

A GIS-Based Method to Evaluate Undeveloped BLM Lands in Alaska

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Abstract—As Alaska's largest land management agency, the Bureau of Land Management (BLM) has responsibility for over 87 million acres (35 million ha) of public lands throughout the state. By using datasets and Landsat scenes within a Geographical Information System (GIS), this study prioritizes wilderness protection through the ranking of BLM blocks (contiguous land parcels), in Alaska based on proximity to current 'development.' Development is defined as 1,000 m (3,280.8 ft) around towns, active oil and gas leasing, mining claims, infrastructure, dams, and disturbance (visible scars on Landsat scenes). A Development Index (DI) was calculated based on the percentage of developed area and size of each BLM block. Of the BLM blocks evaluated, 36.8 percent have no development within 1,000 m of block boundaries. BLM lands with less than 1 percent development comprise 35.6 percent, while 17.6 percent of BLM lands are between 1 and 10 percent developed. Based on the DI, the highest ranking blocks free of development are the National Petroleum Reserve-Alaska (DI = 2,517.3), Nulato Hills (DI = 2,377.3), and Ruby (DI = 2,244.3). This study both demonstrates that under these criteria additional BLM lands qualify for potential Wilderness designation and prioritizes these areas for BLM review and Citizen Wilderness Inventories.

Introduction

The Bureau of Land Management manages some of Alaska's most diverse, spectacular, and unprotected wilderness. As Alaska's largest land management agency, the BLM has responsibility for over 87 million acres (35 million ha) of surface land and 245 million acres (99 million ha) of subsurface mineral estate (BLM 2001). In Alaska, only 780,000 acres (315,655 ha) of BLM lands are classified as Wilderness Study Areas (Central Arctic Management Area WSA) and no BLM lands are designated as Wilderness (BLM 2001) (fig. 1).

The idea of wilderness is a historically controversial subject in Alaska, and thus the BLM has not yet designated any wilderness areas on its lands within the state. Section 603 of the Federal Land Policy and Management Act of 1976 (FLPMA) required the Secretary of the Interior to review all public lands and determine which contain wilderness characteristics. Findings were reported to the President on

recommendations for new units of the National Wilderness Preservation System (NWPS) by 1991. The Alaska National Interest Lands Conservation Act (ANILCA), passed by Congress in 1980, exempted the vast majority of BLM lands in Alaska under Section 1320 from the FLPMA-Section 603 wilderness review process. This was changed in 2001 when former Secretary of the Interior Bruce Babbitt lifted that directive and freed the agency to review wilderness values on BLM lands in Alaska. In 2003, Secretary of the Interior Gale Norton reinstated the old directive for BLM to cease wilderness reviews in Alaska and consider wilderness only when broadly supported by elected Alaska officials. Currently, the majority of Alaska's elected officials are opposed to any new wilderness designation on BLM lands within Alaska.

Per the BLM's Wilderness Inventory and Study Procedures Document (H-6310-1; Release 6-122; dated January 1/10/2001), the "primary function of a wilderness inventory is to document the presence or absence of public lands with wilderness character. The inventory will include gathering information and preparing a file for each inventory area." Several conservation organizations throughout the United States have conducted Citizen Wilderness Inventories (CWI) within BLM lands. The California Wilderness Coalition identified 7.4 million acres (2.9 million ha) as potential Wilderness through the use of volunteers across the state (see <http://www.calwild.org/resources/inventory.php>). The Oregon Natural Desert Association inventoried 363,000 acres (146,901 ha), either wholly or partially within the Andrews Resource Area (see <http://www.onda.org/projects/index.html>).

This project may serve as a model for a CWI and to help prioritize efforts within the State of Alaska. Alaska's enormous size and lack of infrastructure limits the ability of a CWI on BLM lands in Alaska. Thus, this project focused on available spatial datasets, satellite imagery, and GIS technology to evaluate and prioritize BLM lands for future wilderness inventories.

A geographic information system (GIS) is used to determine areas considered 'not-developed.' For this project, the term 'developed' describes areas within 1,000 m (3,280.8 ft) of existing infrastructure, such as roads, railroads, pipelines, electrical transmission lines, oil and gas leases, dams, mining claims, and towns. This report blends concepts from past citizen inventories of wilderness and methods from similar studies utilizing GIS technology.

This project follows similar methods developed by the Conservation Biology Institute (CBI) in the assessment of intact forest within Alaska. Strittholt and others (2006) found 72 individual forest blocks greater than 50,000 ha (123,533 acres) in size within the boreal region of Alaska. Methods used to determine intact forest include the buffering of roads, pipelines, and populated areas at varying distances ranging

