Updating the National Wetlands Inventory (NWI) for Ohio

FINAL REPORT

11/01/09

Submitted to:

Ohio Department of Natural Resources

Submitted by:

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Acknowledgements

Financial assistance for this project was provided by a consortium of Ohio agencies and organizations (ODNR Division of Wildlife, ODNR Information Technology, ODNR Office of Coastal Management, Ohio EPA, Ohio Department of Transportation, Lake Erie Commission, Cleveland Museum of Natural History, Cleveland Metroparks, Upper Mississippi River Great Lakes Joint Venture, and The Nature Conservancy). Additional funding was provided by a grant from the National Fish and Wildlife Foundation through the United States Environmental Protection Agency's Great lakes Grants Program, U.S. Fish and Wildlife Service's Great Lakes Coastal Program and Region 3, and Ducks Unlimited.

Ducks Unlimited would like to acknowledge the following for assisting with the field verification efforts: USDA Natural Resource Conservation Service, ODNR Division of Wildlife, ODNR Office of Coastal Management, Erie Soil and Water Conservation District, Susan Ford, and Jason Warren.

Disclaimer

This project was designed to develop an updated wetlands inventory for: 1) input into habitat models, and 2) planning and targeting habitat restoration and protection efforts. It was not designed, and should not be used, for wetland regulatory issues without proper field verification.

This project has been funded wholly or in part by public funds (federal, state, and local). The contents of this document do not necessarily reflect the views and policies of the federal, state or local agencies, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

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Chapter 1 – Project Summary

Overview

Historically, wetlands were seen as inhospitable and an encumbrance to humans. In the U.S., we have been extremely efficient at draining our wetlands and as a result have lost almost half of our wetlands. In some states, more than 90% of the wetlands no longer exist. We now realize that wetlands are an extremely important component to our ecosystem. A few of the benefits include: acting as a filter for cleaning water, providing flood control, providing habitat for over 300 fish and bird species, and acting as a carbon sink.

The U.S. Fish and Wildlife Service (FWS) is the principal Federal agency that provides wetland information to the public. Mapping wetlands is a key information component because it allows resource managers to develop management plans, assess impacts, develop habitat models, perform habitat surveys, and analyze trends. The FWS established the National Wetlands Inventory (NWI) in 1974 to provide resource managers with information on the location, extent, and types of wetlands.

The NWI for the Great Lakes was accomplished from the late 1970s to early 1980s. Updated the NWI for the Great Lakes is imperative for conservation planning and habitat modeling for many conservation organizations and natural resource agencies. However, with limited budgets, the FWS does not have the funding to accomplish the update. Therefore, a consortium of public and private organization is developing wetland mapping standards so that other groups performing wetlands mapping can standardize methods for inclusion into the NWI.

Ducks Unlimited (DU) is leading a consortium of partners in the Great Lakes to accomplish an updated NWI that can be used for multiple resource activities. DU is also working closely with the FWS to develop efficient methods for tracking wetland changes over multiple time periods. The goal of the NWI update for the Great Lakes is to provide a current wetlands data layer for habitat modeling and resource management, identify potential areas for wetland restoration activities, and to provide information on status and trends of wetlands.

Justification

Ducks Unlimited, Inc. (DU) and its partners have recently completed a research project in the Great Lakes for breeding mallards. The results of the research were used to develop a planning tool that allows resource managers to identify priority areas and acre goals for restoration, enhancement, and protection of habitat in order to reach the Upper Mississippi River – Great Lakes Joint Venture goals for breeding mallards. When implementing the habitat models and planning tool across the Great Lakes, the limiting data layer was the availability of current and consistent wetland information. This problem was recognized when comparing the 2001-2003 field information from the mallard study to the NWI data. A current wetlands layer was also the limiting data layer in another project on identifying all-bird conservation areas in the Western Lake Erie basin and the Saginaw Bay Watershed. Additionally, DU and its partners are currently working on a two-year research project on spring stopover sites for waterfowl and shorebirds – where wetland types play a vital role.

In light of the past experience and anticipated future use of the NWI data, DU completed a pilot project to update the NWI layer for part of Michigan with funding from the U.S Fish and Wildlife

Great Lakes Coastal Program and the Upper Mississippi River – Great Lakes Joint Venture. The pilot project was performed to test the methodology for updating the NWI utilizing on-screen digitizing and digital orthophotos over a large geographic area. The pilot project was successful and has led to engaging other organizations (due to limited FWS funding) in implementing the update for the Great Lakes. The need for this information is great and diverse as can be determined from the current list of cooperators involved in the project – from transportation to environmental to recreational.

Wetland Data

The primary source data for this project is the U.S. Fish and Wildlife Service's National Wetlands Inventory (NWI) which was accomplished using aerial photos from the late 1970s to 1980's (see Figure 1). The NWI does not exist for Wisconsin because the Wisconsin DNR was performing a wetland inventory at the same time. For Wisconsin, the Wisconsin Wetlands Inventory will be used for the update. For Ohio, some of the NWI is not in digital format and therefore needed to be scanned and rectified before the update could occur.

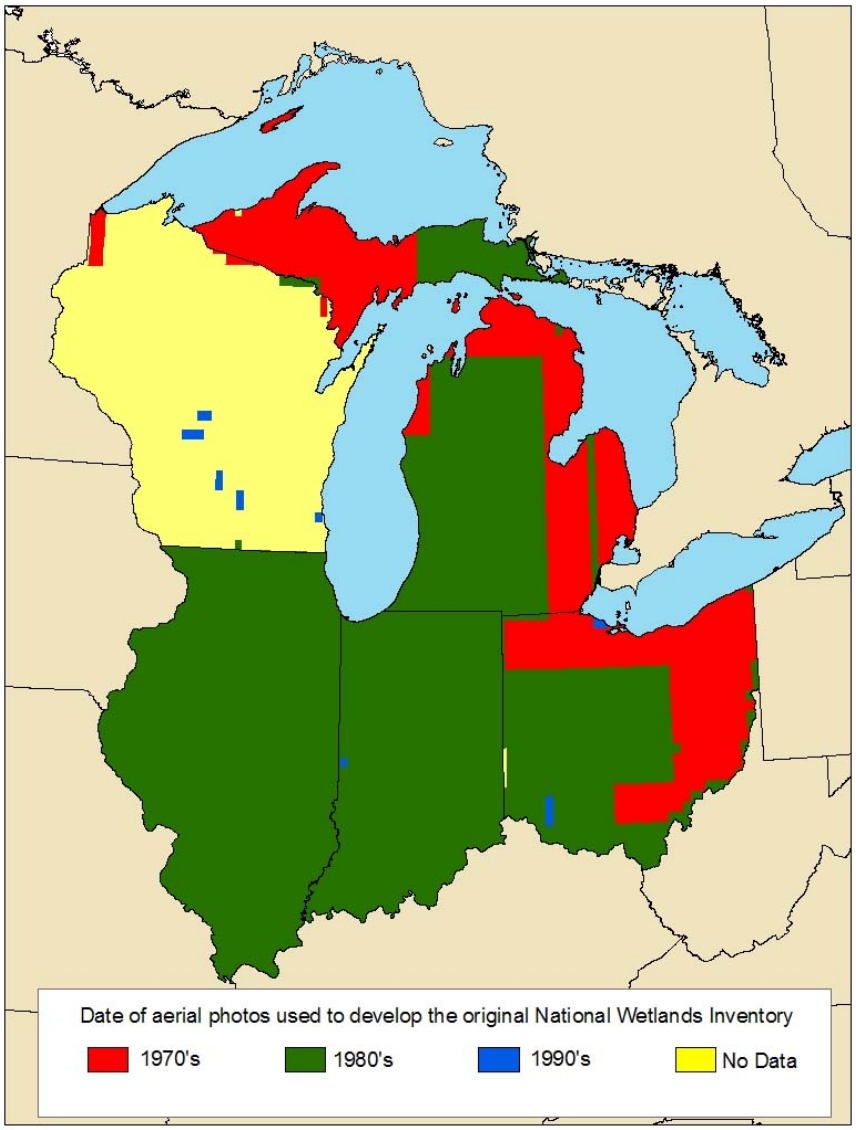


Figure 1. Dates of the aerial photos for the original NWI delineation

NWI Data

A seamless National Wetlands Inventory (NWI) data set is housed and administered by the United States Geological Survey (USGS) in a Master GeoDatabase (USGS MGD) for the FWS. This data set contains the most recent digital NWI data for the United States. When updated NWI data is delivered to the FWS, it is uploaded into the USGS MGD and the original NWI data is archived.

For the State of Ohio, there are 610 USGS 1:24,000 quads that are not in the USGS MGD because they are currently only available in hardcopy format. Most of the state of Wisconsin is also not in the USGS MGD. NWI data was not done for Wisconsin because the State of Wisconsin was already creating a wetlands layer – Wisconsin Wetlands Inventory (WWI). Complete coverage of Illinois, Indiana, and Michigan are currently in the USGS MGD.

Ducks Unlimited received from the USGS a DVD with an ArcSDE export (check out date: February 1, 2006) of the USGS MGD for the lower 48 States. This export was loaded into Ducks Unlimited's SDE database and clipped to the five state area using USGS 1:24,000 quads as the bounding area (referred to as DU MGD throughout the remainder of the document).

Ohio NWI Scans

The NWI data for much of Ohio is still in hardcopy format (Figure 1). Therefore, the additional step of creating the digital data is necessary before the update can occur. The FWS and Ohio Geological Survey has provided DU with the 1:24000 scanned mylar sheets of the hardcopy NWI data in raster format.

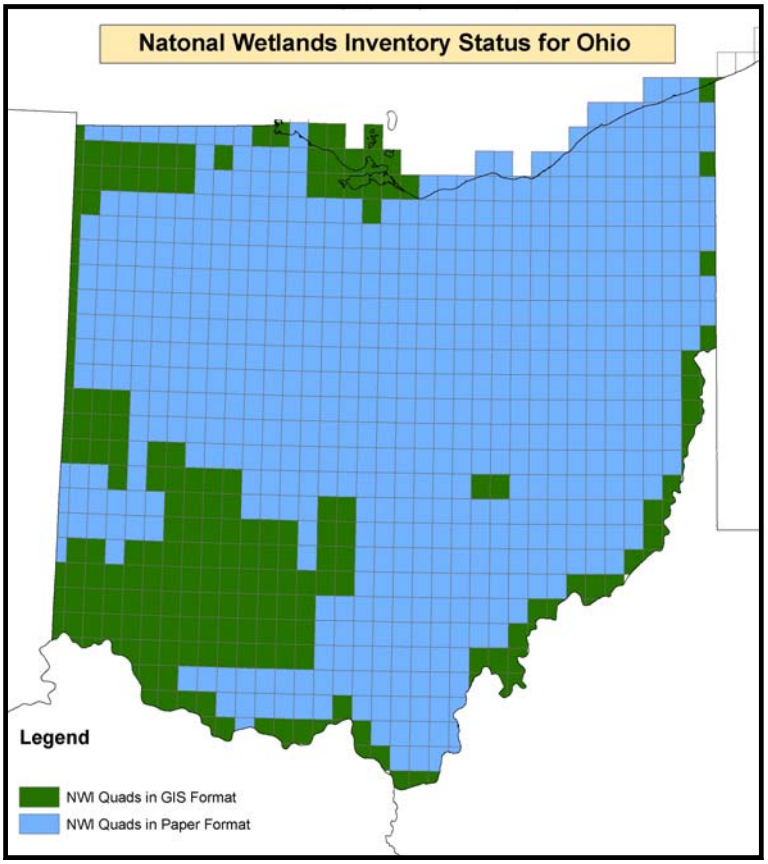


Figure 1. NWI status for Ohio.

Each of the 610 scanned NWI quads for Ohio was registered to USGS 1:24000 topographic maps in Albers Equal Area Projection using the four corners of the quad boundary. The rectification process also clipped the scanned image to the quad boundary, removing all the unnecessary text from the scanned quads. These rectified quads will then be merged into a seamless raster image for Ohio. The wetland polygons will then be digitized by viewing the registered, seamless, raster, NWI images over the digital orthophotos. Any spatial errors in the raster NWI images will be adjusted to the orthophotos. The NWI updating process will then occur using these original NWI polygons.

For the State of Ohio, there are 610 USGS 1:24,000 quads of NWI data that were never converted into a digital GIS layer. All but 14 of the 610 mylar hardcopy NWI quad maps were scanned by the FWS into TIFF format. The remaining 14 quads (Alvordton, Assumption, Berkey, College Corner, Fairhaven, Fayette, Lyons, Morenci, Nettle Lake, New Paris, Pioneer, Southeast Columbus, Sylvania, Whitewater) were scanned by the Ohio Geological Survey into TIFF format. DU has received all 610 scanned NWI quads for Ohio.

Much of Ohio does not have digital NWI data. However, the FWS has scanned the hardcopy mylar NWI maps. The first step was to register the scanned NWI maps so they could be overlaid with the orthophotography for the digitization process. The registration process used Erdas Imagine to register the scanned maps to Albers projection using the four corner tics of the scan and the UGSG 1:24k quad boundary. Note: the registration process will not be exact – so there will be positional errors on the rectified scanned NWI. These errors will be corrected when the wetlands are digitized and updated over the DOQQ imagery.

Folder structure

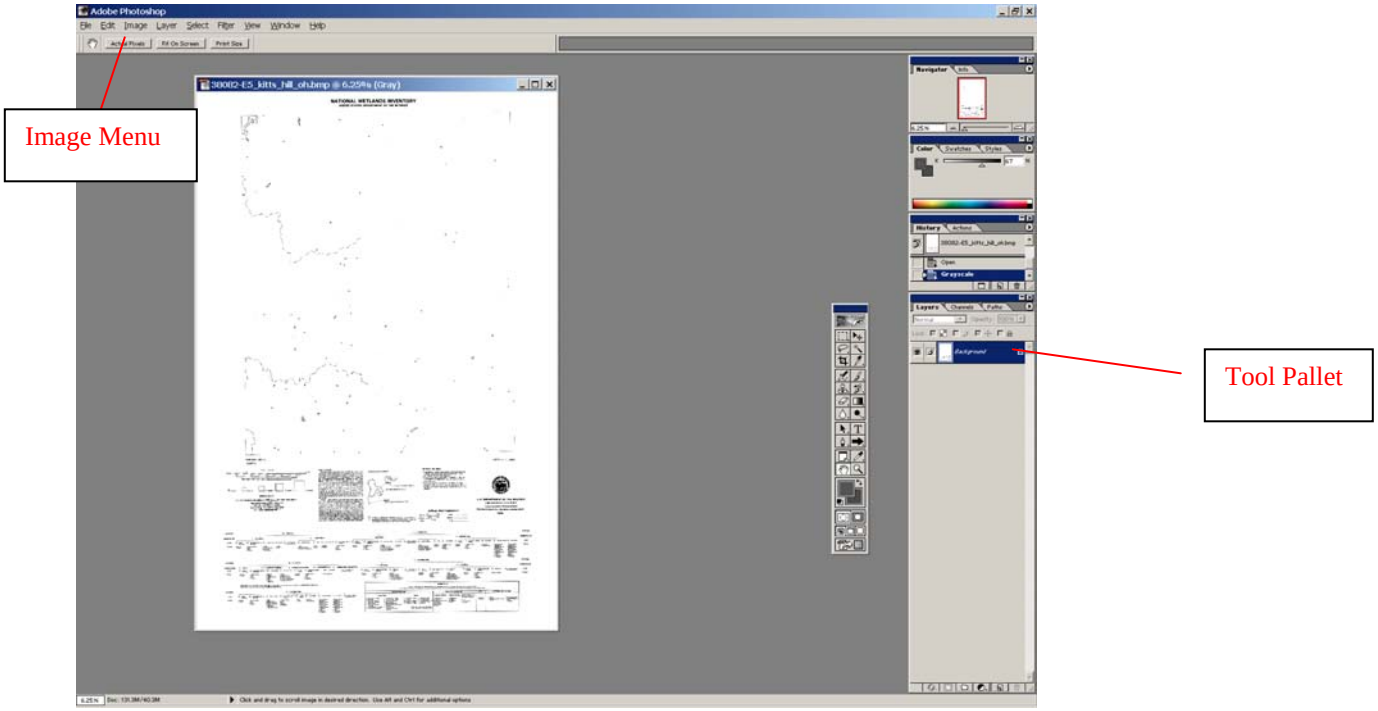
The main files for the project are located on the DU GLARO server under W:\OH_NWI. There are 3 folders;

- The original_files folder contains .zip files of the scans as they were and will be used as a backup.
- The nwi_rectfied_scans contains the scans in imagine format after the scan has been recified.
- The NWI_raster_scans folder are the working versions of the scanned hardcopy NWI maps. This folder contains 3 sub-folders; merged_scans_backup, Incl_Attributes and Separate_Attributes.

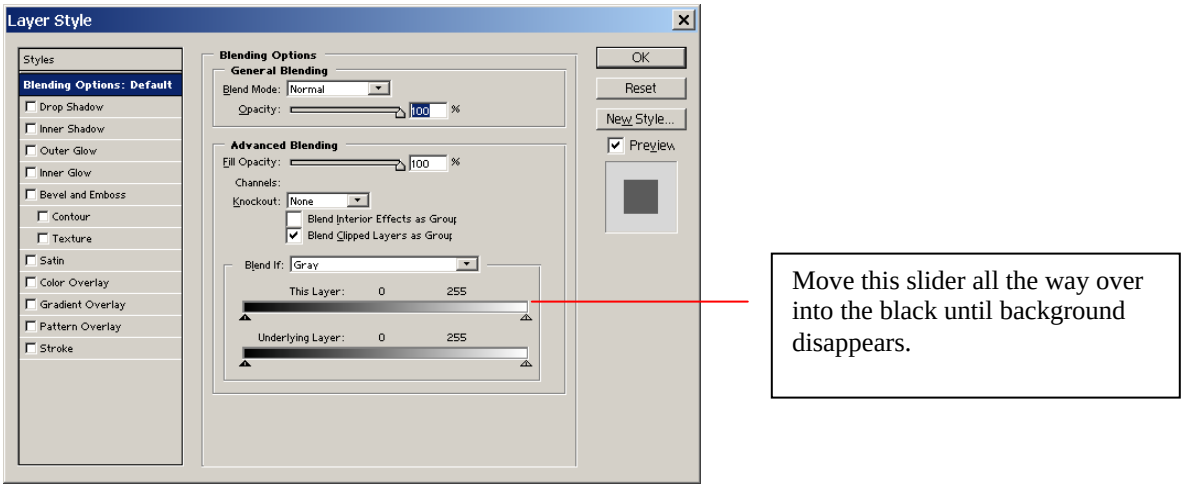
Scan preparation

Some of the NWI quads that were scanned by the US FWS were scanned into two separate files (one with the NWI polygon and line work and one with the attributes. The remaining NWI quads were scanned with both the NWI polygons, line work and attributes in one file. The first step was to combine the polygon bitmaps with the corresponding attribute bitmaps. The files in the Separate_Attributes folder are bitmaps with names like: 38082-E5_kitts_hill_oh.bmp and 38082-E5_kitts_hill_oh_att.bmp. The number (in this case 38082-E5) is the USGS 1:24k Quad number. The name (Kitts Hill) is the 24k quad name. For every quad there will be two separate files; the oh.bmp which are the scans of just the polygons and the oh_att.bmp which are the attributes.

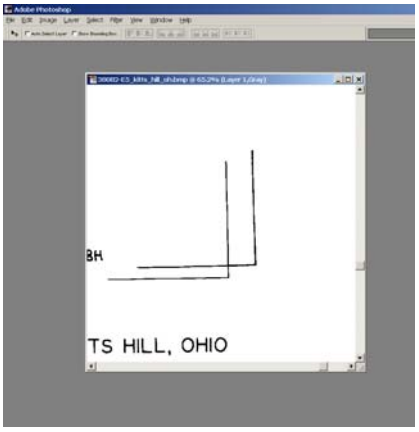
Open the oh.bmp in Adobe Photoshop. Click on the Image menu and select Mode and Grayscale (click ‘OK’ when the pop-up appears). In the layers pallet, double-click where is says background and hit ok when pop-up appears. It should now say layer 0 where background was, and the layer should be unlocked (the little padlock icon will be gone).



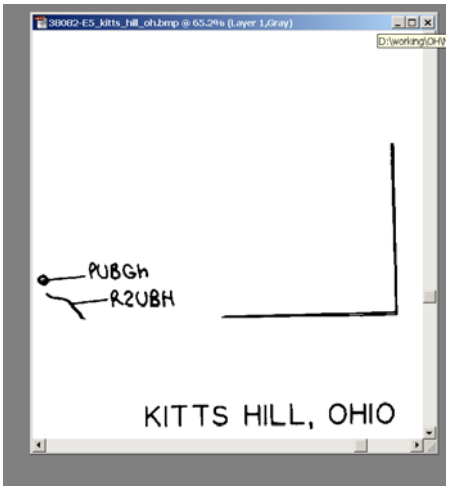
Leave the oh.bmp open and open the att.bmp. Repeat the process above for this image. The double-click where it says layer 0 in the tool pallet. A window will open with two sliders at the bottom. Move the top one of these two sliders all the way to the left (into the black) until background disappears. Then hit ok. It will look like the image is gone, but if you zoom in you will see it is still there.



Select the move tool from the toolbar, drag the att.bmp onto the oh.bmp.
Move the images until the corners are close (you will have to zoom in to see well).



The corners on the image look like this – disregard all the text at the bottom, that will be removed later.



Align the corners so they are very close.

When you align one corner, the other corners may be off. There are a few different tools in the Edit menu under Transform you can use. The rotate tool will let you freely rotate the layer, just move your cursor to the edge of the image and it should turn to the icon shown to the right then just drag slowly in the direction you want to rotate. Sometimes it takes a lot of processor to perform this function, so you may not be able to "preview" the move until you stop dragging it.

The other tool is the distort tool. Like the rotate tool you have to be at the edge of the image to use it. The cursor will turn from black to a speckled gray – then you can click and drag.
When you try to zoom or pan it will ask if you want to apply the transformation – click yes.
You will likely have to go from corner to corner adjusting the image. It does not have to be perfect, we only need to be able to tell which label is pointed to which feature.

Once the corners all seem to be lined up as good as they can, it doesn't hurt to pan around the image and see if the labels make sense where they point at features – again it doesn't have to be perfect, but just look for any glaring errors.

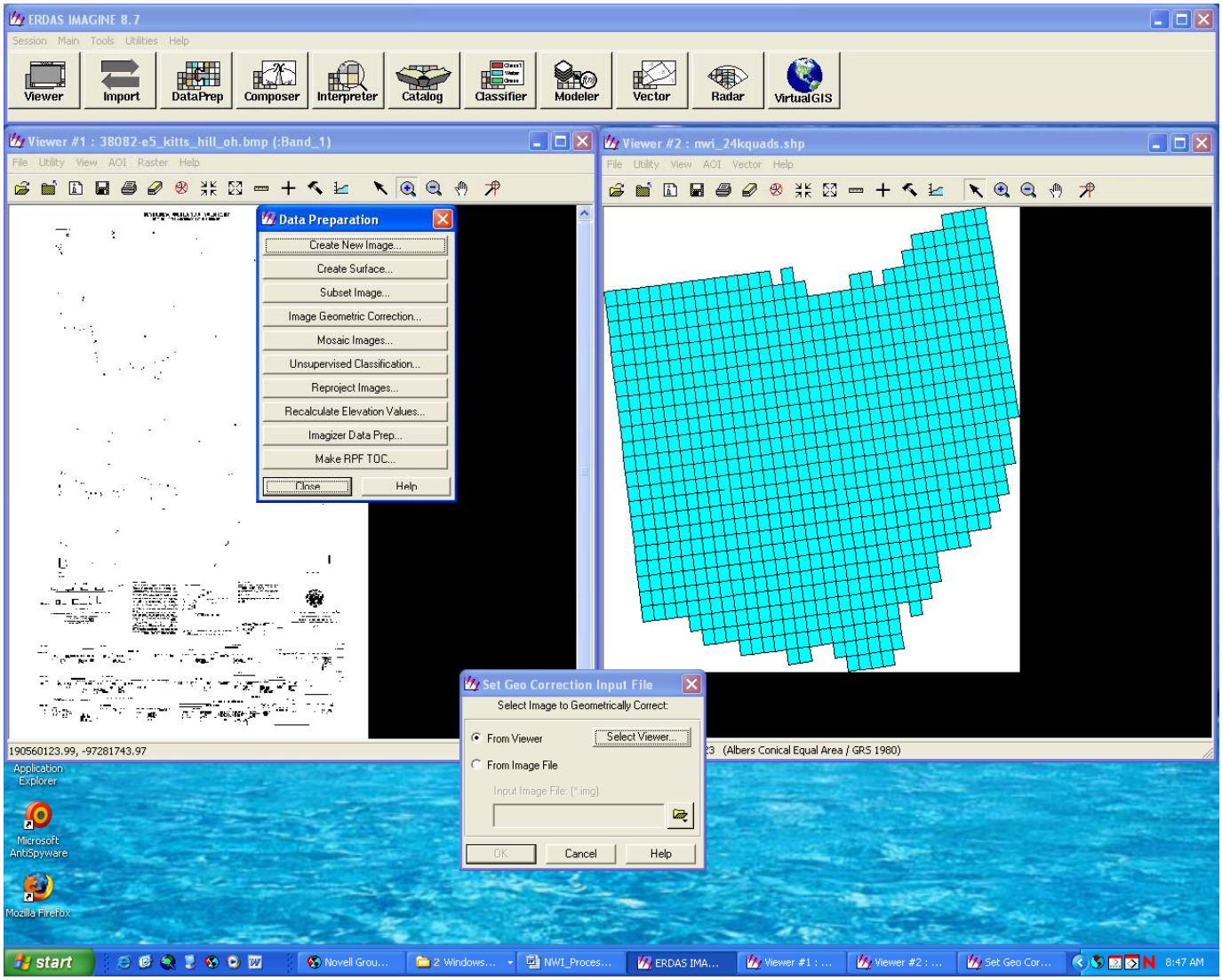
Now save the oh.bmp into the merged_scans_backup folder as a .tiff. This will make a backup of the image with the two separate layers if we need to go back to it later. If this file starts to take up too much room, burn the files to DVD and delete them from the hard drive.

Save the oh.bmp file again, this time into the Incl_Attributes folder as a .bmp. Reopen the file you just saved, click on the Image menu and select Mode and Grayscale (hit ok when pop-up appears).

In the layers pallet, double-click where is says background and hit ok when pop-up appears. At the bottom of the palette window there is a half white/half black circle. Click on that and select invert. This should turn the text white and the background black. Save this file over the existing bitmap. This will be our working version.
Now it is safe to delete the oh.bmp and att.bmp files for the finished quad from the Separate_Attributes folder.

Scan Rectification

In order to overlay the scanned NWI maps with the aerial photos in ArcMap, they must be given real world coordinates – or registered. To do this, open Imagine and two viewers and make them similar sizes and side by side. In the 1st viewer add the quad bitmap from the *Incl_Attributes* folder. In the 2nd viewer add the 24k quad shapefile.



From the Data Preparation menu, select Image Geometric Correction. Then make sure From Viewer is selected and click select viewer in the set input window and click in the 1st viewer (the bitmap). Select the Polynomial option from the set geometric model window. Then just drag the polynomial properties window out of the way.
Click on the GCP tool from the Geo Correction Toolbar (right).

Select Existing Viewer in the GCP Tool Reference window, hit ok and click inside the 2nd viewer (quads).

In the quad frame select Vector – attributes. Scroll through to find the quad you are interested in and select it. Close the attribute table and zoom in on the selected quad.

Zoom way in on the corner mark of the bitmap and the same corner of the quad shapefile. Select the GCP tool and place a point in the corner of the bitmap. The GCP tool should not go to point #2 until you create a point in the quad viewer – if it does select the GCP line 1 and then select the GCP tool again and drop a point in the corner of the quad shapefile. Repeat this process for all 4 corners (after the third set of points are placed, when the 4th is dropped in the bitmap side the corresponding point should appear in the quad viewer). Once all the corner points are in, zoom as far in as you can on each of the quad corners and adjust the points. Then hit the Window pane icon in the GCP Correction tools and save the file in the nwi_rectified_scans folder as the name of the quad.

Once the file is done exporting, it can be opened in ArcMap. Open the properties – symbology and select unique values. You can remove all the values except 255 – then change the color to red or something you can see. Zoom in on some polygons or rivers and load a fairly detailed 8m or less teraserver doqq to make sure the image lines up decent.

Mosaic and Modeling Process

After the rectification process we had all the quarter quads named and separate from each other. The next process we used was in Erdas Imagine. The mosaic tool was used to mosaic the separate quads into (21) specific areas. These areas contained roughly (32) quarter quads each. After each mosaic process the new area would then need to be cropped down to its extent using Erdas Imagines Modeling tool. The modeler allowed us to shrink the file size and to remove any extent that was not necessary. In the modeler unsigned 2-bit was used as the data typed used on all the modeling that was done. A inquire box was used to select what was needed to reduce the extent.

Once all (21) areas had been modeled the next step was then to combine those areas into larger areas. The same process was used once again. Each of the new areas (5 in total) was mosaic together and then the model tool was used to remove any unnecessary extent and to create a smaller file. We ended up with (5) separate areas that covered the Ohio area.

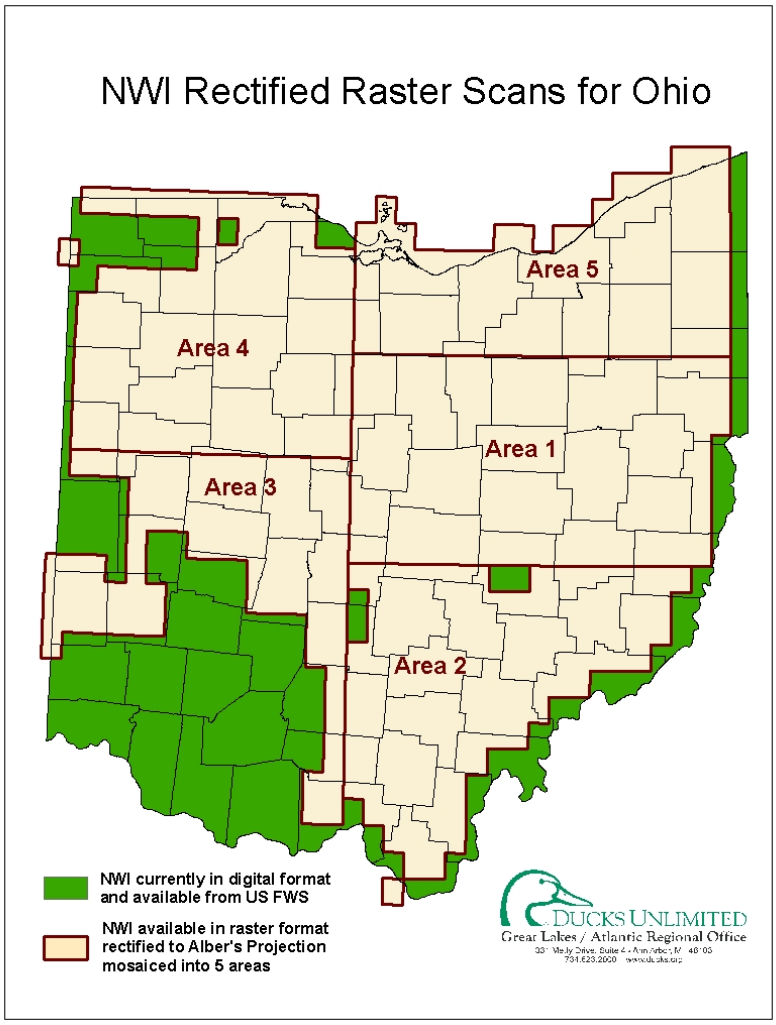


Figure 3: NWI Rectified Raster Scans for Ohio

Aerial Photos

Both spring and summer aerial photos will be used in the update process. The spring photos are best to identify the seasonal wetlands and forested wetlands and the summer photos are best to identify the emergent, aquatic, and farmed classes. The spring photos were typically acquired from state agencies that contracted the photo flights. The summer photos were acquired from the Farm Services Agency's National Agricultural Imagery Program (NAIP). Digital Elevation Models (DEM), hydric soils (from NRCS SSURGO data), and USGS Topographic maps may also be used when available to aid in the updating process. For more information on the data and contacts for each of the sections below, see Appendix B.

The Ohio NWI data will be updated and digitized using spring CIR photos from 2006 for the northern part of the state and 2007 for the southern part of the state as well as summer natural color photos from 2004 (NAIP). In addition, a high resolution Digital Elevation Models (DEM) will be available for the state to aid in the updating process.

Ancillary Data

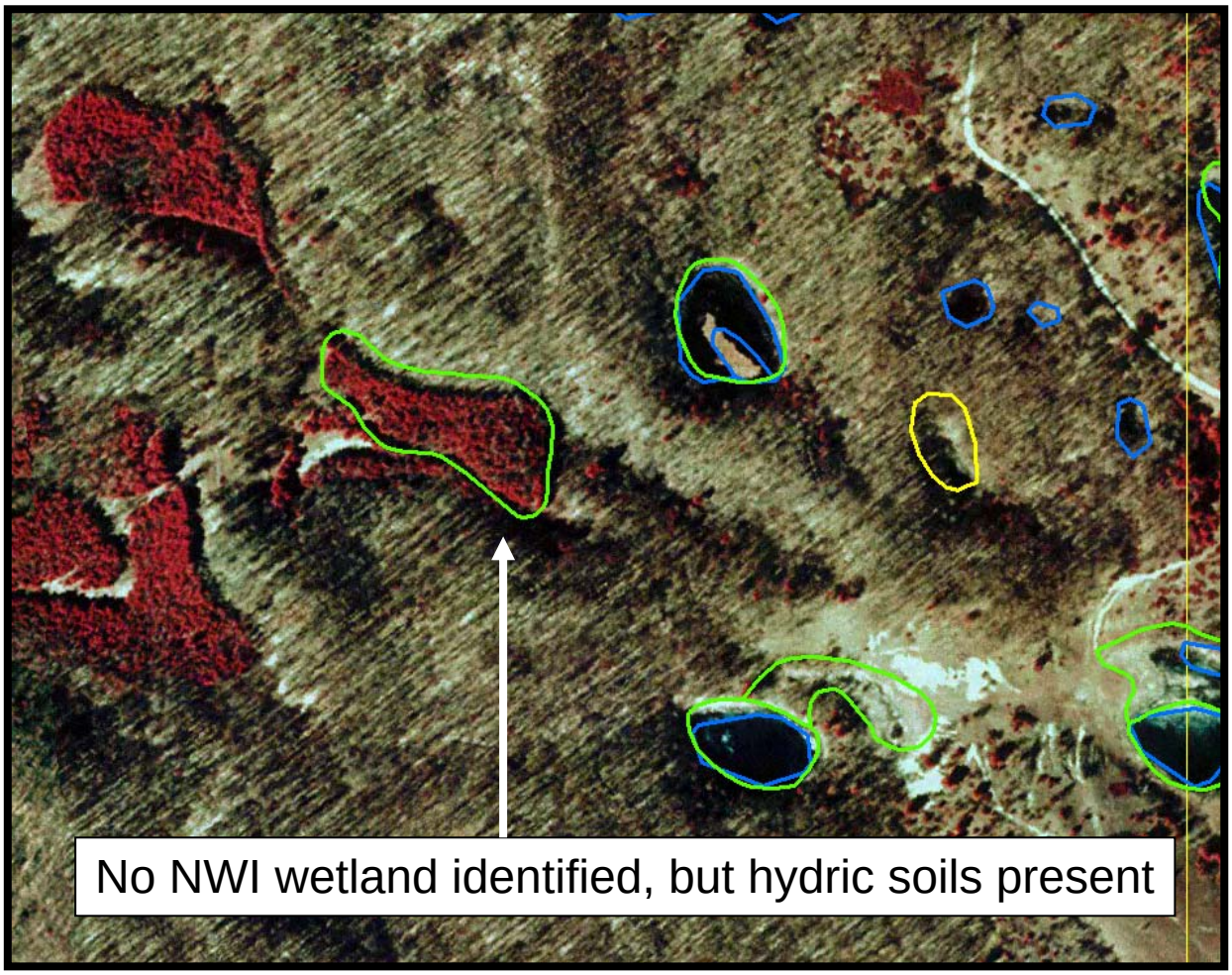
In cases where the wetland interpretation of the aerial photos is not clear, ancillary data can be useful in determining the existence and class of the wetland. Ancillary data sets include topographic maps, hydric soils, SSURGO Special features, and wetland restoration project sites.

