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Natural Resource Stewardship and Science

Landscape Context of Bighorn Canyon National Recreation Area

Natural Resource Report NPS/NRSS/NRR—2015/995

ON THE COVER
A vista to the Bighorn Mountains from the uplands in Bighorn Canyon National Recreation Area (photo credit: NPS).

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Natural Resource Report NPS/NRSS/NRR—2015/995

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Executive Summary

Some of the land and resource management challenges faced by stewards of Bighorn Canyon National Recreation Area (BICA) relate to how BICA fits within the surrounding landscape. BICA is a relatively narrow and elongated stretch of land along the canyon of the Bighorn River, which flows north from Wyoming into Montana. Understanding BICA's resources in a landscape context was formally identified as a priority for park managers in the 2005 Vital Signs Monitoring Plan for the Greater Yellowstone Network. In 2010 the Inventory and Monitoring Division of the National Park Service provided a suite of standard landscape metrics, data sources, and analytical tools for helping parks quantify and document resource conservation vulnerability and opportunity in a landscape context. The study area within a 30-kilometer buffer around and including BICA's managed lands represents the landscape for reporting on housing, population, roads, land cover, conservation status, and climate.

Most residential land use in the area around BICA is rural, with rather slow growth over the past few decades, and population density remains at just over one person per square kilometer after experiencing a slight increase in the 1990s. Weighted road densities estimating traffic volume are relatively low, since there are no interstates and few major highways in the study area. However, smaller roads are widespread across the study area, and these roads can fragment habitats, increase the spread of exotic plants, and affect visitor experience from vehicle traffic. Natural land cover, primarily in the form of shrub/scrub and herbaceous vegetation, occurs over most of the area, except for concentrated areas of cultivated crops and hay/pasture lands in proximity to the Shoshone and Bighorn rivers. In the decade from 2001 to 2011 almost no change took place in the balance of natural versus converted land cover. With Crow tribal lands adjacent to most of the northern half of BICA, and the Pryor Mountain Wild Horse Range and Yellowtail Wildlife Habitat Management Area overlapping and adjacent to BICA, cooperative management of protected areas is a defining theme for park resource specialists and administrators. The natural resource conservation status for tribal lands is not reported here because land management and conservation plans are not yet enacted for the Crow Indian Reservation. About 40% of the study area landscape is under federal management that includes protection for federally listed endangered and threatened species and is generally managed to permanently protect the majority of natural land cover while allowing for some extractive uses. Current and future resource planning and management efforts require understanding changes in climate and addressing how future climatic conditions and trends may interact with natural and cultural resources in BICA and the surrounding landscape. Recent data from BICA found that since 1983, four key temperature variables, including annual mean temperature, have reached the uppermost limits of all observed temperatures since 1901.

With these highlights in mind, this report on the landscape context of BICA provides a foundation for continued monitoring that will inform park managers and motivate researchers to help address how landscape factors relate to BICA's resources.

Acknowledgments

We appreciate the input, assistance, and support from Bighorn Canyon NRA staff members Bill Pickett, Cassity Bromley (now at Gulf Islands National Seashore), Virginia DuBowy, and Superintendent John Bundy. Additional thanks go to NPScape team members Lisa Nelson, Tom Philippi, and Mike Story who contributed to the development of data sets and tools used in this report.

List of Abbreviations

Abbreviations	Description
BICA	Bighorn Canyon National Recreation Area
BLM	Bureau of Land Management
BOR	Bureau of Reclamation
DOD	Department of Defense
DOI	Department of Interior
ESRI	Environmental Systems Research Institute
GAP	Gap Analysis Program
NLCD	National Land Cover Dataset, or National Land Cover Database
NPS	National Park Service
NPScape	National Park Service Landscape Dynamics Monitoring Program
NRSS	Natural Resource Stewardship and Science
PAD-US	Protected Areas Database of the US
SERGoM	Spatially Explicit Regional Growth Model
USFS	US Forest Service
USGS	US Geological Survey

1. Introduction

Extending north into Montana and south into Wyoming between the Pryor and Bighorn mountains, the landscapes of Bighorn Canyon National Recreation Area (BICA) brim with natural and cultural history and resources. The establishment, history, and setting of BICA are described in numerous documents and reports, including the BICA natural resource condition assessment (Komp et al. 2012), the BICA long-range interpretive plan (NPS 2012), and the BICA strategic plan for 2001–2005 (NPS 2000). The National Park Service (NPS) administers BICA to provide for public outdoor recreation and to preserve scenic, scientific, and historic features. Managing BICA entails following NPS management policies and interacting extensively with other federal, state, tribal, and private jurisdictions and interests within, overlapping, and adjacent to the National Recreation Area.

Natural landscapes at BICA are subject to the no-impairment standard defined in NPS management policies (NPS 2006). To help determine whether an impact would harm the integrity of BICA's natural landscapes, including opportunities to enjoy those natural landscapes, it is necessary to quantify and document landscape characteristics in a reliable, repeatable, and comparable way over time. For this reason land use and land cover in and around BICA were identified for long-term monitoring by the NPS Inventory and Monitoring Program's Vital Signs Monitoring Plan for the Greater Yellowstone Network (Jean et al. 2005). Since many national park service units share the need to monitor landscapes, the NPS Inventory and Monitoring Division initiated a service-wide program called NPScape in 2010 to assemble data, develop tools, and provide support for evaluating and reporting on landscape characteristics and changes that extend beyond park boundaries (NPS 2014). The NPScape program assesses natural systems, human drivers, and conservation context to help address questions related to resource vulnerability to landscape change, as well as opportunities for management and mitigation (Figure 1.1). Products from NPScape provide important context for assessing a potential impact's severity, duration, and timing, and its direct, indirect, and cumulative effects.

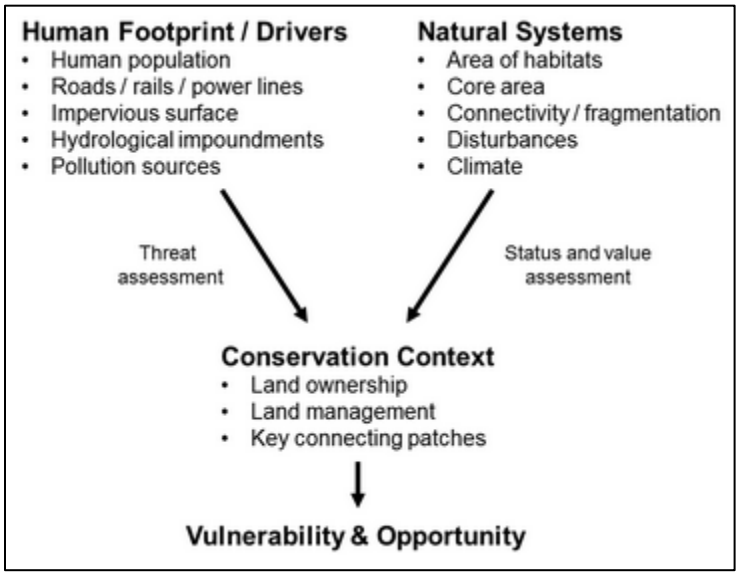

Figure 1.1. NPScape metrics as considerations in a landscape conservation context.

The value of landscape monitoring comes from consistently documenting land cover and land use conditions in and around BICA, including the

- intactness or structural integrity of major habitat types
- spatial and quantitative relationships between natural disturbance and human land use
- size and distribution of roadless areas
- location of other protected areas

Using standard data and methods to measure key landscape variables every few years provides input on resource vulnerability and opportunity that can be factored into park management and planning, and that can help identify research needs to better understand how human drivers in larger systems impact resources within and around BICA.

This is the first report in a series of similar monitoring products to be published and/or updated online approximately every five to ten years to promote the understanding of meaningful landscape-level indicators (Table 1.1) that can reflect changes in and around Bighorn Canyon NRA. This initial account establishes a baseline to help researchers, resource managers, and park administrators recognize and address the complexities of managing resources in a landscape context. Incorporating "landscape-scale approaches into all facets of development and conservation planning and mitigation" is the first principle in the Strategy for Improving the Mitigation Policies and Practices of The Department of the Interior (Clement et al. 2014) - the report in response to the Secretary of the Interior's October 2013 Order 3330 (DOI 2013).

A meaningful companion to this report is the NPScape Interpretive Guide (Monahan et al. 2012): https://irma.nps.gov/App/Reference/Profile/2184927

Table 1.1. Specific landscape indicators presented in this report.

