Wetland Inventory and Classification for Carlton and South St. Louis Counties

Final Report and Deliverables

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Project Description

Accurate maps of the type and locations of wetlands are critical for land use planning, particularly for watersheds undergoing rapid develoment or facing increased development pressure. The important role wetlands play in maintaining habitat, water quality and surface and ground-water protection is well documented, but current information on the types, sizes, and locations of wetlands is difficult to obtain. As coastal environments come under increased pressure from development, this information is essential for zoning, buildout scenarios and numerous other planning objectives. Within the Coastal Program boundary, however, up-to-date information on wetland type and distribution is sparse, outdated, or lacking for many watersheds. While the National Wetland Inventory is the most extensive and commonly used inventory, the limitations with respect to spatial and classification accuracy are well-recognized.

Over several iterations, we have systematically been mapping wetlands within high-growth areas of the Minnesota's Lake Superior Coastal Program. The objective of the current proposal is to use recent MN DNR aerial photography and other spatial data to delineate and characterize wetlands for the southwestern portion the Coastal Program area. These includes approximately three townships in Carlton County and watershed extensions into St. Louis County (Figure 1). Our primary end products are digital maps of classified wetlands and with associated data tables, which are here provided to the Lake Superior Coastal Program for distribution to decision makers and the general public.

Wetland maps are delivered in two formats. As part of this final report to the MN DNR, we have included a DVD that contains the rectified raw imagery, interpreted wetland in GIS format, and metadata for the data layers. We have also created, as part of the CoastalGIS website at the Natural Resources Research Institute, downloadable and on-line versions of the interpreted wetlands. The download versions are delivered in ESRI shapefile format, with associated metadata. We also provide an interactive version using the Arc Internet Map Server, which allows maps to be viewed and manipulated over the Internet with a standard web brower. The NOAA-funded CoastalGIS web site was established in March 2002 to serve as a clearinghouse for spatial data relevant to the Coastal Program. The site currently contains a wide range of data sets on natural resources and infrastructure, and is designed to assist local decision makers and the general public in land use planning. The CoastalGIS web site can be accessed at: *http://www.nrri.umn.edu/CoastalGIS*

This project consisted of three tasks:

1. Aquisition and georectification of MN DNR aerial photographs of the selected watersheds
2. Classification of wetlands from these photographs according to classes of the National Wetland Inventory. This task includes development of metadata according to FGDC standards
3. Delivery of data through electronic media and web-based sources

The key deliverables for this project, included with this document, are:

1. Compressed versions of the scanned and rectified color-infrared photographs
2. A National Wetland Inventory classification of wetlands within the targeted watersheds, delivered in standard GIS database format, included descriptions of the data and a report on data accuracy
3. Electronic media and Internet-based copies of all data developed by this project