USGS Topographic Maps

The digital raster topographic maps can be beneficial when identifying wetlands by looking at the contour lines (wetlands don't generally occur on slopes) and wetland symbols.

Hydric Soils

The Hydric soils attribute from the county level SSURGO soils can be beneficial when identifying wetlands because most wetlands are going to occur on hydric soils.



SSURGO Special Features

The SSURGO Special Features identifies special features (including wetlands) that are too small to map within the soil polygons. Much like the wetland symbols on the topographic maps, this layer can be useful identifying small wetland areas.

Wetland Restoration project sites

Ducks Unlimited has a point file for all of its wetland restoration projects. This layer can be helpful in identifying newly created wetlands and determining the wetland class.

Project Timeline

The agreement was signed between the Ohio Department of Natural Resources and Ducks Unlimited on September 13, 2006. The project completion date is June 30, 2009 with the final report due on November 1, 2009.

Project Budget

The total cost to update the National Wetlands Inventory for the state of Ohio was $339,920. Ducks Unlimited received a grant for $275,420 from the Ohio Department of Natural Resources (Ohio Consortium), for $12,500 the National Fish and Wildlife Foundation (via US EPA Great Lakes Program), and $52,000 from the U.S. Fish and Wildlife Service.

Chapter 2 – System Architecture

NWI Master Geodatabase

The USGS administers a seamless version of the NWI as part of the National Map in an ArcSDE master geodatabase for the FWS. The NWI master geodatabase is in Albers Equal Area projection. All updates will conform to this projection system. DU received an export of the NWI MGD from the USGS and imported the geodatabase into DU's MGD. The exported NWI geodatabase included all the available digital NWI data for the lower 48 states. This database was subset to all the USGS 1:24000 quads that intersect DU's Great Lakes/Atlantic Region. This project will follow the guidelines in the "Wetlands MGD Check-out Instructions" as developed by the FWS and USGS.

Database Setup

The National Wetlands Inventory (NWI) data is stored within a single database at Ducks Unlimited's Great Lakes/Atlantic Regional Office. The database, entitled 'vector,' was created using ESRI ArcSDE 9.1 SP1 and Microsoft SQL Server 8.0 software and resides on DU's GLARO network on the glaro_sde server.

The first steps performed upon configuration of the database server and data drives were to install the database software, create the geographic data repository, and configure backups. Specific steps are outlined below:

Software Installation

1. Microsoft SQL Server 8.0 was installed using Windows authentication. Tempdb is located on the F:\ drive.
2. ESRI ArcSDE was installed.

Database Creation

3. In SQL Server Enterprise Manager, a new database named 'vector' was created to hold vector datasets used at GLARO. The default Primary file location of G:\MSSQL\Data was accepted. The location of the transaction log was changed to E:\ in order to separate it from the datafile drive.
4. Three filegroups were created. The SDE filegroup was made to contain the database's SDE system files. The NWI filegroup was made to contain the NWI data. Finally, the TOPO filegroup was created to hold the topological data associated with the NWI data. A single data file was created for each in G:\MSSQL\Data.
5. Three separate database roles were created. The *dataowner* role was created for data ownership. The *dataeditor* role was created to allow edits to the data. Lastly, the *databrowsers* role was created to permit simple data viewing.
6. The ESRI ArcSDE post-installation software was run to create the SDE repository, to authenticate the software, and to create a service.
7. Finally, the *dbtune.sde* file was edited to reflect the filegroup specifications outlined above.

Database Object Creation

Feature Class Creation

The U.S. Fish and Wildlife Service (FWS) delivered to Ducks Unlimited its NWI data as an SDE export file (*wet_poly_feb_1_2006*) containing all wetlands within the United States. To better manage this data in the context of this project, wetlands outside Ducks Unlimited's Great Lakes/Atlantic Region Office region were deleted and new fields were added to record the update process. This was done by importing the entire dataset, creating a duplicate shell schema with no data, and appending desired data into the shell. The creation of a new feature class with these new fields is outlined below:

1. The sdeexport file was imported using the following command:

   sdeimport -o create -l c_wet_poly_feb_1_06,shape -f \c_wet_poly_feb_1_06.000 -k nwi -i vector_sde -u glarogis -p ********

2. The sdeexport file schema was exported by specifying a where clause condition that is not met by any data. The following command was executed with the indicated results:

   C:\arcgis\ArcSDE\sqlexe\bin>sdeexport -l c_wet_poly_feb_1_06,shape -a all -f

   C:\arcgis\ArcSDE\sqlexe\sdeexports\wet_poly_schema.sdx -w "ATTRIBUTE = 'xxx'" -i vector_sde -u glarogis -p ********

   ```
   ArcSDE 9.0 SQL Server Build 1926 Fri Mar 19 13:29:17 PST 2004
   SDEX File Export Administration Utility
   -----------------------------------------------------
   Exporting ArcSDE object to "C:\wet_poly_schema.sdx" in SDEX 9.0 export format ...
   Exporting table "c_wet_poly_feb_1_06".
   Spatial column "SHAPE"
   No matching records found or table is empty.
   Only the table's schema information is exported.
   0 features converted.
   0 features exported.
   ```

3. The sdeexport file schema was imported into the vector database. The new feature class was created and named 'wet_poly.' The following command was executed with the following results:

   C:\arcgis\ArcSDE\sqlexe\bin>sdeimport -o create -l wet_poly,shape -f C:\arcgis\ArcSDE\sqlexe\sdeexports\wet_poly_schema.sdx -k nwi -i vector_sde -u glarogis -p ********

   ```
   ArcSDE 9.0 SQL Server Build 1926 Fri Mar 19 13:29:17 PST 2004
   SDEX File Import Administration Utility
   -----------------------------------------------------
   Importing SDEX from C:\arcgis\ArcSDE\sqlexe\sdeexports\wet_poly_schema.sdx ...
   Importing spatial column "shape"
   ```

0 record read.
0 record stored.

4. Features within the Ducks Unlimited's GLARO region were appended to the wet_poly feature class:
    a. Merged USGS 24k shapefile features in GLARO region with W:\GLARO\SDE_DATA\quad_areas.shp features that cover shoreline areas not in USGS coverage to create coverage of GLARO region. Output as W:\GLARO\SDE_DATA\quadareas_union.shp.
    b. Selected quad features by state.
    c. Selected c_wet_poly_feb_1_06 features that have their center in selected quad features.
    d. Using ArcToolbox Data Management Tools/General/Append, appended currently selected features to wet_poly.
    e. Cleared selected features.

5. Additional fields deemed necessary for the documentation of the update process were added to the feature class. The added fields are:

NWI_KEY	LONG INTEGER
STATUS	SHORT INTEGER
CONVERSION_TYPE	STRING (1)
PARTIAL	STRING (1)
IMAGE_DATE	STRING (15)
INACTIVE_DATE	STRING (15)
FIELD_VERIFIED	STRING (1)
COMMENTS	STRING (255)
UPDATE_OPERATOR	STRING (50)
UPDATE_DATE	DATE

6. A 'status' subtype was created to apply topological restraints within the 'active' and 'inactive' subsets. To assign a topology rule to such subsets of data, a subtype must be defined for the field. Therefore, a status subtype was assigned for the STATUS field.

7. Domains were created and assigned to support the projects data management guidelines. The following domains were created:

    Field(s): STATUS
    Domain: Status
    Field Type: Short integer
    Code/Description: 0/ACTIVE
    Code/Description: 1/INACTIVE

    Field(s): CONVERSION_TYPE
    Domain: CONVERSION_TYPE
    Field Type: Text
    Code/Description: A/AGRICULTURE
    Code/Description: D/DEVELOPMENT
    Code/Description: R/RECREATION
    Code/Description: O/OTHER

Field(s): PARTIAL, FIELD_VERIFIED
Domain: Y/N
Field Type: Text
Code/Description: Y/YES
Code/Description: N/NO

Field(s): ATTRIBUTE
Domain: ATTRIBUTE
Field Type: Text
Code/Description: tbd

Field(s): UPDATE_OPERATOR
Domain: UPDATE_OPERATOR
Field Type: Text
Code/Description: (per user)

8. A feature dataset was created to hold the wet_poly feature class and its necessary topological rules. The dataset's spatial extent was defined by importing the wet_poly feature class' extent.

9. The topological rules for the wet_poly feature class' STATUS field subsets were created. Features with the attribute 'active' within the STATUS field were given the topology rule: "must not overlap." Likewise, features with the attribute 'inactive' within the STATUS field were given the topology rule: "must not overlap."

10. The attribute values for certain fields were populated at the beginning of the update process. The populated fields and their assigned values are listed below:

    Set status for all features = 0/Active
    Set NWI_KEY = OBJECTID
    Correct 'ATTRIBUTE' values

11. To utilize the NWI Object Inspector, an editing tool designed by GLARO to better enable and standardize the update process (explained within the Process Management section of this document), a change was made to an SDE system table for the wet_poly feature class and checked-out feature classes. The GDB_ObjectClasses table was opened, and in the record with name 'WET_POLY,' insert the following in the EXTCLSID field:

    {D6956100-2A7F-4999-B766-682E79BEB4FA}

Parent Table Creation

12. It was deemed necessary to record all parent-child feature relationships within the updated NWI dataset. Therefore, a single table was created to record all parent-child relationships. The new table was created using the glarogis schema. The table was created by executing the following commands:

    CREATE TABLE PARENT

```
(
   nwi_key int,
   parent_key int,
   unique (nwi_key, parent_key)
) ON NWI;
```

NWI_SEQ Table and Procedure

13. To ensure that newly created features within the updated NWI dataset are provided a unique identifier, as were features within the original dataset, a database object was created that would provide each newly created feature with a new and unique 'NWI key.' The NWI_SEQ table was created using the glarogis schema to provide NWI keys to newly created features. The table was created by executing the following commands:

```
create table nwi_seq (ID int)
insert nwi_seq select 14079586

create procedure nextval
@ID int output
as
update nwi_seq set ID = ID + 1, @ID = ID + 1
go
```

Database Backups

The vector database on glaro_sde is used to store and serve data. Data is not typically edited directly in the database. Instead, data is updated in a disconnected repository, with updates applied to a layer in one operation. Because the data is not actively edited in the database, log file recovery is not needed. Therefore, the vector database is set to the Simple recovery model. A full backup is taken every weekend, with differential backups taken every night. Additionally, the log file is truncated nightly.

GLARO uses the vector database to store and serve multiple feature classes not pertaining to NWI. Therefore, in the event of an editing or data synchronization error, it may not be prudent to restore the entire database in order to retrieve one data layer. Consequently, the *wet_poly* feature class, which is the only feature class that undergoes regular edits, is exported every weeknight. Exports are saved for a full week, after which point they are overwritten. Also, one export per week and one export per month are archived. If necessary, these exports may be used to restore the *wet_poly* feature class only.

Database Maintenance

The *wet_poly* layer and database undergo periodic maintenance for which all users check in their edits that are then reconciled and posted. After all versions are deleted, the database is compressed (as the SDE user) and the layer is unregistered as versioned (as the dataowner). This writes all data updates to the *wet_poly* table. After this is done, the *wet_poly* feature class is analyzed and the feature dataset is then re-registered as versioned.

As routine, the parent table is inspected for NWI key/parent key combinations recorded that no longer exist. Periodically, queries are run to verify that the NWI key and parent key features both still exist. Orphaned records are deleted.

Geodatabase Versioning

The DU MGD administrator is the only person that has permission to edit the DU MGD. The DU MGD will be registered as versioned, which will allow multiple users to edit the data simultaneously. Analysts will edit a version of the master database, not the actual database (see Figure 1). The version will appear the same as the original, however, instead of being a copy or modifying the original data, edits are stored in separate geodatabase system tables. The DU MGD administrator will only post edits after any conflicts have been reconciled and the edits have been checked for quality (see QA/QC section).

Data Editors

As GLARO employs a multitude of interns and volunteers to assist in the update process, additional data editors are commonly added. The following steps detail the creation of a new NWI Update data editor:

Create a login for the new data editor

1. Open the SQL Server Enterprise Manager on glaro_sde.
2. Expand navigation tree to Local Server > Security > Logins
3. Right-click on 'Logins' and select 'New Login…' Make the following entries and click 'OK':
   Login name
   SQL Server Authentication
   Password
   Database: vector

Create a user account for the new data editor

4. Navigate to Local Server > Databases > vector > Users
5. Right-click on 'Users' and select 'New Database User…' Make the following entries and click 'OK':
   Login name: Select login created in step 1.
   User name: User name will automatically populate with the login name.
6. Database role membership: public will be checked by default, also grant the sde_dataeditor role.

Data Model

Geodatabase Feature Dataset

Spatial Reference is as follows:

Projected Coordinate System:
Name: NAD_1983_Albers
  Alias:
  Abbreviation:
  Remarks:
Projection: Albers
Parameters:
  False_Easting: 0.000000
  False_Northing: 0.000000
  Central_Meridian: -96.000000
  Standard_Parallel_1: 29.500000
  Standard_Parallel_2: 45.500000
  Latitude_Of_Origin: 23.000000
Linear Unit: Meter (1.000000)
Geographic Coordinate System:
  Name: GCS_North_American_1983
  Alias:
  Abbreviation:
  Remarks:
  Angular Unit: Degree (0.017453292519943299)
  Prime Meridian: Greenwich (0.000000000000000000)
  Datum: D_North_American_1983
    Spheroid: GRS_1980
      Semimajor Axis: 6378137.000000000000000000
      Semiminor Axis: 6356752.314140356100000000
      Inverse Flattening: 298.257222101000020000

X/Y Domain:
  Min X: -3350595.000000
  Min Y: -729611.000000
  Max X: 18124241.450000
  Max Y: 20745225.450000
  Scale: 100.000000

Data Dictionary

One of the challenges in updating the NWI is to design a system that tracks the historic wetland information so that wetland trends and potential restoration sites (wetlands that have been converted) can be identified. A solution was developed by adding attributes to the current database that identified the converted and partially converted wetlands. These additional attributes allow for flexibility in selecting current NWI polygons, historic wetland polygons, or a combination of both. This system also allows for easy tabulation of the current status of wetlands, wetland trends, and identification of converted wetlands for potential wetland restoration activities. Therefore, several

attribute fields will be added to the DU MGD (see Table 1 and Figure 1). For a more detailed description on how the attributes are used, see the "Update Procedures" documentation.

The updated NWI database includes a number of attributes for each wetland feature. Some of these attributes were of the original NWI data. However, as previously discussed in this document, GLARO added a number of attributes to assist in the documentation and management of the update process. A full list of attributes and their definitions follows: Those in *italics* were added to the FWS layer by Ducks Unlimited.

WET_POLY		
OBJECTID	OID (4)	
ATTRIBUTE	STRING (20)	
HGM_CODE	STRING (10)	
QAQC_CODE	STRING (9)	
WETLAND_TYPE	STRING (50)	
ACRES	DOUBLE (8)	
DECODE	STRING (40)	
NWI_KEY	*LONG INTEGER*	
PARENT_KEY	*LONG INTEGER*	
STATUS	*SHORT INTEGER*	0/1
CONVERSION_TYPE	*STRING (1)*	A/D/R/O
PARTIAL	*STRING (1)*	Y/N
IMAGE_DATE	*STRING (15)*	
INACTIVE_DATE	*STRING (15)*	
FIELD_VERIFIED	*STRING (1)*	Y/N/NULL
COMMENTS	*STRING (255)*	
UPDATE_OPERATOR	*STRING (50)*	*
UPDATE_DATE	*DATE*	DEFAULT
SHAPE	GEOMETRY (4)	
SHAPE.area	DOUBLE (0)	
SHAPE.len	DOUBLE (0)	

OBJECTID	Automatically generated feature id.
ATTRIBUTE	Habitat classification
HGM_CODE	Code generated by the U.S. Fish and Wildlife Service
QAQC_CODE	Code generated by the FWS QA/QC tool
WETLAND_TYPE	Text field describing the NWI wetland
ACRES	Acreage
DECODE	Link to the NWI online decoder
NWI_KEY	Unique id for wetland features
STATUS	Current status of the feature, either Active or Inactive
CONVERSION_TYPE	Purpose for which a wetland was converted, either Agriculture, Recreational, Development, or Other
PARTIAL	Was derived from a prior wetland
IMAGE_DATE	Vintage of imagery used to create polygon
INACTIVE_DATE	Vintage of imagery used when polygon was inactivated
FIELD_VERIFIED	Whether or not the wetland has been verified in the field, either Yes, No, or Null
COMMENTS	Comments
UPDATE_OPERATOR	User that made updates
UPDATE_DATE	When updates where made

Primary/Foreign Keys, Cardinality, Relationships

There is a many to many relationship between the *wet_poly* table and the *parent* table. The nwi_key field in the *wet_poly* object is the primary key while the nwi_key field in the *parent* table is the foreign key.

Domains

Field(s): STATUS
Domain: Status
Field Type: Short integer
Code/Description: 0/ACTIVE
Code/Description: 1/INACTIVE

Field(s): CONVERSION_TYPE
Domain: CONVERSION_TYPE
Field Type: Text
Code/Description: A/AGRICULTURE
Code/Description: D/DEVELOPMENT
Code/Description: R/RECREATION
Code/Description: O/OTHER

Field(s): PARTIAL, FIELD_VERIFIED
Domain: Y/N
Field Type: Text
Code/Description: Y/YES
Code/Description: N/NO

Field(s): ATTRIBUTE
Domain: ATTRIBUTE
Field Type: Text
Code/Description: (per user)

Field(s): UPDATE_OPERATOR
Domain: UPDATE_OPERATOR
Field Type: Text
Code/Description: (per user)

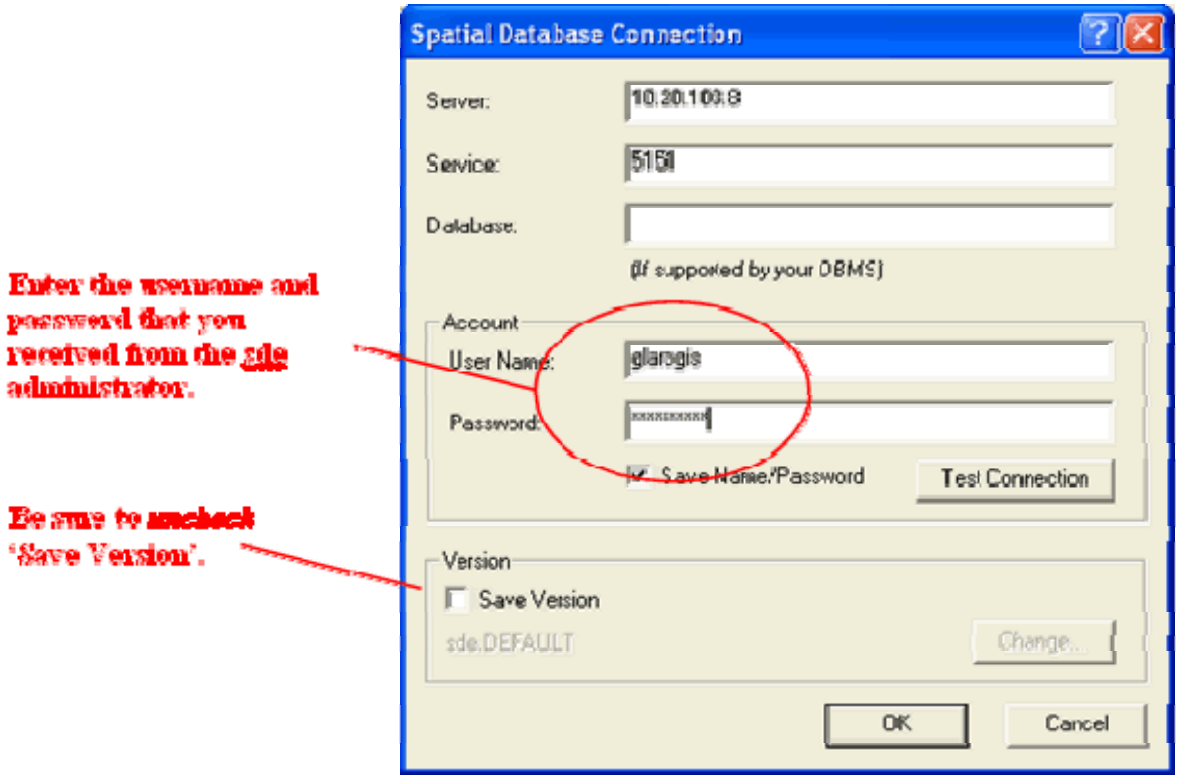
Chapter 3 – Editing Environment

Database Connection

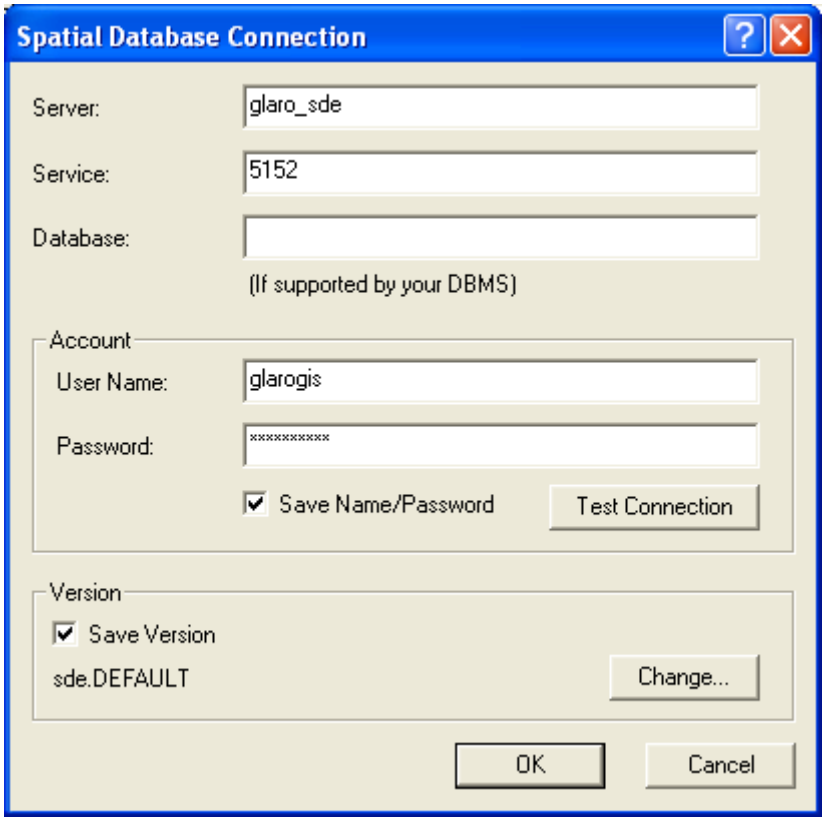
This section details how to set up the editing environment in ArcGIS. These steps need to be performed one time only.

Step 1: Set up Database Connections in ArcCatalog

1. Launch ArcCatalog
2. Expand Database Connection in the catalog tree, double-click on 'Add Spatial Database Connection', enter the following parameters in the dialog, and click 'OK':

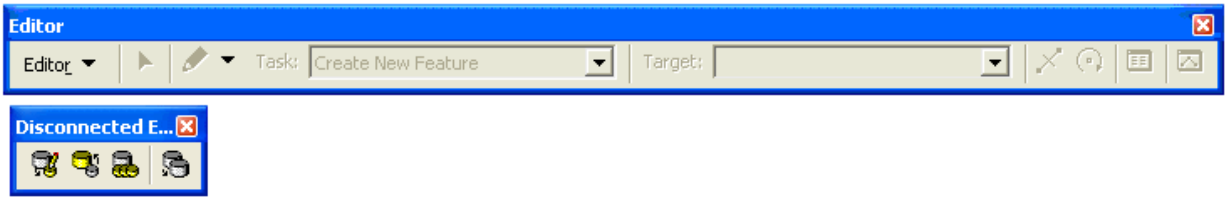


3. Repeat Step 3, using Service: 5152, but leaving ‘Save Version’ checked:



Step 2: Add Editor and Disconnected Editing toolbars

If the Editor and Disconnected Editing toolbars are not present in the ArcMap user interface, they need to be added. First, check for the presence of the following toolbars:



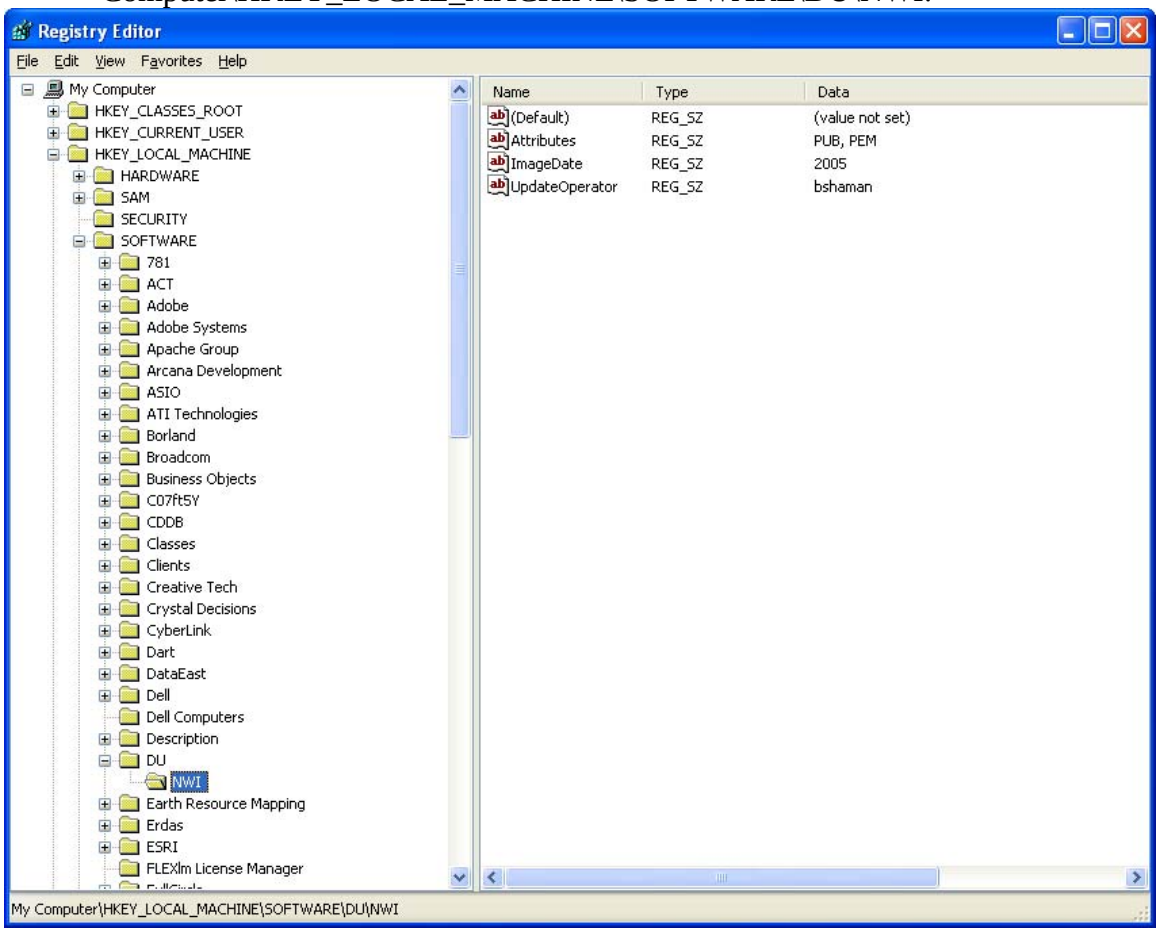
If one or both do not exist, go to View > Toolbars and check 'Editor' and 'Disconnected Editing'.

NWI Object Inspector Installation

Edits made to feature classes that are derived from the wet_poly layer must be made using the NWI Object Inspector. This custom attribute editor includes changes to the attribute dialog, plus actions triggered by editing events.

Installation

1. Navigate to \\Drake\Archive\Installs\GIS Misc\NWI\NWI Object Inspector and execute Setup.exe. Follow the steps in the installation wizard to install the application.
2. Edit the registry
    a. Go to Start > Run, and type 'regedit'. Click 'OK'.
    b. In the Registry Editor, navigate to My Computer\HKEY_LOCAL_MACHINE\SOFTWARE\DU\NWI:



    c. Edit each of the three registry keys by double-clicking on the 'Name' value, editing the text, and clicking 'OK'.
        i. Attributes — Enter attribute values desired in the Attribute combo box. Separate each value with a comma.
        ii. ImageDate — Enter the vintage of the background imagery for the state you will be working
        iii. UpdateOperator — Enter your database username. This follows the naming convention <first_initial><last_name>.

Using the Object Inspector

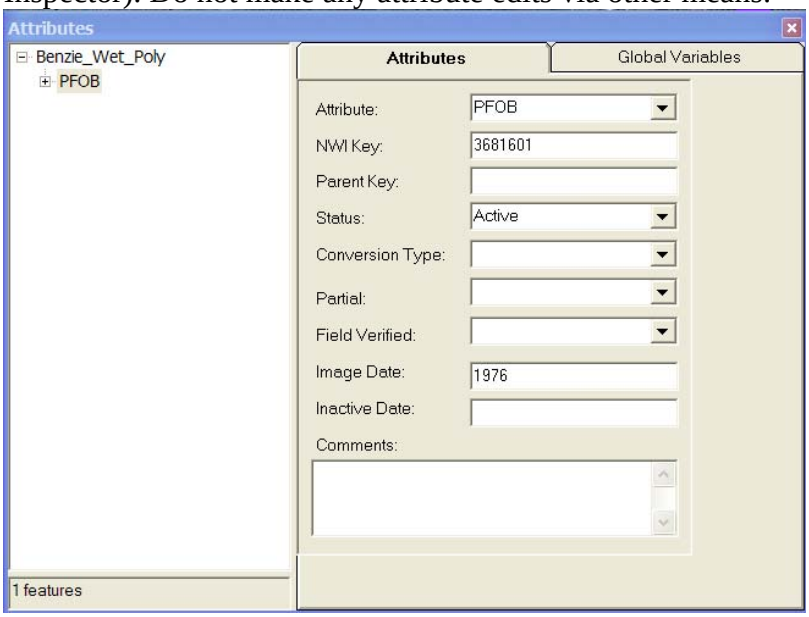
The Object Inspector is the tool that ArcMap uses to edit the attributes of a selected feature during an edit session. DU has customized the standard Object Inspector for the NWI update to improve the efficiency of the update process.

Edit Session

Upon commencement of an editing session, the Object Inspector will determine whether you are editing NWI data or not. If you are making NWI edits, it will automatically capture edit events that properly manage your data.

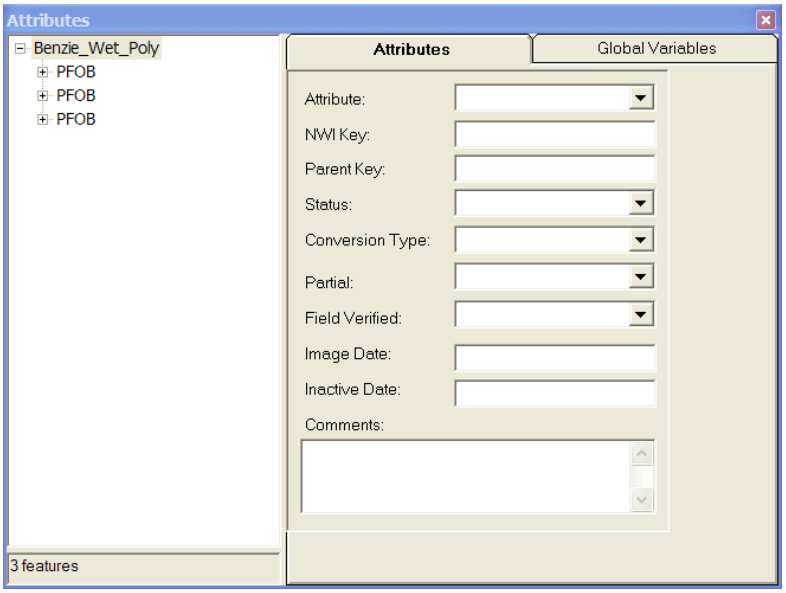
Attribute Edits

All attribute edits made during an edit session must be made through attribute edit window (Object Inspector). Do not make any attribute edits via other means:



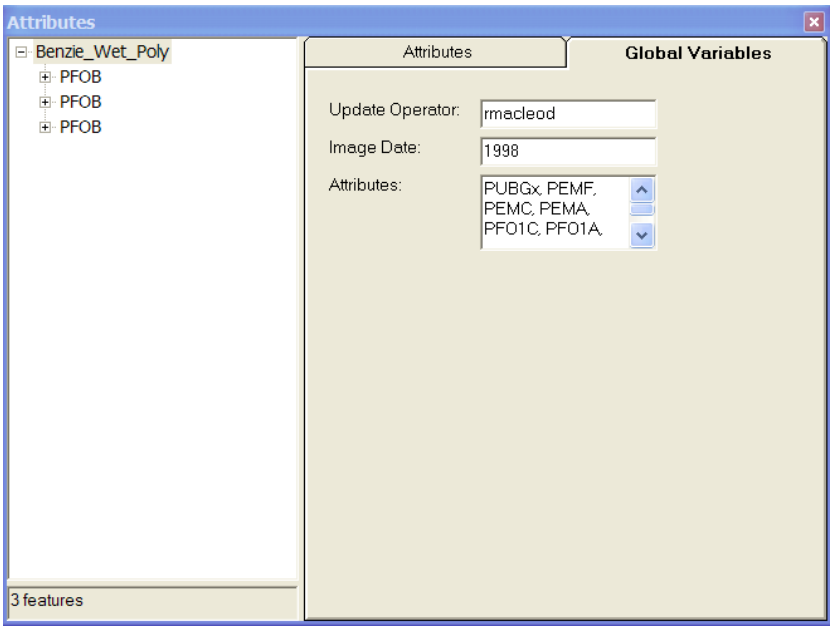
Edits to Multiple Features

Just as with the standard attribute editor, edits can be made to multiple features at once. To do so, click on the layer header in the left panel. Edits made to any attribute will apply to all selected features:



Global Variables

The global variables need to be set when the analyst first starts a county. The update operator will be set based on the login name, be sure this is set to the proper name. The image date will be the date that is filled in for the Inactive Date if a polygon is inactivated or for the Image Date if a new polygon is created. For Northern Ohio, the image date should be set to 2006 and southern Ohio, 2007. Indiana and Illinois the image date should be set to 2005. For Michigan, the image date should be set to 1998, with manual updates to 2005 when changes occur. Attributes that occur frequently (ponds – PUBGx) can be placed in the attributes box. These attributes will show up in the pull down menu for quick assess. There are over 2,000 unique NWI attributes, so it would not be efficient to put all of the attributes in the pull-down menu.

