Accessible Backcountry Skiing in the Shoshone National Forest

Outdoor Alliance GIS Lab

Winter Wildlands Alliance

May 2017

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Executive Summary

In 2015, the U.S. Forest Service (USFS) released new regulations for travel planning in order to better manage and address the impacts associated with over-snow vehicle (OSV) use on National Forest land. The new regulation requires all National Forests that receive adequate snow to support winter recreation by designating routes and areas where OSV use is allowed. Winter travel management planning is conducted to ensure that OSV use on public land is managed in a way that protects resources, promotes the safety of all public land users, and minimizes conflict among user groups. Managing for motorized vehicles also has implications for non-motorized recreation as well.

The USFS is currently developing a winter travel plan for the Shoshone National Forest in Wyoming. To assist with this winter travel planning effort, Outdoor Alliance and Winter Wildlands Alliance has modeled the potential skiable terrain accessed from plowed winter roads, so that USFS can better understand how travel planning will affect winter human-powered recreation. The model is based on Natural Resources Conservation Service snow telemetry data. The USFS is obligated to identify OSV routes in order to minimize impacts to other user groups, including backcountry skiers. The purpose of this report is to present the model of potential skiable terrain in the Shoshone National Forest, and a detailed summary of the methodology used. The USFS can use this information to identify areas where OSV use may conflict with backcountry skiing, so that the USFS can ensure these conflicts are minimized in the travel plan. The information presented here is based on data collected by the National Snow and Ice Data Center, Natural Resources Conservation Service, and U.S. Forest Service.

Based on the model output, the USFS mandate regarding OSV management, and anecdotal information about winter recreation use patterns on the Shoshone National Forest, we recommend that the Shoshone National Forest limit over-snow vehicle use beyond the motorized use zones put forth in the 2016 Proposed Action in order to minimize conflict with non-motorized winter visitors. This analysis indicates that, under the 2016 Proposed Action, there is very little accessible non-motorized terrain available for backcountry skiers and snowboarders within the two most heavily visited over-snow recreation areas on the forest.

Study Area

The Shoshone National Forest borders Yellowstone National Park and Bridger-Teton National Forest to the west, and the Custer-Gallatin National Forests to the north (Fig. 1). The Continental Divide demarks the boundary between the Shoshone and Bridger-Teton National Forests. The altitude in the forest ranges from 4,600 feet (1,400 m) near Cody, Wyoming, to 13,804 ft (4,207 m) at the top of Gannett Peak, an elevation gain of over 9,200 ft (2,800 m).[1] Critical passes through the forest include Togwotee Pass (which provides access to Jackson Hole and Grand Teton National Park), Beartooth Pass (which provides access to the northeast entrance of Yellowstone National Park), and South Pass (which crosses the continental divide at the southern edge of the forest). Togwotee Pass and Beartooth Pass are both important winter recreation destinations.

Snow is a prerequisite for many human-powered winter sports, including backcountry skiing, snowshoeing, cross-country skiing, and fat-tire biking , collectively referred to as winter backcountry recreation. In many U.S. states, winter backcountry recreation is a significant economic driver. The Shoshone National Forest receives an average of over half a million visitors a year.[2] A recent economic analysis in a region encompassing Grand Teton National Park, parts of Bridger-Teton National Forest and Caribou-Targhee National Forest, and Rendezvous Ski Trails in West Yellowstone found that winter backcountry recreation contributes $22.5 million annually to the region's economy.[3]

[1] U.S. Forest Service: Shoshone National Forest, Fire Management Plan
[2] USDA: National Visitor Use Monitoring Results
[3] Winter Wildlands Alliance, Mark Newcomb: Teton-West Yellowstone Region Backcountry Winter Rec Economic Impact Analysis

Figure 1. Study Area: Shoshone National Forest

Data Sources

SNOTEL[4]

The Natural Resources Conservation Service (NRCS) maintains an extensive, automated data collection network called SNOTEL (Snow Telemetry). SNOTEL sites are generally located in remote, high-elevation mountain watersheds where access is difficult or restricted. A SNOTEL site provides snowpack water content data via a pressure-sensing snow pillow. It also collects data on snow depth, all-season precipitation accumulation, and air temperature with daily maximums, minimums, and averages. SNOTEL data can be queried and downloaded in CSV format using web-based tools developed by the NRCS including (1) NRCS Report Generator 2.0, and (2) NRCS Interactive Map 3.0.

SNODAS[5]

SNODAS (SNOw Data Assimilation System) is a modeling and data assimilation system developed by National Weather Service's National Operational Hydrologic Remote Sensing Center (NOHRSC) to provide the best available estimates of snow cover and associated variables to support hydrologic modeling and analysis. The aim of SNODAS is to provide a physically consistent framework to integrate snow data from satellite and airborne platforms and ground stations (e.g. SNOTEL) with model estimates of snow cover[6]. Gridded datasets for the continental United States can be accessed via FTP at 1 km spatial resolution and 24 hour temporal resolution.

U.S. Forest Service[7]

As part of the Shoshone National Forest Travel Management planning process, the Forest Service has published geospatial data for roads, trails, and areas that are open to motor vehicle use. This study utilized a USFS roads dataset that identified roads plowed in the winter.

