





California Board of Forestry and Fire Protection Effectiveness Monitoring Committee (Project EMC -2023-002)



In Memory of Ryan Tompkins

Ryan was slated to serve as co-PI on this project, bringing his deep expertise in forestry, fire, and community engagement. Though he passed before he could take part, his legacy of bridging science and practice continues to guide this work. We honor his contributions to California forestry and hope this project reflects the spirit of knowledge-sharing and stewardship he championed.

INIROLCIION



Background

Lakes, rivers, and riparian zones in California's forests support biodiversity, provide critical water resources, and offer recreation opportunities. Recent high-severity wildfires, especially in the Northern Sierra Nevada, have severely impacted these systems.

Problem Statement

Wildfires have disrupted California's riparian and aquatic networks. WLPZ regulations were designed to protect anadromous fish habitat. However, evaluating how these protections influence fire resilience and vegetation recovery is critical to aligning forest and water protections with evolving wildfire risk.





Objectives

- **Evaluate** fire severity and vegetation recovery in Watercourse and Lake Protection Zones (WLPZs).
- *Compare*outcomes across WLPZ classes and timber harvest regimes.
- *Identify* how management practices near streams influence resilience



Motivation and Core Questions





Motivation

- Riparian zones are critical for water supply, biodiversity, and habitat
- WLPZ rules were designed for fish and water quality, not wildfire outcomes
- Severe wildfires are increasingly altering these systems

Core Questions

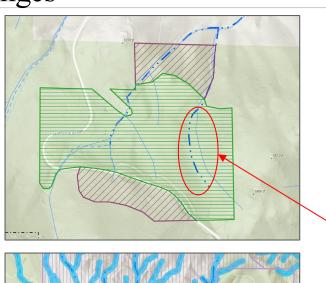
- Do WLPZ regulations influence fire severity and recovery?
- How do timber harvest regimes interact with WLPZ protections?
- What improvements could support both ecological and regulatory resilience?

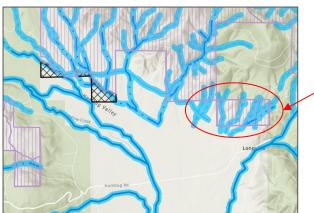
Methods: Data and Challenges



Data

- Hydrology: TA83, CA-NHD
- Fire Data: MTBS, RAVG
- Fire Hazard Models:
 Pyrologix (CFL, FTP, Burn Probability)
- Vegetation Monitoring: PFVMS, NDVI / LandTrendr
- Ownership / Management: CAL FIRE FRAP, TA83 THP records



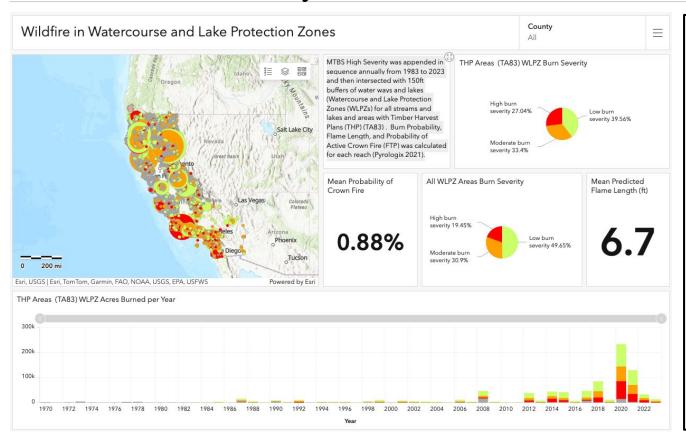


Challenges

- No comprehensive, statewide WLPZ dataset
- TA83: detailed but limited to THP streams
- CA-NHD: complete statewide coverage but lacks stream class detail
- Datasets misaligned cannot be merged
- Adding buffers presents tricky layering challenges
- Hydro and Management datasets not consolidated

