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Special Session - The Southwest Regional Gap Analysis Project (Wednesday, 31 March 2004)

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10:00 AM - 5:00 PM Apollo Room 7

The Gap Analysis Program (GAP) is a national interagency program that maps the distribution of plant communities and selected animal species and compares these distributions with land stewardship to identify biotic elements at potential risk of endangerment. GAP uses Geographic Information System (GIS) technology to assemble and view large amounts of biological and land management data to identify areas (gaps) where conservation efforts may not be sufficient to maintain diversity of living natural resources. Historically, GAP has been conducted by individual states; however this has resulted in inconsistencies in mapped distributions of vegetation types and animal habitat across state lines because of differences in mapping and modeling protocols. This was further compounded from the lack of a national vegetation classification nomenclature. In response to these limitations, GAP embarked on a second-generation effort to conduct the program at a regional scale, using a vegetation classification scheme applicable across the US, and ecoregional units as the basis for segmenting the landscape into manageable units. The programs first formalized multi-state regional effort includes the five states (Arizona, Colorado, Nevada, New Mexico, and Utah) comprising the Southwest Regional GAP Analysis Project (SW ReGAP).

10:00 AM **GAP Analysis Program History.***COLLIN HOMER, SAIC, EROS Data Center, Sioux Falls, SD

10:20 AM **Southwest Regional Gap Analysis Project: an overview of project goals and organization.***PRIOR-MAGEE, JULIE. USGS - Biological Resources Discipline, Las Cruces, NM, USA.

The Southwest Regional Gap Analysis Project (SW ReGAP) is a mapping and assessment of biodiversity for the five-state region encompassing Arizona, Colorado, Nevada, New Mexico, and Utah. It is a multi-institutional cooperative effort coordinated by the National Gap Analysis Program of the U.S. Geological Survey. The primary objective of this project is to use a coordinated mapping approach to create detailed, seamless maps of land cover, habitat for terrestrial vertebrate species, land stewardship, and management status. This information is analyzed to identify animal species habitats and natural land cover types that are underrepresented on lands managed for their long term

conservation. Regional labs at Utah State University and New Mexico State University coordinate the development of products for land cover mapping, animal habitat modeling, and stewardship for the entire five-state region. Individual state labs work cooperatively through the regional labs to produce regionally consistent and seamless data sets for the Southwest. In addition to representatives from Utah and New Mexico State Universities, Colorado State University and Northern Arizona University are represented on the multi-institutional SW ReGAP team. The Colorado Division of Wildlife, U.S. Geological Survey, U.S. Environmental Protection Agency, Bureau of Land Management, U.S. Army Corps of Engineers, and NatureServe also provide staff support for mapping efforts in the Southwest states.

10:40 AM **Pre-Processing Techniques for SW ReGAP Land Cover Analysis.***SCHRADER, THEODORE SCOTT. University of New Mexico, New Mexico Cooperative Fish & Wildlife Research Unit, Las Cruces, NM, USA.

In an effort to create the best possible regional land cover map, several techniques have been utilized to consistently represent imagery across the region. The pre-processing techniques can be described as separate processes: satellite image selection to meet land cover-mapping goals, atmospheric standardization of adjacent imagery, and cloud and shadow removal in individual scenes. The Landsat 7 ETM+ platform was selected as the sensor to provide three seasons of imagery for the Southwest Gap Region: spring, summer, and fall. Characteristics of the ETM+ sensor include wide spatial, spectral, and temporal coverage of the imagery, are ideal for regional land cover mapping. Image standardization is the process of normalizing image pixel values for differences caused by sun intensity/angle, atmospheric effects, and instrument calibration. Several types of atmospheric standardization models were available to the region including DN-to-Reflectance Conversion, COST Atmospheric Correction, and COST Dark Object Subtraction Conversion. Each of these methods provide adequate standardization and only requires information contained within the original NLAPS formatted imagery not in-situ atmospheric measurements that are often difficult or impossible to obtain over vast regions. In some cases the very best available scenes still contain some areas that are inadequate for land cover mapping due to groups of clouds and associate shadows contained within the imagery. Several techniques have been utilized to isolate and remove these areas of the imagery that are influenced by clouds. These pre-processing steps occur before any land cover classifications are preformed and augment the initial scene selection process to create a seamless region-wide dataset of the best quality for land cover mapping.

