Impacts of snow cover and extent on timing of wildfires

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Project Summary

Overview: Predicting wildfire behavior is essential to inform land management policy, community safety, and ecological modeling. However, predicting wildfire timing in a given area is based on localized assessments and not consistent. This study seeks to predict when wildfire season will begin over a given area based on snow cover extent. Study objectives are as follows: **1) Increase understanding of interactions between snow cover and fire. 2) Develop models to predict fire occurrence based on existing trends.**

Snow coverage plays an important role in maintaining moisture content in soil and fuels, which is a factor in determining an area's susceptibility to wildfires. Publicly available satellite-derived snow extent data will be used to determine spatial and temporal coverage. These data will be summarized by hydrologic units (HUC12; subwatershed) from the National Hydrography Dataset (NHDPlus HR), each of which will have an average slope and aspect derived from the areas digital elevation model (DEM) and other variables, such as accumulated precipitation and annual high and low temperature. Fire occurrence for a given area is determined using 1km or 375m resolution data from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS). Preliminary analysis using data from 2000-2020 shows significant correlation between timing of snowmelt and wildfire occurrence for 21 out of 92 HUC12's using snow coverage alone. To improve the output of this analysis, we will develop our model within a Bayesian framework that incorporates temporally and spatially explicit data streams (i.e., snow and fire coverage satellite remote sensing data, ground-based measurements, citizen science data). This enables our model to leverage variable spatial/temporal resolution data to create a map of the Colorado Basin showing each HUC12's susceptibility to wildfire temporally. These risk maps will serve as a predictive tool for future studies and land management policy.

Scientific Merit: A high-resolution regional predictor of wildfire timing for a given better informs future studies modeling fire behavior, flood mitigation, and climate change. The algorithm used to determine a given area's snow coverage in this study is scalable and applicable to a range of locations beyond northern Arizona. Our model can leverage future data sources, including higher resolution satellite imagery and GPS GNSS point data to improve outputs and aid planning of seasonal fieldwork for site-specific studies. This study is novel for its use of publicly available data at variable spatial and temporal scales to predict an area's susceptibility to wildfire at high resolution (HUC12's).

Broader Impacts: The methodology and design of this study will be structured to facilitate reproducibility and support open science initiatives. Aside from the publication, code and model maps being available on DataOne under an open copyright license, all aspects of the study will be documented on public repositories (GitHub) in a tutorial format. This approach will educate participants in interfacing with remote sensing platforms, interpret Bayesian modeling outputs, and show how to successfully run this analysis for their area of interest.

The products created from this proposal are valuable for any land management agency, tribe, or counties in areas with wildfires and snow. Resource allocation of personnel will be better predicted over smaller scales, improving logistics and constraining budget. In addition, collaboration with local schools and tribes to support citizen science campaigns for fire and snow observations increases modeling accuracy and fosters stewardship through educational outreach. This study will present its findings through multiple STEM and wildfire conferences nationally and within northern Arizona. We will also host four two-day workshops for federal and state land managers to generate and interpret their own risk maps at Northern Arizona University.

Project Description

Intellectual Merit

1. Introduction

Wildfire occurrence and severity has been increasing globally over the past several decades due to climate change[1]. The Southwest region of the United States is experiencing increased wildfire activity because of warmer and drier climate conditions[2]. In the past several years alone, the Southwest has recorded some of its driest and warmest conditions yet[3]. However, apart from generally warm and dry conditions, it is important to understand the environmental factors that are contributing to seasonal wildfire occurrence. In particular, the timing of snowmelt is changing and moving earlier in the year[4]. Understanding the connection between wildfire occurrence and snowmelt timing is important to be able to help predict the timing of wildfires in the Southwest region. This project aims to answer the questions **1) Does timing of snowmelt affect the timing of the fire season in the Colorado River Basin? 2) Can these results be used to inform land managers of when and where to expect the start of the fire season?**

Having answers to the questions above will have major implications for ecosystems and human environments within the Colorado River Basin. Understanding the factors that affect fire season timing can help regional land managers better prepare for upcoming fire seasons. For example, the answers to Question 2 would provide land managers with an expected time and location of each fire season, providing them with timely information, allowing them to better prepare and contain fires sooner. Additionally, understanding the relationship of snowmelt and fire season timing can help inform restoration needs. Not only is vegetation in the Colorado River Basin heavily affected by fire[5], but much of the vegetation in this area also relies on winter snowfall for the majority of its annual precipitation[6].

Previous studies have found a connection between the timing of snowmelt and area burned in the Western United States[7–9]. However, this relationship has not been widely studied in the Southwest. In addition, studies that looked at the connection between snowmelt and fire season timing had several limitations that will be built upon through this project. For example, previous studies lacked access to data with high spatial resolutions and long-term temporal coverage which limited the analysis of significant relationships[8]. We now have access to additional datasets that provide data over a longer period, affording us opportunities to explore these relationships in detail.

In this project we will use satellite data from MODIS and VIIRS for fire[10,11] and snow coverage[12]. Additional covariates will be derived from gridded climate data[13] to identify additional fire drivers. To find the relationship between snowmelt timing and fire season timing, we will look at the region through individual hydrologic unit codes (HUCs)[14], giving us a common spatial framework to summarize these datasets. Each of the six datasets has a different spatial and temporal resolution (Table 2). To account for these differences, we will use a Bayesian model to help see how the year-to-year timing of fire season can be expected to begin. This Bayesian framework will help to integrate different types of data with varying temporal resolutions[15], allowing us to integrate a wide range of datasets in our analysis.

