U.S. Fish & Wildlife Service

Technical Procedures for Conducting Status and Trends of the Nation's Wetlands

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U.S. Fish and Wildlife Service

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CONTENTS

General Disclaimer

The use of trade, product, industry or firm names or products in this report is for informative purposes only and does not constitute an endorsement by the U.S. Government or the Fish and Wildlife Service.

TECHNICAL PROCEDURES FOR CONDUCTING STATUS AND TRENDS OF THE NATION'S WETLANDS

PREFACE

These specifications serve as a reference for conducting the image analysis work normally associated with monitoring wetland and deepwater habitat area changes. It is impractical to include all of the technical aspects of data handling and analysis within this document or anticipate all resource monitoring needs. Users are advised that other written conventions may be useful in describing image interpretation and monitoring protocols and should be referenced as appropriate. More detailed wetland field guides, regional information, plant lists and soils descriptions are also available.

This information is intended to provide general guidelines for work performance, but should not be substituted for direct communication with the appropriate Program, Project or Technical Specialist(s) regarding procedural questions. For additional information contact:

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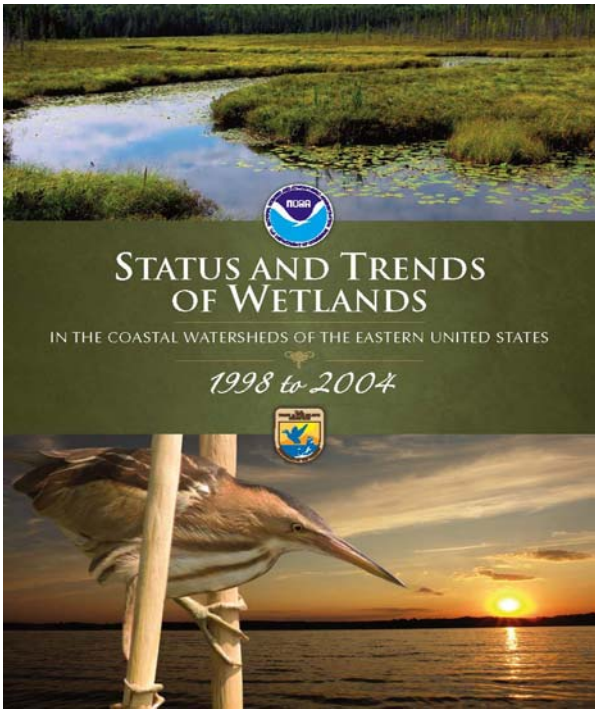
This document is intended to be comprehensive, however situations may develop that require modifications or additions.

I. Introduction

The mission of the U. S. Fish and Wildlife Service (Service) is to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. The Service supports active programs relating to migratory birds, endangered species, certain marine mammals, inland sport fisheries and wildlife refuges. The Service communicates information essential for public awareness and understanding of the importance of fish and wildlife resources and changes reflecting environmental conditions that ultimately will affect the welfare of human beings. To this end, the Service maintains an active Federal role in the inventory and monitoring of wetland habitats of the Nation.

The Service is the principal Federal agency that provides information to the public on the extent and status of the Nations wetlands. The Status and Trends component has had a history of success in providing scientific information to resource managers and decision makers about wetlands resource trends. The scientific integrity of the Wetlands Status and Trends is unchallenged as it represents the most comprehensive and contemporary effort to track wetlands resources on a national scale.

The Service's efforts to monitor wetland status and trends have been enhanced by the multi-agency involvement in the study's design, data collection, verification, and peer review of the findings. The Service is continuing to develop additional applications of its data that will facilitate broader use and relevancy for integrated natural resource management and decision making in the future.



In 2009, the Service, working in collaboration with the National Oceanic and Atmospheric Administration (NOAA - Fisheries), released a report based on further analysis of the national status and trends information in the coastal watersheds of the Atlantic, Gulf of Mexico and Great Lakes. The results of that effort have stimulated subsequent actions from the Federal agencies for further policy considerations and focused conservation efforts in these coastal areas.

In similar fashion, the Service is working closely with the Environmental Protection Agency (EPA) in preparation for the National Wetland Condition Assessment Study. Working in partnership with EPA it has become clear that the Service's Wetlands Status and Trends data set offer one of the best starting points for a probabilistic national condition assessment. The two agencies are collaborating closely on a number of technical monitoring and data collection efforts.

Advances in information technology and geographic information systems have influenced public expectations for greater utility and functionality from Government data sources. There is an ever growing importance and sensitivity placed on data quality and integrity. The Service strives to present information on wetlands, deepwater and related habitats in an accurate, clear, complete and unbiased manner. To ensure the effectiveness and reliability of wetland status and trends data, the Service has established these procedural guidelines and adheres to the various quality assurance and quality control measures described. The goal of these guidelines and protocols is to ensure that the data collection, analysis, verification and reporting methods used produce information suitable to support decisions for which the data were intended.

The technical procedures described here have been developed to provide the processes needed to produce accurate wetland acreage estimates for the Nation.

II. The Service's Wetlands Status and Trends Component

Data from status and trends provide important long-term trend information about specific changes and the overall status of wetlands in the United States. The historical data base that the Service has developed through Status and Trends, provides photographic evidence of land use and wetlands extent dating back to the 1950s. This provides an accurate record to assist in future restoration efforts.

The Service's wetland trends monitoring effort provides comprehensive information available to decision makers and the general public. The Service has rigorously documented the historic downward trend in wetland losses since the 1950s. At that time the average annual wetland loss rate was 458,000 acres. During the mid-1970s to mid-1980s the loss rate had declined to 290,000. The rate again declined to about 59,000 wetland acres annually from 1985 to 1997, and from 1998 to 2004 the gains in wetland acreage exceeded losses by about 32,000 acres annually. The Service has documented this progress and produced five national reports. They are used by Federal and State agencies, the scientific community and conservation groups for planning, decision making and wetland policy formulation and assessment.

Strategic Planning and the Wetlands Status and Trends Component
Contemporary scientific information on wetlands should be the bedrock of good policy. The Service's strategic plan for wetlands is focused on the development and dissemination of wetlands information to Service resource managers and the public. The Service's wetlands expertise positions the Agency to assume an even greater future role in aquatic habitat policy development. Resource managers increasingly need contemporary information on aquatic habitats to address increasingly complex issues. To successfully meet these Agency needs in the 21st century, a strategic vision has been developed to focus on various program elements including: *Trend and Change Analyses of Wetlands and Other Aquatic Habitats* - especially in areas that have experienced substantial wetland change or that are changing rapidly.

<u>Goal Statement</u>

The goal of Wetlands Status and Trends is to provide the Nation with current scientifically valid information on the status and extent of wetland, riparian and related aquatic resources and monitor trends of these resources over time.

III. Mandate and Authorizations

In 1986, the Emergency Wetlands Resources Act (Public Law 99-645) was enacted to promote the conservation of our Nation's wetlands. Congress recognized that wetlands are nationally significant resources and that these resources have been affected by human activities. Under the provisions of this Act, Section 401 requires the Fish and Wildlife Service to conduct wetland status and trends studies of the Nation's wetlands at periodic intervals. Reports on the status and trends of wetland area were produced by the Service in 1983/84, 1990, 1991, and 2000 (Frayer *et al*. 1983; Tiner 1984; Dahl 1990; Dahl and Johnson 1991; Dahl 2000; Dahl 2006; Stedman and Dahl 2008).

An updated wetlands status and trends study in 2005 was produced five years ahead of schedule as a result of a Presidential Directive. This directive effectively placed the Service's Wetlands Status and Trends component on a five year reporting cycle.

IV. Operational Terms and Definitions

Study Objectives
This study was designed to be a quantitative measure of the areal extent of all wetlands in the conterminous United States.

Habitats Addressed: The Service's Wetlands Status and Trends study design, training and operations are aimed specifically at monitoring the nation's wetlands. The Service has specialized knowledge of wetland habitats, classification, and cover type changes. The focus of reporting is on the Nation's wetlands regardless of ownership.

Wetland Definition and Classification
The Fish and Wildlife Service uses the Cowardin *et al*. (1979) definition of wetland. This definition is the standard for the agency and is the national standard for wetland mapping, monitoring, and data reporting as determined by the Federal Geographic Data Committee. It is a two-part definition as indicated below:

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water.
>
> For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Ephemeral waters, which are not recognized as a wetland type, and certain types of "farmed wetlands" as defined by the Food Security Act and that do not coincide with Cowardin *et al.* definition were not included in this study. The definition and classification of wetland types are consistent between every status and trends study conducted by the Fish and Wildlife Service. Habitat category definitions are given in synoptic form in Table 1. The reader is encouraged to review Appendix A, which provides complete definitions of wetland types and land use categories used in this study.

Wetland Classification Applications

The Service has made adaptations to the Cowardin classification system to accommodate the use of remotely sensed imagery as the primary data source. For example, water chemistry, halinity, water depth, substrate size and type and even some differences in vegetative species cannot always be reliably ascertained from imagery. Image analysts must rely primarily on physical or spectral characteristics evident on high altitude imagery, in conjunction with collateral data, to make decisions regarding wetland classification and deepwater determinations[1].

Deepwater Habitats

Wetlands and deepwater habitats are defined separately by Cowardin *et al.* (1979) because the term wetland does not include deep, permanent water bodies. Deepwater habitats are permanently flooded land lying below the deepwater boundary of wetlands. Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium in which the dominant organisms live, whether or not they were attached to the substrate. For the purposes on conducting status and trends work **all lacustrine and riverine waters** are deepwater habitats.

Upland Habitats

The Wetlands Status and Trends study uses an abbreviated upland classification system with five generalized categories as seen in Table 1. Some habitat monitoring projects may require more specialized upland classification. For these projects, the Service uses the U. S. Geological Survey (USGS) land classification scheme described by Anderson *et al.* (1976). More detailed Level 1 or Level 2 descriptors found in Anderson *et al*. (1976) or other schemes may be used to satisfy specific study applications.

An example of the "other upland" category as one of five generalized categories of uplands used in the Wetlands Status and Trends study.

[1]Analysis of imagery is often supplemented with limited field work and ground observations.

Table 1. Wetland, deepwater, and upland categories used to conduct wetland status and trends studies. The definitions for each category appear in Appendix A.

Salt Water Habitats	**Common Description**
Marine Subtidal*	Open Ocean
Marine Intertidal	Near shore
Estuarine Subtidal*	Open-water/bay bottoms
Estuarine Intertidal Emergents	Salt marsh
Estuarine Intertidal Forested/Shrub	Mangroves or other estuarine shrubs
Estuarine Intertidal Unconsolidated Shore	Beaches/bars
Riverine* (may be tidal or non-tidal)	River systems
Freshwater Habitats	
Palustrine Forested	Forested swamps
Palustrine Shrub	Shrub wetlands
Palustrine Emergents	Inland marshes/wet meadows
Palustrine Unconsolidated Shore	Shore beaches/bars
Palustrine farmed	Farmed wetland
Palustrine Unconsolidated Bottom (ponds)	Open-water ponds/aquatic bed
Pond - Natural characteristics	Small bog lakes, vernal pools, kettles, beaver ponds, alligator holes
Pond - Industrial	Mine pits or drainage ponds, highway borrow pits, sewage lagoons, industrial holding ponds
Pond - Urban use	Aesthetic or recreational ponds, golf course ponds, residential lakes, ornamental ponds, water retention ponds
Pond - Agriculture use	Ponds in proximity to agricultural, farming or silviculture operations such as farm ponds, dug outs for livestock, agricultural waste ponds, irrigation or drainage water retention ponds
Pond - Aquaculture	Ponds singly or in series used for aquaculture including cranberries, fish rearing

Lacustrine*	Lakes and reservoirs
Uplands	
Agriculture	Cropland, pasture, managed rangeland
Urban	Cities and incorporated developments
Forested Plantations	Planted or intensively managed forests; silviculture
Rural Development	Non-urban developed areas and infrastructure
Other Uplands	Rural uplands not in any other category; barren lands

*Constitutes deepwater habitat

V. Limitations

Certain habitats were excluded from this study because of the limitations of aerial imagery as the primary data source to detect wetlands. These limitations included the inability to accurately monitor certain types of wetlands such as sea grasses found in the intertidal and subtidal zones of estuaries and near shore coastal waters (Orth *et al*. 1990), submerged aquatic vegetation, or submerged reefs (Dahl 2006). The majority of seagrasses are not delineated as part of the status and trends studies.

Ephemeral waters not recognized as a wetland type by Cowardin *et al*. (1979), are not included in this study.

VI. Technical Aspects and Project Specifications

Sampling Design

The approach used is a stratified random sampling of plots. These are examined, with the use of remotely sensed data in combination with field work, to determine wetland change.

To monitor changes in wetland area, the 48 conterminous States are stratified or divided by State boundaries and 37 physiographical subdivisions described by Hammond (1970) and shown in Figure 1. Zone 36 was added by the Service to include coastal wetlands and nearshore features. In 2008, Zone 37 was added to include the coastal wetlands along the Pacific coast of conterminous U.S. A list of the physiographic regions by name, abbreviation code and map number is provided in Appendix B.

To permit even spatial coverage of the sample and to allow results to be computed easily by sets of States, the 37 physiographic regions formed by the Hammond subdivisions and the coastal zone stratum are intersected with State boundaries to form 220 subdivisions or strata. An example of this stratification approach and the way it relates to sampling frequency is shown for Georgia (Figure 2).

Figure 1. Physiographic regions of the conterminous United States as used for stratification in the Wetlands Status and Trends study (adapted from Hammond 1970).

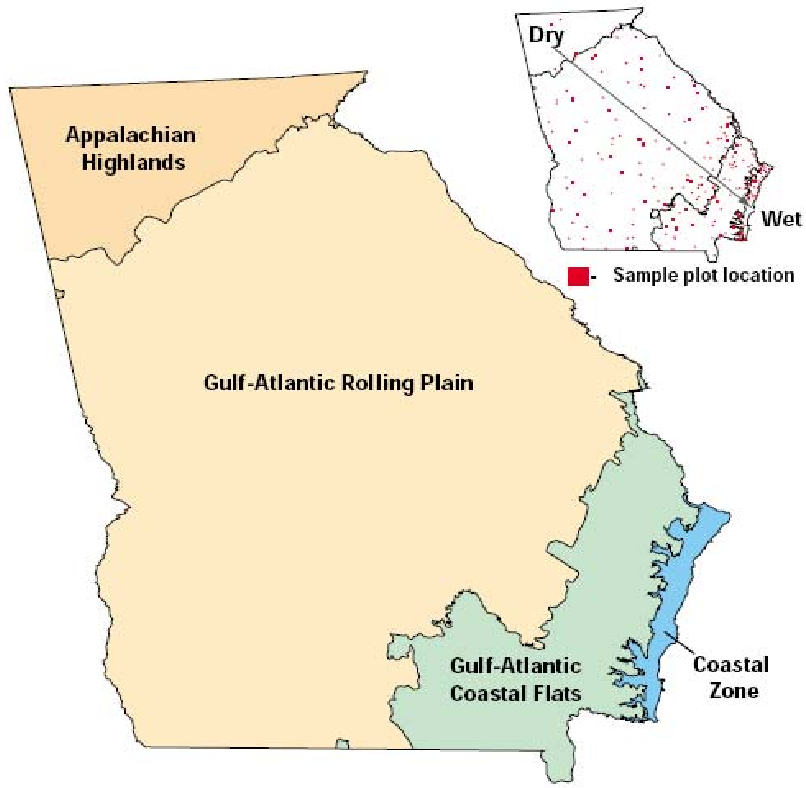


Figure 2. Physiographic strata in Georgia.

Within the physiographic strata described above, weighted, stratified sample plots are randomly allocated in proportion to the amount of wetland acreage expected to occur within each stratum. Each sample area is a surface plot 2.0 miles (3.218 km) on a side or 4 square miles of area equaling 2,560 acres (1,036 ha). The study includes all wetlands regardless of land ownership.

The advantages to this design are that it was developed by an interagency group of spatial sampling experts specifically to monitor wetland changes. It can be used to monitor conversions between ecologically different wetland types, as well as, measure wetland gains and losses.

For each sample plot, the rate of change among all wetland types between the two dates of imagery is used to estimate the total area of the sample plot in each wetland type and the changes in wetland area between dates. The changes are recorded in categories that can be considered the result of either natural change, such as the natural succession of emergent wetlands to shrub wetlands, or human induced change. Areas of the sample plot that have been identified in previous eras as wetlands but are no longer wetlands, are placed into five land use categories including agriculture, upland forested plantations, upland areas of rural development, upland urban landscapes and other miscellaneous lands. The outputs from this analysis are change matrices that provided estimates of wetland area by type and observed changes over time. Rigorous quality control inspections are built into the interpretation, data collection and analysis processes.

