

A CADASTRAL GEODATABASE FOR THE U.S. FISH AND WILDLIFE SERVICE

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ABSTRACT: The U.S. Fish & Wildlife Service “Cadastral Data Working Group,” comprised of Cartographers and GIS Specialists from all management Regions, has produced a state-of-the-art database that will store data for all interests in real property in the National Wildlife Refuge System. Upon completion, the Cadastral Geodatabase will become an integral component of the Refuge Lands Geographic Information System (RLGIS) by supplying boundary and parcel information to the biological geodatabases currently within the RLGIS data model. Cadastral data describes the past, current, and future right, title and interest in real property, including the spatial information necessary to describe the geographic extent. The geodatabase is the common data storage format for geographic features and attributes. A consistent and accurate Cadastral Geodatabase that is common across the nation and can be shared between Regions will enable users to leverage the spatial data to its full potential. Once implemented, the Cadastral Geodatabase will be able to answer boundary and land status queries on a national scale.

Introduction

The U.S. Fish & Wildlife Service (FWS) has been using geographic information system (GIS) technology since the mid-1980’s to map lands and waters for which they have management responsibility. This includes the National Wildlife Refuge System (NWRS), which consists of over 100 million acres located within 548 wildlife refuges (2008). The FWS manages these lands and waters through a regime of eight geographic “Regions,” defined primarily by State boundaries and physical geography (i.e. Region 3 is the Midwest Region, also known as the “Great Lakes / Big Rivers Region.”). While much of the day-to-day management of FWS lands occurs from Field Stations located near a particular wildlife refuge or other FWS property, most of the decisions affecting the entire Region are made from a designated “Regional Office” located in a major city within the Region. Primary mapping capabilities are also found in these Regional Offices. The responsibility for mapping the “land status” (cadastral) information for FWS lands has historically been assigned to the Division of Realty.

The FWS Division of Realty has maintained land status maps in a standardized fashion since the 1940’s. Using traditional cartographic methods, the maps

reflected the NWRS, national fish hatcheries, coordination (shared management) areas, and administrative sites.

In the 1980's, several of the Regional Offices began using the "AutoCAD" software for their mapping activities. AutoCAD, made by Autodesk Inc., was the first mapping software to be incorporated into the official FWS standards for the mapping of real property. As revised in 1995, the "Maps" chapter of the FWS manual reflected AutoCAD hatch patterns to display the various land status categories. It also included guidelines for the specific "Rapidograph" pen size to use for the many linetypes used on the Realty maps.

Separate from the "Maps" chapter effort, a FWS GIS Steering Committee was formed in 1991. The Steering Committee consisted of one representative from each Region, and was chaired by the National Spatial Data Manager. In 1996, the "Service Lands Spatial Data Guidelines Project" was launched. An ad hoc subcommittee of the FWS GIS Steering Committee developed a "Process Description for Creating and Managing Service Lands Boundary Digital Data" ("Standard Operating Procedure 97-01") document. The objective of SOP 97-01 was to "provide an accurate, documented and nationally consistent method for creating and updating a spatial data layer for National Wildlife Refuge boundary information." SOP 97-01 provided specific instructions for digitizing the Division of Realty land status maps. "Process 1" employed the "Arc/Info" software, made by Environmental Systems Research Institute Inc. (ESRI), and "Process 2" was for the AutoCAD software. The data digitized using AutoCAD was intended to be migrated to the Arc/Info coverage environment so that the refuge boundaries and individual land status polygons could be attributed.

The methodology and attribution scheme described in SOP 97-01 was adopted by all of the Regions, and led to the digitizing of all the external boundaries of the National Wildlife Refuges, and much of the internal land status. However, a complete dataset of all digital refuge boundaries combined with all digital land status for the entire NWRS was never achieved.

