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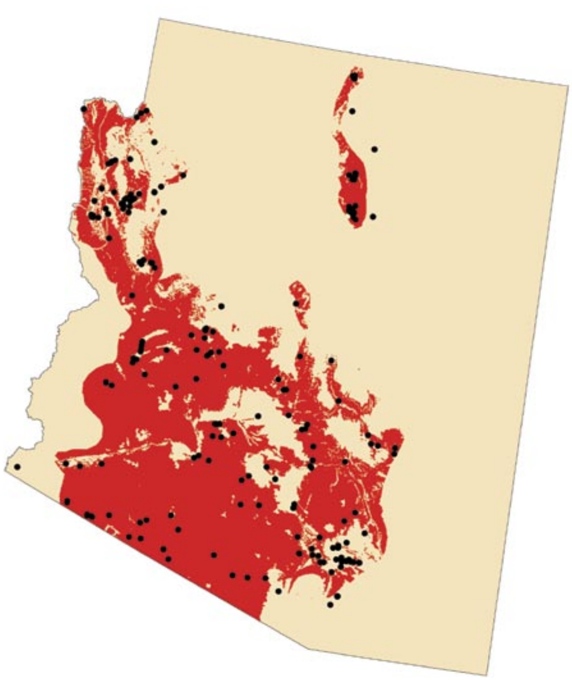
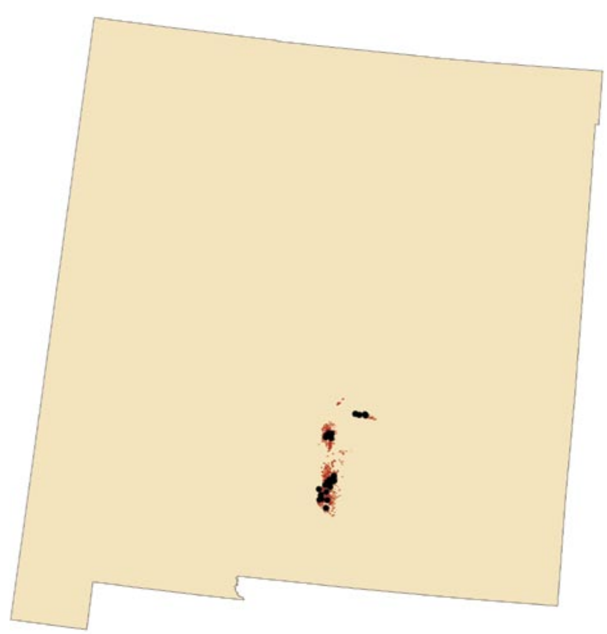
Regional Data to Support Biodiversity Assessments: Terrestrial Vertebrate and Butterfly Data from the Southwest

**Darren J. Bender, Curtis H. Flather,
Kenneth R. Wilson, Gordon C. Reese**

Perognathus amplus

Aneides hardii





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Abstract

Spatially explicit data on the location of species across broad geographic areas greatly facilitate effective conservation planning on lands managed for multiple uses. The importance of these data notwithstanding, our knowledge about the geography of biodiversity is remarkably incomplete. An important factor contributing to our ignorance is that much of the biodiversity data are not readily accessible because they are dispersed across many institutions and often have not been digitized. This report documents our efforts to address these conservation planning constraints. We have compiled extant data on predicted species distributions and more than 680,000 occurrence records for terrestrial vertebrates and butterflies into a single digital database for general use in conducting geographically broad biodiversity assessments across a two-state area (Arizona and New Mexico) that defines the Southwestern Region of the USDA, Forest Service. These data represent one of the most complete databases on species occurrence to be compiled for the Southwest. Our objectives are twofold: (1) to document the types, sources, and characteristics of the data comprising the biodiversity database; and (2) to illustrate the utility of the data in addressing applied conservation problems across the Southwestern Region. We report on three case studies that illustrate how the data can be used to generate simple distribution maps using both point locations and predicted ranges, describe the patterns of species richness for seletected taxa across the Southwest, and provide an example of how managers may use the data to identify where potential resource conflicts may be particularly important on National Forest System lands.

Keywords: butterflies, geographic information systems, geographic range, species associations with grazing, species diversity, species impacted by grazing, Southwestern biodiversity, terrestrial vertebrates

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Regional Data to Support Biodiversity Assessments: Terrestrial Vertebrate and Butterfly Data From the Southwest

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Introduction

Conservation of biological diversity on multiple-use lands is complicated by the inevitable conflicts that arise from varying, and often discrepant, land management objectives held by different segments of the public. Increasingly, resource managers need to account for these conflicts objectively when developing tenable conservation plans and resource management decisions (Mills and others 2001; Hansen and others 1993). The degree to which resource planners are effective in considering biodiversity in policy and management decisions is critically dependent on the availability of detailed knowledge about the taxonomy, distribution, abundance, and life history of the biota within the management area (Savage 1995; Wheeler 1995; Patrick 1997; Gioia and Pigott 2000).

Information about biodiversity contributes to conservation planning in many ways (for review see McNeely 1995; Cracraft 2002; Funk and others 2002; Ferrier 2002; Graham and others 2004). First, and perhaps most fundamentally, it provides a means of generating potentially accurate species lists for an area of interest. Second, when coupled with location information, the spatial distribution of biodiversity can be used to describe how characteristics of the biota (for example, species occurrence or species richness) vary geographically throughout a region of interest. Third, if data are collected periodically, then temporal changes in species occurrence and community composition can be documented. Finally, if biodiversity data are supplemented with ancillary information on the biotic and abiotic environment (for example, soils, elevation, vegetation types, weather), then researchers and planners can model biodiversity as a function of those ecological factors thought to determine its spatial pattern. Inferences from such modeling efforts will contribute to our understanding of why organisms currently occur where they do, and also permit predictions about how biodiversity may change in response to ongoing or proposed land management activities.

Although spatially explicit biodiversity data increase the effectiveness of conservation plans, our knowledge of biodiversity, both systematically and geographically, is woefully incomplete (Wilson 1988; Brown and Roughgarden 1990; Prance 1995; Simpson and Cracraft 1995). Two problems with extant biodiversity data help characterize the nature of the limitations. First, biodiversity data collected to date contain notable biases, including taxonomic and geographic, focusing on easy-to-study species (for example, vertebrates and vascular plants) in easily accessible places (Funk and Richardson 2002; Graham and others 2004). Furthermore, collecting effort has declined over time, resulting in few recent records relative to the number of historical records and an emerging temporal bias in the data (Winker 1996; Smith and others 2000). Second, of the biodiversity data that have been collected, much are not readily accessible because they have not been digitized (Cracraft 2002) and because they are spread across many institutions (Pennisi 2000)—being dispersed among the paper records of research ecologists, museum collections, or government agencies (Brown and Roughgarden 1990). Since biodiversity information is not readily accessible, it is often not considered, at least in a rigorous way, in policy or management decisions (Edwards and others 2000).

If financial and personnel constraints could be overcome, then one solution to the noted data biases could be to design a comprehensive (taxonomically and geographically) biodiversity inventory (Raven and Wilson 1992; Prance 1995). However, the ideal inventory will likely never be available to answer our most pressing species conservation questions (Platnick 1992). Consequently, a feasible, if only partial, solution to biodiversity data limitations will have to address the second problem—that of data accessibility. Given that (1) resource decisions will be made whether comprehensive biodiversity data are available or not, and (2) an enormous amount of information has already been collected about where species occur (Edwards and others 2000), then it seems prudent to first invest in compiling existing biodiversity data so that this information (even with its inherent biases) can provide resource decision-makers with some insights on where resource-use conflicts with biodiversity may be particularly important. Such compilation efforts should not only consider specimens housed in formal museum collections, but also consider species occurrence information from published field studies, the notebooks of researchers and parataxonomists, and extant species monitoring programs such as the North American Breeding Bird Survey (Basset and others 2000; Smith and others 2000).

We take the latter approach in this report—namely we compile extant biodiversity and ancillary data into a single digital database for general use in conducting broad-scale biodiversity assessments across a two-state area (Arizona and New Mexico) that defines the Southwestern Region of the U.S. Forest Service. We have two primary objectives in compiling these data: (1) to document the types, sources, and characteristics of the data that contributed to the database, and (2) to illustrate the utility of the database in three applied conservation problems that relate to the simple description of regional biodiversity patterns and the evaluation of potential resource conflicts.

In addressing the first objective, we document the basic ancillary data that may be useful in establishing ecological relationships with various biodiversity attributes, as well as describe the species range and occurrence information that forms the core biodiversity data. We focused our search for extant biodiversity data on terrestrial vertebrates and butterflies. The choice of these taxonomic groups was determined, in part, by the opportunistic nature of this effort—those groups of species were expected to have the greatest collection effort and also represent a subset of species that we could feasibly compile given the funding level of the study.

In addressing the second objective, we report on three case studies that illustrate how these data could be used to address applied conservation problems. First, we show how the data can be used to generate simple distribution maps using both point locations and predicted distributions. Second, we document the general patterns of species richness across the Southwest noting, in particular, apparent relationships with ancillary environmental data and how the spatial patterns among taxonomic groups relate to one another. Lastly, we illustrate how these data can be used to initially examine the potential conflicts that may arise between biodiversity and extractive resource uses. Ultimately, the data compiled for this study could be used to assess potential conflicts with many resource management issues. However, the database's proximate motivation concerned domestic livestock grazing (Memorandum of Understanding between USDA, Forest Service, Region 3-Southwestern Region and the USDA, Forest Service, Rocky Mountain Research Station, unpublished document); consequently, our third case study focuses on livestock grazing as the context within which to illustrate the value of such geographically extensive data in guiding multiple-use resource planning.

Although our discussions throughout this report focus on broad-scale assessment applications, we hope that those with more local perspectives will still find value in a regional biodiversity database. Because there is mounting evidence that understanding local patterns of biodiversity requires knowledge of regional diversity (Ricklefs 1987; Caley and Schluter 1997; Smith 2001), the data presented here can function to provide the regional context for more geographically focused research and management in the Southwest.

Database Development and Description

Development of the Database

Two main types of data were compiled to create this database. First, we collected data layers (hereafter referred to as base layers) that provide information on environmental conditions, land use/land cover, and administrative boundaries. These include information such as vegetation cover, soils, topographic information, natural features, road networks, and county and Forest Service grazing allotment boundaries. The second type of data in the database includes species occurrence data, both predicted and observed. Our focus in developing the occurrence data was at the species level of taxonomic resolution. However, we did maintain subspecies designations if the original location record or predicted range was recorded at this level. These data represent species range maps predicted from known habitat associations and documented locations where individuals were observed. All data were compiled and then imported into a geographic information system (GIS) to facilitate storage and retrieval, validation, and subsequent processing and analysis (see appendices for data descriptions [Appendix A] and metadata documentation [Appendix B]). The geospatial database that we compiled is designed to be used with GIS software produced by Environmental Systems Research Institute, Inc. (ESRI; Redlands, CA), namely ArcView GIS 3.x (1992-2002), and ArcGIS 8.0 or newer (1999-2002). The data are available on the accompanying DVD[1] in two ESRI file formats: ArcView shapefiles (locations of species observations, base layer maps) and

[1] These data can be downloaded from the following ftp site: ftp://ftp2.fs.fed.us/incoming/ftcol/flather/R3_Biodiversity_Data.

ArcInfo raster grids (predicted species occurrence maps, base layer maps).

Although we did not collect the original data included in this database, the utility of this database is that it brings together a comprehensive set of species occurrence data and associated base layer maps under a common spatial reference system and an interoperable file structure. All information in this database can be queried, viewed, and analyzed within one GIS software system. We anticipate that the comprehensive nature of these data will provide a biodiversity information system that can be used to support land management decisions within Arizona and New Mexico. It may also prove to be valuable for future research, especially as it relates to the predictions of species distributions (Reese and others 2005) and understanding macroecologic patterns of species richness (Shriner and others, in preparation). This section details how the database was developed and describes the contents of the database. A later section, Data Applications, provides examples of how we used this database to examine patterns in regional biodiversity and apply them to a potential threat to native biodiversity, namely livestock grazing.

Data Sources

Ancillary Data (Base Layers)—Many factors determine the distribution of a species including vegetation type, land use, elevation, and species interactions. Further, the management of biotic resources is influenced by jurisdictional boundaries. Thus, it is useful to have spatial data to provide a context for analysis and interpretation of species occurrence. We have compiled a number of GIS data layers that provide information on vegetation cover, soils, hydrology, elevation, natural features, human-made features, and administrative boundaries. All of these data are freely available and distributed to the public, so we have included them as ancillary data in our database.

The sources for the GIS base layers were generally federal and state government agencies. We have attached unmodified versions of these spatial layers (except that they have been converted to a common spatial reference system; see details below). A description of these files, including their original metadata, can be found on the accompanying DVD. Base map layers for Arizona and New Mexico are in the *Basecovs* directory.

Predicted Species Occurrence Data—The U.S. National Gap Analysis Program (GAP) has led an effort to model vertebrate species distributions for each state in the U.S. (Scott and others 1987, 1993; Kiester and others 1996; Jennings 2000). The first generation GAP products for Arizona and New Mexico produced predicted occurrence maps in the 1990s that depict the range extents for extant vertebrate species. These maps are based on habitat suitability models and limits of the species' known occurrence within the region (see Csuti and Crist 2000). These maps are included in the *Predicted* directory on the accompanying DVD. The intent of GAP is to conduct a conservation assessment of biotic resources every 10 years. The second generation of GAP products for Arizona and New Mexico (as well as Colorado, Utah, and Nevada) is currently being conducted and is known as the Southwest Regional Gap Analysis Project. Second versions of the vertebrate distribution models are targeted to be complete in the spring of 2005 (Thomas, personal communication) and they should supersede those contained in this database.

Species Observation Data—For years, numerous individuals, organizations, and institutions have collected species observation data for the Southwest. Although they are not always available to the public or freely accessible, these data constitute an important source of information about the distribution of species. Sources for such information include museum collection records, established volunteer surveys (for example, the North American Breeding Bird Survey and the Audubon Christmas Bird Count), databases from state Natural Heritage Programs, biological atlases, reports from the primary literature, and private and academic collection records.

We utilized all available data sources to build a comprehensive collection of species occurrence data for terrestrial vertebrates (birds, mammals, reptiles, and amphibians) and butterflies. Our general approach was to maximize the number of accumulated species occurrence records. Only occurrence records that were already georeferenced or could be georeferenced from the location supplied with the data source's description for the observed occurrence were incorporated into the database.

Many datasets were publicly available and some were distributed via the Internet. For example, bird observation data from the North America Breeding Bird Survey (BBS) and the Audubon Christmas Bird Count (CBC) were available online in a georeferenced digital format (see USGS 2001; National Audubon Society 2003). Other datasets were obtained from published materials, such as biological atlases of Arizona and New Mexico mammals by Hoffmeister (1986) and Findley and others (1975), respectively. We also conducted extensive literature searches in the primary literature, such as zoological journals, particularly regional journals. However, much of the data that we obtained was not published in print or on the internet. A wealth of species occurrence data for Southwest fauna exists in museum, private, and academic collections, as well as observation databases of non-governmental organizations. We solicited these types of organizations for species observation data that could be used in our database, particularly if the organization had an office in the Southwest. A template of the letter that we used to solicit data is available on the DVD as the file "*Request_template.doc*".