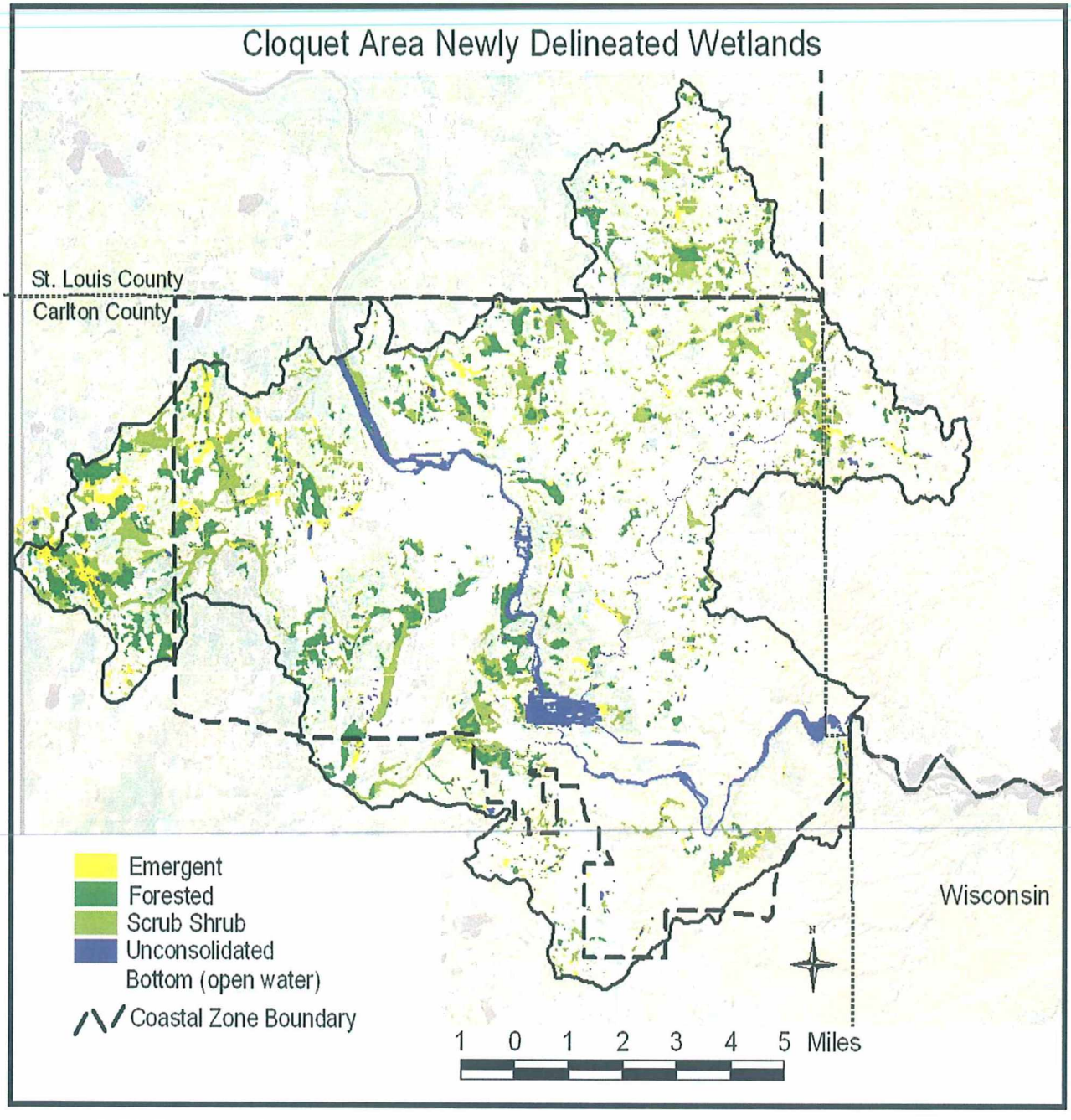

Figure 1. Study area with watershed boundaries and wetland classes

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Task 1 - Photo Acquisition and Georectification

Our original proposal called for the acquisition and georectification of the MN Department of Natural Resources 1:15,840 Color Infrared (CIR) photographs from flights conducted in fall of 1999. During the course of the project, we learned that our wetland classification area was scheduled to be flown in fall 2007. There were a number of advantages to be gained in waiting for this more contemporary imagery to become available. In particular, our previous wetland classification work showed that the age of the photographs relative to the present was a significant factor in misclassification, particularly in shrub-dominated wetlands, which were often dominated by herbaceous species at the time the photos were taken. In addition, the area has undergone considerable development in that eight year interval. For these reasons, we requested and received an extension of the project to digitize wetlands based on the new photography.

The initial new images were delivered in late winter 2007. These images were significantly larger than those used in our previous wetland classification work, consisting of 14.3 k by 14.3 k pixel photos, with a pixel resolution of about 0.5 m^2. The effective resolution of the image is 1:31,680. Each photo covers an area approximately 5,400 hectares (13,400 acres) or about 7.4 km on a side. This new format had advantages and disadvantages: the digital files were extremely large (up to 436MB in TIF format) and consequently cumbersome to manipulate. The resolution, however, was far better than any imagery we had used previously and ideal for on-screen digitizing. The mosaicing of the photos resulted in fewer 'edge' issues.

In total, seven images were used to cover the study area (Figure 2):