Methods

This study investigates snow depth data to better understand suitable backcountry skiing areas in the Shoshone National Forest that are accessible by roads plowed in the winter. A toolset created by the National Park Service was used to download and prepare SNODAS data. "NPScape is a landscape dynamics monitoring project that provides landscape-level data, tools, and evaluations for natural resource management, planning, and interpretation.[8] The goal of the NPScape Climate Grid Analysis Toolset (CGAT) is to provide landscape-scale climate monitoring support to I&M networks and parks; climate which is one of the top ranked vital signs among all of the NPS I&M networks."[9] Specific steps

[4] SNOTEL Data: https://www.wcc.nrcs.usda.gov/snow/
[5] SNODAS Data: http://nsidc.org/data/docs/noaa/g02158_snodas_snow_cover_model/
[6] Carroll, T., D. Cline, G. Fall, A. Nilsson, L. Li, and A. Rost. 2001. NOHRSC Operations and the Simulation of Snow Cover Properties for the Conterminous U.S. Proceedings of the 69th Annual Meeting of the Western Snow Conference, pp. 1-14.
[7] USFS Data: https://www.fs.usda.gov/detail/shoshone/home/?cid=stelprd3846526
[8] NPScape. 2015. NPScape Climate Grid Analysis Toolset. National Park Service, Natural Resource Stewardship and Science. Fort Collins, Colorado
[9] Fancy, Steven G., and Robert E. Bennetts. 2012. "Institutionizing an effective long-term monitoring program in the U.S. National Park Service". Design and Analysis of Long-Term Ecological Monitoring Studies (pp.481-497). Cambridge, England: Cambridge University Press.

and tools are detailed in the attached document, “NPSCAPE_ClimateGridAnalysisTool.pdf” and will only be briefly mentioned here.

The workflow for this study consists of 3 general steps:

1. Define the geographic extent and generate a local archive of the climate data in a standard and efficient format (netCDF). Once in standard format, aggregation and statistical analyses are substantially faster.
2. Export the netCDF file to a raster layer for spatial analyses in ArcMap.
3. Conduct spatial analyses using ArcMap to determine potential skiable areas.

Estimated snow depths from SNODAS modeling data were used to determine areas within the Shoshone National Forest where winter snow depth was greater than 18 inches. A snow depth of 18 inches was used as a minimum depth for backcountry skiing. To inform data preparation decision making and the SNODAS dataset(s) that would be used, snow depth data from 175 SNOTEL stations in Wyoming and Montana were selected from the time period of 2006 through 2016. During this time span, the months and years with the greatest snow depth at each station were evaluated. The analysis revealed that during the past 11 years March and April had the greatest snow depths (Table 1). The months December through June were also evaluated for each year, and revealed that 2014 was an exceptional year during the months of March and April (Table 2). Using the CGAT Toolset, SNODAS data from 3/15/14 was downloaded as a representative dataset.

Table 1. Month with the greatest snow depth from SNOTEL stations around the Shoshone National Forest

