Issues and Perspectives

A National Geographic Framework for Guiding Conservation on a Landscape Scale

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Abstract

The U.S. Fish and Wildlife Service, along with the global conservation community, has recognized that the conservation challenges of the 21st century far exceed the responsibilities and footprint of any individual agency or program. The ecological effects of climate change and other anthropogenic stressors do not recognize geopolitical boundaries and, as such, demand a national geographic framework to provide structure for cross-jurisdictional and landscape-scale conservation strategies. In 2009, a new map of ecologically based conservation regions in which to organize capacity and implement strategic habitat conservation was developed using rapid prototyping and expert elicitation by an interagency team of U.S. Fish and Wildlife Service and U.S. Geological Survey scientists and conservation professionals. Incorporating Bird Conservation Regions, Freshwater Ecoregions, and U.S. Geological Survey hydrologic unit codes, the new geographic framework provides a spatial template for building conservation capacity and focusing biological planning and conservation design efforts. The Department of Interior's Landscape Conservation Cooperatives are being organized in these new conservation regions as multi-stakeholder collaborations for improved conservation science and management.

Keywords: habitat; landscape conservation; structured decision making

Received: May 2, 2011; Accepted: February 16, 2012; Published Online Early: March 2012; Published: June 2012

Citation: Millard MJ, Czarnecki CA, Morton JM, Brandt LA, Briggs JS, Shipley FS, Sayre R, Sponholtz PJ, Perkins D, Simpkins DG, Taylor J. 2012. A national geographic framework for guiding conservation on a landscape scale. *Journal of Fish and Wildlife Management* 3(1):175-183; e1944-687X. doi: 10.3996/052011-JFWM-030

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Introduction

The conservation challenges of the 21st century continue to mount, driven by human development, land-use change, environmental contaminants, habitat fragmentation, invasive species, agricultural practices, and water quality and quantity issues. Accelerating climate change amplifies these existing stressors and presents new threats to fish and wildlife resources (Parmesan and Yohe 2003). The effects of climate change are neither isolated nor limited to a small number of vulnerable species and habitats; the impacts are global (Lovejoy and Hannah 2005), and they are increasing in magnitude (U.S. Fish and Wildlife Service 2009, Archived Material in Dryad, Reference S1, http://datadryad.org/handle/10255/dryad.38037). The combined influences of climate change and other stressors provide the impetus to expand traditional conservation planning to encompass larger spatial scales and unified efforts from multiple partners (Opdam and Wascher 2004).

Since its beginnings in 1871 as the U.S. Commission on Fish and Fisheries, the U.S. Fish and Wildlife Service (Service) has enjoined others to work together to conserve, protect, and enhance fish, wildlife, plants, and their habitats for the continuing benefit of the American people. Recognizing that the challenges of the 21st century will require increased coordination of these efforts at broader spatial scales, the Service has recently undertaken operational changes and improvements to better fulfill its mission and remain an effective leader in conservation. In 2006, the Service adopted strategic habitat conservation (SHC) as a new business model to facilitate adaptive resource management at landscape scales (National Ecological Assessment Team 2006, Archived Material in Dryad, Reference S2, http://datadryad.org/handle/10255/dryad.38037; Williams et al. 2007, Archived Material in Dryad, Reference S3, http://datadryad.org/handle/10255/dryad.38037). Development of the SHC concept was guided by an executive oversight team (EOC) composed of leaders from the Service and its primary science collaborator, the U.S. Geological Survey (USGS). Strategic habitat conservation is a landscape-based approach to resource conservation that focuses on the principles of strategic prioritization and adaptive management and explicitly recognizes that resource conservation goes beyond a single organization or geopolitical boundary. The goal is to maintain or create landscapes that are capable of sustaining explicitly defined population levels of fish and wildlife resources. Successful implementation of strategic landscape-level adaptive management requires integrating biological planning, conservation design, conservation delivery, monitoring, and research into the operations of the Service as well as the entire conservation community. Advancing the focus of the conservation community from site-specific actions with local outputs to desired landscape-scale outcomes for fish and wildlife populations is a primary goal of the Department of the Interior's conservation paradigm. Many other conservation organizations are following these principles in the context of their work (e.g., The Nature Conservancy's Conservation by Design).