Methods: Statewide Analysis



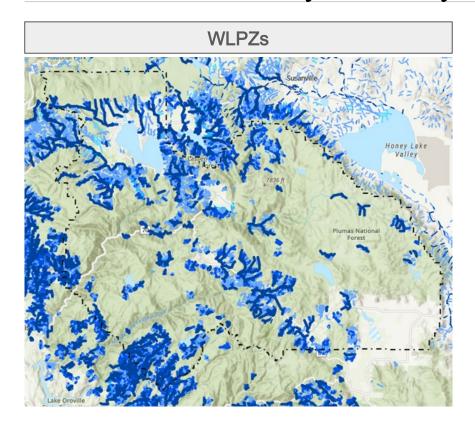


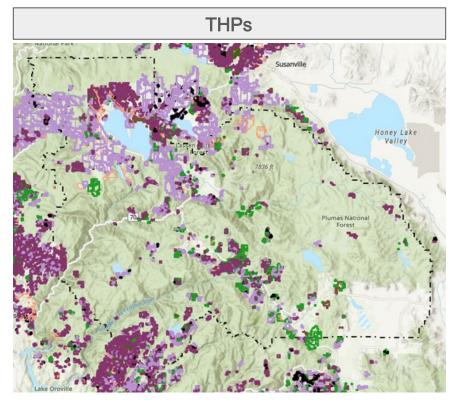
- Used CA-NHD dataset (streams + lakes, statewide coverage) and,
- Used TA83 hydro dataset (streams + lakes, statewide coverage)
- Applied 150 ft WLPZ buffers
- Overlaid with MTBS (1984–2023), RAVG (2012–2023), and Pyrologix hazard metrics
- Results in interactive statewide dashboard