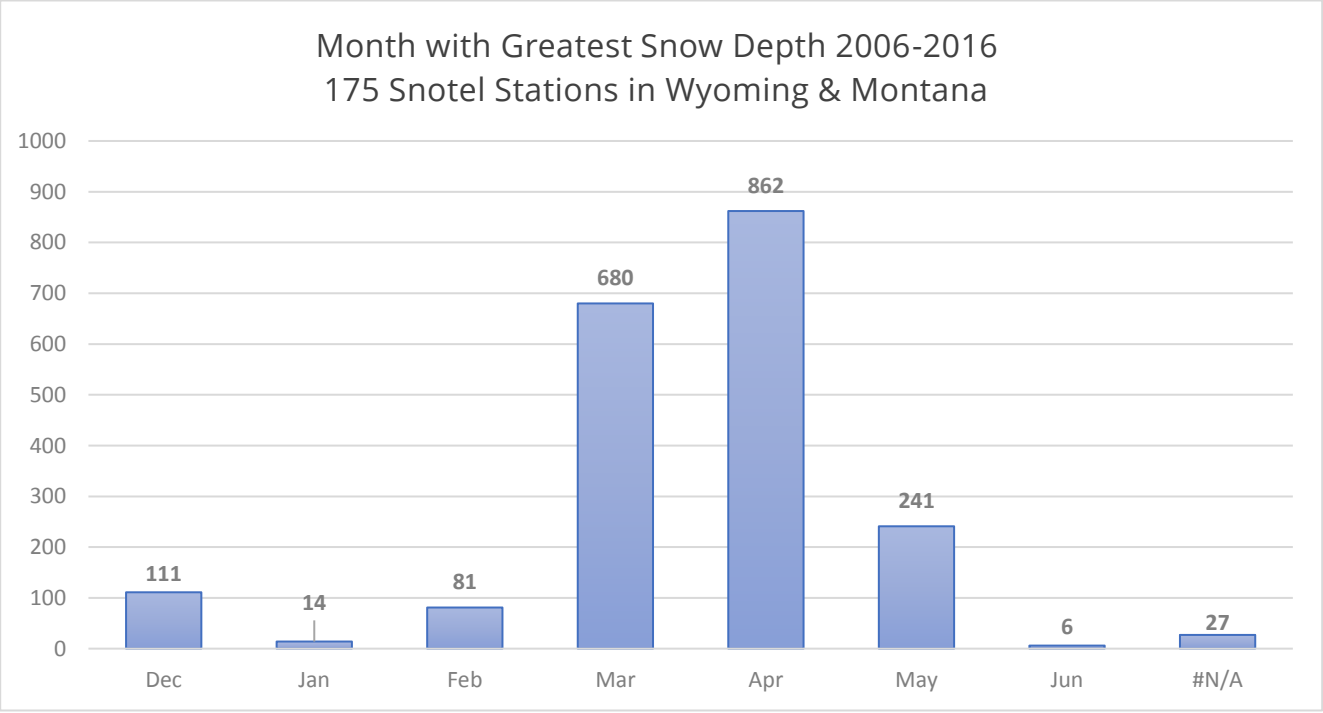
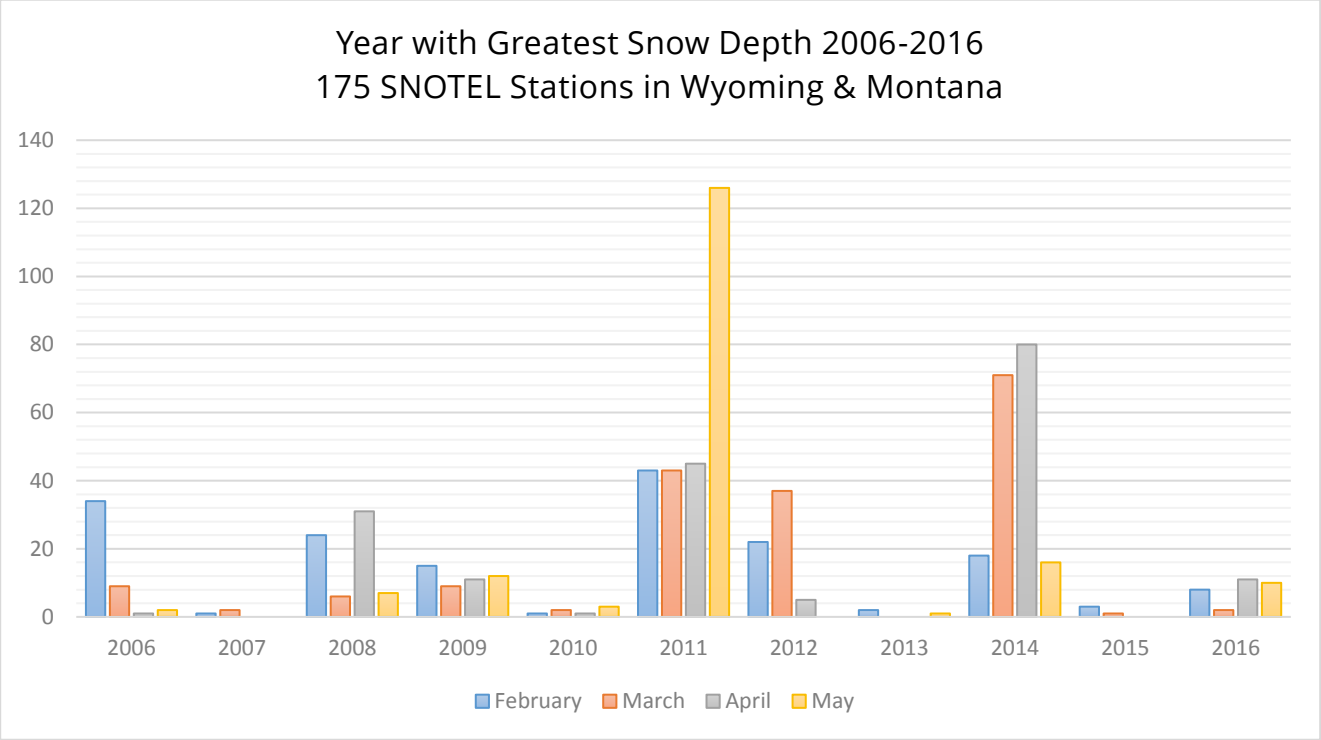


Table 2. Year with the greatest snow depth from SNOTEL stations around the Shoshone National Forest



Accessible Backcountry Skiing in the Shoshone National Forest

This model assumes that accessible skiing areas in the Shoshone National Forest rely on open winter roads that are plowed and maintained for passenger vehicles. The model also assumes that areas with snow depth greater than 18 inches are suitable skiing terrain, and does not attempt to identify terrain that may be unsuitable for skiing (e.g. cliffs, dense trees, etc.) Thus, areas with snow depth greater than 18 inches should be treated as areas that might be "potentially" suitable for skiing (Fig. 2). The estimates for potential backcountry skiing should not be used for determining snowpack characteristics on mountains, features, or avalanche hazards.

