interface, some of the wetlands in 2011 (especially freshwater marshes) were converted from reservoirs, or were located along the edge of reservoirs. The FLUCCS code for reservoirs was not used in the grouping of wetlands and surface waters for this research, as these features often do not provide functions consistent with a natural surface water. A reservoir is defined by SWFWMD as an artificial feature that is used as a source of water supply. This type of feature can be any size, as even small reservoirs can be used for irrigation of the nearby landscape.

It is possible that, as the reservoirs became shallower or collected sedimentation, vegetation began to grow in or around these water bodies. Whether the vegetation is mostly native or invasive cannot be determined without site visits, and whether it was installed as a littoral shelf or grew naturally is unclear. Analysis of aerial photographs using Google Earth Pro showed what appeared to be inconsistent changes based on visual interpretation of the presence or absence of vegetation, especially since it is often difficult to distinguish surface algae from emergent vegetation. Therefore, a figure was not provided for changes between non-wetlands and wetlands, but was provided for changes between wetland types (Figure 4.9 will be discussed in the next paragraph). Since reservoirs are defined by SWFWMD as artificial water bodies, any changes in vegetation in or around the reservoir should not prompt a change in classification of the reservoir to a wetland, as the feature is still artificial. The reasons for changing the FLUCCS codes of reservoirs to wetland habitat types is ultimately unclear, and would require interviews with staff who work on the GIS layers in order to determine how and why those changes took place. However, it is clear that many of these reservoirs are not a good representation of wetlands – many are lined with geotextile instead of soil substrate and lack appropriate storage and filtration mechanisms as well as connectivity with the watershed.

It is also unclear why there was significant change from emergent aquatic habitats and lakes to freshwater marshes; however, a comparison between the SWFWMD GIS interface and Google Earth Pro aerial photographs provides evidence that the water features may have become shallower between 2006 and 2011. This could have caused the different interpretation of habitat type, since emergent aquatic habitats and lakes are generally deeper than freshwater marshes. Figure 4.9 shows an example of DEP-jurisdictional emergent aquatic habitats in 2006 that became freshwater marshes in 2011. The change in color shown in the aerial photographs

indicates that the 2011 water features may not have been as deep as their 2006 counterparts, which could indicate either a lower water table or possibly sedimentation of the water features. It is unclear whether the majority of these changes were caused by shallower waters, and if so, whether the shallower waters are a result of dry weather, groundwater withdrawal, changes in drainage, or other causes.

Table 4.5 Largest Changes Between Specific Habitat Types During 2006-2011 in DEP-jurisdictional Areas. These conversions resulted in over 500 acres of change (GIS data).

Habitat Type in 2006	Habitat Type in 2011	Change in Acreage
non-wetlands	freshwater marsh	7,031.61
non-wetlands	wet prairies	1,176.55
non-wetlands	emergent aquatic	1,440.88
lakes	non-wetlands	2,159.24
stream and lake	non-wetlands	1,962.74
freshwater marsh	non-wetlands	2,685.86
wet prairies	non-wetlands	1,270.53
emergent aquatic	non-wetlands	1,017.18
lakes	freshwater marsh	3,745.82
lakes	wet prairies	1,240.88
stream and lake	freshwater marsh	829.88
freshwater marsh	wet prairies	2,703.24
emergent aquatic	lakes	682.30
emergent aquatic	freshwater marsh	8,418.38
emergent aquatic	wet prairies	553.53

Figure 4.9 Example of Wetland Habitat Type Change. On the left is a reservoir with emergent aquatic habitat in 2006 and the corresponding 2011 feature in which the upper right quadrant is classified as freshwater marsh. Random inspection of the SWFWMD GIS interface and corresponding aerial photographs yielded similar results, including changes from lakes to freshwater marsh. Aerial photographs obtained using Google Earth Pro.

From the analysis of overall wetland loss in the Southwest District, impacts to individual counties should be discussed as well. A limitation to this analysis is that the boundaries of the District Counties layer do not include many areas below the Mean High Water Line. Therefore, the acreage of wetlands shown in the ArcGIS statistics for each county does not account for the actual extent of wetlands because some coastal regions appear to be excluded (see Figure 4.10). This makes sense, as many areas below the Mean High Water Line (marine and estuarine habitats) and the Ordinary High Water Line (non-tidal, or freshwater habitats) are owned by the State of Florida, not the counties. Also, any tidal difference as the time of image capture may also contribute to uncertainty in the analysis. Therefore, the county statistics shown by ArcGIS will be discussed in the following paragraph, but these statistics do not add up to the District's total difference in wetland area between 2006 and 2011.

