# A Comprehensive Managed Areas Spatial Database for the Conterminous United States

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## Abstract

*The compilation of a comprehensive, spatially referenced, digital database of managed areas in the conterminous United States is described. As concern over ecosystem degradation increases, so does the need for accurate, up-to-date information on the spatial location and aerial extent of currently managed and protected areas. This need represents the fundamental motivation for creation of this Managed Areas Database (MAD). MAD includes information on the level of protection each management designation provides, sources used for compilation, and a number of additional attributes. MAD can be used with supplementary data sets for conservation planning, and to determine protection status. The authors believe that this database can and will support a wide variety of environmental studies. We believe, after appropriate verification and revision, that it may someday be part of a necessary global coverage of managed areas.*

## Introduction

When this project began, there was no comprehensive spatial database of managed or protected areas for the conterminous United States. Further, there was generally little data available to study ecosystems over a large spatial extent. This paper describes the creation of such a managed areas database (MAD) for the conterminous United States (McGhie, 1996). MAD contains information on nearly all types of managed areas existing in the conterminous United States, including land held by federal, state, tribal, and private agencies and organizations. A geographic information system (GIS) was used for MAD's creation so that many important analyses can be readily performed. Future MAD development plans involve assessment of the thematic, spatial, and temporal accuracy of the managed areas and their borders. Along with an accuracy assessment for this large spatial database, the benefits of MAD will be examined and some possible uses will be discussed.

There is a need to change the focus of conservation from protection of individual endangered species to protection of entire ecosystems and preservation of biological diversity (Scott *et al.*, 1987). There is also a need for improved coordination among species protection groups and agencies in order to minimize duplication of effort. A comprehensive federal plan for conservation of biodiversity and entire habitats is required (Blockstein, 1990). Inventory is a first logical step in the development of a plan for protecting ecosystems. In addition to inventory of the elements of biodiversity, areas must be identified where floral and faunal associations are managed. We must also identify the level of protection provided by this management and areas where further action should be taken to improve ecosystem protection. An inventory of this type can help prevent further damage to ecosystems and improve ecosystem recovery from previous disturbance. This paper describes preparation for such an inventory.

## Database Development

The focus of this effort is the conterminous United States. The decision to exclude the states of Alaska and Hawaii was based on availability of the base data layer and a realistic project scope of activity and planning. The majority of related work prior to MAD has been limited in spatial extent, management area, and/or information specifics. MAD is the first completed study that addresses the need for digital, spatially coherent, managed areas data in a comprehensive and integrated fashion for the entire conterminous United States.

The conterminous United States Managed Areas Database (MAD) developed for this project was produced by personnel of the Remote Sensing Research Unit (RSRU) at the University of California Santa Barbara. This beta version of MAD includes 84 designations of managed areas. A condensed listing of these designations is shown in Table 1. The database includes attributes that allow it to be manipulated or queried in numerous ways (Table 2). Proper query and manipulation using this coding allows for creation and extraction of new GIS layers or themes which are suited to user specific tasks. By including all types of managed areas in MAD, specific subsets of areas which afford given levels of protection to resources within their boundaries can be extracted.

The database was compiled at a map scale of 1:2,000,000 with a minimum mapping unit (MMU) of approximately 100 hectares. There are some smaller units included which represent private holdings, fragmented or disjunct portions of larger areas, and sliver areas from overlapping unit types. Areas too small to be distinguished as polygons on the compilation data sources were added to a separate MAD dataset of point locations in order to make MAD as comprehensive as possible. A limited number of areas slightly greater than or equal to the MMU may not be included in MAD due to map scale and/or source content issues. The database is compiled in the Albers Equal-Area map projection in metre units of measure. Environmental Systems Research Institute (ESRI) ARC/INFO GIS software was used to develop the database.

The database is divided into two separate GIS coverages. The first data layer contains polygons showing the boundaries of managed areas (Figure 1). The second layer contains data points that were not large enough to meet the MMU. The polygon coverage contains approximately 7500 management

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TABLE 1. EXAMPLES OF THE MANAGED AREAS DESIGNATIONS

| | | |
|---|---|---|
| Indian Reservation | National Recreation Area | Wild and Scenic River |
| Military Reservation | National Seashore | Wilderness |
| National Forest | National Wildlife Refuge | Wilderness Study Area |
| National Grassland | State Forest | Other (numerous) |
| National Monument | State Park | |
| National Park | State Recreation Area | |

units, and the point coverage contains 1580 management units.

