

# Assessing How Groundwater Availability Coincides with Wildfire Risks



## **Authors:**

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## **Client:**

The Nature Conservancy (TNC), California Chapter:

Dr. Kelly Easterday | [kelly.easterday@TNC.ORG](mailto:kelly.easterday@TNC.ORG)  
Lead Conservation Technology Manager at the Jack and Laura Dangermond Preserve

## **Faculty Advisor:**

Bren School of Environmental Science & Management:

TBD | [TBD](#)

## **OBJECTIVES:**

For this capstone project we will assess how groundwater availability coincides with wildfire risks. In particular, we will use freely available statewide geospatial datasets of groundwater dependent ecosystems, water resources, fire history and fire risk/hazard to assess three primary questions.

1. What is the fire history and modeled fire hazard for groundwater dependent ecosystems across the state?
2. How does known groundwater availability influence modeled fire risk/hazard?
3. How can we better integrate existing groundwater data to improve our interpretation of fire risk/fire hazard models?

In collaboration with Kelly Easterday from The Nature Conservancy (TNC), we aim to evaluate these questions and develop an interactive web map that integrates spatial data of groundwater and wildfire risk hazards to help expand and evaluate our understanding of the interactions between the two.

## **SIGNIFICANCE:**

Climatic events such as drought and wildfires have become more frequent and severe in California, causing structural and ecological damage. While most wildfires occur in the Eastern and Central US, due to climatic trends of vapor pressure deficit (VPD) and decreased fuel moisture (Dong et al., 2022, Rao et. al 2022) wildfires in California tend to be larger and more disastrous (Wildfire Statistics 2022). Moreover, prolonged periods of drought in California have been detrimental to the state's already scarce water resources. Specifically, groundwater is essential for many groundwater dependent ecosystems (GDEs) that highly depend on root capillary action for groundwater to survive (Taufik et al. 2017). Critically, while there has been data collected on wildfires, fire regimes, and groundwater, there has been little work directed at integrating groundwater data into wildfire risk models. This integration of data can be beneficial in fire related decisions, generating community wildfire protection plans, prescribed burn plans, and statewide wildfire risk assessments. Additionally, fire managers can integrate these results into their wildfire vulnerability and risk assessments for resource benefits and research ultimately, assisting firefighters and communities at risk at a state-wide level.

## **BACKGROUND:**

While there is an understanding on both freshwater resource management and wildfires, there is a critical need to integrate both to better understand their relationship to accurately quantify wildfire risk (Nolan et al., 2020). Currently, wildfire vulnerability and risk are assessed via field measurements and remotely sensed metrics of above ground processes, however it only accounts for a fraction of the processes driving wildfire risk and vulnerability. To improve our understanding of ecosystem resilience and wildfire risk and vulnerability, we must first understand the linkage between fresh groundwater resources and wildfires. While there is in depth knowledge on both fields, research and decision-making has mostly focused on post-fire effects on water quality and quantity (Williams et al., 2022) and not integrating freshwater, specifically groundwater, data into wildfire risk models, community protection plans, and state-wide wildfire risk assessments.

## EQUITY:

According to the State of California, disadvantaged communities are communities that suffer a combination of economic, health, and environmental burdens (Public Utilities Commission 2022). On average, rural communities that experience higher degrees of burning also had higher poverty rates, unemployment, and residents without college degrees (Masri et al. 2021). The data brings up an environmental justice issue in which disadvantaged rural families cannot afford to move out into urban areas and in return must experience the burden of intense wildfires and its health and socio-economic impacts (Masri et al. 2021). A primary goal of this project is to effectively use the data provided from The Nature Conservancy (TNC), CAL FIRE, and the State of California to evaluate the relationship between ecosystems reliant on groundwater and modeled fire risk across the state.

## DATA:

We outline relevant data sources below which we will standardize and harmonize to a common spatial scale for analysis:

