Assessing Change in Aspen Extent in Northern Yellowstone National Park

Abstract

The removal and reintroduction of the gray wolf (*Canis lupus*) in Yellowstone National Park have played an important role in shaping the ecological composition of this distinct landscape, and it is a textbook example of multi-trophic dynamics. With particular importance to conservation science, the inter-trophic cascades between wolves and species such as the elk (*Cervus canadensis*) and the quaking aspen (*Populus tremuloides*) have been extensively studied. In conjunction with the National Park Service, Yellowstone National Park, Utah State University, and the University of Wisconsin–Stevens Point, this project utilized satellite remote sensing to investigate the long-term trends in aspen extent. Through random forest modeling and phenological approaches, Sentinel-2 Multispectral Instrument (MSI; years 2017–2019) and Landsat 5 Thematic Mapper (TM; years 1987–2011) datasets were used to derive an Enhanced Vegetation Index (EVI), a Normalized Difference Vegetation Index (NDVI), Tasseled Cap Indices (Brightness, Greenness, Wetness), and RGB true color composites. The International Space System Global Ecosystem Dynamics Investigation (ISS GEDI) was used to analyze canopy height. Results were consolidated into maps and time-series that provide an in-depth and intricate depiction of aspen stand extent. The end products will assist the National Park Service in its management practices and inform wildlife restoration and rewilding decisions within and beyond the contexts of Yellowstone National Park.

Objectives

- **Utilize** Earth observations and perform classifications through a random forest model to assess aspen extent and health
- **Identify** aspen stands using a phenological approach of vegetation indices and spectral signatures at various periods
- **Create** aspen stand extent maps to uncover long-term trends in aspen stand regeneration

Earth Observations

Landsat 5 TM

Sentinel-2 MSI

ISS GEDI

Study Area

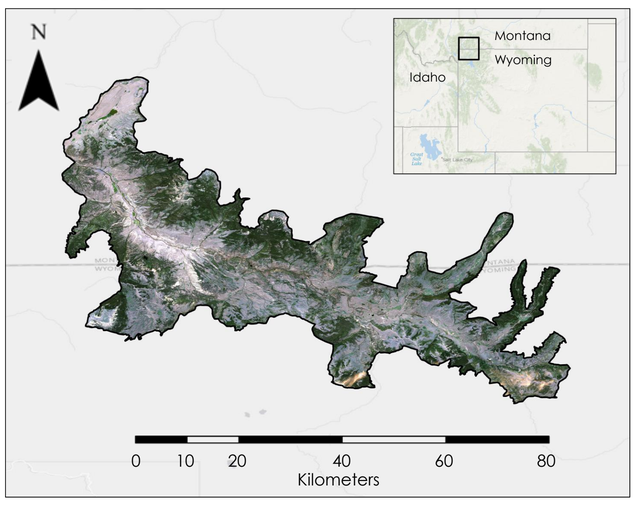


Figure 1: Elk Winter Range, Northern Yellowstone National Park.

Methodology

Random Forest

Create Predictors
True color (RGB), NIR, SWIR, NDVI, EVI, TCG, TGW, TCB

Define Training Classes
Aspen, conifers, water, bare ground, grassland, shrubland, and other deciduous

Build and Train RF Classification Model
Use predictors to classify study area
Perform accuracy assessments

Phenological Approach

Assess Seasonal Signatures
Peak vegetation in summer
Senescence in fall

Phenological Classification
Compare fall and summer images
Utilize NDVI change to identify aspen