2. Research Objectives

In Table 1, we outline three main objectives to help us answer our questions about the timing of snowmelt and wildfire. To address each research objective, we have identified several tasks to help us meet these goals. In O1, assessing the relationship between snowmelt timing and fire timing, we will collect various datasets and summarize them by HUC [T2]. The benefits of this approach are twofold: 1) it gives us a common spatial framework to summarize datasets of varying spatial extent, and 2) model results can then be mapped with spatial footprints that help inform land managers. Second, we will develop a Bayesian GLM model using JAGS [T2] that will be able to take in the datasets from T1 that have varying spatial and temporal resolutions. To complete O2, we will create an AutoRegressive Integrated Moving Average (ARIMA) model [T3] that will allow us to forecast future fire risk within HUCs. In T4, we will use the results from the model created in T3 to create a fire risk map using QGIS that will help inform land managers in the Colorado River Basin. In O3, we plan to make all code and data products that were used in the analysis publicly available through DataONE and a public GitHub repository. To complete T6 we will utilize existing citizen science platforms such as Community Snow Observation (CSO) and Pyrogeography to help fill regional data gaps that exist on these platforms. Lastly, in T7 we will conduct field trips and seminars to local schools to support STEM education in this region.

Objective/ Task	**Objective Description**
	O1: Relationship assessment between snowmelt timing and fire timing
T1	Collect datasets and summarize by HUC
T2	Develop a Bayesian GLM model using JAGS
	O2: Prediction of fire timing using snowmelt timing and climate variables
T3	Create a forecasting model using R
T4	Develop HUC risk assessment map from forecasting model from T3 and distribute to land managers
	O3: Data accessibility and STEM support through broader impacts
T5	Make code and data products accessible to researchers, land management agencies, and the public
T6	Collaborate with citizen science platforms to help fill regional data gaps and better constrain snowpack and fire locations and times
T7	Provide support to local communities and school STEM programs through field trips and seminars

Table 1 - Proposal Objectives and Research Tasks

3. Approach & Methodology

3.1 Site Description

The proposed work will focus on the Colorado River Basin (Figure 1), encompassing approximately 700,000 square kilometers across the U.S. states of Wyoming, Colorado, Utah, New Mexico, Arizona, Nevada, California and extends into Mexico. While locally variable, most of the basin receives less than 500 mm of annual precipitation, elevation ranges from sea level to over 4300 m, and temperatures range from below freezing to 50 °C[16]. Most of the precipitation comes in the form of snowfall, which over 40 million people are dependent upon for daily use and irrigates approximately 5.5 million acres of agricultural land[17]. Preliminary analysis for this proposal focused on the San Francisco Peaks and surrounding lands, located in Flagstaff, AZ (Figure 1).

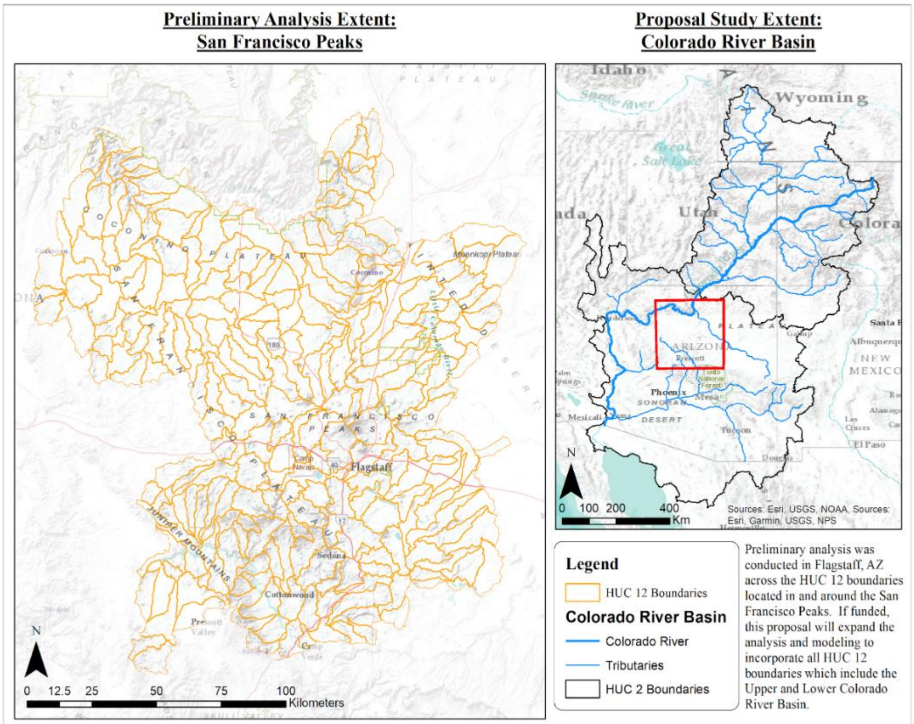

Figure 1 - The map on the left shows the HUC12 boundaries used for the preliminary analysis encompassing the San Francisco Peaks in the Flagstaff, AZ area. The map on the right shows the proposed research extent including the Colorado River Basin.

3.2 Data Products

Table 2 lists the data products this research will use, with additional information in subsequent subsections.

