November 1994

Map Accuracy of National Wetlands Inventory Maps for Areas Subject to Maine Land Use Regulation Commission Jurisdiction

U.S. Department of the Interior
Fish and Wildlife Service
Northeast Region

Map Accuracy of National Wetlands Inventory Maps for Areas Subject to Maine Land Use Regulation Commission Jurisdiction

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November 1994

This report should be cited as follows:

Nichols, C. 1994. Map Accuracy of National Wetlands Inventory Maps for Areas Subject to Land Use Regulation Commission Jurisdiction. U.S. Fish and Wildlife Service, Hadley, MA. Ecological Services report R5-94/6, 14pp.

INTRODUCTION

The Maine Land Use Regulation Commission (LURC) is using National Wetlands Inventory (NWI) maps prepared by the U.S. Fish and Wildlife Service (FWS) as the basis for producing regulatory wetland guidance maps for areas in their jurisdiction. NWI maps are prepared through photointerpretation of high-altitude aerial photography with limited ground-truthing. Wetlands and deepwater habitats were classified according to the Service's official wetland classification system (Cowardin, et al., 1979), following standard NWI mapping conventions (NWI, 1990). LURC supported extensive field review of draft NWI maps to improve the quality of these maps. Given their use of these maps, LURC was interested in knowing how accurate NWI maps are. In 1993, LURC amended an existing memorandum of understanding with the FWS to perform an accuracy assessment of NWI maps in the LURC area.

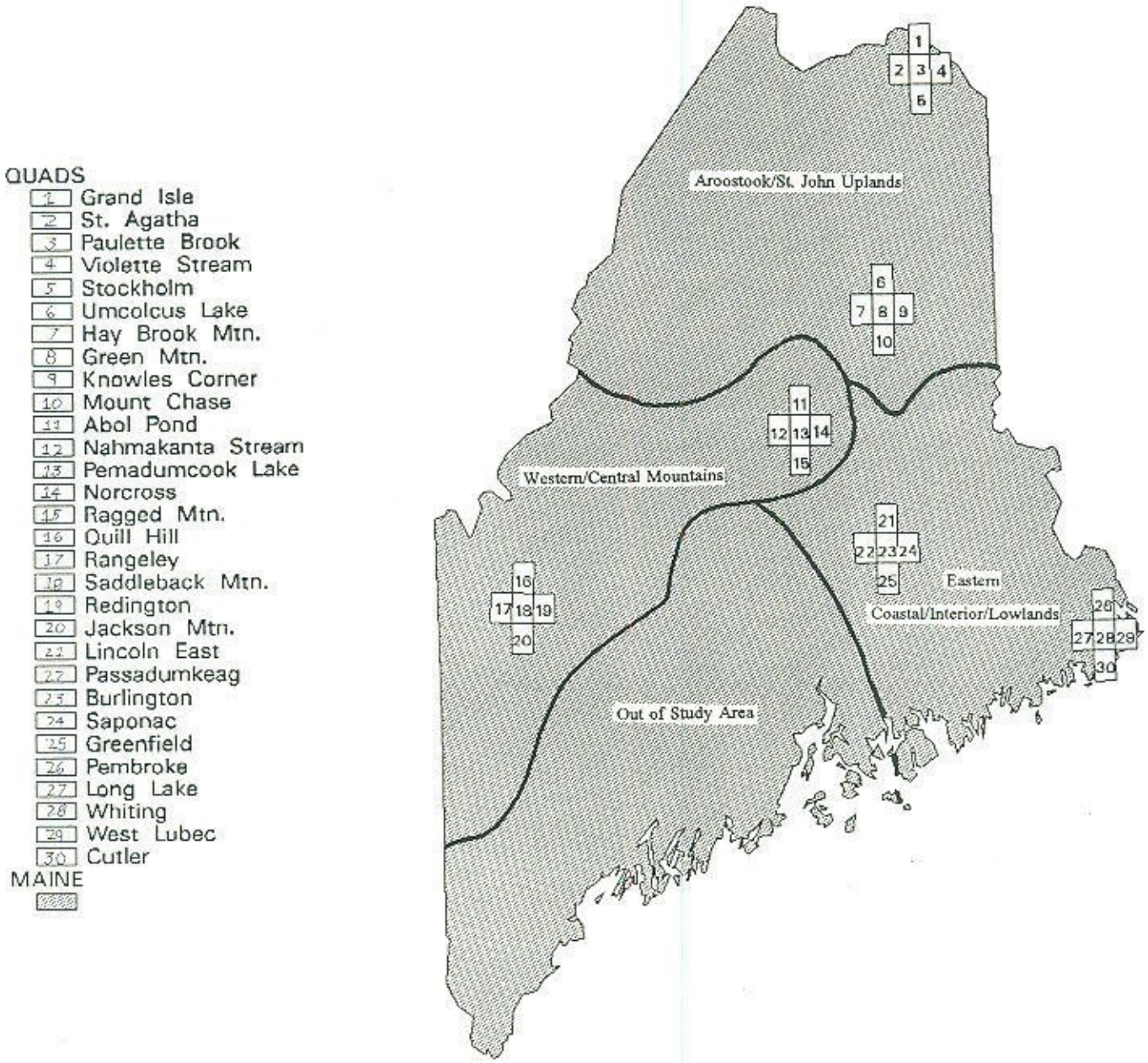
The study had two primary objectives: (1) to determine the accuracy of NWI maps at identifying wetland, deepwater habitat, and upland, and (2) to determine the accuracy of wetland type classification for mapped wetlands on those maps. This report represents the findings of this study. It is divided into two major sections that describe the methods employed and the study's results.