https://gsal.sig-gis.com/portal/apps/dashboards/75b9d9d44911440c871c61ba011cbab6

Methods: Plumas County Case Study

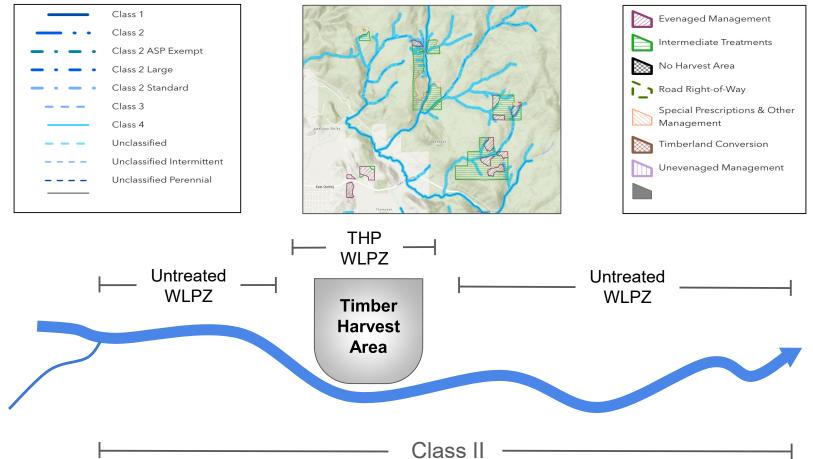






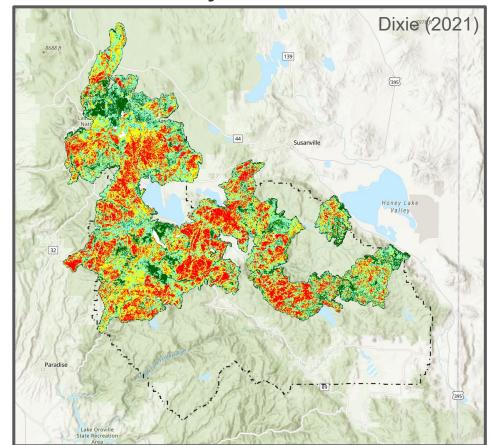
Methods: Stream Segmentation

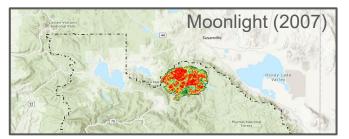


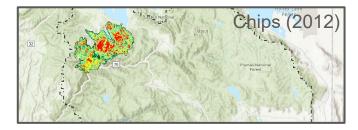


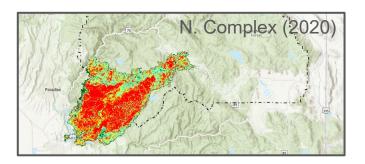
Methods: 4 Major Fires







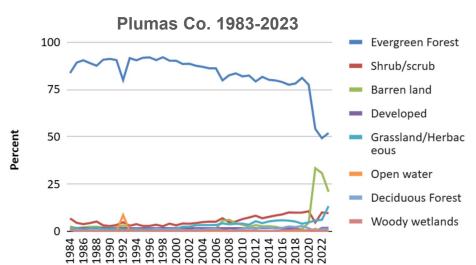


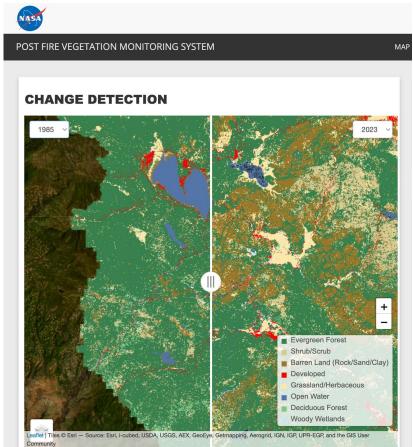


Methods: PFVMS



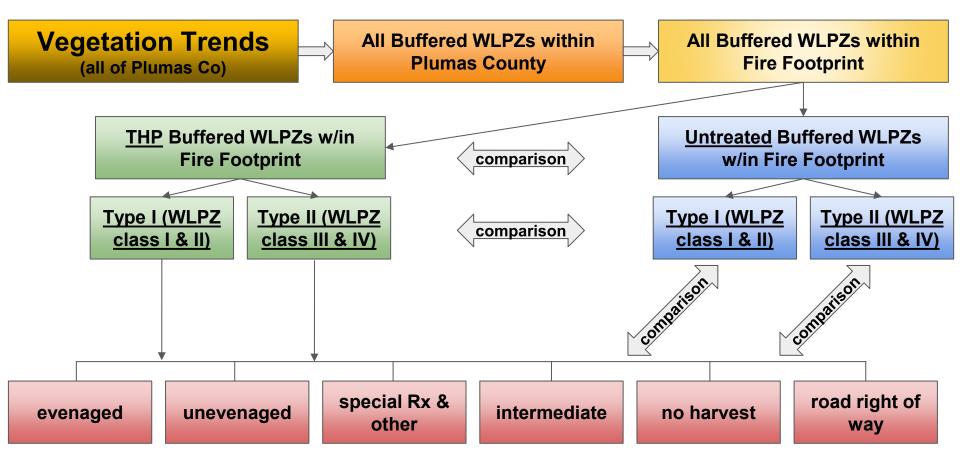
- Google Earth Engine
- Landsat data 1984-Present
- 30m resolution