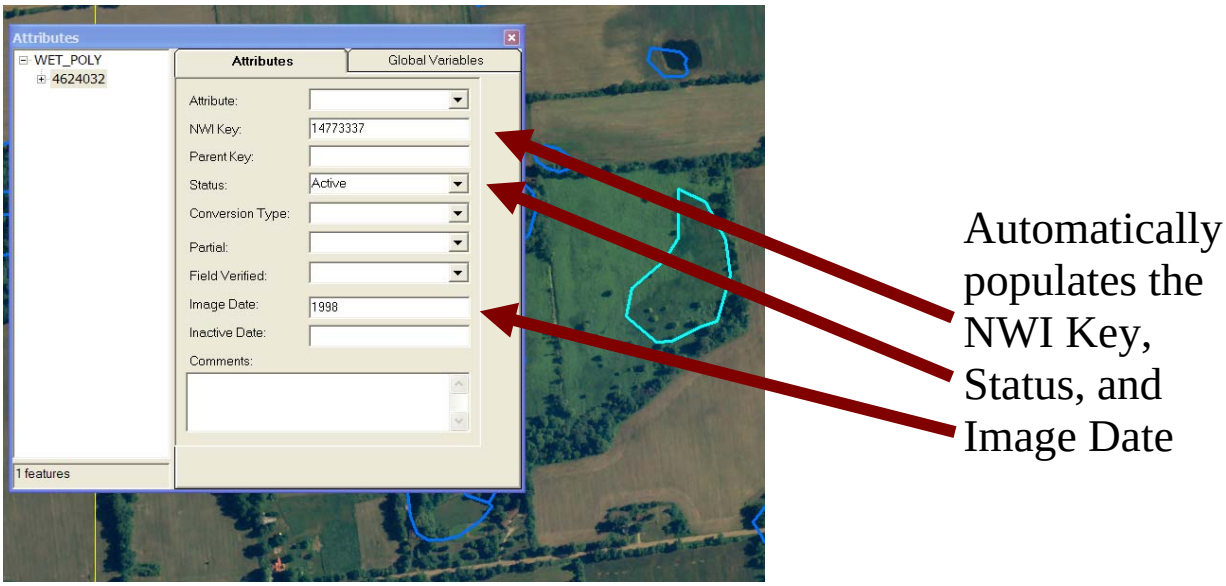


Edit Operations

The nwi key and parent key(s) are managed during Create Feature, Copy/Paste, Cut, and Clip Polygon edit operations. During all other edit operations, the nwi key and parent key(s) must be managed manually.

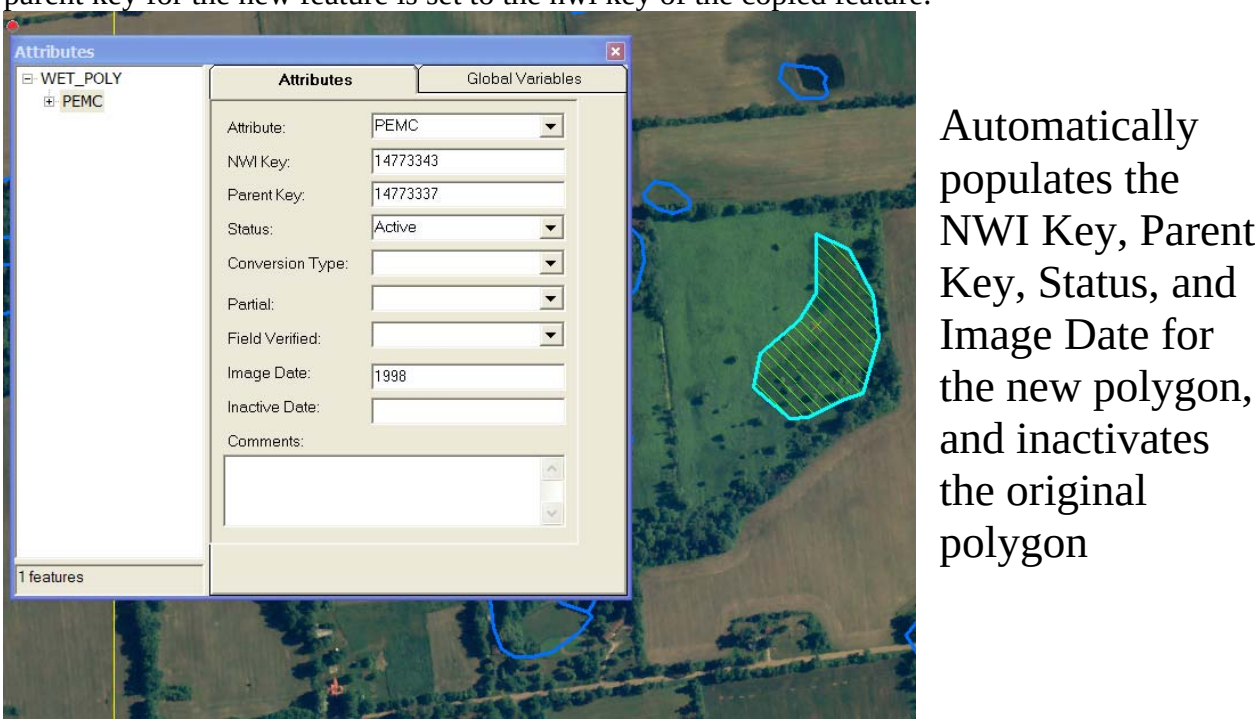
Create Feature

When a feature is created, the Object Inspector automatically populates the NWI key, Status, and Image date.

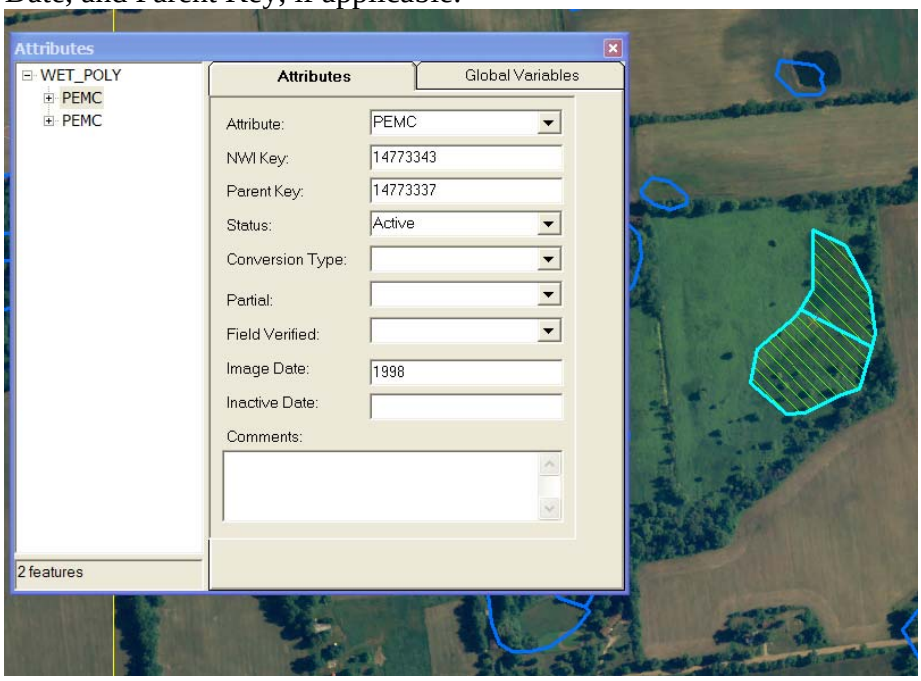


Copy and Paste

When a feature is copied and pasted, the copied feature is automatically made inactive, and the parent key for the new feature is set to the nwi key of the copied feature.



Clip Polygon
When a feature is clipped, the Object Inspector automatically populates the NWI key, Status, Image Date, and Parent Key, if applicable.



Automatically populates the NWI Key, Status, Image Date, and Parent Key if applicable

Attribute

The attribute field contains a drop-down list of often-used values (add new values in the Global Variables tab). Any of these values may be selected, or the user may type in a new value. The list may be edited by added and deleting codes from the Global Variables tab.

NWI Key

The NWI Key is locked from editing by the user. This field is autopopulated by the application for new features. The value in this field can be copied and pasted into the parent key field. See section on “NWI Key Updates” if you need to change the NWI key for a feature.

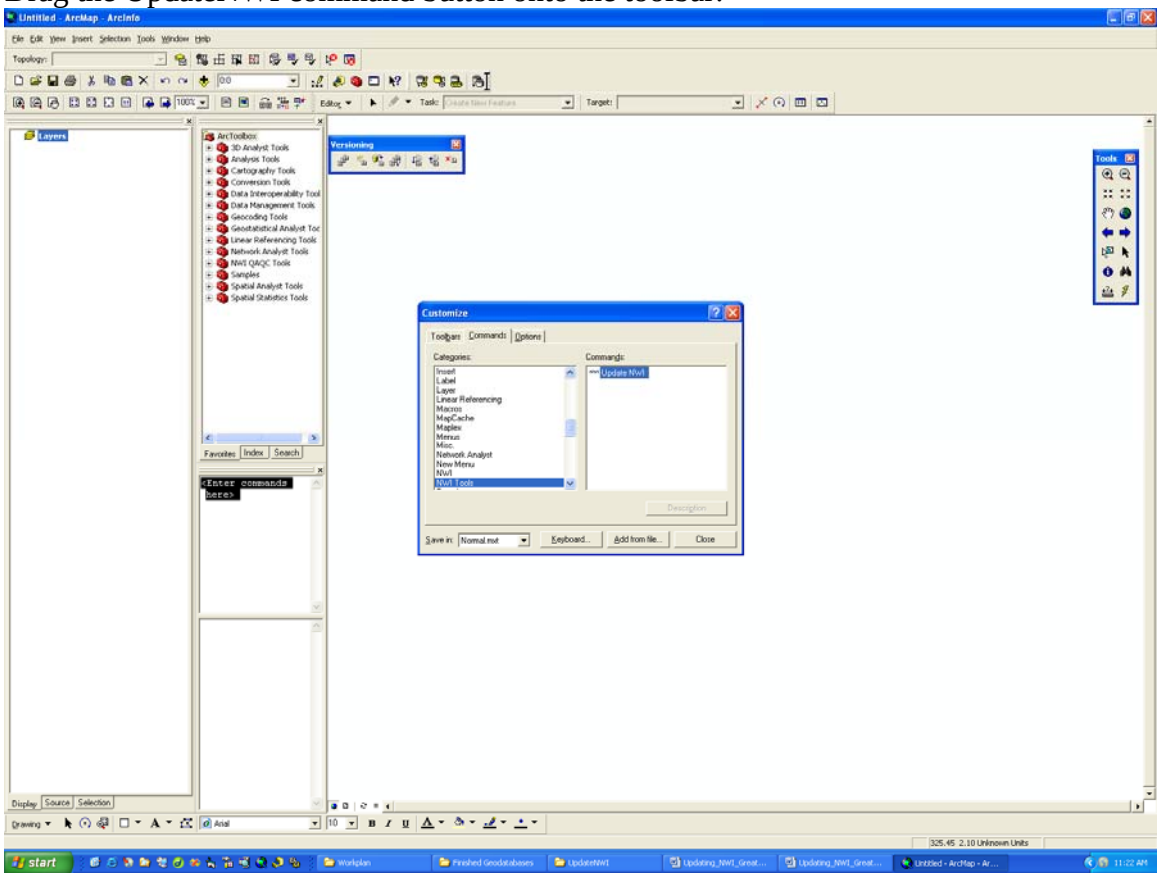
Manual NWI Key Updates

For special cases where NWI Keys were not automatically updated, a utility has been created to do so.

Installation

1. Open ArcMap and create a map document that includes the NWI personal geodatabase feature class that will receive updates.
2. Open the ‘Customize’ dialog > Comments tab. Select the target map document or template.

3. Click ‘Add from file’, navigate to V:\Installs\GIS Misc\NWI\UpdateNWI and select UpdateNWI.dll.
4. Drag the UpdateNWI command button onto the toolbar:



Use

5. Select the features to be updated.
6. Click on the ‘NWI’ button.

Note: The Update NWI tool will function whether there is an active edit session or not. If there is an active edit session and the Object Inspector is visible when the tool is run, the Object Inspector will not be present when the tool completes, even though the edit session will still be active.

Chapter 4 – Overview of Updating Process

The NWI layer will be updated using spring and summer digital orthophotos. The spring photos are best to identify the seasonal wetlands and forested wetlands and the summer photos are best to identify the emergent, aquatic, and farmed classes. Digital Elevation Models (DEM), hydric soils and USGS Topographic maps may also be used when available to aid in the updating process. Only wetland polygons will be updated (no lines or points), as the Wetlands MGD Check-out Instructions (USFWS, 2004) state; "Linear delineations of wetlands are discouraged" and "The wetlands MGD will no longer support wetland point features."

The updating process will involve displaying the original NWI layer on top of the digital orthophotos on a section-by-section basis (1 square mile, approximately 1:10,000). The minimum mapping unit for the update is approximately one-tenth of an acre. The photos will be interpreted as to whether the wetland still exists, if it has changed class, has been spatially modified, or remains in the same condition as the original. A unique system to track the changes to the wetlands was devised through the use of a NWI key and parent key (see Figure 4) A photo interpretation key and the existing NWI data will be used to assist the interpreter in determining the wetland condition and class.

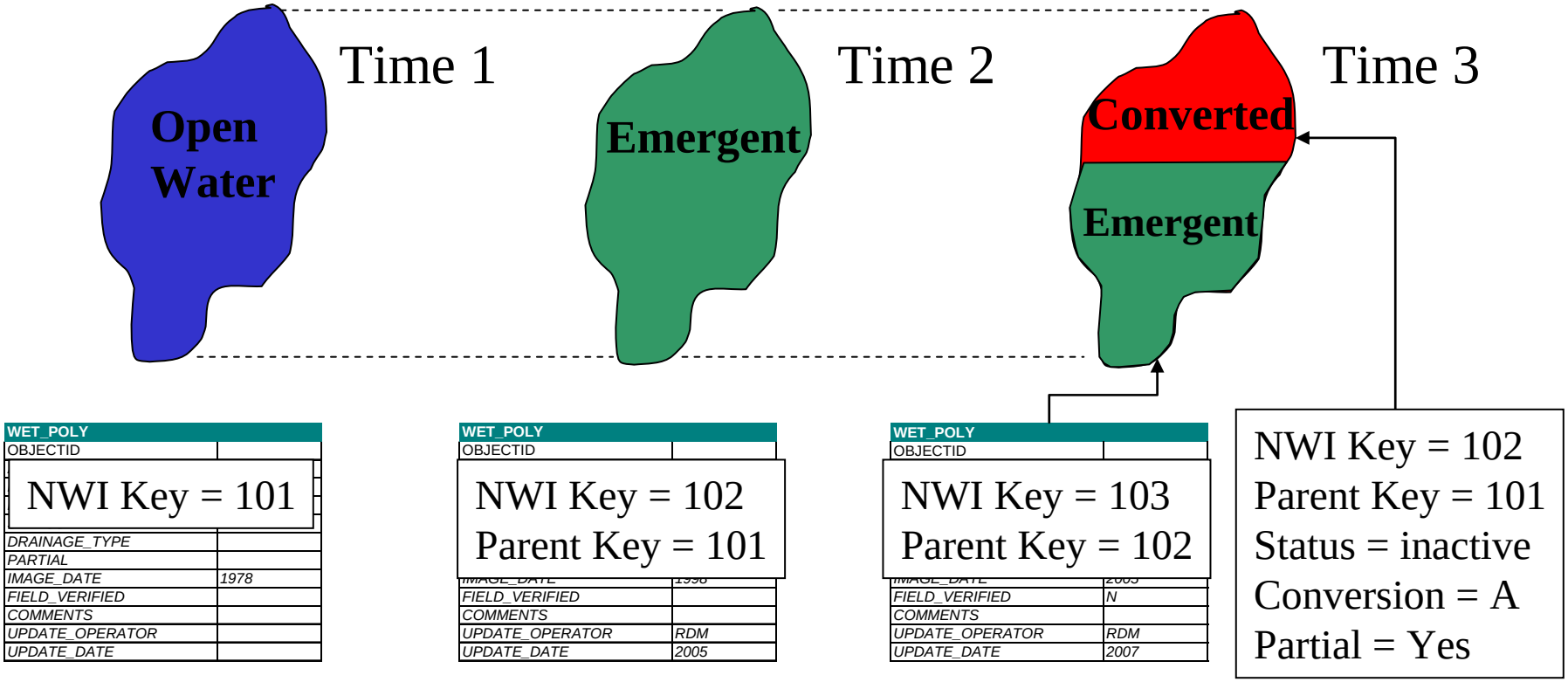
Any wetlands that were either missed by the original NWI or have been created will be digitized and attributed. All existing wetlands that do not spatially register with the digital orthophotos will be modified to match the photo. "New" and modified wetlands will be classified to the class level of the NWI classification scheme according to the USFWS NWI Photointerpretation Convention. The water regime will be attributed to the best of the interpreter's ability and the special modifiers will be attributed when necessary. When the interpretation is possible at the subclass level, they will also be included.

If there is confusion as to the wetland type or condition during the photo interpretation process, they will be flagged for field verification in the database. A map of the flagged wetlands will be produced and sent to cooperators or DU field staff for field verification. Once field verified, the attributes will be updated and the verification process will be noted.

The first step in the NWI updating process is to receive a copy of the USGS NWI Master Geodatabase (MGD) and import the database into DU's Geodatabase (DU MGD) (see Figure 5 for an overview of the NWI process). The photo interpreters will be updating the NWI on a county-wide basis, therefore, the second step is to have the photo interpreters "check out" a version of the MGD for their county to perform the update. Once the update is completed for their county, the third step is to run a QA/QC process to verify the attributes and spatial integrity. The fourth step is to perform the field verification and circulate the draft update for comments from cooperators. The fifth step is to post the version back to the DU MGD. The final step is to return the updated NWI to the USGS MGD. For a more detailed discussion on the geodatabase (DU MGD) and update process, please refer to the "Data Management" and "Update Procedures" documentation.

Following Figure 5 there is a procedural checklist that lists the steps for the NWI update. The remaining chapters will document the process for completing these steps.

NWI Key/Parent Key Example



Status becomes inactive (I) if there is a change in future updates

A new polygon is created that can be linked back to original data through the Parent_Key

If a polygon needs to be split, both of the new polygons can be linked back to the original data through the Parent_Key

Figure 4: Wetland tracking over time.

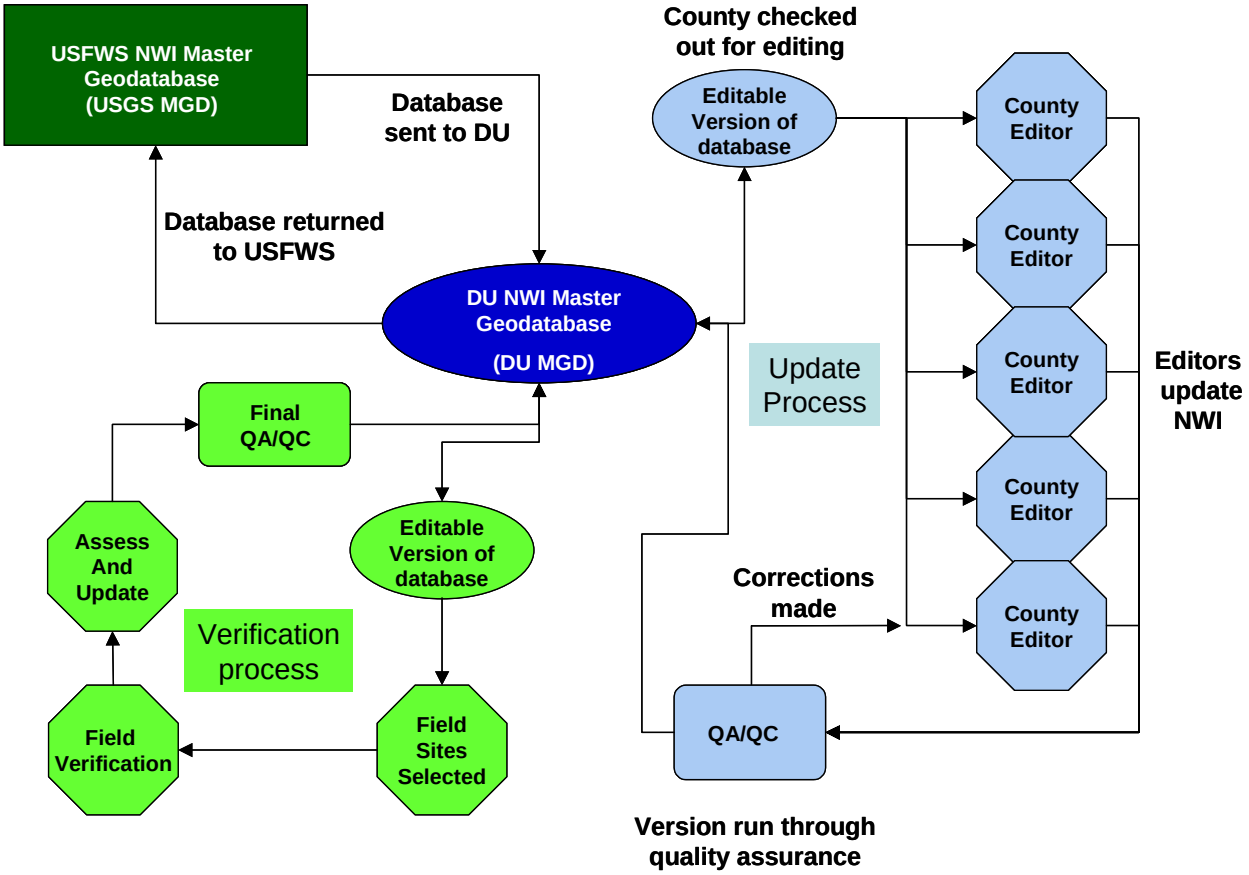


Figure 5. The NWI update process.

NWI Update Procedural Checklist

CHECK OUT PROCESS

- ☐ **1) $PI_{(1)}$ checks out county from DU NWI Geodatabase**
- ☐ **2) $PI_{(1)}$ updates NWI status layer for county (Status = "In Progress")**

UPDATE PROCESS

- ☐ **3) $PI_{(1)}$ performs update on county**
- ☐ **4) $PI_{(1)}$ runs QA/QC tests**
- ☐ **5) $PI_{(2)}$ visually checks 10% of grids in county**
- ☐ **6) $PI_{(1)}$ submits county to Analyst for QA/QC**
- ☐ **7) Analyst performs QA/QC and checks in data**
- ☐ **8) Analyst updates NWI status layer for county (Status = "Complete")**
- ☐ **9) DBA post draft data on web site**

FIELD VERIFICATION PROCESS

- ☐ **10) $PI_{(1)}$ updates NWI status layer (Verified -= "In Progress")**
- ☐ **11) $PI_{(1)}$ runs field selection process**
- ☐ **12) $PI_{(1)}$ produces field maps**
- ☐ **13) MAN enter maps into database**
- ☐ **14) MAN sends maps to cooperators**
- ☐ **15) $PI_{(1)}$ organizes field data and adds field data to the point file**
- ☐ **16) $PI_{(1)}$ updates assessment table with field results**

- ☐ **17) $PI_{(1)}$ verifies field data and update/correct NWI layer**
- ☐ **18) $PI_{(1)}$ submits verified county to Analyst for final QA/QC**
- ☐ **19) Analyst performs QA/QC**
- ☐ **20) Analyst updates NWI status layer (Verified -= "Complete")**

INTREGRATION BACK INTO FWS NWI

- ☐ **21) Analyst prepares data to be sent to FWS**
- ☐ **22) Analyst performs final QA/QC**
- ☐ **23) Analyst creates metadata**
- ☐ **24) Analyst sends data to the FWS**
- ☐ **25) Analyst updates NWI status layer (Status = "Final")**

Chapter 5 – Check-Out Process

Create the Data Repository

1. Launch ArcCatalog and create a personal geodatabase to hold your edits. Store the geodatabase in D:\Working and use the naming convention *County_ST*.

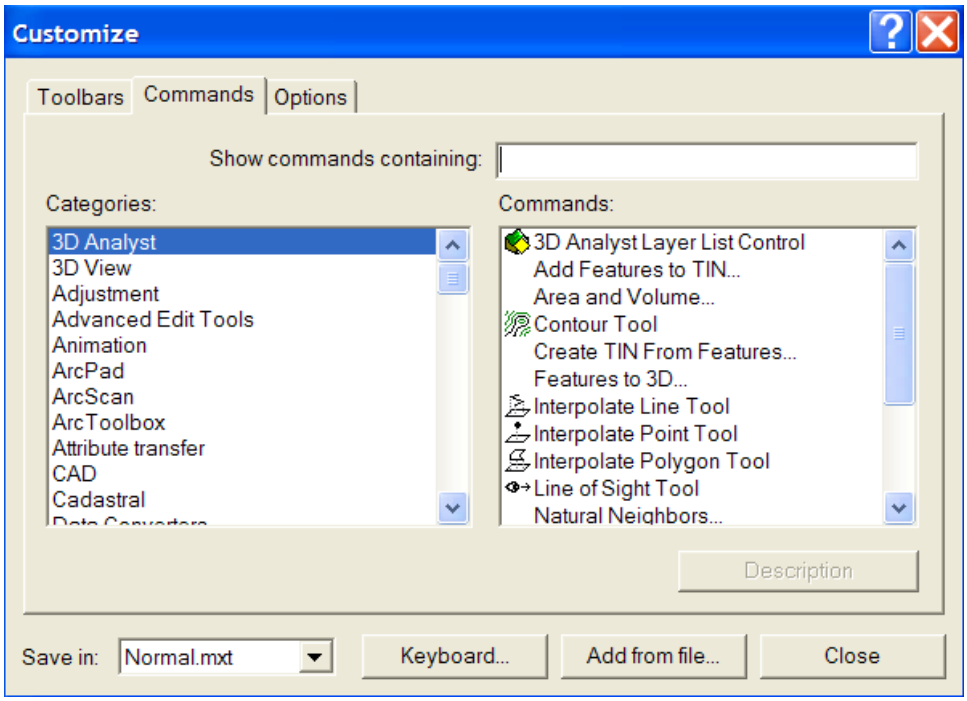
Add Data to ArcMap

1. Launch ArcMap
2. Add data from database connection (Database Connections > Vector > NWI)
3. Add feature datasset vector.GLAROGIS.NWI. This will include the WET_POLY feature class, as well as a county layer and a reference grid.
4. To symbolize, right-click on layer and select 'Properties'. Click on the 'Symbology' tab. Symbolize active and inactive features as desired.
5. Add imagery and other pertinent data (hydric soils, topographic map, etc)

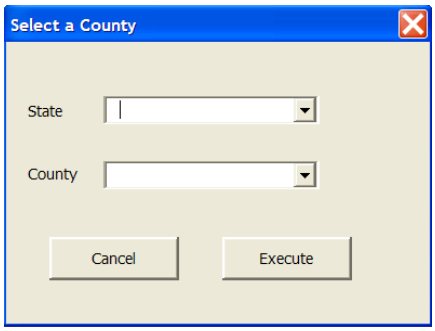
Check Out Data for Edits

ArcGIS manages data edits by multiple users by implementing "versions" of data layers. Rather than making edits directly to the wet_poly layer, editing is performed on disconnected versions of the data which are stored in personal geodatabase format. Each user creates and edits a copy, or version, of a feature class. Upon the completion of each county, the data administrator will reconcile edits and post them to the master data layer. The users then create another version, and the process begins again.

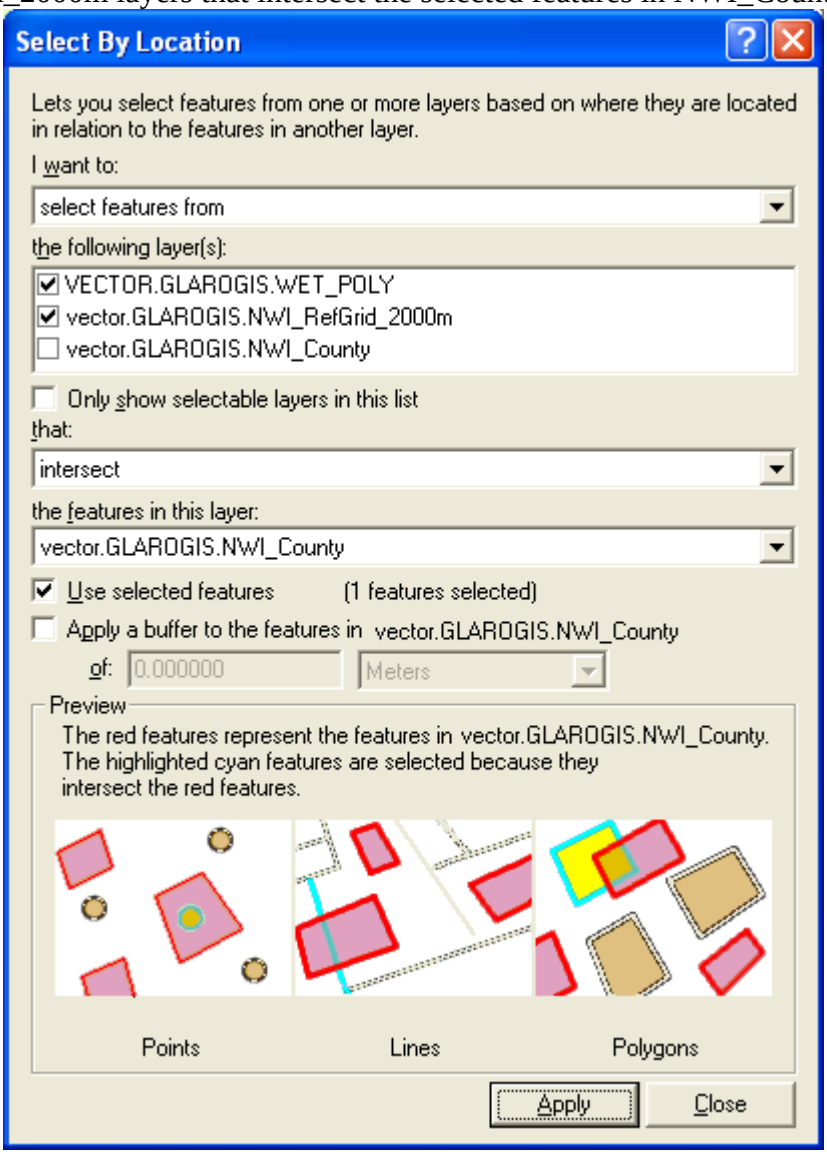
Step 1 & 2 below can be skipped by using the CheckoutSelection tool. This tool performs the selection process and you can skip to Step 3. To add this tool to your tool bar, select Customize from the Tools pull down menu in ArcMap.