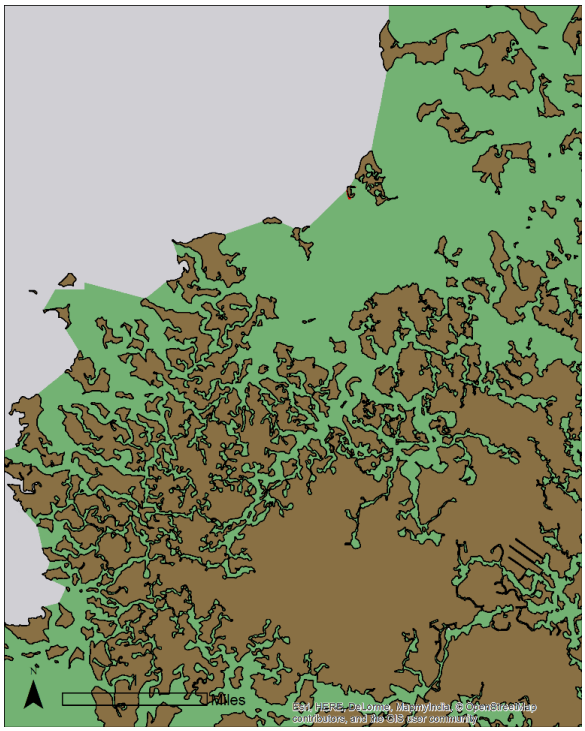

Figure 4.10 View of Discrepancy in County Boundaries. Zoomed-in image of the Citrus County portion of Figure 4.6 to show that the brown areas enclosed by county boundaries are not inclusive of many wetland areas, which are shown in green. The grey area represents open water.

According to ArcGIS with the District Counties layer used, there was zero net change in wetland and surface water acreage between 2006 and 2011. This is contrary to the 1,250 acres as mentioned at the beginning of this section. This discrepancy, however, cannot be due to the MHWL issue because the vast majority of wetland change occurred in inland freshwater areas as opposed to coastal marine environments. It is unclear why the counties showed only a few square feet of change in wetland and surface water areas between 2006 and 2011, and this conundrum could benefit from future research.

Upon visual inspection of Figure 4.7, it appears that Polk County experienced the most gross increase in surface water feature area. The counties within the Southwest District of DEP are shown in Figure 4.11, and were not shown in Figures 4.6, 4.7, and 4.8 because the county lines visually interfered with the wetland polygons. Polk, Pasco, Hillsborough, and Manatee counties appear to have experienced the most gross losses, respectively. Section 4.1 determined that Polk, Pinellas, Citrus, Pasco, and Manatee counties had the most discovered Dredge and Fill violations, respectively (shown in Figure 4.3). It is concluded that the number of discovered violations does not reflect congruent percentages of wetland loss in each county. Please note that 227,050 acres of Polk County were not included in the analysis, as SWFWMD does not regulate that portion of Polk County and DEP SWD does. The South Florida WMD regulates that portion of Polk County, but they did not have GIS data available for the LULC layers for 2006 and 2011. Therefore, it is likely that Polk County would show a slightly greater loss in wetlands had that area been included. However, since Polk County contains approximately 1,287,040 acres, only 17.6% of the county was excluded from the analysis. That only accounts for approximately 5.3% of the Southwest District.