Overall, we obtained and compiled approximately one million species observation records into our database. However, the quality of some records were poor and they were excluded from the database (see subsection Accumulating Species Observation Records Into a Single Database below). The total number of suitable records in the database was 682,663. The largest proportion of our database (about 40 percent) is comprised of records originating from established volunteer surveys such as the BBS, which has been conducted in the Southwest for over 30 years (table 1). The various governmental and non-governmental organizations that maintain species observation record databases also provided a large portion of the database. For example, the Bird Banding Laboratory (USGS 2002) and the state Natural Heritage Programs provided nearly one-quarter of the species records. Established surveys and governmental/non-governmental observation databases were also most likely to deliver public data in electronic format, often via the Internet. Thus, the majority of our data was easily accessible, which is good news for those desiring to duplicate our efforts in other regions. Museum and other academic collections also provided a large number of records. These were often high quality datasets with respect to attribute information – providing, for example, detailed taxonomy, gender, and age information. However, considerable processing was required to extract location information from many of these records as discussed in the next section.

Data Compilation of Species Observation Data

At the outset of this project, only predicted species distribution maps and associated GIS base layer maps were available. Although much effort had been made to collect information on where species were being observed, no efforts had been made to accumulate and compile these data into a single database. A principal goal of this project was to compile as many species observation records as possible into a single GIS database, in part because we believed that having the most complete information on species occurrence was valuable for completing tasks such as identifying critical habitat or hotspots of biodiversity. Comparisons of predicted range maps with observation record locations are also valuable in identifying areas for targeted species surveys. For example, identification of areas where the species is predicted to occur but no location records currently exist could be used to site future inventory work to verify species occurrence within its predicted range. Conversely, geographic areas where point locations fall outside the predicted range could be used to further our understanding of the ecological factors affecting a species' distribution; for example, the ecological attributes associated with such points might suggest that the model used to predict a species' range should be modified.

Plotting Locations of Species Observations—Perhaps the greatest challenge in compiling this database was to accurately represent the location of each species observation within the GIS. Datasets came from very disparate sources and methods for expressing location and reference systems for those locations varied greatly. Much of the digital data (for example, all bird survey data) provided spatial location of observations in geographic coordinates. The process for bringing these data into the GIS was straightforward; we simply used these coordinates to define the location of each observation in the GIS directly. Where complete spatial reference information was not provided, we assumed that geographic coordinates followed the North American Datum of 1927 (NAD 27). When our confidence in this assumption was low, we verified the locations visually by plotting them on 1:24,000 digital raster graphics (DRG) maps in NAD 27 to look for any positional inconsistencies (for example, points that fell in lakes or rivers; plotted

Table 1—The number of suitable records obtained from the various sources of data that provided species observation location records.

Description	Count	Percentage
Volunteer surveys	268,694	39.4
Government and Natural Heritage Programs	168,390	24.7
Museum and other academic collection records	133,827	19.6
Private collection records	61,837	9.1
Published materials	48,588	7.1
Non-government organizations	1,327	0.2
Total	**682,663**	**100**

locations did not match text descriptions, if available). In cases where projected coordinates were provided (for example, UTM locations), the data source had to specify the exact map projection, coordinate system and datum that was used before those records were transformed to geographic coordinates (NAD 27) and compiled into the database.

A large proportion of the data did not have spatial coordinates associated with each species observation record. However, much of these data did contain a textual description of the collection/observation location for the species. In these cases, we manually plotted the location in the GIS using DRG maps referenced to NAD 27. Then, all attributes associated with that location (for example, species name, gender, age, date of collection) were manually entered into the database. This was a difficult and labor intensive process that sometimes involved subjective interpretation of the data. We employed numerous GIS operators to complete this task. To minimize potential operator bias and to standardize the data product, we implemented a standardized operating procedure for plotting textual locations.

First, every operator was provided with DRG maps from the USGS standard topographic map series at the 1:250,000 scale for all of Arizona and New Mexico. The site described in a species observation record could be further referenced with various large- and small-scale road atlases, topographic maps, county maps, and land-use/land cover maps.

Second, operators were trained to judge the precision of each plotted location because textual location descriptions varied greatly in the quality of their spatial reference. For example, a record could describe a location as occurring at the intersection of two well-defined roads. These could be accurately located using road maps and plotted precisely on the GIS using on-screen digitizing from a roads layer. Alternatively, the description of the location could be somewhat vague, such as "10 miles northwest" of the intersection of the same two roads. In this case, the operator would plot the location exactly 10 miles (16.1 km) northwest of the road intersection using on-screen digitizing tools in the GIS, but the precision of this plotted location must be considerably less than in the previous example. To distinguish varying degrees of positional precision in the database, we had operators make a qualitative judgment about whether or not the location estimate had accuracy within 5 miles (8 km).

Third, we verified the operator's plots both automatically and manually. To ensure accuracy and consistency, one individual (G. C. Reese) was designated to oversee and validate all work of the operators. On a regular basis, each operator's work was verified to ensure that gross plotting errors were not occurring and to check that the highest level of positional and attribute accuracy was being attained. To verify the operators' GIS data, a number of checks were used: (1) Coarse positional accuracy was validated for all operators' GIS data records where county names were provided as part of the species observation record in the original data. A spatial join operation was performed on the GIS data set between the plotted species observation locations and a GIS map of the county boundaries. If locations did not fall within the same county as was stated in their description, these records were further investigated and subsequently corrected or removed from the database. (2) A random-subset of records was selected from each operator's work and checked for errors. If errors were found, either those individual records were re-plotted or, when a large number of errors was discovered during either error-checking procedure, the operator was required to check each record in their work set for accuracy or re-plot the entire set of records under regular supervision. Despite our best efforts to eliminate errors, it is certain that some positional or attribute errors were not detected in the compilation of this database. We encourage any user of these data to be conscious of this statement.

During the process of checking the species observation records, we became aware that a number of points were located outside the state boundaries of Arizona and New Mexico. Clearly erroneous data points were removed; however, a number of records were plotted with what we considered to be high accuracy (that is, actual location of observation was likely within 5 miles [8 km] of the plotted location in the database), and nevertheless, they fell outside the state boundaries. In total, there were about 900 anomalous records and all but one of these records came from the same data source (Bird Banding Lab records). We chose not to remove these records because we felt it was important to be consistent in the way we treated these data. We may have introduced a bias if we removed only the records that fell outside the state boundaries. For example, if there were geo-registration problems with the data source that caused a number of points to fall outside the state boundaries, then this represents a systematic error that may have affected all the point locations from that source. By leaving these points in the database, the users of the data can quickly see the problems and judge for themselves whether or not to use these data. Users also get a much better appreciation of the positional accuracy of these data by viewing the points that fell outside the state boundaries.

Accumulating Species Observation Records Into a Single Database—Once each dataset had been imported into a GIS data layer, all datasets were converted into a common spatial reference system. Each dataset was entered into a separate GIS data layer that followed either the spatial reference system specified by the data source or, when manually plotted, was in the Universal Transverse Mercator projection. To facilitate spatial analysis, we did a subsequent conversion of the entire compiled database to the Albers equal-area map projection. This was the final format of the spatial data and is used in the accompanying data DVD.

It was not always possible to plot a location in the GIS for every species observation record, nor was it always possible to determine to which species a record referred. These records were deemed incomplete and were eliminated from the final database that is provided in the accompanying data DVD.

Another challenge was standardization of the taxonomic nomenclature for individual species. Taxonomies are dynamic and some species names are used inconsistently across the time span over which the data were collected and recorded. To resolve these inconsistencies, we standardized all species names to conform to the Integrated Taxonomic Information System (ITIS 2002). We used the ITIS system because it is the taxonomic standard that has been adopted by most North American federal agencies. We used the recorded scientific species name (or the common name, if no scientific name was provided) to attach the ITIS taxonomic serial number (TSN) to each record. We also used ITIS to resolve any apparent conflicts in taxonomic classification (for example, multiple named subspecies were lumped into a single parent species name). ITIS is still a work in progress, and occasionally their database did not contain information for a species in our database. When this occurred, we relied on a second taxonomic authority, the NatureServe Explorer (formerly the Association for Biodiversity Information; see NatureServe Explorer 2002). The NatureServe taxonomic database is also recognized as an authoritative taxonomic source by U.S. federal agencies, such as the USDA Forest Service. Using either ITIS or NatureServe databases, we converted, where applicable, non-current species common names to currently accepted common names. Scientific names, common names, and taxonomic serial numbers (current to our last access of these databases in February 2004) are available in the attached species observation database (on data DVD under the *Observed* directory).

Finally, we also standardized attribute information provided for each record. This was no easy task given that each data source had different collection and/or recording standards, and the information collected about each occurrence could have been for a different purpose. For example, museum collection records commonly included a number of attributes that provided detailed information on the biology of the species (for example, gender, age, reproductive status, and various morphometric measurements). From visual survey sources, such as the BBS, this level of detail was not available. We limited the number of attributes in the species observation records database to fundamental information that was generally common among all data sources. This included information about the date and time (if available) of the observation, the observation method, the gender and reproductive status of the individual (if observed), and, if provided, location descriptors that supplemented the coordinates. If additional, important information was provided in the original source record without an appropriate attribute field in the database, we moved the information into the Comments field of the database. Details regarding attribute fields and the database structure can be found in the attached metadata document (see Appendix A and B) and in the subsection describing the species observation location data that appears below.

Description of Environmental and Physical Data Layers

On the accompanying DVD, vector data (point, line and polygon features) are provided in ESRI shapefile format, whereas raster data are provided in ArcInfo GRID format. These data can also be imported into most other commercial GIS packages. The spatial reference system of each of these layers has been modified from its original system so that layers conform to a common projected coordinate system. This ensures that the data layers align correctly with each other and with the species occurrence data when displayed or analyzed on a GIS.

A summary of the geospatial data layers provided on the DVD is given in table 2, and in the *contents.xls* or *contents.txt* files on the accompanying DVD. In addition to the species occurrence data, we provide geospatial data layers on vegetation/land cover, natural features, and human-made features. Each is described in further detail below.

Vegetation/Land-Cover Layers

Perhaps the most relevant GIS base layer to provide spatial context for viewing and analyzing species distributions is the vegetation/land-cover layer. We acquired the first generation vegetation/land-cover map produced in 1995 for the Arizona GAP. This coverage consisted of over 100 individual vegetation and land-cover categories. The New Mexico generalized vegetation map was produced by the first generation

Table 2—Description of the ancillary data (GIS base layers) provided with the database. The Arizona and New Mexico data can be found in Basecovs directory.

State	File name	File type	Description	Source
AZ	azallot	Shapefile	USFS grazing allotment boundaries	USDA Forest Service
	azcounty	Shapefile	County boundaries	Arizona GAP
	azlnname	Shapefile	Index for named linear features	U.S. Geological Survey
	azplaces	Shapefile	Census populated places	AZ Land Resource Information System
	azptname	Shapefile	Index for named point features	U.S. Geological Survey
	azroads	Shapefile	Major roadways	AZ Land Resource Information System
	azstate	Shapefile	State boundary	AZ Land Resource Information System
	aztrs	Shapefile	Township-range-section lines	AZ Land Resource Information System
	aztwnrng	Shapefile	Township-range lines	AZ Land Resource Information System
	azusfs	Shapefile	USFS national forest boundaries	USDA Forest Service
	azsoils	Shapefile	Statewide soils	AZ Land Resource Information System
	azspring	Shapefile	Springs	U.S. Geological Survey
	azstream	Shapefile	Permanent and intermittent streams	EPA BASINS database
	riparian	Shapefile	Riparian vegetation	AZ Land Resource Information System
	azdem	Arc Grid	Elevation	U.S. Geological Survey ESIC
	azveg	Arc Grid	Vegetation	Arizona GAP
NM	nmallot	Shapefile	USFS grazing allotment boundaries	USDA Forest Service
	nmcounty	Shapefile	County boundaries	New Mexico GAP
	nmlnname	Shapefile	Index for named linear features	U.S. Geological Survey
	nmplaces	Shapefile	FIPS incorporated places	NM Resource Geographic Information System Program
	nmptname	Shapefile	Index for named point features	U.S. Geological Survey
	nmroads	Shapefile	Major roadways	NM Resource Geographic Information System Program
	nmstate	Shapefile	State boundary	New Mexico GAP
	nmtwnrng	Shapefile	Township-range lines	U.S. Geological Survey ESIC
	nmusfs	Shapefile	USFS national forest boundaries	USDA Forest Service
	nmcaves	Shapefile	Caves	U.S. Geological Survey
	nmsoils	Shapefile	Statewide soils	New Mexico GAP
	nmspring	Shapefile	Springs	U.S. Geological Survey
	nmstream	Shapefile	Permanent and intermittent streams	EPA BASINS database
	nmdem	Arc Grid	Elevation	U.S. Geological Survey ESIC
	nmveg	Arc Grid	Vegetation	New Mexico GAP

New Mexico GAP in 1991 and consisted of 43 vegetation/land-cover categories. We provide derived versions of these two maps that follow a generalized 27 category classification system developed by Moir (unpublished paper) to ensure consistency between states. Conversion tables between the two original GAP classification schemes and our 27 category scheme are provided in the *Basecovs* directory as *azvegxwalk.xls* and *nmvegxwalk.xls* (also provided as *azvegxwalk.txt* and *nmvegxwalk.txt*). The vegetation maps on the accompanying DVD are stored as ArcInfo raster grids to facilitate overlay operations and other types of spatial analysis.

The second generation GAP land cover (vegetation) maps are expected to be available to the public by spring of 2005 (Thomas, personal communication). Land cover is being mapped as ecological systems, which are ecological and geographical aggregations of vegetation associations. Mapping is being done so as to minimize inconsistencies of land cover mapping across state administrative boundaries (Thomas, personal communication).

Natural Features

The accompanying DVD provides geospatial data layers for the following natural features: soils, hydrology (streams and springs), riparian vegetation polygons (AZ only), caves (NM only), and topography (through a digital elevation model). For each geospatial data layer, we have provided the original metadata file to that data layer in both ASCII text format (<*layername*>*.txt* files) and Microsoft Word 8.0 format (<*layername*>*.doc* files). These data were obtained through a number of public sources, and a breakdown of these sources can be found in the *contents.xls* or *contents.txt* that is in the root directory of the accompanying DVD. The natural features layers are useful ancillary data for interpreting the vertebrate species occurrence layers. Along with the vegetation/land cover layers, the natural features data can be used to help interpret plant community associations between different species and the locations at which they occur. For example, vegetation cover and elevation are typical constraints on the expected distribution of many species (for example, Scott and others 1993). Many species in the Southwest rely on narrow bands of riparian vegetation that follow water courses, so for these species the hydrological and riparian vegetation layers may be informative. Other species, such as bats, may rely on other natural features such as caves for roosts. Certainly, we have not captured all natural features that exist in the Southwest, but we did compile those features that we believed were useful from the available data. Data type, a short description of each layer, and data sources are listed in table 2 and metadata are provided in the *Basecovs* directory on the accompanying DVD.