11:00 AM **Land Cover Mapping Background: Training Data and Classification Methods.***LOWRY, JOHN, RAMSEY, DOUGLAS, KIRBY, JESSICA C., LANGS, LISA and RIETH, WENDY. Utah State University, Remote Sensing GIS Laboratory, Logan, UT, USA.

The SW ReGAP land cover mapping project involved the efforts of numerous people from five participating states. Mapping responsibilities were partitioned among state teams along ecoregional boundaries rather than political state boundaries. One aim of these partitions, or mapping zones, was to maximize spectral differentiation within areas of uniform ecological characteristics. Mapping zones also functioned as a means to divide the workload into logical units. From a project management standpoint, mapping zones formed the fundamental working unit by which training data were collected and image classification was performed. This presentation provides an overview of training data collection efforts, highlighting field data collection methods, efforts to acquire existing training data from other projects, and efforts to gather training data from remote sources such as aerial photography and digital orthophoto quads. We also provide a basic introduction to the use of Classification Trees for land cover mapping. The use of Classification Tree (CT) algorithms for land cover mapping is becoming increasingly common. Some of the advantages of CT include the ability

to effectively use both categorical and continuous predictor datasets with different measurement scales, good computational efficiency, and an intuitive hierarchical representation of discrimination rules.

11:20 AM **Standardized ecological classification in support of land cover mapping.***COMER, PATRICK J. and SCHULZ, KEITH A. NatureServe, Boulder, CO, USA.

Standardized ecological classification units should form the foundation for effective data collection, assessment, and reporting. Attempts at regional and national gap analysis often falter on this point, or struggle along inefficiently. Over the past decade, NatureServe has worked with the Gap Analysis Program and others to map existing vegetation using the hierarchical U.S. National Vegetation Classification (USNVC) classification standard. Experience has demonstrated the need to develop map units at scales that are intermediate in concept between the alliance level and formation level of the USNVC. The NatureServe terrestrial ecological system classification defines some 600 meso-scale vegetation-based units that are now standardized across the lower 48 United States. Ecological systems are described using multiple USNVC associations where they occur together on a given landscape due to similarities in environmental setting and ecological dynamics. By integrating environmental setting with vegetation into the concept of each unit, this classification lends itself to biophysical modeling and robust characterization of wildlife habitat. Approximately 125 ecological system units form the classification basis for mapping unaltered landscapes in the SW ReGAP effort. Mapping natural land cover using the ecological systems classification, often augmented with modifiers for specific variants in composition and structure, results in robust and standardized maps.

11:40 AM **Classification Tree Modeling: Sensitivity to Training Samples.***SAJWAJ, TODD D. [1], KEPNER, WILLIAM G. [2] and BRADFORD, DAVID F. [2]. [1]US Army Corp of Engineers, Las Vegas, NV, USA; [2]US Environmental Protection Agency, Landscape Ecology Branch, Las Vegas, NV, USA.

The Southwest Regional GAP Project uses a tree classifier algorithm and large quantities of ground-collected vegetation data to generate predictive land cover maps for the southwestern United States. The tree algorithm produces a model of binary decision rules. Because tree models have a strong tendency to be over-fit to sample data used to construct the model, we examined the influence of four characteristics of the initial training data set on model internal validation and map accuracy. **Data set size:** Using randomly-selected subsets of training data, we quantified the effects of data set size on the internal validation and map accuracy of tree models and vegetation maps. **Data screening:** We used new statistical tools to identify outliers within the training data, and compared the internal validation and map accuracies of Screened and Unscreened models. **Vegetation labeling errors:** We quantified our confidence in vegetation labels and assigned alternate labels to those sites with low confidence. The effects of removing those low-confidence training data altogether or using the alternate labels on internal validation and map accuracies were assessed. We will discuss the implications of these analyses on future large-scale mapping efforts, particularly the amounts data needed to map plant communities at large spatial scales, the need for data screening procedures for large, high dimensional data sets, and suggested tools to accompany the National Vegetation Classification System.

LUNCH BREAK 12:00 AM - 1:00 PM

1:00 PM **Overcoming chance agreement in classification tree modeling: predictor variables, training data, and spatial autocorrelation considerations.***WALLER, ERIC K. Colorado

Division of Wildlife, CO, USA.