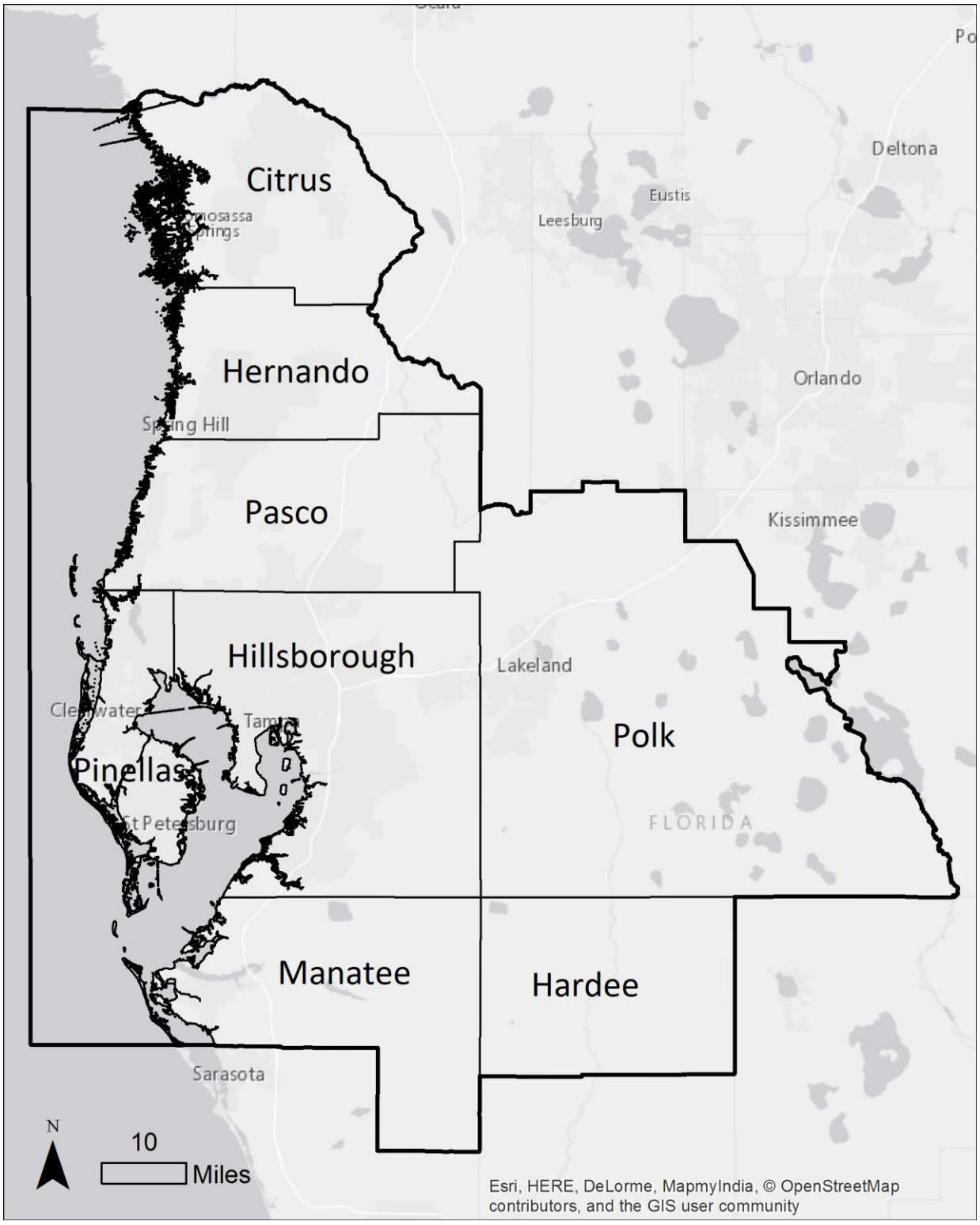

Figure 4.11 County Boundaries within the Southwest District of DEP. Map created in ArcGIS.

4.2.2 Limitations to the GIS Analysis

In addition to limitations associated with the GIS files, which were discussed in Sections 3.2 and 4.2, it is important to note that the term "wetlands" is being used to describe "wetlands and other surface waters" in this thesis. Land use Land cover techniques may include wet detention ponds as lakes, so any stormwater ponds created during the time frame may be off-setting the loss of wetlands calculated, even though they do not provide the same biological functions as natural lakes. This is supported by the study by Schmidt et. al (2017), which showed that artificial water features cause discrepancies in many analyses of No Net Loss achievement. The aerial interpretation of wetlands and surface waters is based on a combination of infrared technology, visual interpretation, existing Wetland Inventory data, and ground truthing (SWFWMD, 2007 and 2012); therefore it is possible that the level of drought or wet weather during the years 2006 and 2011 may have had an impact on the analysis. It is also possible that groundwater withdrawal may have had an impact on wetlands during this timeframe; this might be a subject that could benefit from future research. Permitted activities require mitigation to offset wetland impacts, and since the DEP data indicated a net loss of wetlands in the District, it is possible that most of the gain shown in the GIS analysis occurred from creation of water features that were not meant to be mitigation for wetland loss (such as reservoirs).

Additionally, the analysis is limited by the minimum mapping unit of 0.5 acres for wetlands – since many small-scale alterations result in less than 0.5 acres of impact, the LULC layer may be excluding those small changes. A study by McCarthy et. al (2018) showed that wetland accuracy was improved by 15-33% when two-meter resolution was used to map and classify wetlands as compared to the 30-meter accuracy used by most state and federal agencies. This supports that there may be a great level of uncertainty in the remote sensing imagery used in

this analysis. As noted in a study by Rains et. al (2013), many areas used for mining do not show mitigation in the LULC layer. That is, even when a mined area contains wetland creation or restoration, the area will always be labeled as mining area. This is another limitation of the GIS analysis, as there could be more wetland gain than is shown in the maps, especially in Polk County which contains large phosphate mining activites.

It is also important to note that the ERP Permit SWFWMD layer excludes some areas that are jurisdictional to SWFWMD. This thesis refers to its focus as "DEP-jurisdictional wetlands" or "non-SWFWMD jurisdictional wetlands"; however, agriculturally zoned properties are regulated by SWFWMD and many of these areas are not included in the SWFWMD ERP Permitting layer. That means that those areas were included in this analysis of DEP-jurisdictional areas (there does not appear to be a GIS layer available that will eliminate those properties). Agricultural lands are exempt from most dredging and filling activities due to subsections 373.406(2) and (3) F.S., which state that

> "Nothing herein, or in any rule, regulation, or order adopted pursuant hereto, shall be construed to affect the right of any person engaged in the occupation of agriculture, silviculture, floriculture, or horticulture to alter the topography of any tract of land, including, but not limited to, activities that may impede or divert the flow of surface waters or adversely impact wetlands, for purposes consistent with the normal and customary practice of such occupation in the area…This exemption applies to lands classified as agricultural pursuant to s. 193.461 and to activities requiring an environmental resource permit pursuant to this part…Nothing herein, or in any rule, regulation, or order adopted pursuant hereto, shall be construed to be applicable to construction, operation, or maintenance of any agricultural closed system."