Then click on the “Add from file” button at the bottom of the form. Navigate to V:\Installs\GIS Misc\NWI\CheckoutSelection and select the “CheckoutSelection.dll” file. From the Comands box on the form you should see the text “CheckoutSelection”. Drag and drop this onto your toolbar. When you click on this button on your toolbar, it will ask you for the state and county you would like to select. **You can then skip to step 3.**

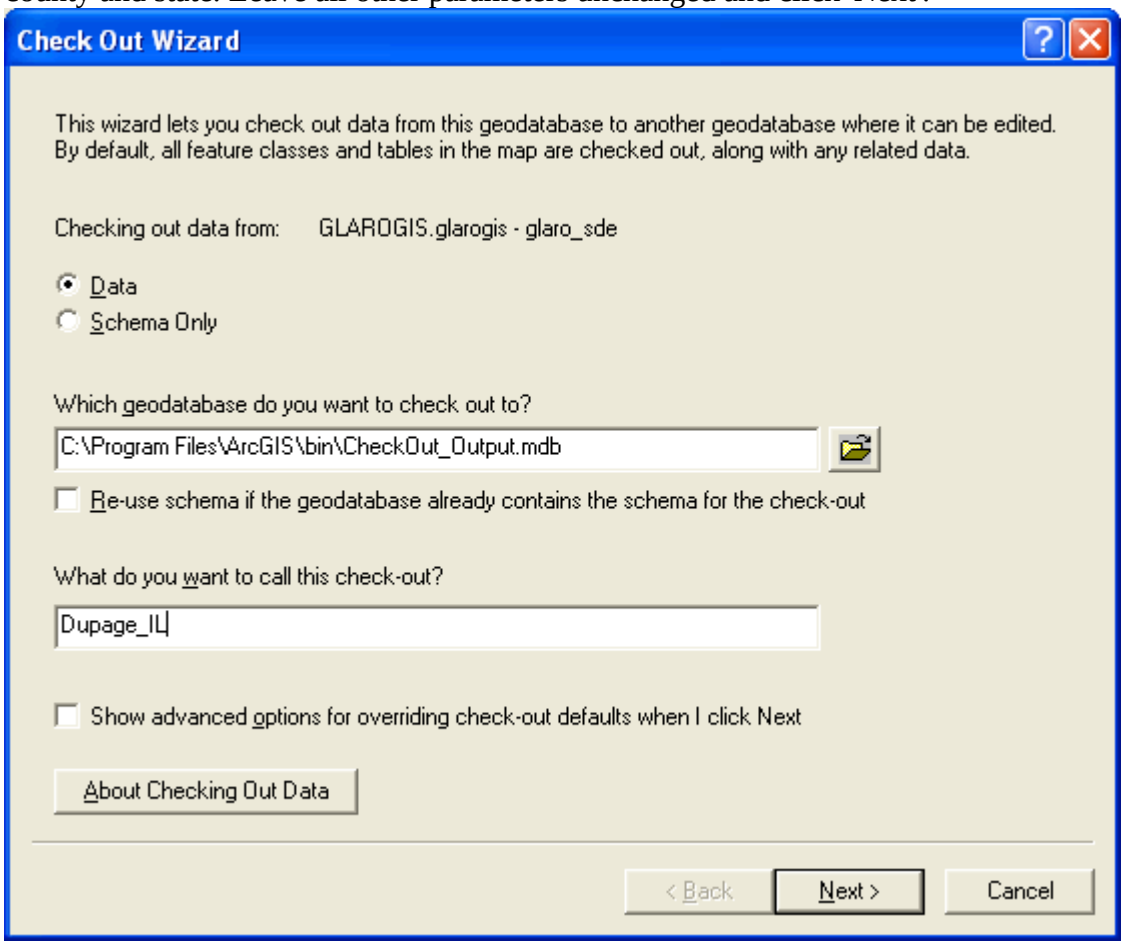


1. Select the target county.
2. Under Selection > Select by Location, select all features from the WET_POLY and NWI_RefGrid_2000m layers that intersect the selected features in NWI_County:

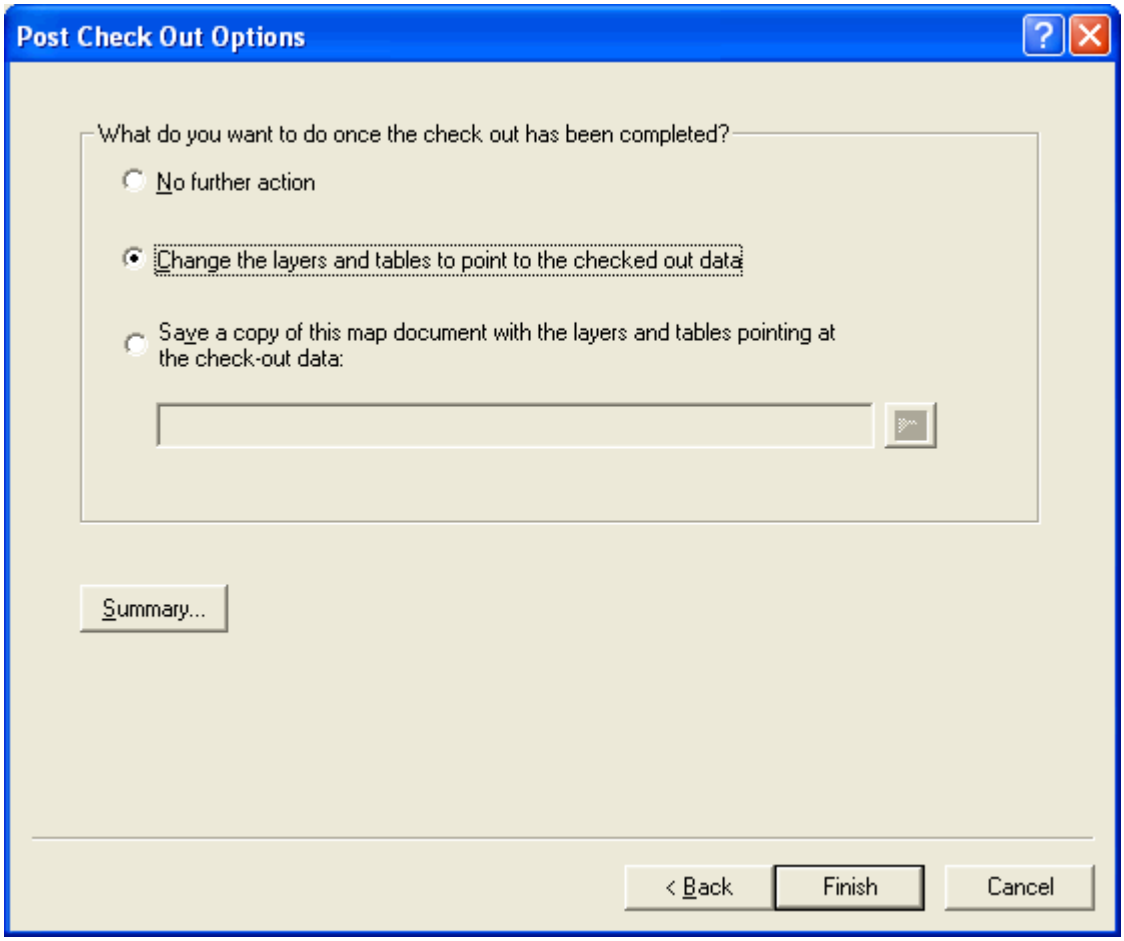


3. Click on the 'Check Out' tool on the Disconnected Editing toolbar:

4. Indicate the geodatabase as the output location. Name the check-out with the name of the county and state. Leave all other parameters unchanged and click 'Next':



5. On the second window, check 'Change the layers and tables to point to the checked out data'. Click 'Finish':



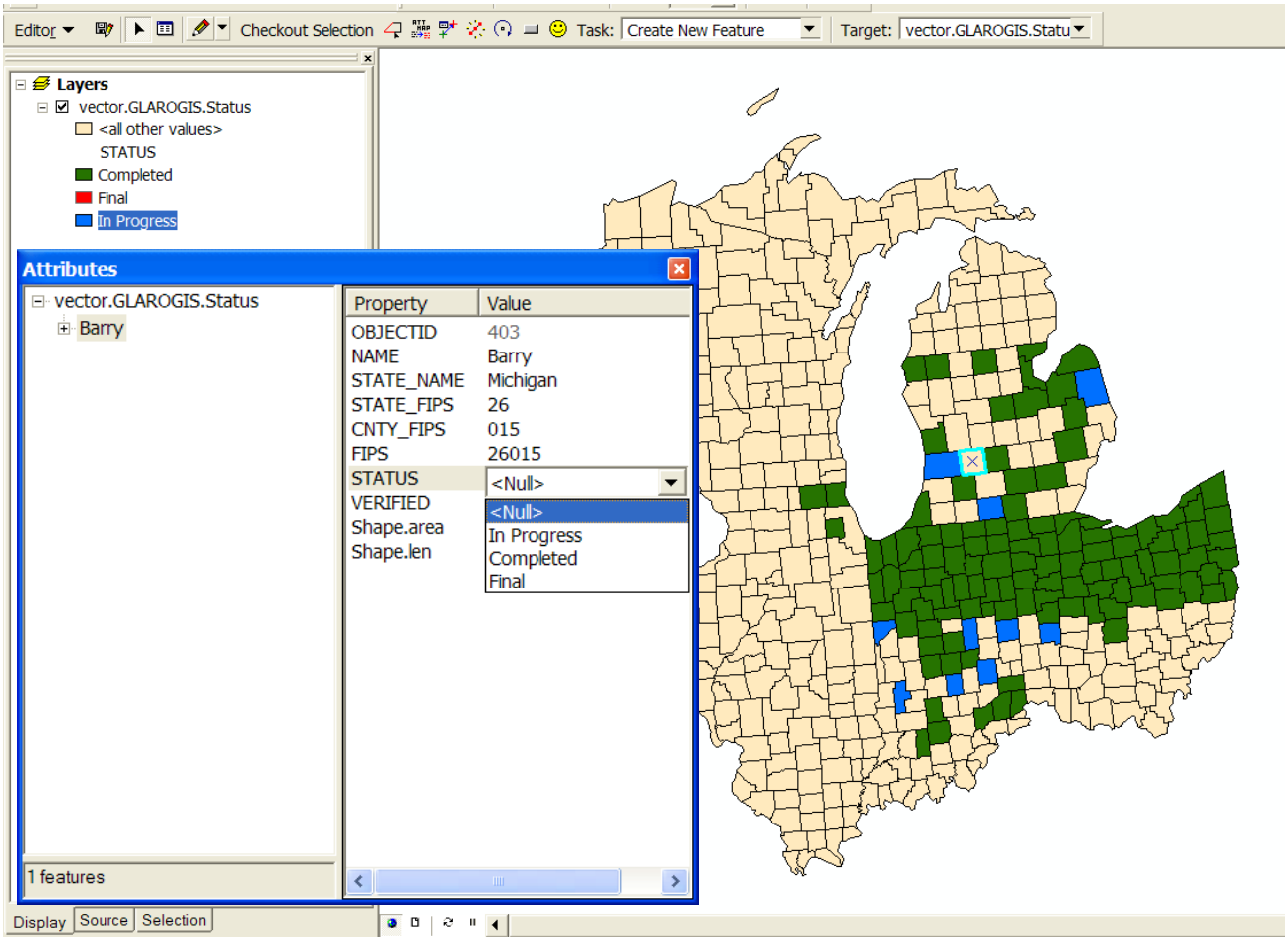
Now, all edits will be made to the new version of WET_POLY.

6. Save the map document (.mxd) file.

Update NWI Status Layer

In order to keep our cooperators informed of the status of the NWI update project, we have created a web page with a ArcServer application to identify which counties we are currently working on and which ones are completed. The ArcServer application uses the NWI Status layer within our Geodatabase to create the map. Once you check out a county for the updating process, you will need to update the NWI Status layer for that county.

1. Add the NWI Status layer to ArcMap Database Connection > Vector > NWI Other > Status
2. Start Editing
3. Select County and change the status to “In Progress”



Status Layer Definitions

<u>Status</u>

In Progress - County has been checked out and the update is currently taking place

Complete - County has been QA/QC'ed and checked back into the geodatabase

Final - Sent to the US FWS for inclusion in the NWI MGD

<u>Verified</u>

In Progress - Wetlands have been selected for field verification and maps have been sent to cooperators

Complete - Field verified wetlands have been checked, point file has been created, wetlands have been updated, data has been checked back into the geodatabase.

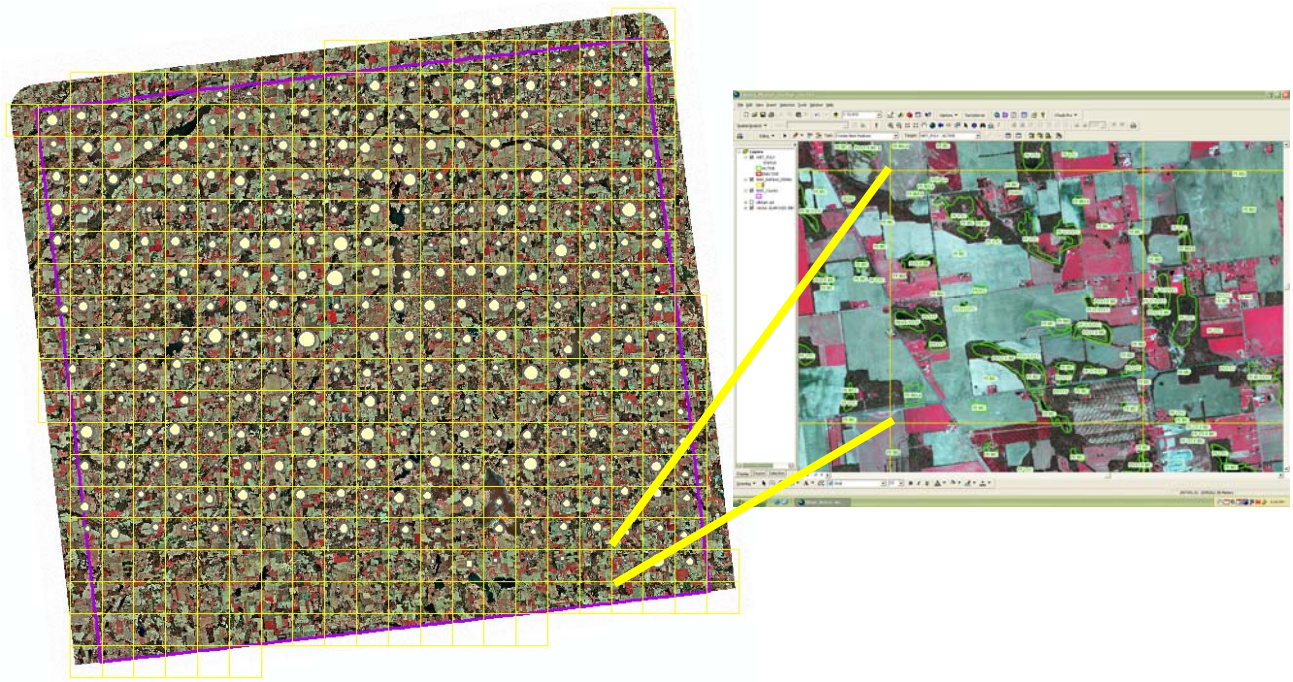
Chapter 6 - Update Process

County Updates

The NWI update will be performed on a county by county basis. Preferably no two counties will be checked out at the same time due to overlapping wetland polygons.

Reference Grid

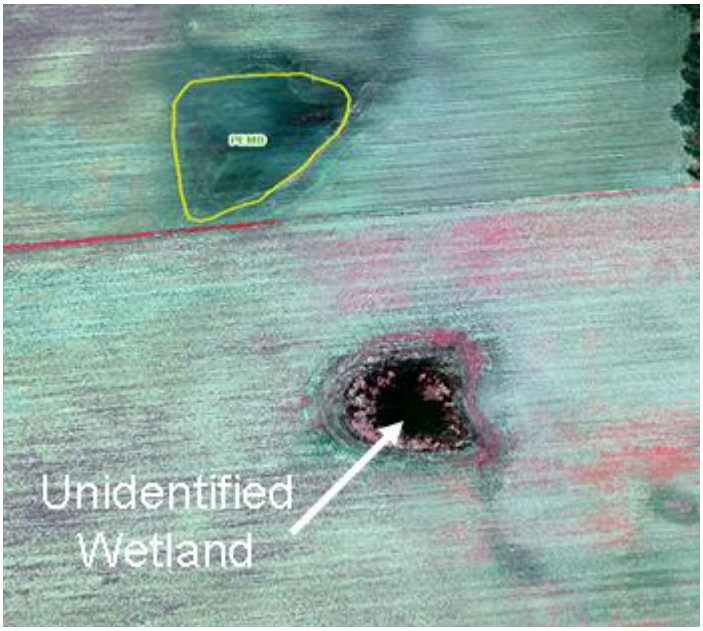
A square mile reference grid was created to track the progress of the NWI update through the county. The grid size was created so that one grid would be viewable at 1:10,000 on the monitor. Once the analyst completes the grid, a graphic is placed in the grid cell to identify its completion. The grid allows the analyst to keep track of the progress and aids in quality control.



Creating a New Feature

Interpretation

The first step in creating a new wetland feature is to identify an unidentified wetland in the aerial photography. In this early spring color infrared image, there is dark area in an agricultural field. This area has different coloring and texture than the surrounding farm field. Also, it does not have plow lines going through it, suggesting that it is too wet to be farmed.



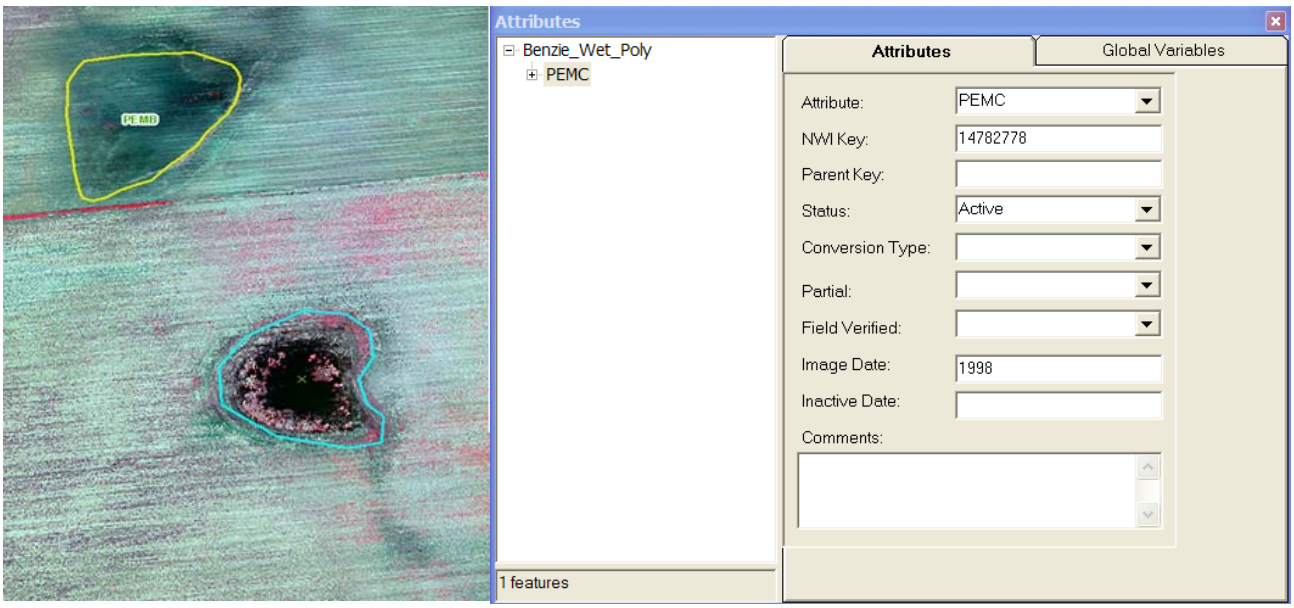
The same area is shown in a summer true color image. This is a good example of an emergent wetland.

Digitize the Feature

1. To digitize this area, click on ‘Start Editing’ in the Editor drop-down box on the Editor Toolbar.
2. Make sure the Task is set to ‘Create New Feature’ and the Target layer is set to ‘WET_POLY:ACTIVE’.
3. Using the Sketch tool, digitize the area around the feature.

Update the Attributes

4. Open the attribute window either by right-clicking on the polygon and selecting ‘Attributes…’ or by clicking on the Attributes button on the Editor toolbar. In the Attribute window that opens, input an appropriate habitat classification value either by selecting the code from the drop down box or by typing it in. The feature in the example has been coded as Palustrine Emergent, which has a code of PEM. Please refer to the Photo Interpretation Guide for determining which NWI code to call the wetland.
5. Note that by default, all newly digitized features will be assigned an NWI Key and will be given a Status of ‘Active’.



Modifying a Feature (Full)

Interpretation

In the lower left corner of the following image, the PUBGx polygon is too small for the current size of the excavated wetland. In this situation, we must replace the existing polygon with a new, larger one that properly represents the current state of the wetland. The original feature will be assigned a Partial value of 'No' and no conversion type indicating that the wetland was modified either spatially or a change in class (emergent to shrub). This change will most often occur with a change in the NWI code (see next example).

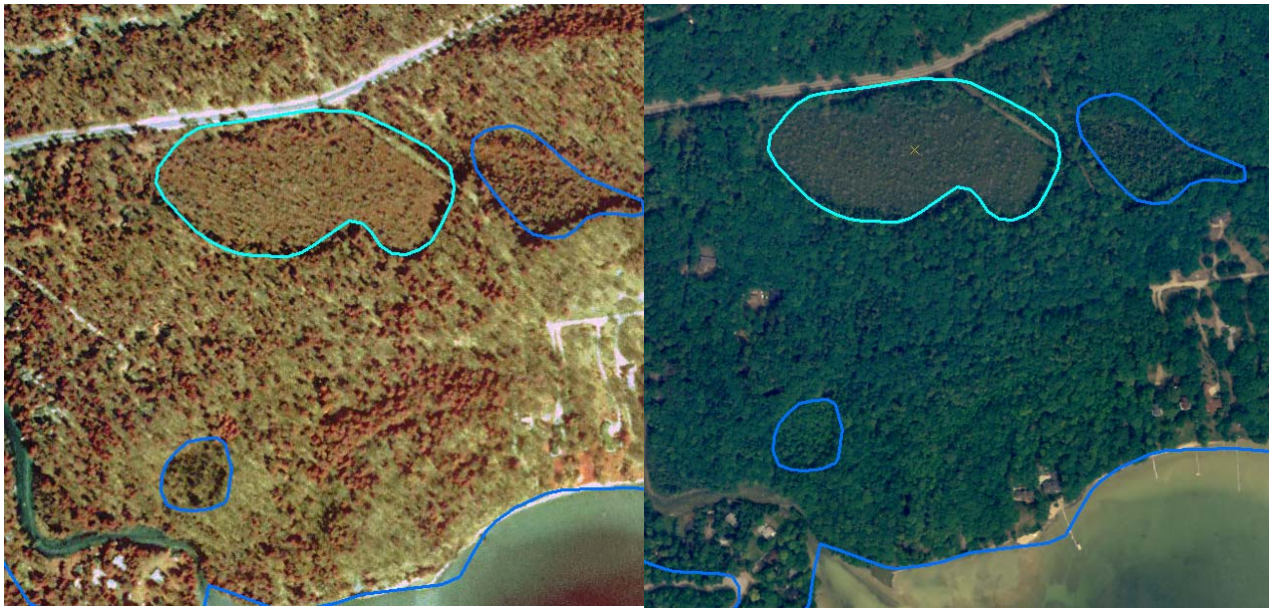
Inactivate the Old Feature

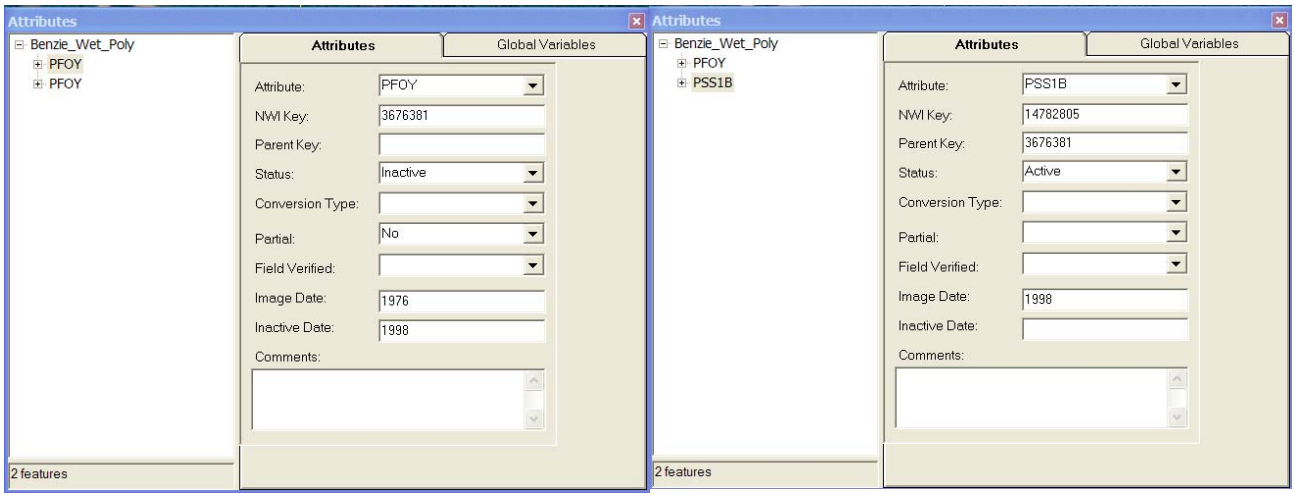
1. Select the polygon and open the Attribute window. Make the following changes:
   - Status = Inactive
   - Conversion_Type = Null
   - Partial = NO
2. Copy the NWI Key to the clipboard.

Create the New Feature

3. On the Editor toolbar, set the task to 'Create New Feature'.
4. Using the Sketch tool, draw a new polygon around the wetland area.
5. Paste the copied NWI Key from the inactivated polygon into the Parent Key field of the new polygon. This indicates that the new wetland feature was created out of the loss of the old.
6. Enter the habitat classification for the new feature in the Attribute field. In the example, the new wetland has been classified as a *Palustrine Unconsolidated Bottom, Permanently Flooded and Excavated*, indicated by a code of *PUBHx*.

In the following example, the selected polygon was labeled PFOY. From the Spring CIR imagery and the summer natural color imagery you can see the tree shadows from the surrounding forest in the SE portion of the selected polygon. This indicates that the polygon is probably not a forested class and should be labeled as a shrub class. This polygon will be copy and pasted with the original PFOY polygon inactivated with no conversion type and partial equal to "No". The new polygon will be labeled as PSS1B with the parent key copied from the NWI Key of the PFOY polygon.

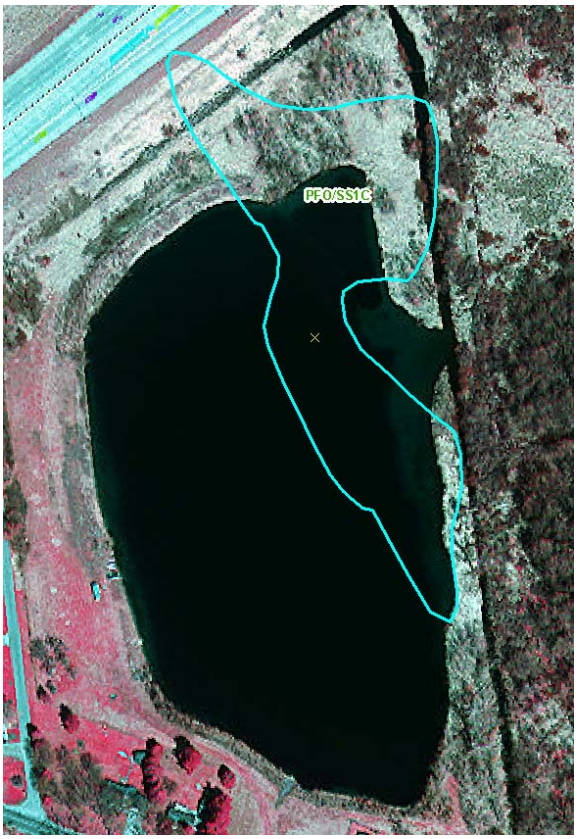




Modifying a Feature (Partial)

Interpretation

In the image to the right, a PFO/SS1C polygon is partially overlapping a newly excavated area. In this case, the original wetland has partially changed its form. The original feature will be inactivated and will be assigned a Partial value of 'Yes', indicating that the existing wetland evolved from the old.



Inactivate the Old Feature

1. Select the polygon, copy the NWI Key, open the attribute table and make the following changes:
   - Status = Inactive
   - Conversion_Type = NULL
   - Partial = YES
2. Copy the NWI Key to the clipboard.

Create the New Feature

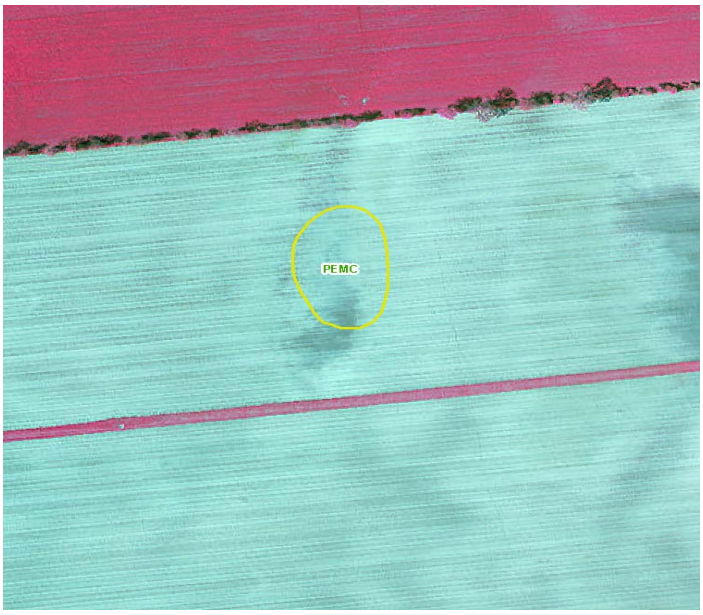
3. On the Editor toolbar, set the task to 'Create New Feature'.
4. Digitize the area around the new, wetland.
5. In the Attribute window, paste the NWI key from the previous polygon into the new polygon's Parent Key field.

6. Enter the habitat classification for the new feature in the Attribute field. In the example, the new wetland has been classified as a *Palustrine Unconsolidated Bottom, Permanently Flooded and Excavated*, indicated by a code of *PUBHx*.

Converting a Feature (Full)

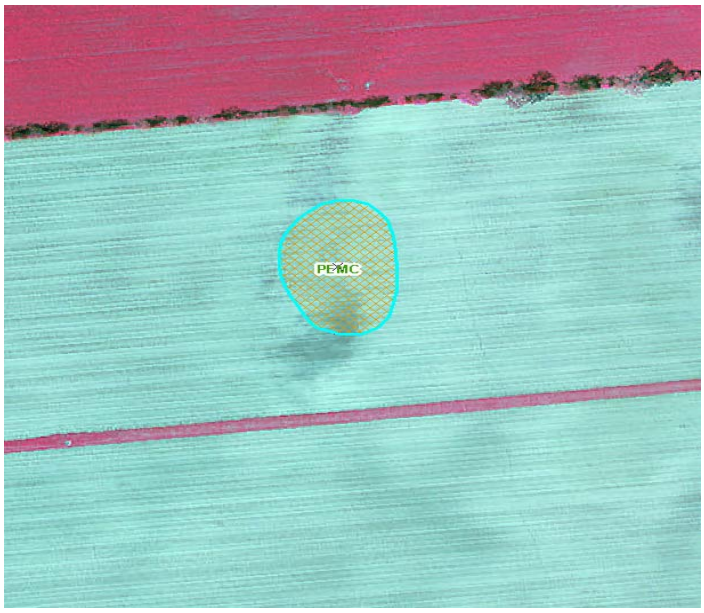
Interpretation

A fully converted polygon is a wetland that no longer has evidence of existence. These polygons have been altered due to Agriculture, Development or Recreation. In cases in which none of these reasons apply, a feature can be assigned a Conversion Type of Other.



Inactivate the Feature

1. Select the converted polygon and open the Attribute Table
2. Change the following Attributes:
    - Status = Inactive
    - Conversion_Type = Agriculture
    - Partial = NO



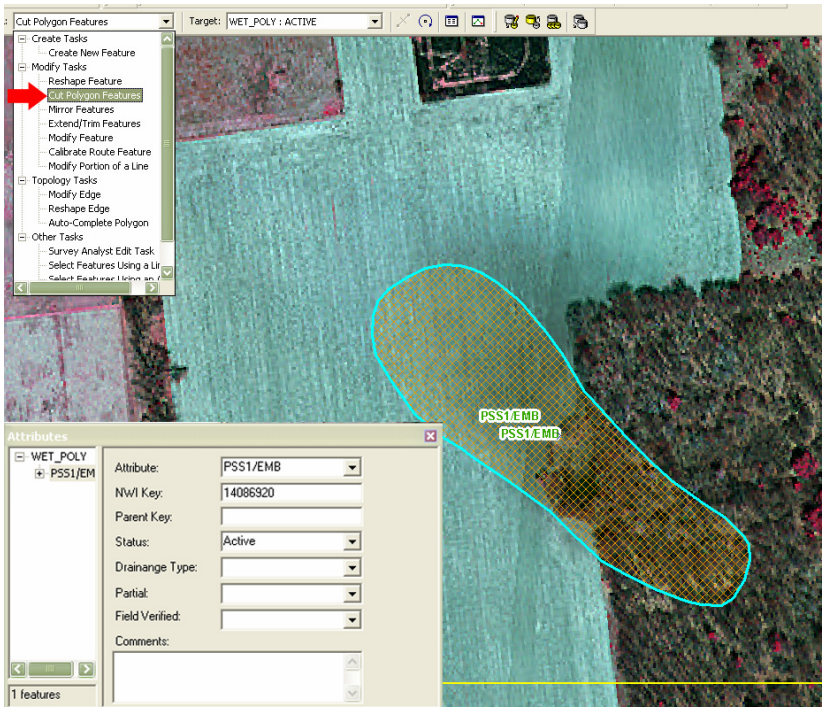
Converting a Feature (Partial)

Interpretation

The wetland represented by the polygon in the following image has been partially converted to agricultural use. The polygon needs to be altered to indicate that the only remaining active portion lies within the forested area.

Copy the Feature

1. Select the PSS1/EMB polygon and copy it to the clipboard.
2. Paste the copied feature into the view. This results in a copy of the original polygon in the same place as the original. The original polygon is automatically inactivated. The new feature is assigned a parent key of the old feature, and is selected for further editing.



Reshape the New Feature

3. On the Editor toolbar, set the task to 'Cut Polygon Features'. Cut the copied polygon along the boundary of the current and former wetland. In the example, the feature is cut along the treeline. Be sure to begin and end the cut outside of the polygon.

Complete Conversion

4. After completing the cut operation, three polygons remain: the original polygon and two new polygons. Select the original polygon and make certain the Status = Inactive. Set the appropriate Conversion_Type, and set the Partial = Yes.
5. Select the new polygon which represents the current wetland extent. Confirm that the Parent Key of this new, active polygon matches the NWI Key from the original, inactive) polygon.
6. Delete the remnant polygon, representing the converted area. This leaves two remaining features: the original, inactive polygon and the new, active one.

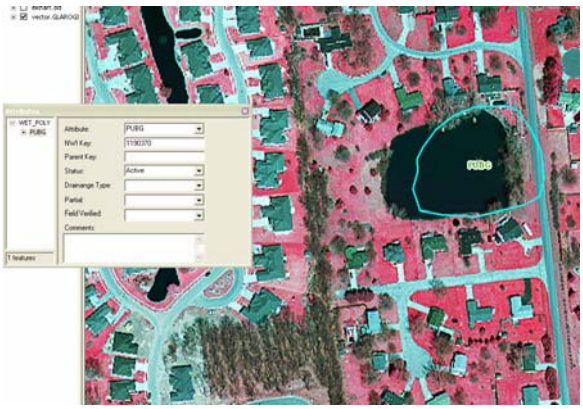
Correcting a Feature

Interpretation

Due to digitizing or georeferencing error, some polygon features do not accurately represent the wetlands from which they were created. If a polygon is clearly meant to cover a wetland area which it currently does not, the polygon should be shifted or otherwise edited to accurately represent the corresponding wetland. In such cases, it is interpreted that the original feature is being corrected. Therefore, no attribute changes shall be made.

Shifting the Feature

1. Click on the polygon to highlight it.
2. Drag the polygon over the wetland.



Correcting the Feature

1. Double-click on the polygon within it to view its vertices.
2. Holding the cursor over a vertex will produce a diamond shape around the vertex. When this appears, one can safely move the vertex without shifting the entire polygon. Continue moving vertices until the polygon accurately portrays the wetland.

(Sometimes using the “reshape feature” task is faster and easier then moving the vertex.)

Changing the Habitat Classification

Interpretation

Sometimes, wetlands evolve from one type to another. In such cases, the Attribute value must be changed to indicate an alteration from one habitat classification to another. In the 2003 summer imagery shown below, there is a polygon labeled *PFO5F*, indicating *Palustrine Forested, Dead, Semipermanently Flooded*.

In the 2005 spring infrared image shown below, we see that the same farm is now being developed. The wetland area is still there, but the trees have been removed, so the *Forested* designation no longer applies.

Copy the Feature

1. Select the polygon, then Copy and Paste it. This action will set the *Status = Inactive* for the original. Manually set the following values:
   - *Conversion_Type = NULL*

- *Partial = NO*.