Classification trees have substantial merit for vegetation mapping, but their application over large areas requires some special considerations. Error can occur in modeling due to chance agreement arising from inadequate sampling of the diversity of map classes with respect to any combination of predictor variables. The likelihood of this chance agreement increases with the addition of any predictor variables and with spatial autocorrelation. The coincidence of spatial autocorrelation in the sampled field data and spatial autocorrelation in the predictor variables that does not relate to natural patterns is especially problematic. The pseudoreplicating approach employed by the Southwest Regional GAP ensures that its training data are spatially autocorrelated. Even different sample sites can be autocorrelated the more so the less an area is sampled for its diversity. Additionally, many of the predictor variables used by Southwest ReGAP (especially those that are DEM derived) are heavily spatially autocorrelated as well. It was determined that these predictor variables did not always help in mapping the high plains of Colorado, and often had negative effects. Rather than sacrificing many of these predictor variables, an effective strategy involved identifying areas of disagreement between maps derived with and without DEM derived variables, and increasing the sampling of class diversity in these areas through satellite image interpretation. Although remotely sensed data have lower labeling confidence than field-collected data, overall map accuracy was improved. For large area vegetation mapping, obtaining training data that represent the diversity of classes across landscape variability appears to be paramount.

1:20 PM **SW ReGAP Land Cover Mapping Summary and Results.*** RAMSEY, DOUGLAS, LOWRY, JOHN, KIRBY, JESSICA C., LANGS, LISA and RIETH, WENDY. Utah State University, Remote Sensing GIS Laboratory, Logan, UT, USA.

Completion of the southwest regional land cover map is anticipated for June 2004. This presentation provides a summary of the work to date and highlights examples of completed portions of the regional land cover map. By dividing the region into regional mapping zones, the regional land cover product is actually a composition of multiple ecoregionally focused land cover maps. We address the issues associated with assuring regional consistency in land cover types across the region, and spatially edge-matching adjacent mapping zones. We also focus on methods to assess the validity of the final land cover map. An internal validation approach that withheld a 20% sample of available training sites was used to test the validity of the classification tree models. Error matrices were produced to estimate a by-class measure of map adequacy. We conclude with a summary of land cover related products that have been developed through the life of this project.

1:40 PM **The approach to animal habitat modeling in the Southwest Regional Gap Analysis Project.***BOYKIN, KENNETH G. [1,2], DEITNER, ROBERT A. [1,2] and PROPECK, SUZANNE [1,2]. [1]University of New Mexico, New Mexico Cooperative Fish and Wildlife Research Unit, Las Cruces, NM, USA; [2]New Mexico State University, Department of Fishery and Wildlife Sciences, Las Cruces, NM, USA.

Modeling animal habitat is a core part of every gap analysis project. This includes identifying species, and collecting and maintaining information on wildlife-habitat relationships (WHR), and updating this information through expert participation. The enormity of these tasks increases for regional projects which must deal with a larger number of species, greater spatial variation of habitats, and more complex personnel issues. The Southwest Regional Gap Analysis Projects task of modeling 836

taxa within the 5-state region provides an excellent platform on which to test new modeling approaches, techniques, and applications. We present an overview of the regional approach to: 1) select the taxa to be modeled, 2) identify lead states to collect taxa WHR models, 3) identify habitat layers for use in WHR associations, 4) model the taxa, 5) review the models, 6) access the models, and 6) contribute habitat information to the overall gap analysis.

2:00 PM **An Entity-Relationship Model of Wildlife Habitat Associations.*** DEITNER, ROBERT A. and BOYKIN, KENNETH G. University of New Mexico, New Mexico Cooperative Fish and Wildlife Research Unit, Las Cruces, NM, USA.

Wildlife habitat associations are typically evaluated with rule-based models meant to describe the suitability of habitats to an animal given a set of habitat criteria. We present a generalization of this process using entity-relationship modeling techniques, the advantage being that it is the basis of a well-designed database system. Wildlife habitat associations can be viewed by analogy to grammar. A wildlife habitat association is a one-paragraph statement that contains an indeterminate number of sentences, the simplest being a single sentence composed of one clause. Thus, there are two major entities involved with a wildlife habitat association. The "clause" is the relationship between suitability and a single habitat criterion. Clauses are classified into four types based on whether the habitat criterion is numeric or categorical and measure of habitat suitability is numeric or categorical. The second entity, "statement," contains the rules for combining multiple clauses into a single measure of habitat suitability. Statements are analogous to a paragraph but are represented as algebraic expressions where individual clauses are combined with operators and functions to produce a single habitat suitability measure. We present an implementation of an integrated data system that is based on this entity-relationship model. Its purpose is to produce spatially explicit depictions of any wildlife habitat relation. Because the system is based on a well-designed database, it scalable and an ideal infrastructure for large-scale habitat modeling exercises like SW ReGAP.

