UC SANTA BARBARA
Bren School of Environmental Science & Management

MASTER OF ENVIRONMENTAL DATA SCIENCE CAPSTONE PROJECTS: REQUEST FOR PROPOSALS 2024-2025

Remote Sensing of Brush Clearance to Enhance Wildfire Preparedness

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Objective: This project will develop remote sensing techniques to identify defensible space activities in order to facilitate prioritization of fire department effort and to evaluate the effectiveness of various wildfire preparedness communications.

Environmental Motivation:
As climate change increases the frequency and severity of wildfire (Williams, et al., 2019), governments and individuals must find ways to prepare and adapt. Unfortunately, both governments and people respond disproportionately after disasters have already created damages (Wibbenmeyer, et al., 2019), and they often do so with actions that do not produce long-term preparedness (Healy and Malhotra, 2009). Mounting evidence suggests that there is also inequity in responses to disasters (Anderson, et al. 2023). While waiting until disasters strike to act is not the most adaptive response, it may be possible to leverage nearby or salient disasters in other locations to spur more preparatory actions. Understanding how to harness salient disasters to generate individual and collective actions, particularly in vulnerable communities, could be an important strategy to achieve longer term resilience.

In this proposal, we focus specifically on maintaining defensible space as a key adaptive strategy that individuals can take to minimize risks to property from wildfire events. We choose this outcome for several reasons. First, this is a task that requires ongoing maintenance, so effort is needed over time to maintain defensible space. Second, with advances in remote sensing technology, it is possible to observe individual responses to prompts about defensible space in near real time. By creating a monthly model of compliance with defensible space requirements and recent brush clearance activity, it will be possible to target communication campaigns more effectively and to evaluate whether those campaigns spur action to maintain defensible space.

Data Science Need:
Measuring defensible space using on-ground audits is time and resource intensive, and it is not guaranteed to identify non-compliant properties. The Santa Barbara County Fire Department's (SBCFD) current approach to identify non-compliant properties is to conduct field audits once per year for every household in state-responsibility areas. They have no information on which households are likely to already be in compliance, which could allow them to save resources by targeting inspections more precisely. Additionally, SBCFD has a variety of outgoing messaging campaigns that aim to encourage maintenance of defensible space, but they have no data on which types or timings of campaigns prompt action or encourage households to remain in compliance. This project will provide fire departments across the West with a new approach to more accurately direct them to non-compliant properties for inspections and allow them to refine communication strategies based on empirical evaluations of outcomes.

This project will characterize what changes in brush cover are possible to detect in remotely sensed images and whether these changes correspond to on-ground compliance data collected by fire department audits over time. In particular, since we have access to changing compliance data

at the household level over several years, the project will develop an algorithm for predicting what features of images predict when households will change their compliance status over time and engage in brush clearing.

Deliverables:

Specific deliverables: The project will produce three deliverables. First, students will calculate the Normalized Difference Vegetation Index (NDVI) for all parcels in the county at a monthly level, using existing remote sensing data and the following formula and Landsat 8-9 data

$$NDVI = (Band\ 5 - Band\ 4) / (Band\ 5 + Band\ 4)$$

All of the data and code necessary for this part of the project are available online. They will use these data to identify changes in NDVI near structures that are likely to be produced due to brush clearing, such as those that are larger than background rates of change in areas that are not near structures and thus are unlikely to have defensible space action.

Second, students will develop a machine learning algorithm that builds upon the NDVI calculations. This methodology will combine compliance data at the parcel-month level from SBCFD, the NDVI calculated above, and remote sensing data from Planetscope to predict brush clearance activity and compliance for parcels across the county. It will enable researchers to get more frequent information about the compliance of homeowners with defensible space directives than the yearly audits currently used, which will enable better targeting of outreach and information. The MEDS team will produce a parcel-month assessment of defensible space compliance during the last five fire seasons. Students will work on this machine learning algorithm in consultation with the clients and other stakeholders. Related projects have already been developed using similar outcomes and techniques (Nasiri et al. 2023).

Third, the project will produce a visualization dashboard for prioritization of inspection effort by the SBCFD using the output of the machine learning model. This product will assist SBFCD to identify properties that need to take additional wildfire preparedness action and to focus their messaging efforts on those properties. It will be an interactive map displaying both remote sensing and compliance data, which clearly identifies properties that require further contact from the fire department. This map will be an interactive online web application for ease of access while the Fire Department is conducting inspections and outreach. This product is intended to be used by SBCFD after project completion by MEDS students.

Audience: The audience for the three deliverables is the faculty contacts and SBCFD.

Ongoing use: As mentioned in the client letter of support, the client will provide financial support to complete and maintain the dashboard showing the results of the data analysis.

Data Access and Availability:

There are two key datasets required to complete this project: existing defensible space audit data from the SBFCD and remote sensing data to build the machine learning model.

