ASPEN DISTRIBUTION ON BLM LANDS IN EASTERN IDAHO DETECTION AND MONITORING WITH NASA EARTH OBSERVING SYSTEMS

DESIGNATED WATERSHED AREA:

The proposed Aspen Distribution and Decline on BLM Lands in Eastern Idaho study is not limited to a specific watershed but rather covers all BLM managed lands within the Idaho Falls District including Upper Snake, Pocatello, Challis, and Salmon BLM Field offices (figure 1).

PROJECT ABSTRACT (4,000 Character Limit):

Award purpose: Aspen (*Populus tremuloides*) were historically the most widespread tree across North America. Current research indicates that many of the historic aspen stands across the western United States have experienced dramatic population declines in recent history. The reasons for this decline are numerous and perhaps not fully understood as it involves changing wildfire frequency, interspecies competition, i.e., conifer and juniper encroachment, changing climate, and the complex interactions between each of these driver variables. To better understand the extent of this decline and the current distribution of the remaining populations, aspen groves will be mapped across BLM managed lands in eastern Idaho (**figure 1**) at five-year intervals between 2000 and 2022 using Landsat satellite imagery. The trend of change in aspen location and extent will be analyzed in relation to the potential driver variables listed above along with additional driver variables identified during the study. The purpose of this research is to better understand changes in aspen populations, identify the cause of these changes, and communicate the findings of this study to BLM managers to support well informed decision processes.

Activities to be performed: Spectral signatures will be extracted from areas of known, current aspen groves. These data will be used to locate other aspen groves with similar spectral (and topographic) characteristics using classification tree analysis and random forest classifiers. The resulting aspen land cover map will be validated using field observation, historic records, and aerial imagery. The trend in aspen land cover change will be analyzed in relation to potential driver variables such as wildfire, seasonal temperatures, precipitation, and aridity.

Expected deliverables or outcomes: This project will provide an improved understanding of the current and past distribution of aspen across the study area as well as determine the extent of aspen decline over the last two decades. In addition, the role of various driver variables will be much better understood as the result of this study.

Intended beneficiaries: Idaho Falls District BLM will directly benefit from this study. In addition, this study has the potential to improve ecosystem health and biodiversity across much of the western United States through the application of the knowledge gained. Lastly, students at Idaho State University (ISU) will benefit from this study by gaining valuable education and research experience and STEM. This will benefit Idaho by improving its talent pipeline.

