ABSTRACT

A COMPARISON OF FIELD-DELINEATED WETLANDS TO THE NEW JERSEY FRESHWATER WETLAND MAPS

by
David P. Moskowitz

A comparison of the New Jersey Freshwater Wetland maps to field-delineated wetlands was undertaken to assess the accuracy of the Freshwater Wetland maps. The evaluation revealed substantial differences in the amount of wetland acreage on the Freshwater Wetland maps compared to field-verified wetlands. Forty study sites comprising 21,877 acres (8,854h) were evaluated. Of these, twenty-seven were overmapped (more wetland acreage than was field-verified), and thirteen were undermapped. Forty-three percent had mapping discrepancies at or above fifty percent; when modified land designations were included as wetlands, the number of sites at this threshold increased to fifty percent.

Paper copies of the Freshwater Wetland maps have been distributed to each municipality in the state and have also been digitized for Geographic Information System (GIS) applications. The maps are now a standard component of the state's GIS database. There is growing evidence that the maps are being used for wider applications than the accuracy of the mapping can justify. The data sources about the purpose and limitations of the maps are confusing and often contradictory.

The analysis conducted as part of this study suggests that the Freshwater Wetland maps should be used for only the most general land-use and planning purposes. They are generally unsuitable for regulatory and land transaction decisions.

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by
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To LJ, JM, SM & HM... What else can I say, But THANKS!
This is every bit as much yours as it is mine.

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CHAPTER 1

INTRODUCTION

> "Not only is it easy to lie with maps, it's essential. To portray meaningful relationships for a complex, three-dimensional world on a flat sheet of paper or a video screen, a map must distort reality. As a scale model, the map must use symbols that almost always are proportionally much bigger or thicker than the features they represent. To avoid hiding critical detail, the map must offer a selective, incomplete view of reality. There's no escape from the cartographic paradox: to present a useful and truthful picture, an accurate map must tell white lies." Monmonier 1996

1.1 New Jersey's Freshwater Wetland Maps

In 1986, the New Jersey Legislature directed the New Jersey Department of Environmental Protection (NJDEP) to map New Jersey's freshwater wetlands (N.J.S.A. 13:9B-1). The maps were intended to supplement the United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) Maps issued in or around 1976. The NWI maps were widely believed to underestimate the extent of the State's freshwater wetlands leading to the need for new maps. In 1988, the NJDEP initiated the new mapping program (officially known as the Statewide Photointerpretation and Delineation of Freshwater Wetlands Project) and the project was completed in 1994 at a cost of 3.7 million dollars (Government Technology 1998).

The NJDEP wetland maps have been digitized for Geographic Information System (GIS) applications and are now a standard component of the State's GIS database. The GIS software, including the wetland map database, is available from the NJDEP for a nominal cost (about $90.00). However, the agency is supplying the entire GIS database, as well as the more expensive (about $1,000.00) software to run the database, at no cost, to non-profit organizations, including municipal environmental commissions and non-governmental organizations (NJDEP 1998). The State's GIS program is now being used by 9 federal, 11 state, and 28 county agencies, 17 municipalities, 5 academic users, 8

utilities, 87 non-profit organizations, and 32 other private groups (p.c. J. Tyrawalski 1998, New Jersey GIS Program).

The use of the maps by state and local governments and non-profit environmental organizations has clearly increased during the past few years. Although, the maps were originally intended to have only limited regulatory applications there is growing evidence that they are being used for wider applications than was originally anticipated and that the accuracy of the mapping can justify. Increasingly, the Freshwater Wetland maps are used by the NJDEP for permitting guidance, and the maps are frequently cited in State legislation and regulations (p.c. N. Wittenberg 1999, Director of Environmental Affairs New Jersey Builders Association). In addition, at least some private land transaction decisions with respect to wetlands are being based on the Freshwater Wetland maps (p.c. R. Krop 1998, Director NJDEP Land Use Regulation Program). Unfortunately, guidance on the purpose and use of the maps is confusing and provides an inadequate understanding of potential limitations and sources of error. The danger here is summarized by Congalton (1991 p. 35): *"Traditionally, the accuracy of photointerpretation has been accepted as correct without confirmation. In fact, digital classifications are often assessed with reference to photointerpretation. An obvious assumption made here is that the photointerpretation is 100% correct. This assumption is rarely valid and can lead to a rather poor and unfair assessment of the digital classification."*

Wetlands shown on the NJDEP maps were primarily derived through the photointerpretation of remotely-sensed data in conjunction with other available resources (NJDEP 1995). Most of these wetlands have not been field-verified. Studies outside of New Jersey have identified considerable errors between remotely-sensed wetland maps and field-verified wetland boundaries (Jensen et al. 1984, Butera 1993, Stolt and Baker 1995). Other studies have also indicated difficulties in identifying wetlands from various remotely-sensed data (Duhaime, et al. 1997, Tiner 1990, Tiner and Smith 1992). Recent studies in New Jersey that compared the photointerpreted maps to field-verified wetlands

in limited geographic areas have also identified discrepancies (HMDC 1997, Fort Dix 1997, Dames and Moore 1998). Determining the accuracy of the maps is critical to effectively utilize the database for planning and land-use decisions. This need for validation notwithstanding, a comprehensive statewide evaluation of the maps has not been performed, and the overall accuracy of the maps is generally unknown. The purpose of this study was to evaluate the accuracy of the New Jersey Freshwater Wetland maps by comparing the extent of wetlands on the maps to field-delineated and field-verified wetland boundaries for selected sites throughout the state. A better understanding of the accuracy and limitations of the Freshwater Wetland maps will improve their utility for planning and land-use decisions.

1.2 Background Information

1986, when the new Jersey Legislature directed the NJDEP to map the State's freshwater wetlands, it was widely believed that existing wetland maps were insufficient to protect the state's wetland resources, as well as inadequate for planning and land-use decisions. Prior to the publication of the NJDEP's Freshwater Wetland maps, the most widely used wetland maps were the USFWS National Wetland Inventory. These maps were not intended for regulatory, planning or land-use decisions (Tiner 1991), and it was generally known that they significantly underestimated the extent of the State's freshwater wetlands. To remedy this problem, the legislature required the NJDEP, through passage of the Freshwater Wetlands Protection Act (N.J.S.A. 13:9B-1 et seq.), to:

> "Develop a functional, complete, and up-to-date composite freshwater wetlands map and inventory using the most recent available data, which shall include, but not be limited to, aerial photographs and soil inventories at a scale suitable for freshwater wetlands regulatory purposes, and shall make appropriate sections of this map and inventory available on a periodic basis to the county clerk or register of deeds and mortgages in each county, as appropriate, and to the clerk of each municipality."

In 1988, when the NJDEP implemented the Freshwater Wetlands Protection Act by promulgating Rules (N.J.A.C. 7:7A), the agency described the official purpose of the maps as:

> "When available, the up-to-date composite freshwater wetlands map and inventory shall be used to locate wetlands as definitively as is practicable, as in informational tool in advising the public of the approximate extent and location of wetlands, and in preparing some letters of interpretation[1] However, exact delineation of wetlands boundaries is required, and measurements shall be made in accordance with the three parameter approach." (N.J.A.C. 7:7A-2.4[f]).

While it is clear that the Freshwater Wetland maps were not originally intended to provide jurisdictional wetland limits, many of the State's supplemental materials and publications describing the maps, provide confusing explanations and guidance on their use, and a poor presentation of their accuracy and limitations.

The NJDEP's information brochure describing the wetland maps illustrates the confusing nature of the materials that are available to assist the occasional map user, particularly those that are unfamiliar with wetlands or maps. The brochure provides:

> **Authorization**: "...These maps give the best indication currently available of where wetlands are, and are not, located in New Jersey. The maps however, are not a regulatory tool. To make development or land preservation decisions about a specific site, particularly if it is in or adjacent to a wetlands polygon, people are urged to first contact the Department of Environmental Protection's Division of Coastal Resources[2] to obtain a Letter of Interpretation."

> **Wetland Delineation**: Each basemap has a corresponding wetlands delineation. Each delineation is based on the 1986 color infra-red photography. This photography produces characteristic wetland images or "signatures." Each characteristic signature is interpreted by experienced photo interpreters and verified by field investigation. Additional information such as county soil surveys are used to assist in the delineation process. Once the analysts have developed a wetland signature, they then delineate all areas of wetlands showing the characteristic signature. These

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[1] A Letter of Interpretation is a letter issued by the Department for the purpose of indicating the presence or absence of wetlands. State open waters, or transition areas; for the purpose of verifying or delineating the boundaries of freshwater wetlands, State open waters, transition areas; or to obtain a wetland resource classification.

[2] The DCR (Division of Coastal Resources) has been incorporated into the Land Use Regulation Program.

delineated areas are placed on the quarter quads[3] as wetland polygons or linear features.

Map Uses: These maps are intended to be used as a planning guide. A review of the map will show areas that may contain regulated wetlands. They will alert the user to both occurrence and type of wetlands. Early planning will allow protection of the wetlands and associated transition areas.