METHODS

Study Area Selection

Since evaluation of all the NWI maps in the LURC area is cost prohibitive, specific maps had to be selected for evaluation. The LURC area was divided into three regions based on biophysical characteristics (climate, topography, and vegetative types) for purposes of randomly selecting final NWI maps for evaluation: 1)Western/Central Mountains, 2) Aroostook/St. John Uplands, and 3) Eastern Coastal/Interior/Lowlands (Figure 1) (McMahon, 1990). Two 7.5' United States Geological Survey (USGS) topographic quadrangles were then randomly selected from each biophysical region. These quads would serve as the focal points for the NWI map evaluation. In the Western/Central Mountains Region, Saddleback Mountain and Pemadumcook Lake were selected. Whiting and Burlington were selected from the Eastern Coastal/Interior/Lowlands Region. In the Aroostook/St. John Uplands Region, Green Mountain and Paulette Brook were selected. To widen the sampling areas and maximize efficiency of field work, four contiguous quads (directly north, south, east, and west) were selected to create a 5-quad study area for map evaluation (Figure 1). The entire study area, therefore, consisted of 30 NWI maps; two sets of 5-quads in each biophysical region.

Figure 1. Sampling Areas within Three Biophysical Regions.



Study Protocols

The study was divided into two parts: (1) assessing the accuracy of NWI maps for locating wetland, deepwater habitat, and upland, and (2) determining the classification accuracy for mapped wetlands. The first part of the study answers the question - If an NWI map designates an area as wetland, deepwater habitat, or upland, how likely is the area to be this feature? In examining this, commission and omission errors of the map would be detected. Commission errors are areas mapped as something else (e.g., upland mapped as wetland or wetland mapped as upland). Missed wetlands (omissions) would also be detected. The second part of the study dealt with wetland classification accuracy and answers the question - How accurate is the classification of mapped wetlands? In other words, if a wetland is mapped as Palustrine Broad-leaved Deciduous Forested Wetland, Seasonally Flooded, how likely is it to be this?

Note on Evaluating NWI Maps

Aerial photographs are the primary source of imagery for all NWI maps. Aerial photos are viewed stereoscopically to interpret, delineate, and classify wetland and deepwater habitat features. Data depicted on NWI maps therefore reflect the status of wetlands as of the date the aerial photograph was captured. Landscape changes that occur after that date will not be represented on the map. When evaluating the accuracy of an NWI map, the above circumstances need to be taken into account. When field checking NWI maps for accuracy, changes in wetlands that have taken place after the photo date should not be considered map errors, although they do reflect wetland dynamics that affect the utility of NWI maps. Users of NWI data should be aware of this convention and should also note that areas of rapid human-induced development and areas subject to beaver colonization/habitation may have changed substantially since the effective date of an NWI map.