Data Product	Variables	Time Period	Spatial Scale	Temporal Resolution
NHDPlus HR[14]	WBD HUC12 footprints	Living Dataset	1:24,000-scale or better	NA
MODIS Snow Cover[12]	Max Snow Cover Extent (presence/absence)	2000 - present	500 m x 500 m	8-day
MODIS Thermal Anomalies[10]	Fire locations (presence/absence) MCD14DL	2000 - present	1 km x 1 km	1-2 days
VIIRS Thermal Anomalies[11]	Fire locations (presence/absence)	2012 - present	375 m x 375 m	12 hours
National Elevation Dataset (NED)[18]	Elevation	NA	⅓ arc second	NA
U of I GRIDMET[13]	Min/Max Temperature; Precipitation amount	2000 - present	4 km x 4 km	Daily
SNOTEL[19]	Snow water equivalent	1991 - 2020	Point estimate	Daily
SMAP[20]	Soil Moisture; Freeze/thaw state	2015 - present	9 km	3 hours; Daily
Land Cover NLCD[21]	Land Cover type	NA	30 m	NA

Table 2 – Proposed data products, associated variables, available time periods, spatial scales, and temporal resolutions.

3.1.1 NHDPlus HR: A spatial summary framework

The NHDPlus HR (Table 2) is a hydrologic geospatial framework which models the surface waters in the United States. There are two main vector datasets stored in the NHDPlus HR: 1) polylines which depict the path of surface water movement across the landscape, resulting in streams and rivers; and 2) the watershed boundary dataset (WDB) polygons which depict adjacent lands which contribute surface water runoff to the flowlines at varying spatial extents. The WBD dataset is organized by HUCs (hydrologic unit code) which are a series of nested watershed boundaries at varying spatial scales. Precipitation which falls into a HUC will eventually flow into the flowlines contained within that HUC. This relationship allows flood mitigation planners, for example, to model potential downstream impacts from large rainfall events in one region to downstream regions.

We will pull NHDPlus HR datasets available from the USGS. The dataset is subset into geodatabases at the HUC 4 level. Four HUC 8 boundaries will be used to select HUC 12 boundaries of interest for modeling purposes. The HUC 12 boundaries falling within the relevant HUC 8 boundaries will be then selected using geoprocessing tools available in QGIS[22]. The HUC 12 boundaries will then be used to standardize and summarize the spatially varying datasets (identified in the following sections) to a common spatial footprint. By using HUC 12 boundaries as the summarizing units, any resulting model outputs can be mapped at a spatial extent that can help inform land managers, fire managers, or anyone interested in incorporating our results into their hydrologic modeling analysis.

3.1.2 Gridded Climate Data

We will employ the use of daily climate data (precipitation, maximum and minimum temperature) from the University of Idaho Daily Meteorological data for continental US along with gridded climate data products to evaluate the drivers of fire season timing (Table 2). The University of Idaho Daily Meteorological data uses a method that combines desirable attributes of gridded climate data from PRISM and temporal attributes of regional-scale reanalysis and daily gauge-based precipitation from NLDAS-2 to derive a spatially and temporally complete high resolution gridded dataset of climate variables from 1979-2020. For our preliminary analysis, these data were downloaded using the R[23] package GeoKnife[24]. In our proposed model, we will test each climate variable as a predictor variable, and test for interactive effects between variables.

3.1.3 Satellite Data

We will source data on fire presence and extent from the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Visible Infrared Imaging Radiometer Suite (VIIRS) thermal anomalies (Table 2; Figure 2). The VIIRS dataset has a higher spatial resolution than the MODIS dataset but is not available for the planned 20-year temporal extent of this study, so we will use the higher resolution data when it was available but supplement it with the lower resolution data during the missing years.

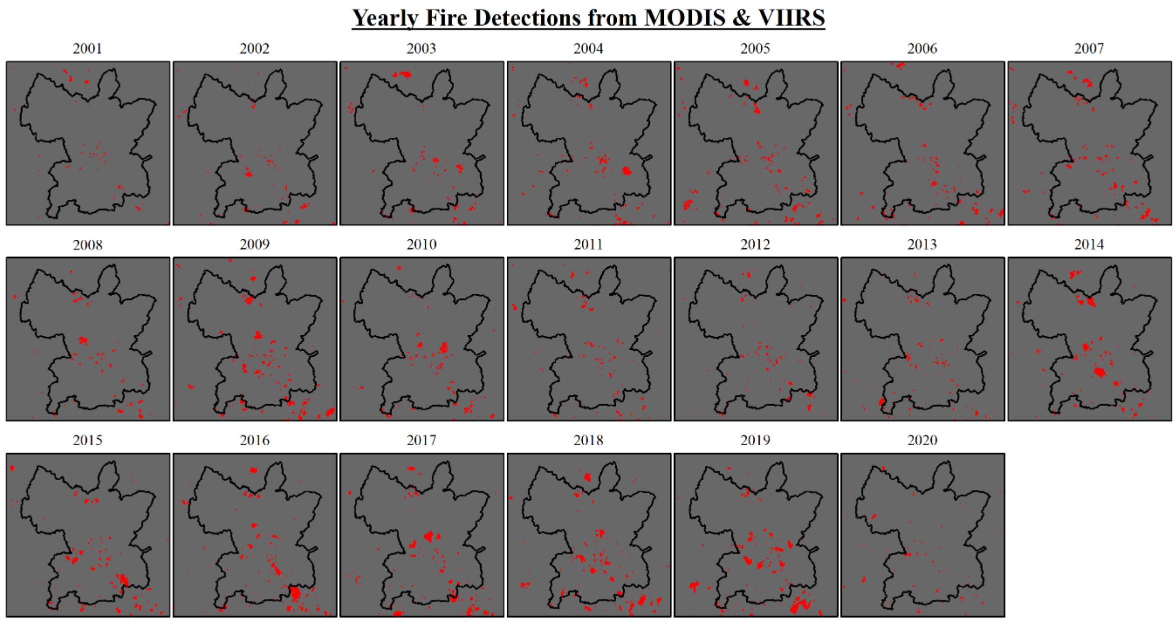

Figure 2 – Yearly fire detections across San Francisco Peaks, Flagstaff, AZ for sites selected for our preliminary analysis. Data for 2001 – 2011 were collected by MODIS and 2012 – 2020 were from VIIRS satellite instrument.