Measure	Indicator(s)	Source Data	Years	Resolution	Reference
Housing	Housing Density	Spatially Explicit Regional Growth Model (SERGoM)	1970–2010	100 m cells	Theobald 2005
Population	Population Density	US Census Bureau	1990 2000 2010	Census Block Groups	US Census Bureau 1991, 2001, 2011
Roads	Road Density, Roadless Area	Environmental Systems Research Institute (ESRI)	Varies, up to 2005	Varies	ESRI 2010
Land Cover	- Natural vs. Converted - Anderson Level 1 Land Cover Area - Anderson Level 2 Land Cover Area - Land Cover Change	National Land Cover Dataset (NLCD)	2001, 2011	30 m cells	Jin et al. 2013
Conservation Status	Gap Status, Land Ownership	Protected Areas Database of the US v1.3 (PAD-US)	Varies	Varies	USGS Gap Analysis Program 2013
Climate	Temperature, Precipitation	Climatic Research Unit (CRU) high-resolution time series version 3.21	1901–2012	0.5 decimal degrees	Harris et al. 2014

From the analysis area options presented in the NPScape Interpretive Guide, a 2 million acre study area within a 30-km buffer of BICA's managed boundary was chosen to represent a relatively local park-centered landscape that effectively integrates human, natural, and conservation metrics for standardized reporting and future monitoring (Figure 1.2). The study area is centered on the 64,000 acres presently managed by the NPS within BICA's 120,000 acre legislated boundary.

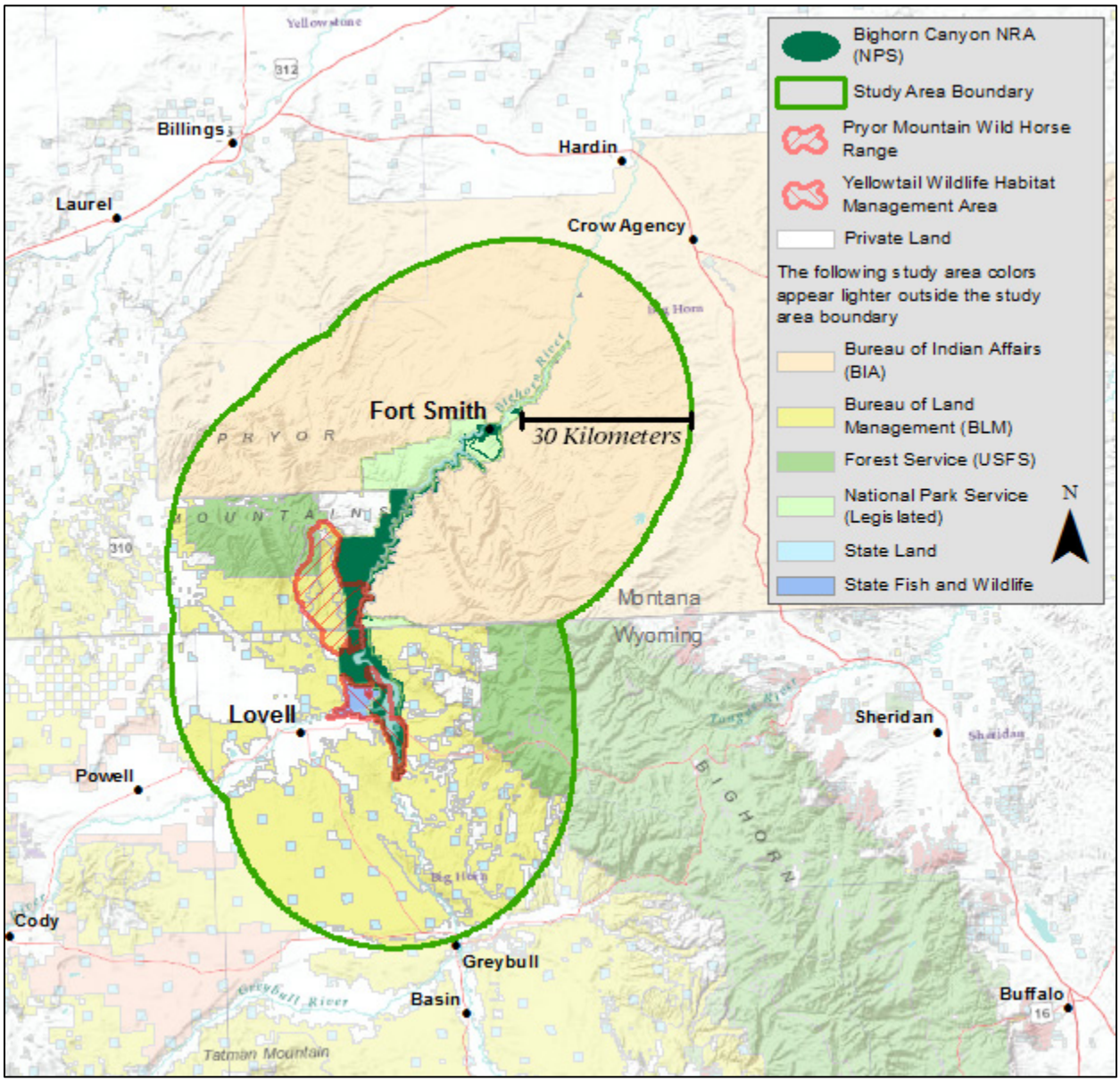

Figure 1.2. Map of surface management/ownership for the area of analysis (study area) within 30 km of BICA's managed boundary. All landscape metrics are computed for the area within the green outline. This is done for consistency throughout this document and to enable comparison with future monitoring reports using the same study area. The vicinity outside the study area is shown for visual context.

2. Housing

Housing density, modeled based on U.S. Census data from 2010, is relatively low within the study area (Figure 2.1). Most residential land use is rural, with six or fewer residential units per square kilometer. Within and near Lovell, Wyoming, a few smaller areas have exurban or suburban housing density up to 1,234 units per square kilometer. Two airports are the only commercial/industrial spaces within the study area.