This rule means that any ERP regulations stated in the rest of the Florida Statutes and Florida Administrative Code are not applicable to agricultural, silvicultural, and horticultural lands which are designated as such by county zoning. This includes cropland as well as lands with livestock, which could be quite large or could be as small as a single-family home that owns a few farm animals. Therefore, it is not possible at the current time to determine what amount of wetland area described above meets the qualifications to be considered jurisdictional to SWFWMD due to agricultural zoning. However, with regard to this analysis that number is somewhat unimportant, as this thesis is determining the extent of wetland loss due to unmitigated activities that are not part of a large development plan. Agricultural lands meet that description, but let it be noted that some of those activities may be exempt from ERP rules and may not be the jurisdiction of DEP.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This research used GIS data to estimate the change in wetland acreage due to DEP-jurisdictional activities and agricultural activities (taking into account both authorized/exempt and unauthorized activities) in the Southwest District between 2006 and 2011, and compared the net change with the unmitigated wetland loss that DEP documented during that time for authorized activities and violations that were discovered. The comparison allowed an estimation of the extent of undocumented change in wetland area that occurred during those six years, which was further analyzed by county. The research provided an assessment of the methodology for permitting and enforcement of wetland alteration activities relating to small-scale projects and how that has affected the No Net Loss of wetlands goal in Southwest Florida. After ascertaining the results to the objectives listed in Chapter 1, this thesis provided the following information:

1. There were 116 small-scale unmitigated wetland violations discovered between 2006 and 2011 in the Southwest District (numbers per county per year are shown in Table 4.1), 88% of non-compliance Dredge and Fill cases remain unresolved, and the net acreage of wetland loss documented by DEP is 28.66 acres.
2. The acreage of small-scale unmitigated wetland gain in the region between 2006 and 2011 was 1,250 acres, as determined by aerial GIS data. Pasco County experienced the most wetland loss, and Polk County experienced the most gain (gross, not net).

3. Wetland gain on small-scale properties that occurred during 2006-2011 is undocumented. This accounts for a 0.12% increase in total wetland acreage in the region, showing that although regulatory methodology has not been effective in tracking and mitigating small-scale wetland loss, the gain due to small-scale activities appears to compensate for any loss. However, gains shown by GIS analysis may be due to water features that do not provide appropriate wetland functions.

The hypothesis of this thesis was that the region has experienced more of a net loss of wetlands due to small-scale activities than state records indicate, and that the delegated county experienced less small-scale unmitigated wetland loss than non-delegated counties. The hypothesis was rejected. The region has experienced a gain of wetlands due to small-scale activities, contrary to State records which indicate a loss. Hillsborough County did not experience the most wetland gain of the eight counties, despite the fact that it is the only county government in the Southwest District that uses state Environmental Resource Program rules. A surprising result was that the data for Hillsborough County appear to be severely incomplete; this indicates that the state should allocate efforts toward ensuring the success of the delegated counties with regard to carrying out ERP responsibilities.

As discussed, the total net loss of wetlands that was documented by DEP for the period between 1/1/2006 and 12/30/2011 (authorized and unauthorized) is 28.66 acres. The total difference in DEP-regulated wetlands (and wetlands on agricultural parcels) between 2006 and 2011 as determined by GIS analysis is 1,250 acres gained, representing a 0.15% gain in DEP-jurisdictional and agriculturally-zoned wetlands due to small-scale activities. Although some of the change in wetland acreage may have been due to agricultural activities which are the jurisdiction of SWFWMD, those activities were not documented by SWFWMD either, as they

are exempt from permitting. Most literature focuses on the larger (mitigated) projects regulated by SWFWMD, but this research shows that SWFWMD only regulates approximately 20% of wetlands, not including agricultural properties. This shows that small-scale projects have the potential to add up to more of an impact than large-scale projects, if left unchecked. However, the small-scale change in wetland acreage during this time frame accounted for a 0.12% increase in all wetlands in the region, which suggests that the new wetland and surface water areas most likely were not the result of required mitigation, but rather are water features (such as reservoirs) that may not provide wetland functions. The existing widespread focus on large-scale projects and mitigation shortcomings may be appropriate, but future research may be needed in order to determine how much of the wetland gain shown by GIS analysis was incorrectly re-classified from a reservoir, as well as how many wetland changes were not detected and represented in the GIS layers due to coarse resolution of the imagery (discussed previously in Sections 3.2 and 4.2).

