Biological Conservation 178 (2014) 117–127

Contents lists available at ScienceDirect

Biological Conservation

journal homepage: www.elsevier.com/locate/biocon

Systematic identification of potential conservation priority areas on roadless Bureau of Land Management lands in the western United States

Brett G. Dickson [a,*], Luke J. Zachmann [a], Christine M. Albano [b]

[a] Conservation Science Partners, Inc., 11050 Pioneer Trail, Suite 202, Truckee, CA, USA
[b] John Muir Institute of the Environment, University of California, Davis, Davis, CA, USA

ARTICLE INFO

Article history:
Received 12 April 2014
Received in revised form 1 August 2014
Accepted 3 August 2014

Keywords:
Biodiversity
BLM
Connectivity
Resilience
Richness
Roadless

ABSTRACT

With ongoing global change, there is an urgent need to expand existing networks of important conservation areas around the world. In the western United States, vast areas of public land, including those administered by the Bureau of Land Management (BLM), present substantial conservation opportunities. For 11 contiguous western states, we used a novel multiple-criteria analysis to model and map contiguous areas of roadless BLM land that possessed important ecological indicators of high biodiversity, resilience to climate change, and landscape connectivity. Specifically, we leveraged available spatial datasets to implement a systematic and statistically robust analysis of seven key indicators at three different spatial scales, and to identify the locations of potential conservation priority areas (CPAs) across 294,274 km^2 of roadless BLM land. Within this extent, and based on conservative thresholds in our results, we identified 43,417 km^2 of land with relatively high conservation value and 117 unique CPAs totaling 6291 km^2. Most CPA lands were located in Utah, Colorado, Arizona, Oregon, and Nevada. Overall, CPAs had higher species richness, vegetation community diversity, topographic complexity, and surface water availability than existing BLM protected areas. CPAs often corresponded with locations known to have important wilderness characteristics or were adjacent to established areas of ecological, social, or cultural importance. These CPAs represent a diverse set of places that can be used by multiple stakeholders in ongoing or future landscape conservation and special designation efforts in BLM and adjacent ownerships. Our methodological framework and novel weighting approach can accommodate a wide range of input variables and is readily applicable to other jurisdictions and regions within the U.S. and beyond.

1. Introduction

In the face of global change, there is a pressing need to design, connect, and conserve new landscapes strategically that more effectively capture biodiversity and associated processes at relevant spatial scales (Margules and Pressey, 2000). Lands that are currently unprotected or threatened by human impacts can complement or enhance the features and functions of existing protected area networks (Rodrigues et al., 2004). The ecological importance and context of these lands should be included in any analysis to determine priority areas for conservation.

Federal lands in the western United States harbor immense opportunities to maintain and further protect important components of biological diversity and function. Currently, only 12% of the total land area of the U.S. is managed primarily for biodiversity conservation (U.S. Geological Survey GAP, 2011), well below the amount of land necessary to ensure that regional biodiversity is conserved (Noss et al., 2012). Despite its relatively vast open spaces, the expanding human footprint in the western U.S. threatens to further impact the few remaining large, intact, and ecologically important areas (Leu et al., 2008), most of which occur on public lands. Indeed, intact public lands and waters in the West are critical to the conservation of biodiversity (Groves et al., 2000), withstanding or mitigating the environmental impacts of climate change (West et al., 2009; Olander et al., 2012), and maintenance of key ecological processes, such as connectivity for wide-ranging species (Crist et al., 2005; Theobald et al., 2012).

More than one quarter (~2.6-million km^2) of lands in the U.S. are federally owned (Gorte et al., 2012). Of these lands, the U.S. Department of Interior's Bureau of Land Management (BLM) administers approximately 1-million km^2, more than any other

* Corresponding author. Tel.: +1 530 214 8905.
E-mail address: brett@csp-inc.org (B.G. Dickson).

http://dx.doi.org/10.1016/j.biocon.2014.08.001
0006-3207/

Table 1
Percentage of lands (total surface area) administered by the Bureau of Land Management (BLM) in the 11 contiguous western states. Percent of BLM-administered lands in each state that is roadless and in our analysis extent (i.e., outside of existing wilderness areas, wilderness study areas, and national monuments) is also shown.

State	Administered by BLM (%)	Roadless lands in analysis extent[a] (%)
Arizona	16.8	46.0
California	15.3	34.0
Colorado	12.5	44.0
Idaho	21.9	35.0
Montana	8.6	31.0
Nevada	68.0	57.0
New Mexico	17.3	31.0
Oregon	26.2	34.0
Utah	43.4	43.0
Washington	1.0	15.0
Wyoming	29.5	23.0

[a] Lands estimated to be roadless were required to be absent of improved or maintained roads as well as railroads and power lines, and >20.2 km^2 in size.

federal agency (Gorte et al., 2012). Most (70%) BLM-administered lands are situated in the 11 contiguous western states (Table 1). These lands provide habitat for a wide diversity of plant and animal species, including roughly 20% of the nation's rare or declining species (Stein et al., 2008). In 2009, Congress permanently established the National Landscape Conservation System (NLCS), offering a conservation-based management focus on nearly 110,000 km^2 of BLM land, including wilderness areas, national monuments, and other designations. Because the NLCS applies to only a small proportion (11%) of the total BLM portfolio, and because many of the NLCS designations still permit extractive uses, the BLM remains uniquely positioned to protect and steward more comprehensively some of the most biologically diverse public lands in the nation.