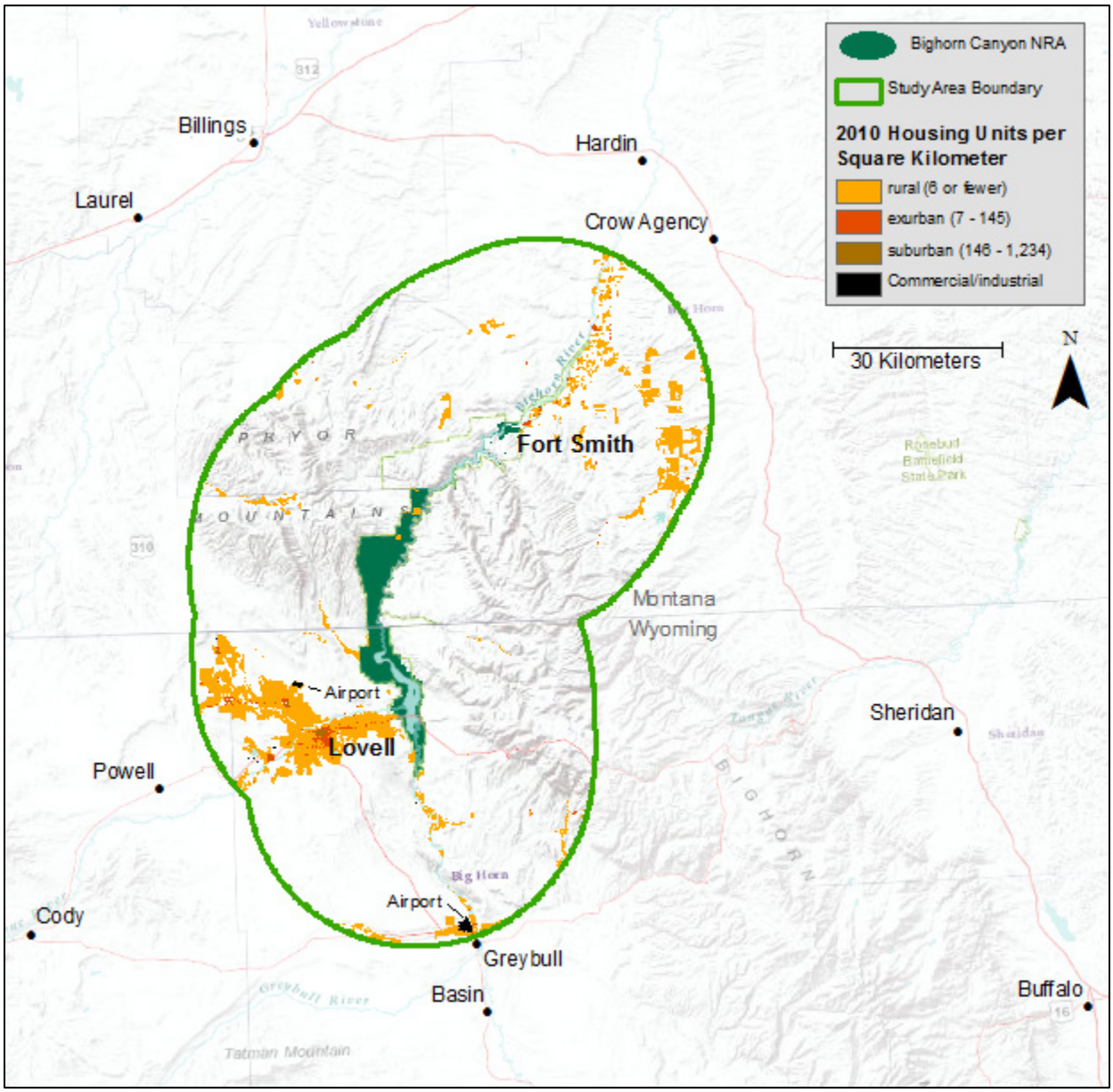

Figure 2.1. Map of 2010 housing density.

Housing density estimates come from a Spatially Explicit Regional Growth Model (SERGoM, Theobald 2005) based on U.S. Census data. The model determines density categories that include low density settings that can be important in terms of quantity and distribution for ecological studies and resource conservation concerns.

From 2000 to 2010, there was essentially no change in the area occupied by the housing categories represented in Figure 2.1. Since 1970 rural areas decreased slightly from 2,990 to 2,982 km^2 (–0.3 %), while exurban areas grew slightly from 10 to 22 km^2 (120%), a reflection of communities beyond the suburbs where residents often commute into towns and use technology and long distance communication to maintain a more urban lifestyle in a rural setting (Goetz et al. 2005). The exurban growth primarily occurs adjacent to established communities like Lovell. Suburban areas also expanded slightly in 40 years from 2.0 to 3.2 km^2 (60%).

For a complete description of the data sources and methods used to analyze housing, please visit the NPScape web site (http://science.nature.nps.gov/im/monitor/npscape/methods.cfm) and see the Standard Operating Procedure for Housing: (https://irma.nps.gov/App/Reference/Profile/2221576).

3. Population

Human population within the study area increased from an estimated 7,600 people in 1990 to around 8,600 people in 2000, but by 2010 the population was only slightly higher (8,700 people). Still, during all three periods population densities were low (~1 person per square-kilometer; Figure 3.1), and this corresponds to the low housing densities described in Section 2.

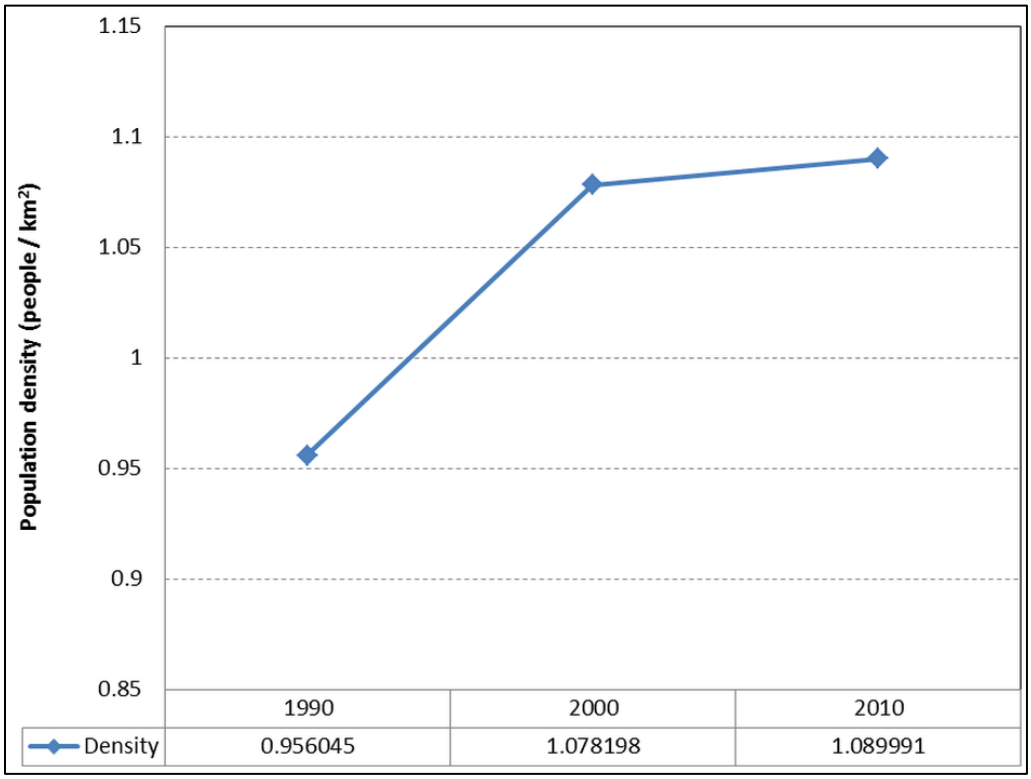

Figure 3.1. Change in total human population density within 30 km of BICA, 1990–2010.

Data on human populations around BICA are from the U.S. Census Bureau (1991, 2001, 2011). Population density (people/km^2) is calculated for inhabited areas. Water and other uninhabitable areas are excluded, primarily the Yellowtail Wildlife Habitat Management Area and Pryor Mountain Wild Horse Range. These two areas are managed mainly for biodiversity, and disturbance processes can be suppressed in them, as discussed in Section 6 (Conservation Status).

Complete details about the data sources and methods used to analyze population are available from the NPScape web site (http://science.nature.nps.gov/im/monitor/npscape/methods.cfm) and the Standard Operating Procedure for Population can be downloaded from: (https://irma.nps.gov/App/Reference/Profile/2221729).

4. Roads

Types of roads and their location and density in the BICA landscape are important considerations for resource management because of habitat fragmentation effects and traffic factors that include sound, light, and vehicle/wildlife collision potential. In semi-arid environments, like those in portions of BICA and the study area, roads can influence the water capacity and content of adjacent soils, thus affecting the types of vegetation that occur and the associated animal habitats. The connection between roads and exotic invasive plant species is a particular concern for park management (Komp et al. 2012). As of 2005, overall road density is low within the study area, and the highest density values occur in and around Lovell, Wyoming (Figure 4.1).