Canopy Profile

Analyze Canopy Height and Plant Area Index
Plot ISS GEDI transect data

Results

Figure 2a

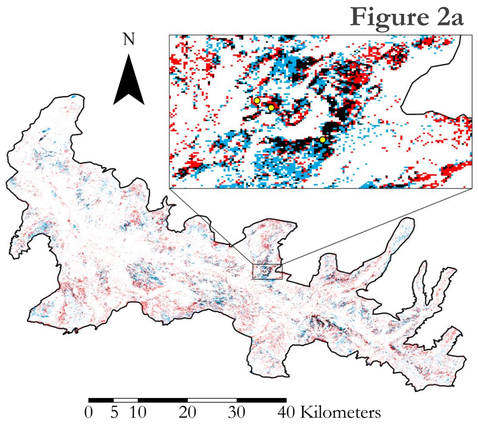
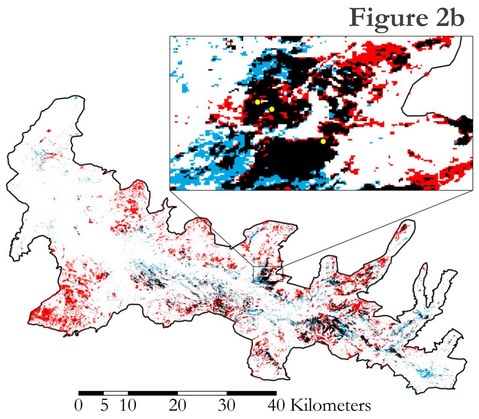


Figure 2b



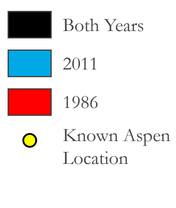


Figure 2: 2a) Change in aspen extent from 1986 to 2011 using the random forest method. 2b) Change in aspen extent from 1986 to 2011 using the phenological approach.

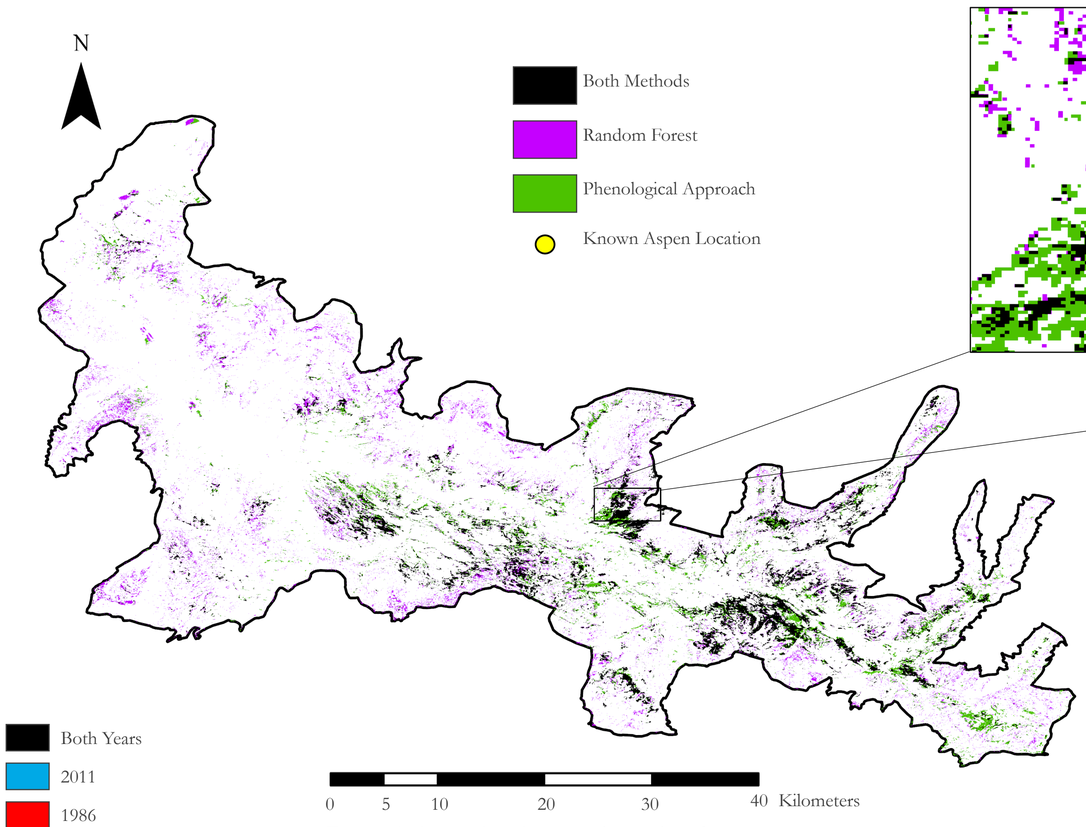
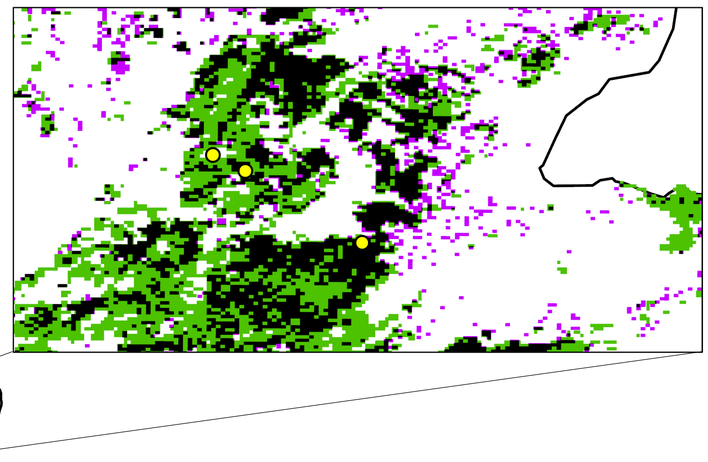