Executive leaders of USGS and the Service proposed that effective implementation of SHC across the nation would require an ecologically meaningful, seamless, and scalable national framework that would identify the appropriate geographic regions in which to organize resources. In 2009, the Service solicited feedback throughout the agency on the need and key criteria for a national geographic framework (Woods and Morey 2009, Archived Material in Dryad, Reference S4, http://datadryad.org/handle/10255/dryad.38037). That effort occurred over a 6-wk period and involved over 80 individuals from diverse positions in the Service. The following three questions were addressed (Woods and Morey 2009, Archived Material in Dryad, Reference S4, http://datadryad.org/handle/10255/dryad.38037): 1) Will a geographic framework improve SHC implementation? 2) Does the Service need a geographic framework that is common to all regions and programs? and 3) What geographic framework should the Service use? During the process, desirable attributes of a national network of conservation regions were developed and contrasted to undesirable attributes (e.g., geographic subunits based solely on political boundaries). The process provided affirmative answers to the first two questions and the third question was resolved with a recommendation that Bird Conservation Regions (BCRs; Map S1, Archived Material in Dryad, http://datadryad.org/handle/10255/dryad.38037), with additional consideration of watershed boundaries, form the basis of the new geographic framework. In response to this recommendation, the EOC convened an interagency team of USGS and Service personnel with experience in ecology, geographic information systems, species biology, and landscape planning. During a 3-d workshop in June 2009, the team was tasked with developing a seamless national geographic framework to provide the spatial context for implementing landscape-scale conservation (i.e., SHC). Here we describe the process, criteria, and information used at that workshop to develop the national geographic framework.

The Workshop

The team was assembled at the National Conservation Training Center in Shepherdstown, West Virginia, for a 3-d workshop in June 2009. The EOC instructed the team to strategically aggregate the existing 35 U.S. BCRs (U.S. North American Bird Conservation Initiative Committee 2000, Archived Material in Dryad, Reference S5, http://datadryad.org/handle/10255/dryad.38037) to form the new national geographic framework. The EOC decided BCRs represent useful building blocks for a national framework because they are based on a hierarchical framework of nested ecological units delineated by the Commission for Environmental Cooperation (CEC 1997). The CEC classification system incorporates all major components of ecosystems: air, water, land, and biota, including humans, and is based on Omernik/U.S. Environmental Protection Agency ecoregions (Omernik 1987). The BCRs were subsequently created by aggregating CEC level II, III, and IV ecoregions in combinations that reflected current understanding of bird species distribution and life history requirements (CEC 1997).

The EOC envisioned the new seamless, nationwide framework would facilitate biological planning and conservation design for migratory bird and terrestrial and aquatic interests, be scalable to address emerging conservation challenges, focus scientific capacity for terrestrial and aquatic species conservation, and be easily understandable. The EOC desired a thoughtful combination of BCRs, or partial BCRs, to accomplish this task and further specified that terrestrial, aquatic, and avian ecotypes be explicitly considered and heterogeneity within the resultant geographic regions (hereafter, ''subunits'') be minimized. Fidelity to BCR boundaries is desirable because these units are continental in scope and are used by the North American Bird Conservation Initiative as a common ecological planning unit for national and international migratory bird conservation.

The team developed both ecological and management-focused criteria to evaluate alternative geographic configurations of BCRs. The team recognized no single map would completely satisfy avian, terrestrial, aquatic, and partnership objectives. Therefore, with ongoing feedback from EOC representatives, the team identified three primary criteria and rationale for aggregating BCRs into larger conservation subunits: 1) avoid fragmentation of BCRs as much as possible, 2) retain ecological homogeneity within framework subunits as much as possible, and 3) respect geographic boundaries already established by existing nationally significant partnerships; for example, state-based conservation efforts and watershed-defined habitat and species restoration collaboratives, in addition to the Migratory Bird Joint Ventures (JVs; partnerships established under the North American Waterfowl Management Plan [NAWMP] to help conserve the continent's waterfowl populations and habitats; NAWMP Plan Committee 2004, Archived Material in Dryad, Reference S6, http://datadryad.org/handle/10255/dryad.38037).