Accuracy: Each base map meets National Map Accuracy standards. This is the most accurate mapping ever compiled of the entire state. Each map contains both latitude and longitude as well as state plane coordinate systems. A diagraph is found on the bottom of each map relating magnetic north to true north.

This information about the maps might suggest to a user unfamiliar with their limitations and purpose that the maps are accurate, show delineated wetland boundaries, and can be used to identify regulated wetlands and transition areas. This incorrect information is echoed and confirmed by the NJDEP Division of Science and Research (1988). The division described the utility of the wetland maps in GIS format as:

> "By housing the data in digital format on the GIS, DCR staff will be able to plot out inland wetland boundaries at any size to register to surveys and maps provided to them by potential permittees. In addition, DCR staff can interactively buffer the wetlands lines depending on a variety of factors including the resource value of the wetland, presence or absence of endangered species, etc. By plotting these buffers, DCR can determine from the survey whether proposed structures or alterations will encroach upon the wetland or buffer zone. This capability may obviate the need for site visits in some cases, saving DCR field personnel time."

A similar use has been described by The New Jersey State Mapping Advisory Committee, charged with overseeing the State's GIS program, further suggesting a use and purpose that could be incorrectly interpreted by users unfamiliar with the wetland maps; *"the wetland databases are an excellent source for both photointerpretation and recompilation at county, municipal, or site level."* (NJSMAC 1997). In fact, the NJDEP is currently utilizing the GIS wetland database for these purposes by overlaying the

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[3] A quarter quad is one quarter of a United States Geologic Service 7.5 minute topographic gradrangle map.

Freshwater Wetland maps on proposed site plans and providing these maps to applicants during pre-application conferences. These conferences provide an opportunity for landowners and other permit applicants to receive guidance from the NJDEP on wetland-related constraints and the types of permits required to develop land in the state.

Despite the increasing use of the State's GIS Wetland database, the information about the wetland mapping that accompanies the database is at best confusing, and perhaps more importantly, potentially misleading. To the user unfamiliar with the maps, the information could readily be misinterpreted to suggest that all wetlands of a given size were mapped and reviewed by the NJDEP and that their boundaries are accurate to within ±20 feet. The information (NJDEP 1996) provides:

> **MAPPING METHODOLOGY AND MAPPING SOURCES:**
> Delineations done on 1986 quarterquad basemaps (1:12000) from interpretation of 1986 CIR photos. Classification system used was a modified Cowardin system. Some field checking was done on each quarterquad. Delineations were done by an outside contractor, with NJDEP input and review.
>
> **MAPPING CRITERIA:**
> All freshwater wetlands polygons greater than 1 are in size, and all linear freshwater wetlands features greater than 10 feet in width were mapped.
>
> **MAPPING ACCURACY AND DATA LIMITATIONS:**
> Delineations were reviewed by NJDEP staff and modified as needed based on field observations and additional photointerpretation. Positions of features on basemaps themselves are good to ±20 feet.

Confusing information on the use and purpose of the maps is also found in the NJDEP's information pamphlet "The Dry Facts: Building Near Wetlands". The pamphlet is intended primarily for landowners and developers unfamiliar with New Jersey's wetland regulations and is available at the NJDEP's wetland program offices. The

pamphlet provides information about the utility of the wetland maps, without information about their accuracy or intended limitations. The pamphlet states:

BEFORE YOU BUY...BEFORE YOU BUILD.

Are you buying undeveloped land? Building a home, a retail center, or marina? How about a driveway or an addition to your house? In every case, the presence of wetlands may affect where and whether you build, buy, or develop. In New Jersey and throughout the United States, wetlands are protected on public and private property.

WHERE DO I GO FROM HERE?

Will wetland protection laws affect your project? You can find out through New Jersey Wetland Inventory maps, Coastal Wetlands maps, discussions with local zoning and Department of Environmental Protection and Energy (DEPE) staff, and the information presented here. Let this fact sheet be a reference as you buy property, design your project, and prepare permit applications. and,

STEP 1. GET TO KNOW THE PROPERTY.

Steep slopes, soil types, existing vegetation, floodplains, and wetlands will all influence your purchase and design decisions. While some of these decisions will be based on observation and good judgement, others may be determined by zoning regulations or environmental protection laws.

1. Gather documents: property descriptions, aerial photographs, zoning maps, ordinances or ordinance summaries, etc.

2. Use New Jersey Wetland Inventory maps to locate area of wetlands. The maps are to be used as planning guides, not to make regulatory decisions. and,

3. To determine wetland locations by a field visit, contact the DEPE, Land Use Regulation Program.

New Jersey Wetland Inventory Maps

The DEPE program classifies and maps wetlands 1 acre and larger throughout the state. Each map covers a 36 square mile section at a 1"=1,000' scale. The maps are resource tools and useful planning documents. Copies of maps are available for review at the municipal clerk's office, county clerk's office, and DEPE offices.

Like many of the other sources of information about the maps, the pamphlet is unclear about the purpose, accuracy and limitations of the maps, particularly to users unfamiliar with wetland maps and wetland mapping. This is consistent with the wide array of other available information on the wetland maps published by the NJDEP and the State of New Jersey. Depending on the information source, the maps either serve as an accurate wetland delineation for regulatory purposes, or a useful but generalized planning tool with no regulatory authority.

1.3 New Jersey Freshwater Wetland Mapping Conventions

1.3.1 Freshwater Wetland Map Product

The Freshwater Wetland maps are published as chronoflex aerial photographs at a scale of 1"=1,000' (1:12000) (Figure 1). The maps follow the USGS 7.5' topographic quadrangles, but are divided into four quarter-quads. A total of 624 quarter-quads have been produced, encompassing the entire state. The base photographs for the maps are 1:58,000-scale quad-centered color infra-red (CIR) aerial photography taken in March 1986 in National High Altitude Photography (NHAP) format. Supplemental 1988, 1989 and 1991-1992 CIR photographs at 1:40,000-scale were also used as needed. CIR positive transparencies were produced for the project from this photography. The minimum mapping unit used for the project was 1 acre and the minimum mappable feature (polygons) was 30 feet wide (for linear features, 10 feet across) (NJDEP 1995). Each base map meets National Map Accuracy Standards (NJDEP 1988).

1.3.2 Freshwater Wetland Mapping Methodology

Wetland boundaries on the maps during the first year of the mapping program (1988) were identified in accordance with the U.S. Environmental Protection Agency's *Wetland Identification and Delineation Manual* (USEPA 1988). During the remainder of the program, the wetland mapping was in accordance with the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989) (p.c. R. Cubberly 1998, Senior Environmental Specialist NJDEP). These manuals utilize a three-parameter approach to wetland identification, generally requiring a coincidence of hydric soils, hydrophytic vegetation, and wetland hydrology in order for an area to be a wetland (NAS 1997). Each wetland on the Freshwater Wetland maps was also classified according to community type based on the classification scheme in Cowardin et al. (1979).

Each map carries the following note:

> "Delineation from various sources including aerial photography and County soil surveys, portions field verified. Classification scheme per Cowardin, 1979. Lines are not regulatory boundaries. Field verification required."

The wetland boundaries on the maps were prepared through an analysis of various existing maps and photos and limited field truthing (p.c. R. Cubberly 1998). During preparation of the maps, detailed field truthing was generally limited to four sites per quarter-quad. These sites were selected for documentation and data collection in order to develop a series of wetland signatures to be extrapolated to the remainder of the maps. Additional visual inspections were performed on many other sites, and in some instances detailed information was collected (NJDEP 1995).