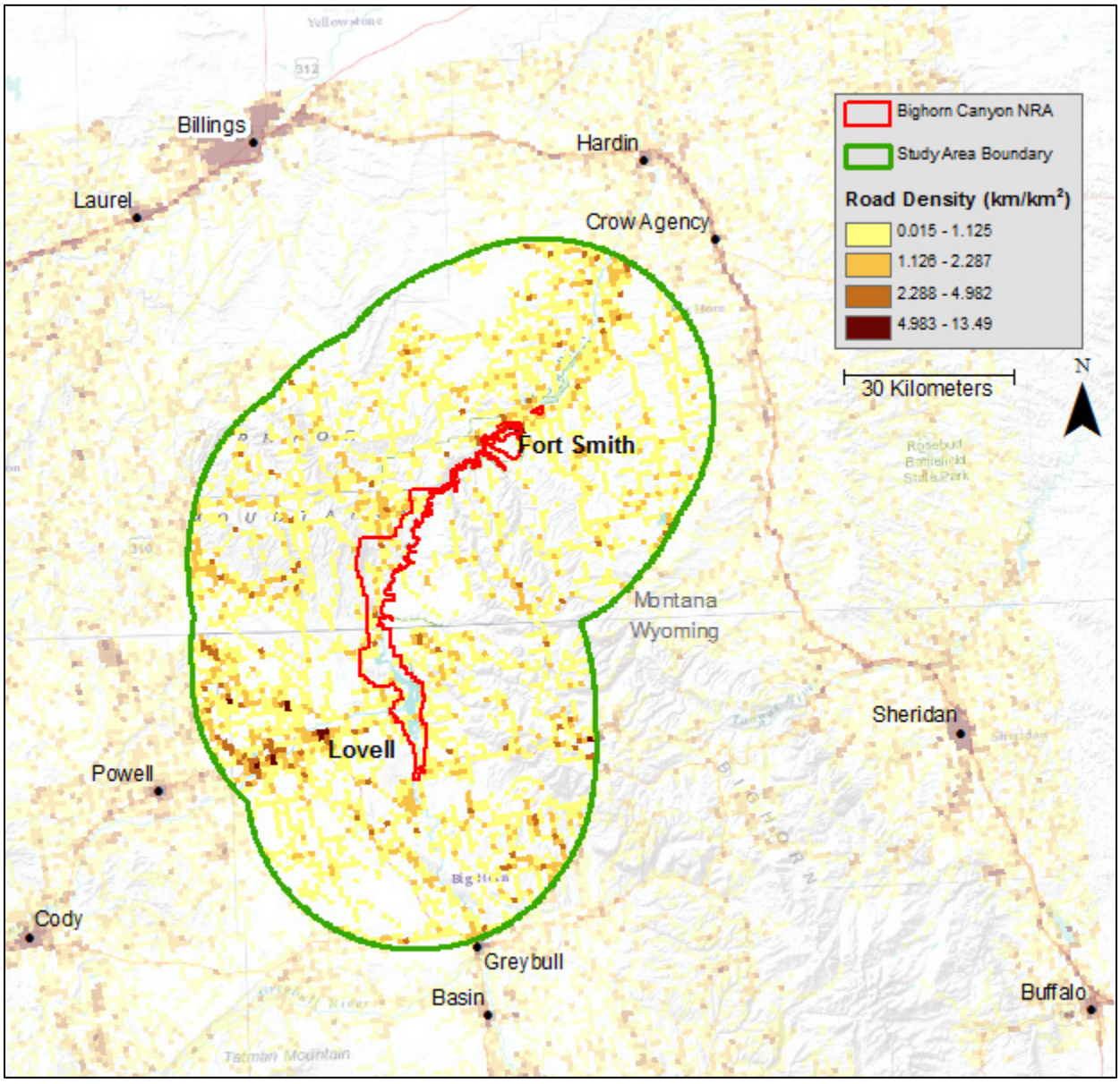

Figure 4.1. Map of nonweighted road density (km/km2) calculated for all roads in the study area as of 2005.

The road network analyzed for this report is from ESRI Data and Maps - U.S. and Canada Detailed Streets, TeleAtlas 2005 (ESRI 2010). To help represent the relative traffic volume of major roads, a weighting factor of 10 is applied to interstates, 3 is applied to highways, and no weighting factor is used for other road types (streets, local roads, etc.). Few if any studies exist to quantify the relationships between roads and wildlife in the study area. A 2000–2002 study of bighorn sheep habitat and population in and around BICA (Schoenecker 2004) does not directly relate roads in general to sheep occupancy or as barriers to bighorn sheep movement, but the study recommends that managers consider roads on a case-by-case basis prior to translocation of bighorn sheep. Given that most roads in the study area are not highways or interstates with heavy traffic (Figure 4.2), habitat fragmentation effects from the existence of all roads may be of more interest to managers than direct impacts from vehicle/wildlife collisions or from the emissions, sounds, and light associated with vehicle traffic.

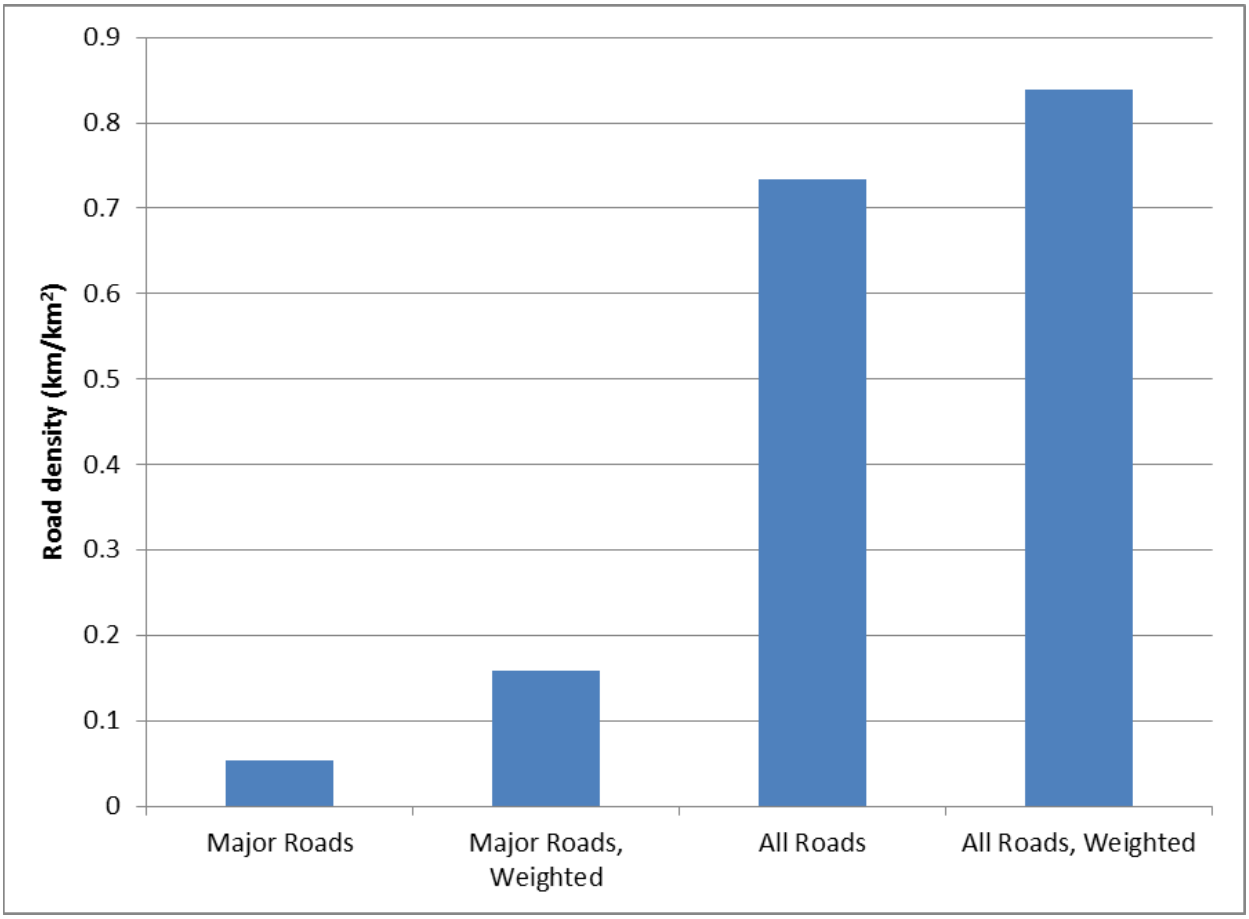

Figure 4.2. Weighted and nonweighted road density for major roads (highways, interstates) and all roads (major roads plus streets) within 30 km of BICA, as of 2005.