Ecological homogeneity was interpreted as fidelity to existing terrestrial and aquatic ecological classifications in the peer-reviewed literature. Omernik's Level II ecoregions (Omernik 1987) and Freshwater Ecoregions (FEs; Abell et al. 2000, 2008) were adopted as fundamental spatial data layers for terrestrial and aquatic homogeneity, respectively. The Omernik terrestrial ecoregion classification was an important and well-recognized input resource for this effort and has been used as the development and reporting basis for other national scale ecological analyses; for example, the National Land Cover Database (NLCD; Homer et al. 2007) and LandFire (Rollins 2009). For the aquatic domain, FEs were selected as the most suitable units to represent habitat because they are 1) identified and characterized for all of North America, 2) perfectly spatially nested from macro units to extremely fine scale units and thus are scalable to the entire geography of interest in the United States, 3) ecologically defined, as opposed to merely topographic drainage units, and 4) the framework adopted by the National Fish Habitat Action Plan (NFHAP) program (NFHAP 2006, Archived Material in Dryad, Reference S7, http://datadryad.org/handle/10255/dryad.38037).

In addition to JVs, the team considered existing partnerships such as state-based initiatives and nationally significant regional conservation partnerships in the Columbia River Basin, the Chesapeake Bay, the Klamath Basin, and the Everglades, when developing the national framework but determined that aggregating BCRs based on these diverse partnerships would be difficult. The EOC and the team recognized that managers could continue to use current partnership boundaries to address particular issues, regardless of the geographic framework produced by the team. The team recognized the significance of existing NFHAP partnerships and agreed that incorporation of FEs into the decision-making process retained adequate fidelity to NFHAP interests.

With these primary guidelines in mind, the team developed the specific allocation criteria and metrics to guide decisions for aggregating BCRs. Preliminary investigations indicated that strict conformity to BCR boundaries would frequently reduce homogeneity within units, particularly with respect to aquatic ecotypes (i.e., the FE boundaries). With EOC input, the team devised decision rules using relative weighting for the criteria when deciding among different BCR aggregation schemes. Fidelity to existing BCR and terrestrial ecoregion boundaries (45%) were valued more heavily than maintaining intact aquatic ecoregions (40%). These ecological criteria were weighted more heavily than fidelity to existing national partnership boundaries (15%).

The team applied the aggregation criteria and decision rules in a group elicitation format to produce preliminary maps. Using lessons learned from this initial exercise, the

Table 1. Aquatic, terrestrial, and partnership criteria and metrics used to guide the team in evaluating and ranking various BCR aggregation schemes.

Objective	Criteria	Guiding metric
Fidelity to BCRs	Intact BCR boundaries	Minimize number of breaks of existing BCR boundaries
Retain homogeneity of terrestrial ecosystems	Omernik's Level II ecoregions	Minimize the number of Omernik's Level II ecoregions within new individual subunits
Retain homogeneity of aquatic systems	Freshwater Ecoregions (FEs)	Maximize the ratio of the number of FEs with >50% of their area within the subunit to the number of different FEs within the subunit
Attention to nationally significant partnerships	Migratory Bird Joint Venture boundaries, state boundaries	Minimize number of splits to Joint Venture boundaries and minimize number of subunits within a state

team further refined the criteria (Table 1) and used them to guide subsequent aggregation alternatives. The final map was developed by combining three data layers in a Geographic Information System (GIS): BCRs, FEs, and USGS hydrologic unit code regions. The team attempted to maintain the integrity of aquatic ecotypes within subunits by avoiding the aggregation of ecologically disparate FEs within any given subunit. Additional GIS data layers, including the migratory bird JVs and Omernik's Level II ecoregions were used to evaluate and inform boundary decisions. Referring to all these layers, and using the refined criteria and decision rules, the team aggregated BCRs into a proposed geographic framework which was consistent with the aquatic, terrestrial, and partnership criteria and metrics described in Table 1.

Several deviations from BCR boundaries were considered when developing the national framework. The collective geographic and ecological expertise of the team was solicited to address these, and the team agreed to implement breaks in BCR boundaries upon reaching consensus that the benefit of each proposed break, with respect to increasing homogeneity of aquatic and terrestrial systems in the new subunits, outweighed the disadvantage of management compromises associated with creating additional conservation partnership boundaries.