The Shoshone National Forest is known as a wild backcountry forest, and there are some amazing winter adventure opportunities deep in the Wind River, Absaroka, and Beartooth mountains. What's at stake in this travel plan, however, and is the Shoshone National Forest's relatively accessible and popular world-class front-country terrain. Specifically Togwotee Pass (Fig. 3) and the Beartooth Pass (Fig. 4). For winter backcountry recreation to remain viable, accessibility to these recreation opportunities is essential. The winter travel plan may not alter accessibility, it may impact the recreation experience by designating OSV use in areas that conflict with quiet, human-powered winter recreation. To ensure opportunities for high quality human-powered recreation experiences, and to minimize conflicts between user groups as mandated by the 2015 OSV Rule, the Forest Service should preserve certain non-motorized areas within close proximity to plowed roads.

Recommendations

For human-powered snowsports enthusiasts traveling from Fremont County, Togwotee Pass (especially the Shoshone side) is the nearest locale that has reliable snow and accessible quality terrain. The non-motorized areas described in the 2016 Proposed Action protect cross-country ski opportunities in the Deception and Pinnacles areas. These trails provide excellent non-motorized recreation opportunities for residents of and visitors to Fremont County and we believe managing these areas for non-motorized use will greatly enhance cross-country ski opportunities on Togwotee Pass. However, these closures do not minimize OSV impacts for backcountry skiers – a different form of non-motorized winter recreation from cross-country skiing. As this analysis indicates, backcountry skiers must travel through several miles of motorized terrain in order to access non-motorized ski terrain. The Forest Service could minimize impacts to backcountry skiers by not designating all of the terrain adjacent to the plowed road for motorized use and instead ensure that there are high-quality and accessible non-motorized areas for backcountry skiers to enjoy. The Forest Service can also help to mitigate the impacts of OSV use by working with stakeholders to increase public education and outreach concerning safety and trail courtesy.

On the northern end of the forest, the Beartooth Pass is a renowned spring and summer ski destination. In late May, when Highway 212 opens to passenger vehicles, this road provides access to thousands of acres of good skiing, often as late as July. Skiers also begin accessing lower elevation areas on the pass – particularly Clay and Beartooth Buttes – earlier in the spring as the road begins to melt out. Memorial Day weekend is the high point of spring skier activity on the Beartooth Pass. There is a long and rich tradition of skiers flocking to the state line, Gardner Lakes basin, and other areas near the summit of the pass to celebrate the start of summer with a weekend of skiing and snowboarding and skiers continue to visit this area well into the summer. The Proposed Action includes an April 30 OSV season closure, which we strongly support. This date provides a winters-worth of OSV recreation opportunity on the Beartooth Plateau and completely eliminates conflict between OSVs and non-motorized uses in the spring.

In addition, under the Wyoming Wilderness Act, the Shoshone National Forest has a legal obligation to manage over-snow vehicle use in the High Lakes Wilderness Study Area, on the Beartooth Plateau, so that it does not exceed the manner and degree of use that occurred prior to October 30, 1984. While this is unrelated to accessibility of backcountry skiing on the forest, it is worth noting that the Proposed Action does not comply with the Wyoming Wilderness Act. Recognizing that it would be virtually impossible to manage visitation to this remote area, we suggest the Forest Service reduce the acreage open to OSV use within the Wilderness Study Area. OSV use in this area should be restricted to a reasonable area surrounding the existing OSV trail network in order to both comply with the Wyoming Wilderness Act and to minimize impacts to wilderness character.

Finally, this analysis indicates that there are several areas proposed as open for OSV use that do not receive substantial or reliable snow. Therefore, these areas should not be designated as open for OSV use in the new winter travel plan.

Figure 2. Overview of Potential Backcountry Skiing in the Shoshone National Forest