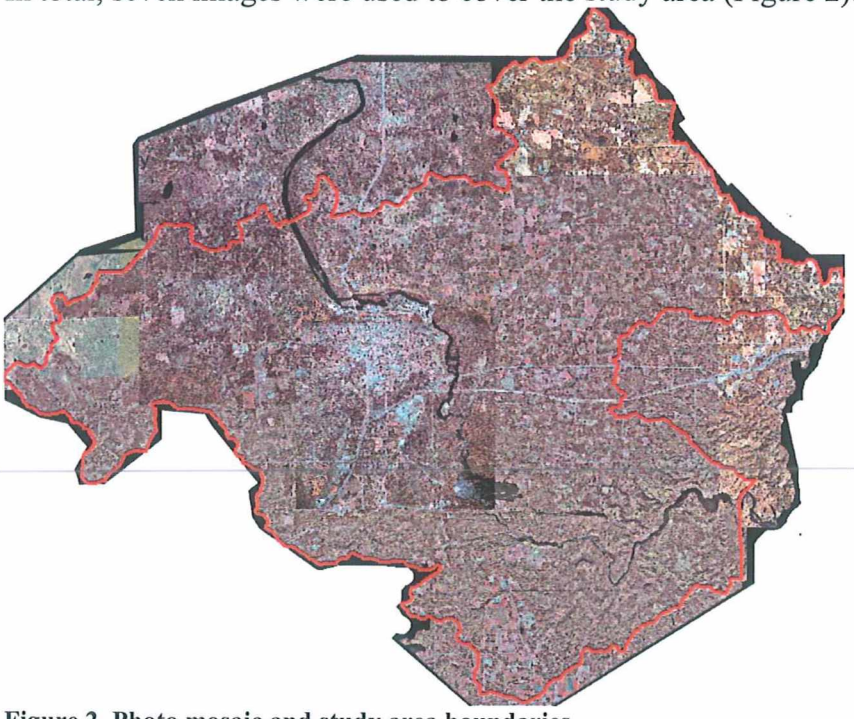

Figure 2. Photo mosaic and study area boundaries.

Task 2 - Classification of wetlands by Cowardin National Wetland Inventory classes

Images were interpreted on screen using "heads-up" digitizing in ArcGIS. This approach allows convenient toggling of ancilliary data layers to ensure accuracy. Ancillary layers included DOQs, digital raster graphics (DRGs), the previous NWI classification, leaf-on FSA photographs, and others. Wetlands were classified and coded according Cowardin et al (1979); the classification scheme is presented in the Appendix.

The revised classification showed a 4% decrease in the numbers of individually-delineated wetlands (3164, down from 3289). The total area in mapped wetland classes, however, decreased substantially - 27% - from 7458 ha to 5472 ha (Table 1; Figure 3).