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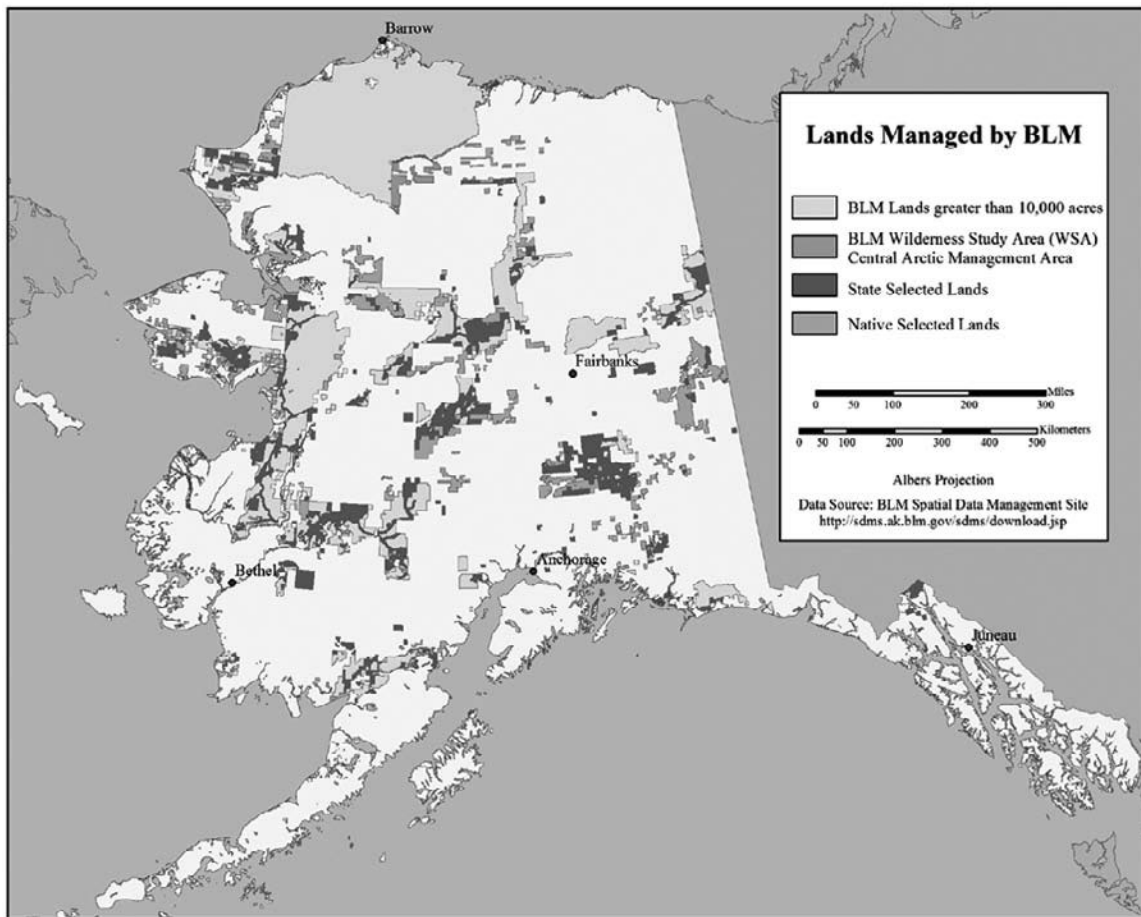


Figure 1—BLM lands in Alaska.

from 1 to 5 km (.62 to 3.1 miles). Landsat satellite imagery was used to identify additional human impacts. Buffered areas were used to eliminate human impacts to reveal areas of intact forests.

Additionally, this project furthers a study conducted by Pacific Biodiversity Institution (PBI), which evaluated the current extent of wildlands within the United States. PBI (Karl and others 2001) found that Alaska has 46.6 percent of the unprotected roadless area within the United States, with 85.6 percent of these wildlands remaining in patches greater than 1 million acres (404,686 ha). However, PBI's methods for Alaska included only the infrastructure GIS layer produced by the Alaska Department of Natural Resources. The infrastructure layer is one of six layers used within this study.

Other studies have focused on perceptual indicators of wilderness to create a continuum or index. Aplet (2000) evaluated the wilderness indicators of solitude, remoteness, uncontrolled processes, natural composition, unaltered structure and pollution to create a Wilderness Index for the contiguous United States. Carver (2002) described remaining wilderness areas in the United Kingdom from public opinion solicited via a website where users defined the minimum level of wilderness quality indicators. This study differs from others by using multiple GIS layers and Landsat scenes to

evaluate altered landscapes on BLM lands in Alaska. The indicators used within this study focus on geographic elements to help prioritize areas for further evaluation using other wilderness attributes.

Methods

This project utilized GIS technology to evaluate “non-developed” BLM lands within Alaska. A GIS is a computer application that stores, retrieves, manipulates, analyzes, and displays geographically referenced information (see <http://www.esri.com>). Several GIS layers are used for analysis to represent phenomena occurring within Alaska's BLM lands.

GIS data layers used within the study came from multiple sources including several divisions within the Alaska Department of Natural Resources (DNR) (see <http://www.asgdc.state.ak.us/homehtml/pubaccess.html>) (Department of Environmental Conservation, Department of Oil and Gas, Department of Community & Economic Development), as well as, the U.S. Army Corps of Engineers and U.S. Environmental Protection Agency. Note that most layers only document phenomena occurring on Federal lands, which is of specific interest to this project. Below is an explanation of the GIS layers used within this study.

- **BLM Lands Layer**—The BLM lands layer is the foundation of this study, as it depicts solely the lands used within the analysis (<http://sdms.ak.blm.gov/sdms/download.jsp>). All lands currently managed by BLM are analyzed, including state selected and native selected lands. Information for this layer is extracted from the statewide land status layer produced by BLM using information within the attribute table. Note that only BLM managed lands greater than 10,000 acres (4,047 ha) are used for analysis, resulting in 552 individual polygons. The smallest unit size is 10,026 acres (4,057 ha); maximum size is 21,901,526 acres (8,863,233 ha); mean size is 147,184 acres (59,563 ha).
- **Oil and Gas Lease Layers**—The oil and gas lease layers included the active lease boundaries for the North Slope Foothills, and North Slope area wide, and Cook Inlet Area. Downloaded layers are from the Alaska Department of Natural Resources (DNR), Division of Oil and Gas in August, 2004 (<http://www.dog.dnr.state.ak.us/oil/products/data/downloads/downloads.htm#>).
- **Dams Layer**—The dam layer is derived from the National Inventory of Dams produced by the U.S. Army Corps of Engineers, who inventories all dam locations in the United States. A file containing downloaded latitude and longitude coordinates from the National Inventory of Dams web site was imported as a GIS layer. The layer contains 112 dams located within Alaska (<http://crunch.tec.army.mil/nid/webpages/nid.cfm>).
- **Mining Layer**—The mining claims layer is a combination of state mining claims, prospecting sites, and Federal claims either selected or patented within the State of Alaska. The layer includes both active and inactive mining claims. Source for layer is the Alaska State DNR (<http://www.asgdc.state.ak.us/metadata/vector/resource/mining/minefs.html>).
- **Towns (Population) Layer**—A towns/villages layer representing Alaska communities is derived from the 2000 census data. The Alaska State Department of Community & Economic Development maintains an online Alaska Communities Database with latitude/longitude locations and current population figures on communities in Alaska (http://www.dced.state.ak.us/cbd/commdb/CF_COMDB.htm). These coordinates are used to create a GIS layer depicting community locations.
- **Infrastructure Layer**—The infrastructure layer consists of the infrastructure digitized primarily from USGS 1:24,000, 1:63,360, and 1:250,000 quadrangles. Source for this layer is the Alaska State DNR (<http://www.asgdc.state.ak.us/metadata/vector/trans/infra63.html>). This includes such themes as roads, transmission lines, tractor trails, airfields, pipelines, railroads, etc. Themes such as foot trails and the Alaska Marine Highway are excluded from analysis.
- **Disturbance Layer**—The method of evaluating human-made disturbance on the landscape using Landsat satellite scenes comes from CBI. All BLM lands greater than 10,000 acres (4,047 ha) are evaluated for disturbance. Disturbance is defined as a linear scar visible within the landscape through Landsat Scenes (30 m/98 ft pixel resolution) at a scale of 1:50,000. Landsat Satellites are part of the Landsat Project, an enterprise for acquisition of imagery of the Earth from space.
- **Pollution Layer**—The pollution layer was obtained from Alaska Community Action of Toxics (ACAT), an organization that aims to protect human health and the environment from the toxic effects of contaminants. ACAT integrated various state and federal databases into a comprehensive view of the location of over 1,600 toxic sites in Alaska (<http://www.akaction.net/pages/mapping/mapindex.html>). Toxic sites vary from gasoline spills to Superfund sites. The pollution layer is used only as reference to determine disturbance scars visible on the landscape.
- **Administrative Boundaries**—The Administrative boundaries layer was obtained from the Alaska State DNR (<ftp://ftp.dnr.state.ak.us/asgdc/adnr/adminbnd.e00.gz>). The layer represents the state and federal boundaries of lands with varying levels of protection. Examples include all Fish and Wildlife Refuges, National Parks, National Forests, and State Critical Habitat Areas. The layer was used for within ecoregional and vegetation analysis. Although each area is managed differently, for purposes of this study administrative boundaries parcels are considered a greater level of protection from development than lands outside administrative boundaries.
- **Ecoregions**—The ecoregions layer was developed cooperatively by the U.S. Forest Service, National Park Service, U.S. Geological Service and The Nature Conservancy (<http://agdc.usgs.gov/data/projects/fhm/index.html#G>). The layer depicts the major ecosystems of Alaska. Examples include the Bering Tundra, Coastal Rainforests, and Seward Peninsula. This layer was used within ecoregional analysis.