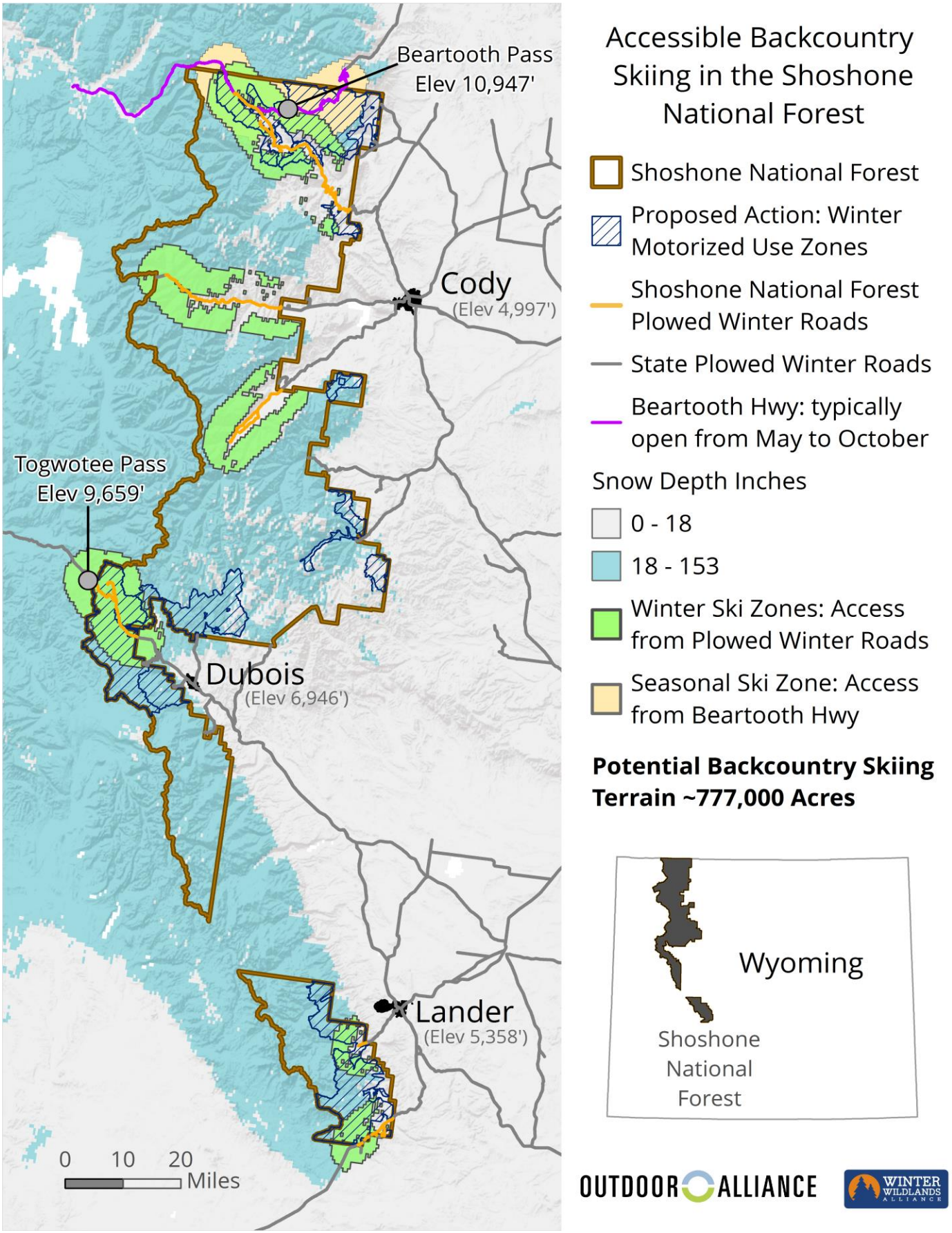
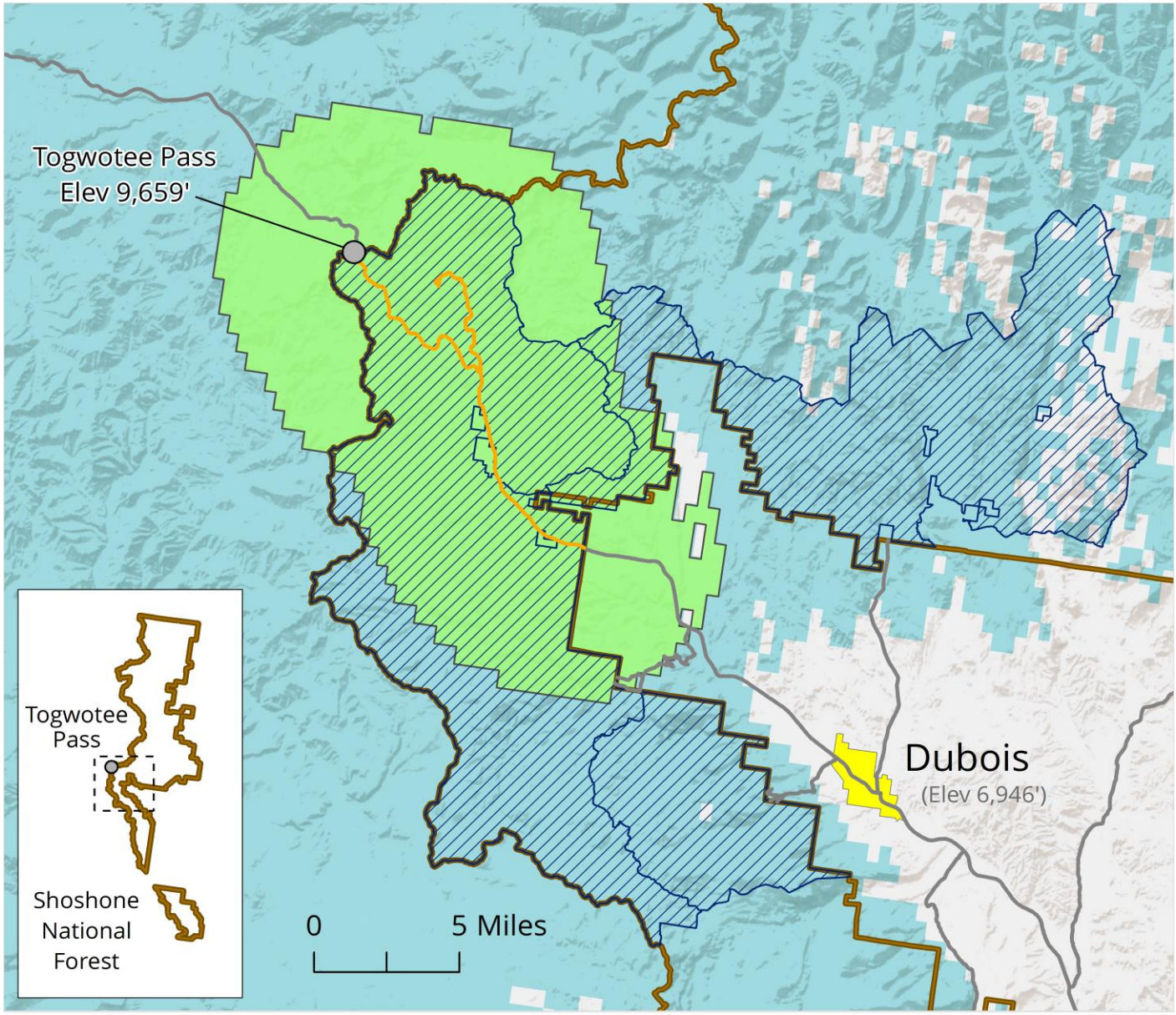