Suitable Imagery

Only good quality imagery is acquired and used. Either high resolution satellite imagery or aerial photography are the primary data sources. The preferred type is color infrared imagery. Traditionally, wetland interpreters have found color infrared to be superior to other imagery types for recognition and classification of wetland vegetation types. However, true color imagery has been proven as an important data source as well.

In some instances, the Service has arranged custom flights to acquire recent imagery that would accurately portray surface water conditions.

Wherever possible, leaf-off (early spring or late fall) imagery is preferred. A number of studies have found that imagery obtained when vegetation is dormant allows for better identification of wetland boundaries, areas covered by water, drainage patterns, separation of coniferous from deciduous forest, and classification of some understory vegetation. (U.S. Environmental Protection Agency 1991) There are distinct advantages to using leaf-off imagery to detect the extent of forested wetland. Visual evidence of hydrologic conditions such as saturation, flooding, or ponding combined with collateral data sources including soil surveys, topographic maps, and wetland maps are used to identify and delineate the areal extent of forested wetlands. Leaf-off imagery is an important tool in this process.

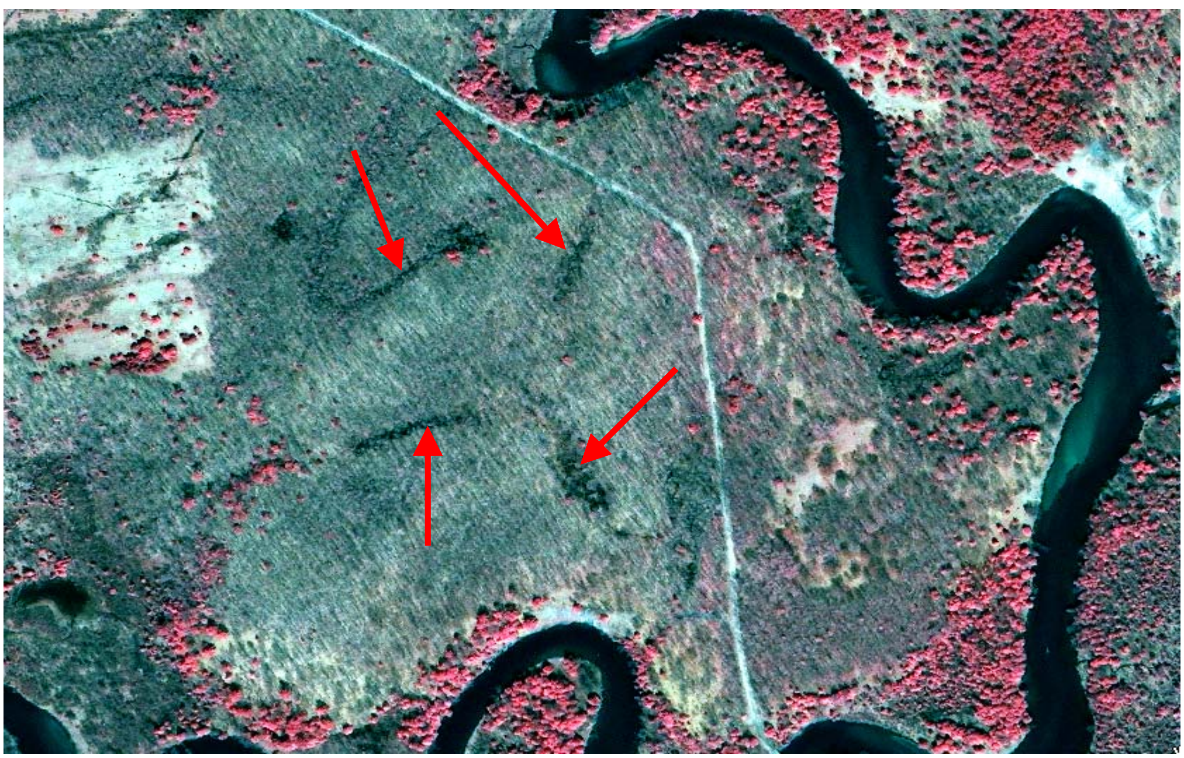


Figure 3. Early spring 2005 Ikonos satellite image of Michigan. Leaf-off condition makes recognition of wetland features easier. These old oxbows or swales (indicated by red arrows) can be masked by heavy tree canopy later in the growing season.

VII. Methods of Data Collection and Image Analysis

The delineation of wetlands, deepwater habitats and riparian features through image analysis forms the foundation for deriving all subsequent products and data results. Consequently, the Service places a great deal of emphasis on the quality of the image interpretation. The Service makes no attempt to adapt or apply the products of these techniques to regulatory or legal authorities regarding wetland boundary determinations, jurisdiction or land ownership, but rather uses the information to assist in making trends estimates characterizing wetland habitats.

Image Interpretation of Wetlands - General Concepts
There are "basic elements" that can aid in identification of wetland habitats from aerial photographs or satellite imagery. The image analyst uses these to make decisions about ecological habitat boundaries to delineate wetlands. These same elements are used in the quality control review of delineated information to check for accuracy and completeness.

Tone (also called Hue or Color) -- Tone refers to the relative brightness or color of elements on an image. It is, perhaps, the most basic of the interpretive elements because without tonal differences none of the other elements could be discerned.

Size -- The size of objects must be considered in the context of the scale of an image. The scale will help you determine if an object is a stock pond or large lake.

Shape -- Refers to the general outline of objects. Regular geometric shapes are usually indicators of human presence and use.

Texture -- The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone on images. It is produced by a set of features too small to identify individually. Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough".

Pattern (spatial arrangement) -- The patterns formed by objects in an image can be diagnostic. Consider the difference between (1) the random pattern formed by a natural grove of trees and (2) the evenly spaced rows formed by an orchard or planted forest.

Shadow -- Shadows aid analysts in determining the height of objects on aerial imagery, however, they also may obscure objects lying within them.

Geographic Location -- This characteristic of imagery is especially important in identifying vegetation types and land forms. For example, large oval depressions can readily be identified as pocosin wetlands in coastal plain of South Carolina.

Association -- Some objects are always found in association with other objects. The context of an object can provide insight into what it is. For instance, golf courses generally contain open water ponds (wetlands) used as water traps.

For general information on photo interpretation and photo interpretation techniques, users are referred to the following publications:

Avery, T.E. 1968. *Interpretation of Aerial Photographs* 2nd edition. Burgess Publishing Co., Minneapolis, MN. 324 p.

Lillesand, T.M. and R.W. Kiefer. 1987. *Remote Sensing and Image Interpretation* 2nd edition. John Wiley and Sons, Inc., New York, NY. 721 p.

W. Philipson (editor) 1996. *Manual of Photographic Interpretation* (Second edition). American Society for Photogrammetry and Remote Sensing. Bethesda, MD

On-Screen (Heads-up) Method. The accepted technique used to interpret and delineate wetlands for Status and Trends is the on-screen method using digital, rectified imagery.

The on-screen or heads-up method involves viewing digital map data that overlays digital imagery on a personal computer screen (monitor). Changes to the data to make it current with the digital imagery can be made on-screen, checked and saved or exported.

The heads-up method, as described here, was primarily developed for updating wetland features. It employs geodatabase formats for viewing, editing and storing the status and trends digital data. This greatly improves the administration, access, management and integration of spatial data. The heads-up method has several distinct advantages:

- Uses digital imagery (DOQs or satellite data).
- Digital Raster Graphics (DRGs) provide a direct backdrop for image interpretation and checking.
- Automated verification routines can incorporate GIS capability.

There are also several disadvantages associated with this method:

- The process is machine/cursor driven. This requires an ArcGIS literate operator.
- On-screen viewing may lower resolution and limited stereo capabilities.
- The image analyst may over delineate features.

The heads-up process relies on the image interpreter's ability to recognize, accurately delineate and classify wetlands, perform edits, and verify the digital data. Attribute domains were created to allow quicker attribution of status and trends features using wetland and deepwater codes as well as upland codes. A custom verification toolset was also developed to provide quality control or logic checks of the digital data.

Editing and updating wetland digital data using the heads - up process implies the following:

- Digital imagery will be used as the base imagery to update the wetlands information.

- The existing status and trends digital data will overlay and register to a USGS DRG of the topographic base map or digital ortho-rectified imagery.

- Use ArcGIS software in a Windows environment to edit existing digital data.

- Use the Service's customized software tools to assist the updating and editing and data verification processes.

Minimum Hardware and Software Requirements
Desktop Work Stations: The customized Verification Toolset is an Arc Toolbox component of the Environmental Systems Research, Incorporated's (ESRI) ArcGIS desktop geographic information system (GIS) product. To run this toolset, any workstation must be capable of running the ArcGIS suite, including Arc Desktop and Arc Workstation. ESRI has published system requirements for ArcGIS on their web site: www.esri.com. The following minimum hardware requirements are necessary:

- CPU with a clock speed of 2 gigahertz or faster.

- 1 gigabyte of physical RAM.

- AGP video card with 64 megabytes of video memory.

- 10/100-base-T network adapter.

- SCSI or ATA100 IDE hard drive.

- 1024 x 768 resolution monitor[2].

Software - ArcGIS 9.3 is currently used to perform update edits in a heads-up environment. ArcMAP provides a suite of efficient editing tools, interactive editing capability and integrated version control of data.

Personnel Qualifications
Using the on-screen method, image analysts are responsible for ecological integrity of the mapping process as well as most of the cartographic accuracy. The identification, delineation and attribution of features is done within the digital data file requiring analysts to understand the ecological aspects of wetlands as well as be able to operate in a computerized mapping environment. For this reason, image analysts using this method should be experienced with Arc Desktop (8.3, 9.0 or later versions) software, and have some familiarity with geodatabases and editing spatial data. Image analysts must have an understanding of surface water hydrology and wetland ecology. The analyst observes the amount of standing water, if any, visible on the photograph and relates it to the date of photography, type of wetland vegetation, local or regional precipitation patterns, length of growing season, soil types, physiographic position, and knowledge of the area gained from supplemental data sources.

[2] Dual monitors may be preferred

VIII. Working with the Digital Imagery and Geodatabase Files Provided

Status and trends plots to be updated are provided to the image analysts via email, ftp, hard drive, CDs or DVD media. Plots are grouped by state and may include all or a portion of the plots per state. Digital wetlands data are provided in file geodatabase format. These data are in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar units are meters. The horizontal planar datum is the North American Datum of 1983, also called NAD83. The data provided will include the following information:

1. The 2009 era (T2 era)digital imagery (all imagery is ortho-rectified).
2. A geodatabase containing the digital wetlands data.
3. The customized status and trends verification toolset.
4. Instructions for tool installation and user information.
5. A standardized field trip report outline to be used when submitting field trip reports.
6. A standardized field site form to be used at specific field check sites.

Analysts must review and update (delineate) all wetland, deepwater and upland features within the plot boundary. ***All work is to be done in ArcGIS 9.3. The verification toolset is designed to work in Arc 9.3.***

Updated plots must be verified and the data returned to the Service for additional quality control reviews.

Acquiring and Incorporating Collateral Digital Data
Minimal data requirements for updating status and trends plots using the heads-up method are recent digital imagery (T2), trend plot digital data files (T1), and digital raster graphics (DRGs). Optional collateral data may include digital soils data, hydrology (NHD), coastal navigation chart data, supplemental imagery, etc.

Imagery, DRGs, NHD hydrography data, soils data or other collateral data are currently available by accessing ***The National Map*** at: http://nationalmap.gov/index.html. Other collateral data are available through agency web sites including the following:

NRCS soils data at: http://soildatamart.nrcs.usda.gov/

NOAA coastal navigation charts at: http://nauticalcharts.noaa.gov/mcd/enc/index.htm

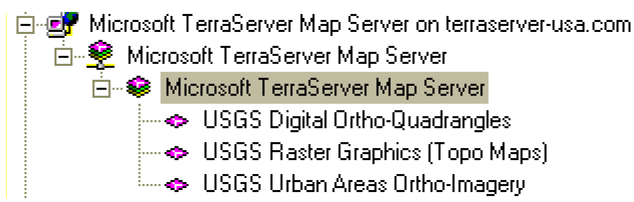
Viewing Reference DRG's and OrthoPhotos in ArcMap
When reviewing digital plot data it is invaluable to have ancillary imagery, topographic maps and other collateral data to use as additional sources of information. This can be achieved

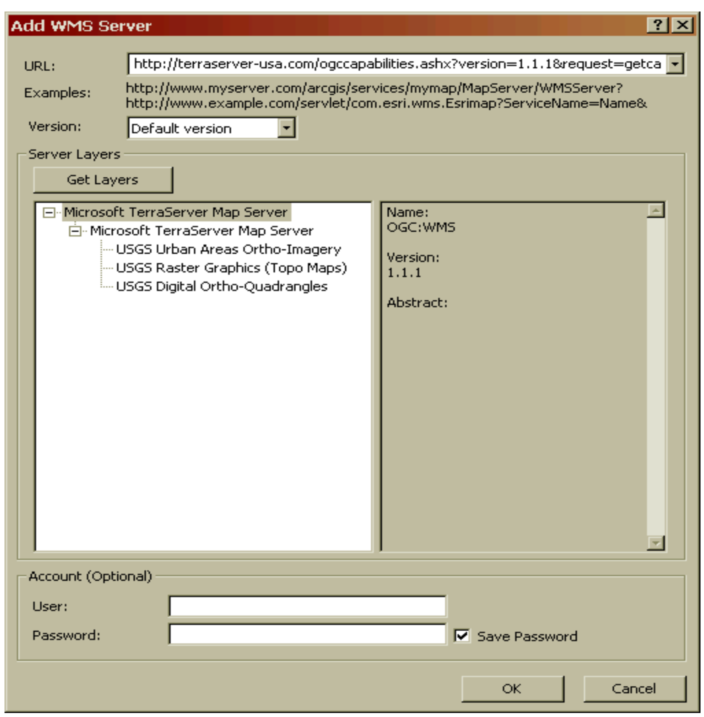
without having the data stored locally, but through the use of Web Mapping Services (WMS). Internet access is required along with some simple customization of ArcCatalog to connect to the Microsoft TerraServer WMS, which serves USGS DRGs, DOQQs and Urban Areas Ortho-Imagery.

Configuring ArcCatalog to connect to Microsoft TerraServer Map Server

a) Expand the GIS Servers folder in your ArcCatalog table of contents

b) Double-click ‘Add WMS Server’
c) Enter the following URL into the top ‘URL:’ text box: http://terraserver-usa.com/ogccapabilities.ashx?version=1.1.1&request=getcapabilities&service=wms
d) Click the ‘Get Layers’ button to view the available WMS layers.
e) Click ‘OK’
f) The WMS connection is now visible in the table of contents in ArcCatalog. The entire Service or each individual component can be added to an ArcMap session.





Digital Raster Graphics (DRGs)
A DRG is a scanned image of a USGS standard series topographic map. The image inside the map neatline is georeferenced to the surface of the earth and uses the UTM projection. The horizontal positional accuracy and datum of the DRG matches the accuracy and datum of the source map. These form the standard base map for the status and trends sample plots and should be used as both a base and as a source of collateral data for identifying wetlands.