For snow cover, we will use the MODIS MOD10A2 snow cover extent dataset, which extends back to 2000 (Table 2; Figure 3). Previous studies that have tested the interactions between snowmelt and fire have been limited by low resolution snow datasets[8], and the MODIS dataset will allow us to analyze snow extent at a higher resolution than was previously available. We will supplement the snow cover data with ground-based snow water equivalent point estimates from Snow Telemetry (SNOTEL; Table 2), available from the Natural Resources Conservation Service (NRCS), and citizen science initiatives.

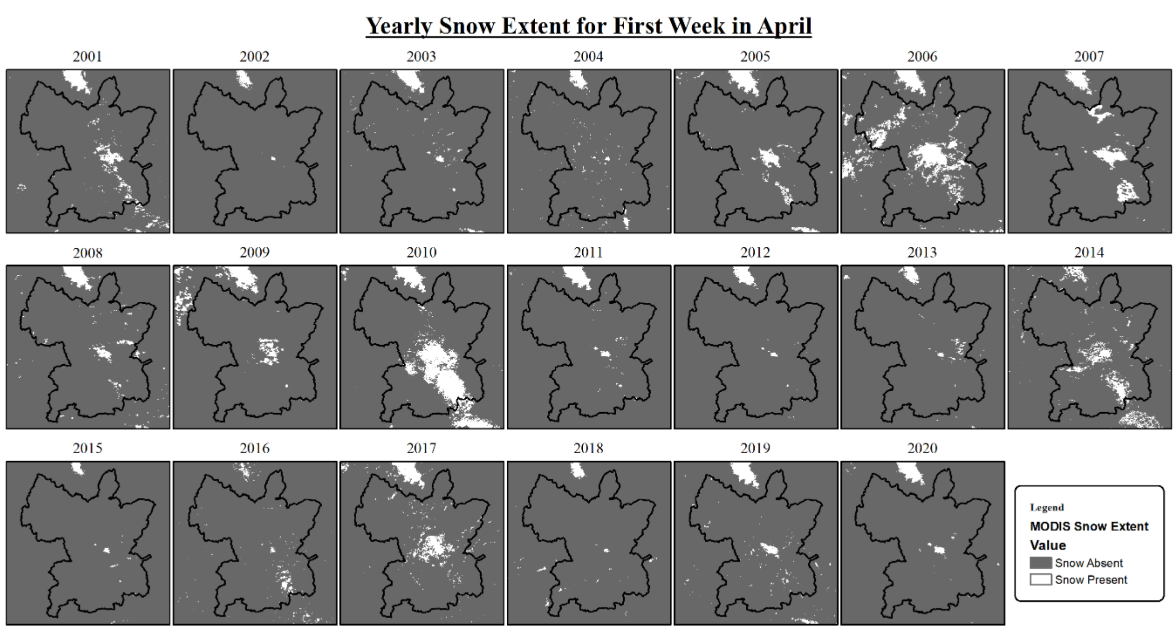

Figure 3 – Yearly snow extent as of the first week in April as identified by MODIS.

In addition to snow, fire, and climate variables, we will use land cover type, soil moisture, and soil freeze/thaw state as predictor variables in the Bayesian model (see § 3.2.2). We will source land cover type from the National Land Cover Database (NLCD), which uses bands from Landsat, to relate the relationship between snowmelt and fire to ecosystem type. We will source both soil moisture and soil freeze/thaw state from the Soil Moisture Active Passive (SMAP) mission.

3.2 Data Synthesis

3.2.1 Preliminary Analysis

In a preliminary analysis, we pulled a small sample of biweekly snow extent, fire extent, and meteorological data for the Flagstaff San Francisco Peaks area. 246 boundaries at the HUC 12 boundary level were manually selected, and snow, fire, and meteorological data were summarized to specific HUCs. Only HUC 12 boundaries with fire present during some point over the study interval were used in the preliminary analysis, resulting in 92 boundaries. To test the correlation between snowmelt timing and the start of the fire season across HUC 12 units, we ran a generalized linear model that tested the correlation between the first sensor-observed fire each year to the snow coverage of each HUC 12 in the first week of April, climate variables (e.g., yearly accumulated precipitation, yearly maximum temperature, and yearly minimum temperature), and topographic variables (e.g., slope and aspect). We sourced fire extent data from MODIS (2000-2012) and VIIRS (2012-2020) datasets. The best performing model with the lowest AIC only included snow coverage, and showed significant interactions ($p < 0.05$, $\alpha = 0.05$) between snow coverage and fire start at 21 out of 92 HUC12s (Figure 5, Figure 7). There were no significant correlations between fire start, snow coverage, and topography, but p-values were near significance for aspect range ($0.06 > p > 0.05$), indicating that aspect range could potentially influence the interactions between snowmelt and fire timing if we expand our spatial testing across a larger area (Figure 6). If funded, our proposed work would expand upon this analysis to include HUC 12s that span the Colorado Basin and pull fire coverage and snow coverage data from more sources.

