ANALYSIS OF BIRD HABITAT-BASED BIODIVERSITY METRICS AT A NATIONAL SCALE

Kenneth G. Boykin[1], William G. Kepner[2], David F. Bradford[2], Anne C. Neale [3], and Kevin J. Gergely[4]

[1] New Mexico Cooperative Fish and Wildlife Research Unit, Department of Fish, Wildlife, and Conservation Ecology, New Mexico State University, Las Cruces, New Mexico, USA, 88003
[2] U.S. Environmental Protection Agency, Office of Research and Development, Las Vegas, Nevada, USA 89119
[3] U.S. Environmental Protection Agency, Office of Research and Development, Las Vegas, Nevada, USA 89119
[4] U.S. Geological Survey, Gap Analysis Program, Moscow, Idaho, USA 83843

Introduction

Ecosystem services have become a key issue of this century in resource management, conservation planning, and environmental decision analysis. Mapping and quantifying ecosystem services have become strategic national interests for integrating ecology with economics to help understand the effects of human policies and actions and their subsequent impacts on both ecosystem function and human well-being. Some characteristics of biodiversity are valued by humans in varied ways, and thus are important to include in any assessment that seeks to identify and quantify the benefits of ecosystems to humans. Some biodiversity metrics clearly reflect ecosystem services (e.g., abundance and diversity of game species), whereas others reflect indirect and difficult to quantify relationships to services (e.g., relevance of species diversity to ecosystem resilience, cultural value of native species). Wildlife habitat has been modeled at broad spatial scales and can be used to map a number of biodiversity metrics.

In the present study, we map metrics reflecting ecosystem services or biodiversity features derived from US Geological Survey Gap Analysis Program data for land cover and habitat models for bird species. We present results of metrics focusing on total bird species and species identified by federal and state agencies or non-governmental organizations as species of interest based on conservation (birds of conservation concern, Partners in Flight, and wetland habitat) or climate vulnerability as identified by Audubon (Climate Endangered and Climate Threatened). The project has been conducted at multiple scales in a phased approach, starting with place-based studies, then multi-state regional areas, culminating in the national-level EnviroAtlas. Previous analysis has been conducted at the watershed and regional scales (See Boykin et al. 2013).

Methods

We focus on ecosystem services representing differing services such as biodiversity conservation recreational, cultural and aesthetic values, and food, fiber (Table 1).

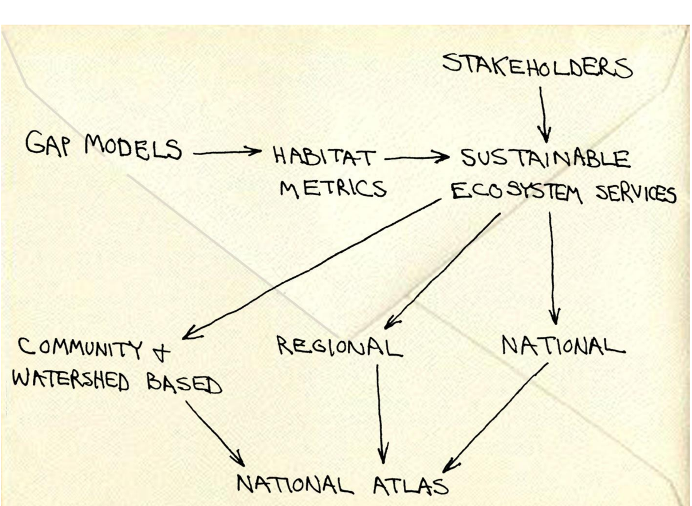
The USGS National Gap Analysis Program (GAP) is completing species distribution models across all vertebrate species' ranges within the U.S. (Aycrigg et al. 2011). These species ranges and models provide a baseline that can be iteratively improved when new data become available (See http://gapanalysis.usgs.gov/). These data also provide the basis of a national biodiversity assessment.