Figure 3. Potential Backcountry Skiing Around Togwotee Pass



Togwotee Pass Region: Accessible Backcountry Skiing in the Shoshone National Forest

Shoshone National Forest Plowed Winter Roads

State Plowed Winter Roads

Shoshone National Forest

Proposed Action: Winter Motorized Use Zones

Winter Ski Zones: Access from Plowed Winter Roads

Snow Depth Inches

0 - 18

18 - 153

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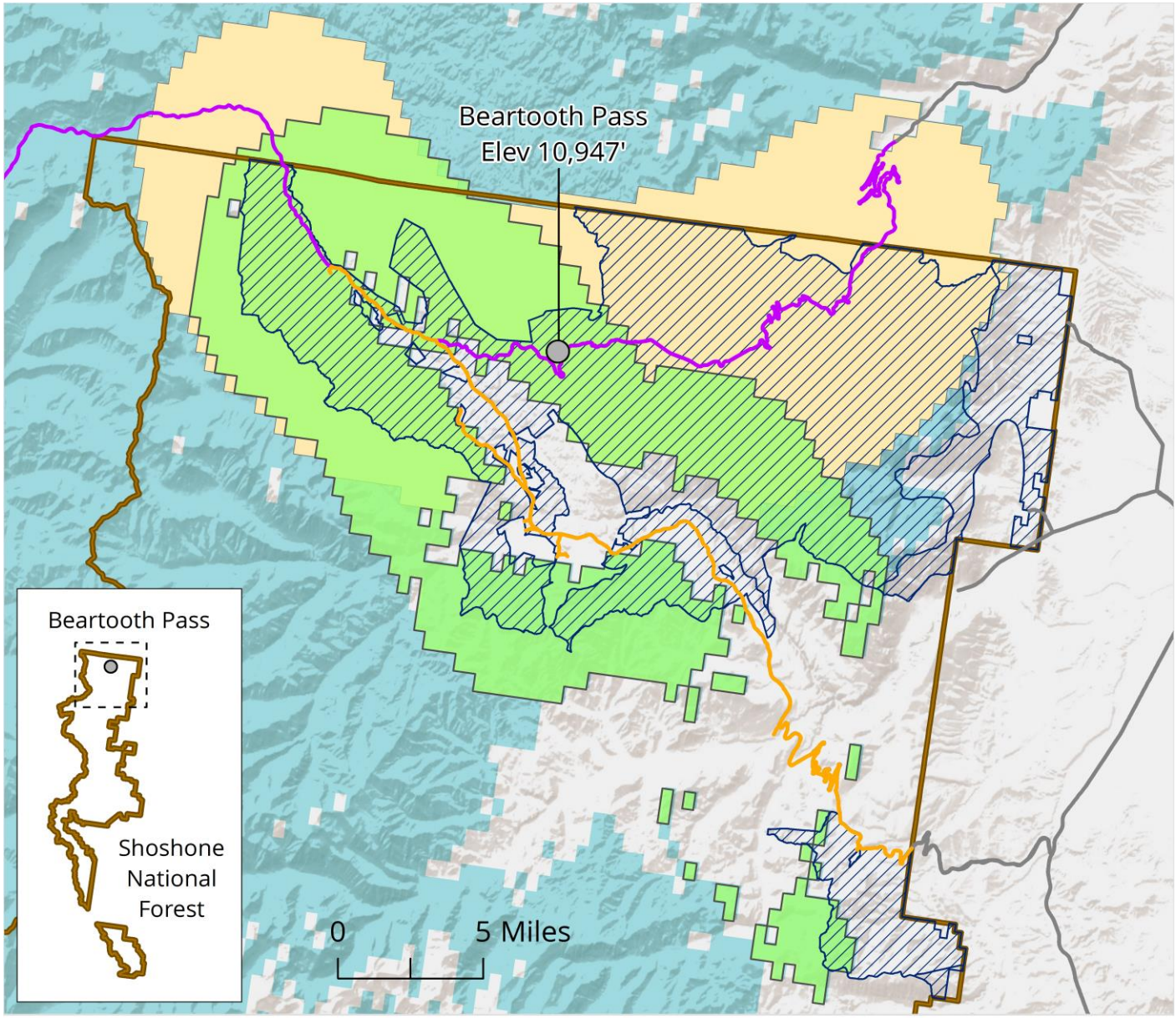
Figure 4. Potential Backcountry Skiing Around Beartooth Pass



