

Proposal for Collaboration Between Tam Air Club, UCSF and CAL FIRE

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Deep Learning-Driven Spatiotemporal Wildfire Risk Modeling and Field-Based Aerial Data Collection for CAL Fire in California

1. Overview

This proposal outlines a collaborative research, field work exposure/testing and educational initiative between **Tam Air Club**, a student-led STEM, aeronautic and environmental technology club from Tamalpais High School in Mill Valley, California, and **CAL FIRE**, the state's leading fire protection and resource management agency.

The partnership will bridge **data science, field observation/testing, data acquisition, and geospatial technology** to enhance the understanding and prediction of wildfire risk in California. By combining historical datasets, coding for data analysis/visualization, deep learning methods, and drone testing in the field, the collaboration aims to develop **season-dependent geospatial wildfire risk maps** while offering students real-world experience in applied environmental science and artificial intelligence.

2. Background and Rationale

California's wildfire landscape has changed dramatically over the past 50 years, driven by climate change, increasing drought frequency, and expanding urban-wildland interfaces. Traditional risk mapping tools, though vital, often rely on static models that approximated rule-based maps that may not fully capture the complexity of evolving environmental and temporal factors such as urban developments, vegetation dryness, weather variability, and fuel accumulation.

To complement these approaches, Tam Air Club and CAL FIRE propose to use **deep learning** algorithms to generate season-dependent fire risk predictions. The project will:

- Leverage **>50 years of wildfire and environmental data** curated by CAL FIRE and public agencies.
- Explore important California datasets with python coding/plotting/visualization.

- Apply **convolutional neural networks (CNNs/LSTM)** and other deep learning algorithms to explore/learn spatial–temporal fire patterns in California.
- Acquire **field data and monitoring** using the Tam Air 3D printed camera equipped fixed wing unmanned air vehicles (UAVs/FPV) and a commercial DJI quadcopter during CAL FIRE–supervised controlled burns.

This 12-month initiative integrates modern AI-driven methods with hands-on environmental observation, reinforcing CAL FIRE’s mission of protecting California’s resources and communities while fostering the next generation of environmental scientists.

3. Project Objectives

1. **Data exploration and basic Python coding**
The student will start by analyzing open-source databases that CAL fire has curated over the years. These will include recorded fire perimeters, vegetation maps, topography, census map, and weather.
2. **Research and Innovation**
Prepare the data inputs for risk map development. Develop a deep learning model capable of predicting wildfire risk with and without seasonal variability across California.
3. **Education and Training**
Expose high school students to real-world applications of data science, coding, AI, GIS, and environmental data science.
4. **Field Data Acquisition**
Capture aerial and thermal data during CAL FIRE–supervised controlled burns to support future model optimization on the regrowth of vegetation and fire fuel.
5. **Community Impact**
Produce visualizations and outreach materials demonstrating data-driven wildfire prevention. These will be shared only with CAL FIRE given the sensitive nature of the data. Next steps could involve a joint publication.

Partner	Primary Role
Tam Air Club	Student research team responsible for reading background material, basic python coding (data exploration and deep learning optimization), GIS exploration, bi-weekly-updates to the team via emails, drone build and flying operations in the field.
UCSF	Group of research professors to assist/guide in the code development and deep learning optimization
CAL FIRE	Provides guidance/mentorship for the students, access to historical datasets, review of plots, coordination/communications of field volunteering with CAL FIRE team, risk model review/guidance, and expert oversight of controlled burns.

5. Work Plan

Phase 1: Foundational Learning and Data Exploration (Months 1–2)

- Students to read relevant published scientific paper/manuscripts/website/books on the history of wildfire and risk mapping in California. Students learn fundamentals of California wildfire science, fire behavior, weather. This includes the CAL FIRE website.
- Learn visualization and analysis software such as QGIS and ArcGIS.
- Explore CAL FIRE's Fire and Resource Assessment Program (FRAP) and historical fire perimeter datasets and vegetation.
- Learn about other open-source dataset and website such as NASA topography and NOAA weather.
- Conduct exploratory data analysis using Python and QGIS (data types, GeoPandas, dataframes, numpy, matplotlib, folium).
- Use Chat GPT and Claude AI coding to accelerate code development.