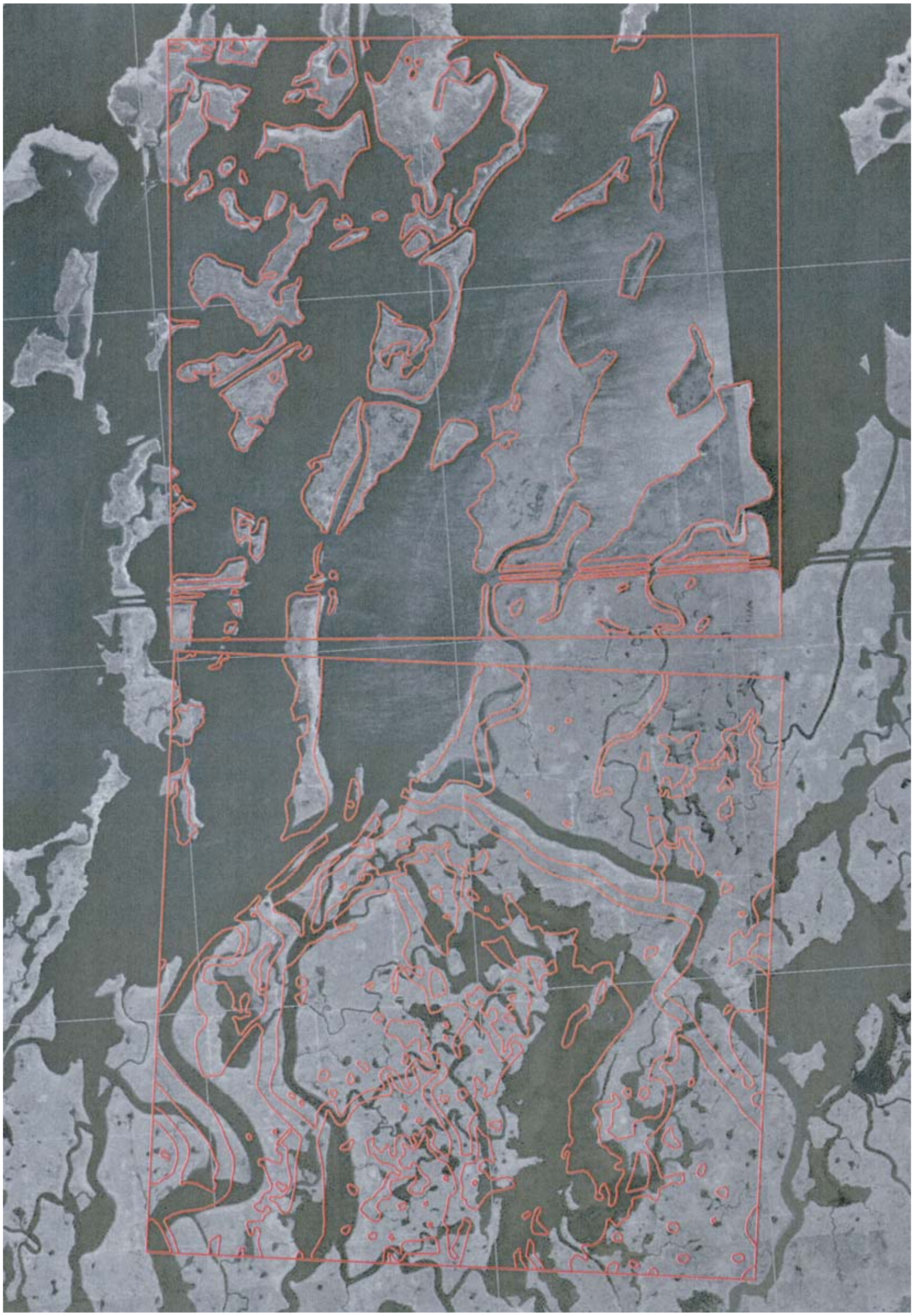
> **Optimum transparency for DRG backdrops -** DRG images should be visible as a backdrop to the imagery being used for mapping. The recommended transparency setting for viewing DRG backdrops is 75%. Transparency settings within an ArcMap session should not exceed 80% or be less than 60%. The DRG image may be toggled on and off as needed when conducting active editing or feature delineations on the digital image.

Digital Orthophotos (DOQs)
Digital orthophotos are rectified digital photography that combine the image characteristics of a photograph with the geometric qualities of a map. Digital orthophotos are geo-referenced. This means that any point on the orthophoto is referenced to its actual latitude/longitude (its actual location on the earth). Ortho-rectification removes distortion in the photo and provides uniform scale throughout the image.

Many digital orthophoto quarter quads (DOQQs) are produced by the USGS and represent a quarter of a standard USGS 1:24,000 quadrangle. DOQQs are either gray scale (black and white) or color infrared and have a 1.0. meter ground resolution. DOQQ's are projected in UTM meters in NAD83 Datum. USGS DOQ's meet National Map Accuracy Standards at 1:12,000 scale for 3.75-minute quarter quadrangles and at 1:24,000 scale for 7.5-minute quadrangles (corresponding to standard, 7.5-minute USGS topographic maps). ***The National Map*** provides DOQs for the country. These can be accessed and used as supplemental photography by image analysts as described earlier.

Checking Data Alignment and Registration
Not all DOQs have been made by USGS and may not meet these specifications. For this reason, checking the accuracy and registration of the DOQ is an important first step. This can be done by aligning the DOQ image with the matching portion of the DRG. Since USGS base map has always, and will continue to be the base map for the wetlands status and trends effort, all digital data is aligned or compared to the standard DRG. If imagery is scanned and rectified, acquired from non-conventional sources or if satellite imagery is used, the images must match the DRG base. This can be accomplished by checking alignment of known features on the image and map for correlation or checking datum corner points. Generally there should be close agreement between the digital imagery, the DRG and the digital status and trends polygonal data. (***Note:*** ***If there are major discrepancies between these data layers (as illustrated in the inset example on the next page), plot(s) should be identified and returned to the project manager. New plots with corrected data will be provided.)***

Using Stereoscopic Interpretation and Collateral Hard-copy Imagery
Hard-copy, historic aerial photography is available for most status and trends plot areas. On a limited basis, these photos may be made available to assist in the update process.



Inset: This illustration shows two plot data sets matched to an imagery base. The top plot is a 'good' match to the imagery. The bottom plot is obviously not aligned properly and is an example of the type of plot that should be returned for corrective action.

Air photo interpretation involving three-dimensional viewing of successive air photos that overlap the same geographic area (between flight lines) provides a useful method to confirm interpretation work. In stereo view, topographic relief features become recognizable. Photos are examined stereoscopically and supporting information from topographic maps, soil surveys, and other land cover maps assist in this process. This, combined with the visual appearance of discrete vegetation communities based on color, texture and relative height, permits an experienced wetlands interpreter to identify wetland habitats. This process has been employed successfully by Service biologists to map wetlands since the mid 1970s. All stereo photo interpretation should be done using equipment equal to or better than four-power (4X) mirror stereoscopes.

IX. Delineation of Status and Trends Plot Data

The Service identifies wetlands and deepwater habitats primarily by the analysis of high altitude imagery. Wetlands are identified based on vegetation, visible hydrology and geography. There is a margin error inherent in the use of imagery, thus detailed on-the-ground inspection of any particular site, may result in revision of the wetland boundaries or classification established through image analysis. The accuracy of image interpretation depends on the quality of the imagery, the experience of the image analysts, the amount and quality of the collateral data, and the amount of ground truth verification work conducted.

Wetlands, deepwater and upland habitats will be labeled using the letter and number code (alphanumeric) that correspond to attribute codes and classification descriptors in Table 2. Classification of each delineated unit shall include the appropriate system, subsystem and class.

Split-class attributes are not allowed and no point or linear features are included in the status and trends data set. Features that are too small to be delineated as polygons will not be included (also see p. 25). However, based on existing data, features as small as 0.1 acre have been included as polygons in the database and are tracked as part of this study.

Wetland delineation line work will follow the border of the wetland boundary. No upland features should be included as part of a wetland feature (i.e. adjacent roads, railroads, etc.).

The aerial imagery in combination with field reconnaissance will prevail as the principle data source for monitoring change. Changes which have taken place since the time of image capture (wetland gains or losses) should not be included as part of the mapping effort. Maximum vegetative summer growth in an average year and at the average low water level shall be basis for classification.

a

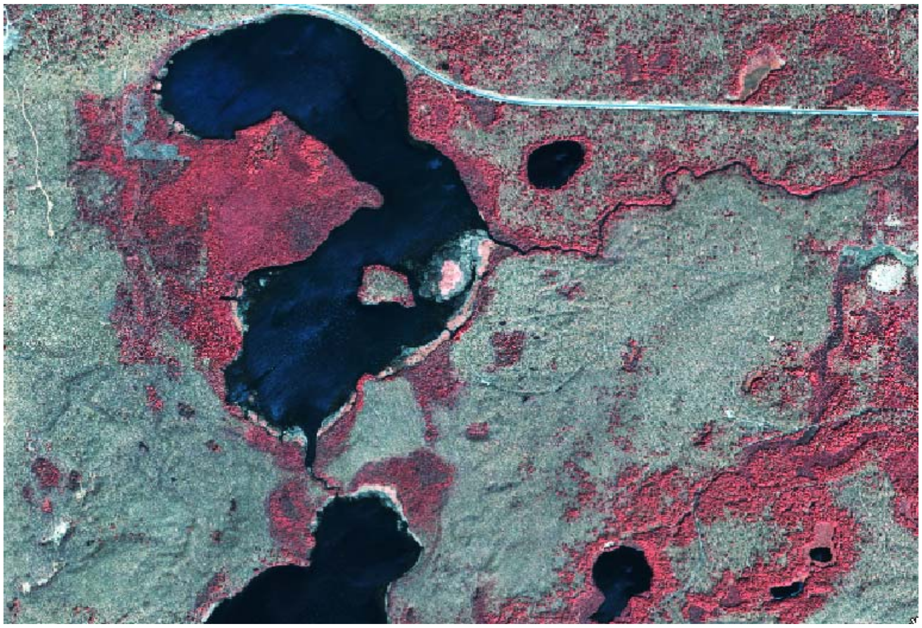


Figure 4a-b. High resolution imagery is the principle data source for determining wetland change. These examples are color infrared, 1.0 m or better resolution satellite images [Ikonos, 2005 (a), GeoEye, 2008 (b)].

b

Table 2. Wetland, deepwater, and upland categories used for wetlands status and trends studies.

Attribute Code	Salt Water Habitats	Common Description
M1	Marine Subtidal*	Open Ocean
M2	Marine Intertidal	Near shore
E1UB	Estuarine Subtidal*	Open water/bay bottoms
E2EM	Estuarine Intertidal Emergents	Salt marsh
E2SS	Estuarine Intertidal Forested/Shrub	Mangroves or other estuarine shrubs
E2US	Estuarine Intertidal Unconsolidated Shore	Beaches/bars
RIV	Riverine* (may be tidal or non tidal)	River systems
Attribute Code	**Freshwater Habitats**	**Common Description**
PFO	Palustrine Forested	Forested swamps
PSS	Palustrine Shrub	Shrub wetlands
PEM	Palustrine Emergents	Inland marshes/wet meadows
PUB	Palustrine Unconsolidated Bottom	Open water ponds/ponds with floating aquatics
PUBn	Pond - Natural characteristics	
PUBi	Pond - Industrial	
PUBu	Pond - Urban use	
PUBf	Pond - Agriculture use	
PUBa	Pond - Aquaculture	
Pf	Palustrine farmed	Farmed wetlands/rice
LAC	Lacustrine*	Lakes and reservoirs
Attribute Code	**Uplands**	**Common Description**
UA	Agriculture	Cropland, pasture, managed rangeland
UB	Urban	Cities and incorporated developments
UFP	Forested Plantations	Planted or intensively managed forests; silviculture
URD	Rural Development	Non urban developed areas and infrastructure
UO	Other Uplands	Rural uplands not in any other category; barren lands

***Constitutes deepwater habitat**

X. Image Analysis Specifications and Guidelines

Wetland Status and Trends employs remote sensing techniques to locate, identify and classify wetlands, deepwater habitats and upland land use. Currently, a combination of digital high altitude photography and high resolution satellite imagery is used. The image analysis of wetlands, deepwater habitats and upland land use forms the foundation for deriving all subsequent products and data results. Consequently, the Service places a great deal of emphasis on the quality of the initial image interpretation process.

Minimum Delineation Unit for Wetlands

The minimum targeted delineation unit for wetlands identified is one acre (0.40 ha). Results of past status and trends studies indicate the actual minimum feature delineated to be about 0.1 acre (0.04 ha), however not all features less than the target size were detected (Figure 5). The minimum size for wetland delineations should not be defined using sample plot boundaries, but by the total size of the feature regardless of the acreage within the Status and Trends sample plot area. All features delineated must be polygons.

There is no minimum unit applicable to wetland change delineation.

Figure 5. Small wetlands less than the minimum target size should be included when detected. This wetland is a fraction of an acre, but is apparent on the source imagery.

Level of Accuracy for Wetland Classification

Minimal classification accuracy shall be 95 percent. Wetland Status and Trends requires accurate delineation and classification to the "Class" level as described by Cowardin *et al*. (1979).

Minimum Delineation Unit for Uplands

Wetland Status and Trends uses a modified version of the Anderson, *et al.* (1976) upland land use categories. The minimum delineation unit for identifying uplands is five acres (2.0 ha). In some instances it may be important to delineate smaller units (e.g. small upland islands created in waterways,) but areas smaller than five acres of one upland land use type surrounded by another upland land use type should not be delineated. The minimum mapping size for upland delineations should not be defined using sample plot boundaries, but by the total size of the feature regardless of the acreage within the Status and Trends sample plot area.

Level of Accuracy for Upland Classification

Minimal classification accuracy shall be 95 percent. Additionally, the following apply:

- Roads within urbanized settings should be classified as upland-urban.
- Major (4-lane or greater) highways in rural areas should be classified as upland-rural development. Smaller roads in rural settings should not be delineated.
- Narrow (less than two or three crown widths) lines of trees (e.g. shelterbelts) should not be delineated. These should be classified with the surrounding upland land use.

Edge Matching Adjacent Sample Plots

Adjacent plots should be identified and where possible, these sample plots should be interpreted together through the change analysis phase. The image analyst is required to take steps to ensure accurate feature edge-matching of all finalized interpretation.

Collateral Data as an Aid to Image Analysis

The analyst is required to use all available and approved imagery, topographic maps, soils information or any other sources of collateral data during image interpretation. Review of these materials is helpful in interpreting aerial photographs or satellite images. Sources of collateral data may include the following:

U.S. Geological Survey (USGS) Topographic Maps or Digital Raster Graphic (DRG): Areas indicated on USGS 1:24,000 scale topographic maps by swamp symbology should be closely inspected on the source imagery. These features are often excellent indicators of wetland and unless strong evidence indicates otherwise, should be included on the map. Due to the nature of USGS topographic mapping, wetlands marked on USGS quadrangles tend to be at least seasonally flooded (U.S. Geological Survey 2001). All permanent water bodies are also mapped by USGS and can be accessed through the National Hydrography Dataset.

USGS maps also provide excellent information regarding slope, land use and some cultural features. Close attention should be paid to the topographic contour lines on the USGS maps. Many interpretation errors can be avoided if the degree of slope is taken into consideration. The location, shape, drainage pattern, and surrounding physical and cultural features are all important clues when delineating wetlands.

Natural Resource Conservation Service County Soil Surveys or Digital Soils Information: Soil survey maps are useful collateral data providing the description, classification, and mapping of soils within a county. Soil maps are a representation of various soil patterns within a landscape. The complexity of the soil patterns, scale of the base photography, field techniques employed, date compiled, and the minimum mapping unit for soil classification all play a roll in how the soils information was produced and the utility as collateral data for mapping wetlands. When used by an experienced image analyst as collateral data, soils maps are useful in assisting in separating upland from wetland (hydric) soils.

The soil survey geographic (SSURGO) data base duplicates the original soil survey maps and presents it in digital form. The SSURGO data represents the most detailed level of digital soil information.

National Oceanic and Atmospheric Administration Navigational Charts: A NOAA navigational, or nautical chart, is a graphic representation of the estuarine, marine and near shore environment. They are primarily used to plot routes for sea-going vessels. All nautical charts depict coastline features, configuration of the sea bottom, tidal ranges, location of man-made and natural hazards to navigation, and the properties of the earth's magnetism. Nautical charts are especially useful in determining the subtidal and intertidal subsystem breaks in the Marine and Estuarine wetland classification systems. They are also useful in determining the location and extent of mangroves, coastal shoals, flats or bars.

Previous Edition National Wetlands Inventory (NWI) Maps and Ancillary Project Information: Whenever a previous edition of an NWI map exists, the analyst will use the map as collateral information to determine the location and extent of wetlands based on an earlier time period. Using previous edition Service wetland maps will provide important information on the presence or absence of wetlands. This information is useful to the analyst using more current imagery, or imagery of a different scale, or emulsion.

Local or Regional Studies or Maps: The analyst is also encouraged to consult appropriate internal and external resources (regional experts, on-site resource managers, etc.) to assist in the interpretation process. Examples of this type of information include: Water management or district maps, vegetation maps or surveys, and local habitat studies or characterizations. The Service's Regional Wetland Coordinators, state agencies, or regional authorities are often good sources for such information. The interpretation and delineation of wetlands and deepwater habitats is expected to meet the Service's standards for accuracy and consistency. Communication and problem resolution procedures to ensure product acceptance should be maintained throughout the project.

XI. Plot Editing Guidelines

The following guidelines have been established to further describe project objectives:

Working scales - The nominal project scale for the Service's wetland status and trends plots is 1:12,000. Over-delineation of features is possible given the quality of some of the digital imagery being used. This should be avoided to realize project efficiencies and has led to establishing specific project scale thresholds.

Universal scale - The universal working scale is the scale where many edits are done in ArcMap and the delineations are reviewed and quality controlled. The universal scale should range between 1:8,000 and 1:10,000 in an ArcMap session. This exceeds the nominal scale to ensure accuracy and sufficient detail.

Maximum zoom - This is the maximum magnification an analyst should use for wetland delineation and classification purposes. This scale is established at 1:5,000. Delineations performed below this maximum zoom threshold greatly exceed the project's nominal scale, and may misrepresent the data as being more precise than can by supported by the techniques and objectives as established by the Service. Delineations performed at scales larger (more detailed) than this threshold lead to project inefficiencies.