Human-Made Features

For each state we also acquired spatial data layers that represent human-made features or potentially important jurisdictional boundaries. Included are layers of National Forests, grazing allotments within National Forests, state and county boundaries, township-range grid lines, U.S. boundaries delineating U.S. Census Bureau designated populated places, major roadways, and landscape features represented by either points or lines. These layers might be used for simple spatial reference or for addressing management questions. Data type, short descriptions, and data sources are listed in table 2 and metadata are provided in the *Basecovs* directory on the accompanying DVD.

Description of Species Occurrence Data

Predicted Range Maps

For terrestrial vertebrates, we have included the predicted habitat maps created by the first generation Arizona and New Mexico GAPs. These are binary maps that define a presumed limit or boundary for each species in each state and we treated these habitat maps as an estimate of the species' potential distributional range across the region. Predicted range maps were available for 673 unique terrestrial vertebrate species across the region. The predicted habitat maps were produced independently by each state using different inputs (for example, habitat suitability models and vegetation maps); consequently, many species ranges do not align at the border between Arizona and New Mexico. An example of this discrepancy is shown for the predicted ranges of the belted kingfisher (*Ceryle alcyon*) in Arizona and New Mexico (fig. 1). Arizona and New Mexico often differed in the detail and resolution at which riparian species were modeled. Procedures also varied within states, with Arizona modeling avian species at fine resolution, but herptile (amphibians and reptiles) species at coarse resolution, while New Mexico modeled avian species at coarse resolution and herptile species at fine resolution. This creates an effect where those species modeled at different resolutions appear to have smaller areal extents in the state that used fine resolution, when in fact this may not be true.

Regardless of inconsistencies between the two states' predicted habitat maps, the data are still useful for visualizing and analyzing coarse-scale predicted distributions of terrestrial vertebrates in the region. Range maps from multiple sources are commonly used to estimate the distribution of species richness and biodiversity across a region (for example, Scott and others 1987; Flather and others 1997; Reid 1998; Myers and others 2000). However, given the differences in the way habitat maps were generated within each state, intra-state comparisons of relative richness (for example, ranking sub-state regions from high to low number of species) are easier to interpret than inter-state comparisons.

Species Observation Locations Data

Perhaps the most valuable contribution of this database is the compilation of species occurrence data. The accompanying DVD contains both geospatial data layers and tabular data on over 680,000 known occurrences of birds, mammals, reptiles, amphibians and butterflies in the Southwest. More than 1,500 species and subspecies are represented in the database. These data represent one of the most complete databases on species occurrence to be compiled for the Southwest.

The geospatial database and the equivalent tabular database contain individual records that describe the observation of a particular species or subspecies (one or more individuals) at a single location on a particular date. The geospatial database is useful for plotting the locations of occurrences, which can be queried by species, location, time period or other species attributes (table 3). The tabular data are provided in a Microsoft Access 2000 database and in dBase IV format on the DVD. The tabular data provide the same information as the geospatial database, but they might be used as part of a relational database for advanced query and (non-spatial) statistical analysis.

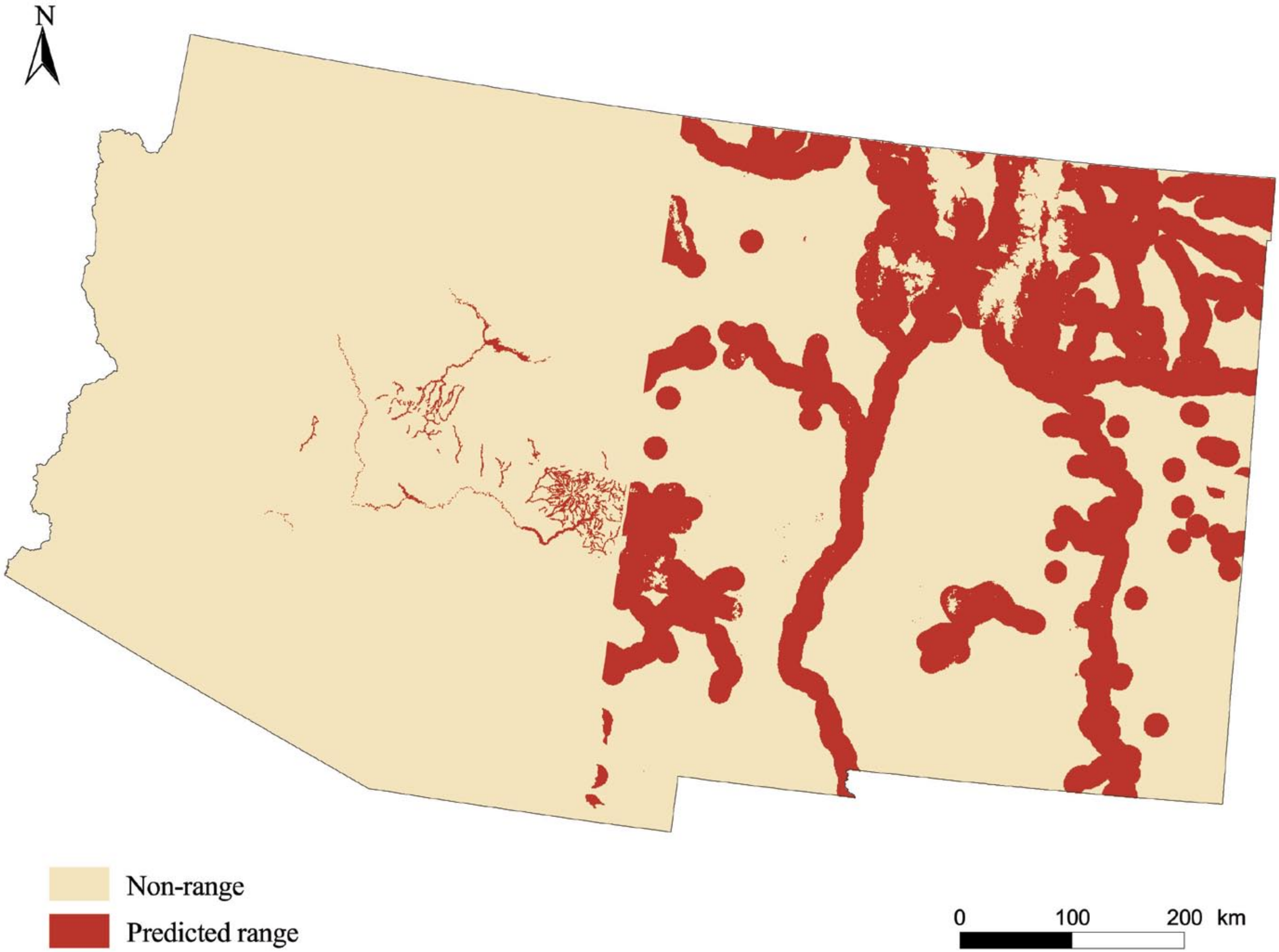

Figure 1—Predicted species distributions from the Arizona and New Mexico GAPs illustrating how different modeling methods can produce different predicted range maps. The belted kingfisher (*Ceryle alcyon*) is shown; it is associated with habitats near water. The two versions of the predicted range maps for the same species reflect a different model definition of the term "near water." New Mexico's model reflects a greater distance to water body threshold than does the Arizona model.

Table 3—A data dictionary for the species occurrence database that lists and describes the attributes available for the species observation records.

Field name	Alias	Attribute type
CSUID	CSU_UNIQUE_ID	number (long int)
SCI_NAME	SCIENTIFIC_NAME	text (100)
COM_NAME	COMMON_NAME	text (100)
TSN	TAXONOMIC_SERIAL_NUMBER	number (long int)
TIME	TIME	time
DATE	DATE	date
DATE_ACC	TIME_DATE_ACCURACY	text (20)
OBS_METH	OBSERVATION_METHOD	text (20)
OBS_NAME	OBSERVER_NAME	text (50)
OBS_QUAL	OBSERVER_QUALIFICATIONS	text (20)
TOT_NUM	TOTAL_NUMBER	number (int)
GENDER	GENDER	text (13)
REPRO	REPRODUCTIVE_STATUS	text (35)
GROUP	GROUP_TYPE	text (20)
LAT	LATITUDE	number (double)
LON	LONGITUDE	number (double)
LOC_DESC	LOCATION_DESCRIPTION	text (memo)
LOC_ACC	LOCATION_ACCURACY	number (long int)
LOC_CONF	LOCATION_CONFIDENCE	text (10)
COMMENTS	COMMENTS	text (memo)
DATA_SRC	DATA_SOURCE	text (50)
SRC_FILE	SOURCE_FILE_NAME	text (20)
SRC_RID	SOURCE_RECORD_ID	number (long int)

[a] Null refers to whether a field can be left blank. An entry of "not null" identifies those fields that must contain an entry, otherwise the entire record is ignored by the database.

Description	Attribute domain	Null[a]
CSU Access database specific unique identifier number.	autonumber	Not null
Taxonomic (genus, species, subspecies) species name, as defined within ITIS.	valid ITIS name	
Common name for species, as defined by ITIS.	valid ITIS name	Not null
ITIS taxonomic serial number.	valid TSN	Not null
The time of day that the species was collected. Values are in local time.	valid time	
The date of collection.	valid date	Not null
The precision of the time and date measurements.	Day, Hour, Month, Previous Year, Year	
How the animal was detected or observed or if a reproductive site for a specific animal was found.	Aural, Capture, Visual, Visual and Aural, Voucher Specimen	
The name of the person who observed or collected the animal.		
The qualifications of the observer to accurately identify the correct species associated with observation. Education and field experience generally define the level.	Experienced, Limited Experience, Taxon Expert, Unknown	
The number of individuals with which the detection is associated. For example, if a single GIS point is associated with a pair of owls, then "2" would be entered into this field.	> 0	
Sex of observed individual.	Male, Female, Unknown, Mixed Group	
The reproductive status of the animal detected, if known. This could include labeling a pair as reproductive, or that there are young present (inferring that the pair is successfully reproducing).	Non-Reproducing, Reproducing, Unknown, With Young	
The description of the size and relationship of the animal group detected.	Family Group, Pair, Unknown	
The latitude of the detection in decimal degrees (NAD27 datum).		Not null
The longitude of the detection in decimal degrees (NAD27 datum).		Not null
Description of the sighting/collection location.		
Horizontal locational accuracy (meters), if known.		
Identifies whether the location was plotted with confidence within 5 mi. of the observation.	Yes, No, Unknown	
The comments that the observer collected during the detection, including key words. A key word or key phrase could precede a portion of text.		
Original source of the data (collector/collection, atlas, or survey name).		Not null
Name of the original shapefile from which the data was consolidated.		Not null
Identification number from the original shapefile.		Not null

It is difficult to use all of the geospatial data simultaneously in a GIS because of the large volume of records. To facilitate easy display, query, and analysis in the GIS, we have sub-divided the geospatial species occurrence data into a number of individual GIS data layers organized by various themes. If one is interested in viewing the records by major taxonomic divisions (birds, mammals, herptiles, or butterflies), individual geospatial datasets are available for each group. We have further subdivided the data by state (AZ and NM) to reduce the volume of data in each geospatial layer. We have also provided another version of the species occurrence data that is further subdivided by the source from which we obtained the data. This version of the data is useful for those interested in viewing only the data from a specific source (for example, the Museum of Southwestern Biology, the North American Breeding Bird Survey). A complete list of the breakdown of each geospatial layer is provided on the accompanying DVD.

Data Layer Accuracy Documentation

Errors associated with the spatial representation of environmental attributes, species distributions, and observed species locations are an inherent characteristic of geospatial databases. Such errors can be caused by a misclassification of an attribute that is mapped (sometimes called "classification error," "attribute error," or "thematic error"), or a misregistration of its location (sometimes called "location error," "spatial error," or "positional error"). With increasing accessibility to geospatial data, there is a growing concern with accuracy and how to assess its effects in the decision-making process (Goodchild and Gopal 1989; Jansen and van der Wel 1994; Hunsaker and others 2001). Errors will never be eliminated, but they should be quantified to some degree to give the users of such databases a sense of the uncertainty associated with decisions based on these data (Flather and others 1997; Dean and others 1997).

Because our efforts to compile environmental and physical data layers (in the *Basecovs* directory) focused on existing data, we were unable to quantify accuracy independently. Rather, we relied on the metadata documentation associated with each data layer to provide the accuracy information, when available. To assist users in evaluating the uncertainty associated with these data, we have compiled a summary of the availability of accuracy information provided in the source metadata files contained on the DVD (see table 4). For the most part, comprehensive accuracy information was sparse—about 30 percent of the files had metadata concerning both attribute and positional accuracy. Nearly 55 percent of the files had metadata on positional accuracy alone. In the absence of accuracy information, users of those particular data files will need to be cautious with their interpretation. We also recommend that users contact the original data providers to obtain the most recent accuracy information if accuracy issues are an important concern.

For the species observation data, we attempted to characterize the locational accuracy associated with each point in two ways (see description of LOCATION_ACCURACY and LOCATION_CONFIDENCE in table 2). First, and if known, the horizontal accuracy of the point location was recorded in meters. Second, and most commonly, we subjectively ranked our confidence that the location was plotted within 5 miles (8 km) of the true location. We did not attempt to characterize the attribute accuracy of the species location records. In this case, attribute accuracy refers to the likelihood that the species was identified correctly. Such an assessment could be accomplished by randomly selecting voucher specimens and confirming the identification, but such an evaluation was beyond what was budgeted for this effort. For those location records that did not actually collect a specimen, attribute accuracy can not be assessed. For these reasons, we assumed that all species identifications were recorded without error. We did verify species scientific names for nomenclature accuracy against two sources: the Integrated Taxonomic Information System (ITIS 2002) and NatureServe (NatureServe Explorer 2002). For additional details related to data quality information on the species location data see our metadata documentation in Appendix B under Attribute_Accuracy and Positional_Accuracy.

Data Applications

The digital species database can be used to address a variety of management issues. The simplest applications could be descriptive in nature and could be used by managers to qualitatively or quantitatively assess species resources within an area. These descriptions could then be used to set the biodiversity context within which more complicated analyses could be conducted to address resource management issues that could potentially affect species conservation. We illustrate the use of the database with three examples: (1) the first involves the process of generating location information for a single species; (2) the second uses predicted species ranges to describe regional patterns of species richness across the Southwest; and (3) the last focuses on a specific, and contentious, resource management issue important to species conservation policy (Fleischner 1994; Brown and McDonald 1995), namely the potential influence of domestic grazing on biodiversity.

Species Observation Locations and Predicted Range Maps

A simple and useful application of the species database is the geographic depiction of species point locations or the delineation of the species' predicted range map. Here we provide examples from each taxon in the database. For selected terrestrial vertebrates, all observation locations within Arizona and New Mexico are presented simultaneously with the predicted vertebrate habitat map (fig. 2). Species point locations were mapped by querying the species observation locations data and plotting the point location coordinates for the species of interest. These were then overlayed on the predicted vertebrate habitat maps that were created by the Arizona and New Mexico GAPs. Although we have illustrated the utility of these data by plotting the actual predicted habitat and observation locations, potential users of these data should realize that summary maps of species occurrence linked to other geographic partitions such as counties, watersheds, and U.S. Forest Service Ranger Districts are also easily generated.