**Table 1: List of freshwater data sources**

<b>Data Provided/ Integrated</b>	<b>Source</b>
Groundwater dependent ecosystems	TNC: <a href="https://kklausmeyer.users.earthengine.app/view/global-gde">https://kklausmeyer.users.earthengine.app/view/global-gde</a> <a href="https://www.scienceforconservation.org/products/natural-communities-groundwater-v2">https://www.scienceforconservation.org/products/natural-communities-groundwater-v2</a>
Groundwater Resource Hub	TNC & Partners: <a href="https://groundwaterresourcehub.org/">https://groundwaterresourcehub.org/</a>
Modeled natural stream flow	TNC: <a href="https://rivers.codefornature.org/#/home">https://rivers.codefornature.org/#/home</a>
Shallow Ground Water Estimation Tool	TNC: <a href="https://igde-work.earthengine.app/view/sage#trend-period=1985-2019;sig-thresh=0.05;lon=-119.84979193465415;lat=34.09964874851395;zoom=9;">https://igde-work.earthengine.app/view/sage#trend-period=1985-2019;sig-thresh=0.05;lon=-119.84979193465415;lat=34.09964874851395;zoom=9;</a>
Surface Water Sampling Locations	California State Water Resources Control Board: <a href="https://data.ca.gov/dataset/surface-water-sampling-location-information">https://data.ca.gov/dataset/surface-water-sampling-location-information</a>
California's Groundwater Update 2020 (GW level change / Depth to GW data)	California Department of Water Resources: <a href="https://data.cnra.ca.gov/dataset/calgw_update2020">https://data.cnra.ca.gov/dataset/calgw_update2020</a>

Periodic GW level measurements	California Department of Water Resources: <a href="https://data.ca.gov/dataset/periodic-groundwater-level-measurements">https://data.ca.gov/dataset/periodic-groundwater-level-measurements</a>
Seeps and Springs	NHD Seeps and Springs: <a href="https://gis.water.ca.gov/app/NCDatasetViewer/#">https://gis.water.ca.gov/app/NCDatasetViewer/#</a>
VPD and Plant Water Sensitivity	<a href="https://www.nature.com/articles/s41559-021-01654-2#data-availability">https://www.nature.com/articles/s41559-021-01654-2#data-availability</a>

**Table 2: List of fire data**

Data Provided/ Integrated	Source
Wildfire Risk to Communities: Spatial datasets of landscape-wide wildfire risk components for the United States	USDA: <a href="https://www.fs.usda.gov/rds/archive/Catalog/RDS-2020-0016">https://www.fs.usda.gov/rds/archive/Catalog/RDS-2020-0016</a>
All Wildfire Perimeters	CA Natural Resource Agency/ FRAP <a href="https://gis.data.cnra.ca.gov/datasets/CALFIRE-Forestry::california-fire-perimeters-all-1/explore?location=39.071768%2C-120.133468%2C6.82">https://gis.data.cnra.ca.gov/datasets/CALFIRE-Forestry::california-fire-perimeters-all-1/explore?location=39.071768%2C-120.133468%2C6.82</a> <a href="https://frap.fire.ca.gov/mapping/gis-data/">https://frap.fire.ca.gov/mapping/gis-data/</a>
Data-driven Forest monitoring system that maps the drivers of wildfire behavior across the state—including vegetation fuels, weather, topography & infrastructure— from space	Forest Observatory: <a href="https://github.com/forestobservatory/cfo-api/blob/master/README.md">https://github.com/forestobservatory/cfo-api/blob/master/README.md</a>
Wildfire Hazard	First Street- Risk Factor <a href="https://firststreet.org/research-lab/published-research/first-street-foundation-wildfire-methodology-simplified/">https://firststreet.org/research-lab/published-research/first-street-foundation-wildfire-methodology-simplified/</a> <a href="https://riskfactor.com/methodology/fire">https://riskfactor.com/methodology/fire</a>

**COMPUTATIONAL TOOLS & NEEDS:**

The computational needs and tools relevant to the project include R, Python, and cloud computing. R will be utilized in cleaning and potentially aggregating groundwater data. We will also utilize R to build our final Shiny App Dashboard. We will likely use both Python and R tools to integrate freshwater data with existing fire data. Due to large data storage needs we will use the Bren School of Environmental Science & Management’s Taylor server to store our data and create a streamline method of collaboration. Use of Earth Engine to retrieve and or analyze gridded data products.

## **POSSIBLE APPROACHES:**

Our approach will rely on the utilization of existing wildfire risk assessments (e.g., LANDFIRE (U.S. Department of Agriculture & U.S. Department of Interior, 2013), a database of burn perimeters, and mapped groundwater dependent ecosystems (GDEs) to conduct several spatial analyses and derivative data products. More specifically we will standardize and aggregate existing geospatial data layers to a common grid (i.e. 30x30m pixels -- see example :<https://towardsdatascience.com/ai-geospatial-wildfire-risk-prediction-8c6b1d415eb4> ). Using this common grid, we will summarize and aggregate variables to better understand fire history, severity, and risk on landscapes identified as groundwater dependent ecosystems. We will aggregate statistics including current fire risk, TSLF, total fires, avg. fire severity for each pixel and overlay these with identified GDEs. We will generate summary statistics and charts to represent the distribution of these variables across all GDEs and compare these to non-GDE areas. We will use summary and comparative spatial statistics to evaluate the relationship of fire on GDEs and non-GDEs, thereby gaining an understanding where current fire hazard/risk models are falling short. Further, we will aggregate these analyses into a shiny dashboard where the viewer can evaluate the fire history of GDEs and contextually evaluate the overlap between existing fire hazard/risk models and mapped freshwater resources across the State.