In 2000, the Headquarters Office for the NWRS in Washington D.C. hired a Chief Cartographer, who was given a primary charge of helping the Regions to complete the digitizing of boundaries and land status within the NWRS. In 2002, a working group was formed with representatives from each Region to develop new mapping standards for the FWS that embraced GIS technological capabilities and streamlined the production of map products. Over the next three years, the "Maps" chapter of the FWS manual was completely rewritten, and a new standard for NWRS maps adopted.

Meanwhile, the Environmental Systems Research Institute (ESRI, Inc.) engineers for the ArcInfo software were making dramatic changes in the architecture of their data storage model. The era of a single-user GIS professional generating individual "coverages" and "shapefiles" and storing them on their personal

computer was evolving into a multi-user environment where maps and data were being accessed via the internet and intranet. “Enterprise Integration” implied a new strategy to manage the GIS from a centralized database using a geographic “geodatabase” environment.

In response to the ESRI product evolution, the same group of professionals who developed new standards for mapping the FWS lands and waters would take up the challenge of developing a geodatabase that would store and manage the FWS cadastral data, creating a *“spatial database for FWS cadastral data and a common boundary dataset for all Regions to utilize.”*

Cadastral Geodatabase defined

The term “cadastral” as defined by the Merriam-Webster dictionary is (1): of or relating to a [cadastre](http://www.merriam-webster.com), and (2): showing or recording property boundaries, subdivision lines, buildings, and related details. (www.merriam-webster.com, 2008).

The Cadastral Subcommittee of the Federal Geographic Data Committee, in their “Cadastral Data Content Standard for the National Spatial Data Infrastructure” (2002) document, defined cadastral data as

“the geographic extent of the past, current, and future rights and interests in real property including the spatial information necessary to describe that geographic extent. Rights and interests are the benefits or enjoyment in real property that can be conveyed, transferred, or otherwise allocated to another for economic remuneration. Rights and interests are recorded in land record documents. The spatial information necessary to describe rights and interests includes surveys and legal description frameworks such as the Public Land Survey System, as well as parcel-by-parcel surveys and descriptions.”

The term “geodatabase” was invented by ESRI, Inc. and is a word not yet recognized by Merriam-Webster. The word implies “geographic database” which was probably the original intent. The actual definition, of which there are several from ESRI, includes:

“An ArcInfo 8 data storage format. A geodatabase represents geographic features and attributes as objects and is hosted inside a relational database management system.”

“A geographic database that is hosted inside a relational database management system that provides services for managing geographic data. These services include validation rules, relationships, and topological associations.”

The key word here is “relational.” The ability for the geodatabase to make a relation (to associate) a particular object to any number of other objects represents a major innovation in GIS technology. In the diagram below (Figure 1), we see a small portion of the geodatabase that the FWS is using to map and manage lands within the NWRs. The “Basedata” (states, cities, streets) is related to the “Hydrology” (lakes, streams) which is related to the “FWSBoundary” (boundary and other cadastral data) which in turn is related to other vectors that reflect agriculture, animal biology, and animal chemical control.

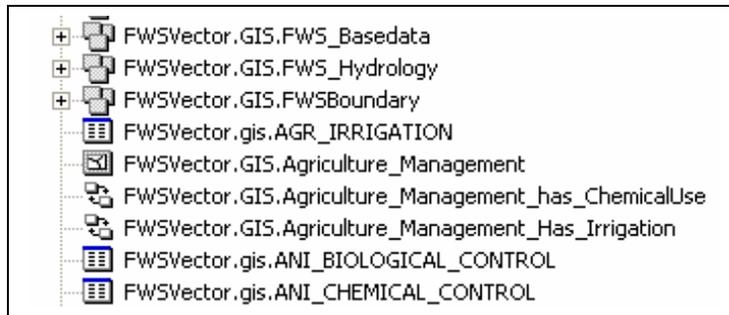


Figure 1: Data layers from the Refuge Lands GIS (RLGIS) geodatabase as viewed in ArcCatalog.