Methods: Comparative Analysis





Statewide Fire Hstory and Current Hazards



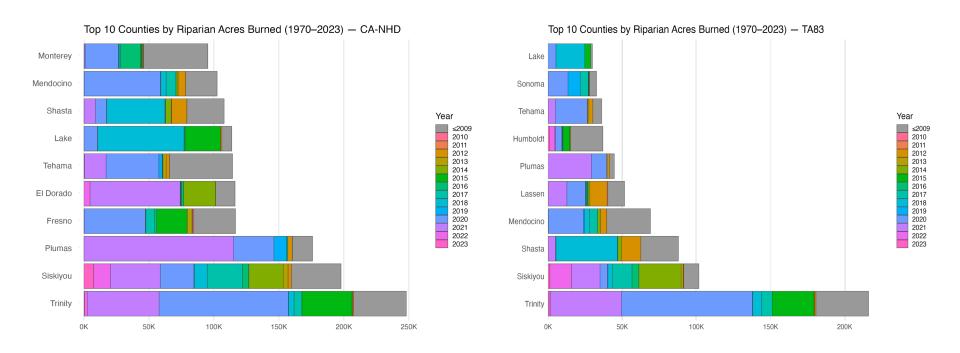


Big Canyon—Placerville, El Dorado County

Silver Fork of the American River – El Dorado County, Caldor Fire

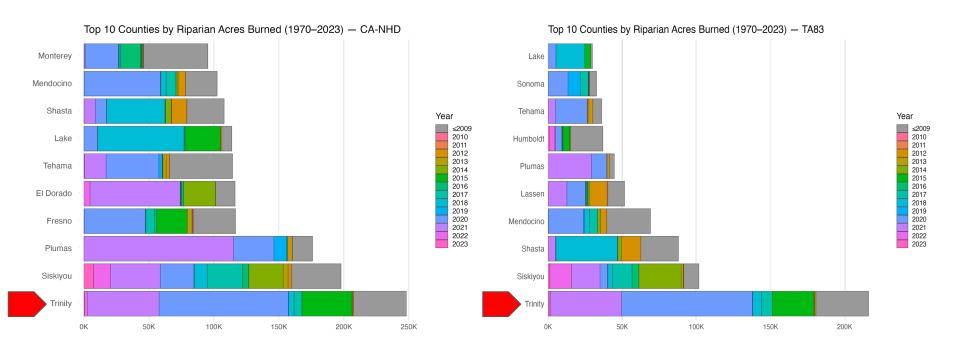
Results: Statewide Fire Hstory





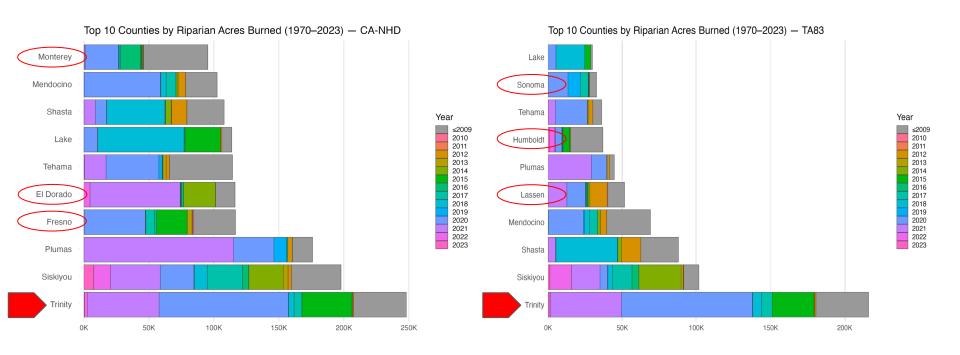
Results: Statewide Fire Hstory





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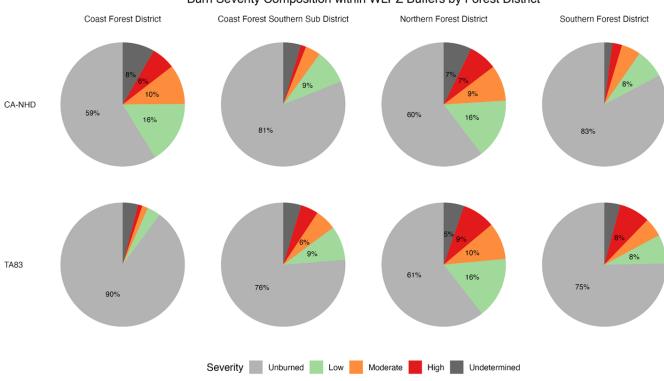