Two GIS layers are modified from their original form; these include the towns and infrastructure layer. Communities with a population of zero are eliminated from the town layer. Examples include the towns Flat, Hobart, and Miller Landing. The infrastructure layer has a large degree of modification through the removal of several line segments using layers' attributes. Descriptions labels vary from specific descriptions (for example, Rabbit Creek Road) to general descriptions (for example, Forest Development Roads). Several segments are removed from this layer as they are not included in the definition of disturbance. Examples of removed segments include the Alaska Marine Highway and hiking trails (such as, Lost Lake Trail). Additional infrastructure layer segments were removed, as they are not visible on Landsat scenes.

The definition of disturbance is a scar visible on the landscape through a Landsat Scene (30 m/98 ft pixel resolution) at a scale of 1:50,000. The pollution layer is used as a reference to find disturbance locations on Landsat satellite scenes. Examples of scars included old roads from military sites and old mining sites. Scars were digitized into the disturbance layer. Scars were also found adjacent to existing infrastructure. These are also added into the disturbance layer. Thus, the disturbance layer is comprised of 'missing' roads and pipelines from the infrastructure layer, plus historical roads and trails not captured in any of the other GIS layers.

GIS Analysis

To perform GIS spatial analysis, data modification is needed. This includes converting from points, lines, and polygons (vector data model) to rows and columns of pixels (raster data model) and calculating a Euclidean distance function to each 'source' cell for all GIS layers. The Euclidean distance function determines the distance to all cells from a specific set of source cells (for example, dams within the dams GIS layer). A conditional statement changes all values greater than 1,000 m (3,280.8 ft) to a value of zero, while values less than 1,000 m become a value of one. This allows for each layer to be added together, resulting in a range of values of zero to six. A value of six equates to an area where a pixel is within 1,000 m (3,280.8 ft) of each of the six GIS layers considered. A combined layer was converted back to a vector layer to determine overlap with BLM lands. Calculating the developed area of each BLM block is done to determine a Development Index (DI). A detailed description and graphical representation of GIS analysis is found in figure 2.

Development Index

A Development Index (DI) is created to allow ranking of BLM managed land units based on both the degree of development and the size of unit. Large areas with little development are ranked higher than small areas with little development. It is advantageous to focus on the management of larger blocks versus smaller blocks in terms of ecological processes and opportunities for isolation and remoteness, thus size is considered as a critical factor in the index. The index is calculated by multiplying the percent non-developed for each block by the natural log of the size of the unit. Taking the natural log of block area normalizes the value, thus allowing comparisons for degree of development. The equation is as follows:

$$(\% \text{ Not developed}) (\ln (\text{Block Area}))$$

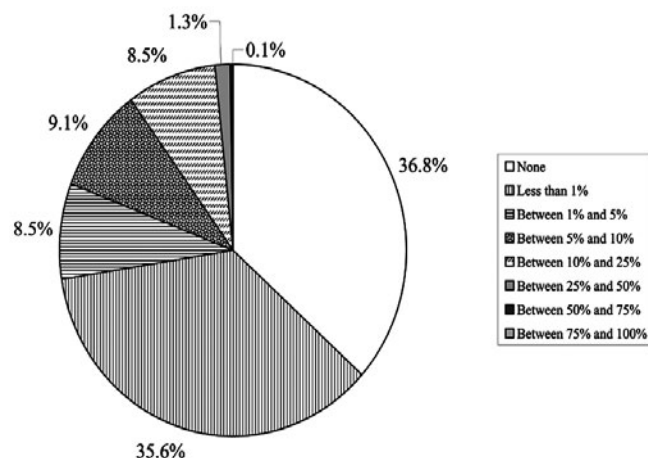


Figure 2—Percentage of developed BLM blocks.

The range of index values is 40.4 to 2,517. A higher index value reflects low development and a large block area and thus a higher wilderness value potential. A low index value reflects both high development and a small block area and lower wilderness value potential. The scenarios below provide a few examples of index scores.

