**Grand Teton Ecological Forecasting**

*Assessing Forage Change and Winter Habitat Availability for Bighorn Sheep that Employ a High-Elevation Overwintering Strategy to Identify Areas for Intervention*

**Project Team**

***Project Team:***

Alex Posen (Project Lead)

Allyson Earl

Sarah Hettema

Michael Hitchner

***Advisors & Mentors:***

Keith Weber (Idaho State University, GIS Training and Research Center)

Joseph Spruce (Science Systems and Applications, Inc. Consultant, Diamondhead, MS)

***Team POC:*** Alex Posen, alexposen@mac.com

***Partner POC:*** Sarah Dewey, Sarah\_Dewey@nps.gov

**Project Overview**

***Project Synopsis:***

Bighorn sheep are an iconic species of Grand Teton National Park (GTNP). Their numbers in the Teton Range have been reduced from historic levels of ~15,000-20,000 (c. 1900) to ~125 (c. 2020) individuals due to a combination of changing habitat conditions and anthropogenic impacts. This species has persisted due to a high elevation overwintering strategy. Our study investigates changes to bighorn sheep habitat using satellite remote sensing to understand how changing land cover and snow cover may affect future habitat suitability for bighorn sheep to help inform current and future conservation strategies.

***Abstract:***

Grand Teton National Park provides habitat for a small native population of approximately 125 bighorn sheep (*Ovis canadensis*). The reduction in population of this species is attributed to loss of low elevation habitat, changing local environmental and climatic conditions, and increased disturbance from backcountry recreation. In response to these changes, this population of sheep employs a unique high-elevation wintering strategy in which they amass large fat stores in the summer and expend as little energy as possible in the winter while foraging on high elevation wind-swept and snow-free areas. For this project, DEVELOP partnered with Grand Teton National Park and used NASA Earth observations including Landsat 8 OLI, 7 ETM, 5 TM, and MODIS Terra snow cover data to assess habitat suitability. Landcover change analyzed between 1987 and 2020 indicated shifting trends in grass and forb cover and tree cover. These trends persisted in the 2031 prediction, with grass cover decreasing and tree cover increasing, which translates to a loss of overall favorable habitat for bighorn sheep. Snow cover analyzed between 2001 and 2020 indicated similar unfavorable trends for the sheep with a decrease in barren areas, important for winter foraging. Finally, habitat suitability was modeled for 2020 and then predicted to 2031, to determine habitat gains and losses for this species across the landscape. Overall, our results predicted decreases in suitable habitat and indicated that while these sheep are highly adaptable, strategies to manage suitable bighorn habitat may need to be employed rapidly to effectively conserve this species.

***Key Terms:***

Remote sensing, habitat suitability modeling, TerrSet, Landsat, MODIS, land cover change, snow cover change

***National Application Area Addressed:*** Ecological Forecasting

***Study Location:*** Grand Teton National Park, WY

***Study Period:*** January1984 – November 2021; Forecasting to 2031

***Community Concerns:***

* The population of bighorn sheep endemic to GTNP has decreased to a group of around 125 individuals from a historical population in the western United States that is thought to have exceeded one million individuals in the 18th century.
* Human activity continues to disrupt the sheep’s rangeland through backcountry recreation and nearby urban development at the fringes of the sheep’s historical range.
* The GTNP bighorn sheep’s high elevation wintering strategy relies upon forage access on windswept patches and other low-snow or snow-free locations, which are sensitive to changing climate conditions.
* This population of native bighorn sheep are an important source of genetic and ecological diversity and a culturally significant component of the local ecosystem, therefore there is a strong desire within the community and local stakeholders to retain their presence on the landscape.

***Project Objectives:***

* Determine characteristics that define suitable habitat for GTNP bighorn sheep
* Analyze past and present habitat suitability for GTNP bighorn sheep
* Forecast future habitat suitability and changes in habitat characteristics for GTNP bighorn sheep
* Provide geospatial information and products on bighorn sheep habitat that will assist partners in developing effective conservation and recovery strategies for GTNP bighorn sheep

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Grand Teton National Park** | Sarah Dewey, Wildlife Biologist;  Carson Butler, Wildlife Biologist | End User | No |
| **Teton Range Bighorn Sheep Working Group** | Jason Wilmot, Wildlife Biologist  USDA USFS, Bridger-Teton National Forest; Nate Yorgason, Wildlife Biologist, USDA USFS, Caribou-Targhee National Forest; Aly Courtemanch, Wildlife Biologist, Wyoming Game and Fish; Michael Whitfield, Research Associate, Northern Rockies Conservation Cooperative; Steve Kilpatrick, former Executive Director, Wyoming Wild Sheep Foundation | Collaborator | No |