Subrecipient activities (if known): none

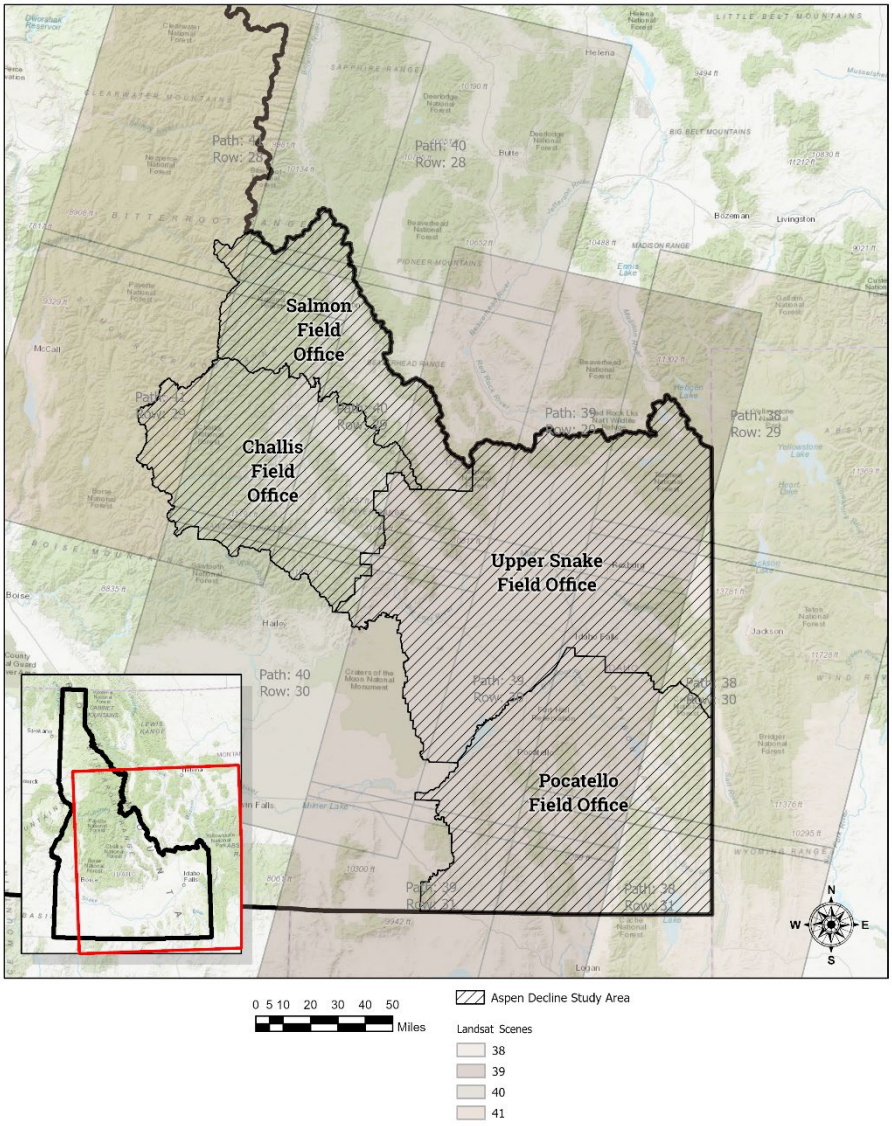

Figure 1. Study area for the proposed Aspen Decline in Idaho research project. Eleven Landsat scene areas will be used in this project to cover 100% of the study area.

STATEMENT OF NEED:

The mission of the GIS Training and Research Center (GIS TReC) at Idaho State University (ISU) is to support well informed decision processes through the application of spatial technologies. The fact aspen populations are declining across much of the western United States almost certainly has strong spatial ties. In addition, aspens are considered a keystone species that help maintain biodiversity and indicate the ecological integrity of western landscapes. In general, aspen landscapes are valuable due to their numerous benefits, including helping to maintain healthy watershed conditions, enhancing soil productivity, and providing some of the best quality food and cover for wildlife. Thus, this project fits very well into the mission and purpose of ISU's GIS TReC.

Importantly, the Aspen Distribution and Decline project also helps the BLM meet its multiple use mission and DOI's priorities. Specifically, having science-based data to support landscape restoration efforts relative to aspen across the Idaho Falls District is important to help justify future management and

treatments. Furthermore, after making well informed decisions supported by this study, the BLM can anticipate increased resilience to the impacts of climate change within these ecosystems[1]. In addition, a hypothesized cause of aspen decline is related to changes in wildfire frequency due to fire suppression and the subsequent increased encroachment of fire-intolerant species such as conifers and junipers. This study will specifically investigate loss of aspen within the study area relative to wildfire and conifer encroachment and provide science-based information to the BLM.

TECHNICAL APPROACH:

The results of the Aspen Decline study will help the BLM develop and implement short and long-term monitoring and maintenance plans relative to wildfire, fuels reductions, and community education. While the data created, information generated, and knowledge gained will focus on aspen, the implications of this study will have broader impacts which are applicable across the entire study area. The approach taken by this study is carefully described below demonstrating the geotechnical capabilities of ISU's GIS TReC.

ISU's GIS TReC is prepared to assist the Bureau of Land Management (BLM) with key geographic information system (GIS) and remote sensing data to help the BLM manage aspen. To do this, the GIS TReC will:

1. Assemble a Landsat dataset with imagery for the years 2000, 2005, 2010, 2015, 2020, and 2022 ($n = 6$) representing the months of March through September each year. This time period was chosen as it corresponds to the phenological time period of active growth for aspen in the study area from early spring, leaf off, to leafing out, and through the early fall. Each selected scene will have less than 10% cloud cover within the study area. The study area includes all or parts of:
    - Path 038 Row 029
    - Path 038 Row 030
    - Path 038 Row 031
    - Path 039 Row 029
    - Path 039 Row 030
    - Path 039 Row 031
    - Path 040 Row 028
    - Path 040 Row 029
    - Path 040 Row 030
    - Path 041 Row 028
    - Path 041 Row 029

    Each path and row combination represents a scene. Each Landsat scene is collected every 16 days. Thus, this project will review a maximum of 15 Landsat acquisition per scene throughout each year of the study (March through September), or 165 scene collections each year (including all 11 scenes), and 990 scene collections for the entire 6-year study.