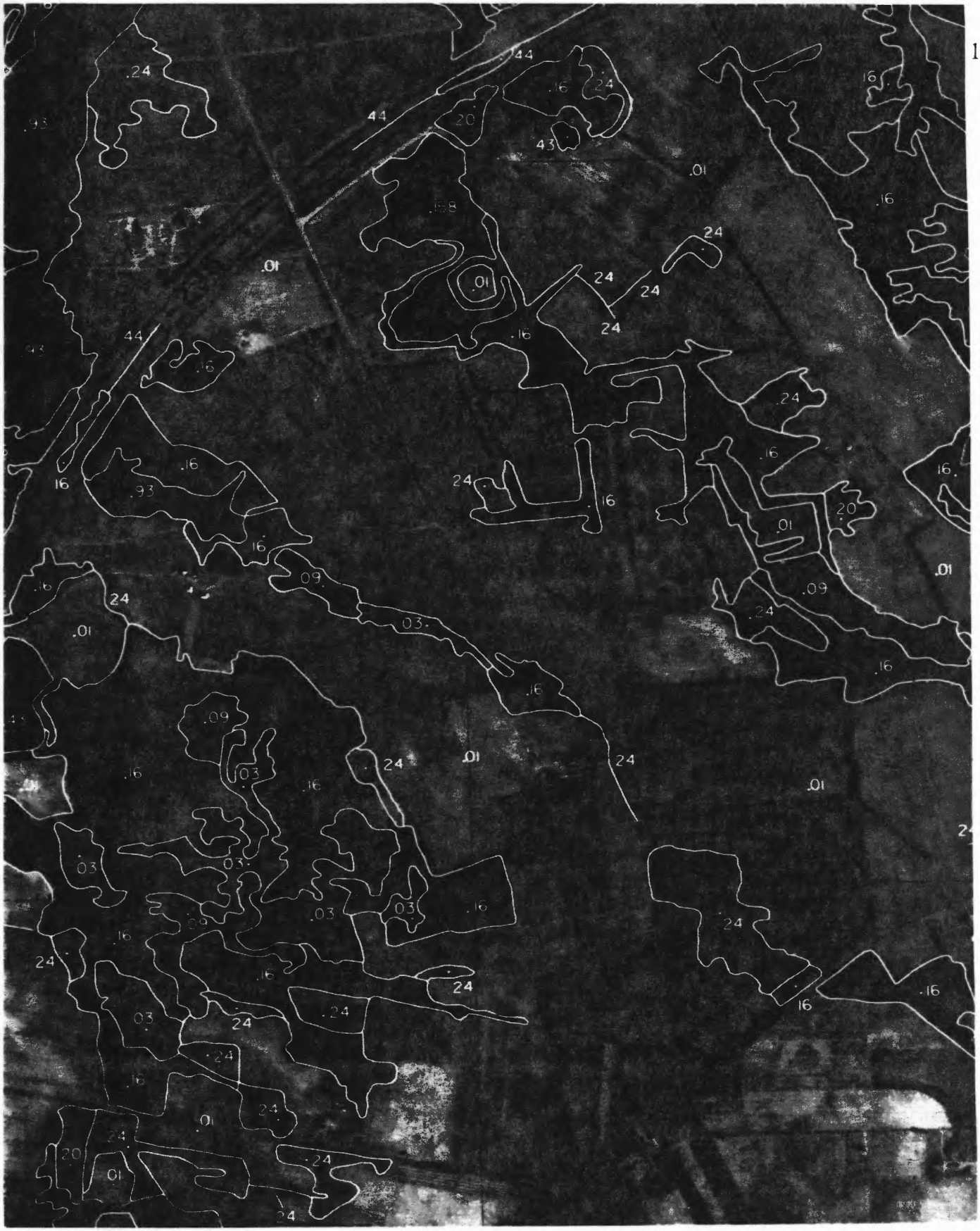


Figure 1. A portion of a New Jersey Freshwater Wetland Map (Bridgeport NJ-PA SW Quadrangle 1986: Scale: 1" = 1000')

CHAPTER 2

METHODS AND STUDY AREA

2.1 General Study Size and Location

The New Jersey Freshwater Wetland Maps were compared to field-delineated wetland boundaries on 40 selected study sites to evaluate their accuracy. The study sites range in size from 106 acres to 2,473 acres, encompassing a total of 21,877 acres. The average study site was 551 acres. In all but the Ridge and Valley Physiographic province, a minimum of 2,000 acres was selected for comparison. Slightly less land area was evaluated in the Ridge and Valley province because of a lack of field-verified sites meeting the specific study criteria (p.c. J. Hielferty, 1999, NJDEP Senior Environmental Specialist).

New Jersey's physiographic provinces are arranged in belts which have a general northeast-southwest orientation. The provinces are generally separated on the basis of differences in geology, soils, and climate (Collins and Anderson 1994, Tedrow 1983). The provinces from northwest to southeast are: Ridge and Valley, Highlands, Piedmont, Inner Coastal Plain and Outer Coastal Plain (Figure 2).

2.2 Specific Study Site Criteria

The study sites were selected on the basis of size and landscape position. Sites were chosen that encompassed entire drainage systems, or that were located adjacent to watercourses. The minimum study site size was 100 acres. These criteria were chosen to provide an evaluation of broad landscape areas at topographic positions where the majority of New Jersey's wetlands occur (Tiner 1985).

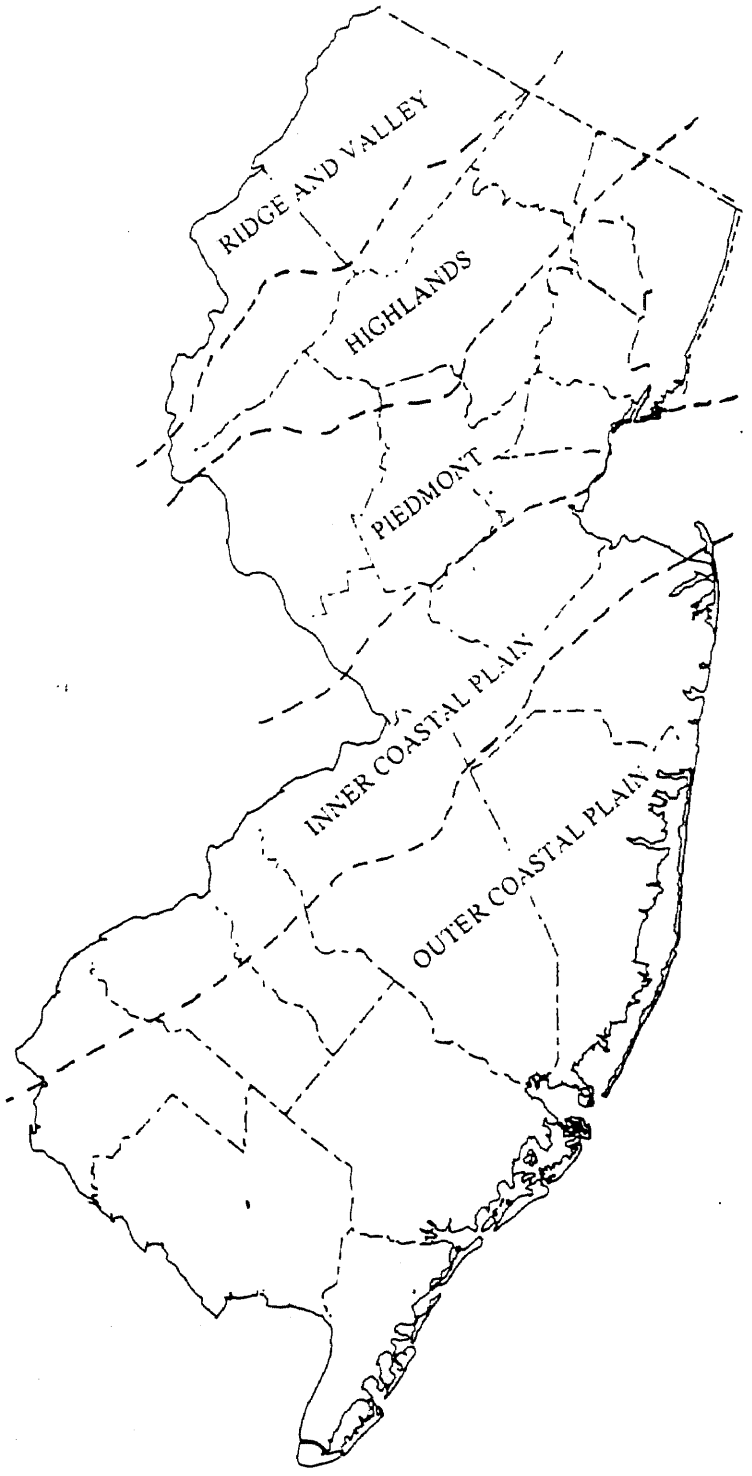


Figure 2. New Jersey's Physiographic Provinces

2.3 Wetland Map Measurements

The extent of wetlands on the New Jersey Freshwater Wetland maps was determined with a Tamaya Planix Digital Planemeter. For polygons, the wetland boundary was measured a minimum of three times and the measurements were averaged (Tamaya 1990). For linear features, the area was determined by measuring the length of the wetland and then multiplying the distance by a width of forty feet. This width was selected to approximate the width of a 0000 point pen line on the base maps (NAS 1997, Tiner 1999). On all but two of the study sites, the acreage of the field-delineated wetlands was calculated by licensed New Jersey surveyors. On these, the wetland acreage was measured with a Tamaya Digital Planimeter following the procedures described above.

2.4 Wetland Field Delineation Methodologies

The field-delineated wetlands on all but three of the study sites were determined in accordance with the *Federal Manual for Identifying and Delineating Jurisdictional Wetlands* (1989). On one site, in the Pine Barrens of southern New Jersey in the Outer Coastal Plain Province, the wetland boundary was determined using *A Pinelands Supplement to the Federal Manual* (Zampella 1991). On two other sites, one in the Piedmont Province, and the other in the Highlands Province, the wetland boundary was determined using the Corps of Engineer's *Wetlands Delineation Manual* (Environmental Laboratory 1987). The delineated wetlands on all but three of the sites were field-verified by personnel from the NJDEP, the Pinelands Commission, or the Army Corps of Engineers, depending upon each agency's area of jurisdiction.

The wetlands on the study sites were marked in the field with plastic flagging (generally spaced no further than 100 feet apart) by professional wetland consultants and the boundaries were then surveyed by New Jersey licensed surveyors. The wetland boundaries were then plotted on outbound and topographic maps, generally with two-foot-minimum contour intervals and minimum scales of 1"=100' (1:1200) (Figure 3).