The National Geographic Framework

The result of this process was a national framework with 20 geographic subunits: 14 in the conterminous

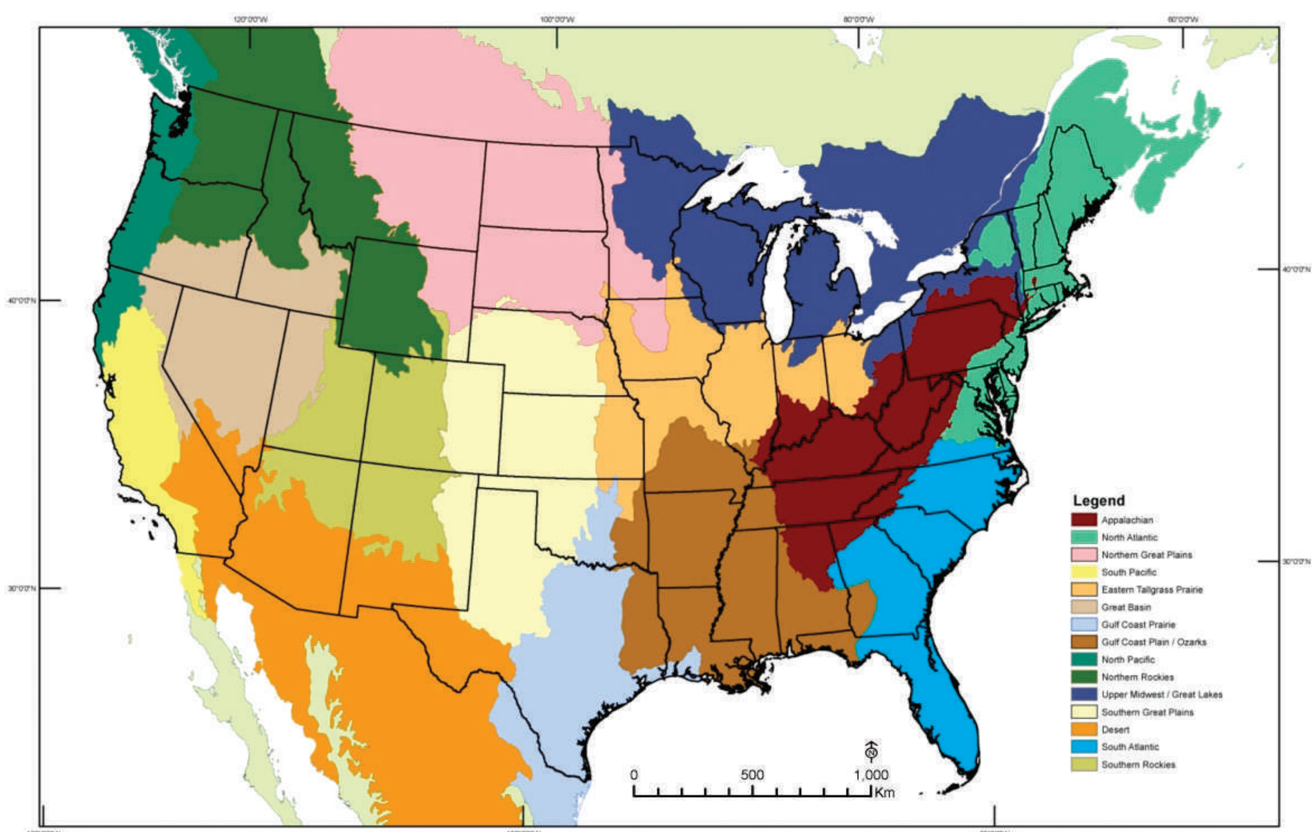

Figure 1. The national framework of geographic subunits for the lower 48 U.S. states recommended by the 2009 workshop team.