    Not all 990 scene collections will be downloaded for this project if a specific scene collection contains excessive cloud cover over the study area. Each acquired scene will be imported into Idrisi Terrset and atmospherically corrected. Additional processing will include:
    - Clipping to the extent of the study area
    - Mosaic individual path/row scenes into a single date-specific scene (e.g., Aspen Study Area March 01, 2000)

[1] Cf. Executive Order 14008 https://www.energy.gov/sites/default/files/2021/02/f83/eo-14008-tackling-climate-crisis-home-abroad.pdf

- Calculate normalized difference vegetation index (NDVI) and other indices as needed.
- An NDVI trend analysis will be performed between 2000 and 2022 using these vegetation indices

2. To identify aspen groves, classification tree analysis (CTA) will be used. This process uses known aspen groves as training sites to identify all aspen groves throughout the study area. Identifying a sample of known, current aspen groves (at least 60) will be accomplished by:

- Acquiring existing data from the BLM and/or Idaho Fish and Game
- On-screen digitizing of visible aspen groves using National Agricultural Imagery Program (NAIP) imagery from 2019 and 2021 (0.6 m spatial resolution)
- Field validation.
- CTA will begin using the most current imagery (2022).

This analysis will use the Landsat imagery collection described above as well as topographic data (elevation, slope, and aspect). Spectral signatures of aspen groves will be extracted and examined as well as principal components analysis. Following classification, a careful accuracy assessment will be completed.

Using the successful methodologies determined for the 2022 growing season, additional years will be classified.

A project geodatabase and raster data library will be assembled and delivered to the BLM at the close of this project along with a final report describing the study, its methodology, and results. A project web page will be developed and hosted on the ISU GIS TReC servers (https://giscenter.isu.edu/index.htm).

This project will provide funding for one part-time graduate student GIS/Remote Sensing Technician and supervision/ mentoring and project coordination from the project PI (Weber, FTE = 0.10). The student GIS/Remote Sensing Technician will work with Weber on a daily basis as well as the BLM point of contact toward completion of the project. The student GIS/Remote Sensing Technician will have office space at ISU's GIS TReC and be supervised directly by the PI (Weber), whose office is also located in the GIS TReC. Meeting briefs with the project team will be held on a monthly basis, facilitated using Zoom webinar/teleconferencing with in-person attendance optional when permitted.

This two-year project is proposed to start on September 1st, 2022 and end on August 30th, 2024.

PROJECT MONITORING AND EVALUTION PLAN:

Project performance for the Aspen Decline study will be evaluated by measuring actual project progress against the expected milestones shown in the table below. A report of this status will be sent to the project POC and Program Officers at the BLM every 6 months (or more frequently as directed). The quality of the satellite remote sensing products will be based upon a classification accuracy assessment, specifically an error matrix showing users', producers', and overall accuracy as well as the Kappa Index of Agreement (KIA). It is anticipated that all final aspen detection maps (2000, 2005, 2010, 2015, 2020, and 2022) will result in an overall accuracy in excess of 70% across the study area.

In addition, the methodology used in this study will be carefully documented to identify data sources and processing steps to the extent that a GIS Analyst at the BLM could replicate the study in another area of the United States as needed.

TIMETABLE OR MILESTONES TO COMPLETE EXPECTED OUTCOMES:

Milestone / Task / Activity	Start Date	Completion Date
Recruit a student GIS/Remote Sensing Technician	January 2024	January 2024
Submit biannual (first 6-month) report		February 2024
Acquire all Landsat imagery required for the study	February 2024	March 2024
Prepare all Landsat imagery for analysis	March 2024	April 2024
Prepare all ancillary spatial data for analysis (e.g., topographic layers)	April 2024	May 2024
Assemble sample site geodatabase with known aspen/non-aspen areas)	May 2024	May 2024
Complete DRAFT 2024 Aspen groves map	June 2024	June 2024
Prepare for field validation campaign	June 2024	June 2024
Collect field data ($\geq$120 field plots)	June 2024	August 2024
Submit biannual (second 6-month) report		August 2024
Complete final 2024 Aspen groves map	September 2024	November 2024
Submit biannual (third 6-month) report		February 2025
Complete DRAFT 2020, 2015, 2010, 2005, and 2000 Aspen groves maps	November 2024	March 2025
Review/revise Aspen groves maps to improve accuracy	December 2024	April 2025
Complete final Aspen groves maps	February 2025	June 2025
Complete land cover change/trend analysis	April 2025	July 2025
Present results at professional conference		August 2025
Write final report (technical report, protocol documentation, presentation, and professional publication (if applicable))	July 2025	October 2025
Submit final report(s) and data delivery		December 2025

DIRECT BENEFIT TO THE PUBLIC AND PROGRAM INTEREST OF THE BLM:

Good management requires an assessment of the object being managed. In this case, the extent of aspen is a management concern due to a growing body of evidence from other parts of the nation indicating a decline in aspen stands. Assuming this is the case in Idaho without knowing this to be true for Idaho could result in a waste of land management efforts. Furthermore, having data documenting the extent of aspen over time is a critical piece of information to support the decisions of the land manager. What's more, this study will address not only the trend of change observed in aspen across eastern Idaho but also the cause of this change especially as the observed change relates to wildfire. Armed with rigorous, science-based information, the land manager will be empowered to make better informed decisions resulting in a healthier and more diverse ecosystem for Idaho.