Low Development Scenario—10 Percent Developed
Non-development (90%) of large block area (8,000,000 acres)

$$DI = (.9) (\ln 8,000,000)$$

$$DI = 14.30$$

Non-development (10%) of small block area (100,000 acres)

$$DI = (.9) (\ln 100,000)$$

$$DI = 10.36$$

High Development Scenario—85 Percent Developed

Non-development (15%) of large block area (8,000,000 acres)

$$DI = (.15) (\ln 8,000,000)$$

$$DI = 2.38$$

Non-development (15%) of small block area (100,000 acres)

$$DI = (.15) (\ln 100,000)$$

$$DI = 1.73$$

Discussion and Results

In this study, we ranked individual BLM blocks greater than 10,000 acres (4,047 ha) based on the percentage of current 'development.' Recall that the definition of development is determined from a distance of 1,000 m (3,280.8 ft) within towns, active oil and gas leasing, mining claims, infrastructure, dams, and other identified disturbance. Of the BLM blocks evaluated, 36.8 percent have no existing development within 1,000 m (3,280.8 ft) of the block boundary. BLM lands with less than one percent development comprise 35.6 percent, while 17.6 percent of BLM lands have between one and 10 percent development (fig. 2). The remaining 10.1 percent of lands are found to have development greater than 25 percent.

The BLM currently manages lands that are selected for conveyance of land ownership by both the State of Alaska (state selected) and Native Alaskans/Corporations (native selected). Within this study, the evaluated BLM lands greater than 10,000 acres (4,047 ha) represent 81,245,323 acres (32,878,816 ha). Unencumbered BLM lands represent 50,088,982 acres (20,270,292 ha) (61.6 percent) of the total lands evaluated, while state selected lands represent 17,473,094 acres (7,071,110 ha) (21.5 percent) and native select comprise 13,683,246 acres (5,537,413 ha) (16.9 percent).

Top Twenty-Five Overall Ranked Blocks

Of the BLM lands, the highest ranking block is the National Petroleum Reserve-Alaska (NPR-A), suggesting a large block with the least amount of development. NPR-A is located north of Noatak National Preserve (NPr) extending to the Arctic Ocean and covers 21.9 million acres (8.8 million

ha). NPR-A has a development index of 2,517.3; this index is based on the percentage of development and the size of block. The second highest ranked block is the Nulato Hills parcel encompassing over 5.2 million acres (2.1 million ha) and has a development index of 2,377.3 with no development present within the block. The third highest ranking block is the Sheklukshuk block, found North of Koyukuk NWR and South of Gates of the Arctic National Park (NP). The Sheklukshuk block is over 1.3 million acres (526,000 ha) with a development index of 2,241.9. Additional ranked BLM block sizes and development indexes are found in table 1; figure 3 graphically represents the top twenty-five BLM blocks.

Top Ranked Native and State Selected Blocks

Of the Native Selected BLM managed lands, the highest ranking block is Fortymile, suggesting a large block with a small amount of development. Fortymile is located North of Selawik NWR and South of Yukon-Charley National Preserve. The Fortymile block is over 1,191,000 acres (481,981 ha) with a development index of 2,133.9. The Denali Block is the largest State Selected Block with over 2 million acres (809,371 ha) and a Development Index of 2,107. The highest ranking State Selected Block is the Ruby State Block. The Ruby block is located South of Nowitna NWR and North of Denali NP. The Ruby block is over 1,458,000 acres (590,032 ha) with a development index of 2,244.3. Figures 4 and 5 locate the top five Native and State Selected Blocks.

Validation

Validation of the 1,000 m from 'developed' areas measure was done by examining several other distances. Distances of 250, 500, 1000, 2000, 3000, 4000, and 5000 m determined the sensitivity of impact on the percent developed for each BLM land unit. The process was conducted in the same manner as previously discussed with the various input distances changed. After comparing varying distances, results are consistent with block ranking. NPR-A was ranked with the greatest index value for all distances evaluated (table 2). Blocks Nulato Hills, Holy Cross—East, Black River, Lime Village, Kandik, Minchumina, McGrath, and Tonzona all had the same index regardless of the distance evaluated. This is attributed to their location away from any existing 'development.' Table 2 shows the Index values at varying distances for the top 20 blocks.

Percentage of Development

Table 3 shows the percentages of development at varying distances for the top 20 blocks. As the distance increased for areas near development, the percentage 'developed' decreased for several ranked blocks. Blocks Nulato Hills, Holy Cross—East, Black River, Lime Village, Kandik, Minchumina, McGrath, and Tonzona again had no change in percent due to distance from 'developed areas.' Table 3 illustrates the top 20 ranked blocks in relation to all GIS used to determine development level.

Table 1—Top 25 ranked blocks of BLM managed lands (based on Development Index).

Rank	Block name	Management	Percent undeveloped	Acres	Index
1	National Petroleum Reserve-Alaska	BLM	99.9	21,901,526.0	2,517.3
2	Nulato Hills	BLM	100.0	5,217,097.0	2,377.3
3	Ruby	SS	99.8	1,458,735.7	2,244.3
4	Sheklukshuk	BLM	100.0	1,347,593.4	2,241.9
5	Tanana	SS	99.8	1,208,116.5	2,227.3
6	Unalakleet	SS	99.9	1,027,210.3	2,213.4
7	Bering Glacier	BLM	100.0	787,081.8	2,188.2
8	Hughes	BLM	99.5	652,930.6	2,158.1
9	Holy Cross (East)	BLM	100.0	568,002.4	2,155.6
10	Holy Cross (West)	BLM	100.0	564,612.7	2,154.9
11	Black River	SS	100.0	557,716.2	2,153.7
12	Lime Village	BLM	100.0	548,015.7	2,151.9
13	Kandik	BLM	100.0	459,927.8	2,134.4
14	Fortymile	NS	95.7	1,191,404.1	2,133.9
15	Dulbi-Kaiyuk Mountains	BLM	100.0	426,925.2	2,127.0
16	Susitna River	NS	98.7	545,009.5	2,123.4
17	Minchumina	NS	100.0	389,561.7	2,117.9
18	Lone Mountains	BLM	98.0	540,969.0	2,108.0
19	McGrath	SS	100.0	352,211.4	2,107.8
20	Denali	SS	92.0	2,174,811.4	2,107.0
21	Tozitna	BLM	100.0	346,878.9	2,106.2
22	Shungak	NS	100.0	342,705.9	2,104.0
23	Bendeleben Mountains	SS	97.3	611,408.8	2,103.7
24	Selawik	BLM	100.0	337,103.7	2,103.4
25	De Long Mountains	BLM	100	312,240.3	2,095.7