Analyzing wetland data by county, it was determined that the most dredging and filling violations discovered were in Polk, Pinellas, Citrus, Pasco, and Manatee counties, respectively (according to DEP data). According to GIS analysis, each county experienced zero net change in wetland acreage. This means that neither the data on file at DEP nor the GIS data used in this research can be used to infer actual wetland loss on a county-scale basis. Upon visual inspection of Figure 4.7, it appears that Polk County experienced the most gross gain in surface water features and Pasco County experienced the most gross loss. As Hillsborough County experienced the fourth highest loss of wetlands out of eight counties (according to DEP data), apparently the regulation of wetland alteration activities using state Environmental Resource Program (ERP) rules has not led to success in achievement of the No Net Loss goal by the county government. This indicates that the state should not only allocate efforts toward its own data accuracy, but

should also train and audit the delegated counties in order to ensure accuracy of their data as well. Future research should determine why each county shows no net change in wetland acreage despite the fact that the District as a whole shows many inland gains and losses.

Analyzing the types of habitat changes that occurred in the region between 2006 and 2011, it is clear that most of the wetland and surface water changes that occurred were inland rather than coastal. Freshwater marshes experienced the most significant net increase, followed by wet prairies. Emergent aquatic habitats experienced the most significant net decrease, followed by lakes. The major types of wetland and surface water net gains and losses that occurred in DEP-jurisdictional and agricultural areas between 2006 and 2011 were conversion of non-wetlands (including reservoirs) to freshwater marsh and conversion of lakes to non-wetlands (including reservoirs). The reasons for these changes are unclear, although it is possible that littoral shelves in reservoirs could have been counted as freshwater marsh areas in the aerial interpretation. Future research should attempt to determine why these types of habitat changes were the most significant contributors to net gains and losses. It would also be interesting to determine why the most significant types of gross habitat gains and losses were from conversion of lakes and emergent aquatic habitats to freshwater marshes. It is possible that aerial interpretation and habitat labeling by SWFWMD staff differed between 2006 and 2011 to cause some of these changes. Using online GIS interface examples of 2006 lakes and emergent aquatic habitats compared with their 2011 counterparts, it is possible that shallower water may have triggered the change in classification to freshwater marsh.

This research studied not only the regulations used to attempt No Net Loss of wetlands in Florida, but also the methodology used by the State in order to carry out the regulations. The lack of cases closed, lack of violations documented, and lack of habitat alteration acreage recorded

implies that the state has a very limited knowledge of the actual change in wetland acreage occurring due to discovered violations, let alone undiscovered violations. Of the 2,118 dredging and filling complaints that were received by the DEP Southwest District office, only 32% of them were closed – with or without enforcement actions. This means that 68% of all Dredge and Fill complaints were not closed. 116 dredging and filling violations were on file for the time frame that was researched. Of these, only 88% remain unresolved (resolution occurs through a fine, restoration, or both).

There are at least 1,156 projects between 2006-2011 that were documented as having altered wetland habitats (authorized and unauthorized) for which data are not included in the Habitat Alterations Report due to lack of acreage information. Additionally, it appears that there are many projects for which a dredge or fill violation was documented but for which there were no habitat alterations reported at all. For the years 2016 and 2017, no habitat alteration was documented for any enforcement projects. Compare this to the 98.753 acres of actual wetland alterations shown for enforcement projects for the period of 2006-2011 (an average of 16.5 acres per year). Data entry appears to have dwindled since the time period being researched in this thesis, as the number of complaints received by the district per year has remained constant; there were 2,156 Dredge and Fill complaints in the six years between 2012 and 2017 as compared to 2,118 in the six years between 2006 and 2011 (a 1.8% difference). The data on file for Hillsborough County, which are entered by EPCHC staff, may not be accurate. The ERPce database shows only ten dredging and filling violations in the period of six years for Hillsborough County, even though 222 Dredge and Fill complaints were received – and none of the violations are documented as being resolved. All of these discrepancies are evidence that the methodology used to regulate wetland alteration using the ERP rules has not been effective in

achieving the No Net Loss goal. However, it appears that regulatory methodology as it relates to small-scale activities did not significantly contribute to overall wetland loss, according to GIS analysis.

This research shows that small-scale unmitigated wetland impacts in Southwest Florida have not been properly tracked for violations that are discovered, violations that are undiscovered, and authorized activities (whether permitted or exempt). Therefore, small-scale unmitigated wetland losses cannot be calculated using documented alterations. Interestingly, aerial imagery may not be an effective way to determine change in wetland and surface water acreage either, as the imagery indicated a net gain in wetlands and surface waters between 2006 and 2011 which may be a result of interference by artificially-created water features such as stormwater detention ponds. Artificially-created water features that were not created for the purpose of mitigation but were rather created for aesthetic, commercial, or industrial purposes may not provide the ecosystem and water storage functions necessary to be considered wetlands in this analysis.