QUALIFICATIONS/PAST PERFORMANCE:

Project personnel:

Key personnel	Responsibilities	Contact
Keith Weber, GISP	PI, day to day management of the project, mentoring/supervising the GIS/Remote Sensing student technician, budgeting, and project reporting.	webekeit@isu.edu 208.282.2757
Student (TBD)	Assemble and analyze spatial data under supervision of project PI (Weber). Conduct field campaign. Co-author technical report, protocol documentation and deliver professional presentations.	n/a

The project PI, Weber is a Certified GIS Professional (GISP) who has worked in the geospatial technologies industry since 1990. Weber is an ecologist who analyzed elk habitat in western Montana as part of this graduate degree in wildlife biology. Weber's career has focused on land cover change assessment and understanding the drivers of change. A substantial body of this research has focused on wildfire across the western US. Weber was the PI for the NASA RECOVER post-wildfire decision support system (https://giscenter.isu.edu/research/Techpg/nasa_RECOVER/index.htm).

The Aspen Distribution and Decline project will work closely with BLM partners throughout the course of this study. Weber has tremendous experience with this and coordinated the NASA ARSET Wildfires workshop (held at Idaho State University 2015)[2] as well as the Geospatial Range Sciences conferences (2005-2010).

No contractors, sub awards, or consultants are part of this project.

Recent federally funded studies

FEMA Cooperating Technical Partner program (2019-2022). These projects focused on the acquisition and value-added processing of aerial lidar data in Idaho, as well as training stakeholders, and providing expertise in the spatial analysis of lidar surface models.

NASA RECOVER post-wildfire decision support system (2012-2019). This study developed the RECOVER DSS, an automated online mapping capability that was used successfully on over 100 large wildfires across the western US. Weber worked closely with fire managers and teams (stakeholders) from the BLM, USFS, NPS, as well as FEMA.

In addition to the more recent projects described above, Weber has worked closely with the BLM (1999-2010) to assess wildfire susceptibility across eastern Idaho using Landsat satellite imagery and field campaigns/sampling (https://giscenter.isu.edu/research/Techpg/blm_fire/index.htm). This study also engaged local fire chiefs in their respective communities providing data and information to assist them in wildland urban interface fire management.

[2] Schmidt, C.; Kuss, A.; Weber, K.; Guay, T.; Hamilton, D.; Carroll, M.; Harriman, L.; Lemig, K. (2015). Introduction to Remote Sensing for Wildfire Applications. NASA Applied Remote Sensing Training Program (ARSET). https://appliedsciences.nasa.gov/join-mission/training/english/arset-introduction-remote-sensing-wildfire-applications-0

Weber is the author of *Actionable Information: Communicating with GIS* [3]which is the culmination of decades of work to provide the results of sound geospatial analysis to support well-informed decisions.

LEVERAGING OF RESOURCES

The Aspen Distribution and Decline project will leverage existing resources at ISU's GIS TReC to support this study. Specifically, the GIS TReC has invested in high performance research workstations, gigabit ethernet connectivity between all workstations and the GIS TReC servers located in ISU's Research Data Center (RDC; https://www.isu.edu/research/centers-and-institutes/research-data-center-rdc/). In addition, the GIS TReC has the necessary Global Navigation Satellite System (GNSS) receivers to achieve sub-meter accuracy of field plots locations as well as a dedicated field truck.

High resolution spatial data already exists at the GIS TReC namely all lidar data collected in the state of Idaho (1-meter spatial resolution), a seamless elevation layer (10-meter spatial resolution) for the entire western US, as well as the experience and expertise to process and analyze satellite imagery such as Landsat and Sentinel using software licensed to the GIS TReC (Esri ArcGIS Pro and Idrisi Terrset).

[3] https://www.amazon.com/Actionable-Information-Communicating-Keith-Weber-ebook/dp/B092WWDB46