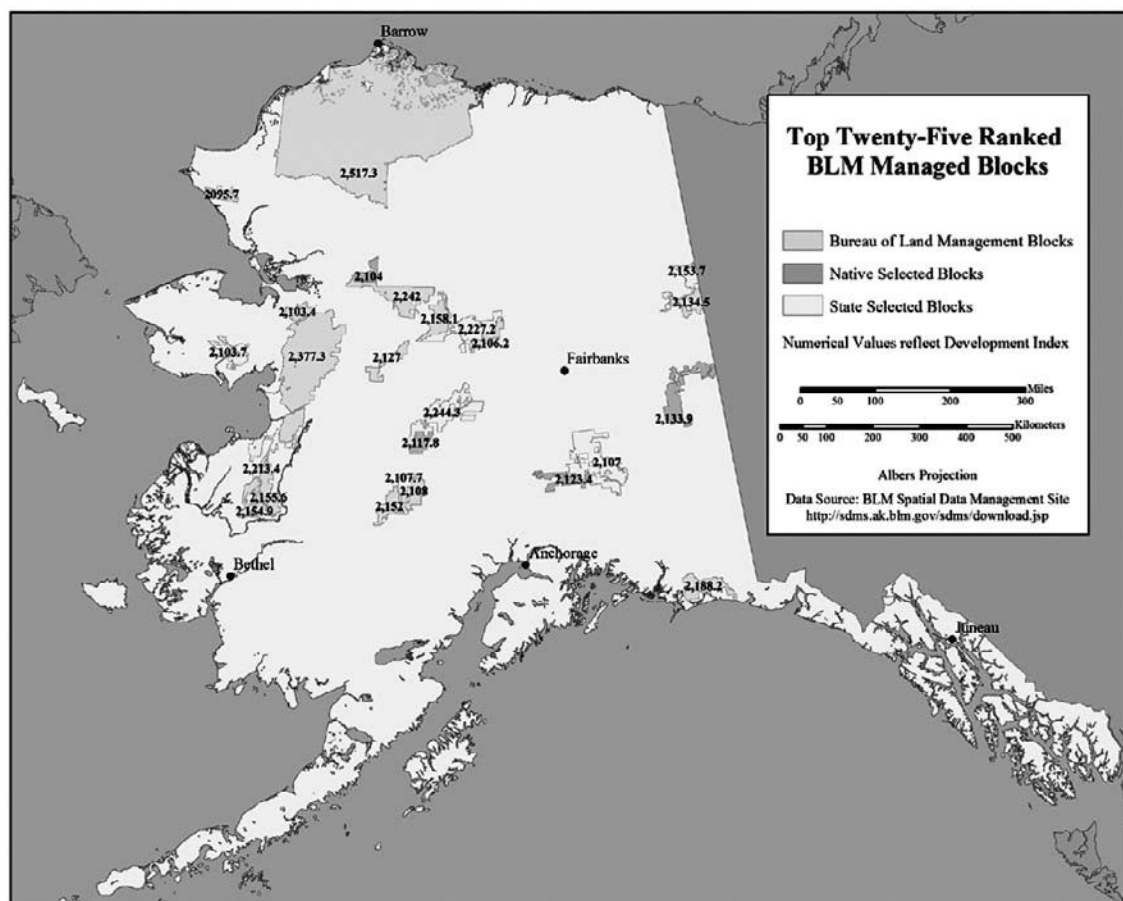


Figure 3—Top 25 ranked BLM managed blocks and Development Indices.

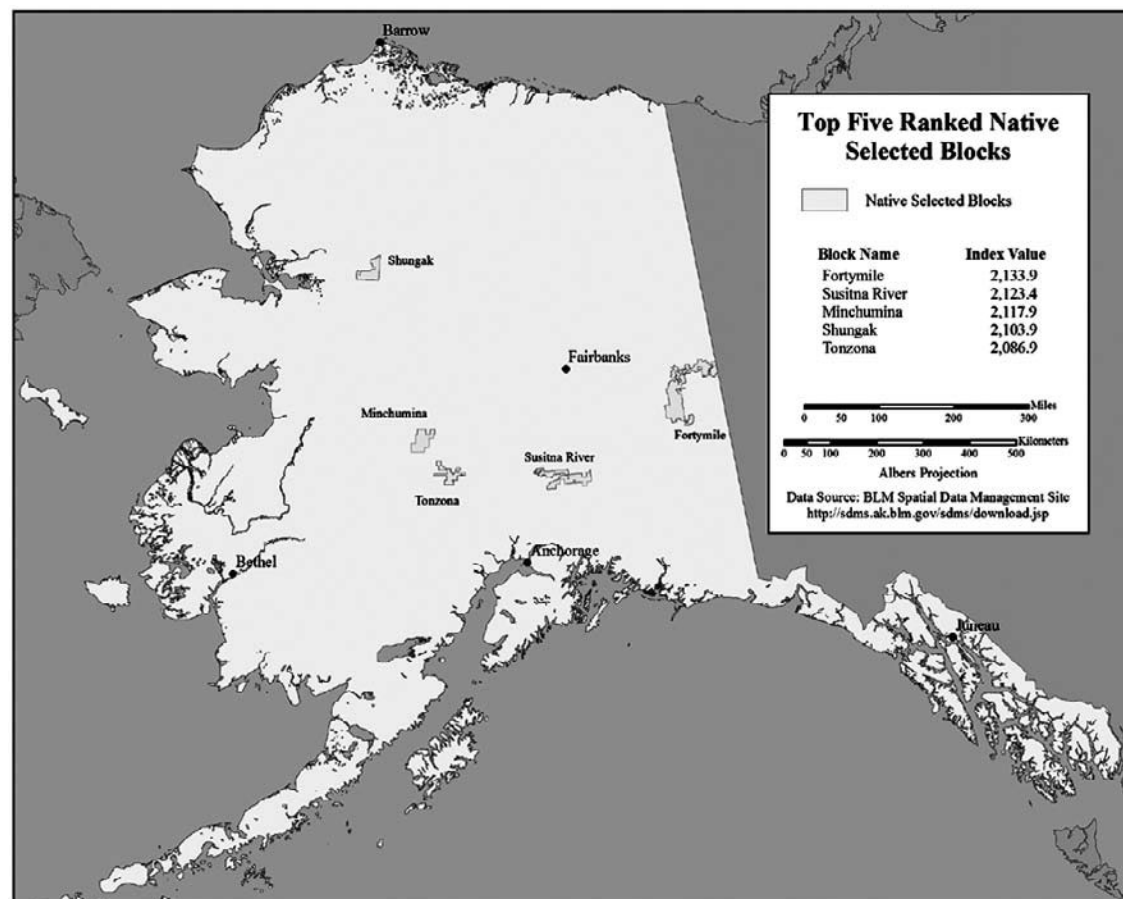


Figure 4—Top five ranked native selected blocks.