***Decision-Making Practices & Policies:***

The bighorn sheep population resides primarily in the rugged mountainous region of Grand Teton National Park, Bridger-Teton and Caribou-Targhee National Forests. Due to this diverse habitat and the diminishing overall sheep population, there is a need for agencies in the region to work cooperatively for the continued restoration and conservation of the species. The National Park Service, which manages a portion of the habitat in which bighorn sheep are found, has a philosophy of using nature-based solutions to address environmental management problems. This philosophy is reaffirmed in the gathering of scientific data, which is then used to make more informed management decisions regarding species conservation. Bighorn sheep locations are currently collected by NPS through the use of GPS collars and through an anecdotal database of sightings. These data have then been used to develop protective buffer zones for bighorn habitat, especially during winter months when the recreational use of their habitat is high. The Teton Range Bighorn Sheep Working Group was created to cooperatively address bighorn management needs throughout the Teton Range and is composed of biologists from US Forest Service, Bridger-Teton and Caribou-Targhee National Forests, Wyoming Fish and Game, Northern Rockies Conservation Cooperative, and Wyoming Wild Sheep Foundation. Managers from all groups are considering implementing restoration and conservation strategies to reclaim low-elevation bighorn sheep winter range in the area which are at risk due to seasonal fluctuations and human encroachment.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra MODIS** | Snow cover | Snow indices will be used to map landcover change and assess habitat suitability including forage and windswept patch availability for bighorn sheep. |

***Ancillary Datasets:***

* Grand Teton National Park Bighorn Sheep Location Data – this collection of GPS collar location data and anecdotal sightings helped to delineate bighorn sheep range and summer/winter location trends
* Grand Teton National Park Bighorn Sheep suitable winter and summer habitat polygons – used to summarize changes to suitable habitat
* USFS Landscape Change Monitoring System (LCMS) - land cover data created by the USDA USFS, used to identify land cover change and forecast future land cover change. LCMS is derived from Landsat 8 OLI, 7 ETM, and 4 and 5 TM, and Sentinel-2.
* USGS National Elevation Dataset (NED) - 10 m elevation data processed by the USGS and includes data from SRTM. Used to derive slope, aspect, and solar radiation of the study area.

***Modeling:***

* TerrSet Land Change Modeler (POC: Keith Weber, ISU GIS TReC) – used to model land cover change and habitat/forage suitability for bighorn sheep out to 2031
* ArcGIS Pro Suitability Modeler (POC: Keith Weber, ISU GIS TReC) – used to model bighorn sheep habitat suitability for 2020 and 2031

***Software & Scripting:***

* Esri ArcGIS Pro 2.8.3 – create time series analysis maps of summer and winter habitat suitability for bighorn sheep as well as land cover change maps of summer forage
* TerrSet 19.0.5 – used to preprocess land cover, snow cover, and driver variable data for use in the TerrSet Land Change Modeler

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Change in landcover and suitable habitat maps (1987-2021)** | Landsat 8 OLI  Landsat 7 ETM  Landsat 5 TM  Sentinel-2 MSI  SRTM | Identifying past and present habitat suitability and highlighting temporal trends will enable partners to make informed conservation decisions. | N/A |
| **Landcover and suitable habitat forecasting maps (2031)** | Landsat 8 OLI  Landsat 7 ETM  Landsat 5 TM  Sentinel-2 MSI  SRTM | Habitat forecasting will allow partners to inform land management decisions and prioritize conservation of future bighorn sheep habitat. | N/A |
| **Change in snowpack map (2001-2021)** | Terra MODIS | Changes to previous snowpack patterns will aid in the understanding of climatic impacts on bighorn sheep winter habitat. | N/A |
| **Snowpack forecasting map (2031)** | Terra MODIS | Predicted future snowpack information will allow partners to advise on backcountry recreation and avalanche mitigation. | N/A |
| **Map layer geodatabase** | N/A | This layer contains all relevant geographic data layers and analysis products utilized during this project for delivery and partners. | N/A |
| **Remote Sensing Tutorial** | N/A | This product will be a written description of map products, layers, and data sources that will allow partners to interact with and conduct further analysis. | N/A |
| **StoryMap** | N/A | This product provides accessible and visual synopsis of project analysis, findings, and modeling in order to communicate project information to a wider audience. | N/A |

***Product Benefit to End User:***

Land and snow cover change maps along with land and snow cover forecasting maps and habitat suitability models, will help partners make informed decisions about conserving the wild bighorn sheep in the Teton region. Given the historical and forecasted information, partners will be better equipped to refine and employ effective conservation strategies such as revegetation, prescribed fire to enhance habitat, and seasonal closures to prevent recreational disturbance that may affect big horn sheep habitat currently and into the future.

**References**

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