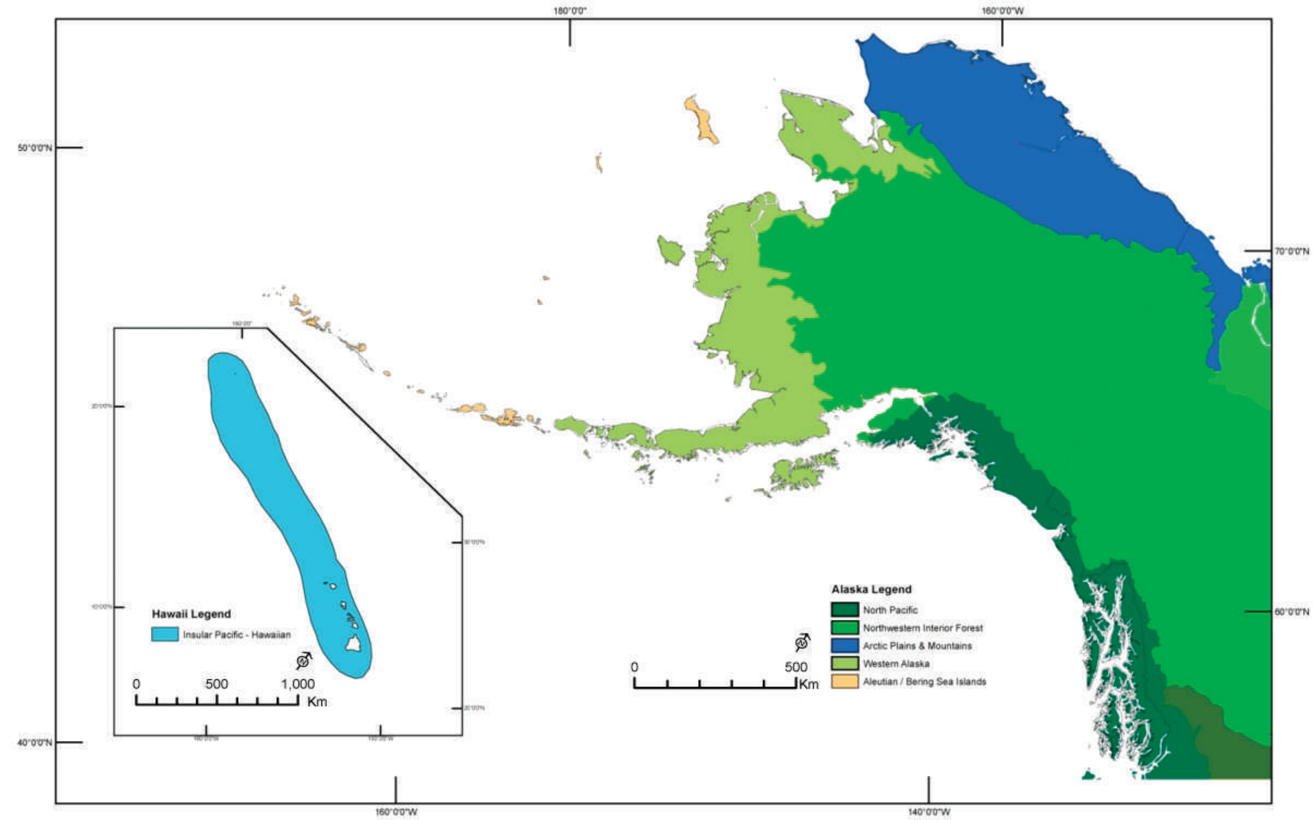

Figure 2. The national framework of geographic subunits for Alaska and Hawaii recommended by the 2009 workshop team.

United States, one which spanned the west coast and Alaska, four discrete subunits within Alaska, and one around the Hawaiian Archipelago (Figures 1 and 2). The five BCRs in Alaska were not considered for aggregation due to their large size and the fact that they currently represent the biome level. Hawaii was initially proposed as a geographic subunit based on the boundaries of BCR 67, but it was subsequently modified to encompass other U.S. Pacific islands.

The team adopted seven deviations from BCR boundaries with the rationale that aquatic and terrestrial integrity was greatly enhanced in the resultant subunits. In each of these cases, careful deliberation by the team resulted in consensus that the modification either improved homogeneity of terrestrial or aquatic systems, or that an important existing conservation partnership would be better served by the result, or both. Three examples of breaks in BCR boundaries illustrate these considerations.

In the first case, the team sought to integrate the eastern half of the Central Hardwoods BCR with the Appalachian Mountains BCR. This boundary configuration also aligned the Ozark Mountains with the Lower Mississippi River system based on both aquatic and terrestrial criteria. The resultant subunits maintained the Ohio River basin intact and combined two areas with ecologically similar FE units. The disadvantage was that this configuration split the Central Hardwoods BCR and Central Hardwoods JV. However, the team agreed that the established partnerships would continue to function effectively within their existing boundaries. A more intuitive break of a BCR boundary occurred in the Sierra Nevada. To enhance integrity for aquatic resources and ecological planning, the team agreed on a watershed-oriented boundary along the crest, which split the Sierra Nevada BCR along the north–south axis of the mountain range. The Sierra Nevada BCR combines the San Francisco Bay Delta and Great Basin watersheds, regions that support very different endemic fish assemblages and conservation needs. The new subunits clearly represent the two distinct watersheds. In a third case, the lower Susquehanna River basin in the east presented a partnership-based challenge. The team sought to keep the Lower Chesapeake Bay watershed intact due to the significant established partnership and watershed management actions underway in this region. The subunit boundaries were therefore established along drainage-based hydrologic unit code boundaries, diverging from the Southeastern Coastal Plain and the Piedmont BCRs. Since both of these BCR units are administered by the Atlantic Coast Joint Venture, the team anticipated that work within the BCRs would not be negatively impacted.