Dates of photography used to delineate and classify wetland and deepwater habitat features within the study area are presented in Table 1.

Table 1. Photo dates for NWI maps in the six study areas.

Biophysical Region	Study Area (Randomly Selected Maps)	Associated Maps	Date of Photography
Western/Central Mountains	Pemadumcook Lake	Abol Pond	May 13, 1986
		Nahmakanta Stream	October 31, 1985
		Norcross	May 13, 1986
		Pemadumcook Lake	May 13, 1986
		Ragged Mountain	May 13, 1986
	Saddleback Mountain	Jackson Mountain	May 13, 1986
		Quill Hill	May 13, 1986
		Rangeley	May 13, 1986
		Redington	May 14, 1986
		Saddleback Mtn.	May 1986
Aroostook/St. John Uplands	Paulette Brook	Grand Isle	May 7, 1985
		Paulette Brook	May 7, 1985
		St. Agatha	May 15, 1986
		Stockholm	May 7, 1985
		Violette Stream	May 7, 1985
	Green Mountain	Green Mountain	May 15, 1986
		Haybrook Mountain	May 13, 1986
		Knowles Corner	October 23, 1985
		Mount Chase	May 15, 1986
		Umcolcus Lake	May 15, 1986

Biophysical Region	Study Area (Randomly Selected Maps)	Associated Maps	Date of Photography
Eastern Coastal/Interior/ Lowlands	Burlington	Burlington	May 7, 1984
		Greenfield	May 7, 1984
		Lincoln East	May 7, 1984
		Passadumkeag	October 21, 1985
		Saponac	May 7, 1984
	Whiting	Cutler	May 18, 1983
		Long Lake	May 18, 1983
		Pembroke	May 18, 1983
		Whiting	May 18, 1983
		West Lubec	May 18, 1983

Procedures for Evaluating NWI Map Accuracy

To analyze NWI map accuracy (correct identification of wetland, deepwater habitat, and upland), a point intercept transect procedure was employed. Existing roads were selected as potential transects, considering access, the need to efficiently use field time, and the ability to accurately locate sample points on the maps and in the field. Road intersections and river crossings were identified on *The Maine Atlas and Gazetteer* (DeLorme Mapping Company, 1993) to determine potential starting points for transect procedures. Three of these intersections and/or river crossings were then randomly selected. For each transect, the direction of travel (i.e., N, S, E, W for a four-corner intersection, or any combination for a 2-3 corner intersection) was also randomly chosen.

Starting points and direction for each 2-mile transect were identified on NWI maps. For employing the point intercept method in the field, the vehicle odometer was reset at the middle of the intersection then the vehicle proceeded until the odometer indicated 0.2 mile. The field biologist then left the vehicle and took two point samples. At each stop, a point sample was taken on each side of the road (transect) 50 feet from the edge of shoulder or right of way and perpendicular to the road. The distance of 50 feet was determined using a measured 50 foot length of rope affixed to a stationary object at the roadside. At 50 feet from the edge, appropriate map evaluation data were recorded (Figure 2). If a map error was detected, corroborative data on soil, plant, and hydrology were collected. Ten stops at the end of each 0.2 mile segment were made for every transect until the 2-mile transect was complete. Thus, each transect had a total of 20 point sampling sites. Three transects were examined per quad for a subtotal of 60 sites per quad, 300 sites per area, and 600 per biophysical region. The projected total number of points for the entire study area was 1800.

Procedures for Evaluating Wetland Classification Accuracy

Along the 2-mile transects used in the map accuracy evaluation study, all wetlands visible from the road were field checked to assess classification accuracy. This included some well beyond the 50 foot point sample sites. The total number of wetlands examined for each study area is as follows:

(1) Saddleback Mountain Area = 88
(2) Pemadumcook Lake Area = 79
(3) Burlington Area = 113
(4) Paulette Brook Area = 81
(5) Green Mountain Area = 81
(6) Whiting Area = 95

Figure 3 shows a blank field data collection sheet for recording this data. Wetlands with different classifications than shown on the NWI map were later examined on original aerial photos by an experienced photointerpreter to determine if the classification differences were a result of true aerial photointerpretation (API) error (misinterpretation) or due to natural succession, NWI conventions, or human-induced changes.