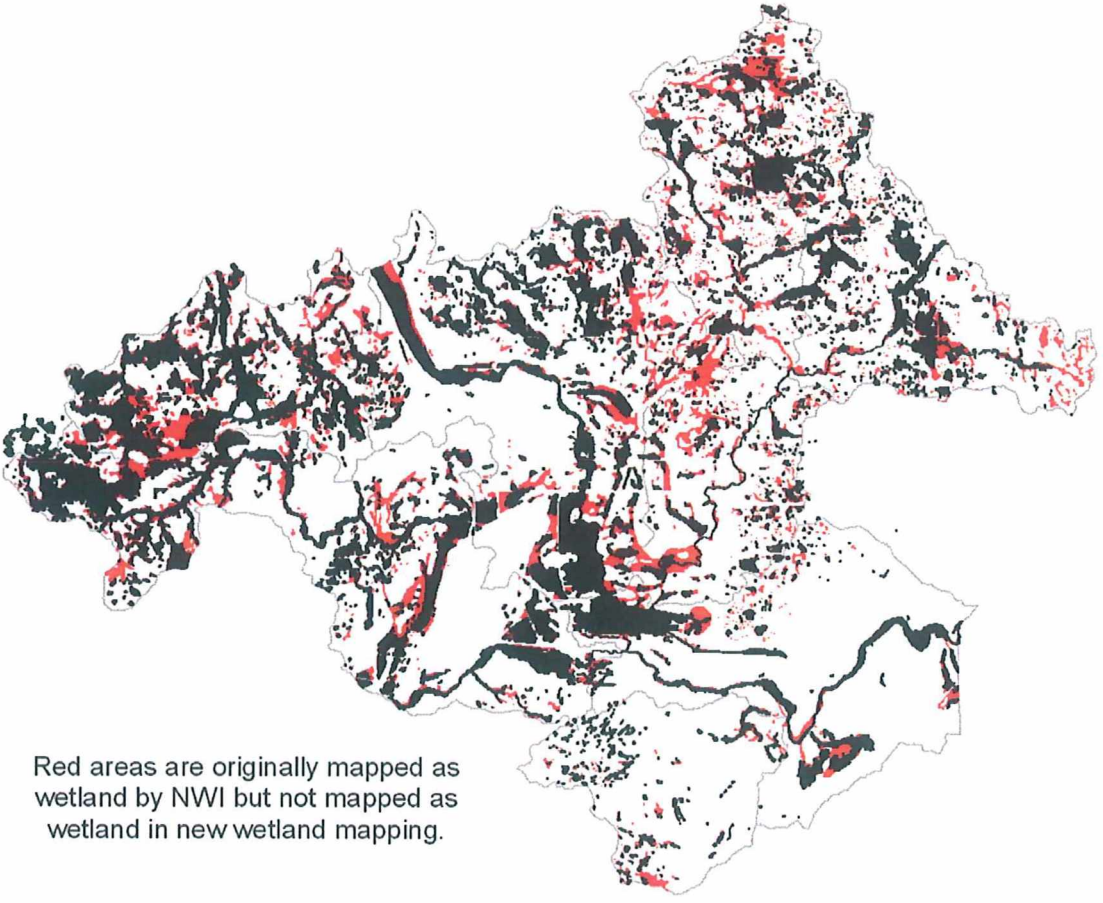

Figure 3. Comparison of original NWI and new wetland map.

While the total area of wetland has certainly changed since the NWI for this area was created, the large decreases in wetland shown in the new inventory do not necessarily reflect actual wetland loss, but differences in mapping accuracy. Much of this difference is due to the use of much higher resolution imagery, as shown in Figure 4. Large areas of the landscape were categorized as wetland in the NWI due to the inability of the classifier to see key wetland details given the scale and resolution of the original photos used.