Figure 4: Comparison between the random forest method and the phenological approach for 2011.



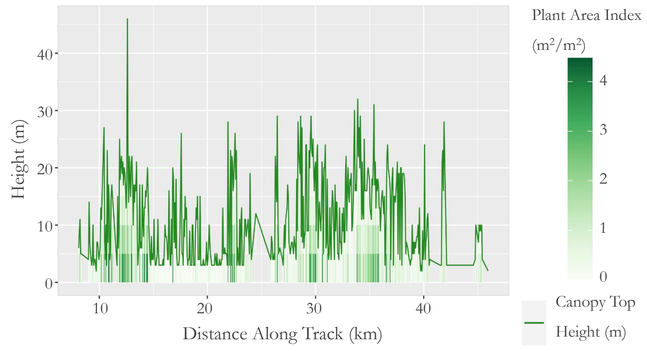


Figure 5: Example canopy height profile transects using ISS GEDI

Conclusions

- Aspen extent changed in the Northern Yellowstone elk wintering range from 1986 to 2011.
- The random forest and phenological approaches showed marked differences in results.
- Increased understanding of aspen response to trophic cascades helps inform management practices and rewilding decisions.

Acknowledgements

Dr. Daniel Stahler, Wildlife Biologist - Yellowstone National Park
Dr. Daniel MacNulty, Professor - Utah State University
Dr. Eric Larsen, Professor - University of Wisconsin – Stevens Point
Nicholas Bergeron, Researcher - Utah State University
Dr. Marguerite Madden, Professor - University of Georgia, Center for Geospatial Research
Dr. Kunwar Singh, Professor - William & Mary, AidData & Global Research Institute
Sarah Payne, Fellow - NASA DEVELOP National Program

Project Partners

- **National Park Service – Yellowstone National Park** *(End User)*
  Dr. Daniel Stahler, Wildlife Biologist
- **University of Wisconsin – Stevens Point** *(Collaborator)*
  Dr. Eric Larsen, Professor
- **Utah State University** *(Collaborator)*
  Dr. Daniel MacNultty, Professor & Nicholas Bergeron, Researcher

Team Members

Kyle Steen
(Project Lead)

Vanessa Bailey

Gabriella Boodhoo

Barry McLaughlin

Ecological Forecasting in Yellowstone

This material is based upon work supported by NASA through contract NNL16AA05C. Any mention of a commercial product, service, or activity in this material does not constitute NASA endorsement. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration and partner organizations.