## **DELIVERABLES:**

The client expects that we will produce a fire risk data product for California that integrates existing surface and groundwater data. The final product will be hosted on an RShiny App Dashboard.

**Objective 1:** To compile and aggregate fire history and modeled fire hazards for groundwater dependent ecosystems

### Deliverables:

- Create a standard grid for California which all geospatial data products will be aggregated to, create a reproducible workflow (i.e., script) to standardize data to this grid.
- Raster/GIS layers of a gridded time since the last burn (TSLF) data product for California.

**Objective 2:** Characterize and determine if known presence of groundwater availability is represented as high or low risk in current models of fire hazard.

### Deliverables:

- A series of charts and analysis that assess fire history, severity, and quantified risk for mapped groundwater dependent ecosystems (GDEs) and analyze the results in comparison to non-GDEs
- A written description of the sources, methods of comparison, and quantification of the results.

- Publication of all datasets, code, metadata, documentation into an open repository (i.e. <https://dangermondpreserve.dataone.org/>) tagged with keyword Dangermond Preserve.

**Objective 3:** Aggregate datasets compiled and created in this project into a single user interface to allow for viewing of metadata, data download, and viewing of the layers and statistics calculated in this project. As time permits, an aggregated presentation of results within the application interface would be ideal

Deliverables:

- RShiny (or similar) application or dashboard that aggregates freshwater data sources and fire risk data sources as specified in the table and in the deliverables.

**AUDIENCE:**

The primary audience for our deliverables will be our client, Kelly Easterday, with the Jack and Laura Dangermond Preserve, along with The Nature Conservancy (TNC). Additionally, anyone else interested in the interactions between groundwater availability and wildfire hazards.

## Supporting Materials

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### CITATIONS:

- Disadvantaged communities*. California Public Utilities Commission.  
<https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/disadvantaged-communities#:~:text=Disadvantaged%20communities%20refers%20to%20the,of%20asthma%20and%20heart%20disease>
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Wildfire in Forests Adapted to Frequent Fire. *BioScience*, 68(2), 77–88.  
<https://doi.org/10.1093/BIOSCI/BIX146>

Taufik, M., Torfs, P. J. J. F., Uijlenhoet, R., Jones, P. D., Murdiyarso, D., & van Lanen, H. A. J. (2017). Amplification of wildfire areas burnt by hydrological drought in the humid tropics. *Nature Climate Change* 2017 7:6, 7(6), 428–431.  
<https://doi.org/10.1038/nclimate3280>

Williams, A. P., Livneh, B., Mckinnon, K. A., Hansen, W. D., Mankin, J. S., Cook, B. I., Smerdon, J. E., Varuolo-Clarke, A. M., Bjarke, N. R., Juang, C. S., Lettenmaier, D. P., & Rinaldo, A. (2022). Growing impact of wildfire on western US water supply. *PNAS*. <https://doi.org/10.1073/pnas.2114069119/-/DCSupplemental>

*Wildfire Statistics - Federation of American scientists*. (n.d.). Retrieved October 8, 2022, from <https://sgp.fas.org/crs/misc/IF10244.pdf>

## **BUDGET & JUSTIFICATION:**

Each group will receive \$250 from the Bren School to cover the group's basic operations and printing. We do not anticipate needing funds for the proposed project.



## Client Letter of Support

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October 10, 2022



To: Group Project Committee  
Bren School of Environmental Science and Management  
Master of Environmental Data Science  
Bren Hall, 2400 University of California, Santa Barbara, CA 93117

From:  
Kelly Easterday, Ph.D.  
Director of Conservation Technology, Dangermond Preserve  
The Nature Conservancy  
[kelly.easterday@tnc.org](mailto:kelly.easterday@tnc.org)

On behalf of The Nature Conservancy (TNC), I am pleased to endorse the proposed capstone proposal for the Dangermond Preserve. The Conservancy is excited to utilize the interdisciplinary skills of MEDS students and faculty to assess fire in groundwater dependent ecosystems. This project is integral in developing long term strategies and baseline information to manage this dynamic place and region. We hope that this proposal will allow Bren students to work to explore and solve environmental issues at this unique place.

This letter serves to highlight The Nature Conservancy's support for the Bren MEDS Group Project and for funding support for data processing or software essential to the project.

We look forward to your favorable consideration of our proposal.

Sincerely,

A handwritten signature in black ink, appearing to read "KJE".

Kelly Easterday, Ph.D.  
Director of Conservation Technology, Dangermond Preserve  
The Nature Conservancy of California