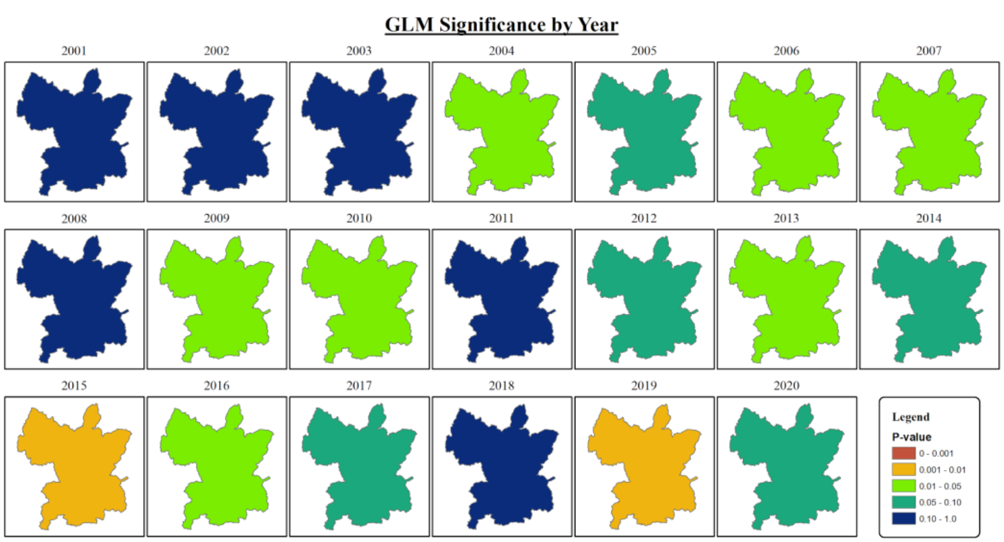

Figure 4 - A time series of significance values over all HUC 12s tested shown by year. The p-value generally decreases as time goes on. From 2012 on, we used finer resolution fire data from VIIRS instead of MODIS, which could have been a factor in our analysis and demonstrates the need for high resolution data.

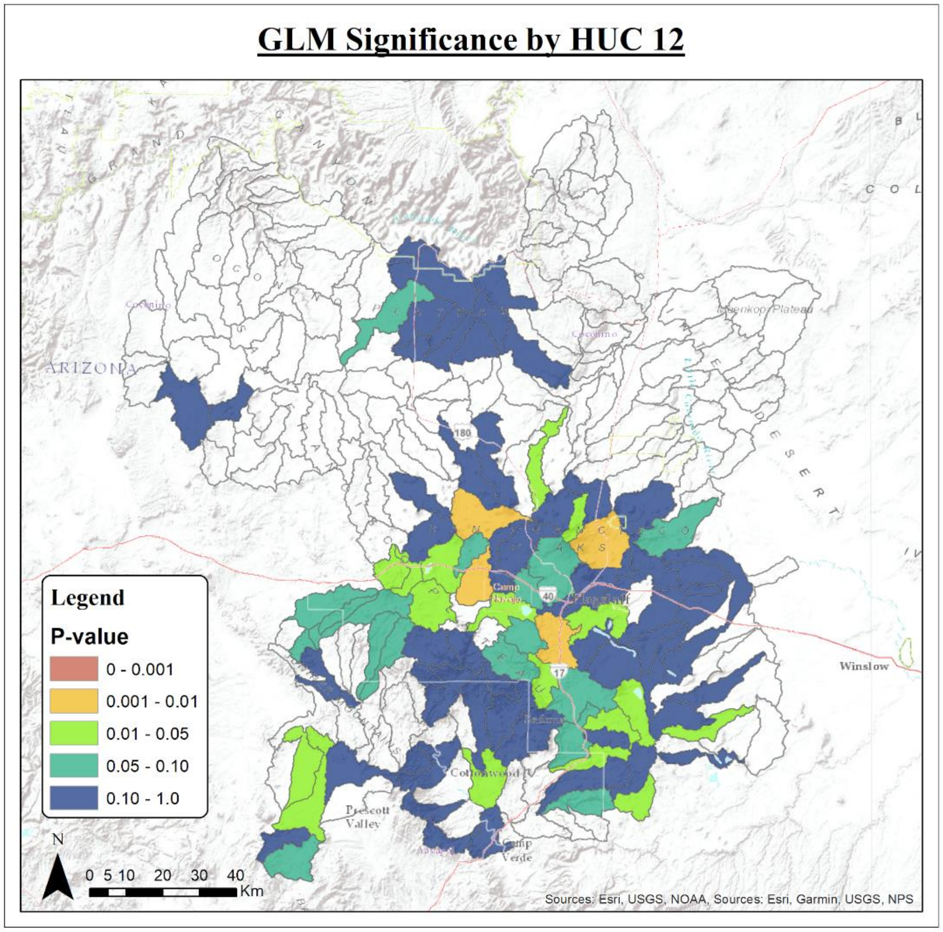

Figure 5 - A map of the p-values from our glm analysis across HUC 12s in the Flagstaff San Francisco Peaks area. We suspect there may not have been significance in some HUCs due to fuel load and lack of snow coverage, because our spatial extent includes some lower high desert areas with less snow cover compared to mountainous regions.

Figure 6 - Graph of aspect, slope, accumulated precipitation, and temperature over all HUC 12s included in the preliminary analysis across years.