Federal land management agencies maintain lists of species that are of conservation concern (U.S. Forest Service 1995), including species listed as threatened or endangered under the Endangered Species Act (PL-205, 87 Stat. 884, as amended). The geographic pattern of known and potential occurrence of such species (for example, see fig. 2a) is fundamental to setting conservation priorities and identifying areas where resource-use conflicts may occur. However, the utility of these maps goes beyond the simple description of where the species has records of occurrence or where the species may potentially occur. Such maps also give managers a sense of the uncertainty surrounding the potential occurrence of the species within a geographic area of interest. The density and distribution of points within the predicted range provide an indication of how well the species range has been represented in location samples. Some species, like the cactus mouse (*Peromyscus eremicus*), have a predicted distribution that appears to be well sampled based on the location of observation records, and few location records fall outside the predicted range (fig. 2b). Conversely, the distribution and point locations for the milk snake (*Lampropeltis triangulum*) indicate that significant portions of the predicted range have no recorded occurrences (fig. 2c), whereas for the Northern leopard frog (*Rana pipiens*) notable clusters of locations fall outside the predicted range of the species (fig. 2d). In these latter two cases our uncertainty about where the species occurs and its potential distribution is greater than for species where point locations are well-distributed throughout and within the predicted range. Spatially explicit depiction of these uncertainties can be useful in targeting future inventory efforts to verify the occurrence of species in a particular location (see Fleishman and others 2001: 1682), or in identifying environmental attributes (that is, information associated with the point locations that fall outside of the predicted range) that have not been captured in existing habitat-suitability models.

Since we lacked predicted range maps for butterflies, we only display point locations for this taxonomic group. Observation locations for butterfly species suggest that the California sister (*Adelpha bredowii*) is wide-ranging (fig. 3a), whereas the sunrise skipper (*Adopaeoides prittwitzi*) has a more restricted range within Arizona and New Mexico (fig. 3b). Although we lack information on the potential distribution of butterfly species, these data highlight another use of generating species-specific location maps—namely the development of empirical distribution models that would allow managers to predict the geographic range of species. Point location data that are geographically associated with environmental factors thought to determine a species' occurrence can be used to generate statistical models to predict species distributions (Peterson 2001; Hirzel and others 2002; Lehmann and others 2002; Reese and others 2005). Such approaches to predicting areas suitable for occupancy are essential if species that we know little about are to be adequately considered in biodiversity conservation planning (Fleishman and others 2001).

Regional Patterns of Biodiversity Across the Southwest

Distributions of species are inherently heterogeneous, and as such exhibit spatial structure on a landscape. One manifestation of this spatial structure is that some areas support more species than other areas. This pattern can be observed when all species, or a subset of species, within some locale share some attribute of conservation interest (for example, rare species, threatened species, or endemic species). Given spatial structure in species distributions, an obvious resource management question in the face of competing uses for a finite land base is which geographic areas should be managed to conserve biodiversity (Reid 1998).

One common approach to setting conservation priorities is to focus on those areas with high biological value

Table 4—Summary of data accuracy information provided in the source metadata documentation for data layers in *Basecovs* directory compiled in our geospatial database.

Data file	Description	Source
azallot	U.S. Forest Service grazing allotment boundaries	U.S. Forest Service
azcounty	County boundaries	Arizona GAP
azlnname	Index for named linear features	U.S. Geological Survey
azplaces	Census populated places	AZ Land Resource Information System
azptname	Index for named point features	U.S. Geological Survey
azroads	Major roadways	AZ Land Resource Information System
azstate	State boundary	AZ Land Resource Information System
aztrs	Township-range-section lines	AZ Land Resource Information System
aztwnrng	Township-range lines	AZ Land Resource Information System
azusfs	U.S. Forest Service national forest boundaries	U.S. Forest Service
azsoils	Statewide soils	AZ Land Resource Information System
azspring	Springs	U.S. Geological Survey
azstream	Permanent and intermittent streams	EPA BASINS database
riparian	Riparian vegetation	AZ Land Resource Information System
azdem	Elevation	U.S. Geological Survey ESIC
azveg	Vegetation	Arizona GAP
nmallot	U.S. Forest Service grazing allotment boundaries	U.S. Forest Service
nmcounty	County boundaries	New Mexico GAP
nmlnname	Index for named linear features	U.S. Geological Survey
nmplaces	FIPS incorporated places	NM Resource Geographic Information System Program
nmptname	Index for named point features	U.S. Geological Survey
nmroads	Major roadways	NM Resource Geographic Information System Program
nmstate	State boundary	New Mexico GAP
nmtwnrng	Township-range lines	U.S. Geological Survey ESIC
nmusfs	U.S. Forest Service national forest boundaries	U.S. Forest Service
nmcaves	Caves	NM Resource Geographic Information System Program
nmsoils	Statewide soils	New Mexico GAP
nmspring	Springs	U.S. Geological Survey
nmstream	Permanent and intermittent streams	EPA BASINS database
nmdem	Elevation	U.S. Geological Survey ESIC
nmveg	Vegetation	New Mexico GAP

[a] Yes—accuracy information is given in the source metadata documentation; No—accuracy information is unavailable.
[b] Metadata files also available in text format (*.txt).

Attribute accuracy[a]	Positional accuracy[a]	Metadata file[b]	Contact information
No	No	azallot.doc	M. Candace Bogart, GIS Program Manager, Southwestern Region, cbogart@fs.fed.us
No	Yes	azcounty.doc	http://sdrsnet.srnr.arizona.edu/index.php
Yes	Yes	azlnname.doc	http://geonames.usgs.gov/
No	No	azplaces.doc	http://www.land.state.az.us/alris/
Yes	Yes	azptname.doc	http://geonames.usgs.gov/
Yes	Yes	azroads.doc	http://www.land.state.az.us/alris/
No	Yes	azstate.doc	http://www.land.state.az.us/alris/
No	Yes	aztrs.doc	http://www.land.state.az.us/alris/
No	Yes	aztwnrng.doc	http://www.land.state.az.us/alris/
No	No	azusfs.doc	M. Candace Bogart, GIS Program Manager, Southwestern Region, cbogart@fs.fed.us
No	No	azsoils.doc	Not available
No	Yes	azspring.doc	http://geonames.usgs.gov/
No	Yes	azstream.doc	http://www.epa.gov/docs/ostwater/BASINS/
No	Yes	riparian.doc	http://www.land.state.az.us/alris/
Yes	Yes	azdem.doc	http://edc.usgs.gov/products/elevation/dem.html
No	No	azveg.doc	http://sdrsnet.srnr.arizona.edu/index.php
No	No	nmallot.doc	M. Candace Bogart, GIS Program Manager, Southwestern Region, cbogart@fs.fed.us
No	No	nmcounty.doc	http://www.gap.uidaho.edu/ or http://rgis.unm.edu/
Yes	Yes	nmlnname.doc	http://geonames.usgs.gov/
No	No	nmplaces.doc	http://rgis.unm.edu/
Yes	Yes	nmptname.doc	http://geonames.usgs.gov/
No	Yes	nmroads.doc	http://rgis.unm.edu/
No	No	nmstate.doc	http://www.gap.uidaho.edu/ or http://rgis.unm.edu/
Yes	Yes	nmtwnrng.doc	http://geonames.usgs.gov/
No	No	nmusfs.doc	M. Candace Bogart, GIS Program Manager, Southwestern Region, cbogart@fs.fed.us
No	No	nmcaves.doc	http://rgis.unm.edu/
No	No	nmsoils.doc	http://www.gap.uidaho.edu/ or http://rgis.unm.edu/
Yes	Yes	nmspring.doc	http://geonames.usgs.gov/
No	No	nmstream.doc	http://www.epa.gov/docs/ostwater/BASINS/
Yes	Yes	nmdem.doc	http://edc.usgs.gov/products/elevation/dem.html
No	No	nmveg.doc	http://www.gap.uidaho.edu/ or http://rgis.unm.edu/

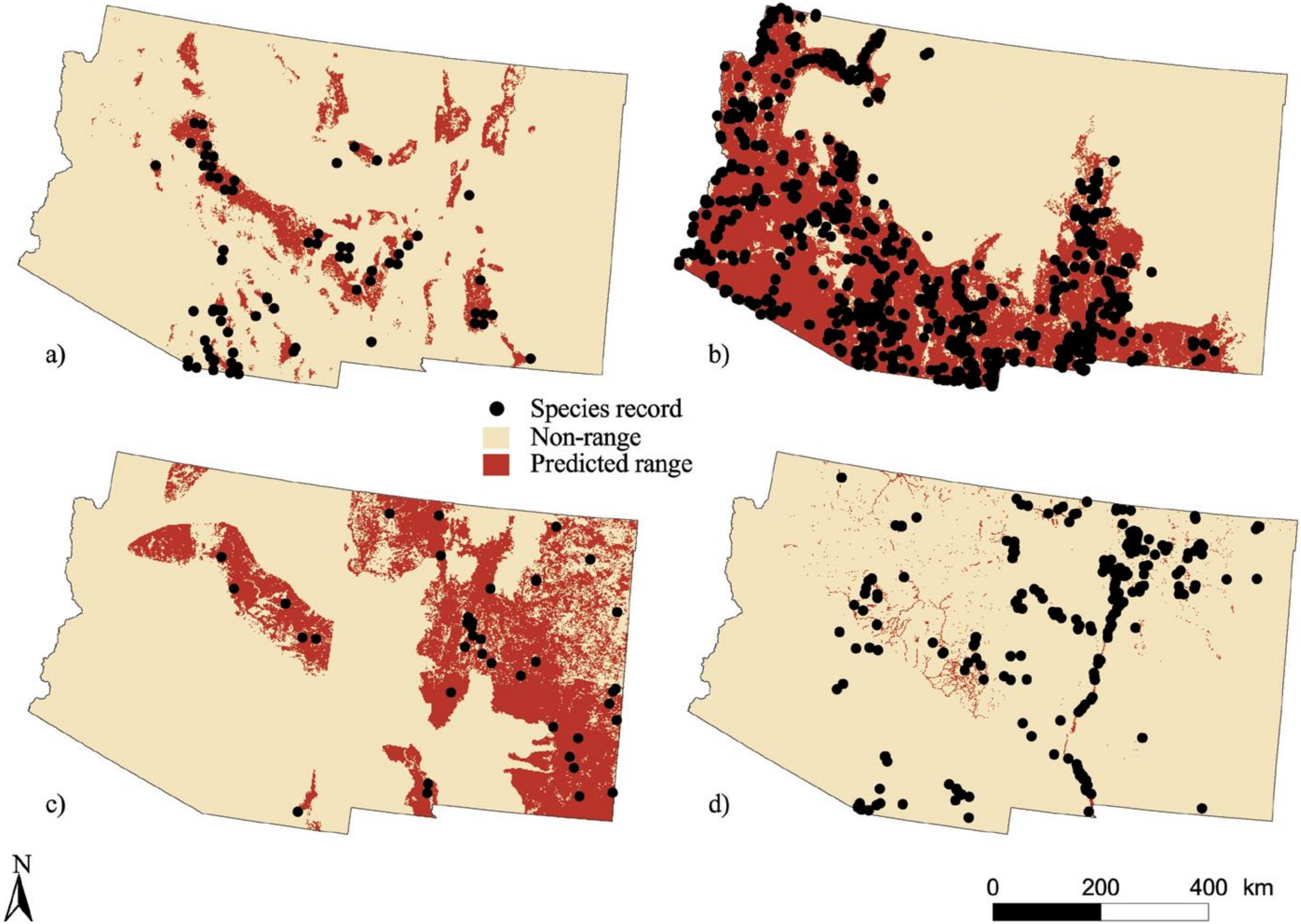

Figure 2—Species occurrence locations and predicted range map in Arizona and New Mexico for the (a) spotted owl (*Strix occidentalis*)[1], (b) cactus mouse (*Peromyscus eremicus*), (c) milk snake (*Lampropeltis triangulum*), and (d) northern leopard frog (*Rana pipiens*). Predicted range maps were created by the Arizona and New Mexico GAPs.
[1] Note: The subspecies occurring in this region [*S. o. lucida*] is listed as threatened under the Endangered Species Act.

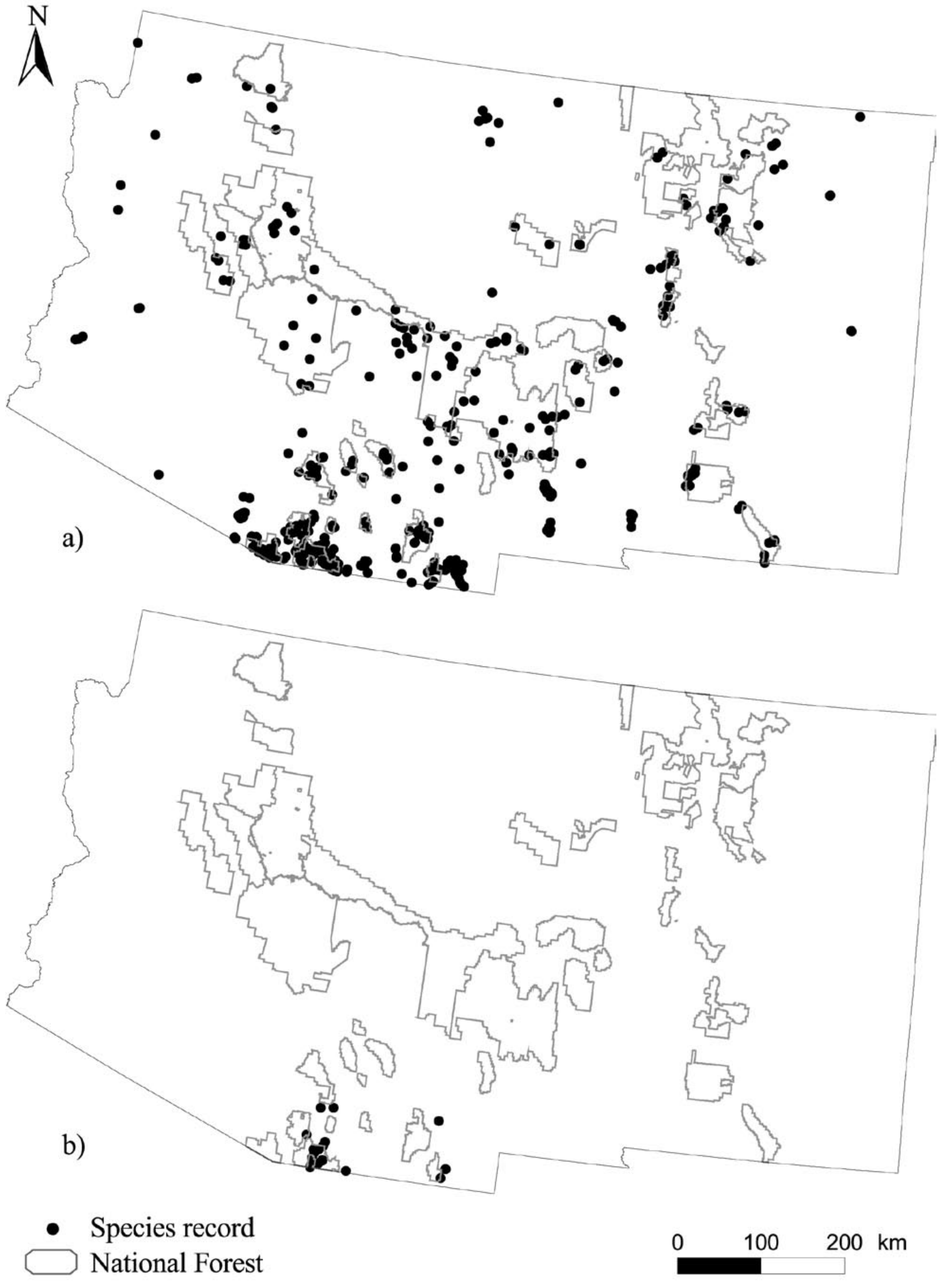

Figure 3—Point locations for two butterfly species in Arizona and New Mexico: (a) California sister (*Adelpha bredowii*), and (b) sunrise skipper (*Adopaeoides prittwitzi*).