Analyst corrections - Corrections to the existing digital data will be made to fix past mistakes. Corrections include such things as missed wetlands, areas incorrectly delineated as wetland, repositioning or rectification of old line work and corrections to the wetland or upland classification. Status and Trends does not generate maps for public distribution. For this reason ***the geo-position of polygons or line work is secondary importance to proper identification and accurate delineation of the wetland feature*** (Figure 6)***.***

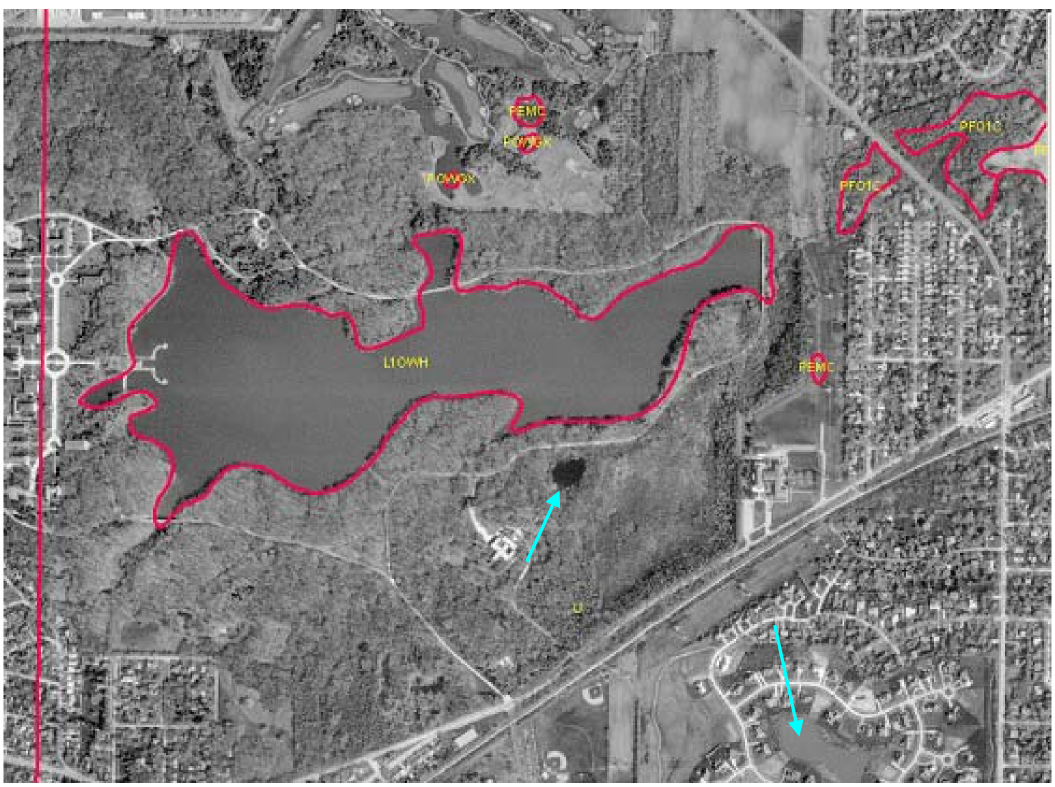


Figure 6. In this example, some the line work around the lake does not fit the basin exactly. However, the size, shape, general location and classification of the lake have not changed over time. There has been no visible ecological change since the last update. In this instance, image analysts shall add the new ponds that have been created (blue arrows) rather than adjust the lake boundary to be more precise.

Change Detection

Change detection and analysis involves identifying wetland gains and/or losses, cover type changes as well as upland land use changes. To determine changes between eras the analyst is required to compare the existing plot information from the past era to more recent imagery or the same area (Figure 7). All changes should represent realistic and logical analysis, avoiding any false or unlikely changes. An example of an unlikely change might involve upland urban (UB) being converted to palustrine forested wetland (PFO) over the course of a five year time span. This type of change will be carefully scrutinized and verified, if possible, by field examination or collateral data.

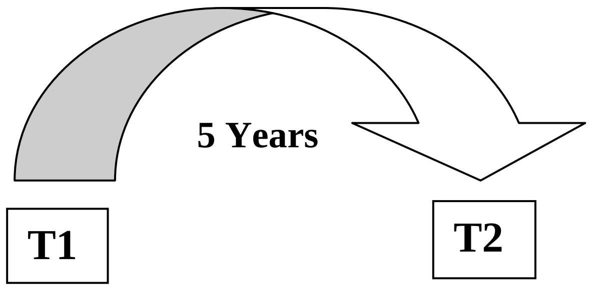


Figure 7. Change detection involves a comparison of two different eras (T1 and T2) over time.

Analyst updates or changes - to the wetland delineations are based on actual change over time. Updates included the 'deletion' of lost wetlands (Figure 8), additions of new wetlands, the reshaping of wetland boundaries based on changes that have occurred over time, and re-classification of wetlands that have changed cover-type. Changes in upland land use that have occurred over time (i.e. agriculture to urban) are not made unless it involves a wetland feature change.

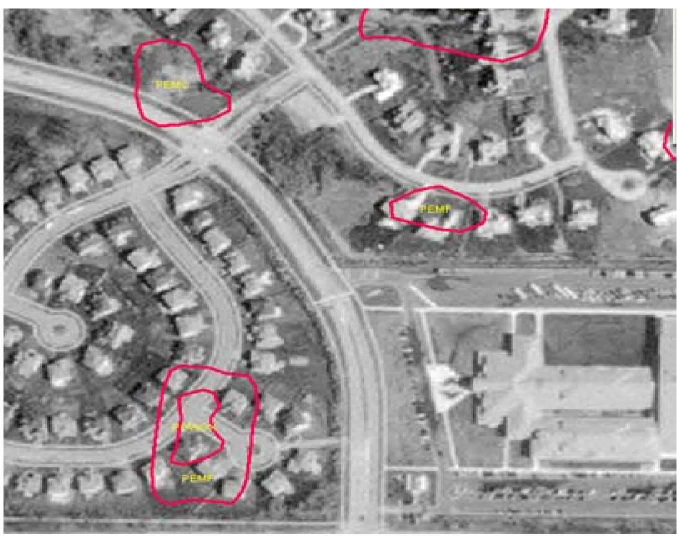


Figure 8. Some update changes are obvious on the imagery. In this example, historic wetlands indicated by red polygons have been lost to urban development.

The goals of updating wetland status and trends plots are to produce data that match existing wetland and deepwater conditions (on-the-ground) as closely as possible, and to use resources efficiently and cost effectively. Extraneous effort to "over delineate" or make previously mapped features conform to criteria greatly exceeding the project objectives should be avoided (U.S. Geological Survey 2001). Editing shall conform to the principles listed below:

- The resulting data set must support clear, unambiguous interpretation and readability of the wetland features that conform to the project's objectives.

- The classification accuracy of the mapped features must meet current standards, and the plot data overall must represent the scientific precision that underlies the Service's habitat monitoring objectives.

Wetland status and trends plots should reflect ecological change or changes in land use that influence the size, distribution or classification of wetland habitats. Enhancements to refine cartographic precision should be undertaken only to the extent they bring products into conformance with the project objectives and quality requirements.

Wetland and deepwater feature delineation and attribution provide the distinguishing characteristics needed to differentiate between features that have some ecological distinction or uniqueness. The decision to retain or change the existing map features or attributes is based on several factors considered to be revision guidelines.

Plot Revision Guidelines:

Retain all lakes, ponds, rivers, bays, sounds, estuaries, perennial streams (polygons) and other water bodies regardless of size, unless a feature has obviously changed or no longer exists.

Revise coastal shorelines only if there are obvious manmade changes or substantial natural changes. Tide stages do not reflect ecological change in shoreline delineations.

Revise wetland or deepwater boundaries by using collateral data sources and the geographical features that define location and configuration.

Revise existing wetland and deepwater habitat delineations and attributes only where reliable collateral data indicates a change or there is positive visual evidence of a change.

Do not revise classifications based on apparent draw down or temporary drought conditions (i.e. changing a permanent reservoir in draw down from lacustrine to palustrine - unconsolidated shore).

Do not revise bathymetric information unless new information is available or where shorelines have obviously been modified.

Revise classification of vegetative surface cover only when one of the following minimum change criteria is met:

- The total area of the feature to be re-delineated or re-classified is greater than 1.0 acre.
- The hierarchy of the re-classification is Cowardin class level or higher.

Avoid False Precision and Misrepresentation of Data
Technological advances in the acquisition of remotely sensed imagery and computerized mapping techniques often provide the ability to capture more detailed information about earth objects. The use of such technologies can be a tremendous advantage in terms of producing better quality natural resource information in a more timely fashion and often at a reduced cost. However, appropriate use of these capabilities requires specific knowledge of project objectives, limitations, and the proper application of the end products.

When mapping wetlands, deepwater and riparian habitats, image analysts will address the following criteria in priority order:

1. Delineation of wetland and deepwater habitats to closely resemble size and shape.

2. Appropriate classification to the Cowardin class level.

3. Approximation of geographical position within 10 m as determined by the imagery.

4. Revisions to reflect more precise geographical location or boundary determination as can be determined by the imagery.

Unrealistic attempts to characterize habitats in greater detail should be avoided unless specifically instructed by Service Project Manager. Detail is often confused with quality. The goal of the Service is to produce high quality products that accurately reflect the status of our nation's wetland resources. Steps that are implemented to add additional detail (delineation or classification of extremely small features or components) lends a sense of false precision and can misrepresent the data in way that it was not intended to be used.

Within a wetland boundary, the delineation of ecologically unsubstantiated internal breaks should be avoided. Intricate sub-delineation of cover-type changes (less than 0.5 ac.) within a wetland is often not warranted. In areas of undulating terrain (i.e. ridge and swale) or complexes of wetland classes (i.e. small shrub islands within emergent meadow), it is best to identify and characterize the wetland by a single classification rather than attempt to delineate and classify internal features.

If wetland sub-units are too small in area based on the minimum delineation unit to allow separate delineation of each cover type, the polygon should be classified to represent the cover type encompassing the greatest acreage (Figure 9a). Polygons that may contain a mosaic of cover types or ecosystem components and cannot be delineated separately will be classified using the dominant component (Figure 9b).

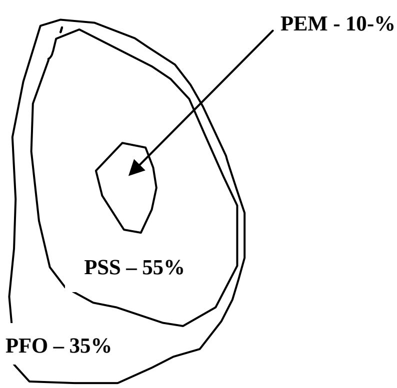


Figure 9a. In this example, a wetland with a total area less than one acre is correctly classified as PSS.

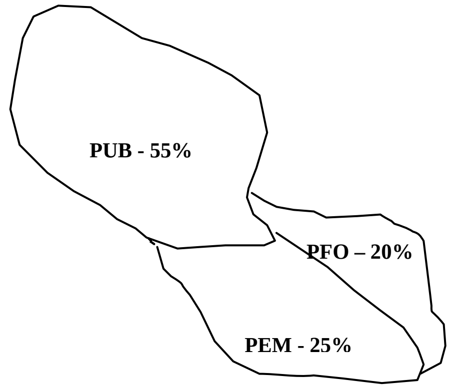


Figure 9b. If a mosaic of cover types cannot be delineated separately, the area should be classified using the dominant component. This wetland complex is correctly classified as PUB.

False Change

False changes are areas where the image analyst is fooled by the appearance of change to the wetland or upland. Common examples of false changes include:

- Palustrine farmed wetlands during dry cycles
- Deepwater draw down
- Drought conditions
- Excess surface water or ephemeral water
- Flooding

Avoid making false changes to the data. In general, false changes can be avoided by observing ***positive visual evidence of a change in land use***. This may include the presence of new drainage ditches (Figures 10, 11and 12), canals or other man-made water courses, evidence of dredging, spoil deposition or fills, impoundments or excavations, structures or pavement or hardened surfaces.

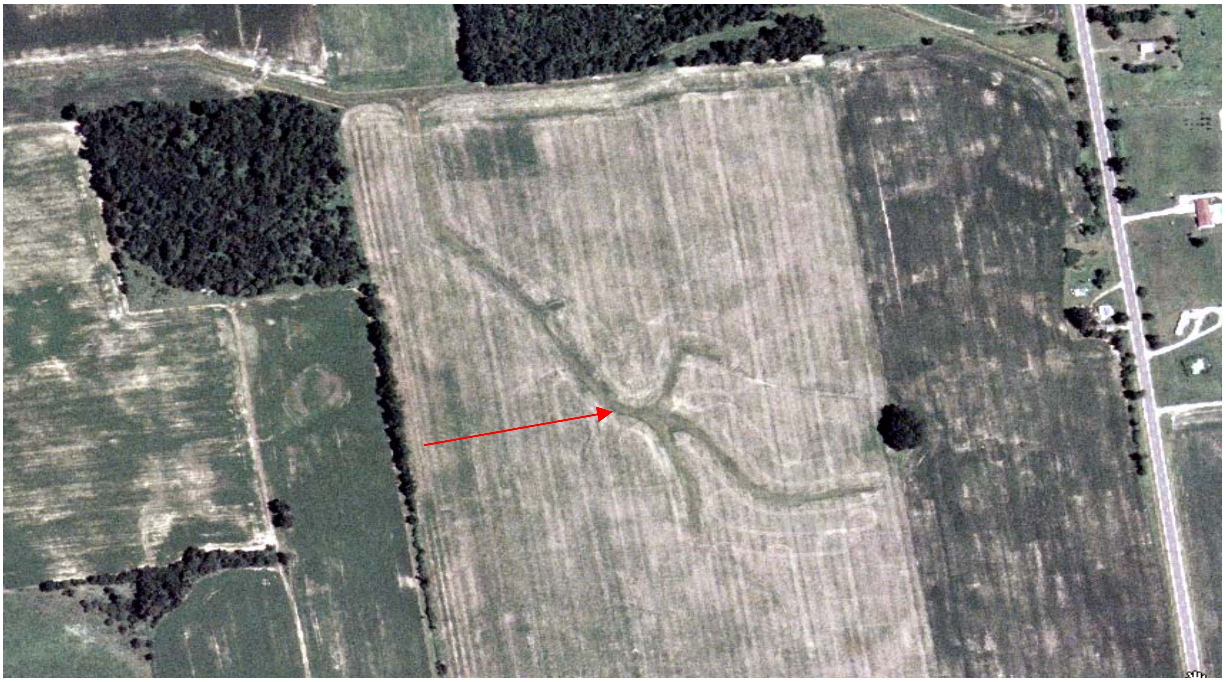


Figure 10. A true color aerial photograph shows a new drainage network (indicated by red arrow) and provides visual evidence of wetland loss. Lack of wetland vegetation, surface water or soil saturation further indicates that this wetland had been effectively drained.

Figure 11. Positive visual evidence of change includes drainage ditches like the one in this photograph. This wetland basin has been effectively drained by this outlet ditch.

Figure 12. The basin outlined in this photograph has been effectively drained by subsurface tile. The tile head is indicated by the red pointer.

Descriptive Categories for Open Water Ponds

The Service's Wetlands Status and Trends Study is a scientific approach to monitor the nation's wetlands using a consistent, biological definition. Cowardin *et al.* (1979) recognized ponds as an important component of the aquatic ecosystem and included them within a larger system of freshwater wetlands. The Service has included open water ponds in every wetland status and trends report.

Water features excluded from the Status and Trends study as non-wetland include the following:

- Stock watering tanks
- Swimming pools
- Industrial waste pits
- Stormwater drains (non-retention features)
- Garden ponds or fountains (coy ponds)
- Water treatment facilities
- Municipal or industrial water storage tanks
- Sewage treatment facilities (other than wetlands)
- Water cooling towers or tanks
- Road culverts or ditches
- Other "ephemeral" waters

Because of the proliferation of created open water ponds in recent years, the Service in conjunction with the Environmental Protection Agency has added additional descriptive categories for open water pond areas. The goal is to provide users of the status and trends data additional information about what types and how many ponds are being created over time.

Subdivision of the ponds category (palustrine unconsolidated bottom) considered the statistical design and sampling integrity of the Wetlands Status and Trends study. Sub-categorization of ponds will allow re-aggregation of data to the original classification unit (all ponds). Additionally, the descriptive categories for ponds can be reliably determined using remotely sensed data. There are five descriptive categories of freshwater open water ponds that have been developed. These are listed below along with a brief description of characteristics and remote sensing indicators that may be used to identify and classify these areas.

Freshwater Pond Categories: Descriptive Types

1) ***Ponds with natural features or characteristics*** as indicated by lack of human modification or development. These may include naturally occurring ponds, bog lakes, vernal pools, potholes, kettles, beaver ponds, alligator holes, muskrat "eat outs", etc.

2) ***Ponds used for industrial purposes*** such as mine reclamation sites, excavated pits or mine drainage ponds, highway borrow pits (Figure 12), sewage lagoons, industrial wastewater holding ponds.