Results: Statewide Severity Patterns



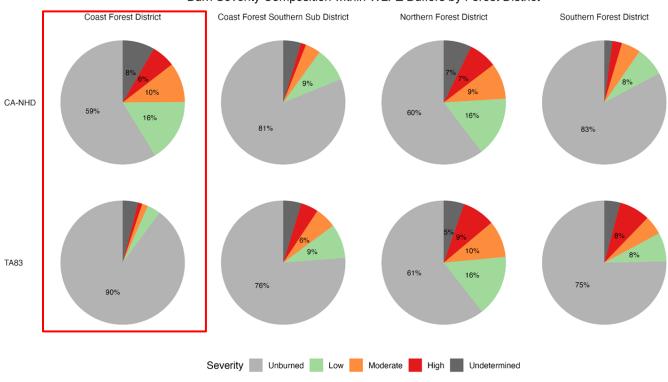




Results: Statewide Severity Patterns

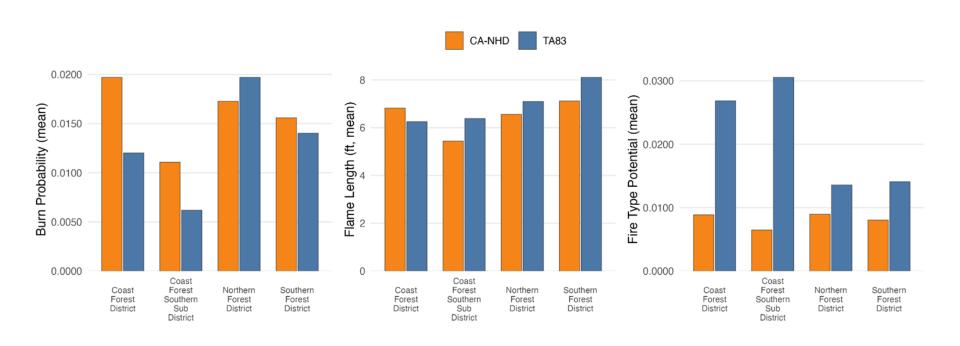






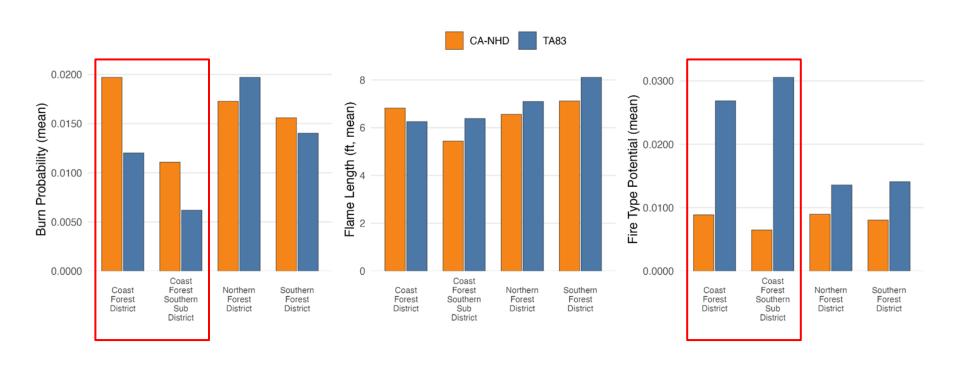
Results: Statewide Hazard Modeling





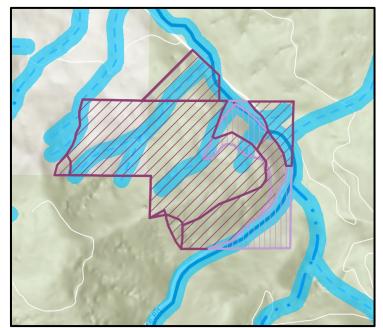
Results: Statewide Hazard Modeling



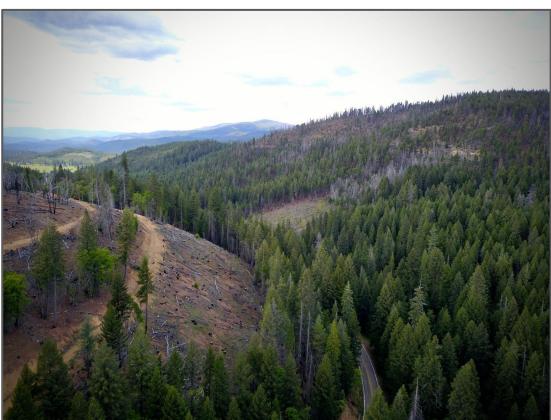


Plumas County Case Study





Thompson Creek Class I WLPZ, N. Complex Fire (2020), Unevenaged and Evenaged Management



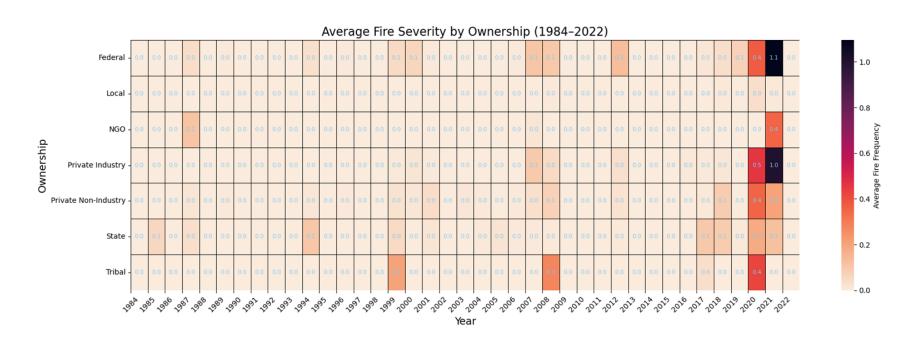
Result: Sample Size



| Fire | Total WLPZ | THP WLPZ | Control WLPZ | WLPZ Evenaged (ac.) | WLPZ Unevenaged (ac.) | WLPZ Special Rx & Other (ac.) | WLPZ Intermediate (ac.) | WLPZ No Harvest Area (ac.) | WLPZ Road Right of Way (ac.) | WLPZ Timberland Con. (ac.) |
|-------------------|---------------|-------------|-----------------|---------------------------|-----------------------------|-------------------------------------|-------------------------------|----------------------------------|------------------------------------|----------------------------------|
| Moonlight (2007) | 2484.8 | 702.8 | 1782.0 | 98.6 | 575.1 | 2.1 | 27.0 | 0.0 | 0.0 | 0.0 |
| Chips (2012) | 2226.5 | 637.2 | 1589.3 | 88.6 | 403.5 | 0.0 | 143.2 | 1.9 | 0.0 | 0.0 |
| N. Complex (2020) | 4891.1 | 731.8 | 4159.4 | 473.3 | 209.6 | 0.0 | 46.1 | 1.9 | 0.9 | 0.0 |
| Dixie (2021) | 23905.0 | 12285.3 | 11619.7 | 1057.8 | 9384.3 | 1098.6 | 569.1 | 172.7 | 2.9 | 0.0 |
| Total | 33507.4 | 14357.1 | 19150.3 | 1718.3 | 10572.4 | 1100.7 | 785.3 | 176.6 | 3.9 | 0.0 |