Figure 2. Data sheet used to assess NWI map accuracy for separating wetland from deepwater habitat from upland.

MAINE NWI ACCURACY DATA SHEET--RANDOM POINT ASSESSMENTS

REPORTED BY: _____ QUAD: _____ ROAD: _____ TRANSECT #: ____

Site #	Wetland= W Upland= U Deepwater Habitat = D	Type of Wetland (in field classification)	Mapped by NWI? Yes (Y) No (N)	NWI Map Code	Is Wetland 1 to 3 acres in size?	Is Wetland less than one acre in size?	Shape of Wetland? Linear=L Point=Pt Sublinear=SL Polygon=P	Comments (e.g., proximity to a wetland)
1l								
1r								
2l								
2r								
3l								
3r								
4l								
4r								
5l								
4r								
5l								
5r								
6l								
6r								
7l								
7r								
8l								
8r								
9l								
9r								
10l								
10r								

Figure 3. Data sheet use to determine accuracy of classification for wetlands designated on the NWI maps.

MAINE NWI ACCURACY DATA SHEET--INDIVIDUAL WETLAND ASSESSMENT
REPORTED BY: _____ QUAD: _____

ROAD: _____ PHOTO INTERPRETER: _____

Wetland #	NWI Map Code	In-field Classification	PI Verified Code

Procedure for Review of Field Results

All sites observed in the field that were classified and/or delineated differently than the polygons on the NWI maps were later reviewed by a trained photointerpreter. Aerial photos were re-evaluated, and reasons for any discrepancies were described and recorded. Changes not considered photointerpretion error were due to five causes: (1) natural succession, (2) NWI mapping conventions, (3) seasonal photographic limitations, (4) man-made changes, and (5) beaver modifications.

Areas that changed between the date of photography and the date of field work due to natural succession were mostly excavated areas (small, shallow ponds) that have become vegetated and are now emergent wetlands or scrub-shrub wetlands. Other successional changes were from emergent wetland to scrub-shrub wetland and scrub-shrub wetland to forested wetlands. These natural processes or human-induced changes (e.g., timber harvest) occurred after the date of photography and are not considered map errors.

For the study area, minimum mapping units (MMUs) for individual wetlands are 1-3 acres in size, although conspicuous wetlands smaller than this size are sometimes delineated within large wetland complexes. Some discrepancies found in the field can be attributed to NWI mapping conventions for internal minimum mapping units (IMMUs). In complexes of different wetland types, (IMMUs) are usually established to improve map readability(NWI, 1990). The IMMU chosen depends on a number of factors, including aerial photograph scale and type, abundance of wetlands, distribution of wetlands, and geography. In large wetland complexes with intricate or highly variable wetland cover types and water regimes, IMMUs may be as large as 5 acres or more in size.

Certain wetland types will be mapped within closely related classifications due to seasonal photographic limitations. These wetlands cannot be classified correctly due to seasonally-related signatures. Needle-leaved deciduous (FO2 or SS2) signatures, which in Maine are restricted to one species, larch *(Larix laricina)*, cannot be distinguished from broad-leaved deciduous species when using spring photography. Since both needle-leaved and broad-leaved deciduous species are bare when the spring photography is flown, no distinguishing signature characteristics appear. As a result, all wetlands dominated or co-dominated by larch were classified as broad-leaved deciduous wetlands (FO1 or SS1) when spring photography was used. Fall photography enables photointerpretation of larch since its needles have yellowed and typically reflect a bright white signature on color infrared photography (David Foulis, pers. comm.).

Areas disturbed due to road construction, gravel excavation, and other human-induced modifications that change the hydrology, plant community, and/or soil characteristics of an area are human-induced changes. Beaver activity can also result in rapid changes to wetland cover type and water regime. Any changes occurring after the date of photography will not be shown on NWI maps.

RESULTS

NWI Map Accuracy for the 30-Quad Study Area

For determining map accuracy (wetland vs. deepwater habitat vs. upland), a total of 1740 points were evaluated. The anticipated number of 1800 points was decreased by 60 points because of lack of passable roads and dangerous conditions encountered in the field, such as logging trucks on steep, winding, non-shouldered roads, bridge deterioration, deep impassable ruts, and abandoned/overgrown roads. The Pemadumcook quadrangle contained only a very short section of unused logging road which accounted for a loss of 20 points. For the Jackson Mountain quadrangle, 40 points were omitted due to lack of roads, dangerous road conditions, lack of shoulder, and logging trucks. A total of 60 points were omitted due to the above conditions.