We used species richness for selected species groups, as metrics to represent ecosystem services or other biodiversity aspects of concern. For example, metrics reflecting harvestable species and high bird species richness represent economic, recreational, and esthetic value. To develop the species richness metrics, we used all the bird deductive habitat models from the National Gap Analysis Program. Predictive environmental variables (e.g., land cover, elevation, distance to water) are used to derive deductive habitat models for each species. Deductive models use expert knowledge and literature to identify wildlife habitat relationships that are then depicted spatially. GAP modeled habitat for 649 bird species across the conterminous United States. Models identified presence/absence of suitable habitat for each 30-m pixel. We then determined species richness for selected groups by combining the individual species datasets included in the group and identified the number of species with predicted suitable habitat for each pixel using ArcGIS 10.1 (ESRI, Redlands, CA, US). The groups of taxa were identified through stakeholder workshops to identify biodiversity metrics of concern, and through presentations at scientific meetings. Stakeholders comprised individuals from federal and state agencies and nongovernmental organization who may ultimately benefit from the information generated within the project in regard to improved environmental decision making. Stakeholders were considered a key element to the metric selection process and provided great input and influence over the project's objectives and outcomes.

We present 6 species richness metrics including all birds, species on the Partners in Flight national list, Birds of conservation concern and birds that use wetlands habitats from the "State of the Birds" report, and birds recently identified by the Audubon climate vulnerable study (http://climate.audubon.org/) including climate endangered and climate threatened species (Table 1). Workshop participants also identified metrics for further consideration (e.g., economic or recreationally important species, and common but declining species). Metric values for two study areas with the Desert Landscape Conservation Cooperative (DLCC) and conterminous US (Nation) are represented as maps. To facilitate comparison of metric values among the study areas, we normalized the mean value for each metric for a given study area relative to the maximum value among all pixels in the nation. Thus, normalized metric values ranged from 0 to 1. These normalized values are represented for in a radar graph to provide a single means of comparison (Tallis et al., 2008).

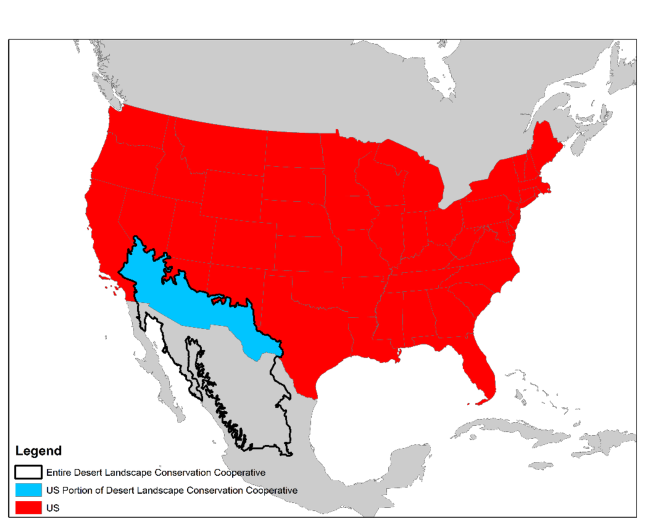
Table 1. Example Metrics

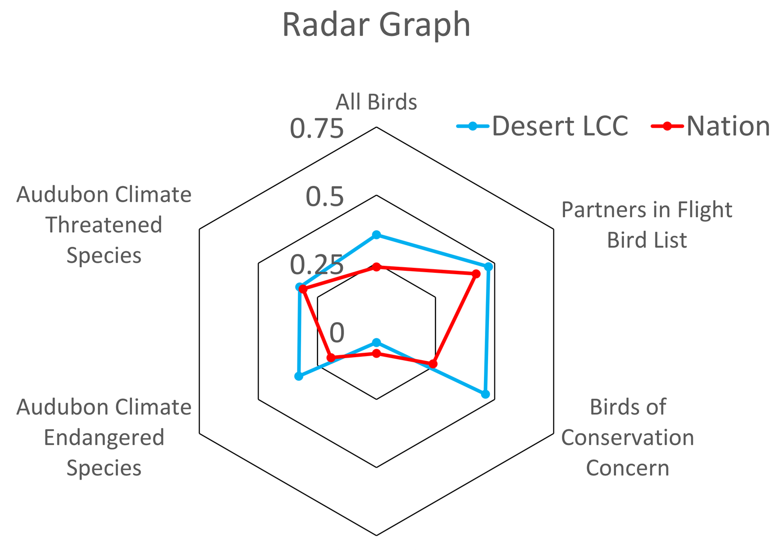
Category	Ecosystem Service	Description
Taxon	Biodiversity Conservation/ recreational, cultural and aesthetic	*Birds (n=649)
Priority Species	Biodiversity Conservation/ recreational, cultural and aesthetic	Threatened and Endangered Species (n=21)
Harvestable	Food and Fiber/ recreational, cultural and aesthetic	All Harvestable Species (n=93)
Ecosystem Specific	Biodiversity Conservation	Riparian Obligate
Ecosystem Specific	Biodiversity Conservation	Grassland Obligates
Specific Taxa	Biodiversity Conservation/recreational, cultural and aesthetic	Breeding birds
Specific Taxa	Biodiversity Conservation/recreational, cultural and aesthetic	Wintering birds
Priority Species	Biodiversity Conservation	Federal Candidate or Sensitive Species (FWS, BLM, USFS, DOD, TNC)
Priority Species	Biodiversity Conservation	Common but Declining Species
Priority Species	Biodiversity Conservation	*PIF - partners in flight - national list (n=154)
Priority Species	Biodiversity Conservation	*Birds of Conservation Concern (n=160) from State of the Birds (2011)
Priority Species	Biodiversity Conservation	*Wetland Habitat (n=152) from State of the Birds (2011)
Priority Species	Biodiversity Conservation	NatureServe Global Rank Species (G1,G2, or G3 Listed)
Priority Species	Biodiversity Conservation	IUCN Listed
Priority Species	Biodiversity Conservation	*Audubon Climate Endangered (n=127)
Priority Species	Biodiversity Conservation	*Audubon Climate Threatened (n=183)