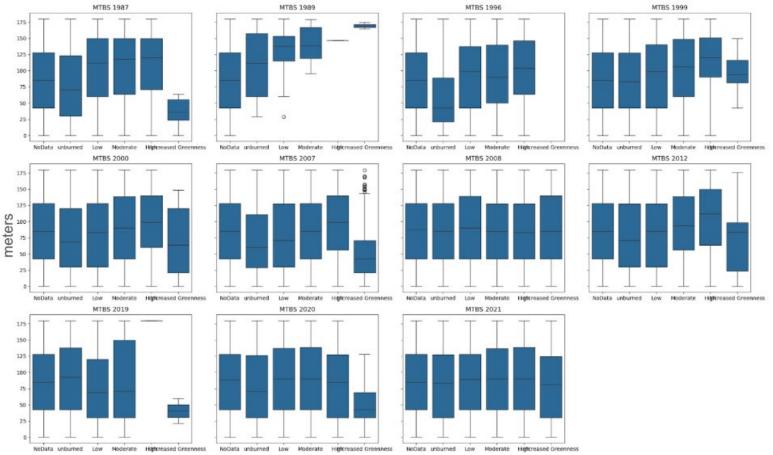
Results: Fire Frequency





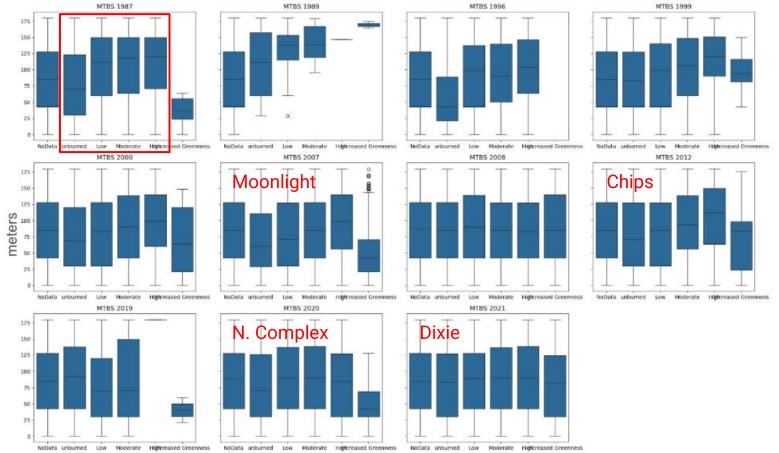
Results: Distance Analysis – Class I&I





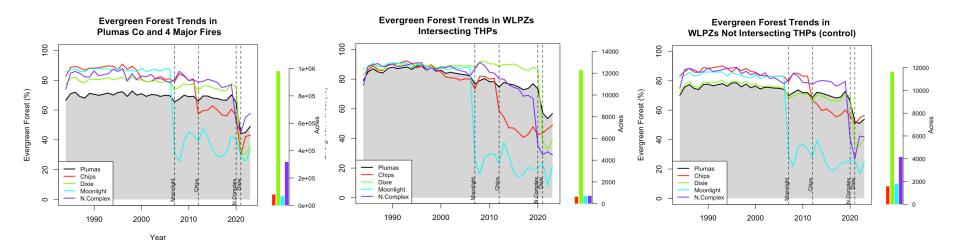
Results: Distance Analysis – Class I&I





Results: Vegetation Trends in WPZs by County and Fire





| | Pre-Fire % | Fire-Year % | Minimum % | Final % | Years Since Fire | AUC % | Recovery Index | BRR | BRR per Year |
|-----------------|------------|-------------|-----------|---------|---------------------|-------|-------------------|-----|-----------------|
| All | 66.6 | - | 44.2 | 49.0 | - | 66.2 | 0.2 | - | - |
| Treated_WLPZs | 79.1 | - | 53.4 | 56.7 | - | 78.4 | 0.1 | - | - |
| Untreated_WLPZs | 70.1 | - | 51.0 | 53.9 | - | 70.8 | 0.2 | - | - |