Two proposed deviations from BCR boundaries were not adopted in the final version of the framework. In both cases, the team decided that the cost of the break to BCR planning and implementation efforts would outweigh the benefits to aquatic interests. First, the team considered splitting the Appalachian Mountain BCR to separate the

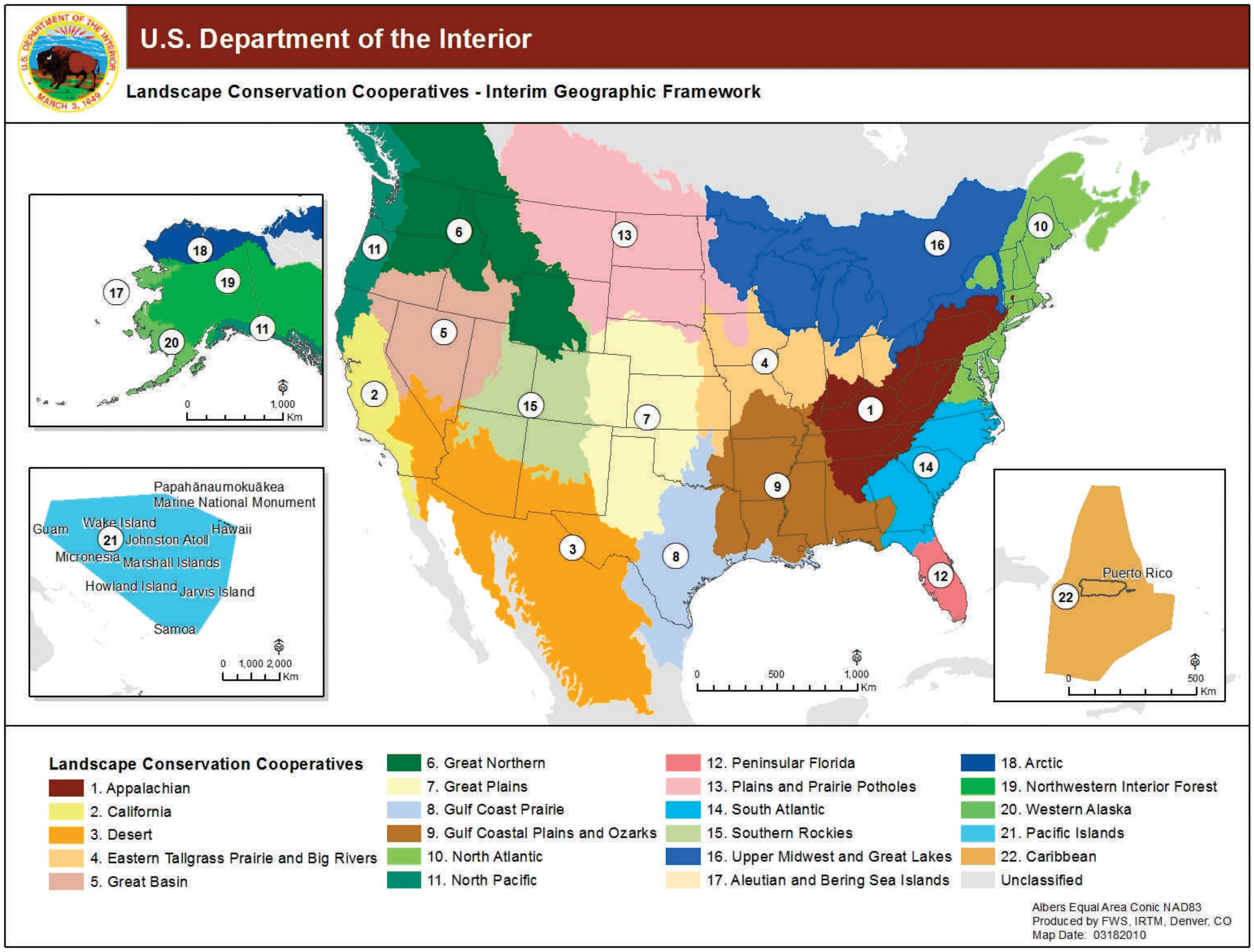

Figure 3. The national framework of geographic subunits for the 50 U.S. states with modifications as of February 2012.