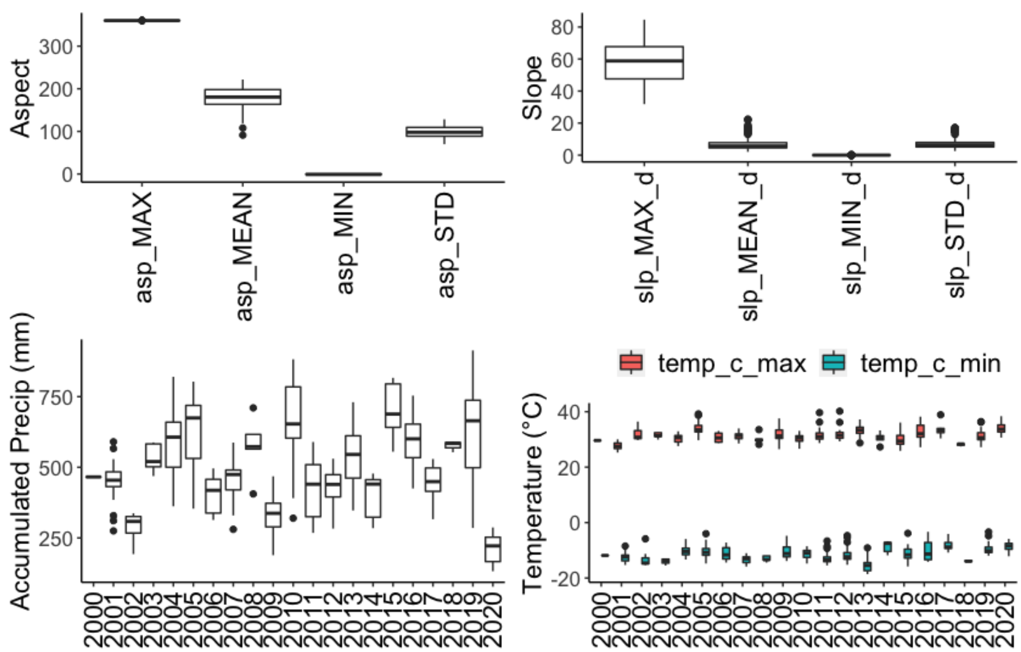

Figure 7 - A graph of snow coverage % and first observed fire day for all years across HUC 12s in the San Francisco Peaks area. HUC 12s designated by asterisks *were found to have a significant relationship between snow coverage and fire start day in the generalized linear model. A single asterisk indicates a p-value between 0.05 and 0.01. Two asterisks indicate a p-value between 0.01 and 0.001.*

3.2.2 Modeling Framework

To improve our preliminary analysis, we will implement a linear mixed effect Bayesian statistical framework that incorporates simultaneous analysis of multiple data streams to allow for the inclusion of various data sources at differing temporal and spatial resolutions[25,26]. A Bayesian approach will allow us to use scale-mismatched data products in a singular framework that produces uncertainty estimates for resulting likelihood distributions. We will use the Bayesian framework as a tool to add ground-based point estimates (i.e., snow water equivalent from SNOTEL and citizen science initiatives). Point measurements will inform our prior, which we will use to relate snow water equivalent to MODIS snow extent (Figure 8). Our model will use the generalized linear model form,

(1)

$$y = \beta_0 + \sum_{k=1}^{K} \beta_k x_k$$

Where $\sum_{k=1}^{K} \beta_k x_k$ represents the sum of all predictor variables (i.e., snow, climate, and topography variables), and y represents the response variable (i.e., fire start day). We are primarily interested in results that vary by HUC 12 boundary, so the results of our analysis can be relevantly summarized to hydrology managers. However, we will also test the relationship between fire start time and topographic variables (which were summarized by HUC 12 boundary), to better assess potential topographic mechanisms behind differences in results of HUC 12 fire start time interactions. We will use JAGS and the R software to conduct this analysis.

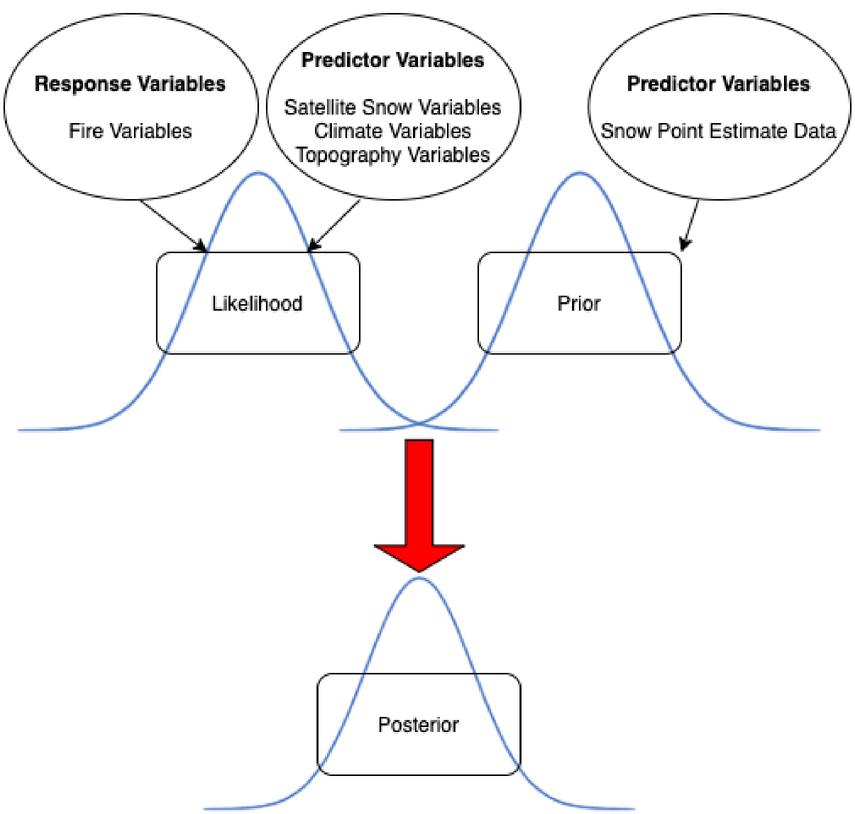

Figure 8 - A diagram of our proposed Bayesian model framework, and the data sources that will inform the model. To improve our predictor variable quality, we will use ground-based point estimates from SNOTEL and citizen science initiatives as an informative prior in our model to relate snow coverage to snow water equivalent, in HUCs where the data is available.