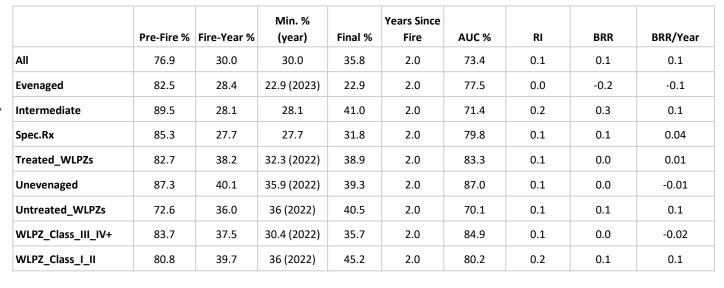
Results: Dixie Fire Vegetation Trends



| | Pre-Fire % | Fire-Year % | Min. % (year) | Final % | Years Since Fire | AUC % | RI | BRR | BRR/Year |
|--------------------|------------|-------------|------------------|---------|---------------------|-------|-----|------|----------|
| All | 76.9 | 30.0 | 30.0 | 35.8 | 2.0 | 73.4 | 0.1 | 0.1 | 0.1 |
| Evenaged | 82.5 | 28.4 | 22.9 (2023) | 22.9 | 2.0 | 77.5 | 0.0 | -0.2 | -0.1 |
| Intermediate | 89.5 | 28.1 | 28.1 | 41.0 | 2.0 | 71.4 | 0.2 | 0.3 | 0.1 |
| Spec.Rx | 85.3 | 27.7 | 27.7 | 31.8 | 2.0 | 79.8 | 0.1 | 0.1 | 0.04 |
| Treated_WLPZs | 82.7 | 38.2 | 32.3 (2022) | 38.9 | 2.0 | 83.3 | 0.1 | 0.0 | 0.01 |
| Unevenaged | 87.3 | 40.1 | 35.9 (2022) | 39.3 | 2.0 | 87.0 | 0.1 | 0.0 | -0.01 |
| Untreated_WLPZs | 72.6 | 36.0 | 36 (2022) | 40.5 | 2.0 | 70.1 | 0.1 | 0.1 | 0.1 |
| WLPZ_Class_III_IV+ | 83.7 | 37.5 | 30.4 (2022) | 35.7 | 2.0 | 84.9 | 0.1 | 0.0 | -0.02 |
| WLPZ_Class_I_II | 80.8 | 39.7 | 36 (2022) | 45.2 | 2.0 | 80.2 | 0.2 | 0.1 | 0.1 |

Results: Dixie Fire Vegetation Trends

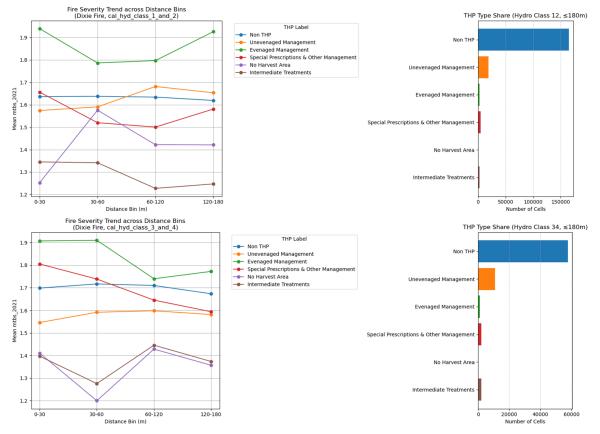






Results: Dixie Fire Burn Severity Distance Analysis





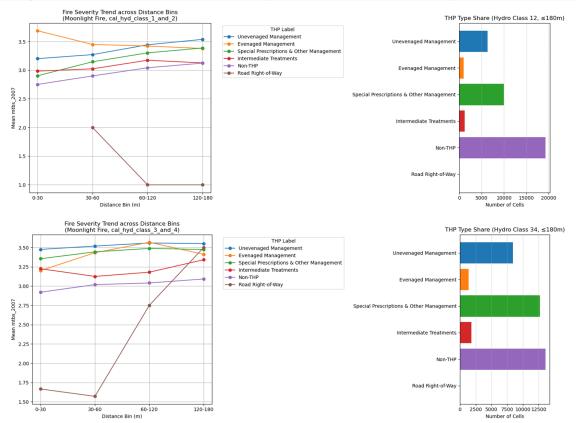
Results: Moonlight Fire Vegetation Trends