Extraction- and recreation-based activities have resulted in the proliferation and use of roads on U.S. public lands, including those administered by the BLM (Havlick, 2002). Considering the well-described impacts of roads on landscapes (Trombulak and Frissell, 2000), unprotected public lands that are relatively roadless and undeveloped may afford the best opportunity to conserve natural landscape elements and ecosystem processes (Davidson et al., 1996; Watts et al., 2007). The BLM defines 'roadless' as the absence of roads that have been improved and maintained by mechanical means in order to insure relatively regular and continuous use (BLM, 2012). Because 'roadlessness' is a prerequisite for wilderness, which is one of the highest possible levels of protection on U.S. federal lands (Icun, 1994), it is important to identify unprotected areas with roadless and wilderness qualities and prevent their development.

Protections of intact roadless and undeveloped landscapes must adequately represent or enhance the biodiversity attributes of a region (Crist et al., 2005; Soulé and Terborgh, 1999). Protected area designation in the U.S. has often been determined by social factors, such as scenic qualities, or legislative opportunities at local or state levels (Pressey, 1994; Stamper et al., 2013), and because of this pattern, the current protected areas network is likely insufficient to guard against the long-term loss of species and the range of ecosystem types they inhabit (Scott et al., 2001). Developing a more effective protected areas network requires identifying a meaningful set of ecological indicators and a robust analytical framework that prioritizes areas to conserve based on their associated ecological values (Margules and Pressey, 2000; Parrish et al., 2003). To our knowledge, a systematic, comprehensive, and conservation-based approach to identify new areas for protection has not previously been applied within BLM lands across the western U.S.

For the 11 western states in which the BLM chiefly operates, our principal objective was to systematically identify and map contiguous areas of roadless BLM land that possess important ecologically based indicators of conservation value. We implemented a statistically robust analysis using seven indicators of biodiversity, resilience to climate change, and landscape connectivity to quantify and map areas within our analysis extent that have high conservation value with respect to these indicators. Because we hypothesized that the spatial scale (i.e., extent) at which the data were summarized would affect resultant conservation priorities (Huber et al., 2010), we conducted the analysis at multiple spatial scales and integrated results to identify conservation priority areas (CPAs) that were robust to our choice of scale. Finally, we compared values of the indicators within our selected conservation priority areas to those in the existing network of protected areas in three different jurisdictions to demonstrate the utility of our approach in selecting areas of relatively high conservation value. A primary goal of our work was to provide a sound scientific basis for future proposals for conservation-based special designations in the western U.S. Our methodological framework was designed to integrate multiple input variables at multiple spatial scales and to be readily applicable to other jurisdictions and regions within the U.S. and beyond.

2. Methods

2.1. Specifying the study and analysis extent

Our study extent included BLM lands in the 11 contiguous western states: Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming (Fig. 1). Ownership data were obtained for each state from their respective BLM websites or state geospatial data clearinghouses. Areas included in the analysis extent were located outside of existing special designations, including national monuments, wilderness areas, and wilderness study areas (WSAs). We excluded WSAs because they are provisionally protected until their designation is changed through legislative action by the U.S. Congress. We used land management designations in the U.S. Protected Areas Database (U.S. Geological Survey GAP, 2011) and a geographic information system (GIS; ArcGIS v10.1, Esri, Redlands, CA) to identify and remove the aforementioned lands from our analysis extent.

Because we were interested in identifying candidate areas that could meet the criteria for the highest level of protection, i.e., wilderness designation, we also required lands in the analysis extent to be contiguous areas > 20.2 km^2 (or 5000 ac, by convention the minimum size for wilderness designation in the U.S.) after removal of areas otherwise occupied by roads, railroads, and electric power transmission lines. Recognizing that no comprehensive dataset exists for all BLM lands that differentiates between maintained and unmaintained roads, we used 2011 TIGER/Line roads data (U.S. Census Bureau, 2011) to buffer (5 m per side) and remove all linear road features from the analysis extent. Additionally, we removed railroads (FRA, 2011) and powerlines (Hanser, 2011), also using a 5-m buffer. Contiguous areas < 20.2 km^2 were removed from consideration in our analysis extent.

2.2. Deriving ecological indicators and spatial data layers

Through an extensive literature review and subsequent consultations with experts in the field of conservation indicators (see Acknowledgments), we identified a suite of seven variables that were both readily available and spatially contiguous across our analysis extent to serve as ecologically based indicators of biodiversity (Noss, 1990), resilience to climate change (Gunderson,