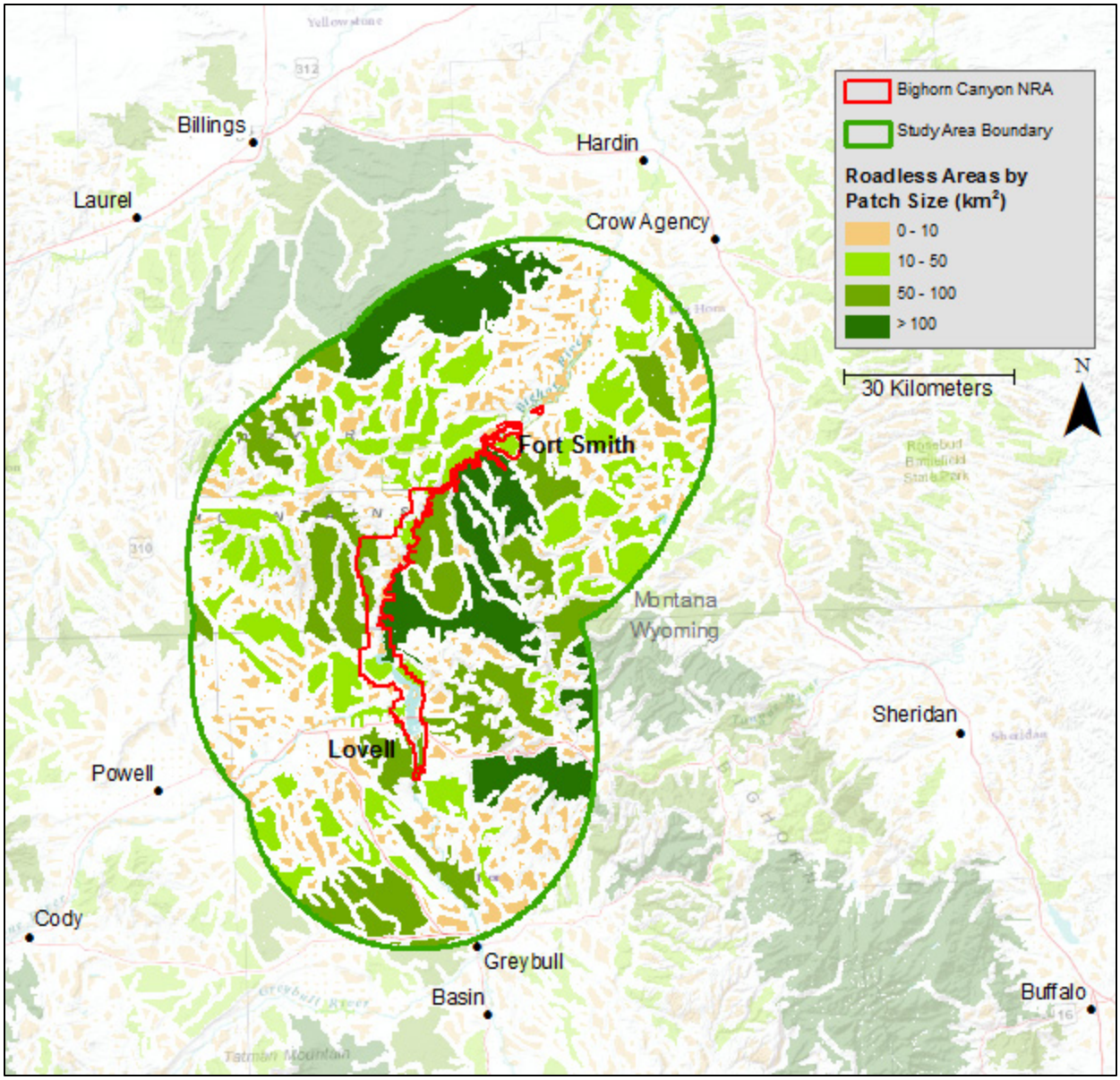

Figure 4.3. Map of the patch size distribution of roadless areas in and around a 30 km buffer of BICA, as of 2005.

Roadless areas are continuous patches of land 500 or more meters from any type of road. The patch size distribution of roadless areas varies considerably around BICA (Figure 4.3), with several large roadless patches (10 to >100 km^2) within and adjacent to the NRA. Additional large roadless areas are evident outside the study area on federal and tribal lands.

Within the study area about 90% (696 of 775) of the roadless patches are less than 10 km^2 (Figure 4.4), but these small areas add up to less than 20% (750 km^2 out of 3815 km^2) of the total roadless area within the 30-km buffer around BICA (Figure 4.5) as of 2005. This reflects the highly dissected nature of the landscape due to roads and brings attention to potential impacts on wildlife populations affected by road fragmentation.

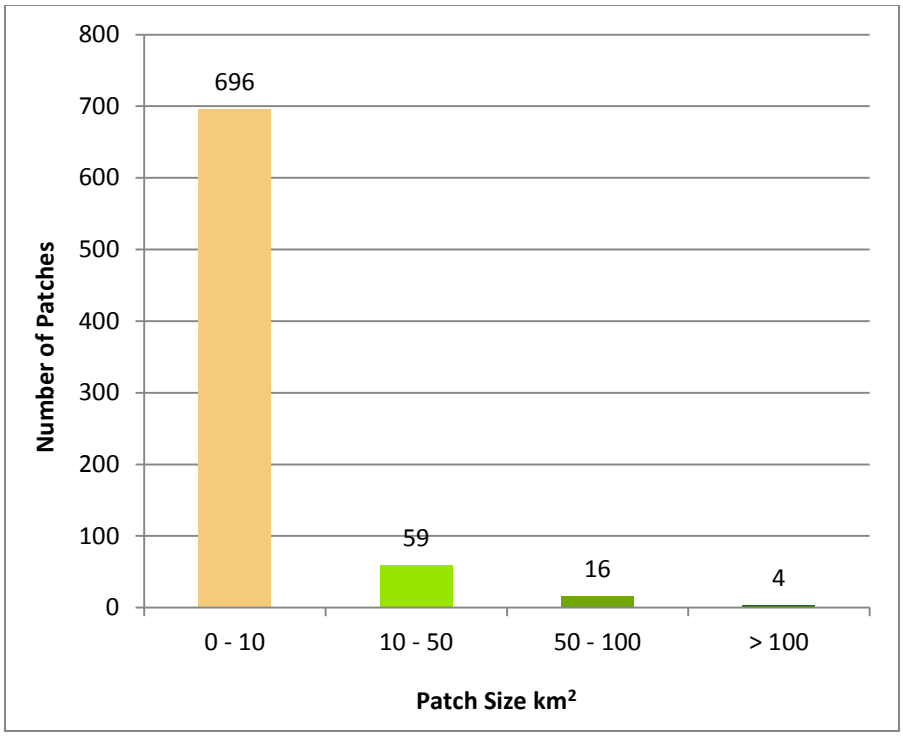

Figure 4.4. Number of roadless patches by patch size (km2) within the study area, as of 2005.

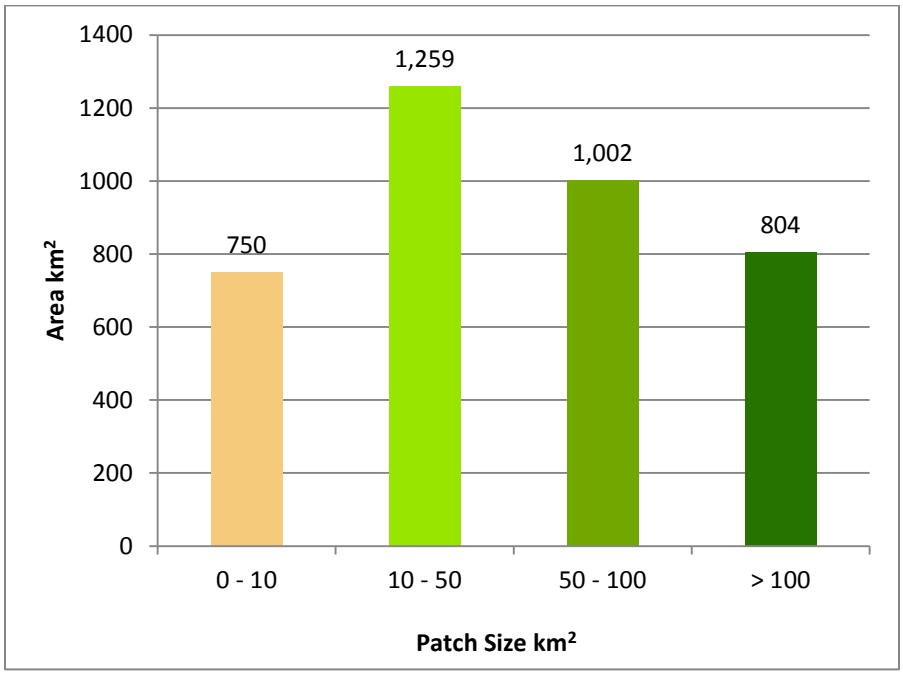

Figure 4.5. Total area (km2) of roadless patch sizes within the study area, as of 2005.

For more information about the data sources and methods used to analyze roads please visit the NPScape web site (http://science.nature.nps.gov/im/monitor/npscape/methods.cfm). The Standard Operating Procedure for calculating roads metrics can be downloaded here: (https://irma.nps.gov/App/Reference/Profile/2221733)

5. Land Cover

Based on a standardized classification from the 2011 National Land Cover Database (NLCD, Jin et al. 2013), natural land cover types occur across most of the study area (Figure 5.1). This has changed very little in the decade since the 2001 NLCD was released (Table 5.1), and these very small differences relative to the 2 million acre study area are well scattered across the landscape. NLCD characterizes and monitors land cover nation-wide using a series of products created from Landsat satellite data at 30-meter spatial resolution. The 16 cover classes from NLCD are grouped to show converted lands (comprising developed areas, cultivated crops, and hay/pasture lands) versus natural lands (all other major cover types).