A number of digital and hardcopy map sources were employed in the compilation of this database (Table 3). Attempts were made to gather source data which represented the desired managed area theme at map scales similar to the chosen base layer. MAD includes a numerically coded attribute indicating the data source(s) of the boundary locations (arcs) for each polygon. Boundaries that are determined not to meet National Map Accuracy Standards (Thompson, 1966) for positional accuracy may require modification by incorporating better source data as they are made available.

Database attribute information was generally taken from source data used for compilation, but a number of additional sources were consulted as needed for information absent from a given source or for verification. In some cases, map sources did not agree on attributes and/or boundaries. In these cases, information that was verified either on the largest number of sources or on the source which was considered most accurate was used. To make these decisions in a systematic manner, a hierarchy of source data was developed.

A reasonably comprehensive digital database was needed as a base data set for MAD. For this, the Federal Lands GIS layer from ArcUSA (ESRI, 1992) at a map scale of 1:2,000,000 was selected, because it contained a large number of managed areas in the United States. This database did not include place names or some Federal Lands boundaries (such as divisions between National Forests) nor any state and private holdings, so major additions and modifications have been made. This base layer data is from the 1970s, and is somewhat outdated, but was still deemed the best overall available source for initial data integration. The next source used was a GIS database of United States administrative boundaries created by John Findley of the United States Geological Survey: National Mapping Division (USGS/NMD). This database included many of the boundaries dividing larger National Forest holdings into their individual units and other managed areas not included on ESRI's Federal Lands layer. Paper map sources employed in MAD development include map series from the U.S. Geological Survey (USGS), the Bureau of Land Management (BLM), and the National Geographic Society (NGS) (Table 3). When using paper source maps, relevant boundaries were digitized for GIS input and transformed for integration into the final product.

The first hardcopy source maps reviewed were the USGS 1:500,000-scale topographical maps. Although the map scale of MAD is coarse, a significant amount of detail was compiled from this map series and can be seen when MAD is examined at the state or regional level. To compile data from this source, each state was viewed in small sections, and boundaries not yet included in MAD were digitized into a separate national GIS coverage. This coverage was then re-projected and merged with the working coverage. This process was repeated with the rest of the paper map series.

Because data were integrated from many sources, numerous MAD polygons were derived from more than one source. For these polygons, the database includes attribute codes for combinations of sources. These overlapping areas also require that attributes be coded for multiple management strategies (Table 2). An example of overlapping designations is a Wild and Scenic River, within a Wilderness Area, which is also part of a National Forest.

The level of management or degree of protection of each of the managed areas included in MAD is a critical attribute. Two separate classification schemes are currently used to depict this attribute. The first is based on the World Conservation Monitoring Centre's (WCMC) list of World Conservation Union (IUCN) categories. Ten levels of protection are used to classify managed areas (IUCN, 1990), but only a small percentage of the areas in MAD could be classified using this scheme. The second approach classified areas into land management categories based on the United States GAP Analysis Project. The GAP system is composed of four classes of protection (Scott *et al.*, 1993), and each area is placed into one of the categories based solely on the area's management designation. This allows each area in the database to be initially classified pending verification and possible revision. A limitation in this system is that areas of the same designation are not always managed with the same goals. For example, parts of military reservations may be pristine, while other sections are utilized for weapons testing or other intensive uses.

## Technical Issues and Error Sources

Spatial data in digital form provide users with more options for processing, update, and analysis than do analog data. Digital data can, however, contain errors which create problems with respect to their use. In the creation of a large, digital spatial database, with multiple data sources having different map scales and projections, a number of positional or thematic errors may be introduced. For example, registering all the maps to a consistent coordinate system and transforming all of the data sets to a common map projection can introduce locational error. Errors may also arise from the process of digitizing unstable paper map sources. Inaccuracy may be introduced where outdated or incorrect source data are employed as input data. A digital database with an unknown or unclear lineage may have other inherited error which cannot or may not be detected. Burroughs (1986) contains a thorough discussion of error in GIS.