Results

In four (all birds, PIF birds, BCC, and climate endangered species) of the six metrics analyzed, the Desert LCC has more species than the conterminous nation on average (Radar Graph). In one metric (climate threatened) both areas are relatively similar. In one metric (wetland habitat), the national average is higher than the Desert LCC. The Desert LCC has less than 2% of the landscape comprised of wetland or riparian areas.

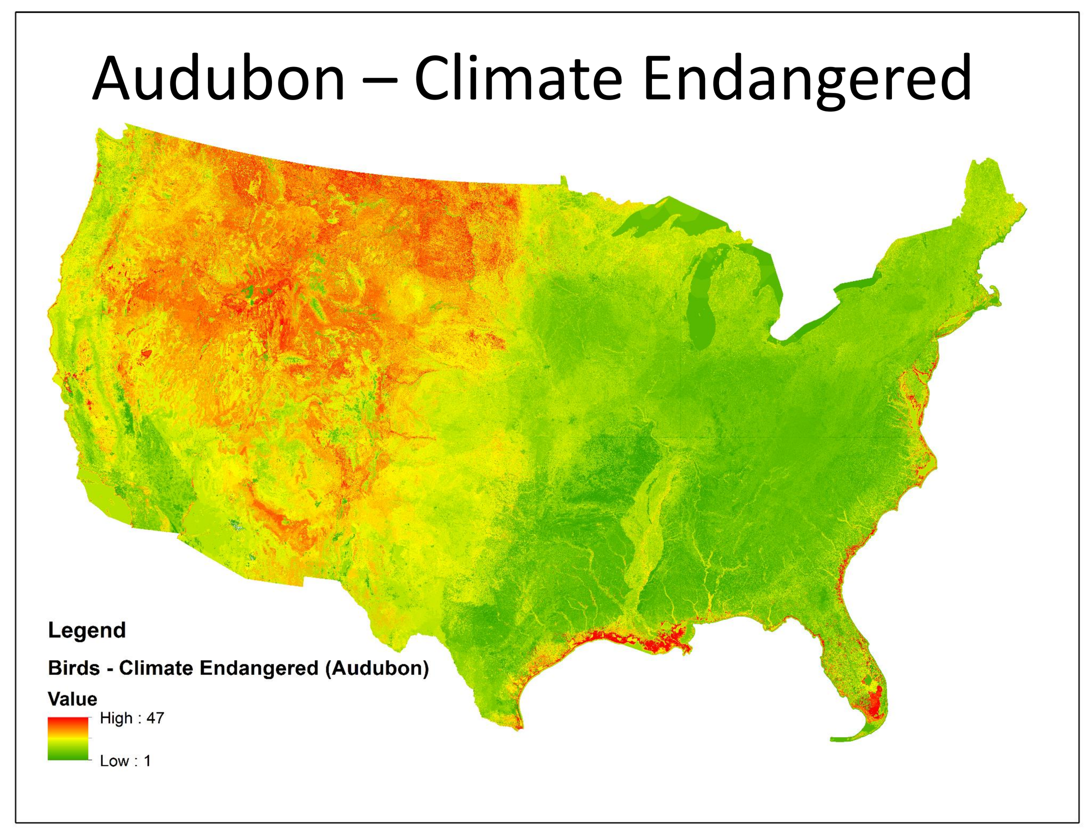


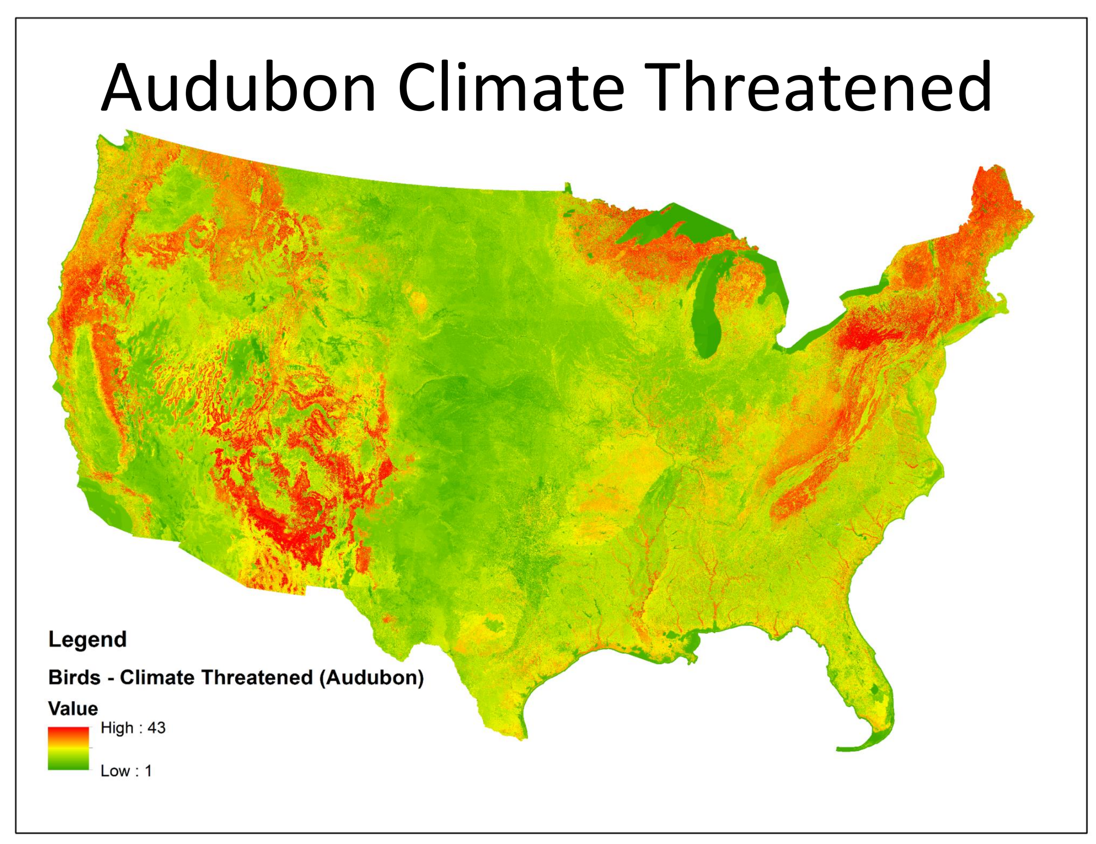


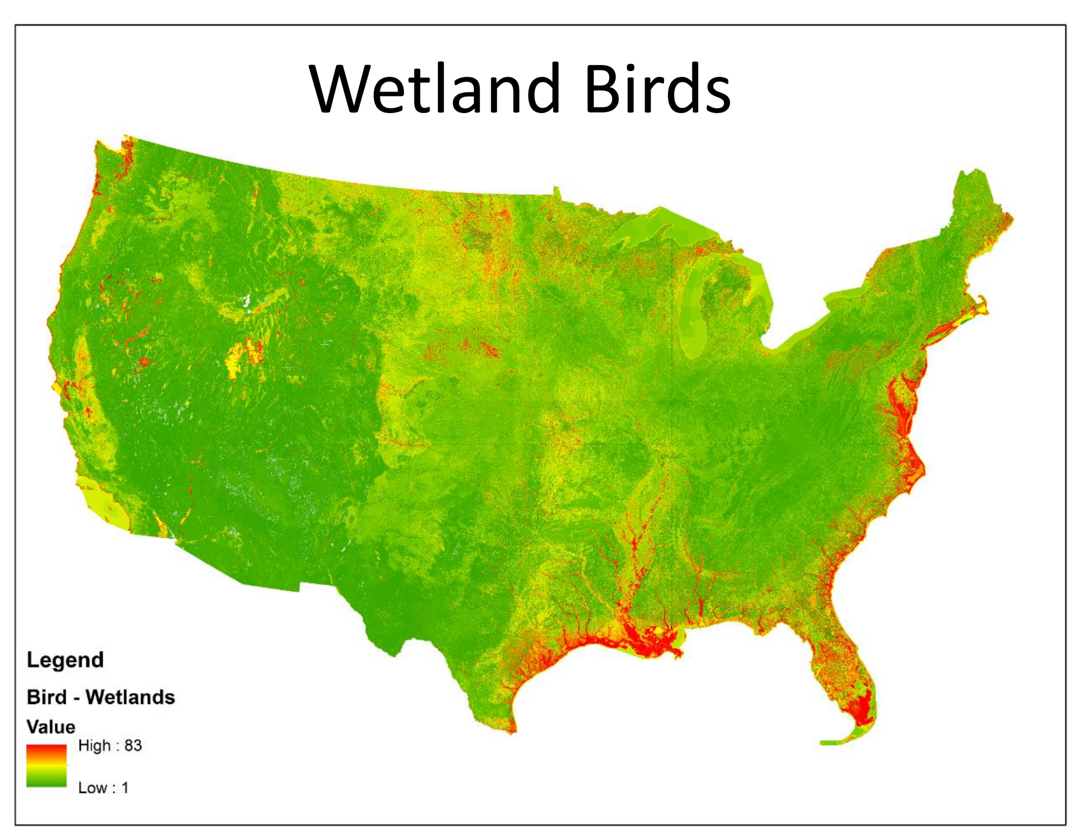
Analysis: The mean normalized index of biodiversity is presented for the Desert Landscape Conservation Cooperative (Blue) and the contiguous United States (Red). Normalized values are presented in the radar graph (left) indicating the value for the metric for the Desert Landscape Conservation Cooperative and the contiguous United States with corresponding colors.

EnviroAtlas -- Nature's Benefits Categories

- Clean Air
- Clean & Plentiful Water
- Biodiversity Conservation
- Natural Hazard Mitigation
- Climate Stabilization
- Food, Fiber & Materials
- Recreation, Culture & Aesthetics
- Food, Fiber & Materials
- Biodiversity Conservation