The geodatabase is an object-oriented vector data model. In the geodatabase, entities are represented as objects with properties, behavior, and relationships. A variety of different object types, such as simple objects, geographic features (objects with a location), network features (objects with geometric integration with other features), and annotation features, can all reside and relate to each other within the geodatabase. The geodatabase model allows the user to define relationships between objects, together with rules for maintaining the referential integrity between the objects.

Several specific entities combine to create the geodatabase:

Feature Class: a collection of geographic features with the same geometry type (such as a point, line, or polygon), the same attributes, and the same spatial reference. Feature classes allow homogenous features to be grouped into a single unit for data storage purposes.

Feature Dataset: a collection of Feature Classes stored together that share the same spatial reference, meaning that they have the same coordinate system and they are located within a common geographic area. Feature Classes with different geometry types may be stored in a Feature Dataset.

An analogy can be made comparing the geodatabase to a library. The Feature Dataset represents a bookshelf, and the Feature Classes represent the books.

Field: a vertical column in a table containing numbers or words that further describe the feature class.

Domain: The range of values allowed for entities in the field within the feature class.

Topology is the term used to describe the rules and behavior used to manage the feature classes. Topology controls the editing tools and helps to maintain integrity of the data. The geodatabase evaluates the data against the topologic rules during a validation process. Any violations to the topologic rules are identified as errors, which can be corrected or identified as exceptions to the rules.

Refuge Land Geographic Information Systems (RLGIS)

RLGIS was developed to assist FWS managers and biologists in the collection, organization, and use of spatial data for their day-to-day management activities as well as the development and implementation of biological programs. Field Station

managers and wildlife biologists within the NWRS indicated a need to collect and manage spatial information in a consistent and effective manner. Based on the data requirements submitted by the field stations, regional GIS support staff developed the data structures, protocols, and applications for creating spatial data, populating databases and managing the resulting information. The product resulting from this effort is RLGIS.

The RLGIS data model encompasses three geodatabases:

- 1) Features, Management Units, and Monitoring (47 Feature Classes)
- 2) Landcover and Habitat (10 Feature Classes)
- 3) Resource Management (15 Feature Classes, 27 Relationship Tables).

A critical component missing from the RLGIS was the cadastral layer. The job of creating a cadastral geodatabase for use with the RLGIS was assumed by the same working group who revised the “Mapping” chapter of the FWS manual. The working group convened to begin this new effort at a meeting in Denver, CO, in October 2005.

Designing a Cadastral Geodatabase for the FWS

Fortunately for the working group, several of the members had been involved with RLGIS and with using geodatabases. Region 7, for example, had already migrated all of their coverage and shapefile data to a cadastral geodatabase they had designed. Many of the concepts from SOP 97-01, and definitions from the new “Mapping” chapter would be used to start building the primary feature classes, fields, and domains.

The working group, now calling itself the “Cadastral Data Working Group” (CDWG), agreed that they were working to assemble a geodatabase model that would be common to all Regions and could be combined (“rolled-up”) to represent all of the FWS lands and waters. Further, the Regions would be responsible for populating and maintaining a specific version of the geodatabase assigned exclusively to their Region. While additional feature classes, fields, and domains could be added to a Regional version, all of the Regions would maintain a national version that would remain intact with the common, agreed upon core features, fields and domains.

A primary goal of the FWS is to acquire land and water areas for the protection of wildlife habitats. Historically, wildlife refuges have been created by a variety of legal actions, from Executive Orders issued by the President, to the donation of lands by a person or group. Since the 1970’s, FWS biologists from the Division of Planning have identified lands or waters that are deemed valuable as habitat for an animal, bird, fish, or plant species. Boundary lines are drawn on maps identifying the valuable habitat areas, and an extensive process begins to approve the areas for inclusion within the NWRS. When the creation of a wildlife refuge

is approved, the process of acquiring lands within the approved boundary begins. The FWS has a policy of acquiring lands only from willing sellers.