A full accuracy evaluation of MAD is underway as we describe in the following section of this paper. While every attempt has been made to insure a high level of accuracy during MAD's compilation (McGhie, 1996), errors are present. MAD has been designated as a 1:2,000,000-scale product, and we expect the precision and the accuracy of the database to be in accord with that scale. Thompson *et al.* (1966) includes information on precision and accuracy based on map scale. This coarse scale must be considered when using MAD for planning issues, and more detailed source data should be

TABLE 2. SELECTED ATTRIBUTES INCLUDED IN THE DATABASE

| | |
|---|---|
| area name* | -the proper name of each managed area represented |
| site code* | -a unique number for each area for database relations |
| designation* | -describes the designation type for each managed area |
| IUCN category* | -a code used by World Conservation Monitoring Center (WCMC) to represent the level of protection status for each designation type |
| GAP category* | -a level of management based on the National Biological Service's Gap Analysis Program (GAP) |
| state | -the state in which the area is located |
| source | -the digital or hard copy map source from which the arc(s) making up the border of the polygon were taken (includes combinations of sources) |

*These attributes have three management levels for areas with multiple or overlapping management profiles.

consulted for specific boundary information. Additionally, this database currently exists as an initial (beta) release for distribution to knowledgeable users who are expected to provide feedback for future corrections and updates.

## Ongoing Activities

Establishing positional accuracy and an approximate map scale in relation to National Map Accuracy Standards (Thompson *et al.*, 1966) will be an important step in the completion of MAD. An assessment of the spatial accuracy of the managed areas' boundaries will be performed by comparing positions of features in the completed database to their actual locations. For this assessment, a geodetic framework must be established to serve as an accurate representation of reality. USGS 1:24,000-scale topographical maps will serve this purpose. Boundary sample points will be drawn using a random sampling scheme on MAD data stratified by source. Samples will be taken at obvious or easily verifiable corners or other distinct features of the political boundaries, and their latitude/longitude coordinates will be recorded. These sample points will then be located on 1:24,000-scale USGS maps, and recorded in the same manner. A statistical analysis will then be completed. A frequency distribution of the distance between paired points and accompanying statistics of means and residuals will be produced. An analysis of accuracy will be stated for the database as a whole as well as for the individual sources used in compilation. Possible error in the map sources used in creation and possible sources of error acquired during compilation will be presented.

TABLE 3. SOURCES USED IN DATABASE COMPILATION

| |
|---|
| ESRI's ArcUSA Federal Lands layer (ESRI, 1992) [1:2,000,000 scale] |
| Bureau of Land Management's Wilderness Status map series (1986-1995) [1:1,000,000] |
| National Geographic Society's Close-Up USA map series (1988) [map scale varies] |
| USGS/NMD's Digital Administrative Boundaries- USAADM (From John Findley; specifics unknown) |
| USGS topographic map sheets (unknown dates) [1:250,000] |
| USGS topographic map sheets (1966-1990) [1:500,000] |
| Individual BLM maps for several states at varying sales (i.e., Public Lands edition) |
| Numerous combinations of the above sources |

After database accuracy is established, use of the database and further research ideas will be examined. An example analysis which is planned using the MAD database involves overlaying MAD with the national ecoregion GIS database developed by Bailey (1995). Simple statistics will be calculated regarding the types and amounts of ecoregions