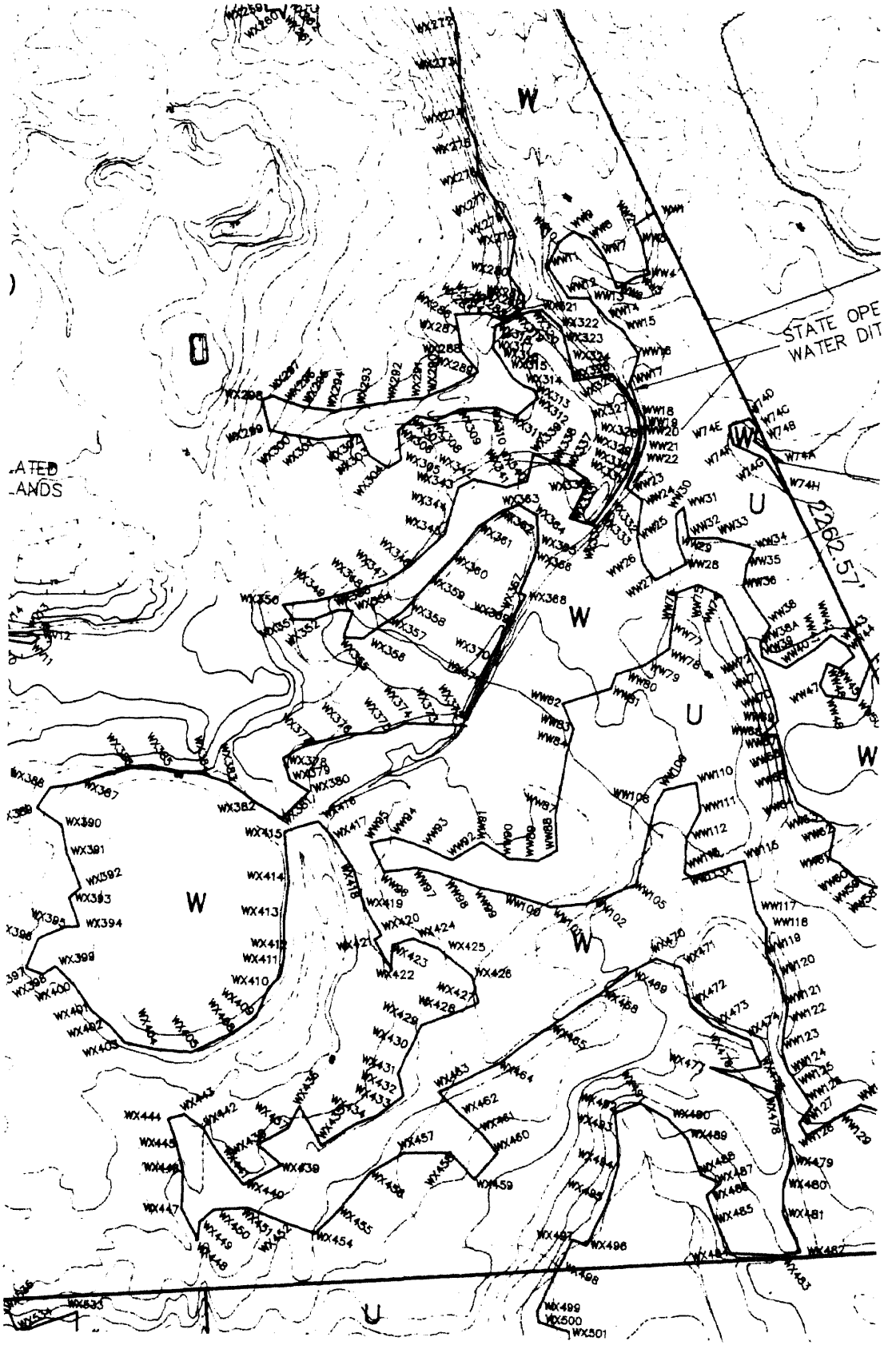


Figure 3. Typical Wetland Delineation Map (Scale 1"=200')

CHAPTER 3

RESULTS AND DISCUSSION

3.1 Wetland Map Comparisons

Comparison of field-delineated and photointerpreted wetland acreage on forty study sites (Figure 4) (21,877a, 8,854h) showed substantial differences with these differences occurring in all of the State's physiographic provinces (Table 1). The differences for individual study sites and physiographic provinces included both overmapping and undermapping on the Freshwater Wetland maps compared to the field-delineated limits of those same wetlands. An overmapping indicates more wetlands being shown on the Freshwater Wetland maps than were field-delineated and, an undermapping, less. Overall, wetlands on the Freshwater Wetland maps were overmapped in three of the State's physiographic provinces and undermapped in the remaining two. For individual study sites, twenty-seven were overmapped and thirteen were undermapped. Forty-three percent of these sites had mapping discrepancies at or above fifty percent (either positive or negative) without including modified mapping units as wetlands and, fifty percent exceeded this threshold, when these mapping units were included.

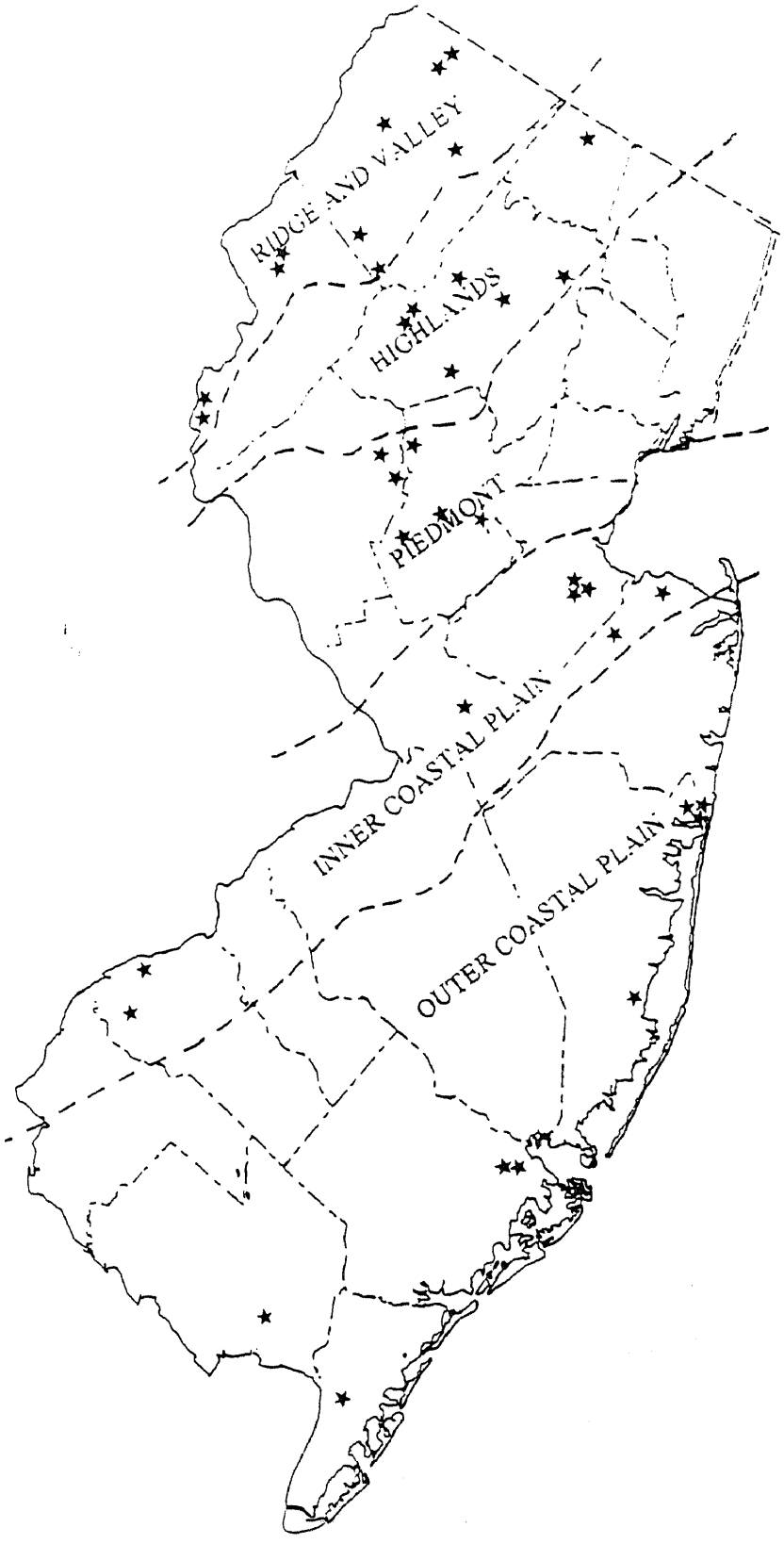


Figure 4. Study Site Locations (Study Sites are shown with stars)