2:20 PM **A Comparison of Approaches for Verifying Southwestern Regional Gap Vertebrate Habitat Distribution Models.***WYNNE, J. JUDSON, DROST, CHARLES A. and THOMAS, KATHRYN A. USGS-Southwest Biological Science Center, Colorado Plateau Research Station, Flagstaff, AZ, USA.

Vertebrate habitat distribution models for the Gap Analysis Program are typically developed using literature-derived information. Accuracy of these regional models is difficult to assess due to their broad geographic extent and the paucity of landscape level verification data for most of the modeled species. For Gap analysis, the recommended approach for accessing model accuracy has been to compare species lists for geographically defined areas (e.g., National Parks) with predictive habitat models to derive a measure of agreement. Due to the generalization of species lists over large areas, and a variety of associated errors and assumptions, this approach has serious limitations and is potentially misleading. We will evaluate species lists, as well as other available datasets for assessing the accuracy of vertebrate habitat distribution models. These datasets include recent National Park Service inventory studies, area-based species lists, and point-based records of species occurrence (e.g., museum specimen data and species presence/ absence data from research projects). Focusing on vertebrate habitat distribution models for Arizona and New Mexico, we will compare and contrast, as well as identify strengths and weaknesses, of these datasets for accuracy assessment.

BREAK 2:40 PM - 3:00 PM

3:00 PM **Depicting uncertainty in wildlife habitat suitability models using Bayesian inference and expert opinion.*** O'BRIEN, LEE E. Colorado State University, Natural Resource Ecology Lab, Fort Collins, CO, USA.

Wildlife habitat suitability models based upon wildlife habitat relationships, such as those used in the Gap Analysis Program, have been criticized because they lack quantification of uncertainty in the final predicted habitat distribution maps. The maps are typically binary maps depicting only suitable and unsuitable habitat without any indication of how strong the evidence is for these predictions across the area. In land cover mapping, the accuracy of extrapolated classifications is derived by withholding field site samples from the classification and comparing them to the final map in an accuracy assessment. This is not feasible with wildlife habitat models, since what is being modeled is wildlife habitat suitability and not wildlife occurrence, and even if wildlife locations could be used as a test of accuracy, comprehensive wildlife distribution data for most species are scarce. Therefore, this method was developed to reveal uncertainty in predicted habitat distributions by using Bayesian inference to combine expert opinion about the strength of wildlife habitat relationships with prior model parameters. An evaluation of the method and the utility to the Gap Analysis Program will be presented.

3:20 PM **A Regional Approach to Stewardship Mapping for the Southwest Regional Gap Analysis Project.** *ERNST, ANDREA E. [1], PRIOR-MAGEE, JULIE [2] and BOYKIN, KENNETH G. [1]. [1]New Mexico State University, New Mexico Cooperative Fish & Wildlife Research Unit, Las Cruces, NM, USA; [2]USGS Biological Resources Division NM, USA.

The primary purpose of GAP is to provide an assessment of conservation status of species and their habitats. One of the fundamental components of a gap analysis is to produce a data layer depicting geographic boundaries that represent land ownership, land management, and a measure of intent to maintain biodiversity. Maps of land ownership have traditionally depicted broadly defined boundaries of individual land parcels, in which subdivisions that receive different levels of protection may not be distinguished. The GAP land steward data depicts the geographic boundaries of public lands by managing agency, voluntarily identified private conservation lands, and other private lands at a finer level of detail. Additionally, this regional approach to stewardship mapping provides a consistent manner of stewardship categorization, which minimizes the subjectivity in interpretation across state boundaries. The SW ReGAP stewardship effort is accomplishing this task by developing a regional geodatabase, which incorporates base information collected from the Protected Areas Database (developed by the Conservation Biology Institute) in conjunction with updates from the Bureau of Land Management ownership data. New information is being incorporated, as new contacts are being established. In addition, current efforts are coordinating with the Colorado Ownership, Management, and Protection project (CO Map). A fundamental data layer to the final GAP product, the land stewardship data updates geographic boundaries of land ownership and provides a spatial representation of the existing network of conservation lands. This information not only provides the basis on which the GAP analysis is performed, but also provides a regional land stewardship map in which more informed management decisions regarding biodiversity protection can be based.