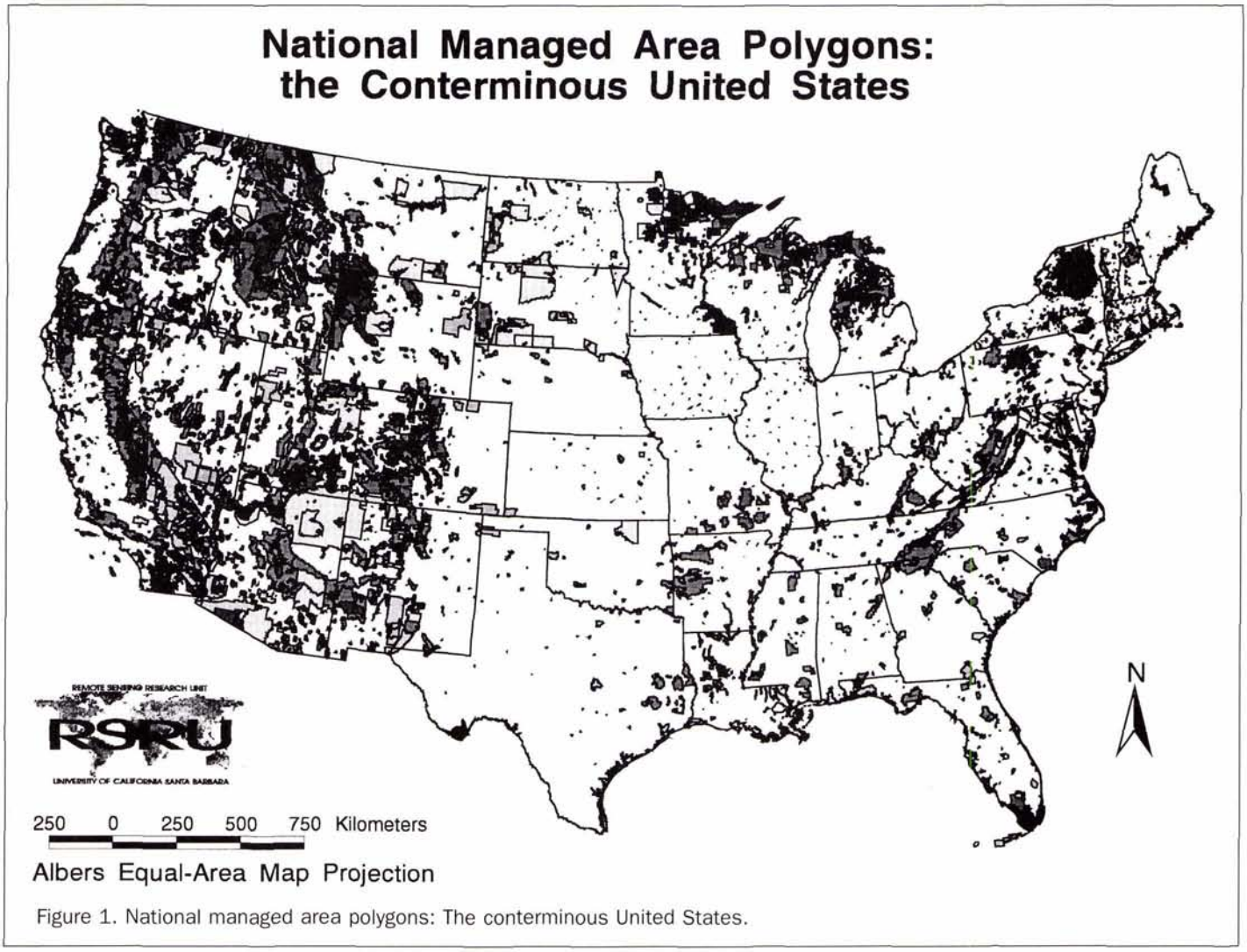


Figure 1. National managed area polygons: The conterminous United States.

within each designation of management. This analysis will provide preliminary information correlating ecosystem protection status with different management strategies. Future plans also involve overlaying MAD with vegetation data derived from remotely sensed imagery in order to determine possible differences in pattern, composition, and fragmentation of vegetation classes between managed, non-managed, and differently managed areas.

## Summary and Conclusions

As described by Scott *et al.* (1987), loss of biodiversity is a worldwide problem and a major focus for conservationists. An estimated 1000 species become extinct each year and these numbers are expected to increase dramatically in the future. It is a daunting task simply to determine which species are at risk. GIS technology may be used to study both species and ecosystems at risk and can provide resource managers with more easily analyzed forms of data. We anticipate that use of this database will demonstrate a significant under-representation of some ecosystem types in the conterminous United States' protected or managed areas system. If this hypothesis is validated, a more critical evaluation of United States protected areas locations and management practices should be considered.

This activity is intended to further the study of the Earth's ecosystems with regard to their management status and viability. There is a need for data and systems that support and improve our ability to study large interlinked ecosystems. Yet, little information with which to study ecosystems and their protection status over large areas is presently available to the research community.

In the United States, at this time, cooperation among land management agencies is inadequate; each has been willing only to inventory and evaluate their own lands as mandated. As a result, comprehensive, integrated environmental planning and resource management suffer to a very real extent. Currently, land management agencies have no administrative or financial incentive to create databases of this type, although their value to researchers, planners, managers, and policy makers is obvious. At this time, we intend to release the database to interested government and private agencies, as well as to state GIS coordinators for their use and evaluation. Personnel in these organizations will be asked for feedback on the accuracy and quality of the database. We propose to update the database as these responses are received and verified. Once verification and revision is completed, an updated version of MAD will be released. The mechanism and responsibility for future revision and long term maintenance of MAD has yet to be determined.


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