Figure 12. Borrow pits (indicated by the blue arrows) found in association with a highway interchange have filled with water (color infrared photograph). The shape and proximity of these ponds provide good indicators for providing further descriptive categorization.

3) ***Urban ponds*** used for aesthetics or recreational purposes such as golf course ponds, small (<20 ac.) residential lakes, ornamental water bodies, water retention basins (Figure 13).

Figure 13. Numerous ponds and small residential lakes (red arrows) including golf course ponds (blue arrows) have been created in this suburban development (true color photograph).

4) ***Ponds found in conjunction to agricultural, farming or silvicultural operations*** such as farm ponds, dug outs for livestock, agricultural waste ponds, irrigation or drainage retention ponds.

5) ***Aquaculture ponds*** occur singly or in series (Figure 14) and are used for aquaculture including cranberries and fish rearing.

Figure 14. A color infrared aerial photograph of artificially created ponds used for catfish farming (blue rectangles). Ponds in series often provide indicators of aquaculture.

Lands with Special Characteristics

Palustrine Farmed Wetland (Pf): Farmed wetlands are wetlands that meet the Cowardin *et al*. definition where the soil surface has been mechanically or physically altered for production of crops, but hydrophytes will become re-established if farming is discontinued.

Status and trends plots will include all types of farmed wetlands. Typically these include cranberry bogs, farmed prairie pothole type depressions, farmed playa lakes, and diked former tidelands in California. Other examples of farmed wetlands that should be included: rice farming, farmed alluvial depressions, farmed floodplain wetlands, and some types of flooded cultivated grassland (Figures 15 and 16).

Figure 15. An example of a farmed floodplain. The wet swale areas in this photograph are still considered wetland because they are not artificially drained.

Figure 16. A farmed wetland occupies this depression.

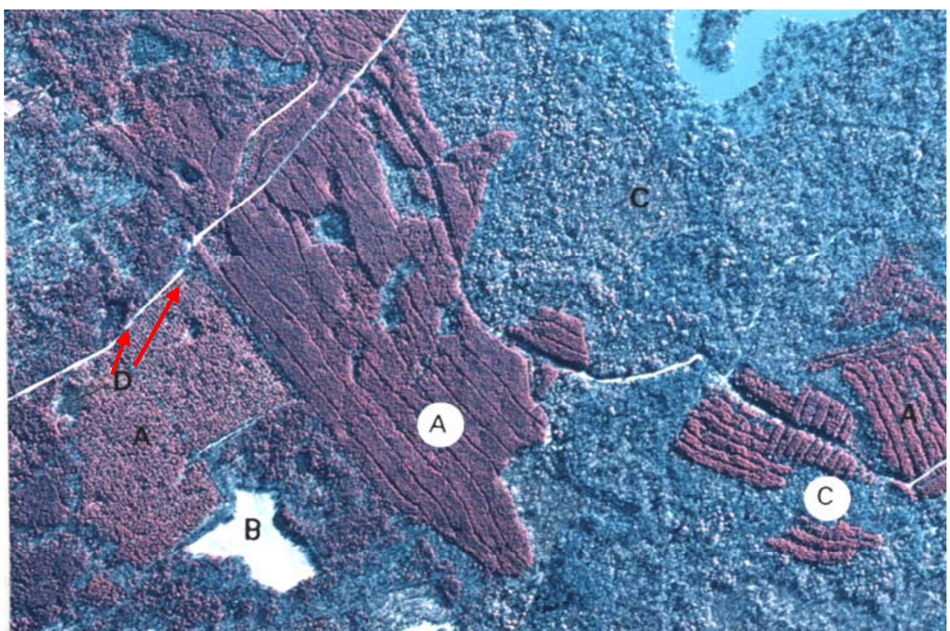
Transitional Lands: Transitional areas include those lands which are changing from one land use to another. They generally occur in larger acreage blocks of 40 acres or more. They are characterized by the lack of any remote sensor information which would enable the interpreter to reliably predict the future use (Figure 17). This transitional phase occurs when wetlands have been drained, ditched, filled, leveled or the vegetation has been removed and the area is temporarily bare. Agricultural lands may be differentiated by surrounding land use; patterned system of irrigation or access roads, etc. Forested Plantations may appear more irregularly shaped with fewer access points. If surrounding land use patterns do not give any indication to the possible future use of the transition area, and the area is determined to be upland, the category Upland Other should be applied.

Figure 17. Lands in transition from one land use to another are characterized by the lack of any remote sensor information that can reliably determine their future use.

Upland Forested Plantation: Forested plantations include upland pine plantations such as those found in the Southeastern United States (Figure 18) and hardwood plantations as found in selected areas (i.e. Arkansas). Forested plantations can be identified by the following remote sensing indicators:

1) Trees planted in rows or blocks
2) Forested blocks growing with uniform crown heights
3) Logging activity and use patterns including access roads or trails, loading and skidding pads.

Figure 18. This color infrared aerial photograph shows many of the remote sensing indicators used to identify forested plantations. Trees with uniform crown height (A);, block or patch cutting/planting (B); trees planted in rows (C); evidence of logging activity and use patterns such as skids and haul roads (D).



In the Southeast, pockets of wetlands are often found within planted tracts of pine. Field observations indicate that planted trees in these wetlands may eventually die off and reveal emergents or wet shrubs on the photography. These identifiable areas should be delineated and classified by the appropriate class descriptor (PEM, PSS, etc).

Where there is no evidence of a wetland (water area, break in canopy cover, cover type change, stressed vegetation, etc) following silviculture plantings, it will be assumed the wetland has been drained or otherwise destroyed and recorded as a loss.

Certain species planted on undrained or incompletely drained hydric soils may thrive. These may occur in floodplains, bays or pocosins and should be delineated as wetland. Other areas may be sufficiently drained or filled such that the area will no longer exhibit wetland characteristics. In these instances silvicultural activities have effectively converted the wetland to upland. These areas will be delineated as a loss.

Hardwood plantations (e.g. St. Francis National Forest in Arkansas) are managed forest stands. Both upland and bottomland hardwood wetlands are managed by clear cutting on an 80-100 year cycle. Reforestation is accomplished by natural regeneration and planting. Wetland/Upland determinations remain unchanged (for this type of plantation).

Christmas tree farms are included in the upland forested plantation category but groves and orchards are categorized as upland agriculture.

Other Special Considerations - Split Plots
Status and trends plots are 2 miles by 2 miles (total 4 square miles). In most plots the entire area is analyzed. However, due to the plot location selection, it is necessary for some plots to be considered split. Plots can be split only by State lines and physical subdivision lines. Map boundaries and photo edges do not split plots.

Split plots may contain an area labeled “out”. This means that this portion of the plot area is outside of the state or physiographic strata the plot was selected to represent. In rare instances some plots may contain an “out” area outside of the bounded study area for the project.

When updating a split plot, it is important to work in the correct state and physical subdivision. Previous era data delineations will determine the area of the plot to be updated. Any questions on determining the boundary location of a split should be directed to quality control personnel; if no decision is reached, consult Service’s Project Manager.

XII. Editing Status and Trends Geodatabase Files

Arc Map Editing - Image Analysis
In an open ArcMap session, there are several digital map parameters that need to be set prior to editing. These include:

Optimal polygon color, fill and line width - It is necessary to set optimal parameters for working with existing digital wetland map data in an ArcMap edit session. Optimum polygon outline color must provide the image analyst good contrast between the line work and source imagery. Thus, polygon color is based on imagery type. Bright yellow or red colors display well against the gray scales of black and white imagery. Other colors may be more appropriate if the imagery is color or color infrared, or if the line work is displayed directly on the DRG backdrop. Black, white and low contrast colors should not be used. A solid polygon fill color should not be used during the wetland interpretation process. This prevents the image analyst from clearly viewing the underlying image and may adversely influence wetland cover type classification. Color fills may be useful in searching and identifying particular polygons or habitat types from the attribute table or for other quality control measures. In these instances, fill color is determined by the analyst.

Polygon outline width (line weight) in ArcMap should not be so heavy as to mask the boundaries of wetlands on the imagery or so thin that they are difficult to detect or give a false sense of boundary precision. Settings for polygon outline width shall not be less than 0.50 or exceed 2.5. Line widths of 0.75 to 1.25 are considered optimum.

Polygon labels - should be displayed for most of the edit session. This enables the image analyst to determine the accuracy of existing feature classifications. Labels may be toggled on and off to better view landscape features or details during an edit session. Label color and font size are determined by the image analyst, but should provide high contrast for easy viewing without masking important image characteristics.

DRG and other collateral layers - may be toggled on and off to facilitate viewing the imagery and delineating features. Collateral data layers may be viewed separately or in various combinations at the discretion of the image analyst.

Editing Status and Trends Plots in ArcMAP

Status and trends plots are unique from wetland maps and the same editing routines that can be used successfully to update a map may not apply to this project. For example, the entire land area of the sample plot is classified based on land use for a specific timeframe. This creates challenges when making certain corrections or update changes to the geodatabase. Additionally, changes in land use and wetland cover type are tracked as reporting categories for determining status and trends.

The following are recommendations for editing the Status and Trends data in ArcMap. Following these steps will reduce errors and problems in habitat delineation.

Adding the Topology Layer

When adding data to an ArcMap session, add only the topology layer from the geodatabase. A message will pop-up asking if you want to add all feature classes that participate in the topology to the map (Figure 19). Click Yes.

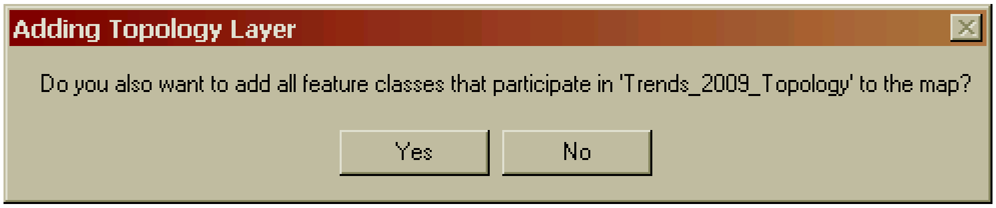


Figure 19. Pop-up message for topology layers.

This will add all the associated feature classes that participate in the topology and everything you need to delineate the Status and Trends plots, except the imagery.

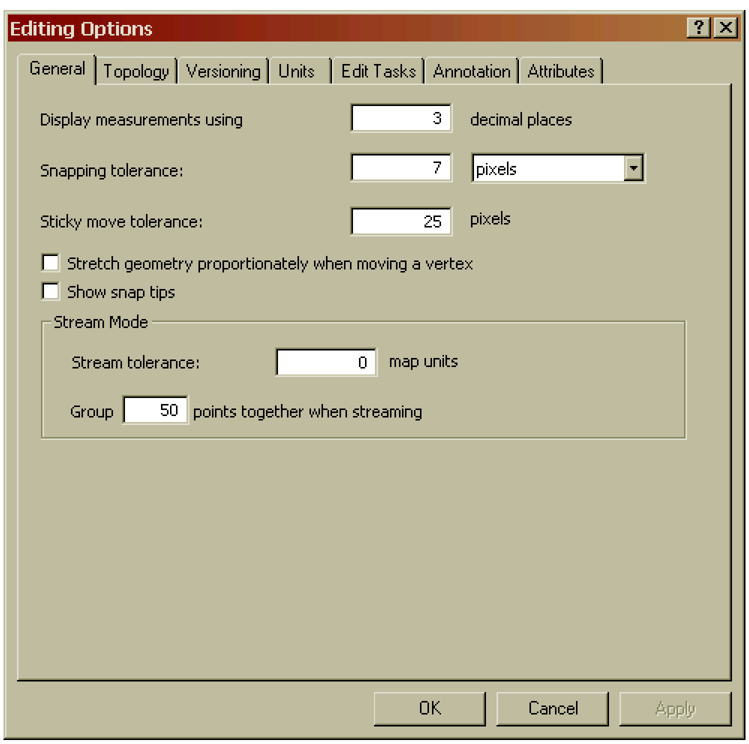
Adding the Topology Toolbar

To use some of the topological tools in ArcMap adding the topology toolbar is required. To view this toolbar in ArcMap, click View > Toolbars > Topology. The topology toolbar will appear and can be anchored to various locations in the ArcMap window.

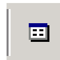
Setting the Sticky Move Tolerance

To ensure that accidental moves of features do not occur during an edit session the sticky move tolerance should be set in ArcMap. This requires a user to move the mouse a certain distance before the software recognizes the intent to adjust the location of a feature.

1. Click ‘Options’ in the ‘Editor’ pulldown menu in ArcMap
2. On the ‘General’ tab of the pop-up window enter ‘25’ in the ‘Sticky move tolerance’ text box. The default units are pixels. This requires the mouse to be moved 25 pixels of the screen resolution before the feature is moved.

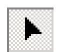


Attributing Polygons

In this study, habitats for both time one and time two are captured for each polygon in the ERA_09_Trend feature class. The ERA_05_ATT field holds the habitat type for time one (~2004) and ERA_09_ATT field holds the habitat type for time two (~2009). Initially the ERA_09_ATT field has been calculated to equal the ERA_05_ATT field, which assumes no change has occurred in that five year time period. When change is observed, the ERA_09_ATT field needs to be changed to represent the habitat for that polygon at time two (~2009). This can be done utilizing the attribute domain of habitat codes that appears as a pull-down menu in the ERA_09_ATT field, when editing, in either the attribute table or the "Attributes Tool"  on the Editor toolbar. There may be some instances where the time one (~2005) habitat was incorrectly identified. To make these corrections select the proper habitat code from the attribute domain pull-down menu for the ERA_05_ATT field.

Cutting Polygons

Cutting current polygons into multiple polygons is the preferred way to delineate change in the Status and Trends plots. This preserves the historic attribution and line work of the previous era. To cut a polygon:

1. Select the polygon of interest with the edit tool  on the editor toolbar.
2. Select "Cut Polygon Features" in the Task pull down menu
   

3. Make sure the appropriate feature class is identified in the Target pull down menu.
   

4. Select the sketch tool  on the Editor toolbar.
5. Click outside the selected polygon, then click (digitize) along the intended border of the new polygon (Figure 20), and double-click outside the polygon to cut the polygon into to pieces (Figure 21).

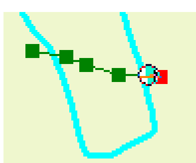


Figure 20.

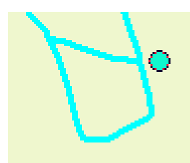


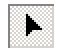
Figure 21.

6. Be sure to change the attribution in the latest era to the correct code.

Deleting Polygons

Deleting polygons is **NOT** recommended as it leaves a hole in the seamless layer and removes all historic attribution of that area. A polygon should not be deleted but rather attributed to its new code. The historic line work must be left intact.

There may be situations where a mistake was made during delineation of a new polygon and it needs to be removed. If this occurs instead of deleting the polygon **merge** it with polygon adjacent to it with the appropriate code.

1. Select both polygons with the edit tool  .
2. With both polygons selected, select the Merge option in the Editor pull-down menu 

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3. In the Merge pop-up window (Figure 22) select the polygon with the appropriate code to merge to. To highlight the associated polygon in the ArcMap window click on the feature record in the pop-up window.