There are two basic types of boundaries associated with a wildlife refuge:

- 1) Approved Acquisition boundary: the line(s) enclosing those lands that the FWS has authority to acquire, in whole or in part. This boundary often encompasses both public and private land, but does not imply that all private parcels within the boundary are targeted for FWS acquisition.
- 2) Interest boundary: the line(s) enclosing those lands for which the FWS has fee (primary, full ownership) or less than fee interest (secondary, such as a “conservation easement”). Where the FWS has the primary interest in the land or water, management responsibility is implied.

On FWS maps, individual parcels of land or water areas are identified by a “Tract Boundary” and “Tract Number.” A “Status Map” depicts the tracts of land or water on which the FWS has acquired a property interest. An “Ownership Map” also depicts *inholdings*, which are lands within the approved acquisition boundary for which the FWS has yet to acquire an interest. Inholdings may be identified by tract boundary and tract number in addition to all of the information found on a Status Map.

In addition to inholdings, the FWS may issue a permit for a specific land use, such as sand or gravel extraction. The FWS also allows an easement or a right-of-way to a private party, such as for a road or trail. These equate to an *encumbrance* on lands managed by the FWS.

There are lands within FWS managed areas that have been designated by Congress as “wilderness”, and rivers that have been designated as “wild and scenic.” These types of *special designations* bring additional regulations and affect how the FWS manages the area.

In the Lower 48 states, the perimeter for all the approved acquisition boundaries is approximately 1,671,010,429 meters (1,038,318 miles). While many of these boundary lines can be described using the PLSS, less than half of these boundary lines have been surveyed and platted by a professional land surveyor. It made sense to the CDWG to reflect not only the accuracy of the line features, but to show where survey monuments have been set along these lines.

The CDWG has defined several feature classes to capture the primary cadastral features.

Polygon Features

“FWSApproved” = FWS Approved Acquisition Boundary.

“AcqApproval” = Acquisition Approval. Describes the approval authority under which land has been or may be acquired.

“FWSInterest” = FWS Interest. Service acquired tracts, fee title or less-than-fee title. Includes all Service managed tracts.

“Inholdings” = Inholdings. Unacquired tracts within the approved acquisition boundary (usually private lands).

“FWSEncumbrance” = FWS Encumbrance. Permits and outgrants issued by the Service. Includes most easements and Rights-of-Way.

“SpecialDesignation” = Special Designation. Boundaries of wilderness areas and other special designations.

Point Features

“SurveyMonument” = Land Survey Monuments.

Line Features

“TractBoundary” = Tract Boundary. Linear feature attributes of FWSInterest tracts (polygons).

Within the Feature Classes are found specific “**Fields**” which add value and further describe the features. Several fields are common to all Feature Classes.

Common Fields

“IFWS” = Department of the Interior-FWS Number. A unique code assigned to each land or water area over which the FWS has some type of jurisdiction.

“LIT” = Literals. Unique alpha codes that identify the FWS lands or waters. Example: Petit Manan National Wildlife Refuge = PMN.

“ORGNAME” = official name of the organization. Example: Petit Manan National Wildlife Refuge.

“ORGCODE” = a unique five-digit numeric code assigned FWS organizations where personnel are assigned, including all unstaffed land management units.

“RSL_TYPE” = Organization Type. Administrative categories that identify FWS organizations by their primary function. Example: National Wildlife Refuge.

“CMPXNAME” = name of the management complex. Some units of the NWRS are managed together in a “complex” because they are located relatively close to each other. Example: Maine Coastal Islands National Wildlife Refuge Complex.

“FWSREGION” = FWS Region Number.

“GISACRES” = Geographic Information System Acres.

“DOCACRES” = Document Acres. Acres indicated in a deed or other official document.

“COMMENTS” = notes of relevance to the feature class.

The following are those Feature Classes that contain Fields that are not common to all Feature Classes.

Unique Fields

FWSApproved:

“MAXACRES” = the maximum number of acres approved for acquisition within this boundary.