These results can be extrapolated to the rest of Florida, as wetland protection at the state and federal level are carried out the same way throughout the state. As discussed in Chapter 3, the timeframe studied in this thesis contained a recession (leading to a decrease in development), which means that there should be more dredging and filling activities occurring today. This indicates that the acreage of undocumented wetland loss between 2012-2017 may be greater than the acreage determined by this study. Future research should focus on recent years, provided that the GIS data become available. It would also be interesting to determine how the agricultural exemption plays into change in wetland habitat, and how artificially-created water features that were not intended to mitigate wetland loss might affect analysis of the LULC data. Another

interesting aspect that could benefit from future research is the affects that groundwater withdrawal had on the water tables in various areas of the District during that time, and whether that could have affected interpretation of the aerial imagery.

If political decisions are being made either based on documented wetland loss or based on wetland gain shown by aerial imagery, then Florida may struggle to meet the No Net Loss goal, as these two techniques show contrary results and it is unclear which is more indicative of actual wetland change. Analysis of the Environmental Resource Program shows that the regulations provide the state with the authority to achieve the No Net Loss goal, aside from the agricultural exemption which authorizes unmitigated wetland loss for agricultural, horticultural, and silvicultural activities. Therefore, the state's documented failure to achieve the No Net Loss goal appears to be predominantly due to lack of public cooperation with the ERP rules as well as the state's inability to enforce the rules, rather than being due to insufficient regulations. Potential solutions to this problem might be increased public awareness of wetland protection as well as increased resources for regulatory agencies to carry out enforcement of the rules.

Currently, the state and federal government each regulate wetland alterations separately in Florida. However, on March 23, 2018, House Bill 7043 was approved by Rick Scott, the governor of Florida. The bill begins a public evaluation of the possibility that the state will assume responsibility for regulation of Section 404 Clean Water Act (CWA) permitting and enforcement on behalf of the federal government (which includes dredging and filling), as is the case in New Jersey and Michigan. This would mean that the U.S. Army Corps of Engineers will no longer take part in wetland regulation in Florida, and the widespread evaluation and scrutiny of their methodology would instead be focused on the Department of Environmental Protection. It would mean that the Clean Water Rule (a more detailed definition of jurisdictional wetlands in

Section 404 of the Clean Water Act) that is currently being considered as discussed in Section 1.3, would allow DEP to implement federal regulations in all Florida surface waters, including isolated wetlands. If this change takes place, it will be even more important for DEP to have accurate data for wetland alterations, as the state will be the only source of data for wetlands which are not regulated by the Water Management Districts – wetlands which account for approximately 80% of all wetlands in Florida.

REFERENCES

Arias, M., Brown, M., & Sansalone, J. (2013). Characterization of Storm Water-Suspended Sediments and Phosphorus in an Urban Catchment in Florida. *Journal of Environmental Engineering*, (2). 277.

Brody, S. D., & Highfield, W. E. (2005). Does planning work? Testing the implementation of local environmental planning in Florida. *Journal of the American Planning Association*, (2). 159.

Brody, S. D., Highfield, W. E., Ryu, H., & Spanel-Weber, L. (2007[1]). Examining the relationship between wetland alteration and watershed flooding in Texas and Florida. *Natural Hazards*, (2), 413.

Brody, S. D., Zahran, S., Maghelal, P., Grover, H., & Highfield, W. E. (2007[2]). The rising costs of floods: examining the impact of planning and development decisions on property damage in Florida. *Journal of the American Planning Association*, (3). 330.

Brown, A.T. (2017). Freshwater Wetland Creation in a Changing Urban Environment: Designing for Long-Term Viability. *University of South Florida Graduate Theses and Dissertations.* http://scholarcommons.usf.edu/etd/6807, accessed 8 June, 2018.

Cohen, M. J., Creed, I. F., Alexander, L., Basu, N. B., Calhoun, A. J., Craft, C., & ... Walls, S. C. (2016). Do geographically isolated wetlands influence landscape functions?. *Proceedings Of The National Academy Of Sciences Of The United States*, (8), doi:10.1073/pnas.1512650113.

Creed, I. F., Lane, C. R., Serran, J. N., Alexander, L. C., Basu, N. B., Calhoun, A. K., & ... Smith, L. (2017). Enhancing protection for vulnerable waters. *Nature Geoscience*, 10(11), 809.

Dahl, T.E. (2005). Florida's wetlands: an update on status and trends, 1985 to 1996. US Department of the Interior. Fish and Wildlife Service, Washington, DC.

Dahl, T.E. (2006). Status and trends of wetlands in the conterminous United States, 1998 to 2004. US Department of the Interior. Fish and Wildlife Service, Washington, DC.