Chesapeake Bay and Ohio River watersheds. This was seen as possibly simplifying aquatic planning (e.g., Ohio River mussel conservation). However, this action would have partitioned the Appalachian Mountains and the team decided to not adopt the boundary break in order to maintain intact the geography of the Appalachian Mountains BCR, the Appalachian Mountain JV, and the Eastern Brook Trout JV. A second proposed break would have split the Eastern Tallgrass Prairie BCR and the Upper Mississippi River-Great Lakes JV. Although combining portions of the Ohio River basin, the new subunit would not achieve significant consolidation of similar FE units. Therefore, the team decided to not adopt the break and to keep the Tallgrass Prairie BCR intact.

An Evolving Process

The geographic framework shown in Figures 1 and 2 was accepted with minor modification by Service executive leadership in August 2009. The framework currently provides the geographic organizing structure in which Landscape Conservation Cooperatives (LCCs) will support SHC; that is, landscape-scale conservation utilizing science to strategically inform on-the-ground actions. The USGS supports and uses these geographies for climate change-related research, assessments, and program development purposes. The framework was subsequently adopted by the U.S. Department of Interior as the base geography for organizing first generation LCCs, constituting a partnership-based network that integrates science and management in support of landscape-scale planning, conservation design, monitoring, and research for physical, biological, and cultural heritage resources. The U.S. Department of Interior is also using these conservation regions in the development of metrics for assessing vulnerability to climate change.

The Service leadership and the coordinators of the developing LCCs continue to deliberate and implement refinements to the original national geographic framework. The Mississippi River delta in coastal Louisiana was rejoined to the coastal drainages of western Louisiana and east Texas. A new subunit was created in peninsular Florida by establishing BCR 31 as a stand-alone geographic region, and a 22nd subunit has been formed in the Caribbean. A clarification was added to more clearly include the Great Lakes within the Upper Midwest and Great Lakes geographic region. Names of the subunits and the LCCs based within them were modified as requested by the appropriate Service regions. A formal process for proposing and adopting boundary modifications has been approved by the Service Directorate (U.S. Fish and Wildlife Service 2006, Archived Material in Dryad, Reference S8, http://datadryad.org/handle/10255/dryad.38037) As of February 2012, the national geographic framework appears as shown in Figure 3. An updated map can be found at http://www.fws.gov/science/shc/lcc.html (*Archived Material in Dryad*, Map S2, http://datadryad.org/handle/10255/dryad.38037 and http://dx.doi.org/10.3996/052011-JFWM-030.S1).

Given forecasted changes in biomes (e.g., Gonzalez et al. 2005) and species distributions (e.g., Lawler et al. 2009) due to a warming global climate, existing ecologically based classification systems may become less relevant in a dynamic landscape with directional change. Creation of the national geographic framework relied significantly on expert opinion and heavily weighted existing conservation partnership boundaries (e.g., JVs and others) to modify the ecologically based classification systems such as Omernik's. Opdam and Wascher (2004) noted that when other stressors such as human-induced fragmentation are considered in a climate change context, the "basis of all regional landscape development should be a spatially explicit vision on the required development of the future landscape network over a large geographical region." The team and the EOC believe this geographic framework satisfies this need.

Marine BCRs were not addressed. The team did recommend reviewing and integrating marine BCRs with the national geographic framework in the future. Fourteen of the 22 current LCCs have borders that include marine coastline and/or Great Lakes shoreline, and one LCC that borders four Marine National Monuments. Participating agency staff and LCC coordinators are currently assessing how to integrate marine BCRs into existing LCCs. This effort indicates a desire to address high priority issues in both land-based and marine environments.