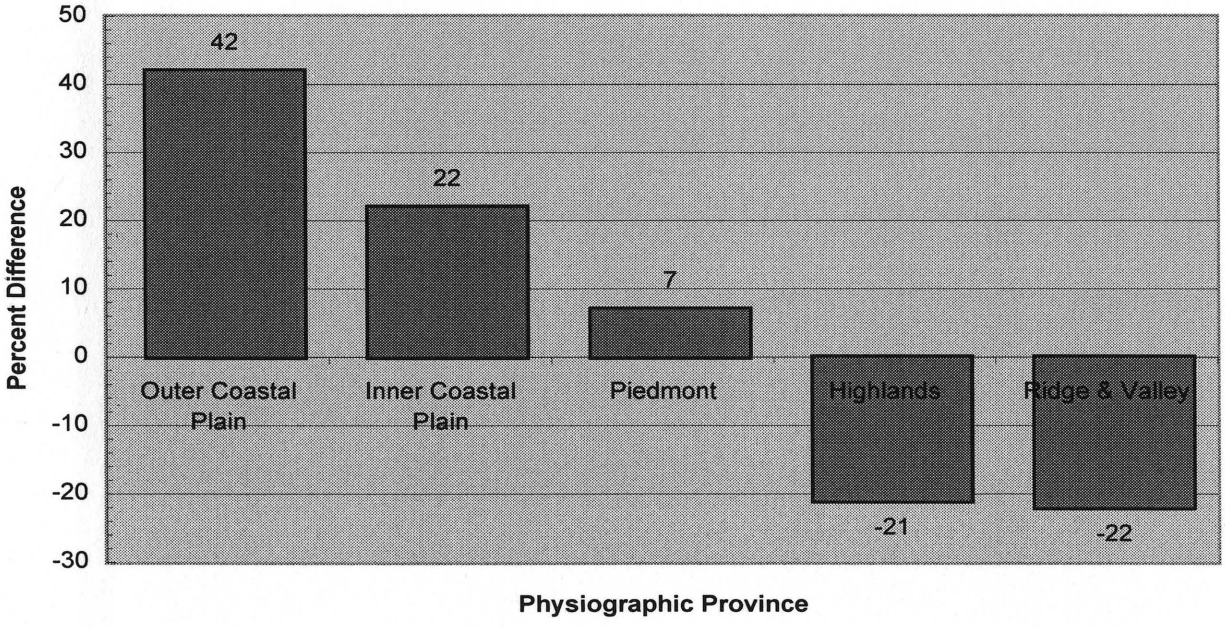
Table 1. Summary results of the comparison between field-delineated wetlands and the New Jersey Freshwater Wetlands maps on selected study sites.

Physiographic Province	Number of Sites	Land area (acres/hectares)	Average Study Site size (acres/hectares)	N.J. Freshwater wetland mapping (acres/hectares)	N.J. Freshwater wetland mapping modified land designations (acres/hectares)	Field-delineated wetlands (acres/hectares)	Percent difference w/o modified land designations	Percent difference with modified land designations
Outer Coastal Plain	8	4608/1865	576/233	894/362	8/3	519/210	42	42
Inner Coastal Plain	8	5708/2310	713.5/289	3780/1530	293/119	2952/1195	22	27
Piedmont	7	2470/1000	353/143	257/104	57/23	240/97	7	35
Highlands	8	7383/2988	922/373	641.55/260	14.58/6	812.27/329	-21	-19
Ridge & Valley	9	1769/716	190/77	249.5/101	7.75/3	331.5/134	-22	-25
Totals	**40**	**21877/8854**	**551/223**	**5822.05/2356**	**380.33/154**	**4854.77/1965**	**17**	**23**

The overall difference for all of the study sites was 17 percent without the modified mapping units included as wetlands. Including these mapping units as wetlands significantly affected the accuracy of the mapping, increasing the overmapping on the Freshwater Wetland maps by six percent, for an overall discrepancy of 23 percent compared to field-delineated limits. Similarly, for many individual study sites, the inclusion of these mapping units caused a significant increase in the discrepancies between the wetland maps and the field delineations.

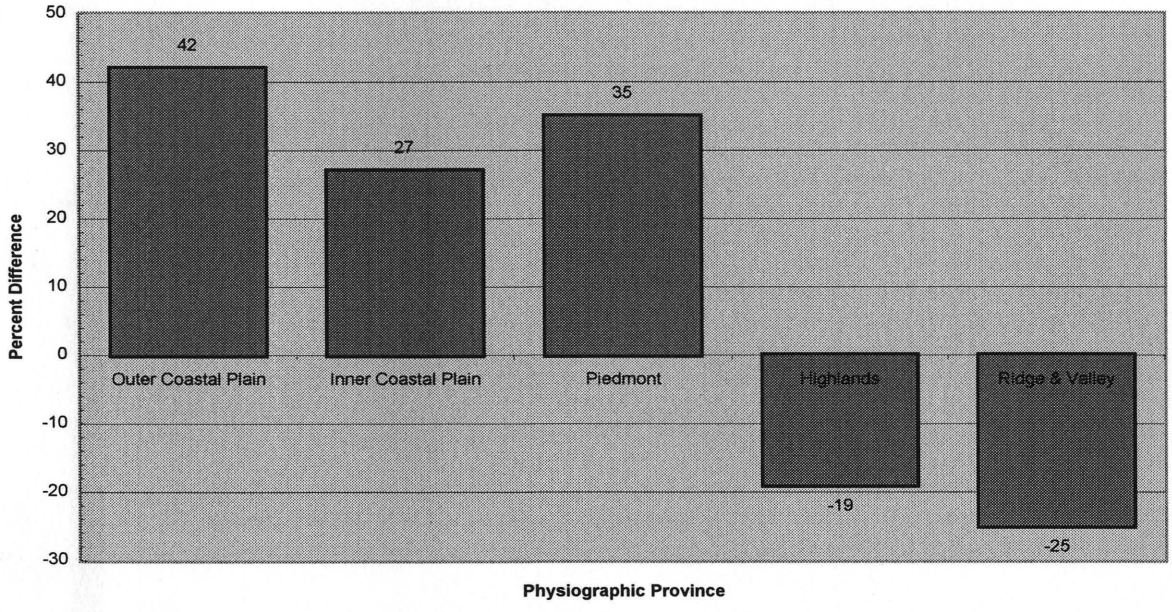
The mapping comparison revealed a distinct north to south pattern in the accuracy of the maps. Wetlands in the northern part of the state, comprised by the Ridge and Valley and the Highlands provinces, were undermapped. In contrast, wetlands in the central and southern parts of the state, from the Piedmont south through the Inner and Outer Coastal Plains, were overmapped. The percent difference between the maps ranged from an overmapping by 42 percent in the Outer Coastal Plain province, to an undermapping by -22 percent in the Ridge and Valley province. The mapping in the Piedmont province was the most accurate as long as the modified mapping units were not included as wetlands.

Table 2. Comparison of field delineated wetlands to the New Jersey Freshwater Wetland maps without modified land designations



The inclusion of the modified land designations as wetlands increased the overall accuracy of the Freshwater Wetland mapping only in the Highlands province and resulted in no change in the Outer Coastal Plain. A relatively small change was observed in the Ridge and Valley Province by including these designations as wetlands and a more modest change in the Inner Coastal Plain. The inclusion of these units as wetlands in the Piedmont province, decreased the accuracy of the mapping greater than in any other province.

Table 3. Comparison of field delineated wetlands to the New Jersey Freshwater Wetland maps with modified land designations



The differences in the accuracy of the mapping between provinces, almost certainly results from varying landuse, geography, topography, vegetation and soils. In addition, a wide variety of other potential problems face the photointerpretor that are likely irrespective of these conditions, but that also effect the accuracy of the maps, relating to mapping scale, photograph quality, varying wetland definitions, and the inherent difficulties of field-delineating wetlands. A discussion of each of these potential sources of error follows:

3.2 Potential Sources of Error

The differences between the Freshwater Wetland maps and field-verified wetlands were not unexpected, based on the author's frequent use of the maps and conversations with numerous other wetland professionals conducting wetland delineations in the state. Recent studies in New Jersey, comparing the Freshwater Wetland maps to field-verified wetlands in limited geographic areas, have also identified discrepancies (Dames and Moore 1998, Dept. of the Army 1997, HMDC 1997).

A comparison of the Freshwater Wetland maps to field-delineated boundaries was made at the Lakehurst Naval Air Engineering Station in Ocean County, New Jersey. The station is located in the Outer Coastal Plain Physiographic province in an area characterized by "pine barrens" vegetation (Dames and Moore 1998). The study found that the Freshwater Wetland maps underestimated the extent of field-delineated wetlands by 10 percent. A similar study at the Fort Dix military base in Burlington County, New Jersey, in the Inner Coastal Plain Physiographic province, identified even greater differences between the Freshwater Wetland maps and field-determined wetlands. In this study, the Freshwater Wetland maps agreed with field plots only 29 percent of the time, leading the researchers to conclude that "Based upon these findings, it appears that neither the New Jersey DEP data (Freshwater Wetlands map), nor the USFW data as a stand alone coverage is adequate for planning purposes." (Dept of the Army 1997).