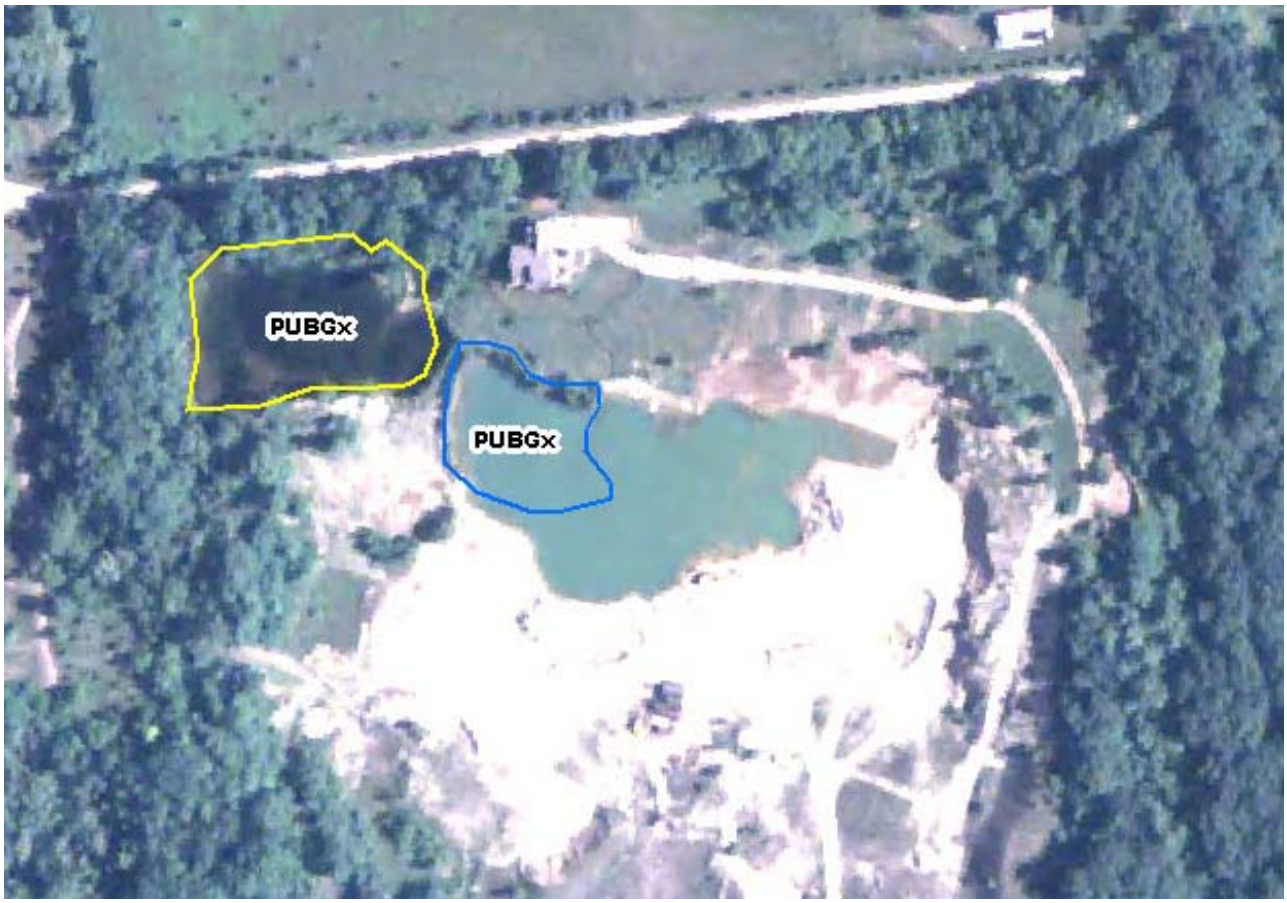
2. Copy the NWI Key from the original feature and paste it into the Parent Key field for the new polygon.

Update the Habitat Classification

3. Change the Attribute to a more appropriate value. In the example, the feature is defined as a Palustrine Unconsolidated Bottom, Intermittently Flooded, Excavated, orPUBGx.
4. The resulting image shows both Attribute values labeled over the wetland area, as well as the orange hashes indicating the inactive parcel. The copied polygon is still active.

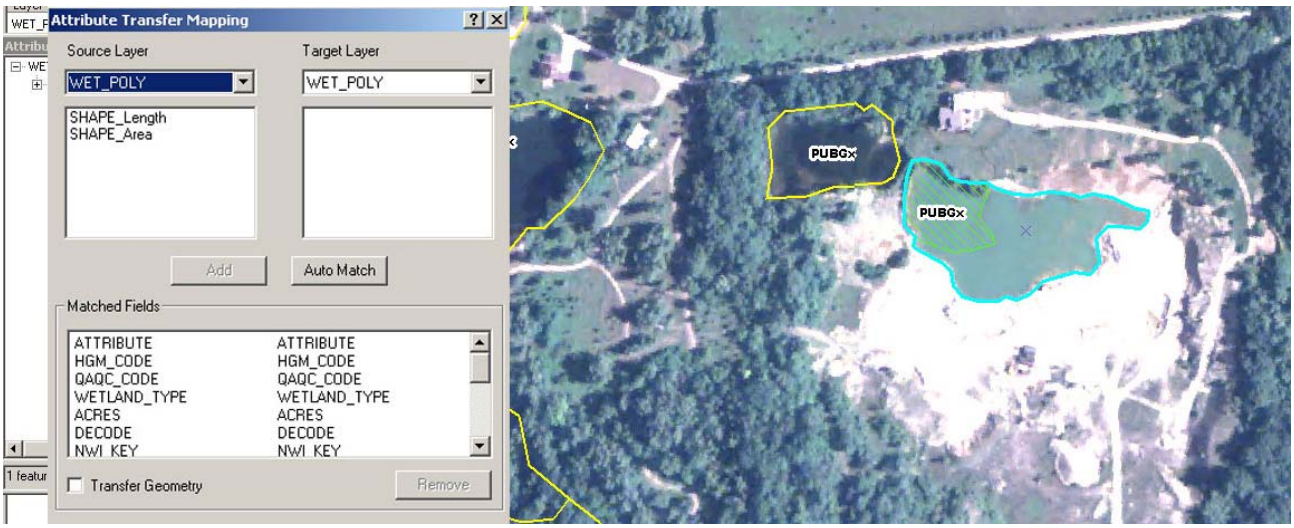
Using the attribute transfer tool

The Attribute Transfer Tool is useful in situations in which a polygon is attributed correctly, but is spatially incorrect. Here is a PUBG polygon that has expanded in the aerial imagery. This wetland must be digitized again to show its correct boundary, as well as the attributes will have to be transferred as this polygon will replace the incorrectly-sized polygon.

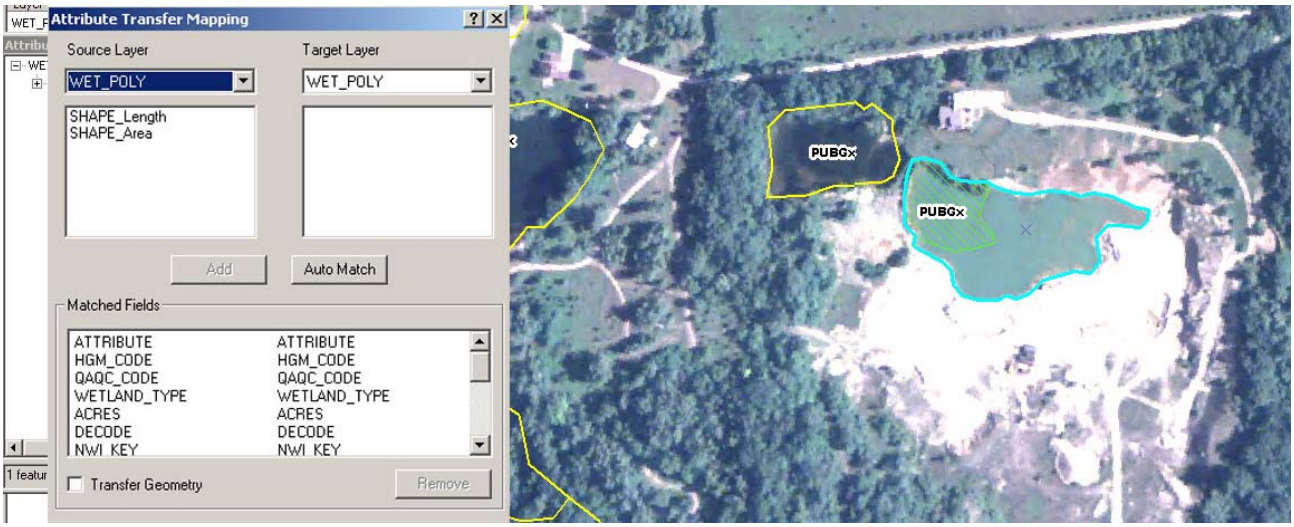


1. Create a new polygon outlining the correct boundary of the wetland.

2. Open the Attribute Transfer Mapping toolbox. In the toolbox, select WET_POLY for the both the Source layer and the Target layer. Then click on the “Auto Match’ button (but DO NOT check the Transfer Geometry) and click OK. This step will only need to be done once for each county being worked on.



3. Deselect both polygons and then click on the Attribute Transfer tool. Click within the boundary of the original polygon (if both polygons overlap, then the “Select a Source Feature” box will appear. Select the original polygon from the list and click OK). Next, click within the boundary of the new polygon.



4. Select both polygons to verify that the Attribute Transfer tool worked properly. If it did, then delete the original polygon.

Here is what the image will look like when this task is completed.

Special Rules and Considerations

1. If a polygon is determined to be fully converted, it can only be a parent to another wetland if there is a specified *Conversion Type*. Otherwise, its NWI Key is never copied and pasted into a new wetland.
2. Wetland features with invalid habitat classification attributes can be corrected without further edits being made.

Backups

Ducks Unlimited does not back up individual computers. It is the responsibility of the analysts to create a zip file of the personal database and map document on at least a daily basis and copy the zip file to the network drive (W:\GreatLakes_NWI_Update\Data Backup).

QAQC Procedures

Once the photo interpreter has completed the NWI update for a county, the version will undergo quality assurance/quality control (QA/QC) before the database administrator posts the version to the DU MGD. The first QA/QC process involves two steps. The first is to run DU's 17-step attribute verification tool that checks for any errors in the additional attributes that were added by DU. The second step is a topology validation in which it is confirmed that no active features overlap and no inactive features overlap. The second step in the QA/QC process is for a different interpreter to visually verify 10% of the county. The third step is to run the USGS NWI attribute and verification tool (created through a cooperative effort between the U.S. Fish and Wildlife Service and the U.S. Geological Survey) to check for NWI attribute errors and spatial errors. The counties must pass the USGS attribute and verification tool in order for the USGS to accept the update back into the USGS MDG. (For more information on the USGS NWI attribute and verification tool, see http://capp.water.usgs.gov/FWS_web/tools.htm.) Once the version has completed the QA/QC process, it will be posted to the DU MGD by the database administrator. This posting process will update DU's Master NWI geodatabase and effectively make any and all edits permanent.

During the QA/QC procedure, geodatabases are stored at W:\NWI_Update\GreatLakes_NWI_Update\Finished Geodatabases, and status is tracked via the QAQC Status.xls spreadsheet that is located in that directory.

Self Validation

DU NWI QA/QC Validations

The data editor runs 17 data validations on the *wet_poly* dataset as a first step in the QA/QC process. As previously discussed, the validations were designed by GLARO to assure adherence to logical and technical rules for the dataset. The validations are listed below:

Test 1: If a feature is inactive and was created prior to 1998, it shouldn't have parent key.
Test 2: The parent key should not equal the nwi key for a single feature.
Test 3: The nwi key cannot be duplicated.

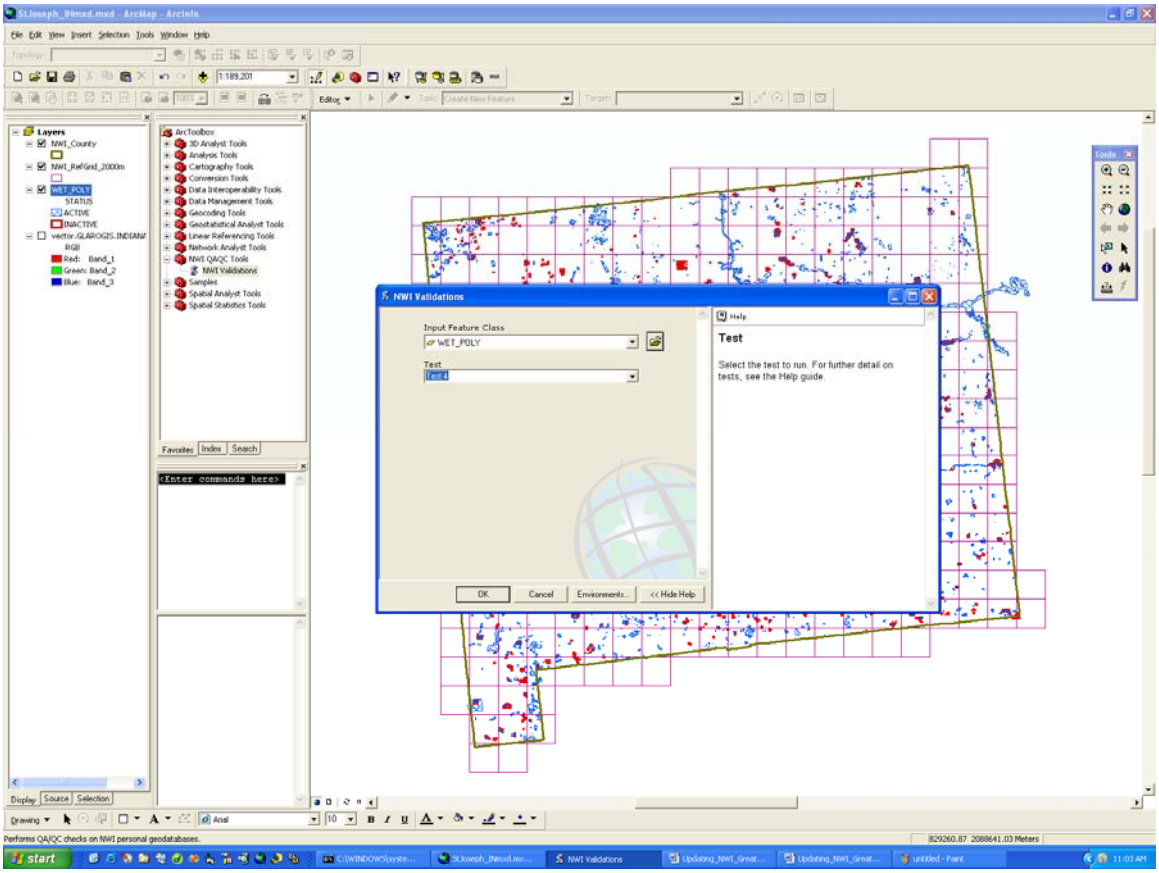
Test 4: Active features should not have drainage types or partial values.
Test 5: If there is a drainage type, partial should be attributed.
Test 6: If a feature is fully drained, it cannot be a parent to another feature.
Test 7: If partial equals yes and drainage type is null, the parent and child objects must have different attributes.
Test 8: Inactive date cannot be earlier than or equal to image date, or be null, on inactive features.
Test 9: If partial equals yes, a feature should be the parent key to an active feature. If partial equals no and drainage type is null, a feature should be the parent key to an active feature.
Test 10: If a features is inactive, partial must be attributed.
Test 11: All features should be active or inactive.
Test 12: All features should have an attribute value.
Test 13: A feature's parent key should always be the nwi key on an inactive polygon.
Test 14: The attribute must be valid on active features.
Test 15: Image Date must not be null or 0, and cannot be greater than 1997 for original features (with few exceptions).
Test 16: Active features cannot have inactive dates.
Test 17: The inactive date on a parent feature cannot be greater than the image date on its child.

First, the operator that worked the county will run a set of tests via ArcToolbox. To install the NWI QAQC Toolbox, follow these steps:

1. Open ArcMap, show the ArcToolbox window by clicking on the icon:
2. Right-click on the ‘ArcToolbox’ header and select ‘Add Toolbox’.
3. Navigate to V:\Installs\GIS Misc\NWI\QAQC Toolbox, select ‘NWI QAQC Tools’, and click ‘Open’. This adds the toolbox to your map document.
4. Right-click on the ‘ArcToolbox’ header again and select Save Settings > To Default. Now, every time you open ArcToolbox, the NWI QAQC Toolbox will be included.

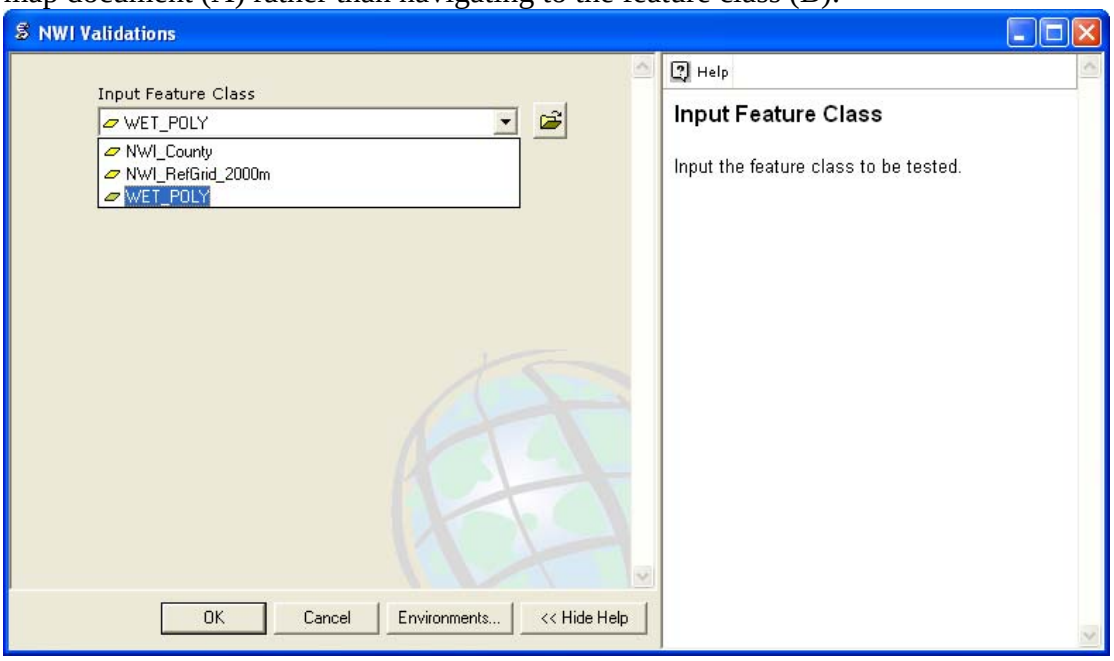
To use the toolbox, you first need to set up your data validation environment. Add the wet_poly feature class to be validated as well as any relevant imagery and other data. Begin an edit session before running the validation script.

The validation script can be run two different ways. First, it is executed by double-clicking on the NWI Validations script in the NWI QAQC Toolbox. Select the wet_poly feature class and the appropriate test.

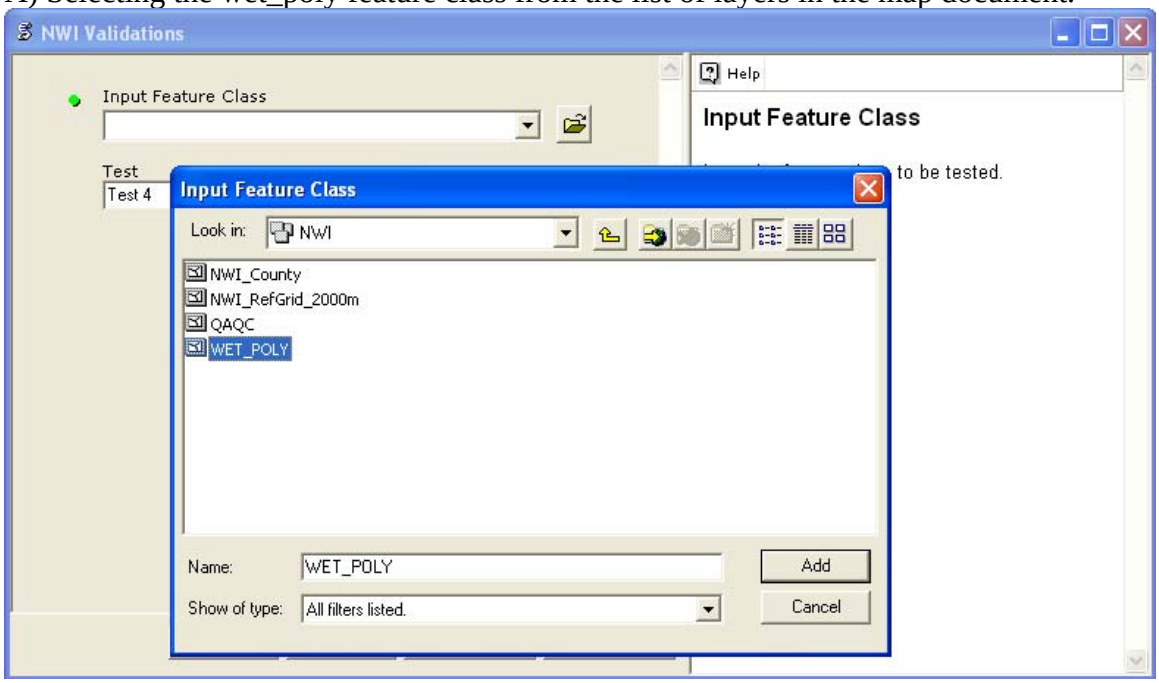


Second, it can be run via the command line. Show the command line window by clicking on the appropriate icon: Run the test by typing “NWI_Validations” followed by the input feature class and the test. For example: NWI_Validations WET_POLY 'Test 1'

Run the tests in order, being sure to select the wet_poly feature class from the list of layers in your map document (A) rather than navigating to the feature class (B).

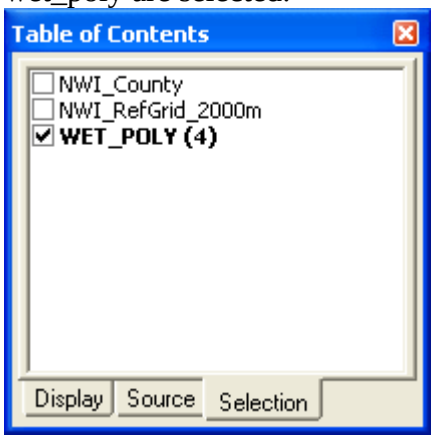


A) Selecting the wet_poly feature class from the list of layers in the map document.

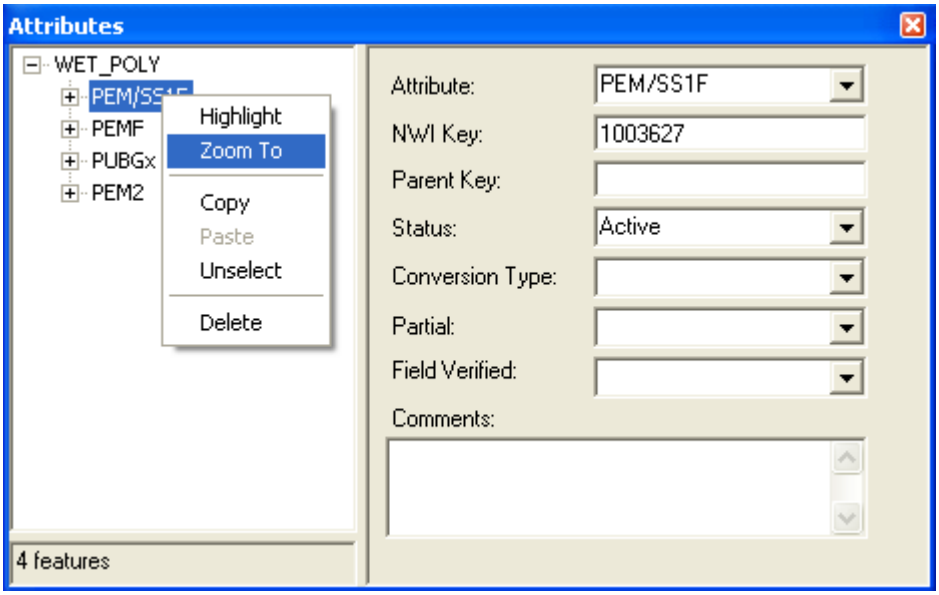


B) Selecting the wet_poly feature class by navigating to its location on disk.

Each test selects features that fail, but does not automatically refresh the view. To see if any features were selected, click on the 'Selection' tab in the Table of Contents to see how many features in wet_poly are selected:



To view selected features, refresh the view, or use the attribute inspector to zoom to each. The attribute inspector will automatically list all selected features in its left window pane. You can zoom to each by right-clicking on the feature label and selecting 'Zoom To':



Further detail on each test is included in the Help for the NWI Validations script. Access the help by right-clicking on the script and selecting 'Help', or by clicking on the Help button on the script dialog window.

Topology
Additionally, no active features should overlap active features and no inactive feature should overlap inactive features. To validate topology, a topology rule must be created in the personal geodatabase. Active and inactive overlaps must be tested separately.

1. Open ArcCatalog, navigate to the personal geodatabase and select the NWI feature dataset.
2. Right-click and select New > Topology.
3. Accept the default name and cluster tolerance.
4. Select the wet_poly feature class to participate in the topology.
5. Accept the default rank.
6. Add the rule that active features must not overlap one another. To select active features only, drop down the feature class combo box and expand the wet_poly feature class.
7. Finish the wizard and validate the entire topology.

To view and edit topology errors:

8. Open ArcMap. Add the topology rule and associated feature class.
9. Add the Topology toolbar to the map document.
10. Start editing the wet_poly personal geodatabase feature class
11. Use the error inspector and topology validation tools to correct and track errors.

Once complete, the topology rule must be changed to validate inactive rather than active features. To do so, close out of ArcMap and return to ArcCatalog. Edit the topology created earlier, removing the previous rule and replacing it with one for inactive features. Validate and correct errors as before.

Cross Validation

A different data editor is asked to review 10% of the completed counties updates as the second stage in the QA/QC process. This is done by randomly selecting 10% of the 2000 meter grid cells that

intersect the county. Do so by adding the NWI_RefGrid_2000m feature class from the personal geodatabase. Manually select 10 percent of the grid features, and export to a 'QAQC' feature class in the same geodatabase. (This preserves a record of the area that was checked.) Visually inspect all selected grid cells. If the reviewing editor finds an unacceptable amount of errors, the county is sent back to the original editor for revision and the QA/QC process begins anew.

Administrator Validation

As the third and final step in the QA/QC process, a data administrator reviews the county's NWI update. The data is spot checked at the beginning of the process and visual inspections continue throughout the final stage of QA/QC. After the initial spot check, the FWS' attribute validation tool is run. Once any errors found by the FWS' tool are corrected, DU's 16 validations are rerun. If any errors are found, they are corrected. All of the steps are repeated until both sets of validations find no errors. The final step is to revalidate topology.

Checking In Data

Upon completion of QA/QC process for each county, the data must be checked back into the database.

Check In Edits

1. Open ArcMap, add the wet_poly personal geodatabase feature class.
2. Click 'Check In' on the Disconnected Editing toolbar. Leave 'Reconcile and Post with parent version' unchecked and click 'Finish'. Access the SDE feature class as the user which checked out the edits. Connect to the version that is checked out (Although any version can be used at this point, it will be important in the next step that you connect to the checked-out version, so it is best to establish that connection now.) This will allow ArcMap to unregister the checkout after checking in the data.

Reconcile and Post Edits

3. Add the wet_poly feature class from the SDE database. Connect as the user that checked out the edits to the version that is being checked in.
4. Start editing the SDE workspace.
5. Click on the 'Reconcile' button on the Versioning toolbar.
6. Reconcile against the sde.DEFAULT version.
7. Click on the 'Post' button on the Versioning toolbar to post the edits to the sde.DEFAULT version.

Update NWI Status layer

Once the update NWI county is reconciled and posted to the SDE databse, the Analyst updates the NWI status layer for that county to "Complete". This information then gets posted to the web site

for the cooperators to view. At this stage the county has been updated, but still needs to go through the field verification step in order to be “Final”.

Post Completed Counties on Web Site

The completed counties will be posted on the DU NWI web site in shapefile format. This allows the cooperators to use the draft data and provide feedback before the update is finalized.

Chapter 7 - Field Verification and Assessment

The field verification will serve two purposes: 1) to help clarify any wetlands that are ambiguous in the photo-interpretation process, and 2) to access the accuracy of the NWI update. Field staff from project cooperators and DU will be used for this process as available.

Ambiguous Wetlands

During the interpretation process, there will be some wetlands that can't be positively identified by wetland type or determine if it still exists from the digital orthophotography. In these cases, the wetlands will be flagged in the NWI geodatabase and a map will be made for field inspection. The maps will be sent to the field staff for field inspection to determine their wetland type and status. Once determined, the NWI geodatabase will be updated with the field verification information and noted in the attributes that the wetland was field verified.

NWI Assessment

The NWI assessment will primarily be an assessment of the wetland status and class. It will not be an assessment of the full NWI classification scheme (subclass and modifier level). Funding to perform a full accuracy assessment of the wetland types is cost prohibitive for this project. The goal of the field assessment is to sample 1% of the wetlands per county and assessing the status and wetland class through a simple field card and digital photo. DU does not have enough field staff to visit all of the sites, so a database of field staff from DU cooperators and volunteers for the Great Lakes will be generated that includes the geographic area each field staff is willing to visit. Once the field samples are selected, they will be sent to the field staff in the representative areas for field verification.

The 1% sample will be stratified based on wetland class and status. Only wetlands close to roads or on public land will be chosen. Once the samples are generated, a field inspection will be conducted by driving to each site, recording the wetland type, and taking a digital photo of the wetland. The methods for the field inspection will be patterned off of Ohio NRCS's field inspection of wetlands in 2006. The resulting field data and photo will be entered into the DU MGD. An error matrix and Kappa statistic (Story and Congalton, 1986) will then be compiled and analyzed by comparing the photo interpretation to the field conditions.

Field Verification Goal

Following updates to the National Wetlands Inventory (NWI), Ducks Unlimited's Great Lakes/Atlantic Regional Office (GLARO) will conduct an accuracy assessment of the inventory's wetland classifications. The assessment will (1) evaluate the accuracy of classifications assigned to wetlands original to the NWI, (2) evaluate the accuracy of classifications assigned to wetlands new to the NWI and (3) evaluate the accuracy of wetlands identified as converted. 1% of wetlands within the updated NWI will be field verified.

Field Verification Process

Participants

GLARO will contact cooperating partners and volunteers to identify those willing to assist GLARO in field verification. Typically, participants will be familiar with wetland classifications. GLARO will then match participants with wetlands within areas that they may conveniently visit.

Field Verification Materials

Each participant will be provided with: a set of directions, maps of the wetlands to be field verified, and a photographic guide to wetland classification. GLARO will also provide disposable digital cameras to participants who require them.

What is asked of participants?

Participants will be instructed through provided directions to visually inspect each wetland, assign a wetland classification and then take a photograph. The participants will then be instructed to return all field verification materials to GLARO.

Wetland Selections

Percentage Goal

GLARO intends for 1% of all wetlands within a county to be field verified. As a variety of problems may prevent the successful verification of a wetland, a surplus of wetland selections will ensure that this goal is met. 2% of wetlands will therefore be selected for field verification. The entirety of this 2% selection will be given to project participants with the intention of at least 1% visited in the field.

Grouped Selections

As previously stated, this assessment intends to (1) evaluate the accuracy of classifications assigned to wetlands original to the NWI, (2) evaluate the accuracy of classifications assigned to wetlands new to the NWI and (3) evaluate the accuracy of wetlands identified as converted. Wetlands, therefore, will be separated into three groups to select wetlands for field verification. The groups are:

1. Wetlands original to the NWI. This includes wetlands unaltered by updates and also wetlands that had been included in the original NWI that have been modified.

2. Wetlands new to the NWI. This includes only wetlands not associated with any wetland included in the original NWI.

3. Wetlands identified by the updated NWI as converted.

Class Selections

To ensure that wetlands selected for field verification are representative of the actual population of wetlands, wetlands will be selected from the above groups stratified by classification type. To clarify, within each group of wetlands, subgroups designated by classification type will be identified

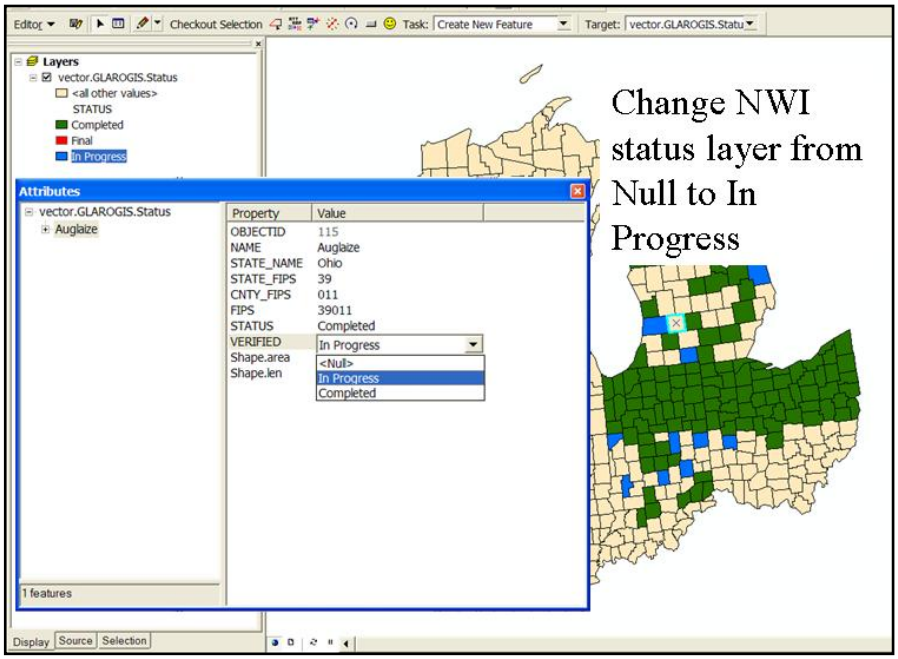
and then selections made from each subgroup. Note, however, that the assessment will recognize only differences in classification according to class level, not subclass or modifiers.

Limited Selection

The assessment recognizes that it is not realistic to expect, or even request permission to inspect wetlands on private property. To accommodate this restriction, only wetlands within 90 meters of a roadway (approximately the distance of one football field) will be selected for verification.

NWI Status Layer

Before the analyst begins the wetland selection process, the "verified" attribute is changed to "In Progress" in the NWI status layer. This allows the manager and staff to identify which counties have started the wetland selection process for field verification.



Wetland Selection Methodology

To select wetlands according to the above specifications, a GIS-based methodology has been developed. This process is performed on a per-county basis. The methodology is outlined below:

1. Navigate to the Field Verification Tool installation package located at V:\Installs\GIS Misc\NWI\Field Verification Selection\Package\setup.exe. Complete the installation process. This step only needs to be done once so if you have already completed the installation please move on to step 2.
2. If one does not already exist, create a folder in your D:\Working folder named 'Field Verification'
3. In ArcCatalog, create a new personal geodatabase in your Field Verification folder named Countyname_Stateabbreviation_FV (i.e. Huron_OH_FV).
4. In that new PGD, create a new polygon featureclass named FIELD_VERIFICATION. Import the coordinate system and the schema from the SDE WET_POLY layer.