In summary, the national geographic framework was developed to provide structure for landscape and species conservation strategies that address terrestrial, avian, and freshwater aquatic dimensions. The methodology used to develop the framework was not a fully quantitative and precise spatial allocation model. Instead, the process depended on prototyping possible solutions through a synthesis of the best nationally available spatial data, expert opinion, and conscientious weighting of decision criteria. The process was transparent and consensus-based within the appointed team. The process and product represent a step forward in incorporating natural resource science and values in a spatially seamless national framework for the Service and its partners to organize institutional capacity and resource planning. Within this framework, a network of LCCs will form as applied conservation science partnerships that utilize a landscape-scale approach to inform on-the-ground strategic conservation efforts. Through this LCC network, the conservation community can better leverage resources to address the highest conservation priorities within and across landscapes nationwide.

Archived Material

To cite this archived material, please cite both the journal article (formatting found in the Abstract section of this article) and the following recommended format for the archived material.

Millard MJ, Czarnecki CA, Morton JM, Brandt LA, Briggs JS, Shipley FS, Sayre R, Sponholtz PJ, Perkins D, Simpkins DG, Taylor J. 2012. Data from: A national geographic framework for guiding conservation on a landscape scale, Journal of Fish and Wildlife Management, 3(1):175-182. Archived in Dryad Digital Repository: http://datadryad.org/handle/10255/dryad.38037

Map S1. Map of North American Bird Conservation Initiative bird conservation regions. (704.9 KB PDF)

Map S2. Geographic Information System files for map of the National Geographic Framework as of February 2012. (Also available at http://dx.doi.org/10.3996/052011-JFWM-030.S1) 4.2 MB ZIP)

Reference S1. U.S. Fish and Wildlife Service. 2009. Conservation in transition: leading change in the 21st century. Washington, D.C.: U.S. Fish and Wildlife Service. (1.624 MB PDF)

Reference S2. National Ecological Assessment Team. 2006. Strategic habitat conservation. Final Report of the National Ecological Assessment Team. U.S. Geological Survey and the U.S. Fish and Wildlife Service report. (2.836 MB PDF)

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Reference S5. U.S. North American Bird Conservation Initiative Committee. 2000. North American Bird Conservation Initiative (NABCI) Bird Conservation Region Descriptions: A Supplement to the North American Bird Conservation Initiative Bird Conservation Regions Map. Arlington, VA: U.S. Fish and Wildlife Service, Migratory Birds. (3.491 MB PDF)

Reference S6. [NAWMP] North American Waterfowl Management Plan, Plan Committee. 2004. North American Waterfowl Management Plan 2004. Implementation framework: strengthening the biological foundation. (2.423 MB PDF)

Reference S7. [NFHAP] National Fish Habitat Action Plan. 2006. Association of Fish and Wildlife Agencies, Washington, D.C. (2.286 MB PDF)

Reference S8. U.S. Fish and Wildlife Service. 2006. Landscape conservation cooperatives. Operational memo for addressing requests for consideration of LCC geographic boundary changes. Washington, D.C.: U.S. Fish and Wildlife Service, Department of the Interior. (367.2 KB PDF)

All found at: http://datadryad.org/handle/10255/dryad.38037

Acknowledgments

The team and their affiliations were Laura Brandt (Service), Jenny Briggs (USGS), Craig Czarnecki (Service), David Eisenhauer (Service), Larry Handley (USGS), Amy Keister (Service), Tom McCabe (Service), Mike Millard (Service), John Morton (Service), Seth Mott (Service), David Perkins (Service), Roger Sayre (USGS), Gary Scoppettone (USGS), Frank Shipley (USGS), Darin Simpkins (Service), Dave Smith (Service), Pam Sponholtz (Service), Jan Taylor (Service), and Doug Vandegraft (Service). The authors thank Chris Horsch and Gregory Breese of the U.S. Fish and Wildlife Service for facilitating the team through the rapid prototyping process. Dave Smith (USGS) provided a primer on structured decision making to the team. The Executive Oversight Committee, comprised of Dan Ashe (Service), Sue Haseltine (USGS), Anne Kinsinger (USGS), Bernie Mazer (Service), Marvin Moriarty (Service), Paul Schmidt (Service), David Russ (USGS), Mike Shulters (USGS), Elizabeth Stevens (Service), Ione Taylor (USGS), Robyn Thorson (Service), and Charles Wooley (Service), provided valuable guidance. We also thank Doug Steinshouer, two anonymous reviewers, and the Subject Editor for valuable assistance.

The use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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