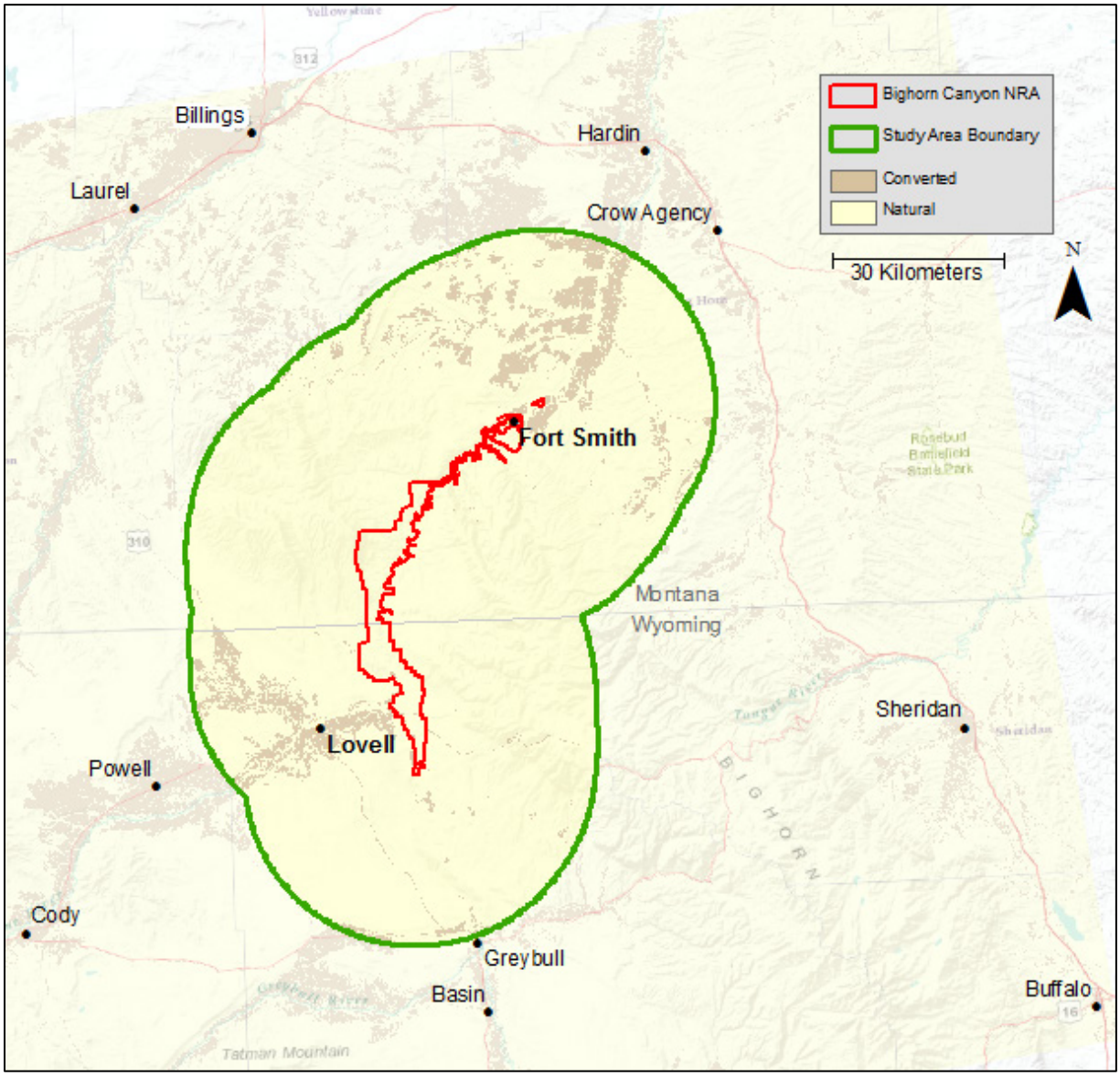

Figure 5.1. Map of natural vs. converted land cover circa 2011 in and around a 30 km buffer of BICA.

Table 5.1. Change in area for major cover types from 2001 to 2011 in the study area. The change values do not total zero because open water and barren cover types are not listed due to very small area values. Also, the relatively minor changes in cover types over a 10-year period across the large study area may result partly from Landsat data processing.

Cover Type	2001 Area km^2	2011 Area km^2	Change in Area km^2
Shrub/Scrub	2,935	2,938	3
Grassland/Herbaceous	3,303	3,305	2
Developed	70	70	no change
Agriculture	540	534	-6
Forest	1,034	1,028	-6
Wetlands	252	235	-17
Natural vs. Converted			
Natural	7,633	7,639	6
Converted	610	604	-6

In 2011 more than 75% of the study area was covered with grassland/herbaceous and shrub/scrub vegetation, while forested areas comprise about 13% (Figure 5.2). Evergreens dominate the forest types, and the classification of 30-meter pixel satellite imagery does distinguish a small amount of deciduous forest and mixed forest in the study area (Figure 5.3). Substantial agricultural use is evident in proximity to the Shoshone and Bighorn rivers, where cultivated crops and hay/pasture lands account for about 7% of the study area (Figure 5.4). Monitoring these broad land cover classes at the landscape level can help put into context the ongoing long-term monitoring of upland vegetation in communities of concern within BICA's managed boundary.

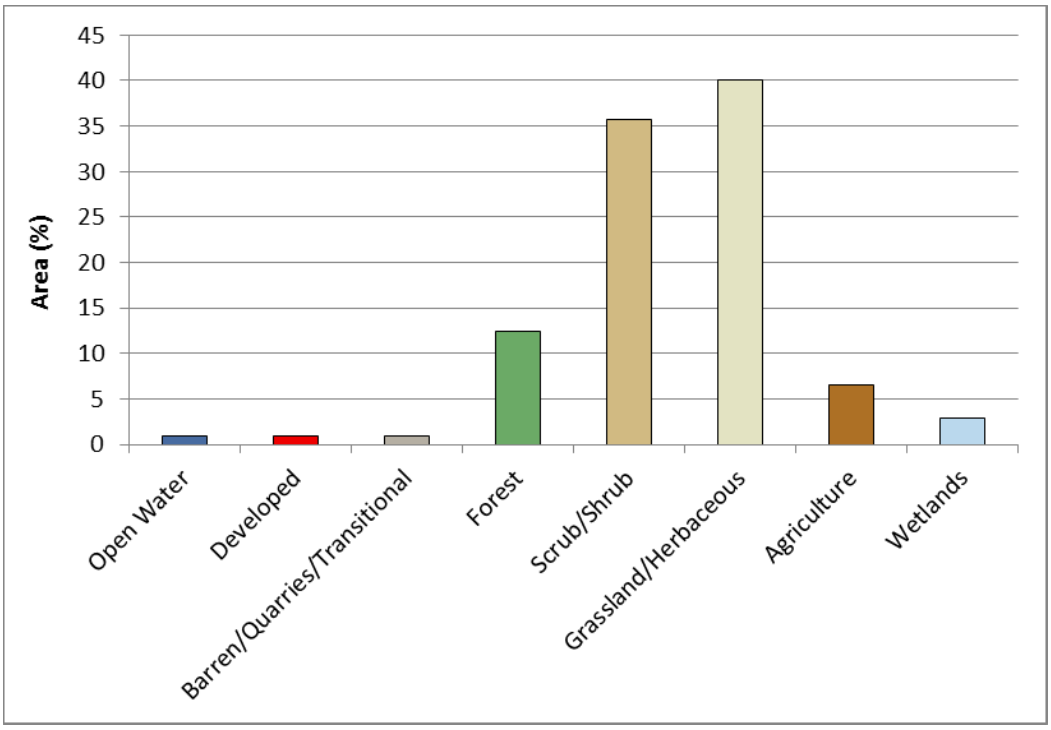

Figure 5.2. Percentage area of major land cover types in the study area circa 2011.