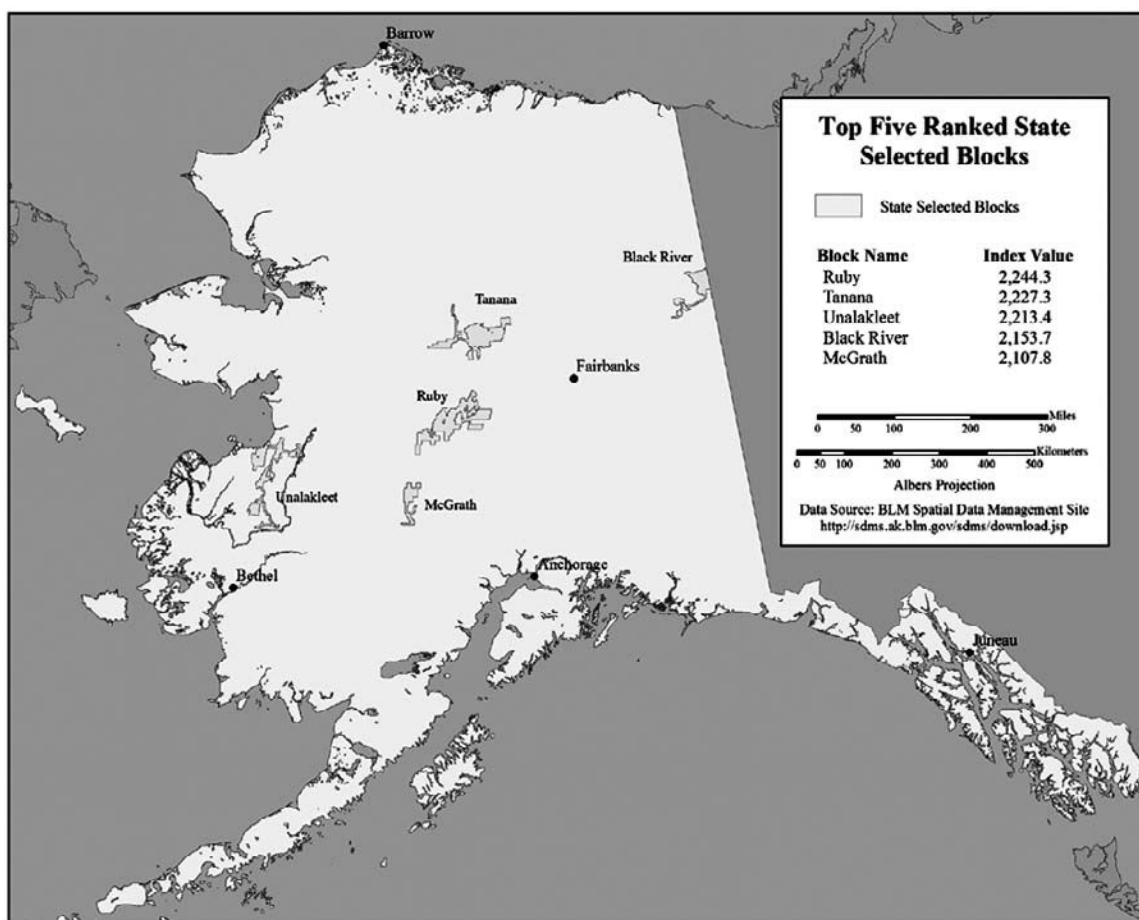


Figure 5—Top five ranked state selected blocks.

Table 2—Development Index values at varying distances for top 20 blocks.

Block name	Index value						
	(250 m)	(500 m)	(1000 m)	(2000 m)	(3000 m)	(4000 m)	(5000 m)
NPR-A	2,520.3	2,519.7	2,517.4	2,509.5	2,498.2	2,483.7	2,466.3
Nulato Hills	2,377.3	2,377.3	2,377.3	2,377.3	2,377.3	2,377.3	2,377.3
Ruby	2,248.2	2,247.3	2,244.3	2,236.7	2,225.6	2,211.5	2,194.8
Sheklukshuk	2,242.0	2,242.0	2,241.9	2,241.4	2,239.0	2,231.2	2,218.4
Tanana	2,229.7	2,229.0	2,227.3	2,223.5	2,219.0	2,212.4	2,205.8
Unalakleet	2,214.8	2,214.3	2,213.4	2,210.0	2,202.1	2,190.8	2,177.1
Bering Glacier	2,188.2	2,188.2	2,188.2	2,188.2	2,188.2	2,186.5	2,181.0
Hughes	2,166.6	2,164.1	2,158.1	2,145.0	2,128.2	2,107.3	2,083.4
Holy Cross—East	2,155.6	2,155.6	2,155.6	2,155.6	2,155.6	2,155.6	2,155.6
Holy Cross—West	2,155.0	2,155.0	2,154.9	2,154.1	2,149.4	2,133.6	2,102.9
Black River	2,153.7	2,153.7	2,153.7	2,153.7	2,153.7	2,153.7	2,153.7
Lime Village	2,151.9	2,151.9	2,151.9	2,151.9	2,151.9	2,151.9	2,151.9
Kandik	2,134.5	2,134.5	2,134.5	2,134.5	2,134.5	2,134.5	2,134.5
Fortymile	2,195.7	2,178.5	2,133.9	2,032.8	1,907.3	1,776.3	1,646.5
Dulbi-Kaiyuk Mts.	2,127.0	2,127.0	2,127.0	2,127.0	2,124.8	2,118.1	2,106.6
Denali	2,137.0	2,133.3	2,123.4	2,093.3	2,052.4	1,994.7	1,920.3
Minchumina	2,117.9	2,117.9	2,117.9	2,117.9	2,117.9	2,117.9	2,117.9
Mcgrath	2,107.8	2,107.8	2,107.8	2,107.8	2,107.8	2,107.8	2,107.8
Shungak	2,105.0	2,105.0	2,103.9	2,100.9	2,097.8	2,092.2	2,086.3
Tonzona	2,086.9	2,086.9	2,086.9	2,086.9	2,086.9	2,086.9	2,086.9

Table 3—Percentage of development at varying distances for the top 19 blocks.