To help make our results relevant to land managers, we will implement an AutoRegressive Integrated Moving Average (ARIMA) model to predict future points in the timeseries. We will use these predictions to summarize the future early fire risk of HUC 12s that lie within the Colorado Basin and produce a color-scaled risk map for hydrologic managers.

4. Project Management Plan

The project team consists of four graduate students with diverse scientific backgrounds. All team members are a part of the ecoinformatics emphasis area of the Informatics & Computing PhD program at Northern Arizona University, a new, novel program that emphasizes the synthesis of ecology and data science. The project team will hold weekly project meetings throughout the duration of the project to access progress. **Cameron Bodine** will lead the spatial organization of the data, and the resulting risk map products. **Emma Reich** will lead the Bayesian model development and communicate with both Cameron Bodine and Jeralyn Poe on data quality assessment. **Jeralyn Poe** will create the forecasting model in R. **Blase Lasala** will lead the broader outreach initiatives, with support from the rest of the team. All team members are trained in team science, and have experience working within NSF, OSHA, and other high-level teams. Table 3 shows the timeline for completing the proposed research, if funded. Figure 9 provides a conceptual diagram showing relationships and connections between each of the proposed tasks.

<table>
<tr><th rowspan="2">Obj.</th><th rowspan="2">Task</th><th rowspan="2">Description</th><th colspan="4">2022</th><th colspan="4">2023</th><th colspan="4">2024</th></tr>
<tr><th>Q1</th><th>Q2</th><th>Q3</th><th>Q4</th><th>Q1</th><th>Q2</th><th>Q3</th><th>Q4</th><th>Q1</th><th>Q2</th><th>Q3</th><th>Q4</th></tr>
<tr><td rowspan="2">O1</td><td>T1</td><td>Collect datasets and summarize by HUC</td><td colspan="3">CB</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>T2</td><td>Develop a Bayesian GLM model using JAGS</td><td></td><td></td><td colspan="4">ER</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">O2</td><td>T3</td><td>Create a forecasting model using R</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">JP</td><td></td><td></td><td></td></tr>
<tr><td>T4</td><td>Develop HUC risk assessment map based on forecasting model from T3 and distribute to land managers</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">CB</td><td></td><td></td></tr>
<tr><td rowspan="3">O3</td><td>T5</td><td>Make all code and data products accessible to researchers, land management agencies, and the public</td><td></td><td></td><td></td><td></td><td colspan="8">BL, JP, CB</td></tr>
<tr><td>T6</td><td>Collaborate with citizen science platforms to help fill regional data gaps and better constrain snowpack and fire ignition locations and times</td><td colspan="12">BL, ER</td></tr>
<tr><td>T7</td><td>Provide support to local communities and STEM programs within schools through field trips and seminars</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">BL, JP, CB, ER</td></tr>
</table>

Table 3 – Project timeline if funded. For each objective and its associated tasks, the gray shade indicates the quarter that the task will be actively worked on. Each shaded region indicates the initials of who will work on the task (CB: Cameron Bodine; ER: Emma Reich; JP: Jeralyn Poe; BL: Blase LaSala) and bold initials indicate who will lead the effort.

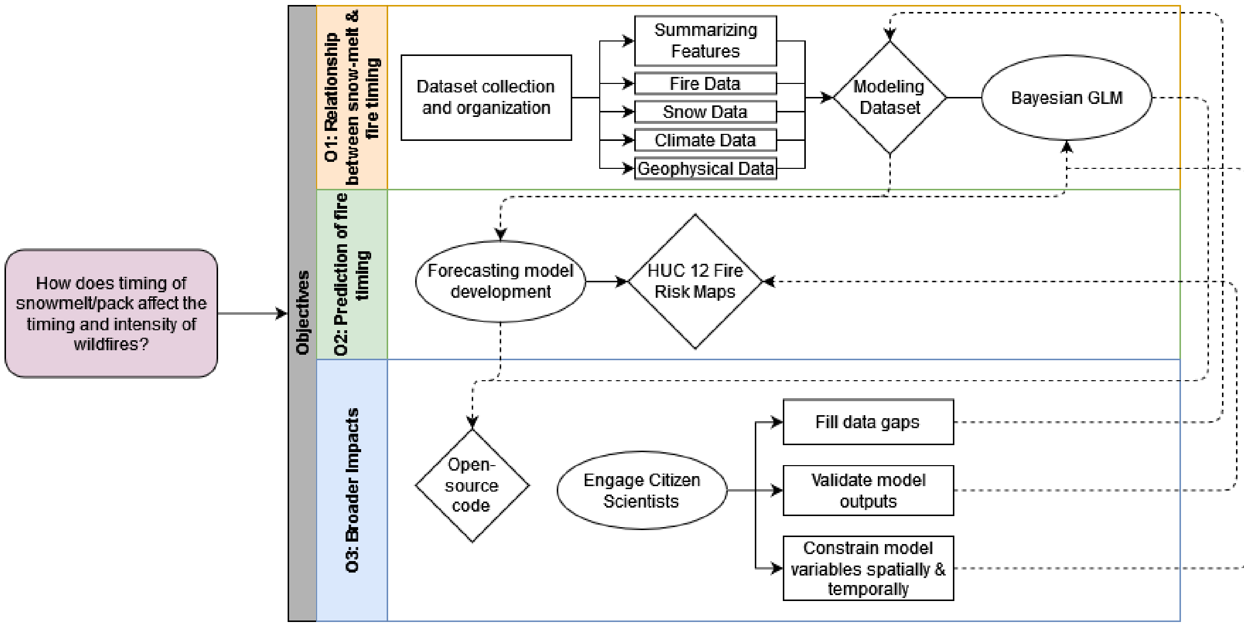

Figure 9 – Workflow diagram depicting each objective, associated tasks, and relationships and feedbacks between each.