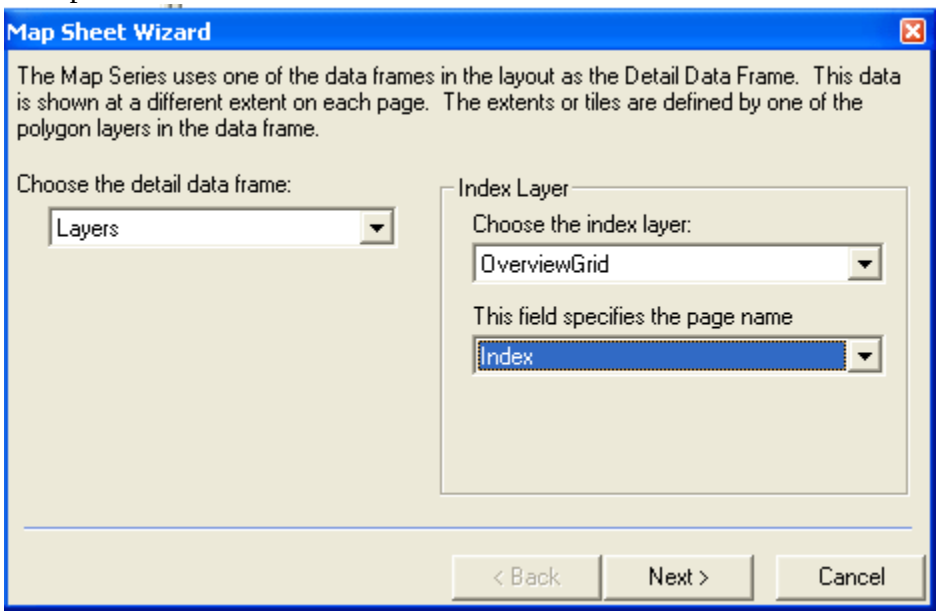
5. Open arcMap and add the SDE WET_POLY and NWI_COUNTY layers to the new map document.
6. If you have already installed the FVSelect.dll, please continue to step 7. Otherwise, Navigate to Tools > Customize > Commands > Add from File and add the FVSelect.dll from the folder C:\Program Files\FVSelect.
7. Navigate to the NWI category in the Categories Window and from the Commands window drag both the 'Select NWI' and 'Field Verification Selection' buttons to the toolbar.
8. Click on the 'Select NWI' button and choose the state and county of interest, then click on the 'Select' button.
9. Extract (do not check out) the selected features to your County's PGD and choose to change the layers and table to point to the extracted data.
10. Add the SDE GrtLks_All_Roads layer to the map document. Select by location all roads intersecting your county and export as a feature class *in the same projection as the data frame* into your County's PGD. This feature class should be named 'GrtLks_All_Roads'. Add to map document. Remove the SDE GrtLks_All_Roads layer from the map document.
11. Add the Vector.GLAROGIS.PARENT TABLE from the vector database on SDE to the map document as well as the new FIELD_VERIFICATION layer from your PGD.
12. Make sure the following are true:
    a. These feature classes must be present and have these specific names in the TOC:
        i. WET_POLY
        ii. GrtLks_All_Roads
        iii. NWI_COUNTY
        iv. FIELD_VERIFICATION
    b. The parent table must be in the map document and must be the only table in the map document
    c. There must not be any raster layers in the map document
13. Begin an edit session *with the FIELD_VERIFICATION layer as the current editable layer*.
14. Click the 'Field Verification Selection' button to start the selection process.
15. Once the selection is completed, save edits and stop editing session.
16. Backup your County's PGD to the appropriates State's folder in W:\GreatLakes_NWI_Update\Field_Verify

Creating Field Verification Maps

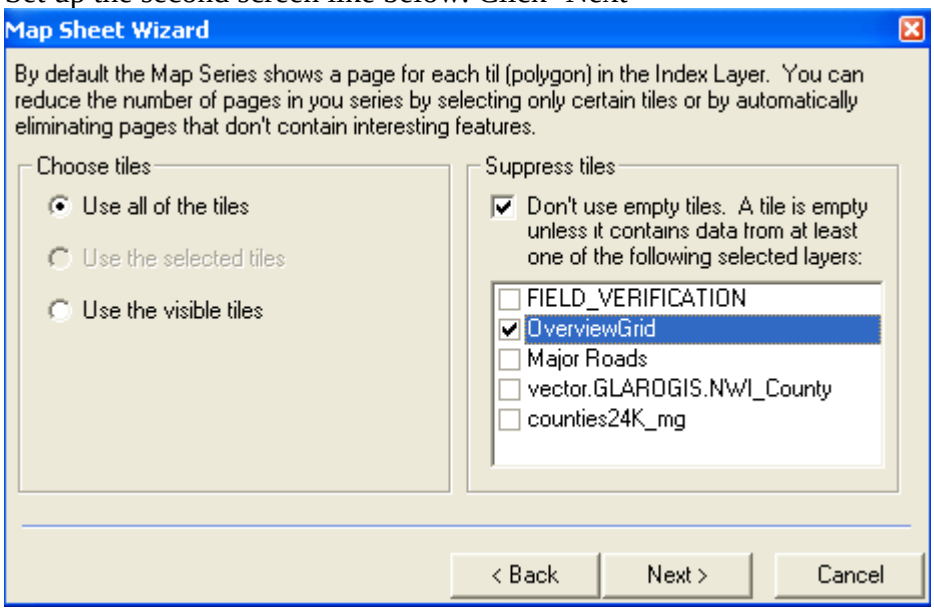
Create Overview Map of County

1. Make sure before you begin that the MapBook is installed on your computer. It will appear as a tab on the Table of Contents in ArcMap. If not, navigate to V:\Installs\GIS Misc\extensions\DS_MapBook\DS Map Book v2 Edited_install.bat to install a customized version of the extension.
2. If you haven't already, copy the 'Field_Verification_OverviewMapbook_Template.mxd' and 'Field_Verification_Mapbook_Template.mxd' files from W:\GreatLakes_NWI_Update\Field_Verify into your FIELD_VERIFICATION folder on your D:/ Drive.

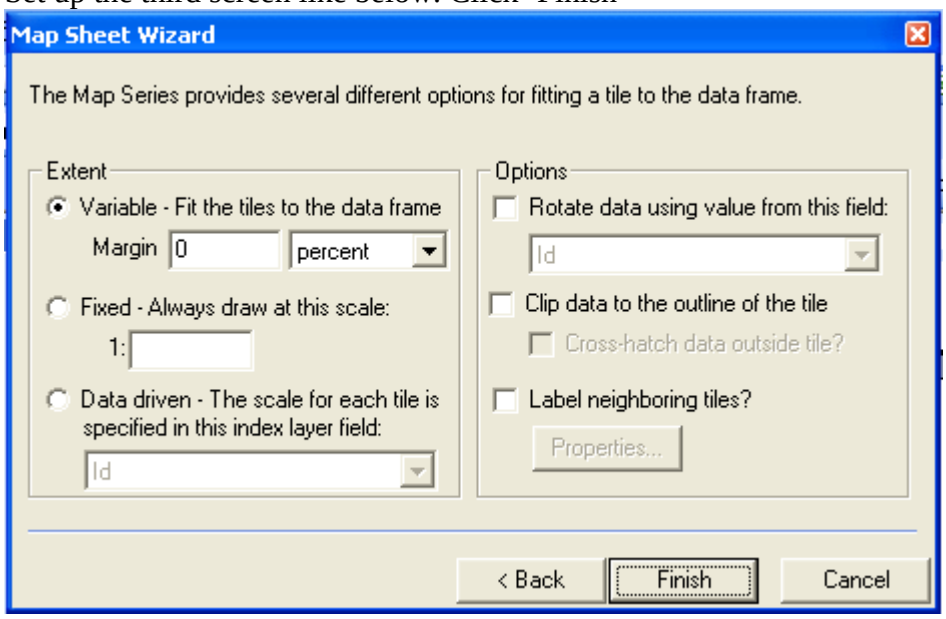
3. Create a new polygon shapefile named “Overview Grid” saved to your D Drive that will be used to divide the County into 4 parts. Add a text field named “Index”. This shapefile can be reused and is just for cartographic purposes so this step only needs to be done the first time you complete this process.
4. Open ‘Field_Verification_OverviewMapbook_Template.mxd’ and view the data source properties for the FIELD_VERIFICATION featureclass. Reset the source to the FIELD_VERIFICATION feature class for the County you are printing field maps for. Zoom to this layer.
5. Symbolize the vector.GLAROGIS.NWI_County featureclass by the County of interest with a White background and All Other Values gray.
6. Reset the data source to the Overview Grid shapefile that you created in step 3. Start an editing session on this shapefile and delete all features in the shapefile. Create a square around the County of interest and then cut this square into 4 quadrants and fill in the text field you created for the shapefile with the number of the quadrant.
7. Update Title with appropriate County name and placement.
8. Print the map.
9. Label the FIELD_VERIFICATION feature class by the NWI_KEY field.
10. Click the ‘Map Book’ tab in the TOC and right-click ‘Map Series’ and delete series if one exists already. Right-click ‘Map Book’ and choose ‘Add Map Series’.
    a. Set up the first screen like below. Click ‘Next’



b. Set up the second screen like below. Click ‘Next’



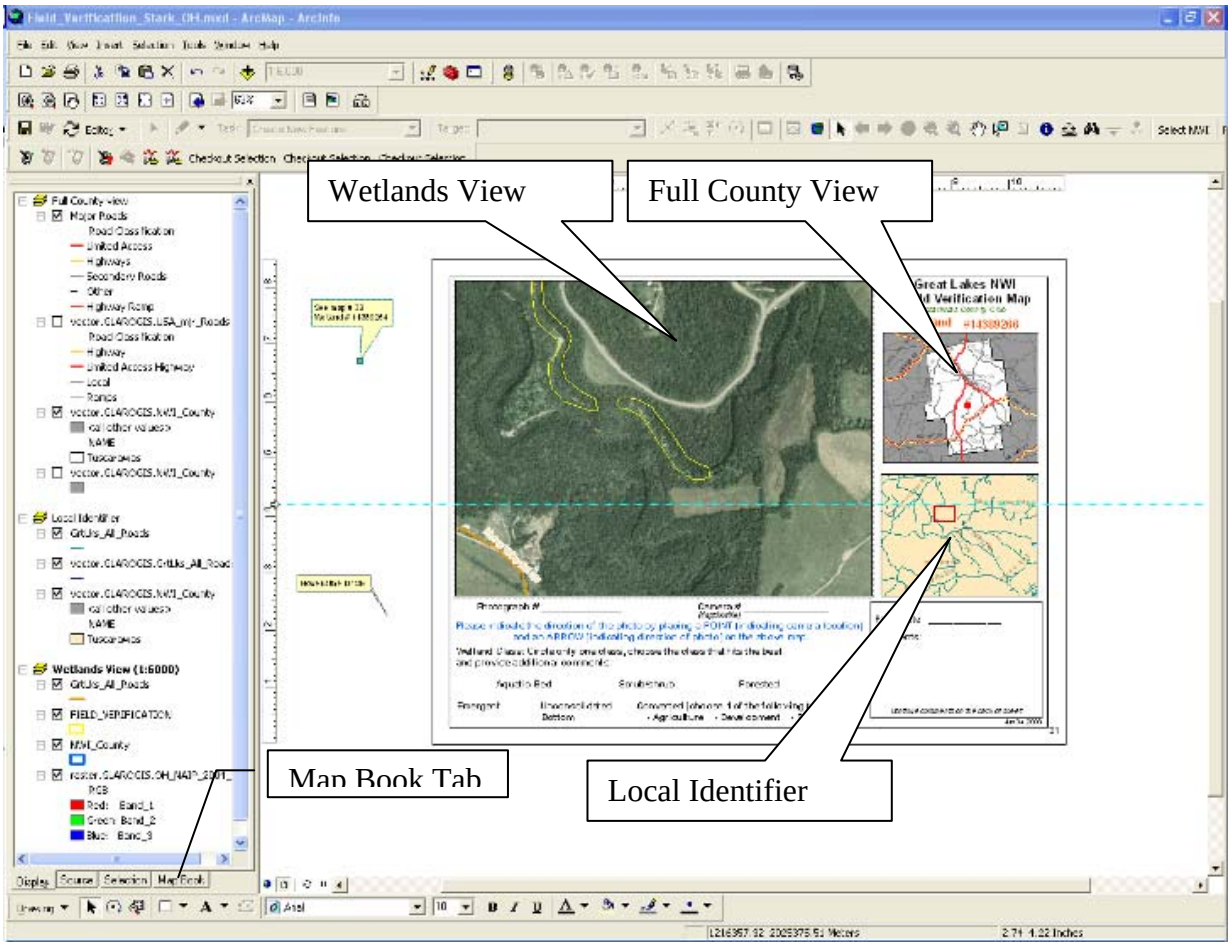
c. Set up the third screen like below. Click ‘Finish’



11. There are now maps for each quadrant you created. Double Click page 1 and change the title to “X County Page Y” and then print the page. Do this for each page.

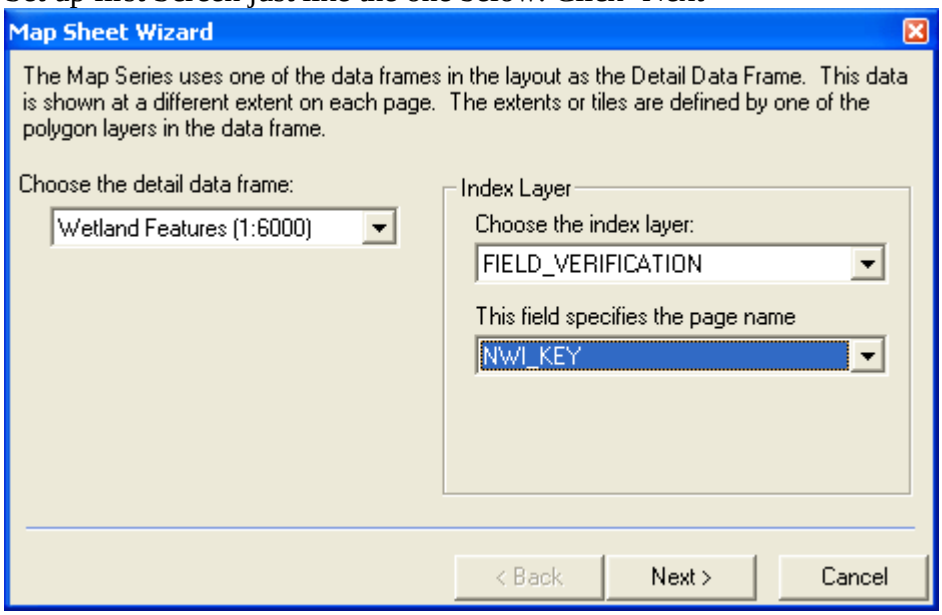
Create the Field Maps

1. Open the Field_Verification_Mapbook_Template.mxd file. Edit the county and state in the top-right corner of the layout.

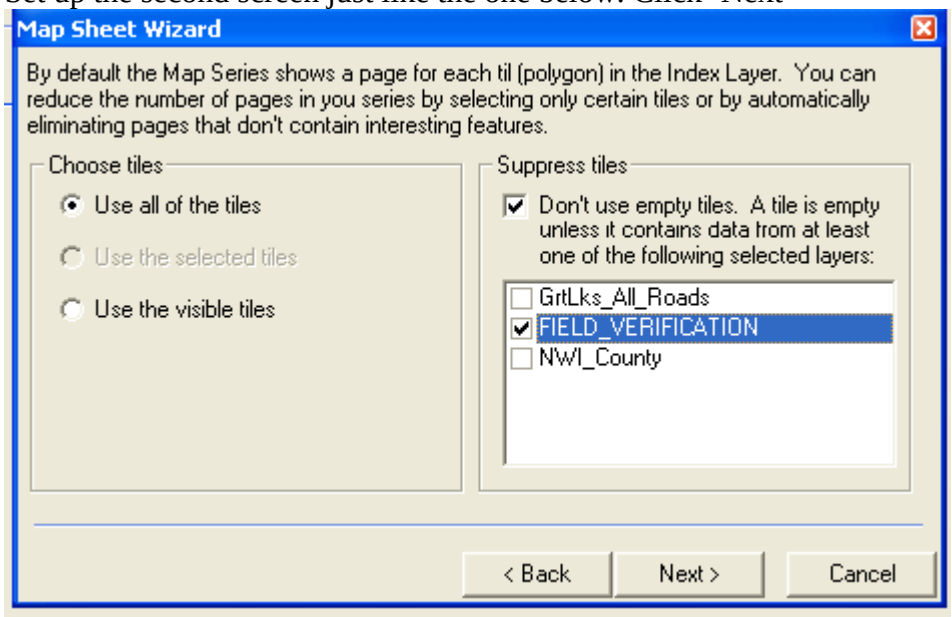


2. Update the TOC for the specific County
   a. Start with the 'Full County View' data frame. Change the County symbology to your County of interest. This County should be White while all other values are gray. Pan the data frame so it can be seen on the map and tweak the scale so you can see the entire County.
   b. Change the 'Scaled Local Identifier' data frame next. For the GrtLks_All_Roads feature class, set the data source to the GrtLks_All_Roads featureclass from your PGD for the County of interest. Also for the vector.GLAROGIS.NWI_County feature class change the symbology to your County of interest with the same beige color and all other values gray. Note: This data frame should stay at the scale 1:120,000.
   c. Finally, change the Wetlands Features (1:6000) data frame. For the GrtLks_All_Roads, FIELD_VERIFICATION, and NWI_County feature classes set the data sources to the data from your PGD for the county of interest following the same procedure seen in the above step. Pan to your County. Note: This data frame should stay at the scale 1:6,000.
   d. In the top right corner of the map, change the name of the County to your County of interest.

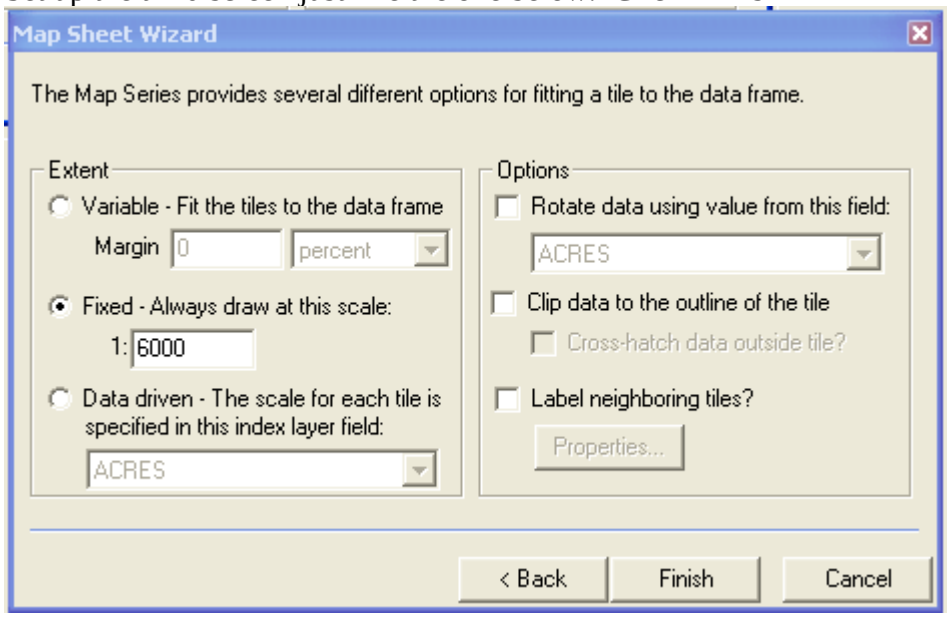
3. Click the Map Book Tab in the TOC. Right-click 'Map Series' and Delete Series if one exists. Right-Click 'Map Book' and select 'Add Map Series.'
   a. Set up first Screen just like the one below. Click 'Next'



   b. Set up the second screen just like the one below. Click 'Next'



c. Set up the third screen just like the one below. Click 'Finish'



d. The map book is now all set up and ready. Double-click on page 1

4. There are Extent Windows set up in the Full County View and Local Identifier Data Frames based on the Wetlands View (1:6000) data frame. The one in the Full County View data frame will appear as a red dot somewhere in the County. For the Local Identifier data frame, you will need to pan around the county to find the red square extent window. Make sure to have this centered for each map.
5. You will need to do these last 2 steps manually for each map.
   a. Note: If there are more than 1 wetland in the Wetlands View (1:6000) data frame, create a callout graphic pointing to the wetland(s) that is not the primary focus of that map.
   b. Note: Sometimes a wetland is too large to fit fully in the Wetlands View (1:6000) data frame at the 1:6000 scale. If this is the case, right-click 'Map Series' and select 'Series Properties. Change the Extent to Variable with a 5% margin and click 'Finish'. You will have to refresh the current page you were working on for this to take effect. Make sure however that after you are finished with that current page, to go back to the 'Series Properties' to change the extent back to Fixed at 1:6000.
6. After the first map is complete right-click the page you are on and click 'Print Page'.
7. Double-click on the next map and follow steps 4-6 until you finish all maps.

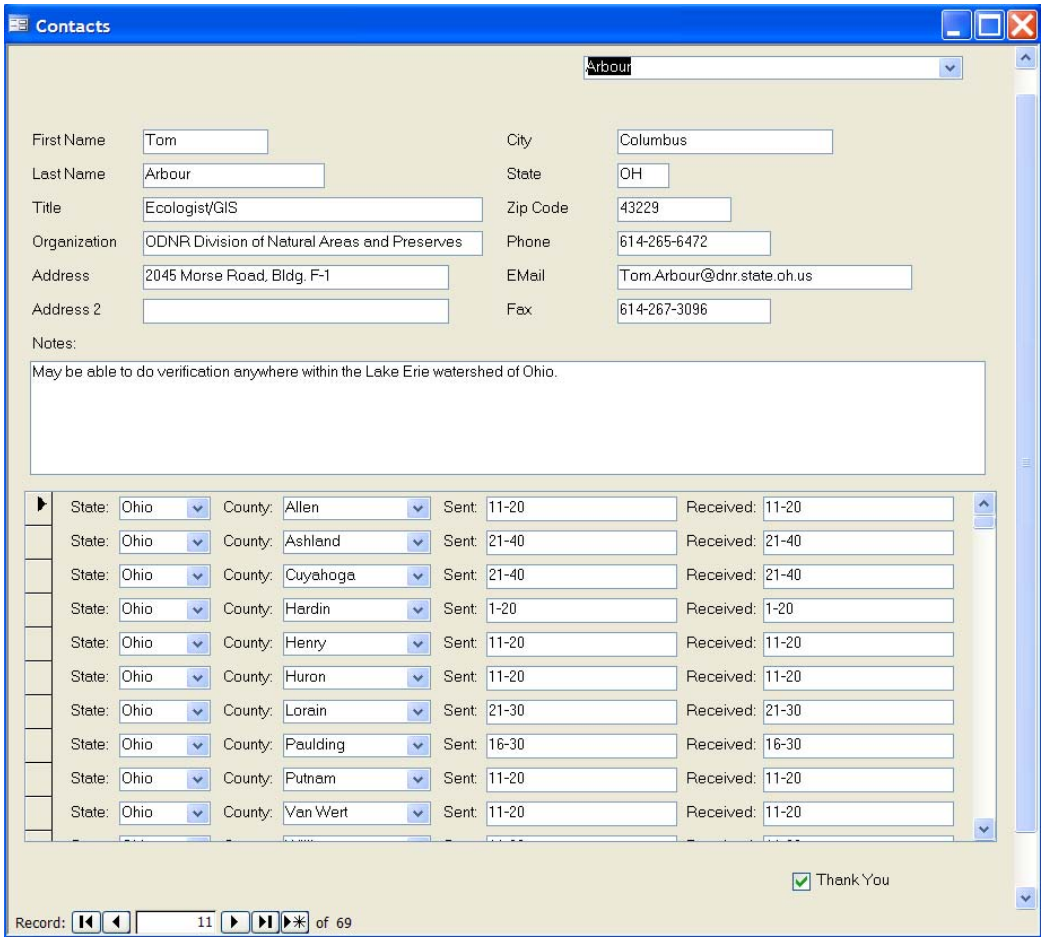
Field Verification

Once the field verification maps are created they need to be sent to cooperators or visited by DU staff. This project does not have a lot of time budgeted to perform the field verification; therefore most of the field verification will be performed by cooperators or volunteers.

Cooperator Database

In order to keep track of the cooperators and volunteers for the field verification, a database was created that keeps track of the name and address of the individuals along with the county and map numbers that were sent. Once the field verification maps are created for a county, the cooperator

database is queried to determine the number of individuals available for field verification. The maps are then split up between the individuals and sent along with instructions (Appendix D). The cooperator database is located at W:\GreatLakes_NWI_Update\Field_Verify\ Field Verification Contacts.mdb.



Field Verification Assessment and Updates

Once the field maps have been verified in the field and returned to Ducks Unlimited, they need to be entered into the NWI Photos geodatabase, compared to the updated NWI data, and make any corrections to the updated NWI.

Check out NWI Data and Add Verification Layers

1) In ArcCatalog, create a new Personal GeoDatabase on your working drive using the County_State_AA_date (ex: Jackson_MI_AA_06_20_08) naming convention.
2) Follow the NWI check out procedures
3) Add the NWI_Photos SDE layer in the NWI_Other GeoDatabase to your map document and change version.
    a. Click on Source tab on the bottom of the ArcMap Table of Contents
    b. Right Click on sde.Default (glaro_sde) and go to “change version”
    c. Change the version to “NWI_Photos”

4) Add NWI Field Verification table (Make sure this table is from the NWI_Phtotos version as well, if not, change it like in step 3.

Add Field Verification Point and add attributes

For pre-selected sites:

1) Use the Find tool (Edit > Find), Features tab to find and zoom to the Wetland # of the pre-selected site that was field verified.
2) Start Editing the NWI_Photos layer and create a point that corresponds to the location of the photo drawn on the field verification map.
3) Add attributes from field verification form to the attribute table.
4) Add digital photo to the raster attribute, click on the attribute and navigate to the photo.

For field selected sites:

1) For field selected sites already in shapefile (OH NRCS), add the shapefile and "copy" and "paste" the points into the NWI_Photos layer. Make sure all of the attributes are copied into the NWI_Photos Layer.
2) For field selected sites without a shapefile, locate the location based on the Lat/long or intersections and aerial photos and add the point like in the pre-selected site.

Update NWI Field Verification Table

1) Add the county, state, NWI Key, NWI code (from the NWI polygon), Field code (from the field data sheet, and the preseleted field.
2) Be sure to look at the field photo and double check that the NWI class from the field verification makes sense. **For the NWI codes, only go to the CLASS level (PUB, PEM, PAB, PFO, PSS, LUB), as we are not verifying the subclasses or modifiers.**
3) **For the converted wetlands – Identify them in the Field Verification Table as: CA = Converted due to Agriculture, CD = Converted due to Development, CR = Converted due to Recreation, CO = Converted due to Other.**

Update the NWI data

1) Update the NWI code in the NWI polygon layer if the class was different from the field verification.
2) Update the NWI polygon shape if necessary
3) **Make sure to change the Field Verification attribute to "YES".**

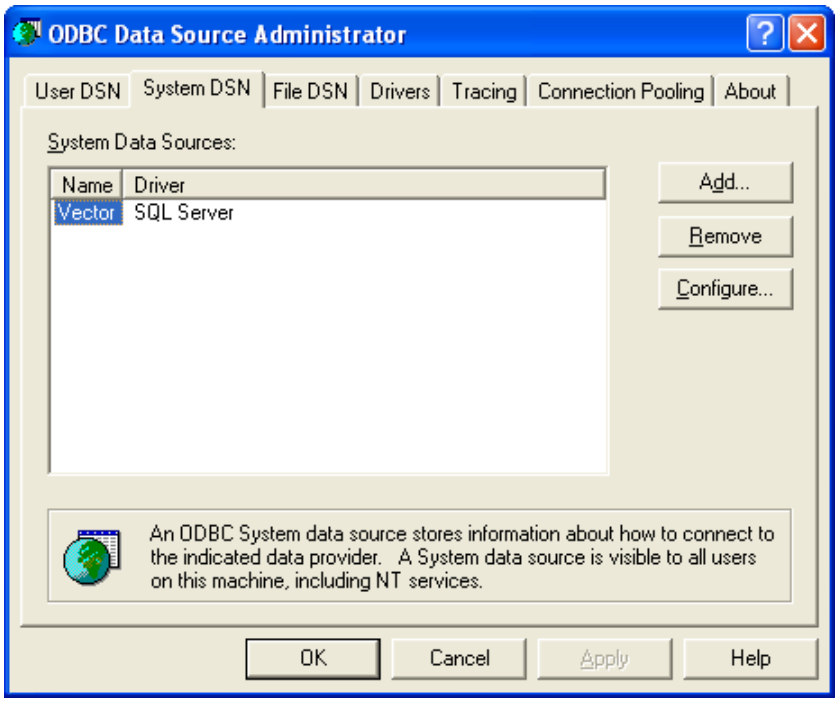
Final QA/QC and check into SDE

1) Run the QA/QC process on the NWI county data and then send to Analyst to check back into the SDE layer.
2) Change the NWI status layer to Finished.

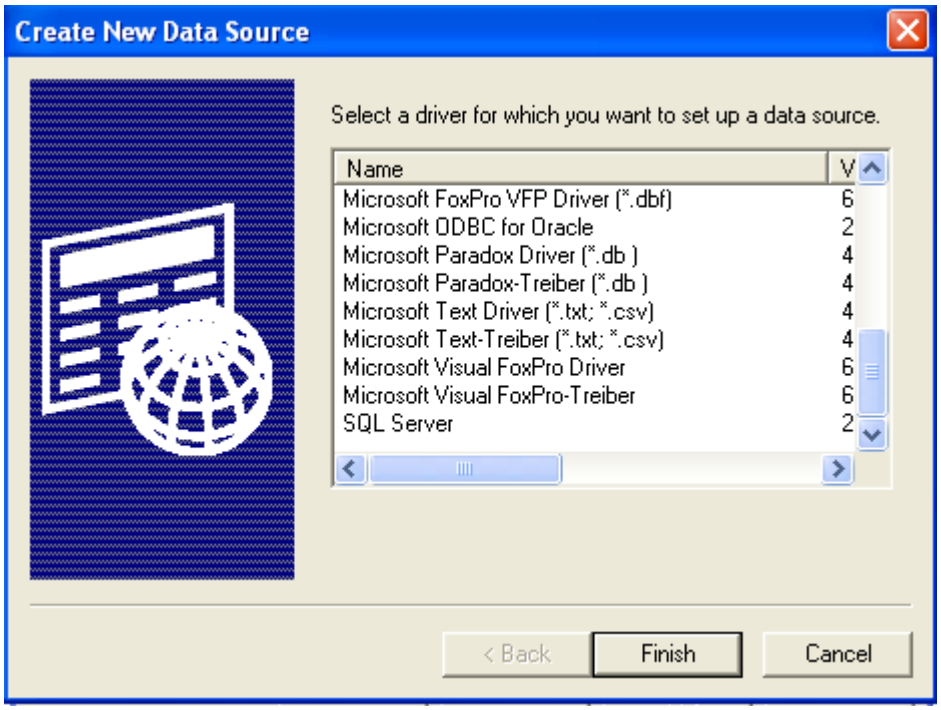
3) Notify Blair to reconcile and post NWI Photos version (specifically mention NWI_Photos featureclass and FIELD_VERIFICATION table) to the default version.

Create Accuracy Assessment Table

1. Create an ODBC Connection to the SQL Server Database for your computer if not already created. If one is already created, proceed to step 2.
    a. From the Control Panel, open Administrative Tools and then Data Sources (ODBC).
    b. The ODBC Data Source Administrator Window opens. On the System DSN tab and click ‘Add’

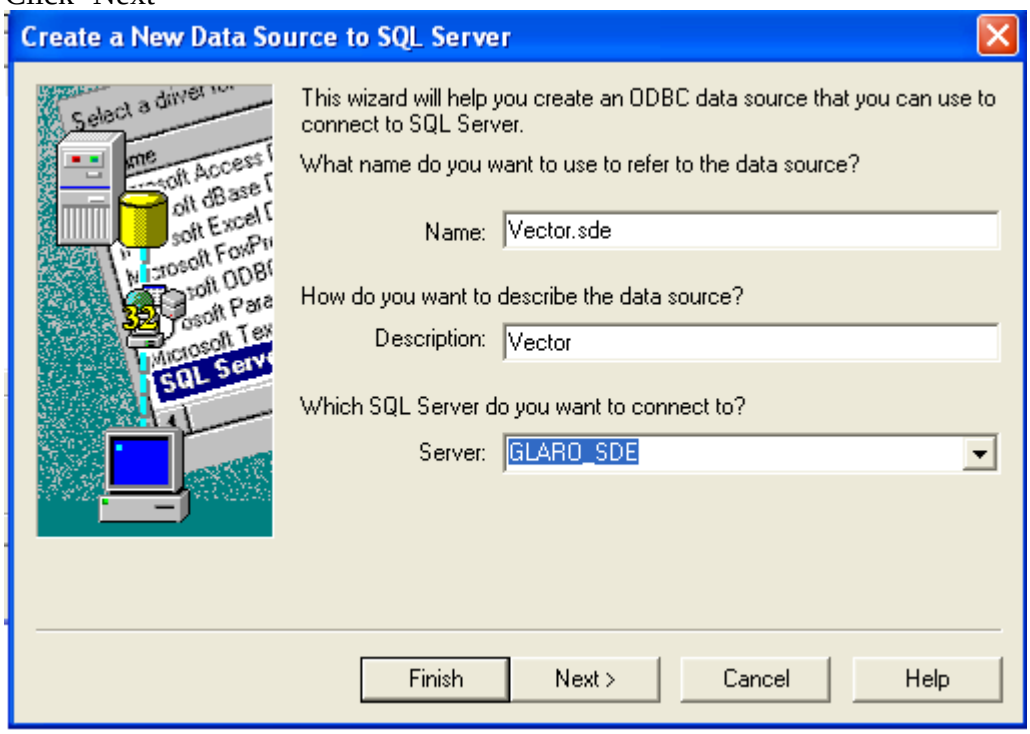


c. Scroll down the list on the Create New Data Source Window and select SQL SERVER and click 'Finish'

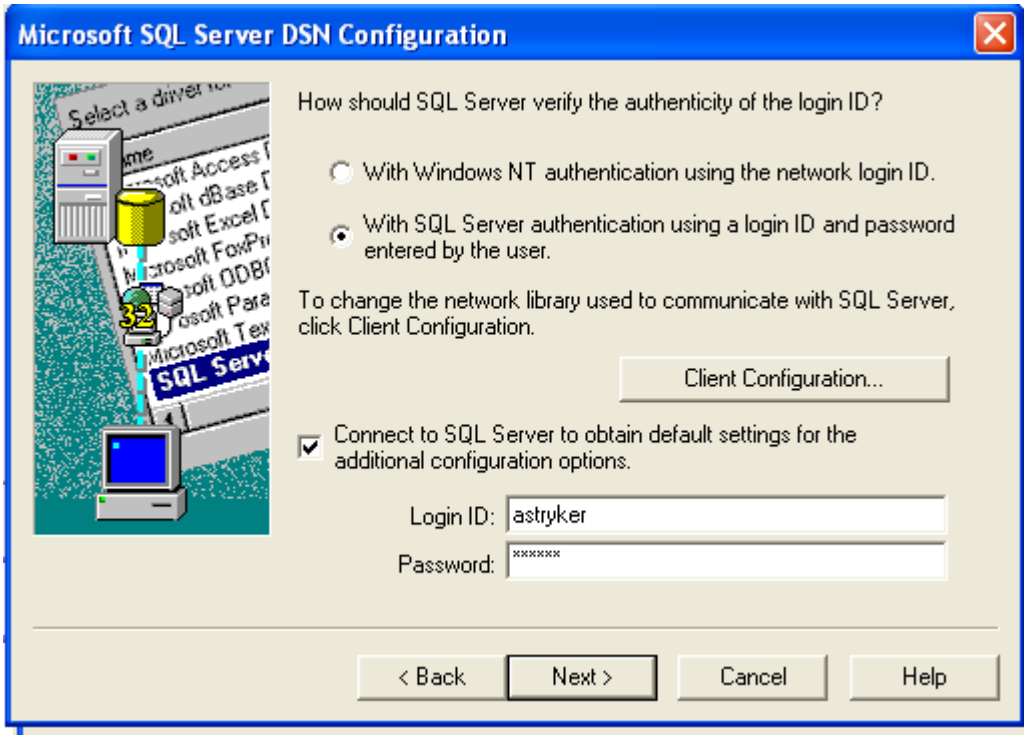


d. On Create a New Data Source to SQL Server screen, name the data source 'vector' and describe it as 'vector'. In the Server drop down menu, choose 'GLARO_SDE'.