Similar comparisons outside of New Jersey have also identified considerable errors between remotely-sensed wetland maps and field-verified wetland boundaries (Jensen et al. 1984, Butera 1993, Stolt and Baker 1995, McMullen and Meacham 1996). In New York, McMullen and Meacham (1996) found considerable errors between state, federal, and soils maps compared to field-delineated wetlands. All of these maps generally undermapped the extent of existing wetlands, ranging from 37 percent less on the state maps, to 61 percent less on the federal maps. The authors speculate several explanations for the inaccuracies, including different mapping scales, quality of the aerial photographs, and jurisdictional limitations. The authors concluded (p. 204) *"The results of this study not only draw attention to the weaknesses and inaccuracies of existing wetland maps, they*

also show the special care necessary when using existing maps in wetland trend analysis. [...] The results of the present study point out that the existing wetland maps are not reliable enough to draw conclusions about losses or gains in wetland extent."

Similar discrepancies between federal wetland maps and field delineations were also found by Stolt and Baker (1995) in Virginia. In this study, the federal wetland maps consistently undermapped the extent of jurisdictional wetlands. The authors speculate a number of reasons for the undermapping, including forest cover that may be concealing wetlands to the photointerpretor, small seepage wetlands that may have been difficult to distinguish on the aerial photographs used for the mapping, wetlands that fall below the minimum mapping unit, and narrow wetlands on floodplains and along small streams where the narrow widths may have made boundary determinations between uplands and wetlands difficult.

3.2.1 Varying Wetland Definitions

One important source of error that may have resulted in the discrepancies observed during this study may be related to the evolving definition of wetlands during nearly the past two decades. During the past 15 years, there have been four different federal wetland delineation manuals each with a different definition and approach to delineating wetland boundaries. Most of New Jersey's Freshwater Wetland maps were based on the Federal Manual (1989) although some utilized the USEPA manual (1988). Delineations on all but three of the study sites evaluated as part of this study were conducted in accordance with the Federal Manual (1989). The other three sites were based on the Corps' or Pinelands' manuals.

All of the various wetland delineation manuals typically require a coincidence of three parameters in order to classify an area as wetlands: hydric soils, hydrophytic vegetation, and wetland hydrology. Nonetheless, it is widely recognized that differences in the wetland boundary can occur between the manuals (Tiner 1989, NAS 1997). Whether the differences result from the methodologies or their application by the wetland delineator is unclear; a recent National Academy of Sciences study (1997 p.77) noted that

"it is difficult to ascertain whether the degree to which differences occur in delineation results occur because of misapplication of a manual or because of actual differences among manuals." It is unknown whether the use of different methodologies for the field delineations and the wetland maps may have resulted in some of the discrepancies observed as part of this study, but it seems likely, given the author's extensive experience with the manuals and the results of other formal comparisons.

At least for the purposes of this study, however, these differences were expected to be minimal, because nearly all of the study sites were delineated using the Federal manual, which was also used to identify the majority of wetlands on the Freshwater Wetland maps. Field comparisons of the manuals in New Jersey have indicated that on a given delineation, the Pinelands supplement results in the largest wetland area (Zampella 1990), followed by a smaller area using the USEPA manual (1988), a somewhat smaller area using the 1989 Federal Manual, and an even smaller area using the 1987 Corps manual (NAS 1997, USEPA 1991). The USEPA and Federal manuals are generally considered to result in similar wetland boundaries (NAS 1997, USEPA 1991).

3.2.2 Difficulties in Aerial Photointerpretation and Field Delineations

Another potentially significant source of error in the Freshwater Wetland maps relates to the inherent difficulties in identifying wetlands from aerial photography. Many wetlands, and in particular their boundaries, are not readily identifiable from remotely-sensed data (Tiner 1999). Acknowledging the difficulty in many cases of delineating wetlands on the ground, it is not surprising that remotely-sensed wetland maps are less accurate than field surveys. Wetland delineations often require the splitting of complex exotones consisting of a confusing mix of wetland and upland plants and subtle changes in hydrology and soils (Allen, et al. 1989, Golet, et al. 1993, Tiner 1999). It should be obvious, therefore, that these difficulties in the field must translate to an even greater difficulty in photointerpretation of wetland boundaries from the air. As Tiner (1997 p.10) notes *it is easy to understand why photointerpretation fails to accurately identify subtle wetland-upland boundaries and many of the drier-end wetlands."*

Many wetlands may also be difficult to photointerpret because of narrow widths or small aerial coverage. Wetlands along narrow drainageways, smaller wetlands in forested landscapes, and forested wetlands in general, may be particularly difficult to identify from aerial photography, and are consistently noted as a problem in wetland photointerpretation (NAS 1997, Stolt and Baker 1995, Tiner 1999). It is widely recognized that aerial photointerpretation of wetlands in forested areas can be extremely difficult due to dense canopy cover that obscures the wetland boundary (Tiner 1999). This problem is likely magnified for smaller forested wetlands and those occurring in narrow bands along small drainageways. Many other studies have noted that forested wetlands are generally poorly mapped from remotely sensed data (DuHaime, et al. 1997, Gammon and Carter 1979, Jensen, et al. 1986, Stolt and Baker 1995). These studies have noted both over and undermapping.

3.2.2.1 Narrow Wetlands and Minimum Mapping Units: Some of the differences between the maps may also be attributed to the way narrow wetlands were designated on the Freshwater Wetland maps. Some of the narrower wetlands were mapped only as a single line rather than a polygon because the narrow width made boundary identification difficult (Tiner 1997). This may contribute to some of the observed differences in the maps, because state and federal agency regulations, and standard practice for field delineations, do not utilize single line mapping for most delineations regardless of the width of the feature. Even narrow wetlands are delineated in the field by demarcating the actual limits.

3.2.2.2 Disturbed and Altered Wetlands: In some cases the differences in maps may also be attributed to the difficulty in photointerpreting wetlands in disturbed or altered circumstances. Much of the New Jersey landscape has been subjected to a long history of disturbance from development, agriculture, and other sources (Robichaud and Buell 1983, Collins and Anderson 1994), and many wetlands and other natural communities have been altered. The identification of wetlands in these situations may be particularly

difficult because one or more of the wetland parameters is missing or difficult to interpret (FWDM 1989). This applies to both aerial interpretation and field delineations.

An attempt was made by the photointerpretors to identify disturbed and altered wetland areas on the Freshwater Wetland maps. Two mapping units identify the majority of these areas contained on the maps; the modified agriculture (ModAg .24) and modified land (ModL .42, .44, .48) designations. These units include wetlands that have been altered by agriculture or by other disturbances, respectively. Because of differences in the mapping scales, a comparison of the actual extent of field-delineated wetlands to those shown on the wetland maps was not made for the study sites. However, it was clear from this analysis that these mapping designations are significantly overmapped. This is consistent with the author's experience, and that of numerous other wetland professionals familiar with the maps.

In most cases, very limited areas of field-verified wetlands exist within the areas mapped with modified wetland designations. In the author's experience, many of the agricultural areas mapped as modified wetlands have been altered by drainage for agricultural purposes. Field delineations in many of these agricultural areas can be extremely difficult and require multi-season hydrologic monitoring (FMWD 1989) or professional judgement. This may contribute to some of the problems noted on the maps in agricultural areas. In addition, many of the areas mapped as modified land have been subjected to vegetative disturbance (utility easements) or fill-and-dredge deposition. Similar to agricultural settings, delineations in these areas may be difficult, and require the delineator to use professional judgement and experience to determine the wetland boundary. However, familiarity with the maps also suggests that the signatures developed for these disturbed lands, as well as agricultural lands, may be in need of reevaluation and revision, because many of these areas mapped as wetlands occur on non-hydric soils or have non-hydrophytic vegetative communities. Clearly, these are important considerations in need of more intensive study if the utility of the maps is to be improved in these landscapes. This may be particularly important to state, county and municipal agencies as farmland and other open space preservation efforts in New Jersey

continue to gain momentum. Until these mapping units are reevaluated, they should be viewed with particular caution. These mapping units seem better suited to identify areas in need of field investigation than as wetland mapping units.

3.3 Differences in Physiographic Provinces

It seems likely that many, if not all, of the limitations discussed in the previous section of this study have contributed to the differences identified between the Freshwater Wetland maps and the field delineated boundaries on the study sites. The reasons are likely different for each physiographic province relating to the soils, hydrology, topography and vegetation of wetlands found in that province. The results of the mapping comparison for each province are described below.

3.3.1 Inner and Outer Coastal Plain Provinces

In the Inner and Outer Coastal Plain provinces, all but one site had less field-delineated wetlands than shown on the Freshwater Wetland maps (Tables 4 and 5). In most cases, the overmapping was extensive. Wetland delineations in these provinces are generally very difficult, because the topographic relief is usually low, the vegetation is often extremely dense, there is often great overlap of wetland and upland species, and wetland hydrology maybe lacking during most of the year (Roman 1985, Zampella 1991). These conditions likely make wetland photointerpretation equally difficult. Tiner (1997) has suggested that forested wetlands in the Coastal Plain are among the most difficult to identify through photointerpretation, and most of the study sites in these provinces featured broad areas of forest. Nonetheless, because wetlands were overmapped on the Freshwater Wetland maps on so many of the study sites, it is likely that the wetland signatures used for the mapping are in need of revision and reevaluation, or that the aerial photography used for the mapping is not sufficient to determine uplands from wetlands.