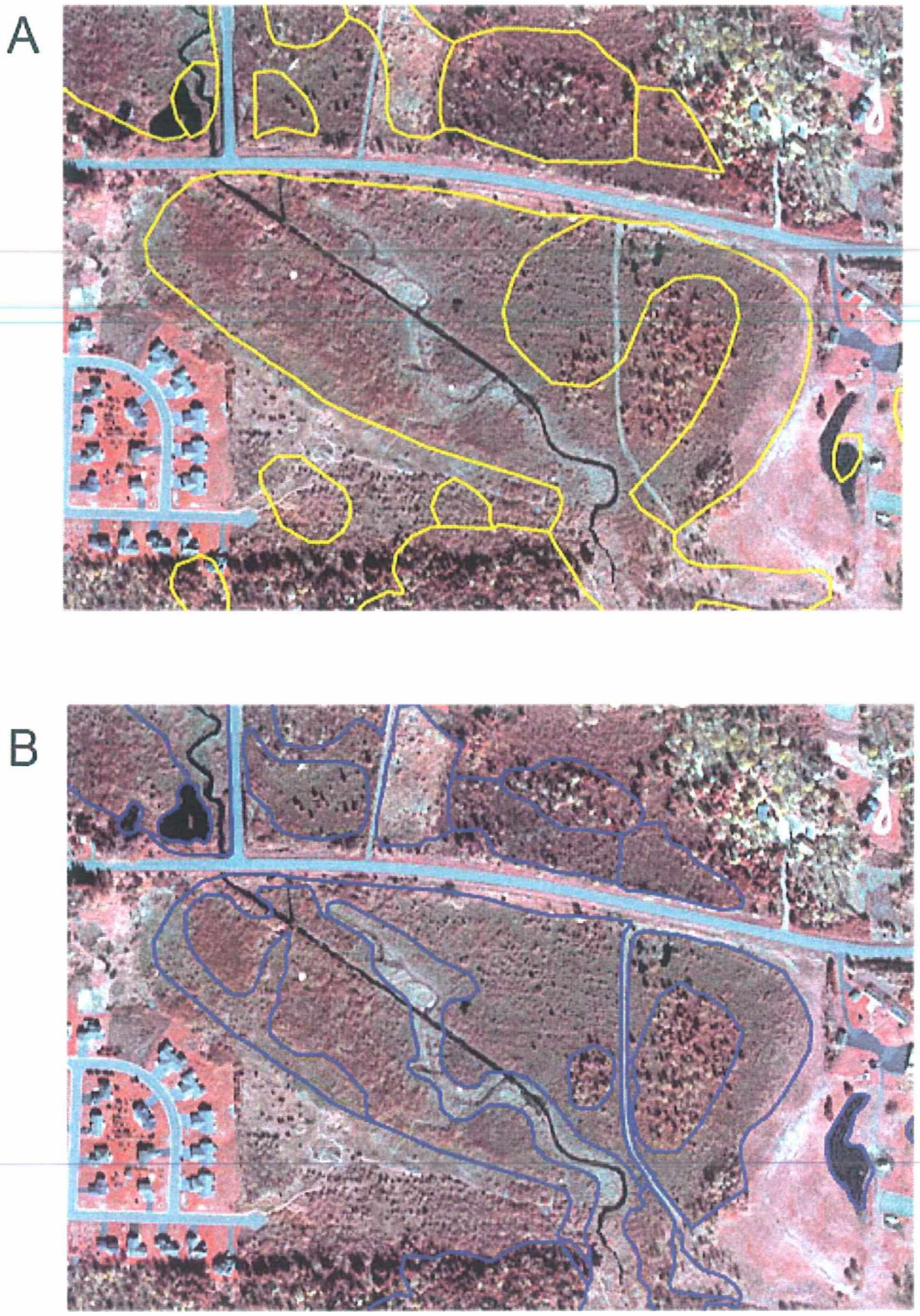

Figure 4. Comparison of wetland mapping; A) National Wetland Inventory, B) Updated Wetland Map

Table 1. Number, area and percent change in wetlands between original National Wetland Inventory polygons and newly delineated wetlands.

	Number of Wetlands			Wetland Area (ha)		
Wetland Class	NWI	New	% Change	NWI	New	% Change
Emergent	520	393	-24	481	448	-7
Forested	1133	963	-15	3455	1853	-46
Scrub-Shrub	1480	1286	-13	2886	2461	-15
Unconsolidated Bottom	156	522	335	636	710	12
Total	3289	3164	-4	7458	5472	-27

A second significant difference between the NWI and the present mapping effort related to mapping across roads. In the new classification, individual roads now bisect wetland polygons on each side of the road. The area occupied by roads, especially main arterials like the I-35 corridor, can be significant. Figure 5 illustrates how the original NWI mapped across roads, whereas the new inventory treats these as separate polygons.