Phase 2: Data Acquisition and Preparation (Months 3–4)

- Aggregate 30 years of relevant data in California. We will need help from CAL FIRE to confirm we are using the best possible datasets.
 - Fire perimeters (dates, agency, fire location and surface area)
 - Vegetation cover/types
 - Topography
 - Census data per district
 - Meteorological data (dates/times, wind, temperature, humidity, vapor pressure deficit, precipitation)
 - Distance to roads (per Shu Li scientific reports)
- Normalize spatial and temporal scales to prepare for machine learning input.
- Generate rasterized, time-indexed datasets suitable for CNN training.

Phase 3: Deep Learning Model Development (Months 5–8)

- Final review and preparation of all data inputs for a yearlong baseline model
- Design and train **CNN and CNN-LSTM hybrid models** for geospatial fire risk prediction without any time/season dependence in the year.
- Introduce temporal dependencies to produce **season-dependent risk maps**.
- Optimize model parameters using historical validation datasets.

Phase 4: Field Operations and Controlled Burn Data Collection (Months 3–9)

(conducted in parallel with Phase 2-3 under CAL FIRE supervision)

- Participate in selected CAL FIRE controlled burns.
- Use **DJI and FPV drones** equipped with RGB and thermal cameras to record aerial footage before, during, and after burns.

- Generate **Ortho mosaic and 3D terrain models** from pre- and post-burn imagery.
- Collect environmental data (temperature, humidity, vegetation density) to ground-truth model predictions.

Phase 5: Model Validation and Integration (Months 9–10)

- Compare CNN-generated risk maps to official CAL FIRE risk maps (baseline + seasonal).
- Evaluate accuracy using AUC, IoU, and precision–recall metrics.
- Incorporate drone-acquired field data to refine predictions and validate vegetation burn response.

Phase 6: Visualization, Reporting, and Outreach (Months 11–12)

- Develop an **interactive GIS dashboard** showing dynamic seasonal fire risk maps.
- Prepare an **analytical report** summarizing methodology, findings, and recommendations.
- Create **educational media** (videos, infographics, presentations) demonstrating the project's impact.
- Present results jointly with CAL FIRE at a community, academic, or environmental forum.

6. Expected Deliverables

1. **30-Year integrated wildfire dataset**
Cleaned, georeferenced datasets combining CAL FIRE, NASA, USGS, and NOAA sources.
2. **Programming code/scripts/notebooks, plots, deep learning models and risk maps**
CNN-generated geospatial fire risk maps varying by season and region.
3. **Aerial imagery and field data repository**
High-resolution drone imagery, orthomosaic maps, and pre-posy-prescribed-burn activities.
4. **Interactive dashboard (optional)**
Web-based interface for visualizing predicted and historical fire risks on the California map.
5. **Final project report and presentation**
Comprehensive documentation of methodology, validation results, and outreach outcomes.
6. **Educational materials**
Student-created videos and exhibits highlighting drone use in wildfire management.

7. Anticipated Impact

- **Scientific advancement:**
Demonstrate how modern AI and drone technology can complement/augment traditional fire management models.
- **Education and workforce development:**
Provide a group of high school students with mentorship and practical experience in data-driven environmental research. Real-life experience of data acquisition in the field of prescribed burns.
- **Operational benefit to CAL FIRE:**
Offer prototype methods and datasets that could inform future risk modeling and fire planning.
- **Public awareness:**
Showcase youth-driven innovation addressing real environmental challenges in California.

Summary

Through this collaboration, **Tam Air Club and CAL FIRE** will jointly explore the intersection of **technology, science, and environmental stewardship**. Students will gain hands-on exposure to real-world wildfire science while contributing valuable insights into predictive modeling and fire prevention strategies. Together, the project aims to build a foundation for future research and inspire the next generation of scientists working to protect California's landscapes.