Table 4. Results of the mapping comparison in the Outer Coastal Plain Province

Municipality	County	Study Site Size (acres/hectares)	N.J. Freshwater wetland mapping (acres/hectares)	N.J. Freshwater wetland mapping modified land designations (acres/hectares)	Field-delineated wetlands (acres/hectares)	Percent difference with modified land designations	Percent difference w/o modified land designations	QuarterQuad
Barnegat	Ocean	200/81	14/6	None	10/4	NA	29	Brookville SE
Brick	Ocean	128/52	67/27	5/2	35/14	51	48	Point Pleasant SW
Dennis	Cape May	165/67	34/14	None	11/5	NA	67	Sea Isle City NW
Dover	Ocean	190/77	114/46	3/1	82/33	30	26	Lakewood SE
Lakewood/Dover	Ocean	628/254	293/119	None	191/77	NA	35	Lakehurst NE Lakewood SW
Galloway	Atlantic	476/193	162/66	None	103/42	NA	68	Oceanville NW
Galloway	Ocean	743/301	22/9	None	2/1	NA	99	Green Bank SE New Gretna NW Oceanville NW Pleasantville NE
Downe	Cumberland	2078/841	188/76	None	85/34	NA	55	Dividing Creek NE/NW/SE/SW
Totals		**4608/1865**	**894/362**	**8/3**	**576/233**	**36**	**36**	

Table 5. Results of the mapping comparison in the Inner Coastal Plain Province

Municipality	County	Study Site Size (acres/hectares)	N.J. Freshwater wetland mapping (acres/hectares)	N.J. Freshwater wetland mapping modified land designations (acres/hectares)	Field-delineated wetlands (acres/hectares)	Percent difference with modified land designations	Percent difference w/o modified land designations	QuarterQuad
Greenwich	Gloucester	1858/752	1374/556	159/64	1227/497	20	11	Bridgeport NJ-PA NE/NW
Logan/Woolwich	Gloucester	342/138	79/32	19/8	50/20	49	27	Bridgeport NJ-PA SW
Marlboro	Monmouth	190/77	56/23	22/9	26/11	67	54	Marlboro NW/SW
Middletown	Monmouth	260/105	79/32	3/1	41/17	50	48	Keyport SE
Old Bridge	Middlesex	231/94	209/85	19/8	84/34	67	60	Freehold NW
Old Bridge	Middlesex	188/76	105/43	7/3	76/31	32	28	Freehold NW
Old Bridge	Middlesex	2473/1000	1868/756	29/12	1414/572	34	30	South AmboySW Freehold NW
Washington	Mercer	166/67	101/41	35/14	34/14	75	66	Allentown NW
Totals		**5708/2310**	**3780/1530**	**293/119**	**2952/1195**	**27**	**22**	

3.3.2 Piedmont Province

Wetlands on the Freshwater Wetland maps were both over- and under-mapped in this physiographic province (Table 6). Most of the Piedmont soils are derived from red shale (Tedrow 1983) and are often red in color as a result. The red color frequently masks the presence of redoximorphic features that are commonly used to identify the wetland-upland boundary. In addition, wetland soils in this province often exhibit significant differences in observable hydrology between the wetter (late-winter/early-spring) and drier (summer/fall) portions of the year (USDA 1976). During drier periods, evidence of wetland hydrology may be completely absent. Coupled with a lack of evident redoximorphic features, these conditions often cause the wetland delineator to rely on professional judgement and experience to identify the wetland-upland boundary during drier periods. The aerial photographs used by the NJDEP were all taken in the spring during the wettest portion of the year and, therefore, should reflect the optimal time for assessing hydrology and for conducting wetland delineations in this province.

While it is possible that some of the differences between the Freshwater Wetland maps and field-delineated wetlands may be attributed to wetland delineations conducted during drier portions of the year, when the delineator may actually have undermapped the extent of wetlands, it has been the author's experience, and that of his colleagues (p.c. T. Auffenorde, M. Kovacs, L. Newgard 1999, EcolSciences, Inc.) that this is not consistently a problem. Just the opposite is probably true, as many non-wetland areas of the Piedmont Province exhibit saturated soils and short-duration surface ponding during the early spring when the aerial photographs were taken, suggesting that, as a result, these areas may have been consistently overmapped by the aerial photointerpretors. These areas often feature plant communities, and in particular canopy species, comprised of a mix of facultative species[4] similar to many wetlands in the Province. Often these non-wetland areas gently grade into wetlands, and the delineation is based on subtle changes in soils and hydrology that would not be readily apparent on

[4]Facultative species occur in both wetlands and uplands with equal frequency (USFWS 1988).

aerial photographs. These factors may combine to create signatures that are extremely similar between some wetlands and non-wetlands, making boundary separation and overall identification extremely difficult. This is more likely the explanation why wetlands in this Province were both over- and under-mapped on the Freshwater Wetland maps.

Table 6. Results of the mapping comparison in the Piedmont Province

Municipality	County	Study Site Size (acres/hectares)	N.J. Freshwater wetland mapping (acres/hectares)	N.J. Freshwater wetland mapping modified land designations (acres/hectares)	Field-delineated wetlands (acres/hectares)	Percent difference with modified land designations	Percent difference w/o modified land designations	QuarterQuad
Franklin	Somerset	290/117	43/17	23/9	12/5	82	72	Bound Brook SE/SW
Hillsborough	Somerset	440/178	124/50	14/6	62/25	55	50	Bound Brook SW
Hillsborough	Somerset	756/306	56/23	11/5	29/12	57	47	Rocky Hill NW/Raritan SE/SW
Readington	Hunterdon	180/73	7/3	2/1	50/20	-82	-86	Califon SE
Readington	Hunterdon	205/83	5/2	None	15/6	NA	-66	Califon SE
Readington	Hunterdon	106/43	None	None	12/5	NA	-100	Califon SE
Tewksbury/ Readington/ Bedminster	Hunterdon /Somerset	493/196	22/9	7/3	60/24	-52	-63	Gladstone SW/Raritan NW
Totals		**2470/1000**	**257/104**	**57/23**	**240/97**	**24**	7	

3.3.3 Highlands Province

Wetlands on the Freshwater Wetland maps for individual study sites in this physiographic province were both under- and over-mapped compared to the field-delineations (Table 7). Overall, however, the Freshwater Wetland maps showed more wetlands than were field-delineated. It seems likely that many of the observed differences are attributable to the abundant forest cover and the difficulty of delineating certain wetlands in this province. All of the study sites in this province featured extensive areas of forest that may have obscured the wetlands to the photointerpretor. It is evident from the mapping comparison that many forested wetland areas, particularly in moderately to steeply sloping topography, were incorrectly mapped. The wetland-upland boundary in these areas often does not occur along a distinct break in topography. The wetland limits are often irregular in shape, based on subtle soil and vegetation changes, and grade gently into the adjacent uplands. Based on the author's experience, and that of his colleagues (p.c. T. Auffenorde, M. Kovacs, L. Newgard), wetlands in these sloping areas also often occur in boulder fields and other rocky areas, and in complex upland-wetland mosaics comprised of facultative canopy species and difficult-to-separate hydric and non-hydric soils. These wetlands may not be readily apparent on the aerial photographs and particularly for the drier-end wetlands, may have signatures that are difficult to distinguish from adjacent uplands. In addition, all of the sites had at least one wetland area mapped as a single line feature corresponding to a small drainageway. In each case, wetlands were field-delineated on one or both sides of the drainageway, likely resulting in mapping discrepancies on the Freshwater Wetland maps in these instances.

In more level topographic areas in this province, other difficulties facing the photointerpretor may have resulted in some of the observed discrepancies. This province was subject to glaciation, any many of the wetlands occur in basins that were blocked by the glaciers or sediments deposited by meltwaters (Golet, et al. 1993, Tedrow 1983, Tiner 1985). The National Research Council (1996 p. 174) has reported that wetland mapping in level landscapes, such as glaciolacustrine plains, is often not precise because the wetland boundary is not evident. These areas often feature wetlands that gently grade into uplands. In many instances, the wetland-upland boundary is based on subtle

differences in soil color and redoximorphic features that would not be obvious on the aerial photographs. In addition, the same vegetative species, particularly in the canopy, may occupy broad areas of wetlands and uplands, likely providing difficult-to-observe textural differences to the photointerpretor (Allen, et al. 1989). Although soil saturation may be widespread in these wetlands in the spring, they commonly lack surface ponding, other than for short duration, and in limited areas (Golet, et al. 1993). Similar hydrologic conditions are commonly found in areas characterized as non-wetlands, further complicating the aerial identification of wetlands in these areas.