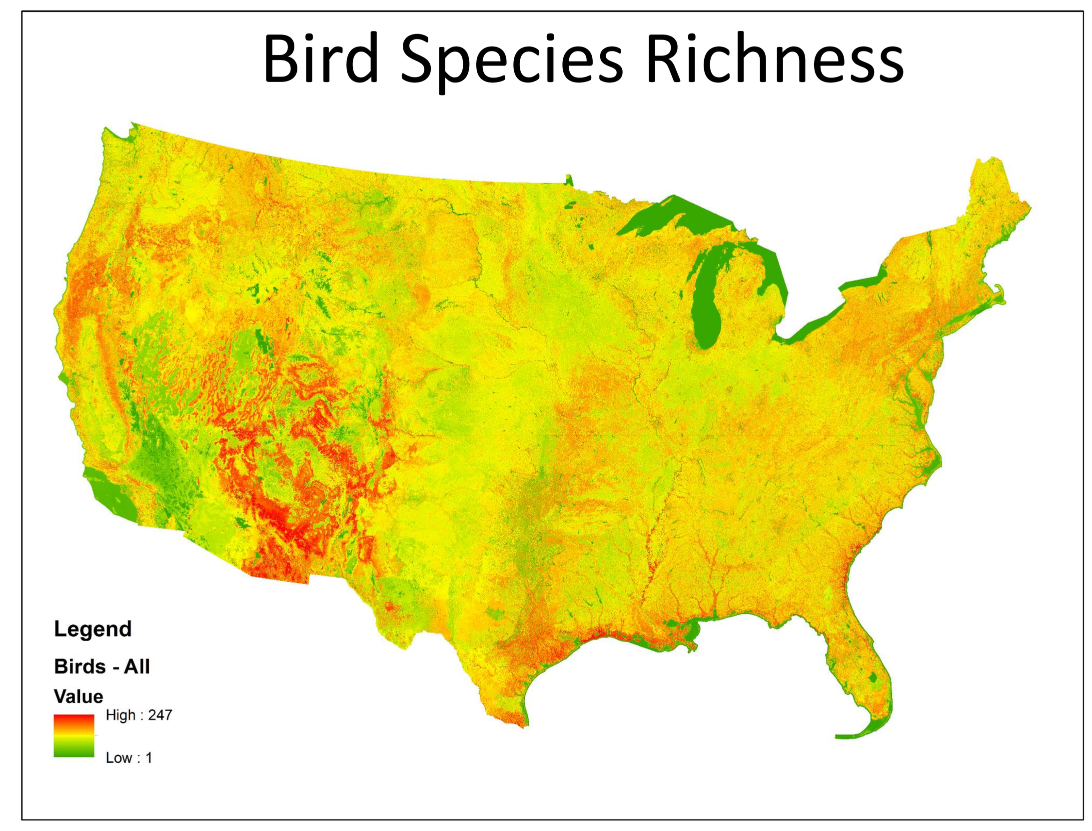


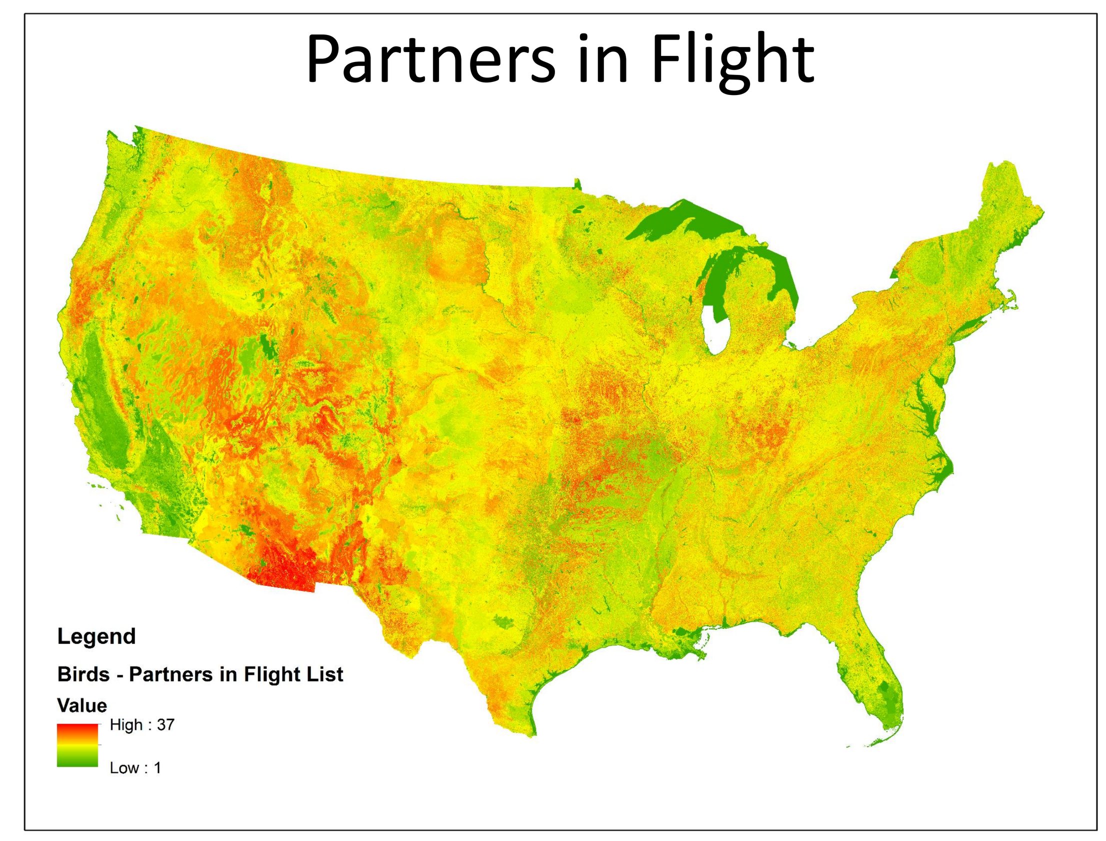


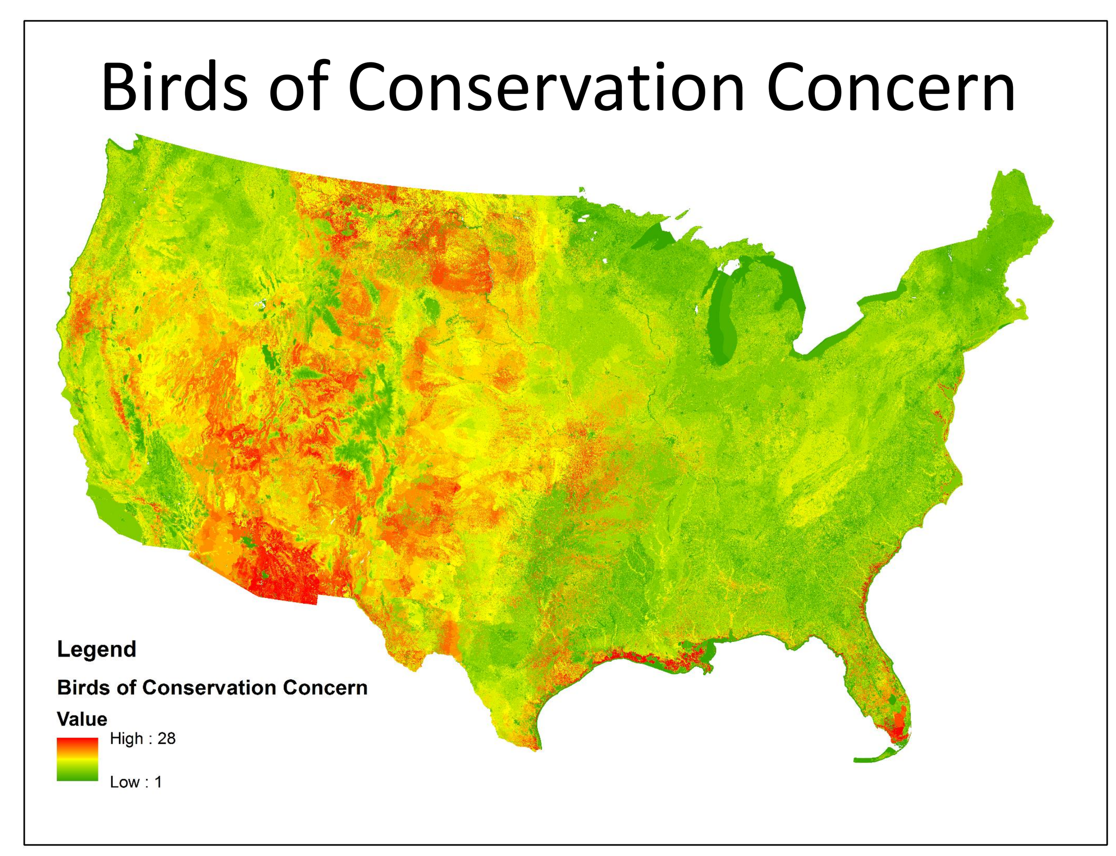


Example National Spatial Data Layers

Biodiversity Conservation & Recreation, Culture & Aesthetics







Discussion

Recently there has been interest in developing common processes and methodologies to monitor the status and trends of ecosystem services and biodiversity, especially scalable metrics (Sparks et al., 2011; UNEP-WCMC, 2011; BIP, 2011). However, ecosystem services and biodiversity are multi-faceted, such that multiple metrics are needed to provide a comprehensive assessment. This approach, including the stakeholder evaluation, can be used anywhere and at varying scales where deductive habitat models and contemporary digital land cover datasets are available. The process can be responsive to stakeholder needs. Decision makers use a wide variety of tools and address a wide variety of questions. This process provides a responsive tool to provide decision makers more information regarding ecosystem services.

We evaluated 6 metrics that reflect broad aspects of biodiversity (i.e., all bird species, birds of conservation concern, wetland habitat, and Audubon listed Climate Endangered species). Total species richness is a fundamental metric of biodiversity that is commonly used to characterize conservation areas of interest (Scott et al., 1987; Egoh et al., 2009). Birds of conservation concern, Partners in Flight list, wetland habitat were identified by bird conservation efforts and provide recreational and cultural services. Species richness for these three groups reflect stakeholder interest and are both directly tied to economic benefit (e.g., bird watching) and expenditure (e.g., species conservation). Climate vulnerable species metrics provide information for the emphasis on climate change.