Block name	DI							
	(1000 m)	250 m	500 m	1000 m	2000 m	3000 m	4000 m	5000 m
		<i>percent</i>						
NPR-A	2,517.3	100.0	100.0	99.9	99.6	99.1	98.5	97.8
Nulato Hills	2,377.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Ruby	2,244.3	99.9	99.9	99.8	99.4	98.9	98.3	97.6
Sheklukshuk	2,241.9	100.0	100.0	100.0	100.0	99.9	99.5	98.9
Tanana	2,227.3	99.9	99.9	99.8	99.7	99.5	99.2	98.9
Unalakleet	2,213.4	100.0	100.0	99.9	99.8	99.4	98.9	98.3
Bering Glacier	2,188.2	100.0	100.0	100.0	100.0	100.0	99.9	99.7
Hughes	2,158.1	99.9	99.8	99.5	98.9	98.1	97.1	96.0
Holy Cross—East	2,155.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Holy Cross—West	2,154.9	100.0	100.0	100.0	100.0	99.7	99.0	97.6
Black River	2,153.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Lime Village	2,151.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Kandik	2,134.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fotymile	2,133.9	98.5	97.7	95.7	91.2	85.5	79.7	73.8
Dulbi-Kaiyuk Mts.	2,127.0	100.0	100.0	100.0	100.0	99.9	99.6	99.0
Denali	2,123.4	99.3	99.2	98.7	97.3	95.4	92.7	89.3
Minchumina	2,117.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mcgrath	2,107.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Tonzona	2,086.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Ecoregion Analysis

The State of Alaska covers a vast land surface with a number of diverse ecoregions. Ecoregions are geographic units that are differentiated by climate, subsurface geology, physiography, hydrology, soils, and vegetation. The ecoregions of Alaska were developed cooperatively in 2001 by the Forest Service, National Park Service, Geological Survey, and The Nature Conservancy (Nowacki 2001). A large portion of Alaska is managed by various federal and state governmental agencies at varying levels of protection, such as Wilderness designation and multiple use management. An analysis evaluating current ecoregional representation by lands within the administrative boundaries layer occurred. For purposes of this study, lands with the administrative boundaries layer are considered more protected from development than lands outside the boundaries. Further analysis included the addition of the top 25 ranked BLM blocks. Table 4 lists the acreage and percent of each ecosystem currently protected.

The top three ecoregions with the greatest representation includes the Wrangell St. Elias (100 percent), Kluane (100 percent), and Alexander Archipelago (99 percent) ecoregions. The Wrangell St. Elias and Kluane ecoregions represented within Alaska are within Wrangell St. Elias National Park and Preserve. The Kluane ecoregion is partially within Wrangell St. Elias National Park and Preserve and extends into Canada's Kluane National Park and Reserve. The Alexander Archipelago ecoregion is completely within the Tongass National Forest.

The World Conservation Union (IUCN) suggests that a representation of 10 percent of each ecoregion is adequate for biodiversity conservation. Currently, three ecoregions in Alaska lack adequate protection based on IUCN recommendations. These include the Kuskokwim Mountains (6.2 percent), Beaufort Coastal Plain (7.1 percent), and Brooks Foothills (7.2 percent) ecoregions. With the addition of specific BLM lands to a conservation status, additional ecoregional

representation would occur in ecoregions currently under-represented (table 5).

The addition of only the top 25 ranked BLM managed blocks would increase representation of the Kuskokwim Mountains by 2,176,427.6 acres (880,769 ha) to 16.5 percent. The Beaufort Coastal Plain would drastically increase acreage with an additional 9,554,660.9 acres (3,866,634 ha), bringing the total to 72.6 percent. The Brooks Foothills would increase 11,593,694.9 acres (4,691,802 ha) to 47.9 percent. The Beaufort Coastal Plain and Brooks Foothills ecoregions representations increase due to the National Petroleum Reserve—Alaska (NPR-A) having a form of protection status. Inclusion of even portions of NPR-A would allow adequate protection of biodiversity according to the 10 percent level suggested by IUCN. Further analysis is needed to determine such portions.

In this study, 72.4 percent of BLM lands greater than 10,000 acres (4,047 ha) are found to have less than one percent 'development.' It should be noted that lack of development does not constitute wilderness quality lands. Rather, these areas should be prioritized for further evaluation. The ranking of lands provides a list of prioritization for citizen evaluation to occur.

NPR-A is the largest BLM managed parcel within both Alaska and the entire United States. However, at the time of writing, several areas within NPR-A have been opened for oil and gas leasing, thus the magnitude and continuity of the original block is much smaller. Identifying the remaining areas currently not leased requires additional analysis.

Recommendations for Future Work

The ranking of blocks in this report represents the most extensive inventory of Alaska BLM lands to date through use of a GIS. Various future steps are possible to refine the

Table 4—Percentage of ecoregions currently in a form of protection status.