Wetland and deepwater habitats shown on NWI maps were correctly mapped as wetland or deepwater habitat at 100 percent of the sites studied (Table 2). Upland areas were mapped correctly on 95 percent of the sites studied; some wetlands were included in upland mapping units. The total percent of sample points correctly mapped as either wetland, deepwater habitat, or upland was 95.4 percent (Table 2).

The total number of wetland points observed along all transects was 186. This total included wetlands of any size. The minimum mapping unit for wetlands on NWI maps is estimated between 1-3 acres in size where 1:58,000 color infrared photography is used (e.g., Maine). Consequently, wetlands observed at field sample points were divided into three size classes: (1) >3 acres, (2) 1-3 acres, and (3) <1 acre, to assess how well NWI maps were in mapping wetlands in each size class. Table 3 summarizes the results for the 30-quad study area. NWI maps identified over 90% of the wetlands greater than 3 acres in size along the sample transects. Over 70% of the wetlands between 1-3 acres in size were mapped. Smaller wetlands (i.e., less than one acre) were also delineated on the maps. These wetlands are below the NWI's minimum mapping unit, so it was not surprising to find that most of these types of wetlands were not mapped along the study transects.

Table 2. Number and percentage of sample points correctly mapped as upland, wetland, or deepwater habitat for the 30-quad study area.

Habitat Type:	**Number & Percentage of Points Correctly Mapped**
Wetland	100% 107 out of 107
Deepwater Habitats	100% 25 out of 25
Upland	95% 1528 out of 1587
Upland, Deepwater Habitat, or Wetland	95.4% 1656 out of 1740

Table 3. Percent of wetland sample points observed in the field that were correctly identified for each size group and in-field classifications of missed wetlands for the 30-quad study area.

Wetland Size	% Wetland Points Correctly Mapped	Wetland Type Missed (Number of Points)
> 3 Acres	91.3%	PFO4E (2) PFO1E (1) PSS1E (1)
1-3 Acres	72.9%	PFO4E (5) PFO1E (2) PFO1C (2) PFO1Ch (2) PSS1E (2) PFO4C (1) PSS1/4E (1) PEM1E (1)
< 1 Acre *	25%	PSS1E (16) PFO4E (13) PFO1C (6) PFO1E (6) PSS4E (3) PEM1C (2) PSS1Eb (2) PSS1Eh (2) PFO2E (1) PFO4C (1) PFO1/SS4E (1) PFO1/4E (1) PSS1/FO1E (1) PUBHb (1)

* Exceeds standard NWI minimum mapping unit.

NWI Map Accuracy By Biophysical Regions

Three distinct biophysical regions were part of the study area: Western/Central Mountains, Aroostook/St. John Uplands, and Eastern Coastal/Interior/Lowlands Regions. Each area had a total of 600 sample points examined for NWI map accuracy, except the Western/Central Mountains where lack of roads and poor road conditions resulted in fewer sample points.

All areas designated as wetlands were wetlands and all areas mapped as deepwater habitats were deepwater habitats for the three biophysical regions (Table 4). The map accuracy for areas designated as uplands was somewhat less, ranging between 94-97%. Mapped uplands included some wetlands. Table 4 lists exact percentages for the three biophysical regions.

Table 4. Percentage of sample points correctly mapped as wetland, deepwater habitat, or upland in each biophysical region.

Correctly Mapped As:	**Western/Central Mountains**	**Aroostook/St. John Uplands**	**Eastern Coastal/ Interior/Lowlands**
Wetland	100%	100%	100%
Deepwater Habitat	100%	100%	100%
Upland	93.8%	96.7%	94.5%
Types Combined	94.1%	97%	95%