Dahl, T.E. (2011). Status and trends of wetlands in the conterminous United States, 2004 to 2009. US Department of the Interior. Fish and Wildlife Service, Washington, DC.

Dahl, T. E., Frayer, W. E., Johnson, C. E., & U.S. Fish and Wildlife, S. (1991). Wetlands, status and trends in the conterminous United States, mid-1970's to mid-1980's. US Department of the Interior. Fish and Wildlife Service, Washington, DC.

Florida Department of Environmental Protection (2018[1]). Boundary map of DEP Southwest District. https://floridadep.gov/waste/waste-cleanup/content/state-florida-agency-and-department-brownfields-contacts, accessed 27 February, 2018.

Florida Department of Environmental Protection (2018[2]). Map Direct. https://ca.dep.state.fl.us/mapdirect/, accessed 15 April, 2018.

Florida Department of Environmental Protection (2018[3]). ERPce Database, ERPce Tab (Environmental Resources Program Compliance and Enforcement Tab). http://depapps.dep.state.fl.us/erpce, accessed 2 April, 2018.

Florida Department of Environmental Protection and Florida Water Management Districts (2013). Environmental Resource Permit Applicant's Handbook Volume I.

Florida Natural Areas Inventory (2010). Guide to the Natural Communities of Florida. http://www.fnai.org/pdf/nc/FNAI_NatComGuide_2010.pdf, accessed 22 January, 2018.

Goldberg, N., & Reiss, K. C. (2016). Accounting for Wetland Loss: Wetland Mitigation Trends in Northeast Florida 2006--2013. *Wetlands*, (2), 373. doi:10.1007/s13157-016-0749-4.

Highfield, W. E., & Brody, S. D. (2006). Price of Permits: Measuring the Economic Impacts of Wetland Development on Flood Damages in Florida. *Natural Hazards Review*, 7(3), 123. doi:10.1061/(ASCE)1527-6988(2006)7:3(123).

Levrel, H., Scemama, P., & Vaissiere, A. (2017). Should We Be Wary of Mitigation Banking? Evidence Regarding the Risks Associated with this Wetland Offset Arrangement in Florida. *Ecological Economics*, 136. doi:10.1016/j.ecolecon.2016.12.025.

Martin, S. R. (2013). New Environmental Resource Permit Rules [notes]. *Florida Bar Journal*, (8), 34.

McCarthy, M.J., Radabaugh, K.R., Moyer, R.P., Muller-Karger, F.E. (2018). Enabling efficient, large-scale high-spatial resolution wetland mapping using satellites. *Science Direct*, 189. doi:10.1016/j.rse.2018.02.021.

McCormick, P. V., Newman, S., & Vilchek, L. W. (2009). Landscape responses to wetland eutrophication: loss of slough habitat in the Florida Everglades, USA. *Hydrobiologia*, (1), 105.

Mitsch, W.J., Gosselink, J.P., 2007. Wetlands, 4th ed. John Wiley & Sons, Inc., Hoboken, New Jersey (USA).

National Academy of Sciences (2001). Compensating for wetland losses under the Clean Water Act. The National Academies Press, Washington, DC.

PBS&J (2010). Tampa Bay Estuary Program habitat master plan update. Technical Report #06-09. Tampa Bay Estuary Program, St. Petersburg.

Pittman, C., & Waite, M. (2009). Paving paradise: Florida's vanishing wetlands and the failure of no net loss. Gainesville: University Press of Florida.

Rains, M. C., Landry, S., Rains, K. C., Seidel, V., & Crisman, T. L. (2013). Using Net Wetland Loss, Current Wetland Condition, and Planned Future Watershed Condition for Wetland Conservation Planning and Prioritization, Tampa Bay Watershed, Florida. *Wetlands*, (5), 949. doi:10.1007/s13157-013-0455-4.

Richard, G. (2015). Planning and permitting to reduce and respond to global warming and sea level rise in Florida. *Journal of Land Use & Environmental Law*, (2), 201.

Schmidt, K., Rains, M., Rains, K., & Landry, S., (2017). Wetland Loss and Artificial Water Feature Gain in the Tampa Bay Watershed, 1950-2007. Society of Wetland Scientists' 2017 Annual Meeting. June 5-8, 2017 in San Juan, Puerto Rico.

South Florida Water Management District and St. John's River Water Management District (2004). New Statewide Environmental Resource Permit (SWERP) Rules. http://eluls.org/wp-content/uploads/2013/08/FINAL-SWERP-Presentation-for-ELULS-11-5-13-handouts.pdf, accessed 20 November, 2017.

Southwest Florida Water Management District (SWFWMD) (2003). Geospatial Open Data Portal, District Counties layer. https://data-swfwmd.opendata.arcgis.com/datasets/district-counties, accessed 28 November, 2017.