Beartooth Pass Region: Accessible Backcountry Skiing in the Shoshone National Forest

Shoshone National Forest Plowed Winter Roads

State Plowed Winter Roads

Beartooth Hwy: typically open from May to October

Shoshone National Forest

Proposed Action: Winter Motorized Use Zones

Seasonal Ski Zone: Access from Beartooth Hwy

Winter Ski Zones: Access from Plowed Winter Roads

Snow Depth Inches

0 - 18

18 - 153

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Appendix – GIS Methodology

SNOTEL Data Preparation

Snow telemetry (SNOTEL) and snow course data were obtained using the National Water and Climate Center's Report Generator 2.0.[10]

- **Select Stations**: Using the Advanced Search feature, (1) stations were filtered by state and county in the area of interest, (2) SNOTEL and Snow Course/Aerial Marker networks were selected, and (3) Active Sites Only checked.
- **Select Columns**: From the Data tab, snow depth > value > none, and snow depth > value > Mean > Daily were added. From the Metadata tab, State Name, County Name, Elevation, Latitude, Longitude were added.
- **Select Time Period, Layout, and Units**:
    - Interval/Duration: Monthly
    - Report Instantaneous Data as: Start of Period
    - Time Period: Custom > December, January, February, March, April, May, June
    - Custom Date Begin: 2005-12-01
    - Custom Date End: 2016-06-30
- **Data Export**: CSV File

The CSV file was imported into Microsoft Excel, and data was organized in a pivot table. The data was used to evaluate the months and years with the greatest snow depth at each station, and can be found in the attached Excel document, "NRCS_SNOTEL_20140315_analysis.xlsx".