Broader Impacts

To broaden the impact of this research, we propose several initiatives. 1) Make all code, findings, and data products widely accessible to both researchers, the public, and land management agencies. 2) Collaborate with several citizen science platforms to fill in regional data gaps and better constrain snowpack and fire ignition locations and times. 3) Provide support to local communities and school STEM programs through field trips, highlighting wildfire's ecological role and preparedness.

In addition, two half-day seminars documenting the workflow created from this study will be held at the international Global Wildfire Management Summit and the 2022 International Association of Wildfire: Fire and Climate Impacts, Issues and Futures (IAWF) conference in Pasadena California. These seminars will be designed to help land managers become more familiar with python scripting and leveraging remote sensing datasets.

1. Open access

The data products and scripts created from this study are valuable to a variety of land management agencies, tribes, and counties to better predict when and where wildfires are expected to occur at high resolutions. While preliminary studies are focused on the greater Flagstaff area in Arizona, the code and analyses can be useful over a wide geographic area. Given the wide applicability and potential for a diverse audience of users, a GitHub repository with a complete, step by step workflow using real world data will be made available and maintained. While this ensures reproducibility and transparency, this repo will also function as an introductory tutorial to interfacing with data portals, python scripting, and containers. This provides value beyond the initial study by enabling broad audiences, using a wide variety of hardware and software, to generate novel data products and familiarize themselves with open data best practices. To build on this, all data generated from this study will also be accessible through DataOne through a creative commons open-source license (CC0.1.0).

2. Outreach and Citizen Science

Given the effects of wildland fire on local communities, recent interest in wildfire management has been high. This study seeks to build on this interest by providing educational resources and support to various schools throughout the region. Outreach will be done through seminars for teachers and community members, and field trips for high school students that focus on citizen science initiatives. An overview of the study's methodology and findings will be presented in the Flagstaff Festival of Science, and STEM-sation events on the Navajo Nation in a hands-on and interactive format. Data product materials and content that can be adopted into high school curriculums will also be made available through the public GitHub repository. Collaborations with local high schools (Flagstaff High, BASIS, and Chinle High school) to introduce students to citizen science campaigns are also planned.

The Community Snow Observation (CSO) citizen science campaign aims to better quantify snow depth variability in mountainous regions. Aside from providing validation of satellite and airborne snow measurements the methodology is easy to understand and implement, requiring only access to an app and a meter stick. Unfortunately, there is a large data gap around the greater Flagstaff area on this platform (Figure 10). This study will support 9 field trips for students and community members to address this gap. By collecting snow depth measurements once a year for 3 years, students from three local schools will gain a better understanding of climate science and provide useful data for the CSO campaign. In addition, these data can be integrated into the model developed in this proposal to provide more accurate temporal and spatial constraints on snow cover. The data collected can also be used for smaller scale student science projects.

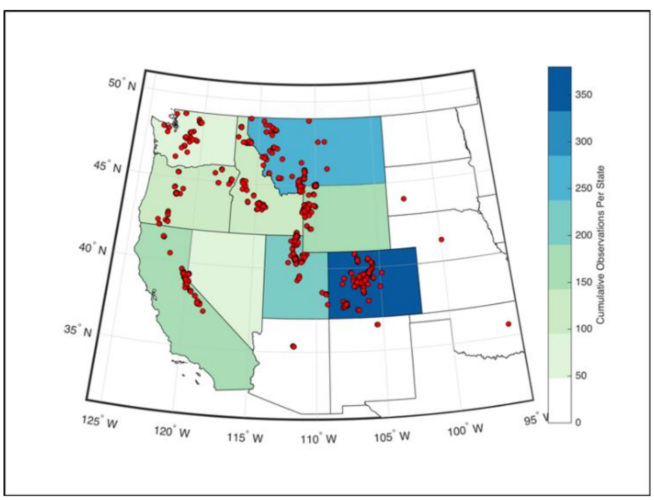

Figure 10 - A map of the western United States showing the extent of observations collected on the Community Snow Observation citizen science app. *This study would help address a data gap located in Northern Arizona through outreach and field trips with local high schools.* https://communitysnowobs.org/snow-data/ *accessed 12/8/2021*

To provide additional data and encourage community participation, this study will collaborate with Castrater and Epicollect5's crowdsourced wildfire activity dataset, Pyrogeography. SciStarter is a platform that facilitates opportunities for interested parties to easily contact and work with scientists. Pyrogeography is a wildfire activity dataset where users can use their smartphone to upload evidence of wildfires. The metadata generated from these data can better constrain fire ignition time, which, like the snow observations, will result in improved model accuracy and a more informed and educated public.

3. Federal Outreach

A primary objective for this study is to provide a tool that is useful for land management agencies to predict potential ignition at high resolution. While all data generated from this study is public, special effort will be made to familiarize federal employees with the methodology. Three 2-day workshops will be made open to local federal and state employees and hosted at NAU's Flagstaff campus. This workshop will cover basic Bayesian modeling, interpreting general linear models, a hands-on introduction to GitHub (version control), and an overview of remote sensing platforms. The goal of this workshop is to give federal employees the ability to run a version of this study on their area of management and understand the outputs. This workshop provides new tools and perspectives in a more personalized and relevant context.

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