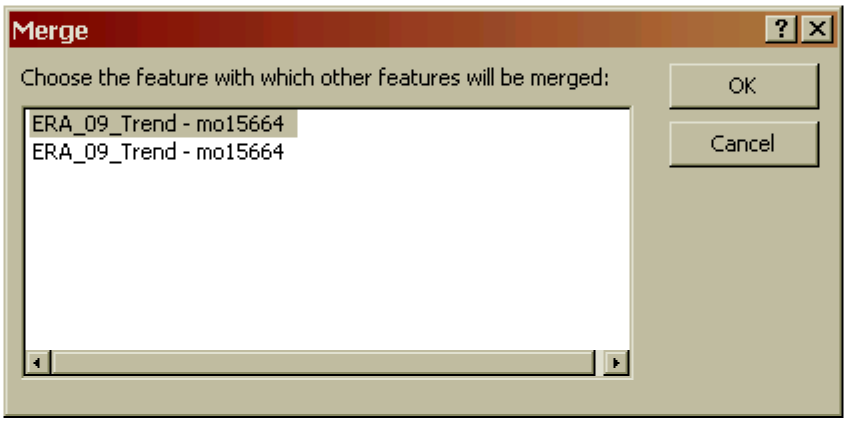


Figure 22. Merge pop-up window

Creating Polygons

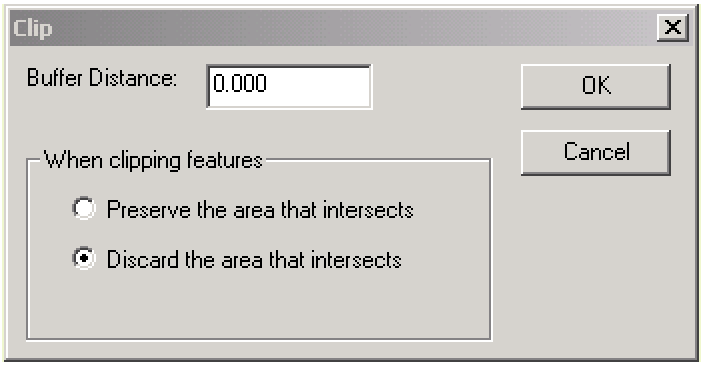
If a new polygon needs to be created use the 'cutting polygons' method described above. Be aware that method only works for new polygons that are on the edge of current polygons. If a new isolated polygon needs to be delineated in the middle of a current polygon use the following recommended procedures:

1. Select the "Create New Feature" task in the editor toolbar.
2. Use the sketch tool  to delineate the new polygon.

3. Make sure the Plot_2009_Tracking layer is not drawn (unchecked)!
4. With the new polygon selected, select the clip option 

in the Editor pull-down menu 

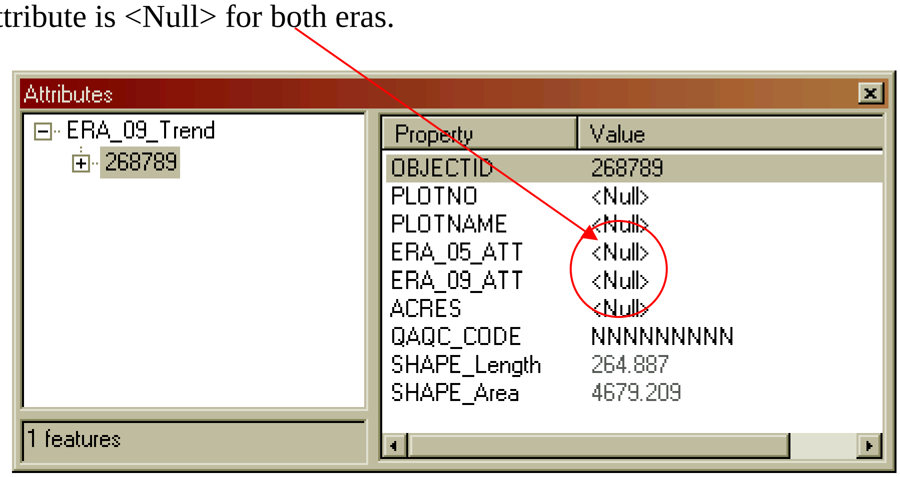
, and discard area that intersects.



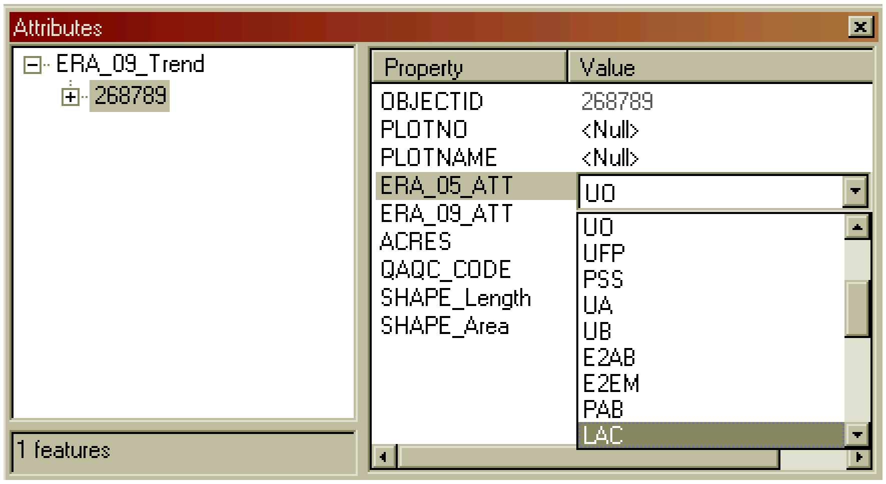
5. The polygon is no longer overlapping, but it does not contain any historic attribute information.

6. With the new polygon selected click the “Attributes Tool”  on the Editor toolbar.

7. The attributes pop-up window for that polygon will show up on your desktop, but notice the Attribute is <Null> for both eras.



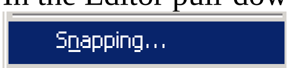
8. Click on the ATT fields and select the correct attribute for the proper eras from the drop down menu. The ERA_05_ATT must match the surrounding polygon as that is where this new polygon originated from. The only attribute that should be different is the ERA_09_ATT.



9. The **PLOTNO** and **PLOTNAME** should also be filled in to match the surrounding polygons. Acreage will be calculated automatically when the verification toolset is used.

Border Polygons
Polygons along the edge of the plot must not be delineated past the plot boundary. To avoid this set the snapping environment to snap to the plot edge.

1. In the Editor pull-down menu 

selecting the snapping option 

.
2. A snapping window should appear in the ArcMap window.
3. In the snapping window check the 'Edge' box for the Plot_2009_Tracking layer.

4. Now when the sketch tool  is used to delineate a polygon near the plot boundary the tool automatically snaps to the plot edge. This allows for exact delineation along the plot boundary. Make sure the Plot_2009_Tracking layer is drawn (checked).

Validating Topology
The topological rules created for the Status and Trends study do not allow polygons to overlap within either layer, and all Status and Trends polygons (ERA_09_Trend) and plot boundary (Plot_2009_Treacking) must be completely cover each other. In other words, no two trend polygons or plot polygons can occupy the same space and all trend polygons must be within the boundaries of the plots. To validate topology:

1. Select one of the validation options from the topology toolbar.

a.  Validate Entire Topology
b.  Validate Current Extent
c.  Validate a Specified Area

2. When the topology layer is visible (checked in the table on contents on the right side of ArcMap) any topological errors should be highlighted in red.
3. If delineations were conducted properly there should be no topological errors.
4. Errors can also be viewed by clicking the Error Inspector  on the Topology toolbar.
    a. The Error Inspector pop-up window appears in the ArcMap window.
    b. Select ‘Search Now’ in this window to view topological errors.
5. Overlapping topological errors can be remedied by clipping one of the polygons and discarding area that intersects.
6. The topological errors caused by polygons extending beyond the plot boundary and be remedied by using the ‘Cut Polygon Features’ task, with the snapping set to Plot edge, and then deleting polygon created outside plot boundary.

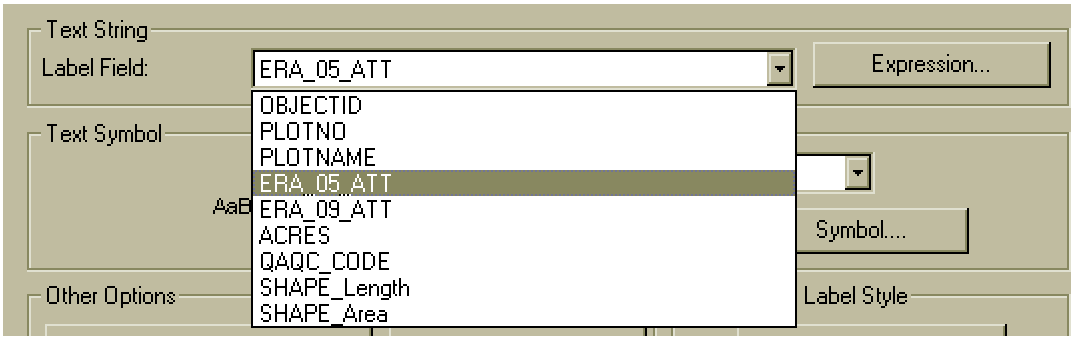
Reshaping Polygons
Reshaping polygons using the ‘Reshape feature’ task should **NOT** be done for normal delineation of Status and Trends polygons. Reshaping a polygon changes the historic line work and thus the historic acreage of previous era delineations.

If the decision is made that the polygon delineation is historically incorrect, it may be reshaped.

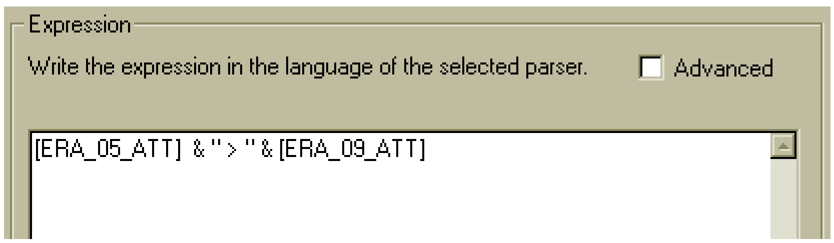
This needs to be done using the Topology Edit Tool  on the Topology Toolbar and the ‘Reshape Edge’ topology task in the task pull-down menu. This reshapes both polygons on each side of the line, which prevents gaps or overlaps from being created.

Labeling Polygons
To view the labels for both Eras of the Status and Trends polygons, you may want to try the following option.

1. Right click the ERA_09_Trend layer in the table of contents in ArcMap.
2. Click Properties.
3. Select the Labels tab.
4. Select ‘ERA_05_ATT’ from the pull-down list in the ‘Label Field’ window.



5. Click the 'Expression…' button next to the 'Label Field' window.
6. In the Expression window click 'ERA_09_ATT' and the 'Append' button.
7. In the Expression text box click between the double quotes and type a single space and then an arrow character (>).



8. Click OK
9. The color can be changed in the 'Labels' tab and the labels may be turned on by checking the 

in the upper left hand corner.
10. Click OK
11. Labeling can also be done by right clicking the ERA_09_Trend layer in the Table of Contents and selecting 'Label Features'.

Status and Trends Verification Toolset

Data verification was developed for use in ArcGIS specifically for status and trends work. It has been designed to address geopositional errors, digital anomalies, and provide logic checking to the wetland information. Some logic checking functions include identifying improbable changes that may represent errors in the image interpretation. Such improbable changes consider the length of time between update cycles and identify certain unrealistic cover-type changes such open water ponds changing to forested wetland. When these features are identified, the image analyst must determine if the data accurately reflect the change in condition.

The verification toolset also checks for other types of errors in the digital data. Listed below are several important features about the trend verification tool:

- Identifies improbable changes

- Identifies unattributed or null polygons

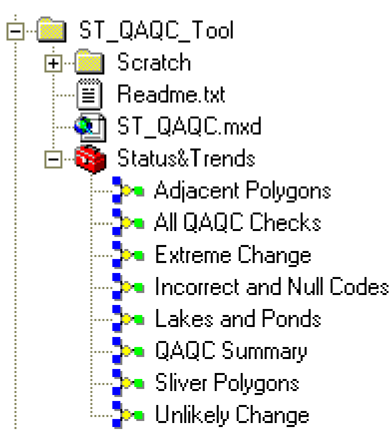
- Finds adjacent polygons with the same attribute in both eras

- Locates potential digital slivers < 0.01 ac

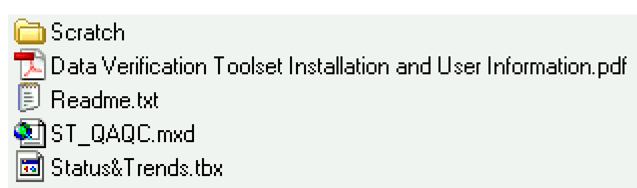
Some functions the verification toolset performs will flag potential problems but provide the image analyst the option of editing or ignoring the feature. This is to accommodate the image analyst's ability to ultimately determine the best ecological portrayal of the data.

The Wetlands Status and Trends Data Verification Toolset is designed to automate the geospatial quality control functions necessary to ensure the data in the Status and Trends geodatabase are accurate. This toolset was created using Environmental Systems Research, Incorporated's (ESRI) ModelBuilder and is compatible with ESRI's ArcDesktop software suite. Data verification is required for all Status and Trends geospatial data files.

The Verification Toolset and associated files are stored in a 'ST_QAQC_Tool' folder. This folder can be stored in any location on your machine and contains a Readme.txt, the Data Verification Toolset Installation and User Information.pdf, a Scratch folder, a ST_QAQC.mxd and the Status&Trends.tbx. The Readme.txt provides a general description of the contents and purpose of the folder. The Data Verification Toolset Installation and User Information document provides descriptions and procedures on the use of the Verification models. The Scratch folder is used for writing intermediate data from the models and contains a file geodatabase named Scratch.gdb that is required for the models to run correctly. The ST_QAQC.mxd is an ArcMap document that can be utilized to identify and locate specific verification errors. The Status&Trends.tbx is the ArcToolbox that contains the Status and Trends QAQC models.

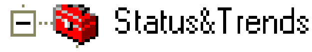


ST_QAQC_Tool view in ArcCatalog.



ST_QAQC_Tool view In Windows Explorer.

Status and Trends Verification Models

To run any of the QAQC models simply navigate to the 

toolbox in ArcCatalog, which is in the ST_QAQC_Tool folder and double-click on any of the models. A window will appear similar to the shown if Figure 23, which will allow the user to select input data and provides a description of the tool on the right pane, if the 

button is selected. Click the browse button  next to the ERA_09_Trend text box and browse to the ERA_09_Trend feature class that the user intends to run verification and press 'Ok'. Each model can be run individually to address specific types of errors or all the verification checks can be run at once using the All_QAQC_Checks model.

Figure 23. Example of a model user interface.

Function of the Individual Verification Models

All QAQC Checks **-** This model performs complete data verification. It includes the Incorrect and Null Codes, Unlikely Change(s), Sliver Polygons, Lakes and Ponds size differentiation, Adjacent Polygons and Extreme Change verification checks (detailed descriptions of these data verification components appear below). The QAQC Summary tool (also explained below) can be run after employing this tool to summarize all potential verification errors.

Incorrect or Null Codes - This model converts the first letter of the QAQC code to a 'C' for those records that have an incorrect or Null value in either the ERA_05_ATT field or the ERA_09_ATT field. A valid codes domain has been implemented for both of these fields to ease data entry, but errors can still be introduced by using some edit procedures. Although the PUB code is currently in the dataset, it is considered an invalid code. Five descriptive pond categories have been implemented in this study and all PUB polygons must be converted to one of those five categories in both the ERA_05_ATT and the ERA_09_ATT. See Table 2 "Wetland, deepwater, and upland categories used in the national status and trends update study" (page 26) for information on wetland codes including the new pond categories.

Unlikely Change **-** This model converts the second letter of the QAQC code to a 'U' for those records that have an improbable change from ERA_05 to ERA_09 based on the length of time between eras and the unlikelihood that those types of land use or ecological processes reflect real conditions. Polygons with these types of changes should be reviewed by the data analyst to ensure they are correct. Improbable changes are listed below.

UA	to	PFO
PUB	to	PFO
PUS	to	PFO
UB	to	PFO
LAC	to	PFO
UB	to	LAC
Any Upland	to	RIV
Any Estuarine	to	Any Palustrine
Any Estuarine	to	RIV
Any Estuarine	to	LAC

This model also identifies Marine or Estuarine polygons that have been coded in non-coastal states.

Sliver Polygons **-** This model converts the third letter of the QAQC code to a 'S' for those records that have an area of less than 0.01 acres. These polygons are very small and are likely errors in delineation and not true Status and Trends polygons. Polygons of this type should be reviewed by the data analyst to ensure they are correct.

Lake and Pond Size Determination - This model converts the fourth letter of the QAQC code to an 'L' for those records that have a lake that is less than 20 acres in size at ERA_09. It also converts the fifth letter of the QAQC code to a 'P' for those records that have a pond that is equal to or greater than 20 acres at ERA_09. Polygons of these types do not follow classification protocols and should be reviewed by the data analyst to ensure they are correct. Many of the lake errors are typically portions of a larger lake on the edge of a plot.

Adjacent Polygons **-** This model converts the sixth letter of the QAQC code to an 'A' for those polygons that are adjacent to another polygon with the same classification label in both the ERA_05_ATT field and the ERA_09_ATT field. These errors are not allowed and need to be resolved.

Extreme Change **-** This model converts the last letter of the QAQC code to an 'E' for those records that are 50 acres or greater and have changed habitat categories from ERA_05_ATT to ERA_09_ATT. Polygons of this type should be reviewed by the data analyst to ensure they are correct.

QAQC Summary **-** This model summarizes errors into a table by conducting a frequency on the QAQC_CODE field (Figure 24). This feature is not included in the 'All QAQC Checks' model. It should be used after the 'All_QAQC Checks' model is run to summarize all potential verification errors. The user needs to direct the model to the appropriate ERA_09_Trend feature class and identify the location and name for the summary table. Typically this location can be in the same file geodatabase as the data. This tool will not over write existing tables so a new table must be identified each time the tool is run. (e.g. QAQC_summary1, QAQC_summary2, or QAQC_Summary_date). This model is not required to complete verification, but assists in the identification and summary of potential errors in the dataset.