The total number of wetland sample points observed along transects was 62 for the Western/Central Mountains, 63 for Aroostook/St. John Uplands, and 61 for Eastern Coastal/Interior/Lowlands. These sample points were divided into three size classes of wetlands: (1) >3 acres, (2) 1-3 acres, and (3) <1 acre, to assess how well NWI maps were achieving their objective of mapping wetlands 1-3 acres in size and larger. Table 5 summarizes the results for the each biophysical region. For the Western/Central Mountains Region, NWI maps identified 90% of wetlands greater than 3 acres in size along the sample transects, more than half of the wetlands between 1-3 acres in size, and over a quarter of the smaller wetlands. For the Aroostook/St. John Uplands, NWI maps identified 91% of wetlands greater than 3 acres in size along the sample transects, more than three-quarters of wetlands between 1-3 acres in size, and over a third of the smaller wetlands. For the Eastern Coastal/Interior/Lowlands Region, NWI maps identified 92% of wetlands greater than 3 acres in size along the sample transects, three-quarters of the wetlands between 1-3 acres in size, and about 15% of the smaller wetlands. For all areas, most of the wetlands less than 1 acre in size were not mapped.

Table 5. Percentage of wetland points correctly mapped & in-field classifications for missed wetlands arranged by size group for each biophysical region.

Size Group	Western/Central Mountains		Aroostook/St. John Uplands		Eastern Coastal/Interior/Lowlands	
	Correctly Identified as Wetland	Classification of Missed Wetlands (# pts)	Correctly Identified as Wetland	Classification of Missed Wetlands (# pts)	Correctly Identified as Wetland	Classification of Missed Wetlands (# pts)
> 3 Acres	90% (9 out of 10)	PSS1E (1)	91.3% (21 out of 23)	PFO1E (1) PFO4E (1)	92.3% (12 out of 13)	PFO4E (1)
1-3 Acres	66.7% (14 out of 21)	PFO1E (1) PSS1E (1) PFO4E (1) PEM1E (1) PFO1C (1) PFO1Ch (2)	77.8% (14 out of 18)	PFO4E (2) PSS1/4E (1) PFO1E (1)	75% (15 out of 20)	PFO4E (2) PSS1E (1) PFO4C (1) PFO1C (1)
< 1 Acre	26.7% (8 out of 30)	PSS1E (5) PFO1C (4) PFO4E (4) PEM1C(2) PFO1E (3) PSS4E (1) PSS1Eb (1) PSS1/4E (1) PSS1/FO1E (1)	35% (7 out of 20)	PSS1E (5) PFO4E (2) PFO2E (1) PFO1C (1) PSS4E (1) PSS1Eh (1) PUBHb (1) PFO1/4E (1)	15.4% (4 out of 26)	PSS1E (6) PFO4E (7) PFO1E (3) PFO1C (1) PFO1/SS4E (1) PSS1Eb (1) PSS1Eh (1) PFO4C (1) PSS4E (1)

Wetland Classification Accuracy Results for 30-Quad Study Area

For evaluating the classification accuracy of mapped wetlands, 539 wetlands were examined. Each wetland's classification was field checked for accuracy to each major level of the Service's Wetland Classification System: System, Subsystem, Class, Subclass, and Water Regime. For the 30-quad study area, the *system* level was 100% correct and *subsystem* was 99% correct. Ninety-seven percent of the sampled wetlands were correctly mapped to *class* (Table 7) at the date of photography. Since that time, some changes have occurred in the mapped wetlands. As of August 1994, the *class* level was 90.3% correct, due to recent

natural succession, beaver activity, and human-induced changes[1]. Areas that changed due to natural succession accounted for 46.2% of the current "misclassified" areas. Beaver activity was responsible for 3.8% and man-induced changes were responsible for 10% of the presently "misclassified" areas (Table 8).

At the *subclass* level, 98% of the wetland areas were correctly mapped at the time of the aerial photos (Table 7). By August 1994, the *subclass* level was 91.6% correct. Natural succession was responsible for over half of the present "misclassifications", while beaver and man-induced changes represented roughly 10% of the "misclassified" areas (Table 8).

Water regime was correctly mapped for 99.4% of the wetlands examined (Table 7). In August 1994, the *water regime* level was 94.9% correct, which is due to recent changes. Natural succession accounted for over half of the "misclassified" wetlands (Table 8). Beaver activity and man-induced changes were each responsible for 10% of the "misclassified" areas.

[1]These areas do not represent misclassifications, but rather the original classification is no longer accurate due to recent changes in the wetland.