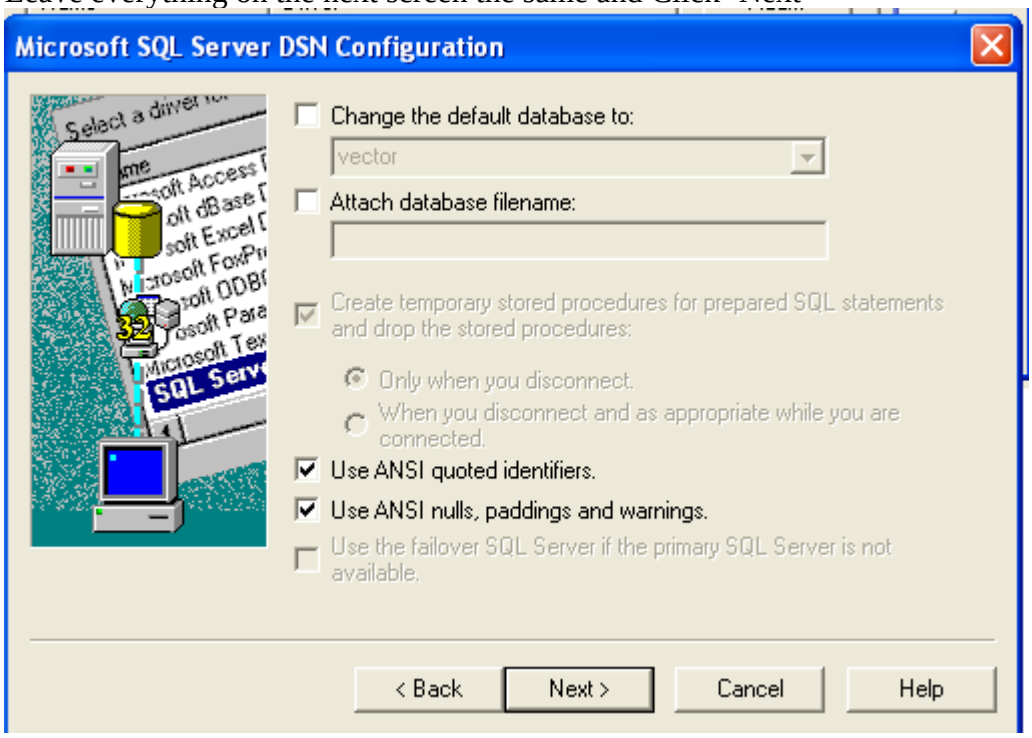
Click ‘Next’



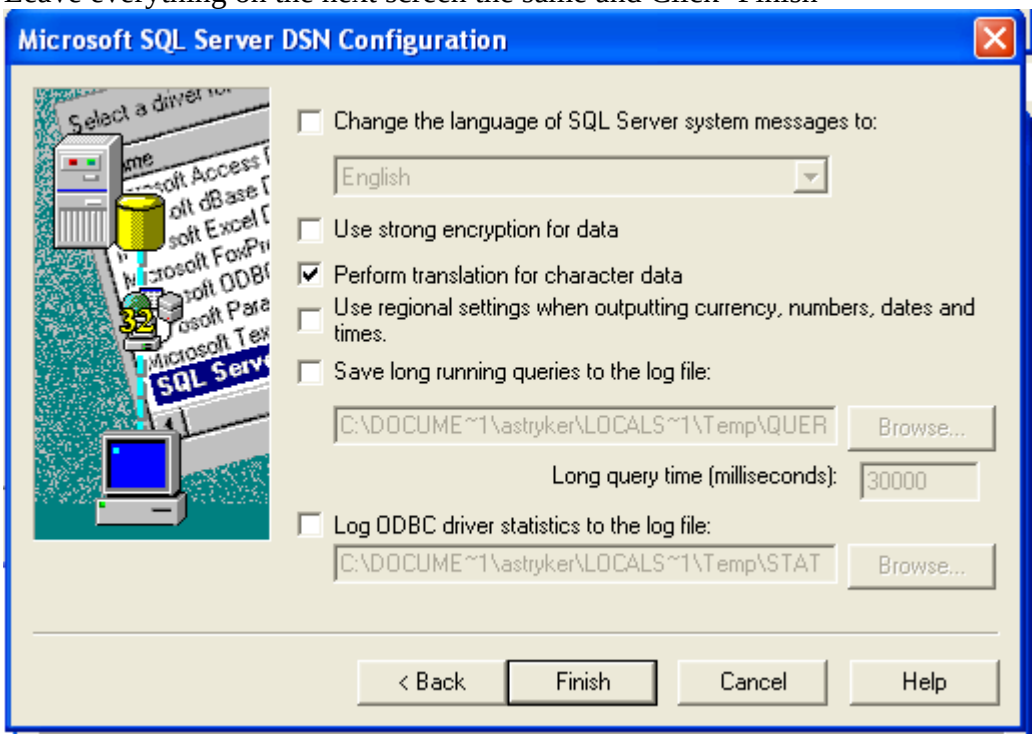
e. On the Microsoft SQL Server DSN Configuration screen, select the second radio button as seen below and make sure the ‘Connect to SQL Server…..’ box is checked. For Login ID enter your user name and for password enter your SDE Password. Note: This is different than your Windows authentication password you login to Windows with. Click ‘Next’



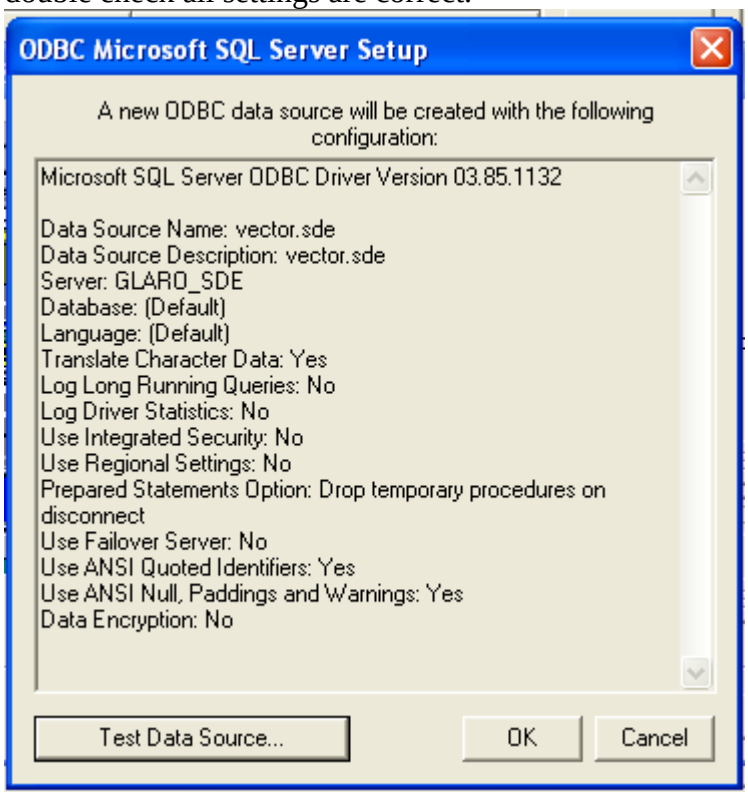
f. Leave everything on the next screen the same and Click ‘Next’



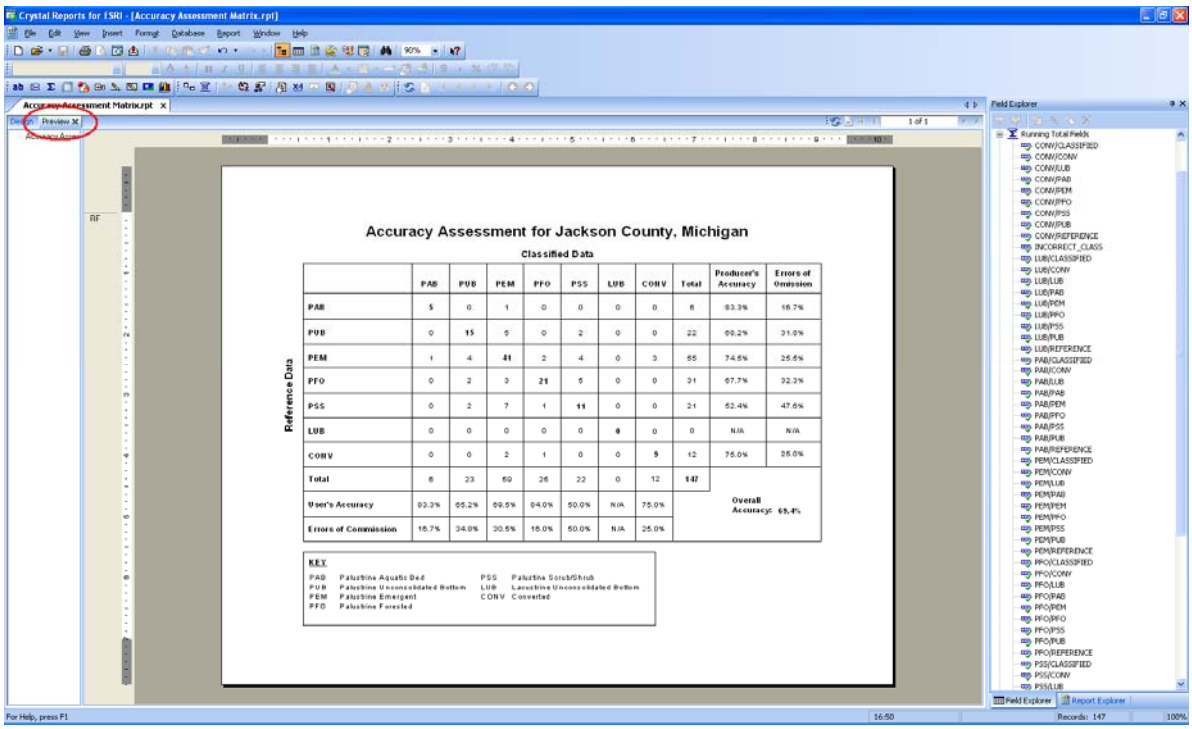
g. Leave everything on the next screen the same and Click ‘Finish’



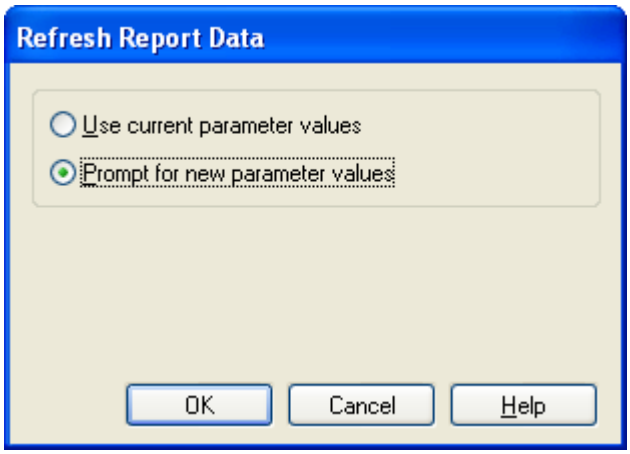
h. Click ‘Test Data Source’ and if successful, Click ‘OK’. If unsuccessful, go back and double check all settings are correct.



2. If you have not done so already, copy the ‘Accuracy Assessment Matrix.rpt’ file from W:\GreatLakes_NWI_Update\Field_Verify onto your D Drive. This is a Crystal Reports file which requires that Crystal Reports be installed on your computer. If you have not already done so, install Crystal Reports for ESRI from the ArcGIS media.
3. Open the ‘Accuracy Assessment Matrix.rpt’ file. If it is not already in the Preview mode, click on the ‘Preview’ tab on the left side of the window.



4. To view the data for a particular county, click on the Refresh button on the toolbar. If you are asked if you want to Refresh Report Data, select 'Prompt for new parameter values and click 'OK'.



5. Enter a state and county from the dialog and click 'OK'.
6. Before continuing, ensure that all wetlands have been properly classified. For the purposes of field verification, we are only classifying to the Class level, meaning that the only valid entries for NWI Code or Field Code in the field verification table are CA, CD, CR, PAB, PEM, PFO, PSS, PUB, and LUB. Any features that have an invalid NWI Code or Field Code will be tallied in red text as an 'Incorrectly Classified Wetlands' notation in the bottom-right corner of the report. Correct these entries are refresh the report. If the notation does not appear, all wetlands have been classified correctly.
7. From the File menu, select Export > Export Report. Select format 'Adobe Acrobat (PDF)' and click 'OK'.
8. Name the file "County_State_AATable_Date" i.e."Jackson_MI_AATable_06182008" and save in the appropriate State's folder in W:\GreatLakes_NWI_Update\Field_Verify.

Chapter 8 – Integration with FWS NWI

This project will result in the creation of two NWI products. All products will be in Albers Equal Area projection as used by the FWS in the NWI MDG. The first product is the DU MGD that will be used to track the status of wetlands across Indiana. Since no additional attributes can be added to the FWS MGD, another product will be created that will be sent to the FWS for inclusion into the NWI MGD. Therefore, all additional fields in DU's MGD will be removed before the layer is sent to the FWS. In order to accomplish this, another version of DU MGD will be created which will have all records of converted wetlands and DU added fields removed.

Upon completion of a 1:100,000 USGS quad cell, the features within the cell are extracted and delivered to the FWS, where they are merged back into the master geodatabase. Active features only are returned to the FWS.

Chapter 9 - Reporting

The reporting for the NWI update is based on a state-wide analysis and county by county analysis using the full DU updated NWI dataset. The dataset sent to the FWS for inclusion in the official NWI data can not be used for comparison between the original and updates NWI (see Chapter 8 for more details). Both wetland numbers and wetland acres were determined and compared between the original NWI (1980-1988) and the updated NWI (2005). The wetland numbers and acres were generated using the status, conversion type, image date and parent key. This chapter will explain the process for calculating the number and acres using the additional attribute fields.

It is important to note that wetlands identified in the update that were not in the original, are not necessarily newly created wetlands. In many cases, the scale of the imagery used in the update (2005) was better than what was used in the original classification. Therefore, many of the newly identified wetlands are small and would not necessarily have been seen in the original classification.

Also note that summing the number of wetlands from the county analysis will not equal the state-wide number because the wetlands that overlap county boundaries will be double counted.

Data Organization and Pre-processing

Below are the data organization and pre-processing steps that need to be performed on the data before calculating the wetland numbers and acres. Some of the layers below refer to data layer names specific to the Ducks Unlimited system, but you can substitute your own county layer or other boundary layer. In summary, the below process extracts the wetlands for a given state from the Great Lakes NWI wetlands geodatabase and adds the Parent Key attribute to identify those wetland that were modified (changed class) from those that were converted.

In ArcCatalog, create a new personal Geodatabase called “state_stats” – with “state” being the name of the state you are summarizing.

Open ArcMap

Add GLAROGIS.USA_County and GLAROGIS.WET_POLY layers

Select by state name in the USA_County layer the state you want to summarize

Select by location all WET_POLY that intersects the selected counties.

Export the selected polygons to the state_stats personal geodatabase and name it “WET_POLY”.

Add an attribute called “Parent” to the newly created “WET_POLY” layer (Text, 2)

Add the PARENT Table

Join the PARENT Table to the WET_POLY layer.

Select by attribute in the WET_POLY layer where Parent_Key is not NULL

Calculate the Parent attribute = Y

Switch selection

Calculate the Parent Attribute = N

Original Wetland Numbers and Acres

In order to report wetland numbers from the original NWI classification, a selection of wetlands is performed where the "Image Date" is from the dates that the original classification was performed. The original dates can be determined from the FWS NWI metadata. For the state of Indiana the original classification was performed from imagery between 1980 and 1988. In summary, the below process selects the wetlands with an image date between 1980 and 1988, intersects it with the county layer and summarizes the number and acres of wetlands by county.

Select from WET_POLY:

Image Date < 1989

Create layer file from selection

Intersect selection with county, and name WET_POLY_Org_Cnty

Re-calculate the Acres field

Summarize by county name on Acres

Current Wetland Numbers and Acres

In order to report current wetland numbers from the NWI classification, a selection of wetlands is performed where the Status is Active (0). In summary, the below process selects the wetlands that are active based on the most current imagery (2005 for Indiana), intersects it with the county layer and summarizes the number and acres of wetlands by county.

Select from WET_POLY:

Status = 0

Create layer file from selection

Intersect selection with county, and name WET_POLY_Act_Cnty

Re-calculate the Acres field

Summarize by county name on Acres

Fully Converted Wetland Numbers and Acres

In order to report the wetland numbers that were fully converted (the entire wetland was converted), a selection of wetlands is performed where the “Status” is “1 - Inactive” and “Partial” is “N” (NO) and “Conversion Type” is not “Null”. The selection is then intersected with the county layer and summarized to determine the number and acres of wetlands by county.

Select from WET_POLY:

Status = 1, Conversion type is not NULL, Partial = N

Create layer file from selection.

Intersect with county layer and name WET_POLY_Full_Cnty

Re-calculate the Acres field

Summarize on county by acres.

Partially Converted Wetland Numbers and Acres

In order to report the wetland numbers that were partially converted (only part of the wetland was converted), a selection of wetlands is performed where the “Status” is “1 - Inactive” and “Partial” is “Y” (Yes) and “Conversion Type” is not “Null”. The selection is then intersected with the county layer and summarized to determine the number and acres of wetlands by county.

Select from WET_POLY:

Status = 1, Conversion type is not NULL, Partial = Y

Create layer file from selection.

Intersect with county layer and name WET_POLY_Part_Cnty

Re-calculate the Acres field

Select from WET_POLY:

Status = 0 (Active)

Create Layer file from selection (WET_POLY_Active)

Intersect WET_POLY_Part_Cnty with the WET_Poly active selection and name WET_POLY_Part_Act.

Dissolve all polygons that have the same NWI Key (Check to make sure you have the same number of polygons as are in the WET_POLY_Part_Cnty layer), name layer WET_POLY_Part_Dis.

Caculate the acres for the Child Acres field (the second “acres” field).
Create new field called “Part_Acres”

Caculate Part_Acres as Acres – Acres_1

This is the number of acres that were converted for the partial wetlands.

Summarize on county by “Part_Acres”.

Additional Wetland Numbers and Acres

In order to report wetland numbers identified in the updated NWI and not in the original NWI (“new” wetlands), a selection of wetlands is performed where the “Status” is “0 - Active” and “Image Date” is greater than “2005” and “Parent Key” is “N”. The selection is then intersected with the county layer and summarized to determine the number and acres of wetlands by county.

Select from WET_POLY:

Status = 0 and Image Date = 2005 and Parent Key = N

Create layer file from selection.

Intersect with county layer and name WET_POLY_Add_Cnty

Re-calculate the Acres field

Select Attribute for “PW”, “Pf” and “PEMAf” and switch selection

Summarize on county by acres.

Chapter 10 - Results

The results reported in this document are for planning purposes only and are not intended for regulatory purposes. Before using any of the reported results, the user should have a through understanding of the methods reported in the previous chapters. Please see Appendix C for a list of wetland statistics by county.

Wetland Conversion by Number and Acreage

The total number of NWI wetlands (circa 1975-1990) that were fully or partially converted (circa 2006-2007) was 26,739 (Table 1). A majority of the wetlands converted were fully converted (20,943). The total acreage of NWI wetlands (circa 1975-1990) that were fully or partially converted (circa 2006-2007) was 38,325.57 (Table 2). The average size of the converted wetlands was 1.43 acres. The majority of the converted wetlands were due to agricultural purposes (50%) with development being the second largest percentage (46%). The geographic distribution of the wetland conversion is concentrated in the northeast and border counties in the northwest parts of the state (Figure 1). The number of acres converted by county varied from 21 to 1,557 acres.

Table 1. The number of wetlands converted by conversion type (1975/90 to 2006/7)

	AGRICULTURE		DEVELOPMENT		RECREATION		OTHER		
	Number	%	Number	%	Number	%	Number	%	TOTAL
FULLY CONVERTED	11,641	55.58%	8,630	41.21%	236	1.13%	436	2.08%	20,943
PARTIALLY CONVERTED	1,852	31.95%	3,776	65.15%	122	2.10%	46	0.79%	5,796
TOTAL	**13,493**	**50.46%**	**12,406**	**46.40%**	**358**	**1.34%**	**482**	**1.80%**	**26,739**

Table 2. The acreage of wetlands converted by conversion type (1975/90 to 2006/7)

	AGRICULTURE		DEVELOPMENT		RECREATION		OTHER		
	Acres	%	Acres	%	Acres	%	Acres	%	TOTAL
FULLY CONVERTED	13,725.69	57.15%	9,579.49	39.88%	277.09	1.15%	436.24	1.82%	24,018.51
PARTIALLY CONVERTED	6,056.61	42.33%	7,928.85	55.42%	239.48	1.67%	82.12	0.57%	14,307.06
TOTAL	**19,782.30**	**51.62%**	**17,508.34**	**45.68%**	**516.57**	**1.35%**	**518.36**	**1.35%**	**38,325.57**

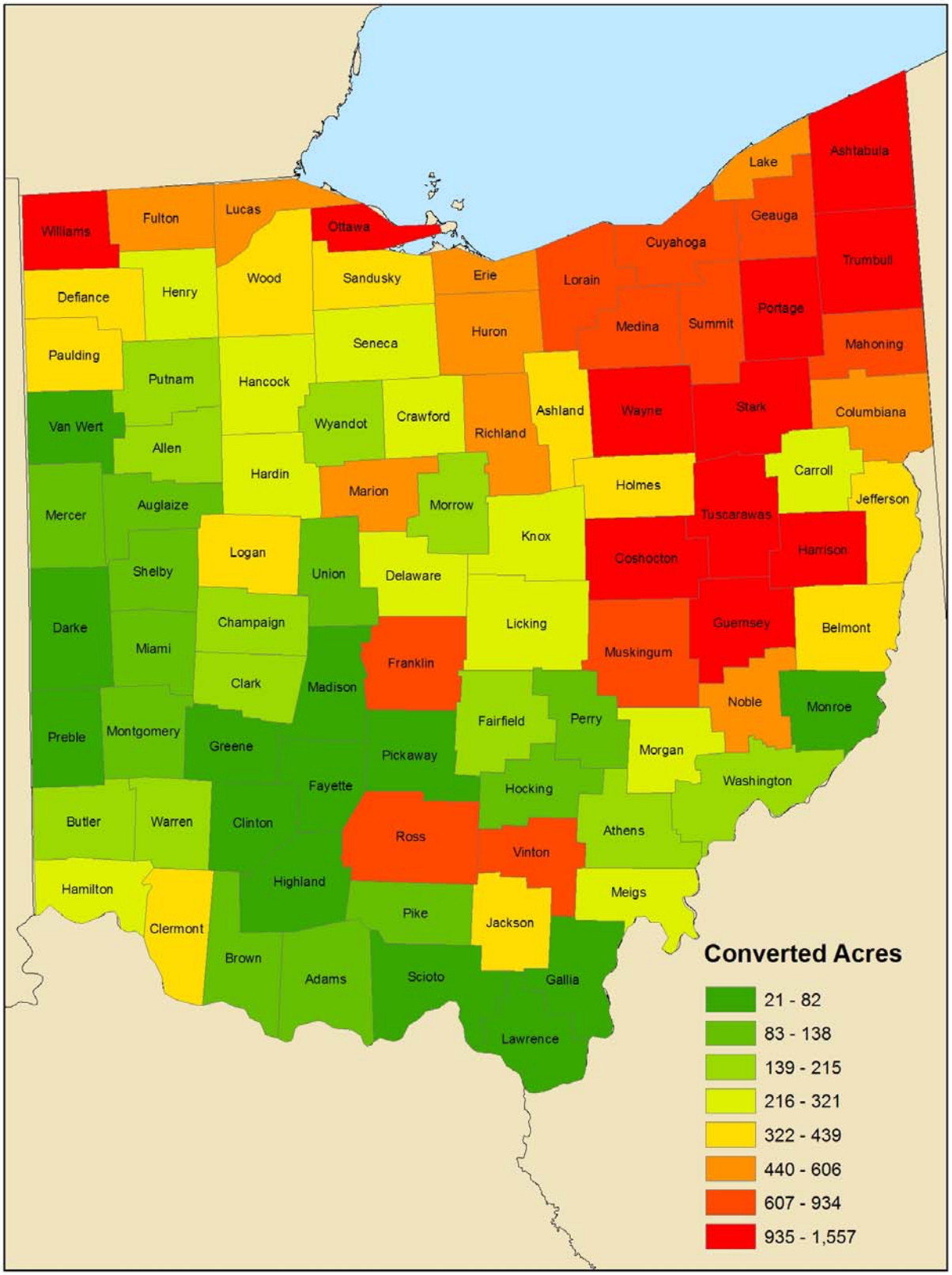


Figure 1. The number of converted acres from the original classification by county.

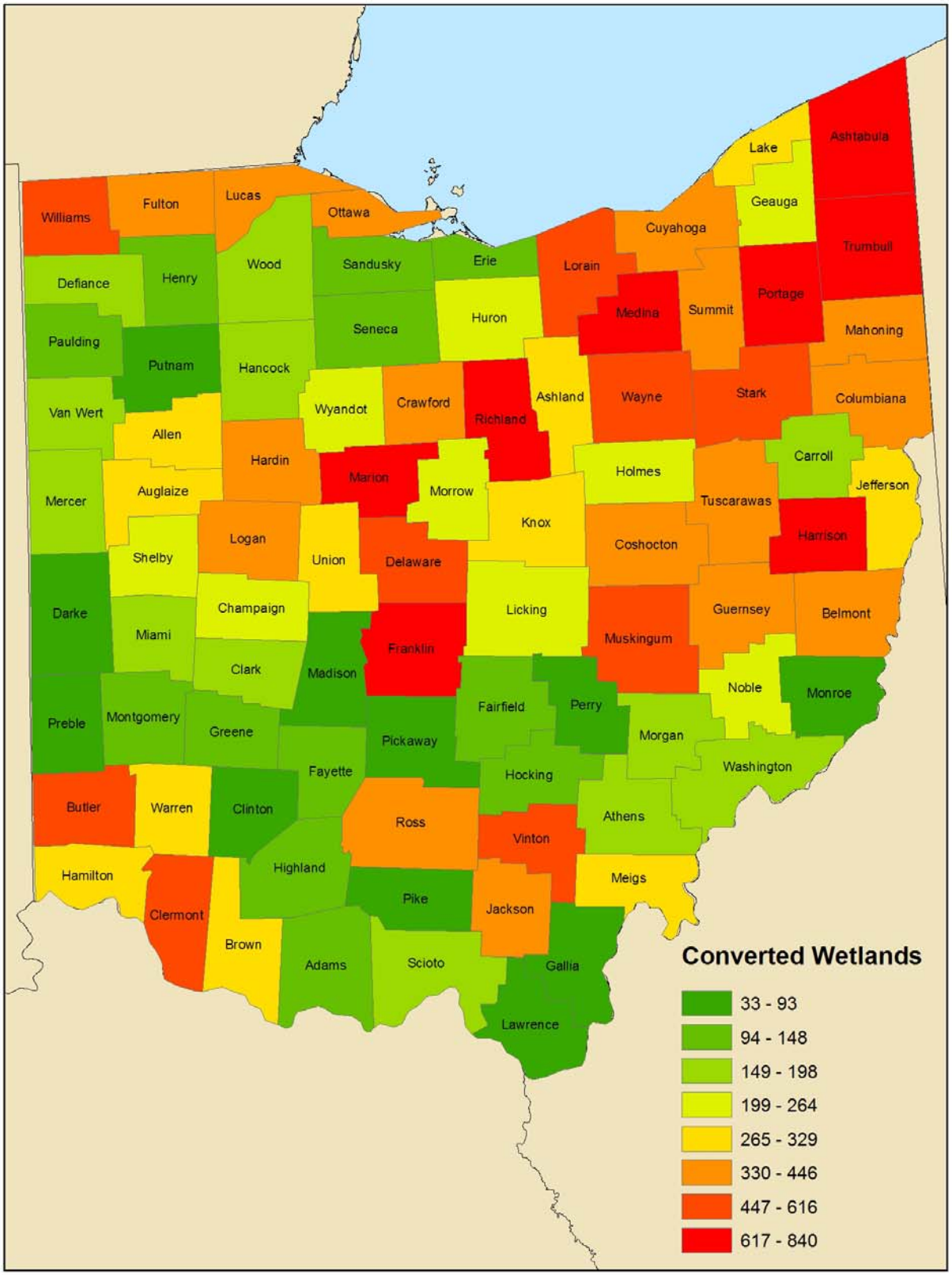


Figure 2. The number of converted wetlands from the original classification by county.

Wetland Conversion by NWI Class

The highest percentage of the wetlands converted was emergent wetlands (39%), with open water at 35% and forested at 14% (Table 3). When comparing the wetland classes converted by acreage, the emergent wetlands still has the highest percentage (33%) but the forested classes is second with 27% of the conversion acres (Table 4). Therefore, the forested wetlands were converted at a lower rate then the emergent wetlands, but larger areas of forested wetlands were converted when the conversion happened.

Table 3. The number of wetlands converted by wetland class (1975/90 to 2006/7)

	AQUATIC BED		EMERGENT		FORESTED		SCRUB-SHRUB		OPEN WATER		SHORE		OTHER		
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	TOTAL
FULLY CONVERTED	50	0%	9,122	44%	1,672	8%	1,551	7%	8,375	40%	95	0%	78	0%	20,943
PARTIALLY CONVERTED	6	0%	1,343	23%	2,154	37%	1,136	20%	1,090	19%	11	0%	56	1%	5,796
TOTAL	**56**	**0%**	**10,465**	**39%**	**3,826**	**14%**	**2,687**	**10%**	**9,465**	**35%**	**106**	**0%**	**134**	**1%**	**26,739**

Table 4. The acres of wetlands converted by wetland class (1975/90 to 2006/7)

	AQUATIC BED		EMERGENT		FORESTED		SCRUB-SHRUB		OPEN WATER		SHORE		OTHER		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	TOTAL
FULLY CONVERTED	24	0%	9,237	38%	4,231	18%	3,198	13%	6,581	27%	119	0%	630	3%	24,019
PARTIALLY CONVERTED	7	0%	3,345	23%	6,233	44%	3,040	21%	1,254	9%	32	0%	396	3%	14,307
TOTAL	**30**	**0%**	**12,582**	**33%**	**10,464**	**27%**	**6,238**	**16%**	**7,835**	**20%**	**151**	**0%**	**1,026**	**3%**	**38,326**

Wetlands not Included in the Original NWI

It is important to note that wetlands identified in the update that were not in the original, are not necessarily newly created wetlands. In many cases, the scale of the imagery used in the update (2005) was better than what was used in the original classification. Therefore, many of the newly identified wetlands are small and would not necessarily have been seen in the original classification. The average size of the added wetlands was 1.7 acres, which is below the minimum size (2-3 acres) of the original NWI mapping scale.

There were a total of 122,825 additional wetlands that were added to the inventory, with a total of 138,515 acres (Table 5). Of the wetlands that were added, 72% were open water, followed by emergent, forested, other, aquatic bed, and shore. The sizes of the additional open water wetlands averaged under an acre and were mostly “backyard ponds”. There was a significant amount of emergent wetlands added to the inventory with 30,346 acres added. The spatial distributions of the added wetlands are displayed in Figure 3 (number) and Figure 4 (acreage).