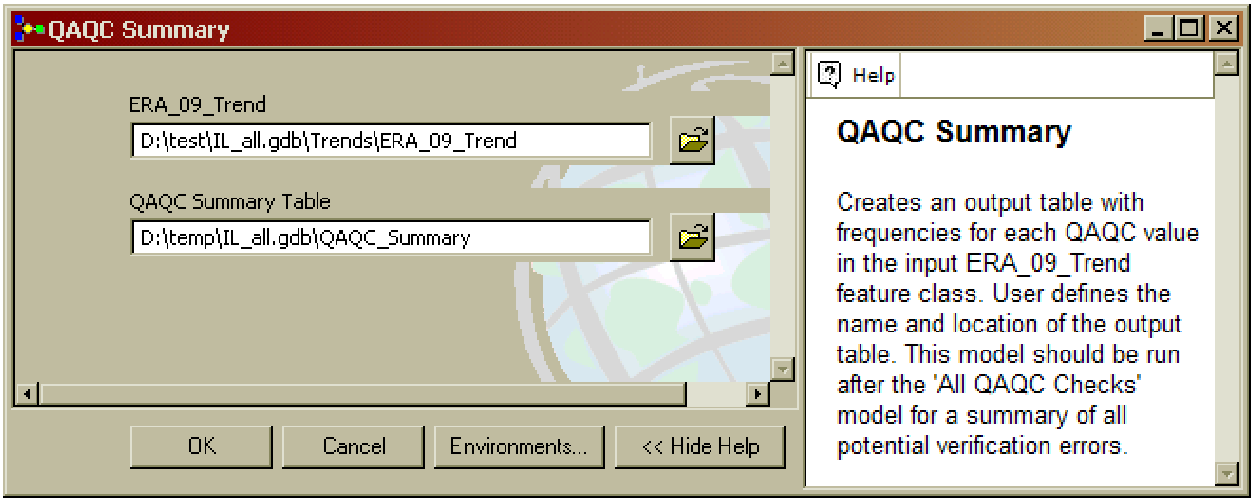


Figure 24. Example of QAQC Summary interface.

ST_QAQC Map Document

There is an ArcMap document in the ST_QAQC_Tool folder that can be used to assist in the identification and location of verification errors. The polygons are symbolized and labeled based on the QAQC_CODE to identify different types of errors. Note that the labels are not visible at scales smaller than 1:24,000. To use this map document either double-click on ST_QAQC.mxd in ArcCatalog or open it from ArcMap using File > Open and navigate to the file. When the map document opens in ArcMap the data links will be broken. To repair the links to the data, right-click any of the layers and select Data > Repair Data Source.

In the pop-up window navigate to the dataset to be reviewed and select the layer with the same name as the one that was right-clicked. This will repair all data links for the map document. To zoom to the data click the button on the navigation tool bar or hold down the Alt key and click the ERA_09_Trend layer. This will zoom to the extent of the data. See Figure 25 for an example of the ArcMap document.

NOTE: To find specific instances of an error sort the attribute table by QAQC_CODE and double-click the gray box associated with a given record on the far left side of the table.

OBJECTID *	PLOTNO	PLOTNAME	ERA_05_ATT	ERA_09_ATT	ACRES	QAQC_CODE
679	4620	mn4620	PUB	PUB	1.714458	CNNNNA
6564	4657	mn4657	PUB	PUB	1.052725	CNNNNA

This will zoom the ArcMap display to that polygon. The 'Select by Attribute' function in ArcMap can also be used to select all records of a defined QAQC_CODE value.

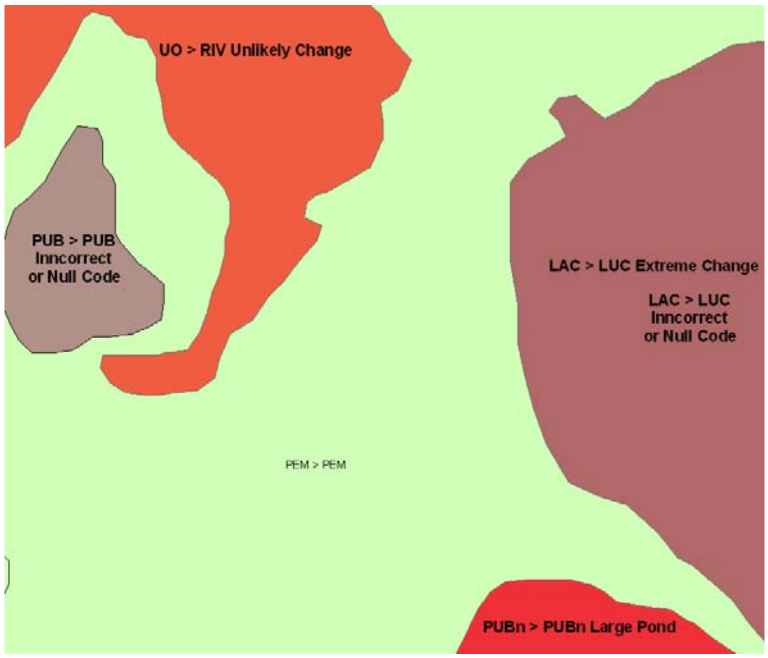


Figure 25. Example of map document with color shaded and labeled errors.

To refresh the cartographic representation of the errors while fixing them, be sure to change the QAQC_CODE to 'NNNNNN' otherwise those polygons will remain shaded as an error until the tool is rerun.

Plot Tracking Fields

The 2009_Plot_Tracking feature class has a few other fields that should be populated by the analyst. Information on the imagery used to determine the habitat category for the ERA_09_ATT field needs to complete. The **Image_Source** field identifies the imagery source (e.g. GeoEye, NAIP, etc). The **Image_Type** field identifies the type of imagery used (e.g. CIR, True color, Black and White, etc.). The **Image_Resolution** field identifies the scale of the imagery used (e.g. 1:40,000, 1 meter, 2 foot). The **Image_Date** field identifies the date of the imagery (e.g. 1/1/2009). These fields may already be populated when the data are received, but may be modified as needed. If any of these fields are left blank they will be flagged in the ST_QAQC.mxd.

Finally the **Comments** and **Update_Status** fields are to assist the user in tracking plot specific information. **Comments** can include anything specific to that plot about imagery, line work, adjustments, changes or no change observed. The **Update_Status** field is to track the status of the plot update. This field contains an attribute domain and will have a default value of 'Not Reviewed'. This should be changed to one of the other two attributes, 'Change' and 'No Change', depending on the outcome of the plot update.

XIII. Field Reconnaissance

Field reconnaissance can address questions regarding image interpretation, land use practices, and classification of wetlands. Field work is also done as a quality control measure to verify information is correct.

Initial field reconnaissance provides an opportunity for image analysts to become familiar with wetland communities and land use patterns. Information gained from field studies in combination with the analyst's skills and experience in image interpretation and use of collateral data should result in successful wetland delineation and classification. Field work shall involve visits to a cross section of wetland types and geographical settings, as well as to sites that may be updated using different image types, scales, and dates.

Timing of field work inevitably influences results, particularly regarding vegetation data and water regime classification. Work conducted in early spring will highlight different components of an ecosystem than work conducted late in fall when different water conditions and plant species may predominate on the same site.

Preparation for Field Reconnaissance
To ensure accurate and consistent interpretation of photography and to resolve various problems, analysts need to spend time in the field correlating image signatures with wetland and upland types. The actual number of person-days required in the field is often determined by access to field sites, weather, travel logistics, etc. Preplanning of the field trip should include identification of hydric soils or hydric soil characteristics likely to be encountered, information about common wetland plants and their distribution, dominant land use, drainage practices, agricultural crops and some preliminary image analysis of sites to be field inspected.

Field sites should be chosen based on such things as commonly occurring image signatures or habitats characterizing an area; unusual but important imagery signatures (some which may be difficult to identify); borderline signatures (those features that might be wetland or upland); and specific signature problems based on the date of photography (recent burning, extreme high or low water conditions). All sites should be accessible.

Field Sites and Data Collection
While in the field, representative photographs (slides or digital) of land use and wetland types should be obtained. Field data sheets for selected sites should be completed. The exact location of the field photographs, site location referred to in notes and other information must be provided. Wherever possible, digital cameras, data recorders, image display laptops, and ground positioning

satellite (GPS) should be used to provide more accurate information.

Any handwritten field notes regarding changes observed should be clear and understandable. Notations might include: 'extend or add this wetland'; 'delete wetland'; or 'refine delineation'.

Time spent in the field is invaluable. To realize the maximum, it is often necessary to reassess some potential field sites based on work already completed versus time, access to sites and priorities.

Field Work as Verification
Image interpreters may conduct field verification exercises to ensure accurate and consistent interpretation of imagery. Field trip reports and field data sheets provide documentation of the field verification efforts including, general descriptions of wetlands and uplands in an area, descriptions of surface water conditions both on the imagery and at the time of field work, and details about the quality of the source materials used.

Aids to Field Determinations:

Plant Species That Occur in Wetlands
The presence of wetland plant species often provide important collateral information to help biologists determine if a site is a wetland or to gain insight to length and periodicity of flooding. Many plant species, however, seemingly grow equally well in wetlands and upland conditions. To clarify what plants may be found in wetlands, the Service has prepared a list of wetland plant species, "*National List of Plant Species That Occur in Wetlands*" (Reed 1988). In the listing, wetland plants are divided into four indicator categories based on a frequency of occurrence in wetland. These categories include:

Obligate wetland - almost always found in wetlands (>99% of the time)
Facultative wet - usually found in wetlands (66-99%)
Facultative - sometimes found in wetlands (33-66%)
Facultative upland - seldom found in wetlands (<33%)[1]

A list of plant species with the wetland indicator status found at a particular site can provide useful information about the site. This information, taken from the field data form, will be entered into a database for future reference and use.

Hydric Soil Lists and Indicators
Hydric soils are defined as soils that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part (Federal Register, July 13, 1994).

A list of the Nation's soils with actual or high potential for hydric conditions has been prepared by Natural Resources Conservation Service. "Hydric Soils of the United States"

[1]The wetlands indicator categories should not be equated to degrees of wetness.

includes at least one phase in the listing that meets the hydric soil criteria. The list does not include soils that are classified at categories higher than the series level in Soil Taxonomy (Soil Survey Staff 1999) nor does it include map units that may contain these series. The list is useful in identifying map units that may contain hydric soils. There is a national list of hydric soils as well as state and county lists. While the state and county lists may provide more regionally specific information, analysts should be aware that they may not be comprehensive in their presentation of all soil series with hydric characteristics.

Hydric soils lists and maps reflect only the soil series or map unit considered hydric. Soil map units may contain inclusions of smaller features with hydric characteristics (wetland). Soils that are artificially drained or protected (for instance, by levees) may be listed as hydric even though it will no longer meet the Cowardin definition of wetland.

Experienced analysts should rely on field indicators as a more reliable way to help identify extant wetlands. Nearly all hydric soils exhibit characteristic morphologies that result from repeated periods of saturation and/or inundation for more than a few days. Saturation or inundation when combined with anaerobic microbiological activity in the soil causes a depletion of oxygen. This anaerobiosis promotes biogeochemical processes such as the accumulation of organic matter and the reduction, translocation, and/or accumulation of iron and other reducible elements. These processes result in characteristic morphologies which persist in the soil during both wet and dry periods, making them particularly useful for identifying hydric soils (U.S.D.A., Natural Resources Conservation Service, Wetland Science Institute and Soils Division 1996). *Field Indicators of Hydric Soils in the United States* (USDA 2003) is a guide to help identify and delineate hydric soils in the field.

Field Forms and Reporting Requirements

A field trip report is required for all status and trends field trips. A standardized field trip report outline is included as Appendix C.

Field trip reports shall discuss the details of the field reconnaissance efforts (including participants, dates, and location), collateral data sources and uses, general descriptions of wetlands and uplands in the area, description of water conditions, details about the quality and interpretation of the imagery and any special problems or findings.

During each field trip, participants are encouraged to complete Field Data Forms at a variety of different check sites which are well distributed throughout the trip area. The exact number of check sites may be determined by specific project specifications, weather conditions, access to sites, trip objectives, etc. Good quality digital photographs should be provided for field sites for which a Field Data Form is completed (Field Data Form is included in Appendix D). Protocols for submitting digital Field Data Forms and digital photographs are discussed below.

Private Land Access Protocol

The Service respects private property and land owner rights. Personnel should contact landowners in advance to obtain permission to access private lands to conduct field verification or evaluations. Site visits will not be made where this is not possible, or landowners can not be contacted. At no time should Service personnel cross fences, gates, barriers or traverse posted property without permission of the landowner.

IVX. Quality Control and Quality Assurance

A quality assurance program is essential for ensuring the validity of analytical data. The Service has developed and implemented quality assurance measures that provide appropriate methods to take field measurements, ensure sample integrity and provide oversight of analyses which included reporting of procedural and statistical confidence levels.

Because of the sample based approach, various quality control and quality assurance measures were built into the data collection, review, analysis and reporting stages. Some of the major quality control steps include:

> ***Plot Location and Positional Accuracy.*** Status and trends sample plots are permanently fixed georeferenced areas that are revisited periodically to monitor land use and cover type changes. The plot coordinates are positioned precisely using a system of redundant backup locators on prints produced from a geographic information system, topographic maps, other maps used for collateral information, and the aerial imagery. Plot outlines are computer generated for the correct spatial coordinates, size and projection. Plot locations are transferred and registered onto all work materials.
>
> ***Imagery, Base Maps, and Collateral Data.*** Aerial imagery is the primary data source, but it is used with reliable collateral data such as topographic maps, coastal navigation charts, published soil surveys, published wetland maps, and State, local or regional studies.
>
> ***Internal reviews and checking.*** Quality control of interpreted map products will be performed on 100 % of the project area by a qualified image analyst other than the person performing the original work. To accomplish this, the review analyst will perform an incremental screen by screen (working west to east or north to south) qualitative review of the project area at 1:12,000 scale or larger. Following completion of row or column of screen views edits should be saved in the personal geodatabase.
>
> Internal quality control review of interpreted images should include a comparison of contours, hydrographic symbols or cultural features from the DRG to wetland delineations and vegetation signatures. There is considerable latitude allowed in conducting qualitative reviews, however, a complete review of the project area with the backdrop of the DRG visible at a scale not less than 1:12,000 must be completed (Figure 26). All work shall adhere to quality requirements and technical specifications.

Figure 26. The DRG backdrop assists in quality control reviews. In this example swamp symbols from the DRG indicate two wetlands (red arrows) that might have been missed.

Data Verification. There are tremendous advantages in using newer technologies to store and analyze geographic data. The Geodatabase is a storage mechanism for spatial and attribute data that contains specific storage structures for features, collections of features, attributes, relationships between attributes and relationships between features. Many of the geopositional data checks are now inherent in the creation of a geodatabase in ArcMap version 9.0. Topological checks such as defined projections are no longer necessary in a geodatabase since the geodatabase itself cannot be created without defining the coordinate system.

A customized data verification toolset has been constructed to automate (to the extent possible) the quality control functions necessary to ensure the geodatabase is accurate. This suite of functions has been designed to address geopositional errors, digital anomalies, and some logic checks that make use of the power of the geographic information system. These tools are extensions to Environmental Systems Research, Incorporated's (ESRI) ArcMap desktop geographic information system (GIS) product.

The geospatial analysis capability built into this study provides a complete digital database to better assist analysis of wetland change information.

Minimizing Procedural Error

Procedural or measurement errors occur in the data collection phase of any study and must be considered. Procedural error is related to the ability to accurately recognize and classify wetlands both from multiple sources of imagery and on-the-ground evaluations. Types of procedural errors include missed wetlands, inclusion of upland as wetland, misclassification of wetlands or misinterpretation of data collection protocols. The amount of introduced procedural error is usually a function of the quality of the data collection conventions; the number, variability, training and experience of data collection personnel; and the rigor of any quality control or quality assurance measures. The image analyst must take the appropriate steps to ensure that procedural error is minimal.

Rigorous quality control reviews and redundant inspections are incorporated into the data collection and data entry processes to help reduce the level of procedural error.

XV. Materials Handling and Tracking – Safeguarding Information

The Service's wetland Status and Trends plot locations are considered ***proprietary information***. Their location shall not be disclosed by copying or transmitting plot locations, geographical coordinates, or other locator information. Plots boundaries or data shall not be displayed, published or otherwise distributed.

The location of these sample plots is not made public in an effort to avoid abnormal land use actions or compromise any privacy issues regarding private lands. Work materials and files should be safeguarded and distribution of information or work materials should be done only with the consent of the Service's Wetlands Status and Trends Project Manager.

There may also be copyright or use restrictions on the imagery used to update the plot information. Do not copy, duplicate or distribute this imagery.

When receiving or transferring status and trends plots or data, keep good records of both incoming and outgoing work materials.