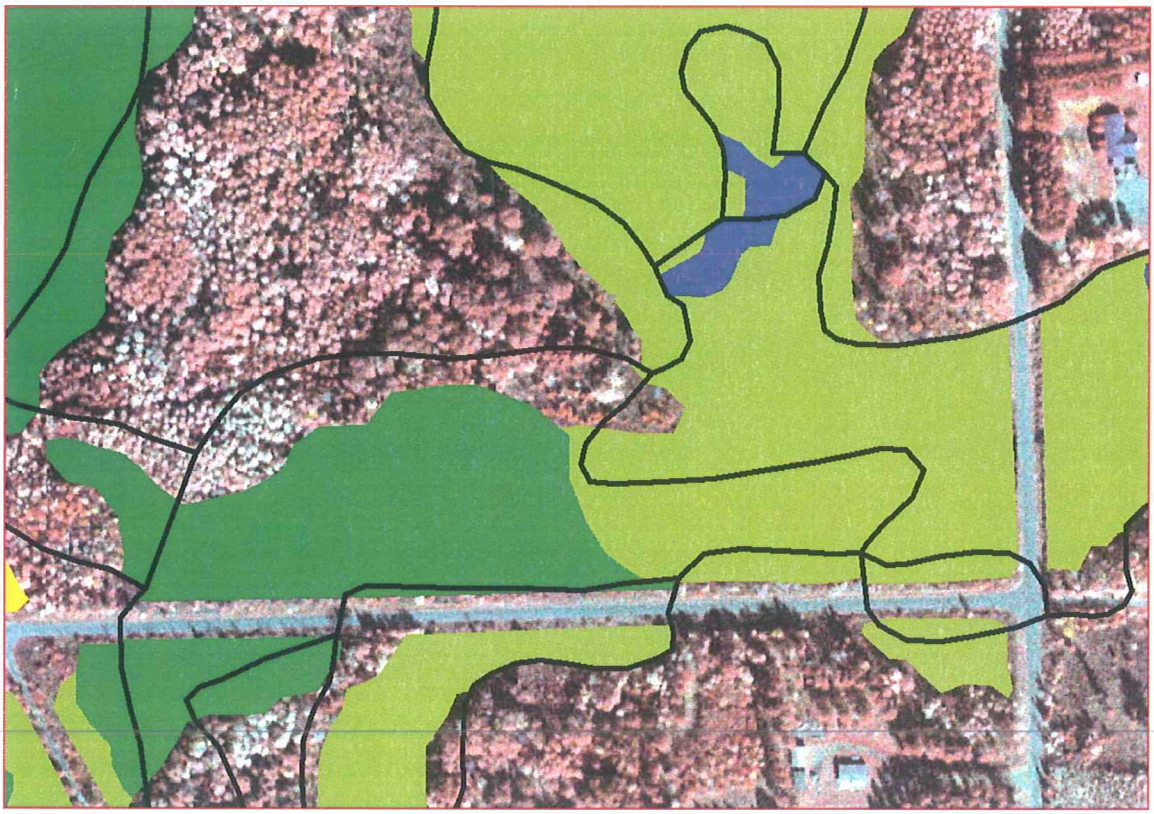

Figure 5. Comparison of NWI (linework) and newly delineated wetlands (light and dark green polygons), showing how road areas excluded from new classification.

There were also changes in the relative proportions of wetland classes. Forested wetlands decrease from 46 to 34%, and Shrub-scrub wetland increased from 39 to 45%. The Unconsolidated Bottom type increased from 8 to 13%, and the proportion of Emergent vegetation remained low and relatively unchanged (6% NWI, 8% New classes).

Accuracy assessment

Field evaluations of wetland polygons were conducted in fall 2008. Fifty sites were visited and classified in the field using standard wetland keys; the numbers of sites per class were proportional to their relative abundance. Field classified sites were compared with the image-based classification.

We obtained a classification accuracy of 87 percent with regard to wetland type (CLASS) and subclass (SUB1 and SUB2). The use of contemporary photography proved effective in determining both class and subclass, and avoided errors in previous classifications caused by differences in the acquisition date relative to the date of field evaluation.

Table 2. Error matrix and percent errors for field evaluation of classified wetland types.

	Field sites (# of wetlands)				
Classified as...	Emergent	Forested	Scrub-Shrub	Unconsolidated Bottom	TOTAL
Emergent	4	0	1	0	5
Forested	0	15	3	0	18
Scrub-Shrub	1	3	22	0	26
Unconsolidated Bottom	0	0	0	1	1
					50

	Field sites (%)			
Classified as...	Emergent	Forested	Scrub-Shrub	Unconsolidated Bottom
Emergent	80	0	20	0
Forested	0	83	17	0
Scrub-Shrub	4	12	85	0
Unconsolidated Bottom	0	0	0	100

Water Regime (WREG) had a higher misclassification rate: 70 percent of the field checked polygons were accurately classified while the remaining wetlands were evenly split between too wet or too dry. Approximately 15 percent of the visited polygons were given a WREG of "B" (saturated) while a field check showed these were actually "C" (seasonally flooded). Conversely, the other 15 percent were found to be more dry (classified as "C" – actually "A" or "B"). There were a few instances (5%) where the wetland was much wetter (flooded) than determined from the air photo, most likely a result of the area's recent high rainfall. In general, based on high resolution digital photos, the wetland subclasses have relatively high classification accuracy, while the moisture regime is sensitive to the antecedent moisture conditions prior to the photo dates, and should be interpreted more carefully.

Digital photos of representative wetlands were taken at the field sites; these are included on the data disk.

Citation

Cowardin, L.M, V. Carter, F. C. Golet and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. US Dept of Interior Fish and Wildlife Service FWS/OBS-79/31. 47 p.

Task 3 - Delivery of data through electronic media and web-based sources

The enclosed DVD contains the following data for the Cloquet area wetlands

Directory Listing

\Carlton_Area_Imagery - DNR photos used for project
\field_check_photos - digital camera field photos
\GIS_files - GIS data in various formats
\Metadata – FGDC-compliant metadata
\reports – copy of final report and graphics

Web Postings

The wetland shapefiles and metadata have been posted on the CoastalGIS web site:
http://www.nrri.umn.edu/coastalgis/coastalwetlands/coastalwetlands.htm

The Internet Map Server (IMS) data is located at:
http://gisdata.nrri.umn.edu/nrgis_interactive_maps.htm