(Kareiva and Marvier 2003). Myers and others (2000) argued that greater conservation benefits could be realized if efforts were focused in those areas where endemics were concentrated, areas that they termed “hotspots.” Since Myers’ specific usage with endemism, the term hotspot has become generalized to refer to an area, or set of areas, that rank high on any number of ecosystem attributes including species richness (Scott and others 1993), threatened or endangered species (Dobson and others 1997; Flather and others 1998), imperiled species (Chaplin and others 2000), or indicators of ecosystem condition (Hof and others 1999).

For purposes of illustration we define hotspots using a species-richness criterion. This criterion has served as the basis for setting conservation priorities under an approach generally referred to as gap analysis (Burley 1988) and has been formally implemented as part of the U.S. National GAP (Scott and others 1993). Using the Arizona and New Mexico GAP maps of predicted bird distributions, we present an example that extends the single-species focus of the previous case study to one that focuses on attributes associated with a collection of species. Arizona predicted species distribution maps were converted from vector (that is, polygon) to raster (that is, grid) format with cell resolutions of 100 m to correspond to the New Mexico GAP maps. Our approach was to simply overlay the distributions of all avian species in the database and compute the count of species whose range fell within each 100 x 100-m grid cell. Certainly other measures of biodiversity could have been computed and plotted (for example, counts of Forest Service Sensitive species, measures of biotic similarity between sites [see Cook and others 2000]), and we could have considered the relationship between biodiversity and other ancillary data (for example, topographic variation, land use, and land cover). Our choice to focus on species richness as a measure of biodiversity is not meant to limit the examination of other measures. Rather, we hope others will be motivated to explore alternative measures of biodiversity that can be estimated with species occurrence information (see Magurran 1988).

Avian species hotspots were defined as those grid cells falling within the upper 10th percentile of the frequency distribution of bird richness among all grid cells (that is, those 10 percent of cells with the greatest bird richness) within each state. Similarly, avian species coldspots were those grid cells falling within the lower 10th percentile. A plot of hotspot cells indicates a strong pattern of association between high bird richness and montane forest and riparian habitats, with the Mogollon Plateau being a prominent physiographic feature that is discernable in the avian hotspot range (fig. 4). It is interesting, although perhaps not surprising, that National Forest System lands intersect with 44 percent of the hotspot map, while only intersecting 5 percent of the coldspot map (fig. 4). This suggests that management of natural resources on Forest Service lands has the potential to affect a significant proportion of those areas supporting the greatest local richness of bird species. This pattern varies taxonomically, with other species groups showing the converse pattern, namely richness hotspots occurring predominantly outside National Forest lands and coldspots occurring in association with National Forests. For example, only 7 percent of herptile richness hotspots intersect with National Forest lands compared to nearly 20 percent of the richness coldspots (fig. 5).

Although we have stated previously that our intent with these case studies is to be illustrative, we do want to point out that a number of approaches could have been used to explore regional patterns of diversity among Southwestern taxa. For example, we could have used the BBS data to empirically interpolate bird distributions (sensu Maurer 1994; Price and others 1995) as an alternative to the Arizona and New Mexico GAP habitat affinity models. However, since we were comparing across taxa in this case example (birds and herptiles), it was to our advantage to compare regional richness patterns based on a consistent methodology. Data like the BBS are, at the moment, unique to birds. However, it would be an interesting analysis to compare, within a single taxon, species richness patterns using alternative methodologies. Diversity patterns derived from different methodologies that matched would give resource managers confidence that the patterns observed from any one approach could not be dismissed as an artifact of the specific methodology used.

Biodiversity and Domestic Grazing

In this example, we use the biodiversity database to explore the relationship between the regional distribution of the biota (at least as reflected in terrestrial vertebrates) and management of domestic grazers. Our example is motivated by concern for the influence of ungulate grazing on biodiversity in arid southwestern ecosystems (Memorandum of Understanding between USDA, Forest Service, Region 3-Southwestern Region and the USDA, Forest Service, Rocky Mountain Research Station, unpublished document). Several investigators have reported on the high concentration of species in the Southwest that are of conservation concern (see Dobson and others 1997; Chaplin and others 2000) and grazing has been cited as a prominent factor contributing to the formal listing of species as threatened or endangered

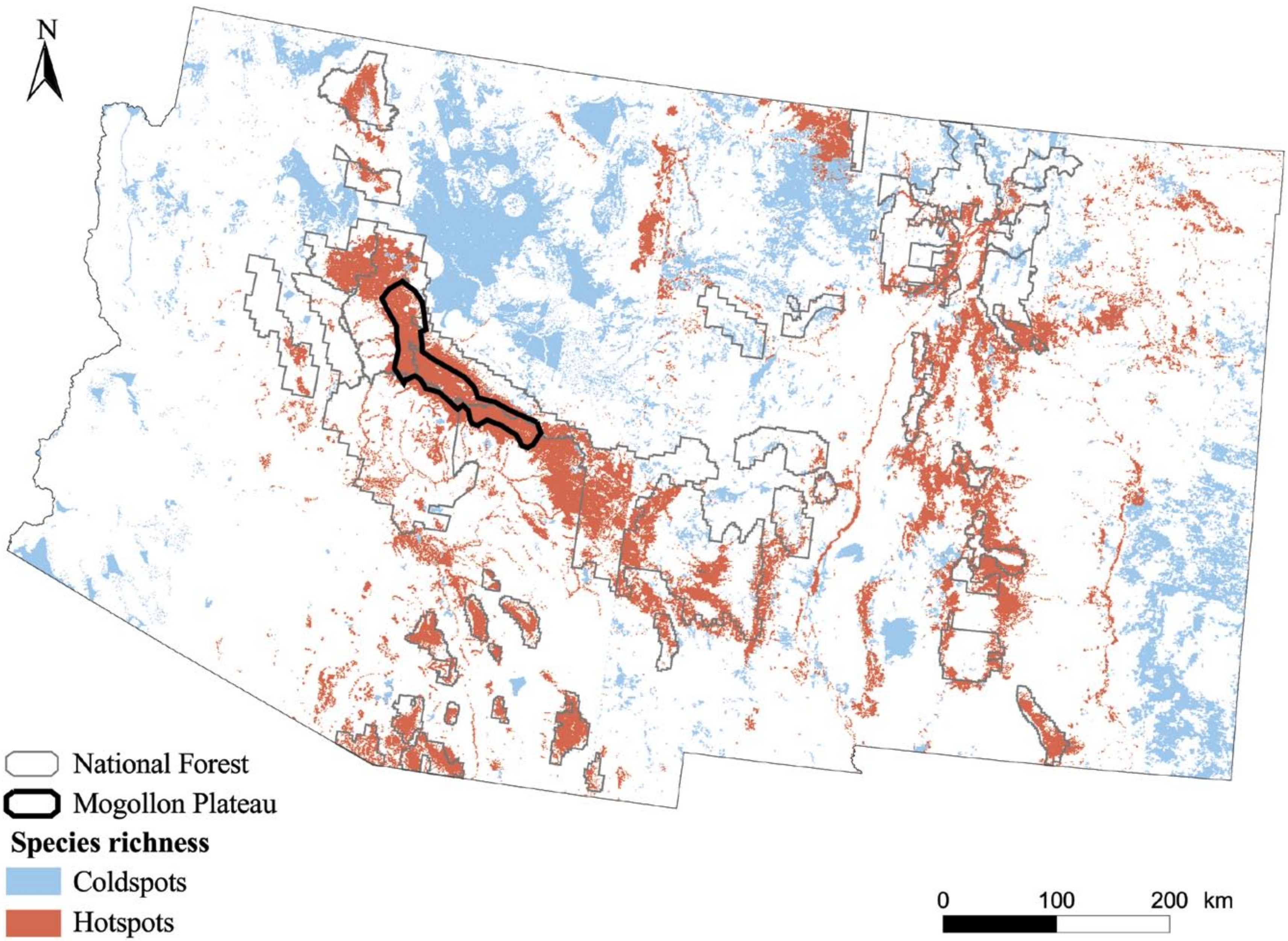

Figure 4—(a) Hot spots (upper 10 percent), and (b) cold spots (lower 10 percent) in avian species richness for Arizona and New Mexico based on predicted range maps created by the Arizona and New Mexico GAPs.

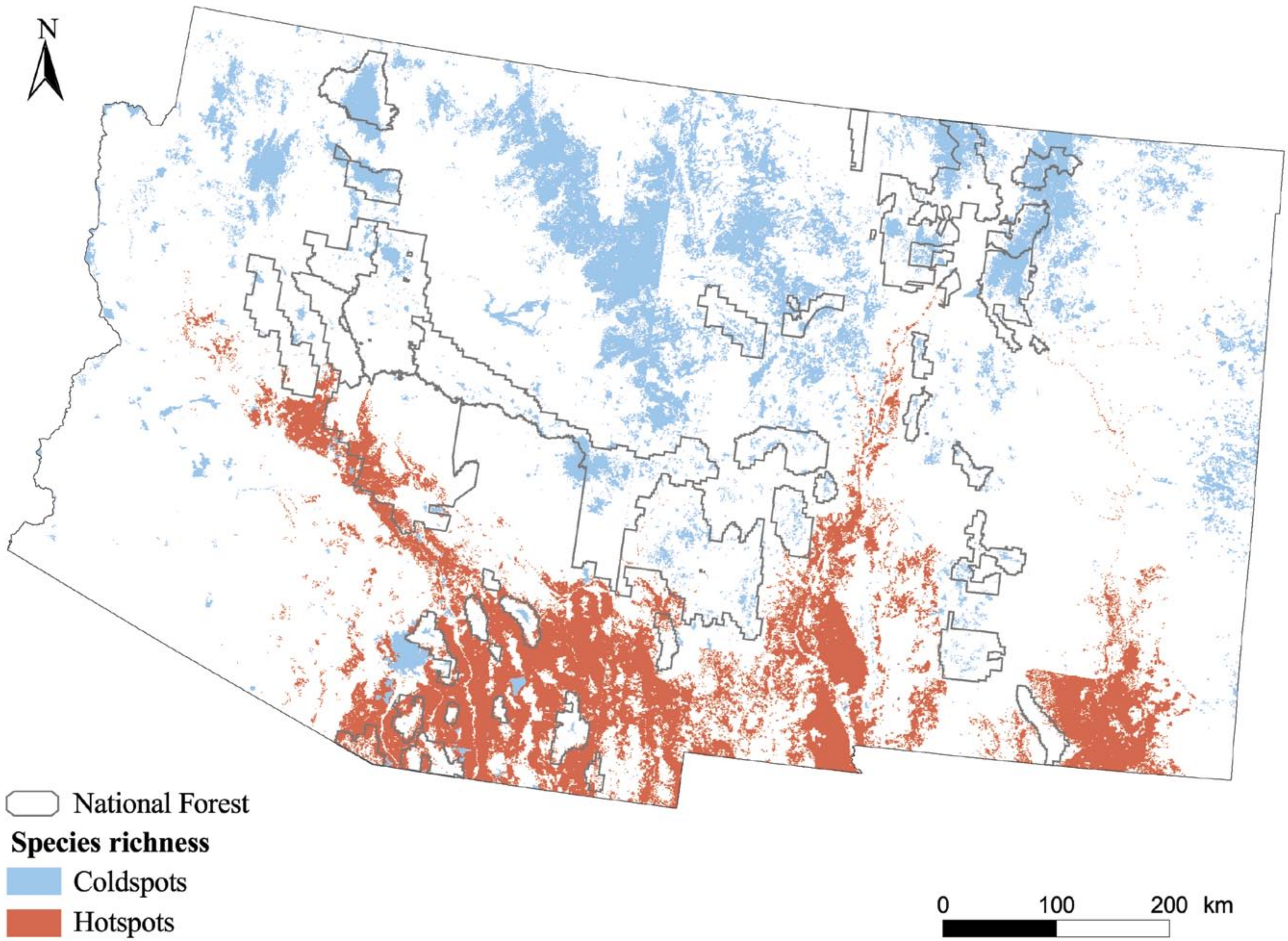

Figure 5—(a) Hot spots (upper 10 percent), and (b) cold spots (lower 10 percent) in herptile species richness for Arizona and New Mexico based on predicted range maps created by the Arizona and New Mexico GAPs.

in this region (Flather and others 1998). The effects of grazing, from both domestic and native herbivores, on biodiversity is an extremely complex issue. Some species and ecological processes clearly benefit from the disturbances associated with grazing while others do not (Brown and McDonald 1995). However, evidence from an extensive review of the literature suggests that many of the plant communities in the Southwest did not coevolve with large generalist herbivores (Milchunas, in press). This suggests that biotic communities in this region may be particularly sensitive to grazing and that sustainable use of forage resources will require careful management.

For this case study we focus on displaying biodiversity patterns among those species that are thought to respond in a negative way to grazing by domestic and native herbivores. We relied on the classification reported in Zwartjes and others (in press) to identify the list of species that expert panels judged to be negatively affected by grazing. Certainly, the process outlined in Zwartjes and others could be repeated for species thought to benefit from grazing. However, given the overall objective of reducing resource management conflicts between grazing and biodiversity conservation (Memorandum of Understanding between USDA, Forest Service, Region 3-Southwestern Region and the USDA Forest Service, Rocky Mountain Research Station, unpublished document), our focus in this case study is on describing the geographic pattern of occurrence among those species whose distribution and abundance is thought to be harmed by grazing activities. Concentrations of species that are sensitive to grazing activities in certain geographic areas would allow managers to target where grazing management may require attention to reduce species impacts.

For each grazing allotment in the Southwestern Region (see *Basecovs/HumanMade/AZ/azallot.shp* and *Basecovs/HumanMade/NM/nmallot.shp*), we counted the number of species that were predicted to potentially occur within that allotment. We then cross-referenced this list of species against those species that are thought to respond negatively to grazing (see Zwartjes and others [in press]). From these two lists, we computed the percentage of species that potentially occur in each allotment that were thought to be negatively affected by grazing.