AcqApproval:

“AUTHTYPE” = the type of authority that approved the lands within the boundary for acquisition. Examples: Executive Order, Public Law;

“DATEAPPR” = the date that the area was approved for acquisition.

“COMMENTS” = any additional information can be added here.

FWSInterest:

“USRIGHTS” = a claim or title which is enforceable by U.S. law.

“INTTYPE1” = Interest Type No. 1. The primary real property interest (land or water) held by the FWS.

“INTTYPE2” = Interest Type No. 2. The secondary real property interest (land or water) held by the FWS.

“INTIDNO” = internal identification number.

“MGMTCODE” = management code to reflect the managing station of a particular unit.

“STATUS” = a subtype field that assigns the attributes: 0 for ‘Acquired’ and 1 for ‘Inholding.’

FWSEncumbrance:

“ENCBTYPE” = the type of encumbrance (easement, Right-of-Way, etc.)

“ISUDATE” = the date the encumbrance was issued.

“EXPDATE” = the date the encumbrance will expire.

“ENCBIDNO” = the identification number of the encumbrance.

FWSInterest & FWS Encumbrance:

“DIVNAME” = name given to a FWS organizational division.

“UNITNAME” = name given to a FWS organizational unit.

“SUBNAME” = name given to a FWS organizational subunit.

“SURACRES” = the number of acres determined by a land survey.

Inholdings:

“OWNERNA” = name of the owner of the inholding.

FWSInterest & FWS Encumbrance & Inholdings:

“TRACTNO” = a number assigned to a tract of land or water.

SpecialDesignation:

“DOCNAME” = name of the legal document creating the special designation.

“DESNM” = name of the special designation.

“DESTYPE” = type of the special designation.

“DESDATE” = date that the special designation became effective.

“REACHMIL” = number of river reach miles within the special designation.

SurveyMonument:

“DESIGNAT” = designation (specific purpose of the monument).

“TYPE” = specific type of monument (brass cap, iron rod, etc.).

“DESCRIPT” = description of monument (corner number).

“LOCATION” = location of monument (PLSS, latitude/longitude coordinates).

“SETBY” = who (agency, private firm) the monument was set by.

“SETYEAR” = year the monument was set.

“YEARFND” = year the monument was found/inspected.

“CONDITN” = condition of the monument.

“PROBLEM” = any known problem with the monument.

“PROBDESC” = further description of the problem.

TractBoundary:

“INTLCODE” = internal code number.

“RELICODE” = reliability code number (value pertaining to accuracy).

The following **Domains** contain specific values allowed within the fields that further describe the feature class.

ApprType = Approval Type.

IntCode1 = Interest Code #1. The primary interest of the FWS.

IntCode2 = Interest Code #2. The secondary interest the FWS

EncbType = Type of Encumbrance.

USRights = U.S. Rights.

FWSReg = FWS Region name.

OrgName = Organization Name.

RslType = Organization type.

Lit = Literal.

LinCodes = Line Codes. The codes represent the specific interest that exists on either side of the line.

RelCodes = Reliability Codes. The codes represent the accuracy of the line itself.

MonType = Monument Type.

SetMon = Set Monument. Who (firm or agency) set the land survey monument.

MonCond = Monument Condition (the actual condition of the land survey monument).

MonPyn = Monument Problem (any known problem with the land survey monument)

Conclusions

The goal of a complete dataset of all digital National Wildlife Refuge boundaries combined with all digital land status for the entire NWRS is close to being achieved. The CDWG will also work to compile a draft "User's Manual" so that the processes of populating the geodatabase with cadastral data are documented.

Completion and maintenance of the cadastral geodatabase will provide the users of RLGIS the essential boundary and parcel information for the biological geodatabases currently within the RLGIS data model. The future display of the cadastral geodatabase spatial data on a web page will provide the FWS Directorate and FWS employees an accurate, convenient and consistent avenue to view FWS lands and waters, which will aid in decision making.

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