Table 5. The number and acres of additional wetlands by wetland class

	AQUATIC BED		EMERGENT		FORESTED		SCRUB-SHRUB		OPEN WATER		SHORE		OTHER		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	TOTAL
ADDITIONAL ACRES	641	0%	30,346	22%	24,559	18%	5,800	4%	51,760	37%	96	0%	25,313	18%	138,515
ADDITIONAL NUMBER	679	1%	19,523	16%	9,182	7%	2,902	2%	87,913	72%	54	0%	2,572	2%	122,825
AVERAGE SIZE	0.94		1.55		2.67		2.00		0.59		1.78		9.84		1.13

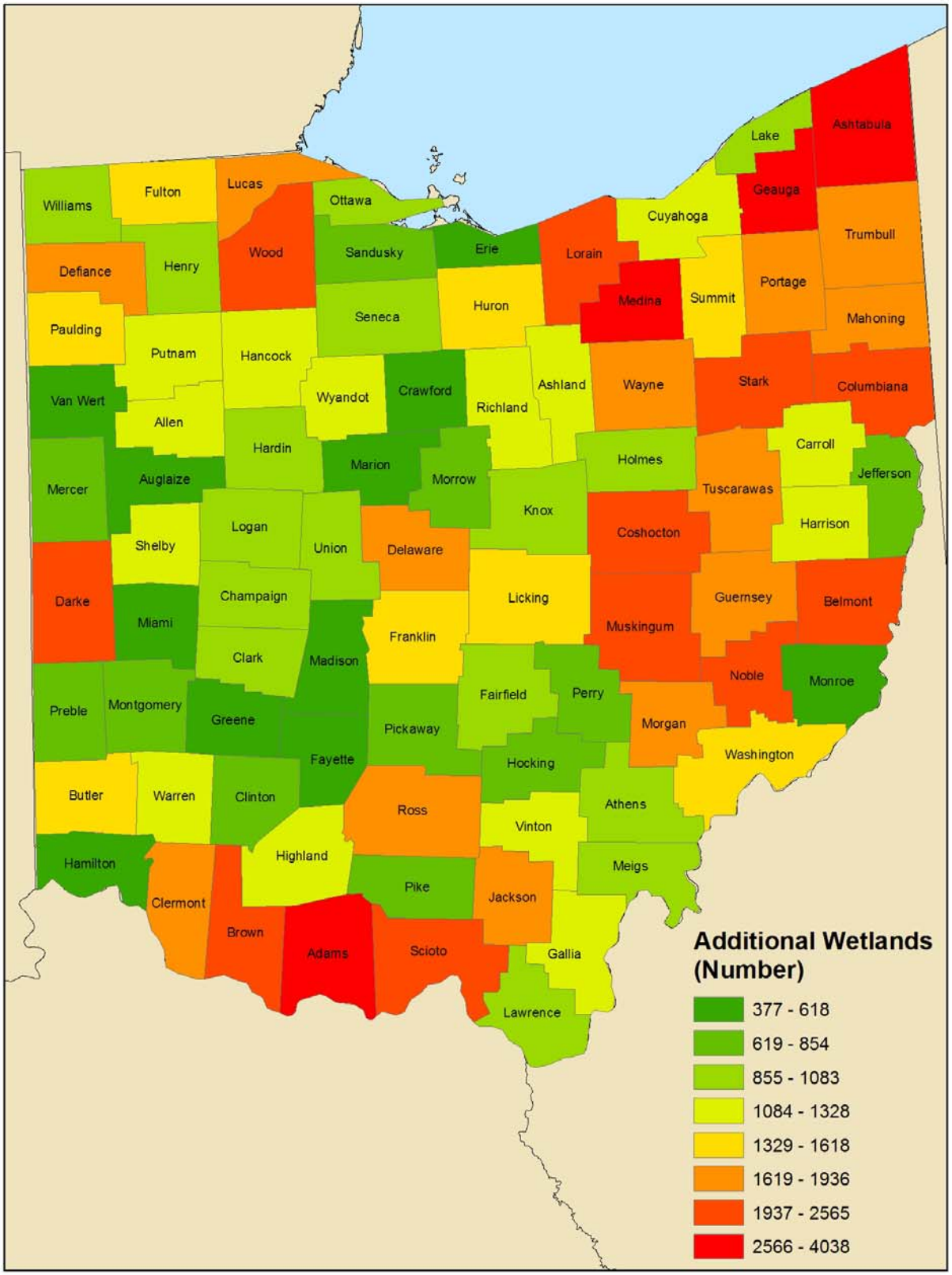


Figure 3. The number of additional wetlands by county

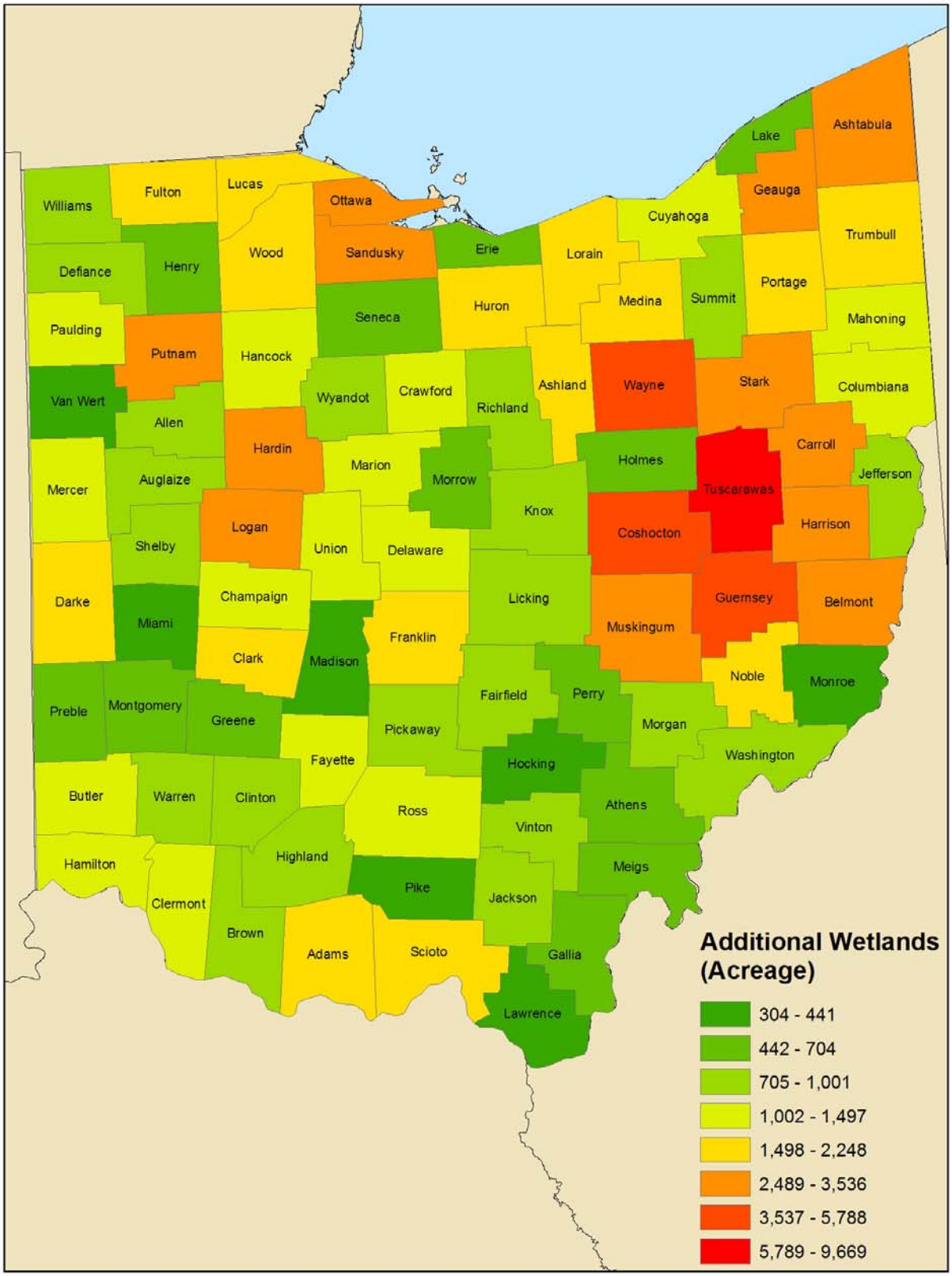


Figure 4. The acreage of additional wetlands by county

Net Wetland Change from 1975-1990 to 2006-2007

Please use extreme caution when using these numbers. The reported change in wetlands is a useful planning tool, however, several factors should be used in conjunction with the reported numbers. First, as described in the additional wetlands section above, the additional wetlands may or may not have existed during the original classification due to the scale of the original imagery. Second, the wetland change does not consider wetland type in the analysis. All wetlands are not created equal when determining habitat value or function. For instance, a net gain of 5,000 acres in a county may sound good, but if there was a loss of 10,000 acres of emergent wetlands and a gain of 15,000 acres of open water (backyard ponds) than this would not necessarily be good as far as habitat value.

For the state of Ohio, there was a net change of 96,086 wetlands with a gain of 100,189 acres (Table 6 and 7). The only wetland class that lost wetlands was Unconsolidated Shore. However, the scrub-shrub class had a loss when looking at net change in wetland acreage. The wetland losses (number) were limited Marion County, with acreage loss limited to Lake, Summit, and Williams Counties (Figure 5 and 6).

Table 6. The net change in wetland numbers from 1975-90 to 2006-7

	AQUATIC BED		EMERGENT		FORESTED		SCRUB-SHRUB		OPEN WATER		SHORE		OTHER		
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	TOTAL
CONVERTED NUMBER	56	0%	10,465	39%	3,826	14%	2,687	10%	9,465	35%	106	0%	134	1%	26,739
ADDITIONAL NUMBER	679	1%	19,523	16%	9,182	7%	2902	2%	87913	72%	54	0%	2572	2%	122,825
TOTAL	**623**		**9,058**		**5,356**		**215**		**78,448**		**-52**		**2,438**		**96,086**

Table 7. The net change in wetland acreage from 1975-90 to 2006-7

	AQUATIC BED		EMERGENT		FORESTED		SCRUB-SHRUB		OPEN WATER		SHORE		OTHER		
	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	TOTAL
CONVERTED ACRES	30	0%	12,582	33%	10,464	0	6,238	16%	7,835	0	151	0	1,026	3%	38,326
ADDITIONAL ACRES	641	0%	30,346	22%	24,559	18%	5,800	4%	51,760	37%	96	0%	25,313	18%	138,515
TOTAL	**610**		**17,764**		**14,095**		**-439**		**43,925**		**-54**		**24,287**		**100,189**

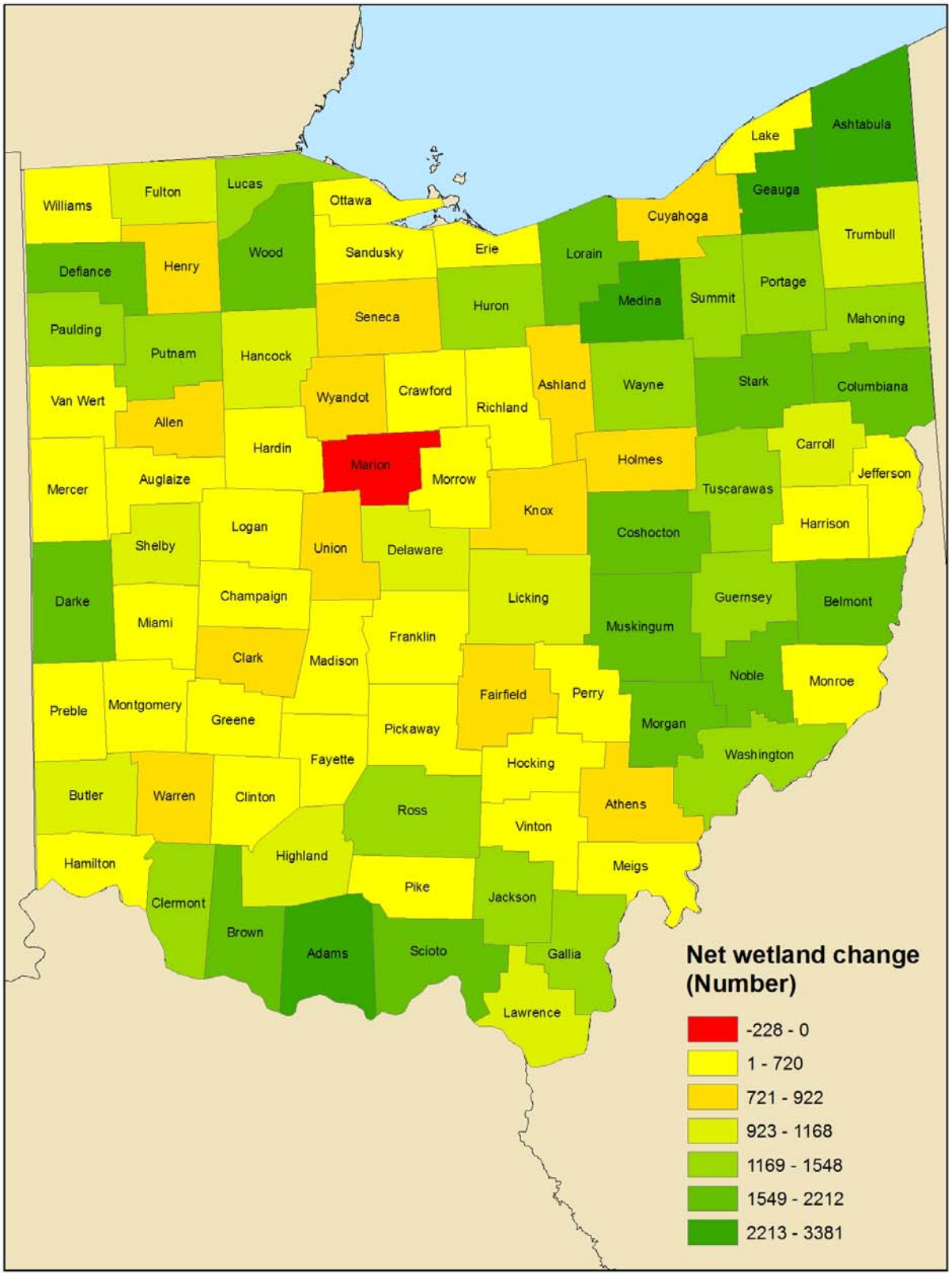


Figure 5. The net change in wetland numbers by county

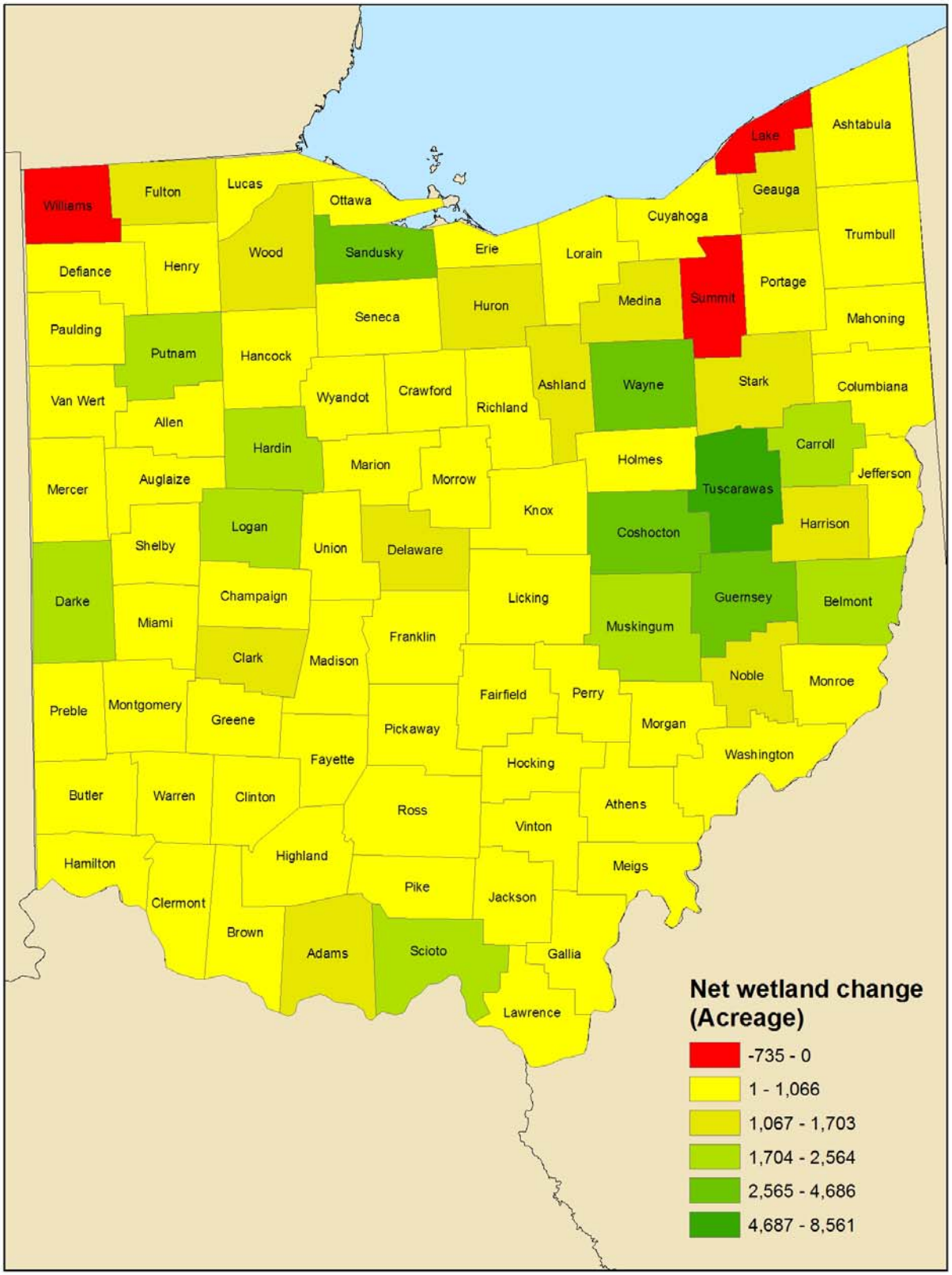


Figure 6. The net change in wetland acreage by county

Field Verification

The overall accuracy based on the field verification of the wetland delineation was 94% (1291 out of 1374). This means that 94% of the time the updated NWI classified a wetland, it was verified as a wetland in the field. Of the wetlands that were misclassified, 47% (39 of the 83) were when the interpretation was an emergent wetland, but the field verification was converted due to agriculture. The comments of some of the misclassified emergent/agricultural class contained notes on seeing wetland vegetation or depressions. Due to the variation in interpreting wet agricultural fields in the field and the PEMA class from photos may be the cause of this confusion.

The overall accuracy based on the field verification of the wetland class identification was 77%. This means that 77% of the time the updated NWI classified a wetland class (open water, aquatic, emergent, shrub, forested), it was verified as they wetland class in the field. A majority (54%) of the within class errors were on wetlands there were under an acre in size and were between the emergent, shrub, and forested class. These classes are very hard to distinguish from aerial photos at that size due to nearby tree cover. Very few (17%) of the misclassifications were on wetlands over 5 acres in size.

Additional work needs to be done on the assessment of the updated NWI classification, particularly in the between class errors and determining the accuracy of the classes at different scales. It would also be interesting to determine if there were significant differences between counties.

References

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. *Classification of Wetlands and Deepwater Habitats of the United States*. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC. FWS/OBS-79/31.

Johnston, C.A. and P. Meysembourg. 2002. Comparison of the Wisconsin and National Wetlands Inventories. *Wetlands*, 22:386-405.

Story, M and R.G. Congalton. 1986. Accuracy Assessment: A User's Perspective. *Photogrammetric Engineering and Remote Sensing*. Vol. 52, No. 3, pp. 397-399.

Appendix A – Data Contacts

NWI Data Contacts:

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Ohio Photos

2006/07 Spring CIR Photos

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NAIP 2004 Summer

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Appendix B – Field Verification Sample Documents

Great Lakes NWI Field Verification: Directions

DUCKS UNLIMITED
Great Lakes/Atlantic Regional Office

Enclosed in this packet are: (1) a map of the wetland and its surrounding area, (2) a wetland classification document, (3) a disposable digital camera (if you had requested one from Ducks Unlimited). Wetlands have been randomly selected for field verification but have been limited to within 90 meters of a road to allow verification from the roadside. **Please respect private property rights.**

Preparations:

1. Review the Wetlands and Deepwater Habitats Classification diagram and the Great Lakes NWI Field Verification: Wetlands and Deepwater Habitats Classification Explanation document. If you are not already, familiarize yourself with the wetland classifications employed by the NWI.
2. Review the wetland's maps and determine the wetland's location.

In the field:

3. Identify the wetland's class. Consult the classification documents if necessary and circle the corresponding classification on the wetland's map.
5. Photograph the wetland. Record on the wetland's map the photograph's number and in what direction the photograph was taken by drawing an arrow on the map.
6. Write any additional comments or notes concerning the classification on the back of the map.

Finishing:

7. If using your own camera, burn all photographs onto CD. If using the disposable digital provided by Ducks Unlimited, simply mail the camera in its accompanying envelope.
8. Return the wetland's map and photo CD (if using your own digital) to Ducks Unlimited.
9. Please record the dates and time you spent doing the field verification and send with the wetlands information. This data will be used for reporting and tracking the time involved in collecting the field information.
10. You're done. Thanks for your time and help!

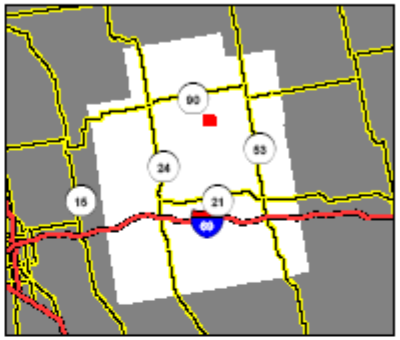
For questions, comments or problems, contact:

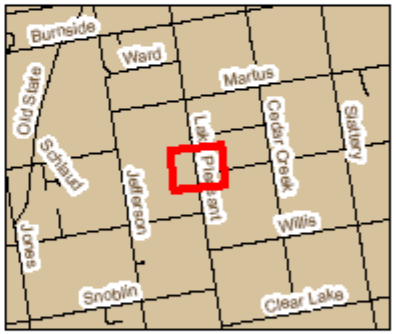
Robb Macleod
Ducks Unlimited, Inc.
Great Lakes/Atlantic Regional Office
Ann Arbor, MI 48103
(734) 623-2000
rmacleod@ducks.org

Great Lakes NWI Field Verification Map

Lapeer County, Michigan

Wetland #3884606





Photograph # _____ Camera # _____
(if applicable)

Please indicate the direction of the photo by placing a POINT (indicating camera location) and an ARROW (indicating direction of photo) on the above map.

Wetland Class: Circle only one class, choose the class that fits the best and provide additional comments:

Open Water Aquatic Bed Scrub/shrub Forested

Emergent Unconsolidated Bottom Converted (choose 1 of the following): - Agriculture - Development - Recreation

Photo Date _____

Comments:

Continue comments on the back of sheet

Jun 21, 2007

Great Lakes NWI Field Verification:
WETLANDS AND DEEPWATER HABITATS CLASSIFICATION DESCRIPTIONS

Unconsolidated Bottom (UB)

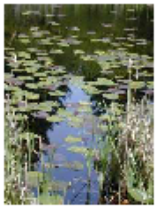
Definition: open water with no vegetation. Unconsolidated bottom includes all wetland habitats with at least 25% cover of particles smaller than stones, and a vegetative cover less than 30%.

Description: unconsolidated bottoms are characterized by the lack of large stable surfaces for plant and animal attachment and may possess cobble-gravel, sand, mud or organic bottoms. Shallow ponds with little or no vegetation and backyard ponds are typical of the class.

Aquatic Bed (AB)

Definition: submergent vegetation often including lily pads. Aquatic bed includes wetlands dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Description: aquatic beds represent a diverse group of plant communities that require surface water for optimum growth and reproduction. They are best developed in relatively permanent water or under conditions of repeated flooding. The plants are either attached to the substrate or float freely in the water above the bottom or on the surface. Aquatic bed wetlands may be characterized by algae, aquatic moss, rooted vascular, floating vascular, unknown submergent and unknown surface life.



Emergent (EM)

Definition: emergent wetlands are characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants. All water regimes are included except subtidal and irregularly exposed.

Description: In areas with relatively stable climatic conditions, emergent wetlands maintain the same appearance year after year. In other areas, such as the prairies of the central United States, violent climatic fluctuations cause them to revert to an open water phase in some years. Emergent wetlands are found throughout the United States and are known by many names, including marsh, meadow, fen, prairie pothole, and slough.

Scrub-Shrub (SS)

Definition: scrub-shrub includes areas dominated by woody vegetation less than 6 meters (20 feet) tall. The vegetation species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

Description: scrub-shrub wetlands may represent a successional stage leading to forested wetlands, or they may be relatively stable communities. They are on of the most widespread classes in the United States. Scrub-shrub wetlands are known by many names, such as shrub swamp, shrub carr, bog, and pocosin. For practical reasons, the scrub-shrub class includes forests composed of young trees less than 6 meters tall.

Forested (FO)

Definition: forested wetlands are characterized by woody vegetation that is 6 meters tall or taller.

Description: forested wetlands are most common in the eastern United States and in those sections of the West where moisture is relatively abundant, particularly along rivers and in the mountains. They normally possess an overstory of trees, and understory of young trees or shrubs, and an herbaceous layer.

Converted (Converted)

Definition: wetlands that have been converted to other uses such as agriculture, development, recreation, etc.

Description: converted wetlands were wetlands in the past but have since been converted to other uses. Wetlands that show plow lines or support crops, for example, will have been converted for agricultural purposes. Wetlands perhaps supporting built structures have been converted for development. Wetlands supporting golf courses will have been converted for recreational purposes.

Appendix C – Wetland Statistics by County

COUNTY	Original #	Full Convert #	Part Convert #	Total Convert #	Total Convert %	Additionl #	Net Wetland #	Original Acres	Convert Acres	Additional Acres	Avg Size Conv	Avg Size Add	Net Acreage
Adams	2,031	133	0	133	0.07	2,981	2,848	2,890.61	125.41	1,794.83	0.94	0.60	1,669.42
Allen	2,650	259	38	297	0.11	1,243	946	4,807.19	169.28	987.47	0.57	0.79	818.18
Ashland	2,572	244	68	312	0.12	1,201	889	8,277.12	439.54	1,889.31	1.41	1.57	1,449.77
Ashtabula	9,464	633	190	823	0.09	3,484	2,661	63,398.61	1,557.96	2,459.05	1.89	0.71	901.09
Athens	2,711	140	25	165	0.06	961	796	6,161.92	205.30	519.59	1.24	0.54	314.29
Auglaize	2,422	249	26	275	0.11	600	325	5,391.34	131.08	838.10	0.48	1.40	707.03
Belmont	1,690	335	25	360	0.21	2,293	1,933	6,494.03	430.57	2,913.46	1.20	1.27	2,482.89
Brown	3,306	314	4	318	0.10	3,413	3,095	5,180.35	107.59	1,755.87	0.34	0.51	1,648.28
Butler	3,079	470	3	473	0.15	1,589	1,116	5,544.38	216.00	1,297.26	0.46	0.82	1,081.26
Carroll	1,257	88	67	155	0.12	1,161	1,006	7,748.60	321.29	2,558.64	2.07	2.20	2,237.36
Champaign	2,714	228	35	263	0.10	977	714	4,755.68	197.58	1,235.22	0.75	1.26	1,037.64
Clark	1,315	134	34	168	0.13	1,058	890	4,782.41	152.19	2,042.99	0.91	1.93	1,890.81
Clermont	4,522	434	68	502	0.11	1,908	1,406	9,532.65	383.06	1,105.93	0.76	0.58	722.88
Clinton	1,087	60	10	70	0.06	734	664	2,120.57	51.25	771.61	0.73	1.05	720.36
Columbiana	3,292	278	75	353	0.11	2,567	2,214	10,249.85	524.58	1,497.34	1.49	0.58	972.76
Coshocton	2,169	258	107	365	0.17	2,147	1,782	9,828.75	1,061.34	4,404.63	2.91	2.05	3,343.29
Crawford	2,873	397	38	435	0.15	584	149	5,798.01	262.62	1,225.93	0.60	2.10	963.31
Cuyahoga	1,376	271	175	446	0.32	1,205	759	5,871.29	836.38	1,291.77	1.88	1.07	455.39
Darke	2,020	45	1	46	0.02	2,207	2,161	2,984.17	35.84	2,192.16	0.78	0.99	2,156.32
Defiance	1,406	105	92	197	0.14	1,865	1,668	6,375.15	344.05	1,002.24	1.75	0.54	658.20
Delaware	4,013	530	86	616	0.15	1,746	1,130	11,830.39	259.53	1,430.32	0.42	0.82	1,170.79
Erie	958	69	74	143	0.15	514	371	8,666.43	477.25	703.93	3.34	1.37	226.68
Fairfield	2,154	100	14	114	0.05	1,005	891	4,966.91	148.13	769.42	1.30	0.77	621.29
Fayette	617	110	13	123	0.20	654	531	1,995.84	82.39	1,256.76	0.67	1.92	1,174.37
Franklin	3,229	618	132	750	0.23	1,442	692	7,913.31	910.67	1,802.28	1.21	1.25	891.62
Fulton	1,456	160	241	401	0.28	1,457	1,056	5,722.01	494.09	1,752.18	1.23	1.20	1,258.09
Gallia	2,855	76	1	77	0.03	1,328	1,251	5,424.34	60.57	614.22	0.79	0.46	553.66
Geauga	3,546	111	145	256	0.07	2,875	2,619	31,855.86	849.03	2,534.42	3.32	0.88	1,685.39
Greene	1,230	123	4	127	0.10	523	396	2,464.95	69.81	621.55	0.55	1.19	551.74
Guernsey	1,707	247	127	374	0.22	1,871	1,497	14,805.20	1,356.91	5,279.26	3.63	2.82	3,922.35
Hamilton	1,537	275	1	276	0.18	590	314	9,842.48	226.37	1,116.84	0.82	1.89	890.47
Hancock	1,509	96	74	170	0.11	1,218	1,048	4,861.60	268.54	1,146.76	1.58	0.94	878.22
Hardin	2,388	310	35	345	0.14	1,078	733	3,835.95	228.23	2,694.59	0.66	2.50	2,466.36
Harrison	2,185	486	197	683	0.31	1,233	550	11,571.50	1,253.24	2,624.74	1.83	2.13	1,371.50
Henry	665	75	49	124	0.19	999	875	5,430.23	258.03	731.92	2.08	0.73	473.89

COUNTY	Original #	Full Convert #	Part Convert #	Total Convert #	Total Convert %	Additionl #	Net Wetland #	Original Acres	Convert Acres	Additional Acres	Avg Size Conv	Avg Size Add	Net Acreage
Highland	1,948	119	10	129	0.07	1,120	991	4,533.21	43.02	814.15	0.33	0.73	771.12
Hocking	2,216	97	23	120	0.05	760	640	3,688.65	127.68	307.07	1.06	0.40	179.39
Holmes	1,499	183	75	258	0.17	998	740	5,324.47	403.95	693.40	1.57	0.69	289.45
Huron	2,452	185	41	226	0.09	1,502	1,276	16,063.53	606.14	2,289.13	2.68	1.52	1,683.00
Jackson	2,690	376	5	381	0.14	1,685	1,304	8,158.15	435.74	945.83	1.14	0.56	510.09
Jefferson	1,784	266	12	278	0.16	823	545	5,030.35	408.51	876.91	1.47	1.07	468.40
Knox	2,520	246	52	298	0.12	1,105	807	6,177.18	284.18	1,079.28	0.95	0.98	795.11
Lake	1,413	172	157	329	0.23	966	637	4,760.89	750.96	524.89	2.28	0.54	-226.07
Lawrence	1,774	65	3	68	0.04	1,017	949	3,688.16	41.83	441.88	0.62	0.43	400.05
Licking	4,996	219	35	254	0.05	1,431	1,177	7,315.92	314.87	958.02	1.24	0.67	643.15
Logan	3,634	364	67	431	0.12	1,057	626	12,017.01	388.44	2,725.27	0.90	2.58	2,336.83
Lorain	3,351	332	167	499	0.15	2,244	1,745	8,335.51	785.30	1,792.94	1.57	0.80	1,007.64
Lucas	1,413	165	176	341	0.24	1,902	1,561	14,725.11	527.95	1,802.15	1.55	0.95	1,274.20
Madison	1,268	30	3	33	0.03	398	365	2,500.90	21.05	374.77	0.64	0.94	353.72
Mahoning	3,480	312	53	365	0.10	1,683	1,318	17,304.32	697.86	1,080.71	1.91	0.64	382.85
Marion	3,558	730	110	840	0.24	621	-219	4,594.52	484.33	1,305.80	0.58	2.10	821.47
Medina	3,841	336	321	657	0.17	4,038	3,381	10,291.96	864.69	2,116.03	1.32	0.52	1,251.34
Meigs	2,336	278	0	278	0.12	931	653	4,620.28	294.43	538.89	1.06	0.58	244.46
Mercer	1,780	190	5	195	0.11	691	496	14,071.17	88.52	1,157.07	0.45	1.67	1,068.55
Miami	1,689	174	16	190	0.11	452	262	3,417.82	137.15	416.30	0.72	0.92	279.15
Monroe	700	56	0	56	0.08	522	466	1,994.91	58.56	324.83	1.05	0.62	266.27
Montgomery	1,833	113	18	131	0.07	651	520	4,749.07	110.13	569.08	0.84	0.87	458.95
Morgan	1,351	152	2	154	0.11	1,808	1,654	4,814.97	248.19	932.14	1.61	0.52	683.95
Morrow	4,390	214	13	227	0.05	855	628	4,095.57	156.59	551.15	0.69	0.64	394.56
Muskingum	3,049	387	103	490	0.16	2,313	1,823	15,982.86	934.69	3,529.36	1.91	1.53	2,594.67
Noble	1,127	245	1	246	0.22	2,370	2,124	5,456.82	545.00	2,248.46	2.22	0.95	1,703.46
Ottawa	2,124	213	218	431	0.20	1,052	621	19,329.62	1,310.17	2,321.05	3.04	2.21	1,010.88
Paulding	834	97	51	148	0.18	1,460	1,312	6,182.95	385.40	1,314.68	2.60	0.90	929.29
Perry	3,681	82	11	93	0.03	768	675	5,492.64	106.91	504.19	1.15	0.66	397.28
Pickaway	1,820	55	5	60	0.03	754	694	5,638.13	76.99	1,032.31	1.28	1.37	955.32
Pike	2,065	69	16	85	0.04	654	569	4,612.80	138.04	348.40	1.62	0.53	210.35
Portage	4,720	364	356	720	0.15	1,942	1,222	36,067.32	1,271.69	2,256.48	1.77	1.16	984.78
Preble	1,452	93	0	93	0.06	754	661	1,860.35	38.79	656.41	0.42	0.87	617.63
Putnam	808	78	9	87	0.11	1,310	1,223	5,174.54	168.51	2,720.48	1.94	2.08	2,551.97
Richland	3,781	511	186	697	0.18	1,211	514	9,438.74	592.55	827.77	0.85	0.68	235.22
Ross	3,064	339	17	356	0.12	1,742	1,386	9,872.95	800.07	1,262.25	2.25	0.72	462.18

COUNTY	Original #	Full Convert #	Part Convert #	Total Convert #	Total Convert %	Additionl #	Net Wetland #	Original Acres	Convert Acres	Additional Acres	Avg Size Conv	Avg Size Add	Net Acreage
Sandusky	783	57	80	137	0.17	747	610	9,570.48	409.91	3,541.89	2.99	4.74	3,131.98
Scioto	1,927	153	0	153	0.08	2,224	2,071	6,720.74	79.30	2,116.40	0.52	0.95	2,037.10
Seneca	900	83	19	102	0.11	912	810	5,333.52	237.84	566.01	2.33	0.62	328.17
Shelby	2,630	208	20	228	0.09	1,206	978	3,715.53	102.61	883.57	0.45	0.73	780.96
Stark	3,373	443	118	561	0.17	2,269	1,708	15,178.57	1,134.86	2,540.00	2.02	1.12	1,405.14
Summit	3,000	234	144	378	0.13	1,618	1,240	15,213.76	902.73	808.52	2.39	0.50	-94.21
Trumbull	7,565	615	209	824	0.11	1,939	1,115	47,594.54	1,432.89	1,849.36	1.74	0.95	416.47
Tuscarawas	1,744	276	127	403	0.23	1,873	1,470	11,310.94	1,108.29	9,675.10	2.75	5.17	8,566.80
Union	3,556	285	5	290	0.08	1,083	793	2,897.05	115.69	1,152.31	0.40	1.06	1,036.62
Van Wert	1,121	182	16	198	0.18	506	308	1,669.27	68.52	425.76	0.35	0.84	357.24
Vinton	2,317	497	100	597	0.26	1,321	724	8,711.92	868.27	1,002.16	1.45	0.76	133.89
Warren	3,676	269	5	274	0.07	1,149	875	7,930.04	167.27	816.42	0.61	0.71	649.16
Washington	2,271	162	0	162	0.07	1,377	1,215	6,979.18	184.30	944.19	1.14	0.69	759.89
Wayne	2,844	300	188	488	0.17	1,810	1,322	12,672.04	1,101.68	5,789.18	2.26	3.20	4,687.51
Williams	3,281	456	92	548	0.17	1,008	460	12,546.51	1,185.60	949.92	2.16	0.94	-235.68
Wood	847	115	39	154	0.18	2,104	1,950	6,953.30	378.49	1,827.55	2.46	0.87	1,449.06
Wyandot	2,338	240	24	264	0.11	1,378	1,114	4,191.71	152.85	1,124.31	0.58	0.82	971.45
TOTAL	**214,619**	**20,943**	**5,797**	**26,740**	**0.13**	**122,825**	**96,086**	**785,952.12**	**38,326.26**	**138,514.75**	**1.39**	**1.18**	**100,189**