Table 7. Results of the mapping comparison in the Highlands Province

Municipality	County	Study Site Size (acres/hectares)	N.J. Freshwater wetland mapping (acres/hectares)	N.J. Freshwater wetland mapping modified land designations (acres/hectares)	Field-delineated wetlands (acres/hectares)	Percent difference with modified land designations	Percent difference w/o modified land designations	Quarter Quad
Boonton	Morris	507/205	80/32	7/3	109/44	-20	-27	Boonton NE/SE
Jefferson	Morris	890/360	76/31	None	68/28	NA	10	Dover NE/NW
Mendham	Morris	492/199	37/15	None	12/5	NA	68	Bernardsville NW ChesterSE Gladstone SE Mendham SW
Mt. Olive	Morris	490/198	69/28	4/2	88/36	-17	-22	Chester NW
Mt. Olive	Morris	628/254	61/25	1/.04	111/45	-44	-45	Stanhope SW Tranquility SE
Pohatcong	Warren	600/243	0.55/0.22	3.58/1	0.27/0.1	96	51	Easton PA-NJ SE/SW
Rockaway	Morris	1702/689	165/67	None	194/79	NA	-15	Boonton NW/SW
West Milford/Ringwood	Passaic	2074/839	153/62	None	230/93	NA	-33	Greenwood Lake NY-NJ SE
Totals		**7383/2988**	**641.55/260**	**15.58/6**	**812.27/329**	**-19**	**-21**	

3.3.4 Ridge and Valley

Wetlands in this province were both over- and under-mapped on the Freshwater Wetland maps compared to the field-delineated limits (Table 8). Overall, the wetlands were undermapped more than in any other province. The Ridge and Valley is the smallest province in the state and features strong topographic relief and abundant forest. As in the Highlands, these conditions likely contribute to the observed discrepancies between the aerial wetland mapping and the field delineations. Wetlands in this region often occur in densely wooded rocky terrain, in seepages, or along small, often intermittent streams, or in densely wooded, broad, often rocky, level to sloping landscapes. In the stonier areas, the surface can often be covered by rocks that nearly completely obscure the ground and evidence of wetland hydrology. Microtopography and the stones often create small, better-drained areas that allow Facultative upland[5] species to occur in these wetlands, particularly in the canopy. This combination of obscured hydrology and ground surface, and upland trees, must exacerbate the difficulty of mapping wetlands in this region from aerial photography and almost certainly contributed significantly to the extensive undermapping of wetlands in this province. With the exception of the Pohatcong site, that was primarily agricultural, the remainder of the study sites in this province were nearly completely wooded and featured strong topographic relief.

[5]Facultative upland species occur in with greater frequency in uplands than in wetlands (USFWS 1988).

Table 8. Results of the mapping comparison in the Ridge and Valley Province

Municipality	County	Study Site Size (acres/hectares)	N.J. Freshwater wetland mapping (acres/hectares)	N.J. Freshwater wetland mapping modified land designations (acres/hectares)	Field-delineated wetlands (acres/hectares)	Percent difference with modified land designations	Percent difference w/o modified land designations	Quarter Quad
Andover	Sussex	229/63	67/27	None	56/23	NA	16	Newton East SE
Frankford	Sussex	236/96	14/6	None	44/18	NA	-68	Branchville NE
Fredon	Sussex	250/101	61/25	5/2	45/18	-32	-26	Newton NW
Green	Sussex	156/63	45/18	1/0.4	28/11	39	38	Tranquility NW/SW
Knowlton	Warren	156/63	7/3	1/0.4	6/2	25	14	Portland NJ-PA SE
Lopatcong Greenwich	WarrenSussex	180/73	3.5/1	0.75/0.3	2.5/1	41	29	EastonNE Bloomsbury NW
Oxford	Warren	118/48	34/14	None	24/10	NA	29	Washington NW
Wantage	Sussex	196/79	10/4	None	28/11	NA	-17	Branchville NW
Wantage	Sussex	187/76	8/3	None	45/18	NA	-82	Branchville NE
Totals		**1769/716**	**249.5/101**	**7.75/3**	**331.5/134**	**-22**	**-25**	

CHAPTER 4

RECOMMENDATIONS AND CONCLUSIONS

4.1 Overview

Despite the identified discrepancies between the New Jersey Freshwater Wetland maps and field-delineated boundaries of wetlands shown on those maps, the wetland maps are an important and useful resource for land-use and other planning purposes. These maps currently represent the best available inventory of the State's freshwater wetlands, and are being used by a broad array of resource and regulatory agencies, and other groups. However, because in many cases significant differences exist between the wetlands shown on the maps and actual field-delineated boundaries, the maps must be used with caution and with a clear understanding of their inherent limitations for all but the most general land-use and planning purposes. In virtually no instances should they be used for regulatory or land transaction decisions. In addition, a wide variety of information has been published by the NJDEP regarding the utility and purpose of the maps. Much of this information appears contradictory, or at least confusing, and cautionary statements about the limitations of the maps are often not prominently featured in the resource materials that accompany the digital and paper copies of the maps.

4.2 Recommendations

A number of recommendations, if implemented, will increase the utility of the database. These include:

- The Freshwater Wetland Maps should be routinely updated to include field-verified wetland boundaries. New Jersey is fortunate to have a number of regulatory programs in place that require the field delineation of nearly all wetland boundaries, and agency confirmation of the jurisdictional limits. The wetland boundaries on more than 18,000 sites (p.c. P. Shepard 1999) have received formal confirmation through regulatory inspections, creating a vast

database of wetland conditions and limits throughout the state. By incorporating this database of field-verified wetlands into the Freshwater Wetland maps, the accuracy and utility of the maps will be significantly improved.

- Wetland delineations submitted to the NJDEP or other regulatory agencies are currently described by metes and bounds, and are provided only in paper copy (N.J.A.C. 7:7A). The submission requirement should be changed to require wetland delineations to be submitted in a form compatible with New Jersey's GIS format. This would be consistent with other NJDEP regulatory programs, including the Technical Requirements for Site Remediation (N.J.A.C. 7:26E-3.13 9(c)3v), that now require electronic submissions. This will facilitate the updating of the Freshwater Wetland maps and will minimize the Department's resource requirements for this task.

- When significant wetland mapping differences in a particular area are identified during the updating of the maps with field-verified boundaries, a comprehensive review of the quarter-quad or region should be undertaken. By utilizing localized, field-confirmed wetland signatures and, the landscape position of these field-verified wetlands, the accuracy of the Freshwater Wetland maps should be greatly enhanced. Tiner (1999) has suggested a similar approach for enhancing the accuracy of the National Wetlands Inventory maps.

- The explanatory materials provided with the State's GIS software with respect to wetlands, as well as with the paper copies of the Freshwater Wetland maps and other NJDEP information sources, should be revised to more clearly provide the user with an understanding of their accuracy and limitations. This will improve the utility of the maps for planning and other land-use purposes. The Special Note/Disclaimer contained on the United States Fish and Wildlife Service National Wetland Inventory maps could serve as a model. The disclaimer reads:

"This document was prepared primarily by stereoscopic analysis of high altitude aerial photographs. Wetlands were identified on the photographs based on vegetation, visible hydrology, and geography in accordance with Classification of Wetlands and Deepwater Habitats of the United States, (FWS/OBS-79/31 December 1979). The aerial photographs typically reflect conditions during the specific year and season when they were taken. In addition, there is a margin of error inherent in the use of the aerial photographs. Thus, a detailed on the ground and historical analysis of a single site may result in revision of the wetland boundaries established through photographic interpretation. In addition, some small wetlands and those obscured by dense forest cover may not be included on this document.

Federal, State, and Local regulatory agencies with jurisdiction over wetlands may define and describe wetlands in a different manner than that used in this inventory. There is no attempt, either in the design or products of this inventory, to define the limits of proprietary jurisdiction of Federal, State, or Local government or to establish the geographical scope of the regulatory programs of government agencies. Persons intending to engage in activities involving modifications within or adjacent to wetland areas should seek the advise of appropriate Federal, State, or Local agencies concerning specified agency regulatory programs and proprietary jurisdictions that may affect such activities."

- In most cases, very limited areas of field-verified wetlands exist within the areas mapped with modified agricultural wetland designations. In the author's experience in these areas, many of the farmed areas mapped as modified wetlands have been altered by drainage or occur on non-hydric soils. In addition, many of the areas mapped as modified land have been subjected to fill-and-dredge deposition or occur on non-hydric soils and are often not wetlands. Until the signatures and mapping techniques used for these mapping units are reevaluated, they should be viewed with particular caution. These mapping units seem better suited to identify areas in need of field investigation rather than wetland mapping units.

- The maps should be used in conjunction with other available mapping sources. Other studies have shown that by combining various wetland-related mapping resources, the accuracy of interpreting the wetland boundary without field-verification can be greatly improved (Tiner 1999, Dames and Moore 1997, Dept. of the Army 1997). Many of these resources, such as topography, soils and floodplains, are already incorporated into the State's GIS database facilitating their use.

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