Southwest Florida Water Management District (SWFWMD) (2007). Geospatial Open Data Portal, 2006 Land Use Land Cover layer. http://data-swfwmd.opendata.arcgis.com/datasets/f45d89c67f5d4b65bd64bf8824fdf7cf_6, accessed 28 November, 2017.

Southwest Florida Water Management District (SWFWMD) (2012). Geospatial Open Data Portal, 2011 Land Use Land Cover layer. http://data-swfwmd.opendata.arcgis.com/datasets/f325a3417c92444d9cba838154d6fa0d_11, accessed 28 November, 2017.

Southwest Florida Water Management District (SWFWMD) (2017). Geospatial Open Data Portal, Environmental Resource Permits layer. http://data-swfwmd.opendata.arcgis.com/datasets/44ca67d2d82442b7a88e3246c588303a_10, accessed 28 November, 2017.

Southwest Florida Water Management District (SWFWMD) (2018). Boundary Map of SWFWMD. https://www.swfwmd.state.fl.us/data/map/, accessed 27 February, 2018.

Southwest Florida Water Management District (SWFWMD) and the Florida Department of Environmental Protection (DEP) (2007). Operating Agreement concerning regulation under Part IV, Chapter 373, F.S. https://floridadep.gov/sites/default/files/SWFWMD_OperatingAgreement7_1_07.pdf, accessed 13 May, 2018.

Staff, N. C., & Losses, C. W. (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington: National Academies Press, 2001.

Stedman, S., Dahl, T.E. (2008). Status and trends of wetlands in the coastal watersheds of the eastern United States, 1998 to 2004. National Oceanic and Atmospheric Administration, National Marine Fisheries Service and US Department of the Interior, Fish and Wildlife Service, Washington, DC.

Stein, E. D., Brinson, M., Rains, M. C., Kleindl, W., & Hauer, F. R. (2009). Wetland Assessment Debate. *The Society Of Wetland Scientists Bulletin*, (4), 20. doi:10.1672/055.026.0405.

Stelk, M.J., Christie, J., Weber, R., Lewis, R.R.III, Zedler, J., Micacchion, M., … Merritt, J. (2017). Wetland Restoration: Contemporary Issues and Lessons Learned. Association of State Wetland Managers, Windham, Maine.

Turner, R.E., Redmond AM, Zedler JB (2001). Count it by acre or function – mitigation adds up to net loss of wetlands. *National Wetlands Newsletter* 23(5-6): 14-16.

University of Florida, IFAS Extension (2006). Wetland Threats and Loss. https://soils.ifas.ufl.edu/wetlandextension/threats.htm, accessed 10 November, 2017.

US Army Corps of Engineers (USACE) (2018). Corps of Engineers Regulatory Jurisdiction. http://www.nwp.usace.army.mil/Missions/Regulatory/Jurisdiction.aspx, accessed 10 May, 2018.

US Department of the Interior (USDOI) and US Fish and Wildlife Service (USFWS) (2005). Florida's Wetlands: An update on status and trends. https://www.fws.gov/wetlands/Documents/Floridas-Wetlands-An-Update-on-Status-and-Trends-1985-to-1996.pdf, accessed 22 January, 2018.

US Environmental Protection Agency (USEPA) (2017[1]). Section 404 of the Clean Water Act. https://www.epa.gov/cwa-404/section-404-permit-program, accessed 10 November, 2017.

US Environmental Protection Agency (USEPA) (2017[2]). Wetlands Classification and Types. https://www.epa.gov/wetlands/wetlands-classification-and-types#marshes, accessed January 22, 2018.

United States Geological Survey (USGS) (2008). Tampa Bay Watershed; 1992 land cover characteristics. https://edna.usgs.gov/watersheds/ws_chars.php?title=Tampa%20Bay&name=tampabay, accessed April 27, 2018.

Vaissière, A., Levrel, H., & Pioch, S. (2017). Wetland mitigation banking: Negotiations with stakeholders in a zone of ecological-economic viability. *Land Use Policy*, 69512-518. doi:10.1016/j.landusepol.2017.09.049.

ABOUT THE AUTHOR

Katie Castor grew up in Maryland and fondly remembers the time she spent outdoors with her yellow Labrador, Callie. She graduated from the University of Florida in 2012 with a Bachelor of Science Degree in Environmental Science and a minor in Wildlife Ecology and Conservation. After holding several positions in both the public and private sectors, she landed at the Florida Department of Environmental Protection in 2015. As an Engineering Specialist III with responsibilities in the Environmental Resource Program, she became passionate about protecting the functions and services that Florida's wetlands provide. She is grateful for an exciting learning experience at the Department and hopes her research will lead to positive changes in regulatory methodology. Katie married her college sweetheart, Joshua Castor, in 2016, and the couple explored Switzerland for their honeymoon. They welcomed the newest member of their family in January 2018; a redhaired daughter named Claire Allene. Katie loves being a mom and is excited for the adventures and challenges that lie ahead.