Ecoregion	Total acres	Represented	
		acres	percent
Kuskokwim Mountains	21,092,616.4	1,298,096.2	6.2
Beaufort Coastal Plain	14,588,338.0	1,033,316.2	7.1
Brooks Foothills	28,474,359.8	2,064,210.8	7.2
Seward Peninsula	11,699,497.2	1,532,031.1	13.1
Bristol Bay Lowlands	7,903,904.4	1,485,669.5	18.8
Lime Hills	7,095,642.6	1,410,279.2	19.9
Nulato Hills	14,433,468.7	2,929,858.4	20.3
Ray Mountains	12,662,292.3	2,692,525.5	21.3
Tanana-Kuskokwim Lowlands	15,818,452.4	3,777,518.2	23.9
Yukon-Tanana Uplands	15,751,751.5	5,315,907.3	33.7
Cook Inlet Basin	7,186,328.5	2,560,747.2	35.6
Alaska Range	25,534,335.6	9,131,743.6	35.8
Kobuk Ridges and Valleys	13,624,067.3	5,752,655.2	42.2
Copper River Basin	4,729,188.3	1,998,695.9	42.3
Bering Sea Islands	2,347,535.3	1,032,700.0	44.0
North Ogilvie Mountains	3,140,003.5	1,464,040.8	46.6
Kodiak Island	3,144,990.6	1,928,596.6	61.3
Alaska Peninsula	15,745,598.2	10,449,710.0	66.4
Ahklun Mountains	9,565,898.9	6,679,602.1	69.8
Yukon River Lowlands	12,782,649.2	8,992,486.3	70.3
Davidson Mountains	7,167,008.2	5,309,821.6	74.1
Chugach-St. Elias Mountains	19,562,085.2	14,556,968.0	74.4
Kotzebue Sound Lowlands	3,359,282.8	2,598,297.6	77.3
Brooks Range	31,810,902.8	24,640,947.3	77.5
Yukon-Old Crow Basin	13,991,868.5	10,926,244.3	78.1
Gulf of Alaska Coast	4,346,173.0	3,631,847.6	83.6
Boundary Ranges	5,000,643.1	4,778,493.2	95.6
Yukon-Kuskokwim Delta	18,964,960.7	18,471,824.1	97.4
Alexander Archipelago	13,005,243.6	12,869,937.2	99.0
Kluane Range	1,242,338.8	1,242,250.9	100.0
Wrangell Mountains	3,537,150.0	3,537,150.0	100.0

Note: The Aleutian Islands ecoregion was excluded from analysis.

Table 5—Increase in percentage of ecoregions with top 25 BLM block addition.

Ecoregion	Total acres	Represented acres	Representation	
			Increase	Top 25 BLM blocks
			percent.	
Brooks Range	31,810,902.8	684,095.2	2.2	79.7
Yukon River Lowlands	12,782,649.2	367,442.3	2.9	73.2
Yukon-Old Crow Basin	13,991,868.5	500,464.8	3.6	81.7
Chugach-St. Elias Mountains	19,562,085.2	750,044.8	3.8	78.2
Tanana-Kuskokwim Lowlands	15,818,452.4	1,102,100.2	7.0	30.9
Yukon-Tanana Uplands	15,751,751.5	1,191,404.1	7.6	41.3
Alaska Range	25,534,335.6	2,193,698.3	8.6	44.4
Kuskokwim Mountains	21,092,616.4	2,176,427.6	10.3	16.5
Seward Peninsula	11,699,497.2	1,240,193.3	10.6	23.7
Copper River Basin	4,729,188.3	526,132.9	11.1	53.4
Kobuk Ridges and Valleys	13,624,067.3	1,942,913.4	14.3	56.5
North Ogilvie Mountains	3,140,003.5	517,179.1	16.5	63.1
Ray Mountains	12,662,292.3	2,266,849.1	17.9	39.2
Brooks Foothills	28,474,359.8	11,593,694.9	40.7	47.9
Nulato Hills	14,433,468.7	6,814,183.0	47.2	67.5
Beaufort Coastal Plain	14,588,338.0	9,554,660.9	65.5	72.6

Note: Only ecoregions overlapping with top 25 BLM blocks would have an increase.

results. The following recommendations for future work cover the accuracy of GIS Data, Landsat scenes quality and dates, verification of results, and use of collected GIS data and results.

Accuracy of GIS Layers

For this report, it is assumed that all GIS layers are accurate in their depiction of mines, dams, infrastructure, etc. The GIS layer presenting the greatest concern is the infrastructure layer. Several segments of the layer were not attributed. If such segments passed through BLM lands in study, the presence of scars with Landsat scenes occurred. Landsat scenes may not allow all scars to be detected due to 30 m (98 ft) resolution.

Landsat Scenes

Landsat scene dates varied from 1986 to 2002. Scenes are obtained for free from the University of Maryland's Global Land Cover Facility (see <http://glcf.umd.edu/index.shtml>). Using the scenes allowed all BLM lands to be evaluated for disturbance, however, the using of older scenes may lead to an underestimation of disturbance. It should be noted that most of the disturbance was found around historic military sites in the state. The resolution of Landsat scenes is 30 m (98 ft) pixels. This may lead to a large number of trails and roads being overlooked when searching for disturbance. Gravel or dirt roads are visible, but not all historical tractor trails are visible on scenes. A better resolution of satellite scenes may allow off-road vehicle trails to be mapped. This would prove a critical layer not only within a Wilderness Inventory, but also as a way to manage off-road vehicles on all lands in Alaska.

Verification of Results

The described methods were conducted through a GIS with no fieldwork involved to assess or verify accuracy of data layers. It is recommended that future steps involve such verification to confirm results. Volunteer fieldwork within past Citizen Wilderness Inventories comprised most of the labor component. Within Alaska it would prove difficult to orchestrate a large CWI due mostly to difficulty of access to BLM blocks. However, this report prioritizes areas for examination of wilderness qualities.

Use of GIS Data and Results

This report recommends the top ranked BLM blocks be prioritized for field verification of wilderness characteristics outlined in BLM's Wilderness Inventory and Study Procedures Document. Data collected and created within this study should be refined and field checked in prioritized BLM blocks. GIS datasets and Landsat scenes should be used when working with neighboring communities of top ranking BLM blocks. These datasets, in conjunction with other existing GIS datasets, will allow questions on local knowledge of wilderness quality to be answered as well as the conservation value by providing connectivity between existing conservation units in Alaska.

Conclusion

Of the BLM lands greater than 10,000 acres (4,047 ha), 36.8 percent have no 'development.' BLM lands with less than one percent development comprise 35.6 percent, while 17.6 percent of BLM lands had between one percent and 10 percent 'development.' These results confirm the long held notion that Alaska remains relatively pristine. Wilderness is unique in that once it is altered it cannot be recreated. Further study focused on identifying BLM lands in Alaska for potential Wilderness designation is necessary before wilderness qualities are degraded by development activities. It is unlikely that all of these lands can be designated as Wilderness. However, using these prioritized blocks, conservation planning can better identify significant areas with wilderness and conservation potential.

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