Appendix A. COWARDIN WETLANDS AND DEEPWATER HABITATS CLASSIFICATION (Cowardin et al 1979)

```
SYSTEM                SUBSYSTEM         CLASS                        SUBCLASS

                                      |- RB=Rock Bottom
1=Bedrock
                                      |                              2=Rubble
                                      |
                                      |- UB=Unconsolidated Bottom
1=Cobble-Gravel
                                      |                              2=Sand
                   |--1=TIDAL--------|                              3=Mud
                   |                  |
4=Organic
                   |                  |
                   |                  |-*SB=Streambed
1=Bedrock
                   |                  |                              2=Rubble
                   |                  |
3=Cobble-Gravel
                   |--2=LOWER         |                              4=Sand
                   |    PERENNIAL----|                              5=Mud
                   |                  |
6=Organic
                   |                  |
7=Vegetated
                   |                  |
                   |                  |- AB=Aquatic Bed              1=Algal
R=RIVERINE------|--3=UPPER         |
2=Aquatic Moss
                   |    PERENNIAL----|                              3=Rooted
Vascular
                   |                  |
4=Floating
                   |                  |
Vascular
                   |                  |
5=Unknown
                   |                  |
Submergent
                   |--4=INTERMITTENT-|
6=Unknown Surface
                   |                  |
                   |                  |- RS=Rocky Shore
1=Bedrock
                   |                  |                              2=Rubble
                   |                  |
                   |                  |- US=Unconsolidated Shore
1=Cobble-Gravel
                   |--5=UNKNOWN       |                              2=Sand
                   |    PERENNIAL----|                              3=Mud
                      (used on older |
4=Organic
                       maps)          |
5=Vegetated
```

```
                                    |
                                    |-**EM=Emergent
2=Nonpersistent
                                    |
                                    |- OW=Open Water/Unknown Bottom (used
on older
                                    |
maps)
                                    |-*STREAMBED is limited to TIDAL and
                                    | INTERMITTENT SUBSYSTEMS, and
comprises
                                    | the only CLASS in the INTERMITTENT
SUBSYSTEM.
                                    |
                                    |-**EMERGENT is limited to TIDAL and
LOWER
                                    | PERENNIAL SUBSYSTEMS.


SYSTEM              SUBSYSTEM         CLASS                       SUBCLASS

                                    |- RB=Rock Bottom
1=Bedrock
                                    |                             2=Rubble
                                    |
                                    |- UB=Unconsolidated Bottom
1=Cobble-Gravel
                                    |                             2=Sand
                                    |                             3=Mud
                                    |
4=Organic
                                    |
                |-- 1=LIMNETIC----|- AB=Aquatic Bed             1=Algal
                |                   |
2=Aquatic Moss
                |                   |                             3=Rooted
Vascular
                |                   |
4=Floating
                |                   |
Vascular
                |                   |
5=Unknown
                |                   |
Submergent
                |                   |
6=Unknown Surface
                |                   |
                |                   |- OW=Open Water/Unknown Bottom (used
on older
                |
maps)
L=LACUSTRINE----|
                |
                |
```

```
                  |                   |- RB=Rock Bottom
1=Bedrock
                  |                   |                              2=Rubble
                  |                   |
                  |                   |- UB=Unconsolidated Bottom
1=Cobble-Gravel
                  |                   |                              2=Sand
                  |                   |                              3=Mud
                  |                   |
4=Organic
                  |                   |
                  |                   |- AB=Aquatic Bed              1=Algal
                  |                   |
2=Aquatic Moss
                  |                   |                              3=Rooted
Vascular
                  |                   |
4=Floating
                  |-- 2=LITTORAL----|
Vascular
                                      |
5=Unknown
                                      |
Submergent
                                      |
6=Unknown Surface
                                      |
                                      |- RS=Rocky Shore
1=Bedrock
                                      |                              2=Rubble
                                      |
                                      |- US=Unconsolidated Shore
1=Cobble-Gravel
                                      |                              2=Sand
                                      |                              3=Mud
                                      |
4=Organic
                                      |
5=Vegetated
                                      |
                                      |- EM=Emergent
2=Nonpersistent
                                      |
                                      |- OW=Open Water/Unknown Bottom (used
on older

maps)


SYSTEM              SUBSYSTEM         CLASS                          SUBCLASS

                                      |- RB=Rock Bottom
1=Bedrock
                                      |                              2=Rubble
                                      |
```

```
                                        |- UB=Unconsolidated Bottom
1=Cobble-Gravel
                                        |                              2=Sand
                                        |                              3=Mud
                                        |
4=Organic
                                        |