The distribution of grazing allotments that support a high percentage of terrestrial vertebrates thought to be negatively impacted by grazing shows no strong geographic pattern. There are clusters of allotments distributed throughout the Southwestern Region that support a high percentage of species believed to be negatively impacted by grazing (fig. 6a). There is some evidence that the likelihood of encountering a grazing allotment supporting a high percentage of vertebrate species judged to be grazing-impacted covaries with latitude, but the nature of that relationship depends on the state and taxonomic group. In Arizona, the high percentage classes of grazing-impacted species appear to occur more frequently in southern allotments (that is, negatively related to latitude) across all taxa (fig. 6b-d). Conversely, only New Mexico birds show a higher incidence of high percentage grazing-impacted classes in southern allotments (fig. 6b); New Mexico mammals (fig. 6c) and herptiles (fig. 6d) show a greater incidence of high percentage grazing-impacted classes in northern allotments. Estimated Spearman's rank correlations[2] (r_s) between latitude of each grazing allotment centroid and the percentage of vertebrates thought to be impacted by grazing confirm these visual patterns (table 5). It is doubtful that latitude per se is the causative factor behind the manifestation of these patterns. Rather, other ecological gradients including precipitation, plant composition, productivity, and evolutionary history of grazing likely covary with latitude in complex ways (see Milchunas [in press] for a discussion of the interactions between these factors and biodiversity response to grazing) to affect how many species within the pool may be negatively impacted by domestic grazers.

It is also possible that the percentage of species judged to be negatively impacted by grazing is correlated with the overall number of species that could potentially occur within that allotment. Highly productive allotments may simultaneously support high numbers of species and also support higher densities of large ungulate herbivores—a combination that may predispose these areas to grazing/biodiversity conflicts. In Arizona, terrestrial vertebrates in general, and birds and mammals in particular, showed a positive relationship between overall taxon richness and the percentage of grazing-impacted species (table 5). We must note, however, that the magnitude of the correlations indicates a weak pattern of association. In New Mexico, overall taxon richness appears to be negatively correlated with the percentage of species thought to be sensitive to grazing (table 5). This negative relationship is particularly strong for herptile species (r_s = -0.69). The fact that the magnitude and direction of the response changes between the two states likely reflects the complex interaction between the ecological factors that affect biodiversity response to grazing (see Milchunas in press).

This case study has shown that when basic distributional data are linked with other life history databases

[2] Spearman's rank correlation was estimated since it does not assume an underlying bivariate distribution and it offers a more general measure of association between two variables when that relationship is expected to be monotonic but not necessarily linear.

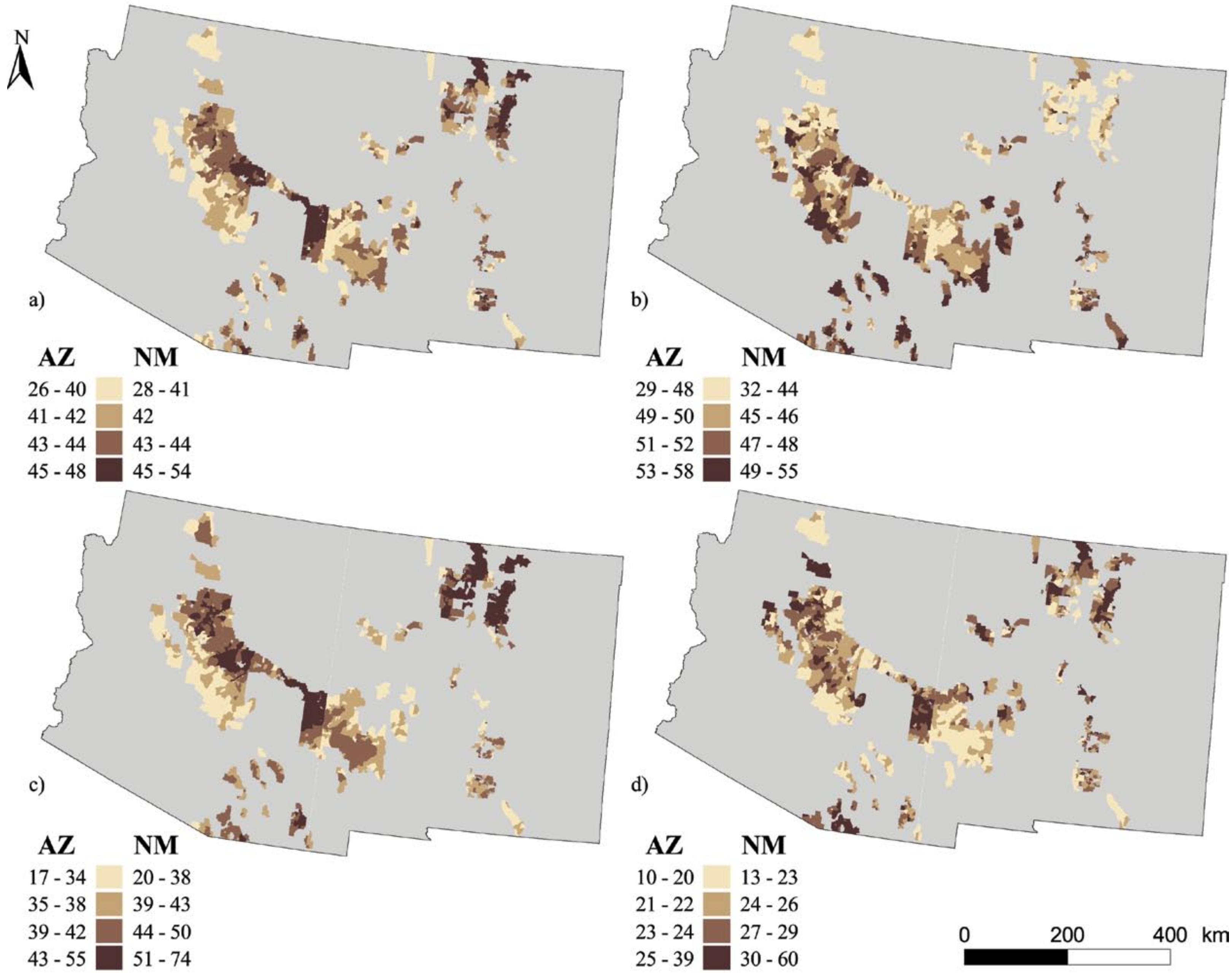

Figure 6—The percentage of vertebrate species [(a) all terrestrial vertebrates, (b) avian, (c) mammal, and (d) herptile] thought to be negatively impacted by grazing activities (as estimated by Zwartjes and others [in press]) within U.S. Forest Service grazing allotments in the Southwestern Region. We assigned equal areas of grazing allotments to each percentage class based on an independent analysis of Arizona and New Mexico. This explains why the class cut-points vary between states (see legend).

Table 5—Spearman's rank correlations (r_s) between the percentage of species thought to be impacted by grazing (as estimated by Zwartjes and others [in press]), latitude, and overall taxon richness among grazing allotments in the Southwestern Region. The latitude of a grazing allotment was based on the geographic centroid of the allotment.

Taxonomic group	Spearman's correlation between latitude and percent grazing-impacted species			
	Arizona		New Mexico	
	r_s	P	r_s	P
Terrestrial vertebrates	-0.120	0.001	0.143	<0.001
Birds	-0.369	<0.001	-0.456	<0.001
Mammals	-0.271	<0.001	0.224	<0.001
Herptiles	-0.182	<0.001	0.335	<0.001
	Spearman's correlation between overall taxon richness and percent grazing-impacted species			
	Arizona		New Mexico	
	r_s	P	r_s	P
Terrestrial vertebrates	0.405	<0.001	-0.171	<0.001
Birds	0.403	<0.001	-0.062	0.083
Mammals	0.506	<0.001	0.350	<0.001
Herptiles	0.022	0.552	-0.690	<0.001

like that represented in Zwartjes and others (in press), then simple, yet powerful, analyses can be accomplished. Our analysis was useful in identifying those grazing allotments where the potential conflicts between biodiversity conservation and grazing may be substantial and deserving of critical consideration in land management planning activities. Similar analyses could be completed on other resource management activities (for example, timber harvesting, fire, recreation) so long as reliable information on species responses to these activities exists or could be compiled.

Conclusions

Documenting biodiversity patterns over broad geographic areas as a basis for guiding natural resource management is a conceptually simple idea. This simplicity belies the challenges posed by inadequate species occurrence inventories for most groups of species (Lubchenco and others 1991; Lawler 2001). Certainly, data that could contribute to determining broad-scale distributional patterns exist for a subset of well-studied taxa; however, even these data are not readily available (Brown and Roughgarden 1990; Pennisi 2000; Peterson 2001; Cracraft 2002). A common strategy for overcoming the dearth of taxonomic inventories has been to predict species distributions based on known or hypothesized habitat affinity relationships (Scott and others 1993; Fleishman and others 2001).

In this report we have compiled both kinds of information. We have consolidated species location records from a systematic search of state and federal agencies, institutions, and individual collections along with extant predictions of species ranges from state GAP databases. We used these data in three case examples to illustrate how basic occurrence information could be used to analyze the distributional patterns of selected species, to document geographic patterns of richness among suites of species, and to examine the occurrence pattern among species whose populations are thought to be negatively affected by grazing activities in the Southwest. Furthermore, we have compiled extensive layers of ancillary data that can be used in conjunction with species location information to further our understanding of the factors that limit the occurrence of species across broad geographic areas. Use of these data in this capacity was beyond the scope of this report, but we are involved in other efforts to further managers' capacity to describe and analyze biodiversity (for example, Reese and others 2005; Shriner and others, in preparation).

This effort represents an opportunistic compilation of extant data; there was no primary data collection on our part. For this reason, a number of caveats warrant remark. First, conservation managers and researchers must realize that this database should not be treated as the definitive source for biodiversity in the Southwest. New sources of location records will undoubtedly be discovered, and new collection and sighting records will be compiled. Thus, this database should be updated frequently and evolve as new information becomes available. As such, the database should best be treated as an adaptive source of biodiversity data with current patterns driving future inventories that will extend and verify our present understanding of biodiversity patterns across this two-state region.

Second, users of the database must recognize that there are multiple sources of error in the data. There is a tendency for users of geographic information to treat spatially explicit information as error free (Monmonier 1991). However, specimens can be misidentified, location coordinates can be recorded incorrectly, and predicted distributions may be based on erroneous habitat affinities, all of which can lead to errors in geographically explicit conservation recommendations (Flather and others 1997). To a certain extent, the comparison of predicted species ranges with location records provides an initial indication of distributional uncertainty for each species as we have discussed. However, there is still a need for error analysis routines that will provide resource planners with an indication of how robust spatially explicit conservation recommendations will be under varying levels of error.

Finally, it is well-known that collection and sighting records are usually not based on well-designed sampling surveys across a landscape. Consequently, sampling biases can confound the development of tenable species distribution models. Although algorithms for predicting species distributions that are robust to such sampling biases are being investigated (Peterson 2001; Hirzel and others 2002; Reese 2003), use of this database to construct inferential models must explicitly consider effects associated with potentially biased sampling effort.

These caveats notwithstanding, the information contained in this database is fundamental to any broad-scale study of biodiversity patterns. It represents the first generation of what should be an evolving database. We purposefully focused broadly in our compilation of species location data, predicted distributions, and ancillary environmental data, rather than restricting our efforts to that subset of species relevant to a specific resource management issue. For this reason, the data should be applicable to a broad set of resource management issues.

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Appendix A: DVD content description

The enclosed DVD data diskette contains the entire GIS database described in this report, plus associated tabular data. The DVD is organized into four major types of data: base coverages, observed species locations, predicted species ranges, and estimated species richness hotspot data, which are structured under the four main directories on the DVD (see fig. A1). A complete listing of the contents of each directory and its sub-directories is provided in table A1.

Data Formats

A number of data file formats have been used to represent the various geospatial and tabular datasets. The geospatial data are compatible with the ESRI family of GIS products, namely ArcView 3.x, ArcGIS 8.x, and ArcGIS 9. The tabular data are compatible with the Microsoft Office 2000 (or newer) suite of business software, namely Excel and Access. Where practical, tabular data are also provided in space-delimited ASCII text files to ensure compatibility for any user.

Two GIS file formats are used for the GIS datasets. First, all vector-based GIS data are provided in the widely used ArcView shapefile format. Second, all raster-based GIS data are provided in ArcInfo raster GRID layer format. Both formats can be accessed directly from the DVD.

Most of the base map layers (*Basecovs* directory) and all of the species observation point data (*Observed* directory) have been provided in the shapefile format. The shapefile data structure actually uses multiple files to store the components of each individual GIS map layer (for example, geometric information is stored in a *.shp* file, tabular attribute data are stored in the associated *.dbf* file). For this reason, it is recommended that shapefiles should not be copied from the DVD individually using anything other than a GIS application. For the sake of convenience, the tabular attribute data for all the species observation data also have been provided in the Microsoft Access 2000 relational database format. Due to the large size of the database, the file had to be compressed (zip format) to fit on the DVD. The zip archive of the database can be found within the *Observed/AccessDB* directory as the file named *spprecords.mdb*.zip.

All of the predicted species distributions and species richness (for example, biodiversity hotspot) maps have been provided in the ArcInfo raster GRID format. The digital elevation data and the vegetation maps have also been provided in the GRID format. The ArcInfo GRID data structure uses multiple files (and directories) to represent a single raster map layer. As such, it is recommended that one should never attempt to copy a single raster layer from the DVD except with a GIS application. Otherwise, it is possible that the raster layer may become corrupted.

Metadata

A complete, FGDC compliant metadata document has been provided for the species observation GIS database in Appendix B. This document is also generally applicable to the equivalent non-spatial tabular version of the database (that is, the Microsoft Access database), but one should obviously be aware that the format of the data differs. The remainder of the GIS datasets were obtained through other sources and are provided in an unmodified form, except that each geospatial dataset was transformed into a common spatial reference system (Alber's Equal Area projection, NAD27 datum). Accordingly, we provide the unmodified metadata document that was provided with these datasets when they were obtained. The metadata documents (if available) for each geospatial dataset are provided in the same directory as the geospatial layer (shapefile or grid) on the DVD. Note that we have made no attempt to verify the accuracy of these metadata documents nor have we attempted to update them in any way. The original sources for each geospatial dataset have been provided in table A1 and on the DVD, and users of this report are encouraged to contact the original data provider for updated datasets and/or metadata documentation.

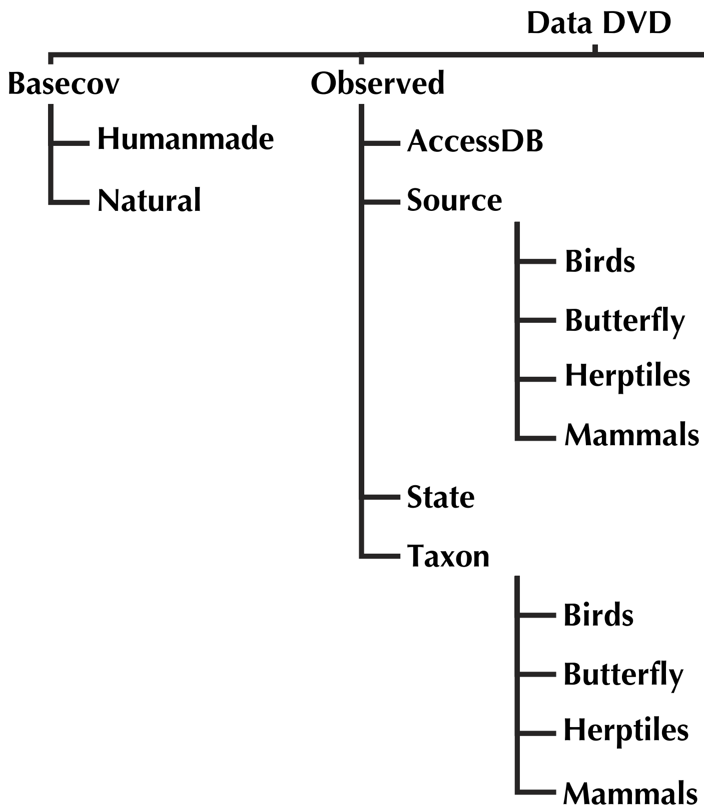

Figure A1—Data structure of the DVD shown as a tree diagram. The four major types of data (base coverages, observed species locations, predicted species ranges, and estimated species richness hotspot data) are organized in the DVD under four main directories, which are depicted in the first row of the tree. Sub-directories to each main directory are shown below. Note that for the lowest level of each sub-directory above, the data files are stored within additional sub-directories labeled AZ (Arizona) and NM (New Mexico). The redundant AZ and NM sub-directory structure is omitted to keep the diagram simple.