Use certified mail, FED EX or other reasonable methods of mailing photography or other original work materials to provide a means of tracking and prevent loss.

XVI. Mandatory Submissions

A completed Status and Trends Tracking Form (Appendix E) that will indicate the number of plots completed, state, date, image analyst, and any "NO CHANGE" plots must be returned with the updated digital plot data.

Submission of completed field data forms, field trip reports and/or field photographs are required. This information should be clearly labeled with the source, date and contents. Photographs submitted must be linked to subject matter discussed on the field data sheet or the field trip report. Photographs submitted in digital format will be provided at 72 dpi in j-peg or tiff format or better.

Photographs will be entered into the database and linked to representative plot information. Photographs shall be good quality. Poor quality photos that are out-of-focus, blurred or that otherwise do no clearly depict useful information about a site will not be accepted into the database. Photographs that contain private property information such as street addresses, telephone numbers, advertisements, vehicle license plates or recognizable profiles of individuals should be avoided. Copyrighted photographs will not be accepted.

Digital Data Requirements and Delivery

The digital data must conform to the following criteria:

- Digital wetlands data must be provided in file or personal geodatabase format.
- Data will be in a uniform projection (Albers Equal-Area Conic Projection). The horizontal planar datum is the North American Datum of 1983, also called NAD83.
- Data must have passed verification and all quality control review(s).
- Internal to the project area, data should be seamless.

Meta Data

Because Wetlands Status and Trends distributes no map products directly to the public, there are no specific metadata forms to be completed. Metadata for the project are stored to comply with the Service's Metadata Documentation and Record system. These data address the informational content of the trend plot materials. Submittal of complete and correct information on the updated plot transmittal sheet is important to keep these metadata records current. Information regarding the date, content and source of the update submissions must be completed on the transmittal sheet prior to submission to the Service.

XVII. Achieving Quality Requirements for Wetland Status and Trends

Quality requirements for status and trends digital files are defined in this document. They include quality goals for wetland identification, delineation and classification accuracy. Additional requirements for digital data accuracy and metadata ensure data are complete and accurate.

The Service has produced step-down Information Quality Guidelines for information disseminated by the agency. These guidelines are applicable to all Service offices that disseminate information to the public to ensure the information complies with the basic standards of ***quality*** to ensure and maximize its ***objectivity***, ***utility*** and ***integrity***.

The quality and integrity of the Service's wetland status and trends data are based on a three step quality assurance process. The data must pass these quality control procedures to ensure the information is accurate. The steps include: 1) review by technical specialist(s) 2) pass automated verification routines, and 3) pass final verification and data integrity inspection as provided by a database manager. These three processes are described below:

A) Review by Technical Specialist(s) - This quality assurance step defines the responsibilities of the image analyst(s) for data quality and completeness. There are two mandatory sub-steps:

Internal Inspections of Data Quality - Quality control of interpreted images will be performed by a qualified image analyst other than the person performing the original work. The reviewing analyst will adhere to all standards, quality requirements and technical specifications and will perform a 100% review of the work. This internal inspection may be completed by non-Service personnel under the specific technical direction of and performance monitoring by a Government official through an extramural agreement.

Internal quality control review of interpreted images should include a comparison of contours, hydrographic symbols or cultural features from the USGS base map to wetland delineations and vegetation signatures. All available collateral data should be used during this quality control review. The responsible reviewer must record the pertinent information regarding the review process to accompany the appropriate metadata for the project area.

Service Quality Control Review - This is considered to be exclusively a Service function that must be performed by responsible Service personnel. Final quality control of status and trends plots entails checking the project area in its entirety by qualified personnel. Any qualified Service personnel may conduct final quality control reviews. These reviews may entail using various technical means or field verification to check the work. Final quality control reviewers must coordinate closely with project Manager regarding revisions or modification to the work products.

B) Data Verification

All digital data files will be subjected to rigorous quality control inspections. Digital data verification includes quality control checks that address the geospatial correctness, digital integrity and some cartographic aspects of the data. These steps take place after the ecological data collection phase of the project has been completed, reviewed and approved as qualitatively acceptable. Implementation of quality checks ensures that the data conform to the specified criteria, thus achieving the project objectives.

C) Oversight, Data Integrity and Database Management

The Wetlands Geodatabase Manager has primary responsibility for the operation the Service's wetlands geodatabase configuration and systems. This includes responsibility for the integrity and distribution of the digital geo-spatial data developed by the Service. The Geodatabase Manager is key to the processes used to verify, assimilate, distribute and archive geo-spatial wetland data. The Geodatabase Manager plays a substantial role in the quality assurance of the digital data files. This includes the following responsibilities:

- **Final Data Verification -** The Geodatabase Manager performs the final verification checks of the digital data before it is approved and entered into the wetlands geodatabase. This final check involves some geospatial analysis, logic checking, and ensuring the necessary supporting documentation has been provided in proper format.

- **Records and Documentation -** Additional reporting requirements including submission of the Tracking Form, Field Trip Report(s) and Field Data Form(s) are required. These will be used as project specific metadata information.

  Updated digital data must be returned to the Service's Geodatabase Manager on a CD or DVD with the contents and date marked. Only data in geodatabase format will be accepted[1]. Data must have passed verification and quality control review(s).

  Submission of field photographs are also required with geopositional location recorded as latitude/longitude or as a point feature class. These should be clearly labeled and become the property of the Government.

Finally, when the data pass these quality assurance steps, any information disseminated for any reason must be authorized by the Branch of Resource and Mapping Support or the Division of Habitat and Resource Conservation.

[1] Exceptions include data provided by the Advanced Systems Center.

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APPENDIX A. Definitions of Habitat Categories Used by Status and Trends

Wetlands[1]

In general terms, wetlands are lands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. The single feature that most wetlands share is soil or substrate that is at least periodically saturated with or covered by water. The water creates severe physiological problems for all plants and animals except those that are adapted for life in water or in saturated soil.

Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes[2], (2) the substrate is predominantly undrained hydric soil[3], and (3) the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

The term wetland includes a variety of areas that fall into one of five categories: (1) areas with hydrophytes and hydric soils, such as those commonly known as marshes, swamps, and bogs; (2) areas without hydrophytes but with hydric soils—for example, flats where drastic fluctuation in water level, wave action, turbidity, or high concentration of salts may prevent the growth of hydrophytes; (3) areas with hydrophytes but non-hydric soils, such as margins of impoundments or excavations where hydrophytes have become established but hydric soils have not yet developed; (4) areas without soils but with hydrophytes such as the seaweed covered portions of rocky shores; and (5) wetlands without soil and without hydrophytes, such as gravel beaches or rocky shores without vegetation.

Marine System The marine system consists of the open ocean overlying the continental shelf and its associated high energy coastline. Marine habitats are exposed to the waves and currents of the open ocean. Salinity exceeds 30 parts per thousand, with little or no dilution except outside the mouths of estuaries. Shallow coastal indentations or bays without appreciable freshwater inflow and coasts with exposed rocky islands that provide the mainland with little or no shelter from wind and waves, are also considered part of the Marine System because they generally support a typical marine biota.

Estuarine System The estuarine system consists of deepwater tidal habitats and adjacent tidal wetlands that are usually semi enclosed by land but have open, partly obstructed, or sporadic access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the land. The salinity may be periodically increased above that of the open ocean by

[1]Adapted from Cowardin *et al.* 1979.

[2]The U.S. Fish and Wildlife Service has published the list of plant species that occur in wetlands of the United States (Reed 1988).

[3]U.S. Department of Agriculture has developed the list of hydric soils for the United States (U.S. Department of Agriculture 1991).

evaporation. Along some low energy coastlines there is appreciable dilution of sea water. Offshore areas with typical estuarine plants and animals, such as red mangroves (*Rhizophora mangle*) and eastern oysters (*Crassostrea virginica*), are also included in the Estuarine System.

Marine and Estuarine Subsystems

Subtidal The substrate is continuously submerged by marine or estuarine waters.

Intertidal The substrate is exposed and flooded by tides. Intertidal includes the splash zone of coastal waters.

Palustrine System The palustrine (freshwater) system includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, farmed wetlands, and all such wetlands that occur in tidal areas where salinity due to ocean derived salts is below 0.5 parts per thousand. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 20 acres (8 ha); (2) an active wave formed or bedrock shoreline features are lacking; (3) water depth in the deepest part of a basin less than 6.6 feet (2 meters) at low water; and (4) salinity due to ocean derived salts less than 0.5 parts per thousand.

Classes

Unconsolidated Bottom: Unconsolidated bottom includes all wetlands with at least 25 percent cover of particles smaller than stones, and a vegetative cover less than 30 percent. Examples of unconsolidated substrates are: sand, mud, organic material, cobble gravel. Fresh water ponds (unconsolidated bottom) are further described by sub-categories in this document.

Aquatic Bed Aquatic beds are dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Examples include seagrass beds, pondweeds (*Potamogeton spp*.), wild celery (*Vallisneria americana*), waterweed (*Elodea spp*.), and duckweed (*Lemna spp*.).

Emergent Wetland 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.

Shrub Wetland Shrub Wetlands include areas dominated by woody vegetation less than 20 feet (6 meters) tall. The species include true shrubs, young trees, and trees or shrubs that are small or stunted because of environmental conditions.

Forested Wetland Forested Wetlands are characterized by woody vegetation that is 6 meters tall or taller.

Farmed Wetland: Farmed wetlands are wetlands that meet the Cowardin *et al.* definition where the soil surface has been mechanically or physically altered for production of crops, but where hydrophytes will become reestablished if farming is discontinued.

DEEPWATER HABITATS:

Wetlands and deepwater habitats were defined separately because the term wetland does not include deep, permanent water bodies. For conducting status and trends studies, Riverine and Lacustrine were considered deepwater habitats. Elements of Marine or Estuarine systems can be wetland or deepwater. Palustrine includes only wetland habitats.

Deepwater habitats were permanently flooded land lying below the deepwater of wetlands. Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium in which the dominant organisms live, whether or not they were attached to the substrate. As in wetlands, the dominant plants were hydrophytes; however, the substrates were considered nonsoil because the water is too deep to support emergent vegetation (U.S. Department of Agriculture 1975).

Riverine System The Riverine system includes deepwater habitats contained in a channel, with the exception of habitats with water containing ocean derived salts in excess of 0.5 parts per thousand. A channel is "an open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water" (Langbein and Iseri 1960).

Lacustrine System The lacustrine system includes deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30 percent coverage; (3) total area exceeds 20 acres (8 ha).

Uplands

Agriculture[1]: Agricultural land may be defined broadly as land used primarily for production of food and fiber. Agricultural activity is evidenced by distinctive geometric field and road patterns on the landscape and the traces produced by livestock or mechanized equipment. Examples of agricultural land use include cropland and pasture; orchards, groves, vineyards, nurseries, cultivated lands, and ornamental horticultural areas including sod farms; confined feeding operations; and other agricultural land including livestock feed lots, farmsteads including houses, support structures (silos) and adjacent yards, barns, poultry sheds, etc.

Urban: Urban land is comprised of areas of intensive use in which much of the land is covered by structures (high building density). Urbanized areas are cities and towns that provide the goods and services needed to survive by modern day standards through a central business district. Services such as banking, medical and legal office buildings, supermarkets, and department stores make up the business center of a city. Commercial strip developments along main transportation routes, shopping centers, contiguous dense residential areas, industrial and commercial complexes, transportation, power and communication facilities, city parks, ball fields and golf courses can also be included in the urban category.

[1] Adapted from Anderson *et al.* 1976.

Forested Plantation: Forested plantations include areas of planted and managed forest stands. Planted pines, Christmas tree farms, clear cuts, and other managed forest stands, such as hardwood forestry are included in this category. Forested plantations can be identified by observing the following remote sensing indicators: 1) trees planted in rows or blocks; 2) forested blocks growing with uniform crown heights; and 3) logging activity and use patterns.

Rural Development: Rural developments occur in sparse rural and suburban settings outside distinct urban cities and towns. They are characterized by non-intensive land use and sparse building density. Typically, a rural development is a cross-roads community that has a corner gas station and a convenience store which are surrounded by sparse residential housing and agriculture. Scattered suburban communities located outside of a major urban center can also be included in this category as well as some industrial and commercial complexes; isolated transportation, power, and communication facilities; strip mines; quarries; and recreational areas such as golf courses, etc. Major highways through rural development areas are included in the rural development category.

Other Land Use: Other Land Use is composed of uplands not characterized by the previous categories. Typically these lands would include native prairie; unmanaged or non-patterned upland forests and scrub lands; and barren land. Lands in transition may also fit into this category. Transitional lands are lands in transition from one land use to another. They generally occur in large acreage blocks of 40 acres (16 ha) or more and are characterized by the lack of any remote sensor information that would enable the interpreter to reliably predict future use. The transitional phase occurs when wetlands are drained, ditched, filled, leveled, or the vegetation has been removed and the area is temporarily bare.

APPENDIX B: Physiographic Subdivisions and Code Abbreviations as used to determine the Wetlands Status and Trends in the U.S. (adapted from Hammond 1970).

	PHYSICAL SUBDIVISION	ABBREVIATION and NUMERIC CODE
1	Adirondack - New England Highlands	ANEH (1)
2	Appalachian Highlands	AH (2)
3	Basin and Range Area	B+RA (3)
4	Blue Mountains	BM (4)
5	Cascade-Klamath-Sierra Nevada Ranges	CKSNR (5)
6	Central Valley of California	CVC (6)
7	Coast Ranges	CR (7)
8	Colorado River Plateau	CRP (8)
9	Columbia Basin	CB (9)
10	Dakota-Minnesota Drift and Lake-bed Flats	DMDLBF (10)
11	East-Central Drift and Lake-bed Flats	ECDLBF (11)
12	Eastern Interior Uplands and Basins	EIUB (12)
13	Gulf-Atlantic Coastal Flats	GACF (13)
14	Gulf-Atlantic Coastal Rolling Plains	GARP (14)
15	Harney-Owyhee Broken Lands	HOBL (15)
16	High Plains	HP (16)
17	Lower Mississippi Alluvial Plain	LMAP (17)
18	Lower New England	LNE (18)
19	Mid-Continent Plains and Escarpments	MCPE (19)
20	Middle Rocky Mountains	MRM (20)
21	Middle Western Upland	MWU (21)
22	Nebraska Sand Hills	NSH (22)
23	North Central Lakes-Swamp-Moraine Plains	NCLSMP (23)
24	Northern Rocky Mountains	NRM (24)
25	Ozark-Ouachita Highlands	OOH (25)
26	Puget-Willamette Lowland	PWL (26)
27	Rocky Mountain Piedmont	RMP (27)
28	Snake River Lowland	SRL (28)
29	Southern Rocky Mountains	SRM (29)
30	Southern Wisconsin Hills	SWH (30)
31	Stockton-Balcones Escarpment	SBE (31)
32	Upper Gila Mountains	UGM (32)
33	Upper Missouri Basin and Broken Lands	UMBBL (33)
34	West-Central Rolling Hills	WCRH (34)
35	Wyoming-Big Horn Basin	WBHB (35)
36	Coastal Zone	CZ (36)
37	Coastal Zone - Pacific	CZP (37)

APPENDIX C: Field Trip Report Outline

Standardized Field Trip Report Outline

WETLAND STATUS AND TRENDS
TRIP REPORT
(Give Location i.e. Coastal Louisiana)

1.) Dates: Field trip dates

2.) Areas Visited in the Field: Location information (coastal/interior/landmark cities etc.)

3.) Purpose of Trip:

4.) Personnel: List people on the trip (also include any other agency personnel and the dates they traveled)

5.) Summary of Findings: Brief description of area in general (coastal, inland, county, etc.)

Note land use and dominant land forms, field conditions, etc.

6.) Wetlands: Synopsis of problems/conditions relative to wetlands in the study area. This may be broken out into inland and coastal discussion, etc.

7.) Uplands: Same as for Wetlands section. Mention predominate crops, upland plant communities, development, etc.

8.) Vegetation List: Does not need to be extensive but representative of wetland vegetation.

9.) Plot List: List by Quad Name, Plot Number, and sites field inspected.

APPENDIX D: WETLAND STATUS AND TRENDS FIELD DATA FORM

Status and Trends Field Data Form

Plot number: ____________________ State:______________

Date of field visit:_____________________________________

Study: 2009 era Update_______________________________

Field personnel:____

____

Coordinates or site location:____

Ownership:____

Wetland/upland field classification:____

Vegetation:____

____

____

Soil Name:____

Survey date:___________________________________

Listed as hydric: Yes________ No_________

List used: National_______ State_______ County________

Remarks:

APPENDIX E.   STATUS AND TRENDS TRACKING FORM

Status and Trends Tracking Form

State ______   **Date_________________**

Project Area___________________(from plot delivery CD)

Analyst Name____

Organization____

Address/Contact Information ____________________________________

____

____

Plot #s Included (list by plot number)

No Change Plot #s (list by plot number)

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

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