Table 7. Percentage of wetlands correctly identified to class, subclass, and water regime at the time of the aerial photographs for mapped wetlands in the 30-quad study area. Classifications for misinterpreted wetlands are also shown for each level, with the number of affected wetlands shown in parenthesis.

CLASS 97% or 511 correct out of 527 wetlands*	**SUBCLASS** 98% or 432 correct out of 441 wetlands*	**WATER REGIME** 99.4% or 532 correct out of 535 wetlands*
Misclassifications: Map » In-field PSS1E » PEM1E (3) PEM1E » PFO1/SS1E (1) PEM1E » PSS1E (1) PEM1Eb » PSS1/EM1Eb (1) PEM1Eb » PEM1/SS1Eb (1) PEM1Fh » PEM1/SS5Fh (1) PEM1/SS1Eh » PEM1Eh (1) PFO1E » PSS1E (1) PFO1E » PSS1/FO1E (1) PFO4E » PSS1E (1) PFO4/SS1E » PSS1/4E (1) PSS1E » PFO1E (1) PSS1Fh » PEM1Fh (1) PUBF » PEM1E (1)	*Misclassifications:* Map » In-field PFO4Eb » PFO1/4Eb (2) PEM1Fh » PEM1/SS5Fh (1) PFO4E » PFO1A (1) PFO4E » PSS1E (1) PFO4/SS1E » PSS1/4E (1) PFO5Eh » PFO4/1Eh (1) PSS3Ba » PSS7Ba (1) PUBF » PEM1E (1)	*Misclassifications:* Map » In-field PFO4E » PFO1A (1) PSS3E » PSS3Ba (1) PUBF » PEM1E (1)

*Total number of wetlands vary due to classifications, e.g., not all wetlands had subclass designated.

Table 8. Causes of wetland classification changes, showing percentage responsible for change in wetland classification since the date of photography for the 30-quad study area.

Reason for Change	**Class***	**Subclass***	**Water Regime***
Natural Succession	46.2%	42.1%	57.1%
Beaver Activity	3.8%	5.3%	7.1%
Human-Induced	9.6%	13.2%	10.7%

*These percentages do not equal 100% since the remaining percentage represents map classification errors or are classifications for wetlands below the minimum mapping unit.

Wetland Classification Accuracy Results by Biophysical Regions

The NWI map study for accuracy of classification type examined each aspect of the classification system for each biophysical region. Each region was 99-100% correctly mapped for system, subsystem, and wetland versus upland or deepwater habitat. The only exception was within Aroostook/St. John Uplands where the subsystem level was 92.9% correct. This lowered accuracy resulted from riverine misclassifications. Table 9 displays the percentage correct at the class, subclass, and water regime levels for each biophysical region.

Table 9. Percentage of wetlands correctly mapped to class, subclass, and water regime for each Biophysical Region.

Biophysical Region	Class	Subclass	Water Regime
Western/Central Mountains	96.4%	98%	98.2%
Aroostook/St. John Hills and Uplands	97.4%	97%	100%
Eastern Coastal/Interior	97.1%	99%	99.5%

CONCLUSIONS

In summary, all areas designated as wetland and deepwater habitat at sample points along the study transects were accurately identified, while the accuracy of upland designations ranged from 93% to 97%. Some wetlands were included as uplands due to mapping conventions (i.e., minimum mapping units) and misidentifications. Most of these wetlands were less than 1 acre in size. Of the mapped wetlands, covertyping was over 90% accurate. Most of the discrepancies were the result of recent changes (i.e., since aerial photos were acquired).

ACKNOWLEDGMENTS

Many thanks are extended to the following individuals for their assistance with this study. Ralph Tiner designed the sampling protocol and provided study oversight. He also helped with data analysis and presentation. David Foulis performed photointerpretion review and provided technical information and language regarding API conventions. John Eaton and Kay Ross assisted with map production and computer operations. Henry Nichols and Stephen Andrews assisted with field work in Maine. Final map production for study areas and mapping convention information was provided by Glenn Smith. Becky Stanley promptly relayed photo packs and information requests. Irene Kenenski, Todd Nuerminger, Glenn Smith, and David Foulis meticulously proofread the final report. Statistical assistance was provided by Tim Fannin and Paul Steblein.

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