3:40 PM **Gap analysis: GIS, maps and a new view of regional conservation.*** THOMAS, KATHRYN A. U.S. Geological Survey Southwest Biological Science Center, Flagstaff, AZ.

The fourth step of a gap analysis, as developed by the National Gap Analysis Program, is an assessment of the representation of vegetation types and vertebrate species in areas managed for long-term maintenance of native biodiversity. This conservation assessment uses the products of the first three steps; a land cover map, vertebrate-habitat distribution maps and a land stewardship map;

as input. The land cover map is overlain with the land stewardship map in a GIS to produce statistics on the representation of vegetation types among four stewardship categories which each represent a different level of legally mandated conservation management. Likewise, each vertebrate-habitat map is overlain with the land stewardship map to produce statistics of the representation of the vertebrate predicted habitat among the stewardship categories. Gap analysis also produces maps showing spatial patterns of conservation protection, conservation gaps and predicted species richness. Products developed through these analyses may assist decision makers and managers at a regional and landscape scale by providing the information to: (1) determine the contribution of a particular land unit to species or community conservation; (2) evaluate the continuity or fragmentation of conservation stewardship across the landscape; (3) assess the overall stewardship representation of a particular species, suite of species or vegetation community (4) identify potential biodiversity hot spots; and, (5) develop habitat management plans.

4:00 PM **Projected Benefits of Regional Gap Analysis in Support of State Wildlife Agency Development of Comprehensive Wildlife Conservation Plans.***SCHRUPP, DON L. Colorado Division of Wildlife - Habitat Section, Denver, CO, USA.

Gap Analyses have primary goals to provide assessments of the management status for vegetation communities and animal species, and to provide land stewards information on the representation of these elements on their lands to provide for informed decision making about management practices relative to maintaining biodiversity. State wildlife agencies that are participatory under the State Wildlife Grants program (USFWS) need to develop Comprehensive Wildlife Conservation Plans by October, 2005. Forty-seven of the fifty States are projected to have State GAP reports completed on or before 2004, which should be of some utility in identifying their 'Species of Greatest Conservation Need'. However, in order for a State to project species conservation needs in an ecological sense, they would benefit in portraying their species habitat conservation needs from a landscape perspective. Given even subtle variations in development of State GAP baseline information and models, aggregations of individual report information to a landscape level are not without problems. A number of the underlying inconsistencies are being targeted for resolution under the developing methodologies for 'Regional Gap Analysis Projects'. I'll identify the sought after benefits of regionally developed datasets that should help in addressing landscape perspectives that could be applied to Comprehensive Wildlife Conservation Plan development.

4:20 PM **The Southwest Regional Gap Analysis Project: A Database Model for Regional Landscape Assessment, Resource Planning, and Vulnerability Analysis.*** KEPNER, WILLIAM G.[1], COMER, PATRICK [2], OSBORNE, DIANE [3], SEMMENS, DARIUS [4] and GERGELY, KEVIN [5]. [1]US Environmental Protection Agency, Las Vegas, NV, USA; [2]NatureServe, Boulder, CO, USA; [3]US Bureau of Land Management, Denver, CO, USA; [4]USDA, Agricultural Research Service, Tucson, AZ, USA; [5]U.S. Geological Survey, Moscow, ID, USA.

The Gap Analysis Program (GAP) is a national interagency program that maps the distribution of plant communities and selected animal species and compares these distributions with land stewardship to identify biotic elements at potential risk of endangerment. Acquisition of primary data and database development are an initial feature of any landscape indicator and assessment project, including conservation mapping. The Southwest Regional GAP spatial data have been developed for the purpose of creating a regional tool for assessing biodiversity protection. One intent of the project is to make the database available in a format that can be used by other researchers, public agencies, resource managers, non-governmental organizations, decision-makers, and user groups. Additionally, the information can be utilized for resource management planning actions and other geographic

initiatives to characterize relative vulnerability of natural resources within the 5-state area. It is the premise of this project that landscape composition and pattern measures are diagnostic of environmental and hydrological condition and can be quantitatively measured using GIS and remote sensing-based technologies. Acquisition of primary data is the first step of any research process to develop regional, state, and watershed scale environmental assessment and to predict future environmental risk to include other socially relevant end-points in addition to biodiversity.

4:40 PM **Southwest Regional GAP Analysis Special Session Closing** *COLLIN HOMER, SAIC, EROS Data Center, Sioux Falls, SD