Esri ArcMap - Climate Grid Analysis Toolset

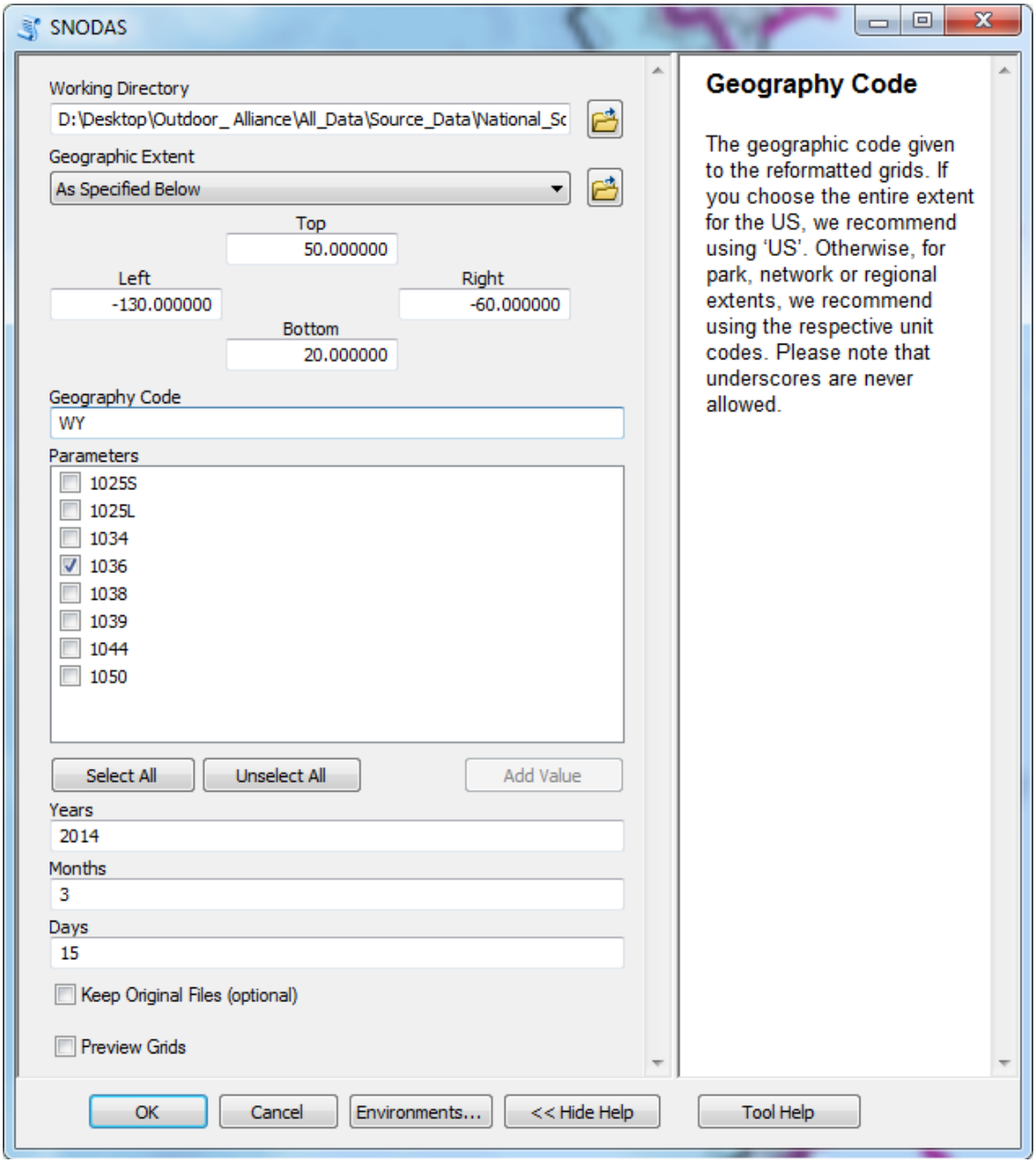
1. SNODAS Data Preparation

Download the CGAT Toolset[11], and add the CGAT Toolbox to ArcToolbox in an open ArcMap session. Right click ArcToolbox, Save Settings > To Default (this will save the CGAT Toolbox in ArcToolbox for future use). Open the SNODAS Data Prep tool (ArcToolbox > 01 – Data Prep > SNODAS) and download snow depth (Parameter 1036) for the appropriate time period (Fig. 5). Detailed directions can be found in the accompanying CGAT documentation, as well as the tool descriptions.

[10] NRCS National Water and Climate Center Report Generator 2.0

[11] NPScape Climate Grid Analysis Toolset: https://irma.nps.gov/DataStore/Reference/Profile/2222056

Figure 5. Inputs to retrieve SNODAS dataset and generate local netCDF file.



2. Make NetCDF Raster Layer

After importing the SNODAS data, the next step involves converting the netCDF grid to a raster layer. It is important to keep in mind that this tool only creates a temporary raster, and will be deleted once the ArcMap session is terminated. Export the temporary raster layer into a geodatabase for further analysis (e.g. SNODAS_20140315).

The raster layer only contains a Value field (Depth in millimeters) and Count field in the attribute table. To convert from millimeters to inches, add a new field called "Depth_IN", and enter the following formula in the Field Calculator:

([Value]/1000)*39.3701

*Important: Value 55537 represents Null Values and are not to be confused with 0.

Layer Symbology

i. Classified
    - Value: Depth_IN
    - Classification: Manual, 7 classes

3. Defining Forest Service Roads Open in the Winter

The U.S. Forest Service provided a transportation layer that included a "Plowed" field attributed by yes or no, and was used to select roads plowed in the winter and open to the public. This layer was exported as "USFS_Roads_PublicOpen2017_plowed" (herein winter roads) and was compared to Wyoming DOT's transportation layer and Wyoming's Travel Information Web Map for completeness. The winter roads layer was then clipped to the Shoshone National Forest Boundary for further analysis.

i. ArcToolbox > Analysis Tools > Extract > Clip
    - Input Features: USFS_Roads_PublicOpen2017_plowed
    - Clip Features: Shoshone_NF_boundary
    - Output Feature Class: USFS_Roads_PublicOpen2017_plowed _clip

4. Open Winter Roads Buffer

To calculate the area that backcountry skiers can potentially access in the Shoshone, the clipped winter roads layer created in the previous step was used to create a 5-mile buffer. This buffer represents the distance that backcountry skiers typically travel in a day trip.

i. ArcToolbox > Analysis Tools > Proximity > Buffer
    - Buffer Input: USFS_Roads_PublicOpen2017_plowed _clip
    - Buffer Ouput(s): USFS_Roads_PublicOpen2017_plowed _clip _buff5mile
    - Distance: 5 miles
    - Dissolve Type: ALL
    - All other options are set to default

ii. Fragmented road sections (generally less than 1 mile) were removed.

5. Calculate areas with Snow Depth > 18 inches

To calculate areas that contain Snow Depth greater than 18 inches and represent potential skiable areas:

Extract raster cells by mask from the 5-mile buffer

i. ArcToolbox > Spatial Analyst Tools > Extraction > Extract by Mask
    - Input raster: SNODAS_20140315
    - Input raster or feature mask data: USFS_Roads_PublicOpen2017_plowed _clip _buff5mile
    - Output raster: SNODAS_20140315_PublicOpen2017_buff5mile

Extract rasters cells with snow depth > 18 inches from 5 buffer

ii. ArcToolbox > Spatial Analyst Tools > Extraction > Extract by Attributes
    ii. Input raster: SNODAS_20140315_PublicOpen2017_buff5mile
    iii. Where Clause: Depth_IN > 18
    iv. Output Raster: SNODAS_20140315_PublicOpen2017_buff5mile_greater18

This step multiplies each cell by 0, thereby making all cell values 0. A workaround to the remove the grid layout during the Raster to Polygon conversion.

iii. ArcToolbox > Spatial Analyst Tools > Map Algebra > Raster Calculator
    - Codeblock: Int("Raster_layer" * 0)
    - Output raster: SNODAS_20140315_OpenPublic2017_buff5mile_greater18_int

Convert Raster to Polygon

iv. ArcToolbox > Conversion Tools > From Raster > Raster to Polygon
    - Input raster: SNODAS_20140315_OpenPublic2017_buff5mile_greater18_int
    - Field: Value
    - Output polygon features: SNODAS_201403151_OpenPublic2017_buff5mile_greater18_int_polygon
    - Uncheck simplify option

v. Add field "Acres" to the newly created polygon files. Open Field Calculator and Calculate Geometry by acres.