Ecosystem services and biodiversity are valued by humans in diverse ways and have subjective significance depending on culture and perspectives based on assumed roles, e.g., user groups, resource managers, and regulatory decision-makers (Turnhout et al., 2012). The stakeholder outreach conducted in the present study, i.e., workshop and presentations at scientific conferences, yielded a better understanding of the needs and relevance of existing metrics and the identification of additional relevant metrics. Although some of the metrics may be useful to some users for characterizing a single area or theme of interest, other users may consider the metrics to be of great utility in addressing biodiversity conservation. Moreover, ecosystem services represented by biodiversity metrics may not be provided by the entire ecosystem and the 'service' may only be provided by select sets or groups of species, especially those that provide specific ecosystem functionality or economic incentive (Ridder, 2008).

Multiple national and international (e.g., IPBES, TEEB, GEO BON, DIVERSITAS) outlets are appropriate for the products we have presented. Our work is one component of the EnviroAtlas that is currently under development by the US Environmental Protection Agency and its partner agencies. The Atlas allows users to view and analyze these data spatially and within a framework that simultaneously allows the analysis of multiple categories of ecosystem services and biodiversity, highlighting opportunities for improving the provision of ecosystem services and benefits from the environment. By linking to other decision support tools, the EnviroAtlas will provide an increasingly functional tool to inform decision-making from the national to local scale.

References

Aycrigg J., G. Beauvais, T.Gotthardt, K. Boykin, S.Williams, S. Lennartz, K.T. Vierling, S. Martinuzzi, and L.A. Vierling. 2011. Mapping Species Ranges and Distribution Models across the United States, Pp. 12-20. In Maxwell, Jill, Gergely, K., and Aycrigg, J., editors. 2011. Gap Analysis Bulletin No. 18. USGS/BRD/Gap Analysis Program, Moscow, ID

Biodiversity Indicators Partnership, 2011. Guidance for National Biodiversity Indicator Development and Use. UNEP World Conservation Monitoring Centre, Cambridge, UK, p. 40.

Boykin, K.G., W.G. Kepner, D.F. Bradford, R.K. Guy, D.A. Kopp, A.K. Leimer, E.A. Samson, N.F. East, A.C. Neale, and K.J. Gergely. 2013. A National Approach for Mapping and Quantifying Habitat-based Biodiversity Metrics across Multiple Spatial Scales. *Ecological Indicators*, 33:139-147. ISSN 1470-160X, 10.1016/j.ecolind.2012.11.005.

Egoh, B., Reyers, B., Rouget, M., Bode, M., Richardson, D.M., 2009. Spatial congruence between biodiversity and ecosystem services in South Africa. Biol. Conserv. 142, 553–562.

Ridder, B., 2008. Questioning the ecosystem services argument for biodiversity conservation. Biodivers. Conserv. 17, 781–790.

Scott, J.M., Jacobi, J.J., Estes, J.E., 1987. Species richness: a geographic approach to protecting future biological diversity. Bioscience 37, 782–788.

Sparks, T.H., Butchart, S.H.M., Balmford, A., Bennun, L., Stanwell-Smith, D., Walpole, M., Bates, N.R., Bomhard, B., Buchanan, G.M., Chenery, A.M., Collen, B., Csirke, J., Diaz, R.J., Dulvy, N.K., Fitzgerald, C., Kapos, V., Mayaux, P., Tierney, M., Waycott, M., Wood, L.R.E.G., 2011. Linked indicator sets for addressing biodiversity loss. Oryx 45, 411–419.

Tallis, H., Karieva, P., Marvier, M., Chang, A., 2008. An ecosystem services framework to support both practical conservation and economic development. Proc. Natl. Acad. Sci. U.S.A. 105, 9457–9464.

Turnhout, E., Bloomfield, B., Hulme, M., Vogel, J., Wynne, B., 2012. Conservation policy: listen to the voices of experience. Nature 488, 454–455.

United Nations Environment Programme World Conservation Monitoring Centre, 2011. Developing Ecosystem Service Indicators: Experiences and Lessons Learned from Sub-global Assessments and Other Initiatives. Secretariat of the Convention on Biological Diversity, Montréal. Canada, Technical Series, 58, p. 118.