Table A1—Description of the contents of the enclosed data DVD.

Directory	Sub-directory	File name	File type	Description	Source[1]
.	.	contents	Text and Excel spreadsheet	Description of the contents of the DVD (this table)	CSU
Basecovs	.	azvegxwalk	Text and Excel spreadsheet	Cross-walk with GAP vegetation classification	CSU
	.	nmvegxwalk	Text and Excel spreadsheet	Cross-walk with GAP vegetation classification	CSU
	HumanMade/Az	azallot	ArcView shapefile	USFS grazing allotment boundaries	USFS R3
	HumanMade/Az	azcounty	ArcView shapefile	County boundaries	AZ GAP
	HumanMade/Az	azlnname	ArcView shapefile	Index for named linear features	USGS
	HumanMade/Az	azplaces	ArcView shapefile	Census populated places	ALRIS
	HumanMade/Az	azptname	ArcView shapefile	Index for named point features	USGS
	HumanMade/Az	azroads	ArcView shapefile	Major roadways	ESRI
	HumanMade/Az	azstate	ArcView shapefile	State boundary	ALRIS
	HumanMade/Az	aztrs	ArcView shapefile	Township-range-section lines	ALRIS
	HumanMade/Az	aztwnrng	ArcView shapefile	Township-range lines	ALRIS
	HumanMade/Az	azusfs	ArcView shapefile	USFS national forest boundaries	USFS R3
	HumanMade/Nm	nmallot	ArcView shapefile	USFS grazing allotment boundaries	USFS R3
	HumanMade/Nm	nmcounty	ArcView shapefile	County boundaries	NM GAP
	HumanMade/Nm	nmlnname	ArcView shapefile	Index for named linear features	USGS
	HumanMade/Nm	nmplaces	ArcView shapefile	FIPS incorporated places	NM GAP
	HumanMade/Nm	nmptname	ArcView shapefile	Index for named point features	USGS
	HumanMade/Nm	nmroads	ArcView shapefile	Major roadways	ESRI
	HumanMade/Nm	nmstate	ArcView shapefile	State boundary	NM GAP
	HumanMade/Nm	nmtwnrng	ArcView shapefile	Township-range lines	USGS ESIC
	HumanMade/Nm	nmusfs	ArcView shapefile	USFS national forest boundaries	USFS R3
	Natural/Az	azsoils	ArcView shapefile	Statewide soils	ALRIS
	Natural/Az	azspring	ArcView shapefile	Springs	USGS
	Natural/Az	azstream	ArcView shapefile	Permanent and intermittent streams	EPA BASINS
	Natural/Az	riparian	ArcView shapefile	Riparian vegetation	ALRIS
	Natural/Az	azdem	ArcInfo grid	Elevation	USGS ESIC
	Natural/Az	azveg	ArcInfo grid	Vegetation	AZ GAP
	Natural/Nm	nmcaves	ArcView shapefile	Caves	USGS
	Natural/Nm	nmsoils	ArcView shapefile	Statewide soils	NM GAP
	Natural/Nm	nmspring	ArcView shapefile	Springs	USGS
	Natural/Nm	nmstream	ArcView shapefile	Permanent and intermittent streams	EPA BASINS
	Natural/Nm	nmdem	ArcInfo grid	Elevation	USGS ESIC
	Natural/Nm	nmveg	ArcInfo grid	Vegetation	NM GAP
Observed	AccessDB	spprecords.mdb.zip	Microsoft Access database	All geo-referenced species records	Various
	Source/Birds/Az	birds	ArcView shapefile	Known locations of birds from unique sources in AZ	Various
	Source/Birds/Nm	birds	ArcView shapefile	Known locations of birds from unique sources in NM	Various
	Source/Butterfly/Az	butterfly	ArcView shapefile	Known locations of butterflies from unique sources in AZ	Various
	Source/Butterfly/Nm	butterfly	ArcView shapefile	Known locations of butterflies from unique sources in NM	Various
	Source/Herps/Az	herps	ArcView shapefile	Known locations of herps from unique sources in AZ	Various
	Source/Herps/Nm	herps	ArcView shapefile	Known locations of herps from unique sources in NM	Various
	Source/Mammals/Az	mammals	ArcView shapefile	Known locations of mammals from unique sources in AZ	Various

	Source/Mammals/Az	mammals	ArcView shapefile	Known locations of mammals from unique sources in NM	Various
	State/Az	azptobs	ArcView shapefile	Known locations of all terrestrial vertebrates and butterflies in AZ	Various
	State/Az	az_dates	ArcView shapefile	Species observations in AZ with various date formats or dates prior 1900	Various
	State/Nm	nmptobs	ArcView shapefile	Known locations of all terrestrial vertebrates and butterflies in NM	Various
	State/Nm	nm_date	ArcView shapefile	Species observations in NM with various date formats or dates prior 1900	Various
	Taxon/Birds/Az	azbirds	ArcView shapefile	Known locations of all birds in AZ	Various
	Taxon/Birds/Nm	nmbirds	ArcView shapefile	Known locations of all birds in NM	Various
	Taxon/Butterfly/Az	azbutfly	ArcView shapefile	Known locations of all butterflies in AZ	Various
	Taxon/Butterfly/Nm	nmbutfly	ArcView shapefile	Known locations of all butterflies in NM	Various
	Taxon/Herps/Az	azherps	ArcView shapefile	Known locations of all amphibians and reptiles in AZ	Various
	Taxon/Herps/Nm	nmherps	ArcView shapefile	Known locations of all amphibians and reptiles in NM	Various
	Taxon/Mammals/Az	azmammal	ArcView shapefile	Known locations of all mammals in AZ	Various
	Taxon/Mammals/Nm	nmmammal	ArcView shapefile	Known locations of all mammals in NM	Various
Predicted	.	GridNames	Text and Excel spreadsheet	Cross-walk with BISON codes, scientific and common names	CSU
	Birds/Az	g04*	ArcInfo grid	Predicted distributions for birds	AZ GAP
	Birds/Nm	g04*	ArcInfo grid	Predicted distributions for birds	NM GAP
	Herps/Az	g02* or g03*	ArcInfo grid	Predicted distributions for amphibians and reptiles	AZ GAP
	Herps/Nm	g02* or g03*	ArcInfo grid	Predicted distributions for amphibians and reptiles	NM GAP
	Mammals/Az	g05*	ArcInfo grid	Predicted distributions for mammals	AZ GAP
	Mammals/Nm	g05*	ArcInfo grid	Predicted distributions for mammals	NM GAP
Richness	Birds/Az	azbirds	ArcInfo grid	Hotspots distribution of all birds	AZ GAP/CSU
	Birds/Nm	nmbirds	ArcInfo grid	Hotspots distribution of all birds	NM GAP/ CSU
	Herps/Az	azherps	ArcInfo grid	Hotspots distribution of all amphibians and reptiles	AZ GAP/CSU
	Herps/Nm	nmherps	ArcInfo grid	Hotspots distribution of all amphibians and reptiles	NM GAP/ CSU
	Mammals/Az	azmamms	ArcInfo grid	Hotspots distribution of all mammals	AZ GAP/CSU
	Mammals/Nm	nmmamms	ArcInfo grid	Hotspots distribution of all mammals	NM GAP/ CSU

[1]Key to Abbreviations used for Sources:

ALRIS — Arizona Land Resource Information System
AZ — Arizona
CSU — Colorado State University
EPA BASINS — Environmental Protection Agency (Better Assessment Science Integrating Point and Nonpoint Sources)
ESRI — Environmental Systems Research Institute
GAP — Gap Analysis Program
NM — New Mexico
USFS R3 — US Forest Service, Region 3
USGS ESIC — US Geological Survey, Environmental Systems Information Center

Appendix B: Metadata documentation for the species observation GIS database

USFS/CSU Species Point Observation Records Database for AZ and NM

Identification_Information:
  Citation:
    Citation_Information:
      Originator: USDA Forest Service, Rocky Mountain Research Station
      Originator:
        Colorado State University, Department of Fishery and Wildlife Biology
      Publication_Date: Unpublished Material
      Title: USFS/CSU Species Point Observation Records Database for AZ and NM
      Edition: 1.00
      Geospatial_Data_Presentation_Form: vector digital data
      Series_Information:
        Series_Name:
          USDA Forest Service, Rocky Mountain Research Station, General Technical Reports Series
        Issue_Identification: RMRS-GTR-152
      Publication_Information:
        Publication_Place: Fort Collins, CO
        Publisher: USDA Forest Service, Rocky Mountain Research Station
      Other_Citation_Details: Appendix to Gen. Tech. Rep. RMRS-GTR-152
      Online_Linkage: ftp://ftp2.fs.fed.us/incoming/ftcol/flather/R3_Biodiversity_Data
  Description:
    Abstract:
      This database contains point locations of species observations for terrestrial vertebrates (birds, mammals, amphibians and reptiles) and butterflies for Arizona and New Mexico. Each point observation is described by information such as the species name, date observed, details of the observer and method, animal information, and data quality. Source data was compiled from various sources, including museums, private collections, established bird surveys (North American Breeding Bird Survey and Audubon Christmas Bird Count Survey), and government and non-government organizations.
    Purpose:
      The purpose of this database was to provide a catalog of geospatially referenced species observations for Arizona and New Mexico. These data are valuable to scientists and managers for the purpose of mapping species distributions from known occurrences, and may also be used, in aggregate, to indicate the distribution of biodiversity resources in the region. When these data are accompanied by sufficient environmental GIS data, the species observation database is valuable for modeling observed species occurrence to predict the likely occurrence of species in areas that have been undersampled.
  Time_Period_of_Content:
    Time_Period_Information:
      Range_of_Dates/Times:
        Beginning_Date: 1819/04/20
        Ending_Date: 2000/12/10
    Currentness_Reference: ground condition
  Status:
    Progress: Complete
    Maintenance_and_Update_Frequency: None planned
  Spatial_Domain:
    Bounding_Coordinates:
      West_Bounding_Coordinate: -116.435036
      East_Bounding_Coordinate: -102.554120
      North_Bounding_Coordinate: 38.547881
      South_Bounding_Coordinate: 30.405698

Keywords:
  Theme:
    Theme_Keyword_Thesaurus: None
    Theme_Keyword: point observation
    Theme_Keyword: species occurrence
    Theme_Keyword: species sighting location
    Theme_Keyword: terrestrial vertebrates
    Theme_Keyword: butterflies
    Theme_Keyword: birds
    Theme_Keyword: mammals
    Theme_Keyword: reptiles
    Theme_Keyword: amphibians
  Place:
    Place_Keyword_Thesaurus: None
    Place_Keyword: American Southwest
    Place_Keyword: Arizona
    Place_Keyword: New Mexico
    Place_Keyword: USDA Forest Service Region 3
Access_Constraints:
  Under review. Some data remains the property of individual donors and may not be accessible for public use. Data management is under review by the USDA Forest Service. Access can be negotiated by contacting the data distributor.
Use_Constraints: Under review by USDA Forest Service.
Point_of_Contact:
  Contact_Information:
    Contact_Person_Primary:
      Contact_Person: Dr. Curtis Flather
      Contact_Organization: USDA Forest Service, Rocky Mountain Research Station
    Contact_Position: Research Wildlife Biologist
    Contact_Address:
      Address_Type: mailing and physical address
      Address: USDA Forest Service
      Address: Rocky Mountain Research Station
      Address: Natural Resources Research Center
      Address: 2150 Centre Avenue, Building A
      City: Fort Collins
      State_or_Province: Colorado
      Postal_Code: 80526-2098
      Country: USA
    Contact_Voice_Telephone: 970-295-5910
    Contact_Facsimile_Telephone: 970-295-5959
    Contact_Electronic_Mail_Address: cflather@fs.fed.us
    Hours_of_Service: daytime hours, most weekdays
Data_Set_Credit:
  The principle contributors to the compilation of this data set were Curtis Flather, Kenneth Wilson, Rosamonde Cook, Gordon Reese and Darren Bender.
Security_Information:
  Security_Classification_System: UNDETERMINED
  Security_Classification: Sensitive
  Security_Handling_Description: Under review by USDA Forest Service
Native_Data_Set_Environment: ESRI ArcView 3.2a/ArcInfo 8.0.2; Microsoft Access 2000

Data_Quality_Information:
  Attribute_Accuracy:
    Attribute_Accuracy_Report:
      No formal attribute accuracy assessment was conducted. All values were assumed to be accurate, as provided in the original data sources. Random samples of records (approximately 15%) were verified for transcription errors. If an operator was observed to have committed numerous transcription errors for a

block of entries (100 - 1000 records), that block was checked exhaustively for errors and/or re-transcribed entirely. Taxonomic data (species names) were also verified (see below).

Quantitative_Attribute_Accuracy_Assessment:

Attribute_Accuracy_Value: SCI_NAME

Attribute_Accuracy_Explanation:

Scientific (Latin) species names were verified for nomenclature accuracy and currentness against two sources. The first authority used was the Integrated Taxonomic Information System (ITIS) online at <http://www.itis.usda.gov>. If the species was not listed or unverified in ITIS, the Natureserve (formerly the Association for Biodiversity Information) online taxonomic database was used (<http://www.natureserve.org/explorer/>). Verification was most recently done in March 2004 and 11 changes were deemed necessary and are current as of October 2004. The names changed were (1) Anthanassa texana to Phyciodes texana, (2) Anthocharis pima to Anthocharis cethura, (3) Ascia howarthi to Ganyra howarthi, (4) Celaenorrhinus fritzgaer to Celaenorrhinus fritzgaertneri, (5) Chlosyne nycteis to Chlosyne ismeria, (6) Euphilotes mohave to Euphilotes mojave, (7) Eurema boisduvalianum to Eurema boisduvaliana, (8) Heliopetes domicella to Heliopyrgus domicella, (9) Incisalia henrici to Callophrys henrici, (10) Nymphalis atalanta to Vanessa atalanta, and (11) Thomomys umbrinus grahamensis to Thomomys bottae mearnsi.