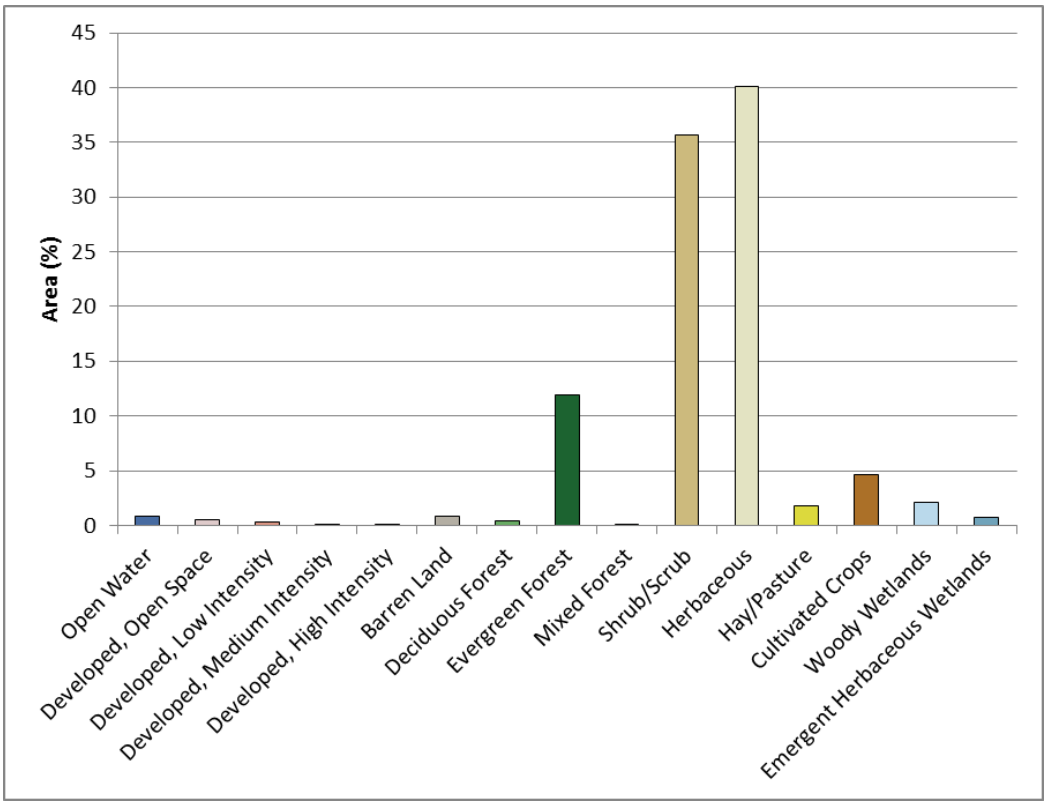

Figure 5.3. Percentage area of all NLCD cover types in the study area circa 2011. Perennial snow and ice cover is not shown because it does not occur in the study area.

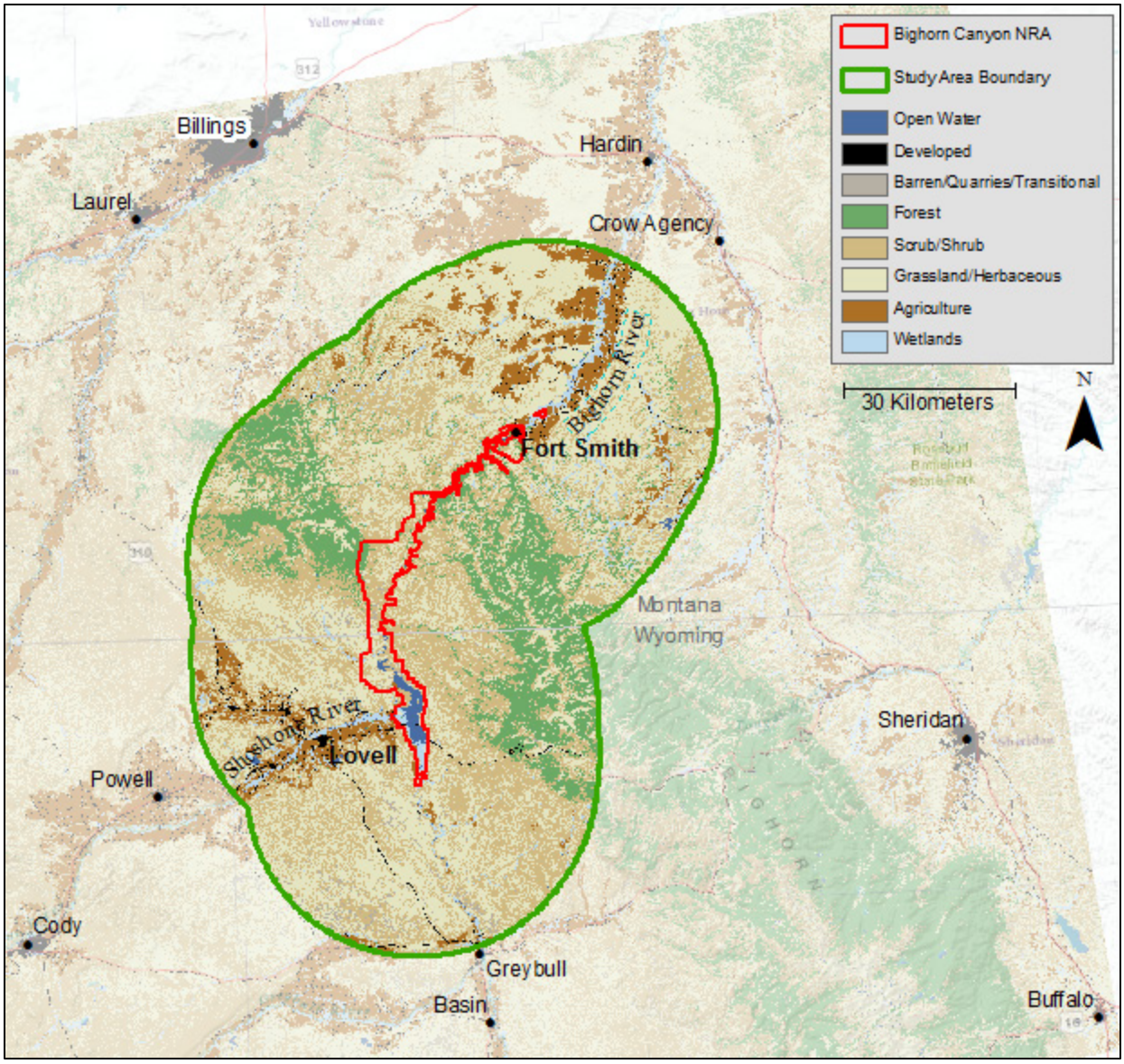

Figure 5.4. Map of major land cover types circa 2011 in and around the study area.

For comprehensive information about the data sources and methods used to analyze land cover please visit the NPScape web site (http://science.nature.nps.gov/im/monitor/npscape/methods.cfm). The Standard Operating Procedure for calculating land cover metrics can be downloaded here: (https://irma.nps.gov/App/Reference/Profile/2221549).

6. Conservation Status

Most of the publicly administered land in the study area, including BICA, is managed to protect the majority of natural land cover but can allow some extractive uses of either a broad, low-intensity type (e.g., logging) or a localized intense type (e.g., mining) (Figure 6.1). This is according to the U.S. Geological Survey's Gap Analysis Program Protected Areas Database for the United States (PAD-US), the official inventory of protected open space in the United States. (U.S. Geological Survey 2013). The PAD-US requests and aggregates data from federal and state sources, and national conservation organizations, in order to assign all lands to one of four biodiversity management status ranks (GAP Status) using established criteria (after Scott et al. 1993; Edwards et al. 1994; Crist et al. 1996). Criteria include prescribed management and the intent of a land steward as evidenced by legal and institutional factors. This latest update to the PAD-US does not include conservation status data for some BLM land in the Pryor Mountains, the small military training area southeast of Lovell, and adjacent tribal lands in Montana. These are represented in the PAD-US database with the term "no known mandate for protection." However, all federal and state lands include protection for federally listed endangered and threatened species, and recent resolutions by the Crow Tribal Legislature signify the tribe's interest in developing a land management act and natural resource management plan for tribal lands (Crow Tribe 2008). Portions of the Yellowtail Wildlife Habitat Management Area and some parts of the Pryor Mountains adjacent to BICA are managed to maintain a primarily natural state but may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance. No portions of the study area have management policies to permanently protect and maintain a natural state where natural disturbance events are allowed to proceed without interference or by mimicking natural disturbance through active management.