1. **Defensible space compliance data** has been provided by the SBCFD. This dataset consists of georeferenced information, at the individual parcel level, of the extent to which properties in the State Responsibility Area comply with the defensible space requirements per local regulations. In addition to the geographic coordinates, the data includes other attributes of the property. The SBCFD data will be provided to students in a Dropbox/UCSB Box folder at the beginning of the project. As this data includes parcel-level features, it has not been provided to the committee but the researchers already have the data and have done preliminary analysis to ensure that it is usable. Please feel free to contact Dr. Martinez to confirm.
2. **Remote sensing land use data:** The PlanetScape remote sensing data has the appropriate scale and timing to allow for remote sensing of clearing for defensible space. UCSB has an institutional subscription to this data. As an alternative, Google Earth Engine data are also usable and open access. (https://earth.esa.int/eogateway/missions/planetscope#data-section).
3. **Additional data:** It is possible that other remote sensing products (elevation, precipitation, temperature) will be used to augment the machine learning model:

- Climate data are available from UCAR/NSF: (https://climatedataguide.ucar.edu/climate-data/prism-high-resolution-spatial-climate-data-united-states-maxmin-temp-dewpoint).
- Digital elevation data are available from the USGS: (https://data.usgs.gov/datacatalog/data/USGS:77ae0551-c61e-4979-aedd-d797abdcde0e).
- Vegetation plot characterization, Santa Barbara County: https://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=2295

Project Requirements:

Approach: As this project aims to assess whether fire danger messages to individual property owners are more effective in times of high fire danger, the approach will use both the NDVI and machine learning to identify if/when property owners take actions to reduce wildfire risk on their parcels. Students will be (a) implementing the widely used NDVI and (b) adopting and adapting the existing use of remote sensing data within the wildfire space. For example, Bhandary and Muller (2009) use similar data to predict housing loss in wildfires. In addition, our colleague Dar Roberts is a remote sensing expert who will be helping us with the machine learning and remote sensing part of the project. There is an existing ML model that can be adopted for recognizing the degree of defensible space clearance, though there is certainly still room for application of the students' skills to improve the model.

Technical Requirements: Technical requirements for implementation are consistent with the Bren School's typical software and the project can use either R or Python for coding.

SUPPORTING MATERIALS:

a. **References.**

Anderson, Sarah E., Andrew J. Plantinga, and Matthew Wibbenmeyer. “Inequality in Agency Response: Evidence from Salient Wildfire Events.” *The Journal of Politics* 85.2 (2023): 625–39.

Bhandary, U., & Muller, B. (2009). Land use planning and wildfire risk mitigation: an analysis of wildfire-burned subdivisions using high-resolution remote sensing imagery and GIS data. *Journal of Environmental Planning and Management*, *52*(7), 939–955. https://doi.org/10.1080/09640560903181147

Healy, Andrew, and Neil Malhotra.“Myopic Voters and Natural Disaster Policy.” American Political Science Review 103.3 (2009): 387–406.

Nasiri, V., Hawryło, P., Janiec, P., & Socha, J. (2023). Comparing Object-Based and Pixel-Based Machine Learning Models for Tree-Cutting Detection with PlanetScope Satellite Images: Exploring Model Generalization. International Journal of Applied Earth Observation and Geoinformation, 125, 103555.

Wibbenmeyer, Matthew, Sarah E. Anderson, and Andrew J. Plantinga. “Salience and the Government Provision of Public Goods.” Economic Inquiry 57.3 (2019): 1547–67.

Williams, A. Park et al. “Observed Impacts of Anthropogenic Climate Change on Wildfire in California.” *Earth’s Future* 7.8 (2019): 892–910.

b. **Client letter of support.**

Please see attached.

c. **Budget and justification.**

No funding needs beyond the standard $250 are anticipated.

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Capstone Projects Selection Committee
Master of Environmental Data Science
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We are thrilled to support the capstone project entitled "Remote sensing of brush clearance to enhance wildfire preparedness". In the proposed project, MEDS students will use remote sensing data to identify households in the Santa Barbara area that need to take additional wildfire preparedness action. In particular, the students will explore remote sensing data available using the campus license for Planetscope. They will develop a protocol for identifying brush clearance and home retrofits, perhaps adopting a machine learning approach. The students will calibrate what is detectable, identify target households, and provide the tools to observe whether they undertake wildfire preparedness activities.

As such, the two main deliverables of the project are: (1) a machine learning algorithm that predicts compliance with defensible space based on remote sensing imagery; (2) a dashboard that presents the results of the model for Santa Barbara County. The client commits to provide the data necessary to train and test the machine learning model, including information about compliance with defensible space at the property level and access to repositories of satellite imagery, for example PlanetScope, among others. In terms of funding, the client will provide students with the funds necessary to support the release of the dashboard.

This project supports a larger research question regarding whether the timing of messaging regarding defensible space affects compliance. The Santa Barbara County Fire Department is interested in this and has been an active collaborator. Dr. Sarah Anderson and Dr. Mark Buntaine are collaborators on the project. We are open to arrangements for client and advising roles that would facilitate the project and we are all committed to mentoring the students and engaging with them on the substantive and technical aspects of this exciting work. Across these faculty, we have expertise in remote sensing, machine learning, and wildfire policy and management.

Sincerely

Sarah Anderson

Mark Buntaine

Cesar B. Martinez-Alvarez

Bren School of Environmental Science and Management and Department of Political Science