Quantitative_Attribute_Accuracy_Assessment:

Attribute_Accuracy_Value: COM_NAME

Attribute_Accuracy_Explanation:

Common species names were verified for nomenclature accuracy and currentness against two sources. The first authority used was the Integrated Taxonomic Information System (ITIS) online at <http://www.itis.usda.gov>. If the species was not listed or unverified in ITIS, the Natureserve (formerly the Association for Biodiversity Information) online taxonomic database was used (<http://www.natureserve.org/explorer/>).

Logical_Consistency_Report: not applicable

Completeness_Report: not applicable

Positional_Accuracy:

Horizontal_Positional_Accuracy:

Horizontal_Positional_Accuracy_Report:

No formal accuracy assessment has been completed. The digitizing operator subjectively plotted points from text descriptions, and labelled them as ‘accurate’ or ‘not accurate’. The term ‘accurate’ means that the operator was confident that the location described was within 5 miles (8 km) of the plotted point location in the GIS. This confidence in accuracy is provided in the LOC_CONF (LOCATIONAL_CONFIDENCE) field as a ‘yes’ (accurate) or ‘no’ (not accurate). Data that were provided in digital form with a quantitative locational reference (for example, latitude and longitude) were judged to be accurate to within 5 miles (8 km). When the county of each species collection/observation point was recorded, the digitized points were cross-validated using a GIS map of counties to ensure that the plotted point actually fell within the named county. If not, these records were flagged as potential digitizing errors, and were verified or re-digitized. Random samples of records (approximately 15%) were also verified for digitizing errors. If an operator was observed to have committed numerous digitizing errors for a block of work (100 - 1000 records), that block was checked exhaustively for errors and/or re-digitized entirely.

Vertical_Positional_Accuracy:

Vertical_Positional_Accuracy_Report: none

Lineage:

Process_Step:

Process_Description:

All points were plotted/digitized manually and rechecked for transcription errors.

Process_Date: 2002/01/31

Spatial_Reference_Information:

Horizontal_Coordinate_System_Definition:

Planar:

Map_Projection:

Map_Projection_Name: Albers Conical Equal Area

Albers_Conical_Equal_Area:

Standard_Parallel: 29.500000

Standard_Parallel: 45.500000
Longitude_of_Central_Meridian: -96.000000
Latitude_of_Projection_Origin: 23.000000
False_Easting: 0.000000
False_Northing: 0.000000
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1927
Ellipsoid_Name: Clarke 1866
Semi-major_Axis: 6378206.400000
Denominator_of_Flattening_Ratio: 294.978698

Entity_and_Attribute_Information:
Detailed_Description:
Attribute:
Attribute_Label: FID
Attribute_Definition: Internal feature number.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Shape
Attribute_Definition: Feature geometry.
Attribute_Definition_Source: ESRI
Attribute_Domain_Values:
Unrepresentable_Domain: Coordinates defining the features.
Attribute:
Attribute_Label: SCI_NAME
Attribute_Definition:
Taxanomic (genus, species, subspecies) species name, as defined within ITIS.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Codeset_Domain:
Codeset_Name: Standardized nomenclature.
Codeset_Source: Integrated Taxanomic Information System (ITIS)
Attribute:
Attribute_Label: SRC_UNIQUE
Attribute_Definition: [not implemented]
Attribute:
Attribute_Label: COM_NAME
Attribute_Definition: Common name for species, as defined by ITIS.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Codeset_Domain:
Codeset_Name: Standardized nomenclature.
Codeset_Source: Integrated Taxanomic Information System (ITIS)
Attribute:
Attribute_Label: TSN
Attribute_Definition: ITIS taxanomic serial number.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Codeset_Domain:
Codeset_Name: Taxanomic serial number
Codeset_Source: Integrated Taxanomic Information System (ITIS)
Attribute:
Attribute_Label: TIME
Attribute_Definition:
The time of day that the species was collected. Values are in local time.

Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Unrepresentable_Domain: Valid time (24-hr)
Attribute:
Attribute_Label: DATE_
Attribute_Definition: The date of collection.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Unrepresentable_Domain: Valid Gregorian calendar date
Attribute:
Attribute_Label: DATE_ACC
Attribute_Definition: The precision of the time and date measurements.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Exact
Enumerated_Domain_Value_Definition:
The time and date are exact to the minute for the detection.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Hour
Enumerated_Domain_Value_Definition:
Only the exact hour, day, month, and year are known.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Day
Enumerated_Domain_Value_Definition:
Only the exact day, month, and year are known.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Month
Enumerated_Domain_Value_Definition:
Only the exact month and year are known.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Year
Enumerated_Domain_Value_Definition: Only the exact year is known.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Previous Year
Enumerated_Domain_Value_Definition:
The detection can only be temporally fixed to some time previous to the entered year.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Attribute:
Attribute_Label: OBS_METH
Attribute_Definition:
How the animal was detected or observed or if a reproductive site for a specific animal was found.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Visual and Aural
Enumerated_Domain_Value_Definition:
The animal was detected by seeing it and hearing it.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Visual
Enumerated_Domain_Value_Definition: The animal was detected by seeing it.

Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Aural
Enumerated_Domain_Value_Definition: The animal was detected by hearing it.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Reproductive Site
Enumerated_Domain_Value_Definition:
A reproductive site for a species was detected (for example, nest, den).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Track
Enumerated_Domain_Value_Definition:
Evidence of the animal was found in the form of a track (foot print, drag pattern of a body part).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Excrement
Enumerated_Domain_Value_Definition:
Evidence of the animal was found in the form of excrement (for example, scat, regurgitated pellets).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Capture
Enumerated_Domain_Value_Definition:
The animal was detected by some type of physical capture (for example, netting, trapping).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Radio Telemetry
Enumerated_Domain_Value_Definition:
The animal was detected by the use of radio telemetry.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Voucher Specimen
Enumerated_Domain_Value_Definition:
A specimen collected for identification in a laboratory or for submission to a taxon expert. May or may not be retained in a voucher collection.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Other
Enumerated_Domain_Value_Definition:
Evidence of the animal or detection was by means other than those above (for example, hair snare, track plate, antler rub, plucking post).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Unknown
Enumerated_Domain_Value_Definition: Method of detection is unknown
Enumerated_Domain_Value_Definition_Source: CSU database team
Attribute:
Attribute_Label: OBS_NAME
Attribute_Definition:
The name of the person who detected the animal or sign of the animal.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Unrepresentable_Domain: Free text
Attribute:
Attribute_Label: OBS_QUAL

Attribute_Definition:
The qualifications of the observer to accurately identify the correct species associated with observation or detection. Education and field experience generally define the level.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Taxon Expert
Enumerated_Domain_Value_Definition:
A person who has extensive field and research level experience with the species detected.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Expert
Enumerated_Domain_Value_Definition:
A person who has extensive field experience with the species detected.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Limited Experience
Enumerated_Domain_Value_Definition:
A person with limited field experience with the species detected. Capable of making positive identifications among similar species or subspecies, or other species.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: No Experience
Enumerated_Domain_Value_Definition:
A person with no field experience identifying the wildlife species. Positive species identification made from description.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Unknown
Enumerated_Domain_Value_Definition:
The experience level of the observer is unknown. Positive species identification is made from the description.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Attribute:
Attribute_Label: TOT_NUM
Attribute_Definition:
The number of individuals with which the detection is associated. For example, if a single GIS point is associated with a pair of owls, the number '2' would be entered into this field.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0
Range_Domain_Maximum: 32767
Attribute:
Attribute_Label: GENDER
Attribute_Definition: Sex of observed individual.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Male
Enumerated_Domain_Value_Definition: Male animal(s)
Enumerated_Domain_Value_Definition_Source: CSU database team
Enumerated_Domain:
Enumerated_Domain_Value: Female
Enumerated_Domain_Value_Definition: Female animal(s)
Enumerated_Domain_Value_Definition_Source: CSU database team
Enumerated_Domain:
Enumerated_Domain_Value: Mixed group

Enumerated_Domain_Value_Definition:
At least one male plus at least one female in a group of individuals described by one record.
Enumerated_Domain_Value_Definition_Source: CSU database team
Enumerated_Domain:
Enumerated_Domain_Value: Unknown
Enumerated_Domain_Value_Definition: Animal gender was not determined.
Enumerated_Domain_Value_Definition_Source: CSU database team
Attribute:
Attribute_Label: REPRO
Attribute_Definition:
The reproductive status of the animal detected, if known. This could include labeling a pair as reproductive, or that there are young present (inferring that the pair is successfully reproducing).
Attribute_Definition_Source: USFS NRIS Fauna
Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Reproducing
Enumerated_Domain_Value_Definition:
The animal observed or nest/den found shows evidence of current season reproduction.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Non-reproducing
Enumerated_Domain_Value_Definition:
The animal observed or nest/den found shows positive evidence of non-reproduction in the current season.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Failed Reproduction
Enumerated_Domain_Value_Definition:
The animal observed or nest/den found shows evidence of reproduction that has failed (for example, dead young, abandoned eggs). Failure could be complete or partial loss of reproductive effort.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: With Young at Reproductive Site
Enumerated_Domain_Value_Definition:
The animal or group was observed with young on/at a nest or den.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: With Young
Enumerated_Domain_Value_Definition:
The animal or group was observed with young not at a nest or den.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Unknown
Enumerated_Domain_Value_Definition:
Reproduction status cannot be confirmed due to lack of evidence.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Not Applicable
Enumerated_Domain_Value_Definition:
The animal or group was observed outside of its reproductive season.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Attribute:
Attribute_Label: GROUP
Attribute_Definition:
The description of the size and relationship of the animal group detected.
Attribute_Definition_Source: USFS NRIS Fauna

Attribute_Domain_Values:
Enumerated_Domain:
Enumerated_Domain_Value: Single
Enumerated_Domain_Value_Definition:
The animal observed was not part of a pair or family group. Only one animal was observed.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Pair
Enumerated_Domain_Value_Definition:
The animals observed were considered a pair due to protocol rules or professional judgment.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Family Group
Enumerated_Domain_Value_Definition:
The group of animals observed was a family group or part of one (more than two adults or two adults with young).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Group
Enumerated_Domain_Value_Definition:
The group of animals was a congregation of singles, pairs, family groups, or a mix of types (for example, herd, flock, swarm).
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Enumerated_Domain:
Enumerated_Domain_Value: Unknown
Enumerated_Domain_Value_Definition:
Group type could not be determined due to lack of evidence found.
Enumerated_Domain_Value_Definition_Source: USFS NRIS Fauna
Attribute:
Attribute_Label: LAT
Attribute_Definition: The latitude of the detection in decimal degrees
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Unrepresentable_Domain: Geographic coordinates using NAD27 datum
Attribute:
Attribute_Label: LON
Attribute_Definition: The longitude of the detection in decimal degrees
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Unrepresentable_Domain: Geographic coordinates using NAD27 datum
Attribute:
Attribute_Label: LOC_DESC
Attribute_Definition: Description of the sighting/collection location.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Unrepresentable_Domain: Free text
Attribute:
Attribute_Label: LOC_ACC
Attribute_Definition: Horizontal locational accuracy (meters), if known.
Attribute_Definition_Source: CSU database team
Attribute_Domain_Values:
Range_Domain:
Range_Domain_Minimum: 0
Range_Domain_Maximum: 32767
Attribute_Units_of_Measure: meteres

Attribute:

Attribute_Label: LOC_CONF

Attribute_Definition:

Identifies whether the location was plotted with confidence within 5 miles (8 km) of the observation.

Attribute_Definition_Source: CSU database team

Attribute_Domain_Values:

Enumerated_Domain:

Enumerated_Domain_Value: Yes

Enumerated_Domain_Value_Definition: Locational confidence was achieved.

Enumerated_Domain_Value_Definition_Source: CSU database team

Enumerated_Domain:

Enumerated_Domain_Value: Y

Enumerated_Domain_Value_Definition: Locational confidence was achieved.

Enumerated_Domain_Value_Definition_Source: CSU database team

Enumerated_Domain:

Enumerated_Domain_Value: No

Enumerated_Domain_Value_Definition: Locational confidence was not achieved.

Enumerated_Domain_Value_Definition_Source: CSU database team

Enumerated_Domain:

Enumerated_Domain_Value: N

Enumerated_Domain_Value_Definition: Locational confidence was not achieved.

Enumerated_Domain_Value_Definition_Source: CSU database team

Enumerated_Domain:

Enumerated_Domain_Value: Unknown

Enumerated_Domain_Value_Definition: Locational confidence was not determined.

Enumerated_Domain_Value_Definition_Source: CSU database team

Attribute:

Attribute_Label: COMMENTS

Attribute_Definition:

The comments that the observer collected during the detection, including key words. A key word or key phrase could precede a portion of text.

Attribute_Definition_Source: CSU database team

Attribute_Domain_Values:

Unrepresentable_Domain: Free text

Attribute:

Attribute_Label: DATA_SRC

Attribute_Definition:

Original source of the data (collector/collection, atlas, or survey name).

Attribute_Definition_Source: CSU database team

Attribute_Domain_Values:

Unrepresentable_Domain: Free text

Attribute:

Attribute_Label: SRC_FILE

Attribute_Definition:

Name of the original shapefile from which the data was consolidated.

Attribute_Definition_Source: CSU database team

Attribute_Domain_Values:

Unrepresentable_Domain: Free text

Attribute:

Attribute_Label: SRC_RID

Attribute_Definition: Identification number from the original shapefile.

Attribute_Definition_Source: CSU database team

Attribute_Domain_Values:

Range_Domain:

Range_Domain_Minimum: 0

Range_Domain_Maximum: 2147483647

Overview_Description:
Entity_and_Attribute_Overview:
See accompanying USFS General Technical Report regarding the development of this project and the Point Observation Records database.
Entity_and_Attribute_Detail_Citation: not cited

Distribution_Information:
Distribution_Liability: Under review.
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Option:
Offline_Option:
Offline_Media: CD-ROM
Recording_Format: ISO 9660
Fees: TBD

Metadata_Reference_Information:
Metadata_Date: 20020214
Metadata_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Dr. Darren Bender
Contact_Organization: University of Calgary
Contact_Position: Assistant Professor of Geography
Contact_Address:
Address_Type: mailing address
Address: Department of Geography
Address: Univerity of Calgary
Address: 2500 University Dr NW
City: Calgary
State_or_Province: Alberta
Postal_Code: T2N 1N4
Country: Canada
Contact_Voice_Telephone: 403-220-6398
Contact_Facsimile_Telephone: 403-282-6561
Contact_Electronic_Mail_Address: dbender@ucalgary.ca
Hours_of_Service: daytime hours, most weekdays
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Access_Constraints: none
Metadata_Use_Constraints: none
Metadata_Security_Information:
Metadata_Security_Classification_System: none
Metadata_Security_Classification: Unclassified
Metadata_Security_Handling_Description: none
Metadata_Extensions:
Online_Linkage: <http://www.esri.com/metadata/esriprof80.html>
Profile_Name: ESRI Metadata Profile
Metadata_Extensions:
Online_Linkage: <http://http://www.fgdc.gov/standards/status/sub5_2.html>
Profile_Name: Biological Data Profile

RMRS
ROCKY MOUNTAIN RESEARCH STATION

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals.

Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

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Ogden, Utah
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*Station Headquarters, Natural Resources Research Center, 2150 Centre Avenue, Building A, Fort Collins, CO 80526.