                                        |- AB=Aquatic Bed              1=Algal
                                        |
2=Aquatic Moss
                                        |                              3=Rooted
Vascular
                                        |
4=Floating
                                        |
Vascular
                                        |
5=Unknown
                                        |
Submergent
                                        |
6=Unknown Surface
                                        |
                                        |- US=Unconsolidated Shore
1=Cobble-Gravel
                                        |                              2=Sand
                                        |                              3=Mud
                                        |
4=Organic
                                        |
5=Vegetated
                                        |
                                        |- ML=Moss-Lichen              1=Moss
                                        |                              2=Lichen
                                        |
P=PALUSTRINE----------------------------|- EM=Emergent
1=Persistent
                                        |
2=Nonpersistent
                                        |
                                        |- SS=Scrub-Shrub              1=Broad-
Leaved
                                        |
Deciduous
                                        |
2=Needle-Leaved
                                        |
Deciduous
                                        |                              3=Broad-
Leaved
                                        |
Evergreen
                                        |
4=Needle-Leaved
                                        |
Evergreen
                                        |                              5=Dead
```

```
                                        |
6=Indeterminate
                                        |
Deciduous
                                        |
7=Indeterminate
                                        |
Evergreen
                                        |
                                        |- FO=Forested                1=Broad-
Leaved
                                        |
Deciduous
                                        |
2=Needle-Leaved
                                        |
Deciduous
                                        |                           3=Broad-
Leaved
                                        |
Evergreen
                                        |
4=Needle-Leaved
                                        |
Evergreen
                                        |                           5=Dead
                                        |
6=Indeterminate
                                        |
Deciduous
                                        |
7=Indeterminate
                                        |
Evergreen
                                        |
                                        |- OW=Open Water/Unknown Bottom (used
on older
maps)


                                        MODIFIERS

                                        |- A=Temporarily Flooded
                                        |- B=Saturated
                                        |- C=Seasonally Flooded
                                        |- D=Seasonally Flooded/Well Drained
                                        |- E=Seasonally Flooded/Saturated
                                        |- F=Semipermanently Flooded
                |--Non-Tidal------      |- G=Intermittently Exposed
                |                       |- H=Permanently Flooded
                |                       |- J=Intermittently Flooded
                |                       |- K=Artificially Flooded
                |                       |- W=Intermittently Flooded/Temporary
(used on
```

```
                  |                  |
older maps)
                  |                  |- Y=Saturated/Semipermanent/Seasonal
(used on
                  |                  |
older maps)
                  |                  |- Z=Intermittently Exposed/Permanent
(used on
                  |                  |
older maps)
WATER REGIME----  |                  |- U=Unknown
                  |
                  |
                  |
                  |
                  |                  |- K=Artificially Flooded
                  |                  |- L=Subtidal
                  |                  |- M=Irregularly Exposed
                  |                  |- N=Regularly Flooded
                  |--Tidal----------|- P=Irregularly Flooded
                                     |-*S=Temporary-Tidal
                                     |-*R=Seasonal-Tidal
                                     |-*T=Semipermanent-Tidal
                                     |-*V=Permanent-Tidal
                                     |- U=Unknown
                                     |
                                     |-*These water regimes are only used
in
                                     |  tidally influenced, freshwater
systems.


                                     |- 1=Hyperhaline
                                     |- 2=Euhaline
                  |--Coastal         |- 3=Mixohaline (Brackish)
                  |  Halinity-------|- 4-Polyhaline
                  |                  |- 5=Mesohaline
                  |                  |- 6=Oligohaline
                  |                  |- 0=Fresh
                  |
                  |
                  |
WATER CHEMISTRY-  |
                  |                  |- 7=Hypersaline
                  |--Inland          |- 8=Eusaline
                  |  Salinity-------|- 9=Mixosaline
                  |                  |- 0=Fresh
                  |
                  |
                  |
                  |
                  |--pH Modifiers    |- a=Acid
                     for all         |- t=Circumneutral
                     Fresh Water----|- i=Alkaline
```

```
SOIL-----------------------------|- g=Organic
                                 |- n=Mineral



                                 |- b=Beaver
                                 |- d=Partially Drained/Ditched
SPECIAL MODIFIERS----------------|- f=Farmed
                                 |- h=Diked/Impounded
                                 |- r=Artificial Substrate
                                 |- s=Spoil
                                 |- x=Excavated
```

U = Uplands