While this basic classification of conservation status broadly reflects management intent to conserve biodiversity, the PAD-US does not account for every local land management policy, action, or outcome. Still, these categories of conservation status provide consistent data using standard criteria for monitoring conservation status at the landscape-level in order to help managers identify and respond to changes or concerns.

About 12% of the 8,425 km^2 study area is private property, mostly concentrated in the vicinity of Lovell, with additional private holdings scattered throughout. Tribal lands comprise most of the northern half of the study area and make up 51% (3,754 km^2) of the nonprivate lands. Approximately 46% (3,428 km^2) of the nonprivate land is federally managed by NPS, USFS, BLM, BOR, or DOD. The remaining 3% (220 km^2) of the nonprivate lands are parcels of state land, including the Yellowtail Wildlife Habitat Management Area.

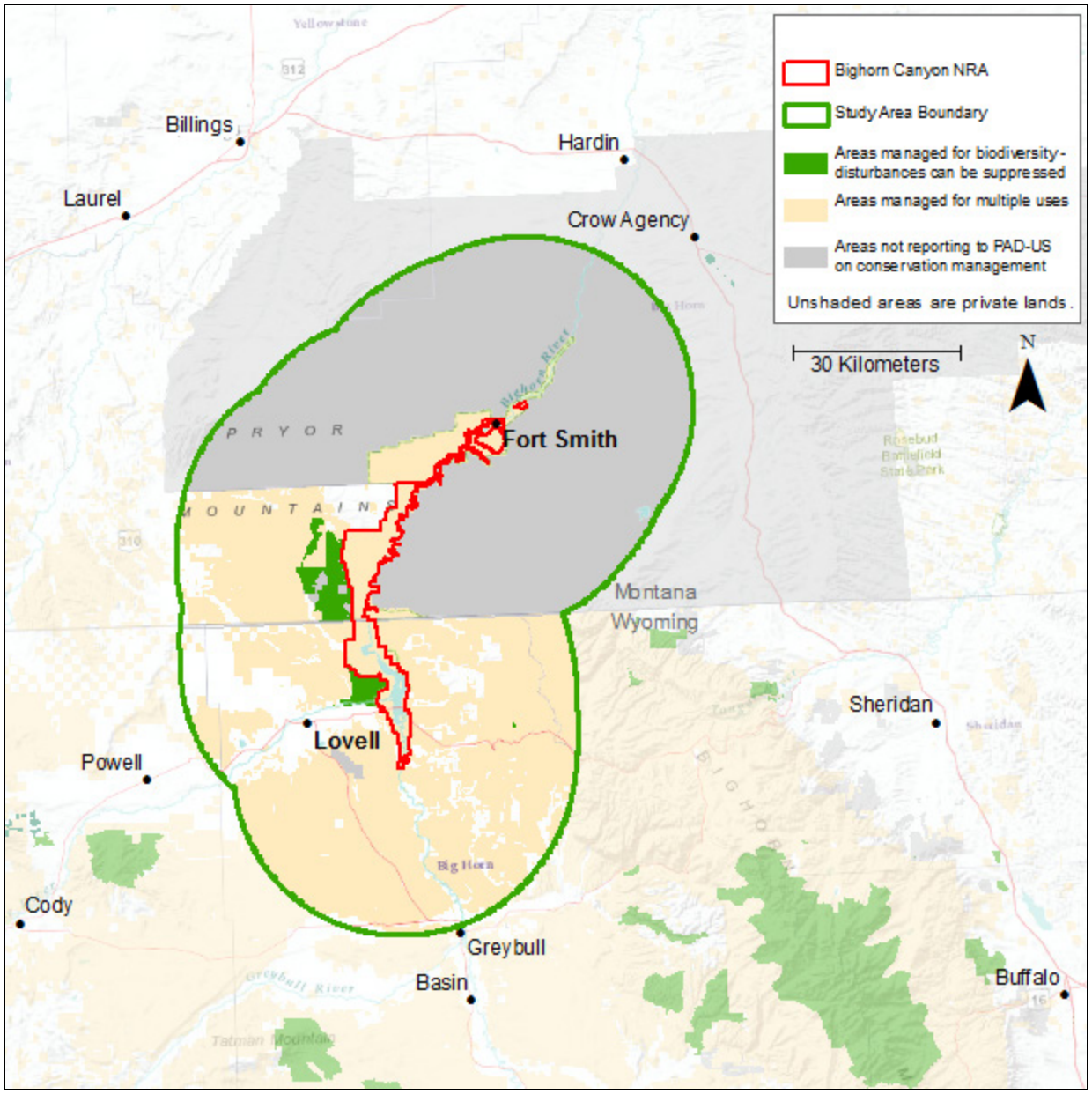

Figure 6.1. Level and type of land protection in the study area.

For comprehensive information about the data sources and methods used to analyze conservation status please visit the NPScape web site. (http://science.nature.nps.gov/im/monitor/npscape/methods.cfm). The Standard Operating Procedure for calculating the conservation status metrics can be downloaded here: (https://irma.nps.gov/App/Reference/Profile/2221712)

7. Climate

A recent report on climate exposure in U.S. national parks (Monahan and Fisichelli 2014) found that, for the BICA study area, four temperature variables over the past 10 to 30 years were "extreme warm" when compared to the 1901–2012 historical range of climatic conditions (annual mean temperature, maximum temperature of the warmest month, minimum temperature of the coldest month, and mean temperature of the warmest quarter). "Extreme" conditions were defined as exceeding 95% of the historical range of variability for each climate variable. The study also found that precipitation of the warmest quarter was "extreme dry."

Ongoing and future climate change will likely affect all aspects of park management, including natural and cultural resource protection as well as park operations and visitor experience. Effective planning and management requires a thorough understanding of the climate's past dynamics, present conditions, and projected future change. Climate awareness involves understanding variations in average conditions as well as planning for particular climate-related events that can include more intense storms, flooding, or drought, any of which may substantially affect the conditions of park resources.

For graphics and a summary of methods, results, and climate change adaptation ideas, please see the resource brief "Recent Climate Change Exposure of Bighorn Canyon National Recreation Area" (NPS 2015; http://irmafiles.nps.gov/reference/holding/497068).

8. Conclusion

Bighorn Canyon NRA, unlike many other units in the National Park System, retains its rural character with low housing and road densities and slowly growing human populations. The study area, encompassing lands within 30 km of BICA's managed boundary, contains primarily natural vegetation, about half of which is on Crow tribal lands. Most nontribal lands in the study area are managed for natural resources conservation by the National Park Service, the Bureau of Land Management, or the U.S. Forest Service. Only 12% of the study area is privately held and substantial agricultural use occurs on only about 7% of the study area, primarily along the Shoshone and Bighorn rivers. Based on this report, the prevailing and prospective landscape-scale considerations for BICA managers are the potential spread of exotic plants, particularly along well-traveled roadways; the lack of opportunity to manage for ecological processes such as natural fire regimes; potential for low level extractive uses such as logging and mining; and the impacts of climate change on vegetation, water availability, and other resources and natural processes that are projected to respond to a changing climate.. This report serves as a baseline for evaluating future changes in housing density, human population, roads, land cover, conservation status, and climate, using standardized landscape-level data and analytical procedures that are repeatable over time and thus conducive to long-term monitoring.

Other ongoing and future studies are also important landscape information sources for BICA managers. As online data and interactive maps become more common, these information delivery systems will likely supplement or replace traditional reports to interactively provide products when needed, and to integrate results from independent studies. It is likely that BICA's next report on landscape dynamics will involve an online, interactive tool for timely and dynamic information delivery, one that incorporates data used for this report with newer data as it becomes available, such as when population and housing data are available from the 2020 census, and when the next version of NLCD is available for land cover. These online tools will integrate and synthesize data and results that show relationships between landscape metrics and resources such as wildlife habitat and migration routes. The following online map viewers and services are available now, and their content and functions are expected to expand over time.

NPS Planning Division's Park Atlas:
http://insideparkatlas.nps.gov/Gallery/

NPS Inventory & Monitoring Division's NPScape Viewer:
http://science.nature.nps.gov/im/monitor/npscape/viewer/

USGS Gap Analysis Program Protected Areas Viewer:
http://gapanalysis.usgs.gov/padus/viewer/

The Great Northern Landscape Conservation Cooperative:
http://greatnorthernlcc.org/overview

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The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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