| | Pre-Fire % | Fire-Year % | Min. % (year) | Final % | Years Since Fire | AUC % | RI | BRR | BRR/Year |
|--------------------|------------|-------------|---------------|---------|---------------------|-------|-----|-------|----------|
| All | 85.7 | 31.6 | 25.5 (2008) | 33.1 | 16.0 | 63.7 | 0.1 | 0.03 | 0.002 |
| Evenaged | 71.6 | 15.7 | 8.5 (2008) | 12.1 | 16.0 | 53.8 | 0.1 | -0.1 | -0.003 |
| Intermediate | 91.8 | 47.8 | 14 (2021) | 29.4 | 16.0 | 65.7 | 0.2 | -0.4 | -0.025 |
| Spec.Rx | 92.8 | 25.4 | 11.5 (2022) | 31.5 | 16.0 | 65.2 | 0.3 | 0.1 | 0.006 |
| Treated_WLPZs | 86.6 | 26.1 | 8.4 (2022) | 21.5 | 16.0 | 59.0 | 0.2 | -0.1 | -0.005 |
| Unevenaged | 95.8 | 23.0 | 8.6 (2008) | 33.5 | 16.0 | 63.4 | 0.3 | 0.1 | 0.009 |
| Untreated_WLPZs | 82.3 | 28.5 | 16.9 (2022) | 25.1 | 16.0 | 58.4 | 0.1 | -0.1 | -0.004 |
| WLPZ_Class_III_IV+ | 90.2 | 23.8 | 6.1 (2022) | 22.1 | 16.0 | 60.7 | 0.2 | -0.03 | -0.002 |
| WLPZ_Class_I_II | 82.6 | 28.6 | 11.1 (2022) | 20.9 | 16.0 | 57.0 | 0.1 | -0.1 | -0.009 |

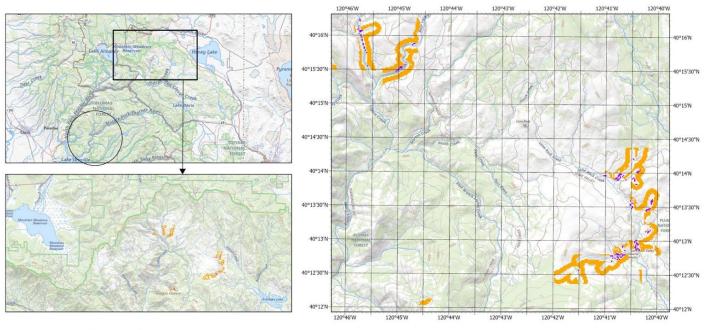
Results: Monlight Fire Burn Severity Distance Analysis





Boots on the Ground, Eyes in the Sky





Legend

Moon_high_60_120m_unevenaged.tif Value

Moon_low_0_60m_unevenaged.tif Value

This map highlights the Unevenaged management landscape Moonlight fire. The purple color is the 0-60m from class 1&2 and burned with low severity. The orange cells burned with higher severity and are further away from class 1&2.

Boots on the Ground, Eyes in the Sky



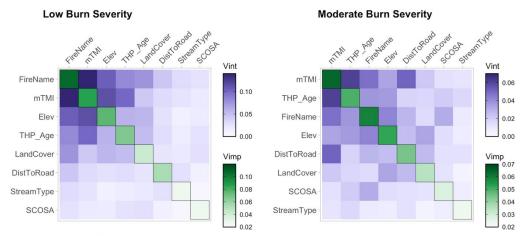




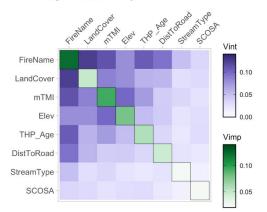


Statistical Analysis: Variable Importance & Interaction





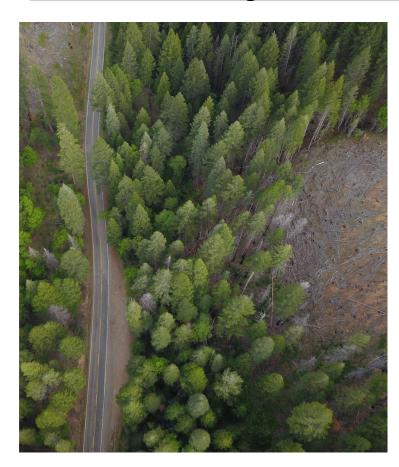
High Burn Severity

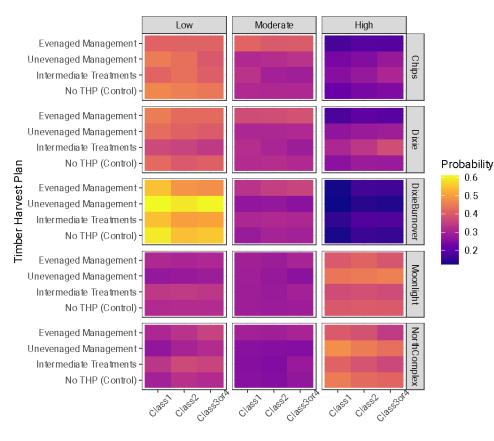




Results: Partial Dependence Probability



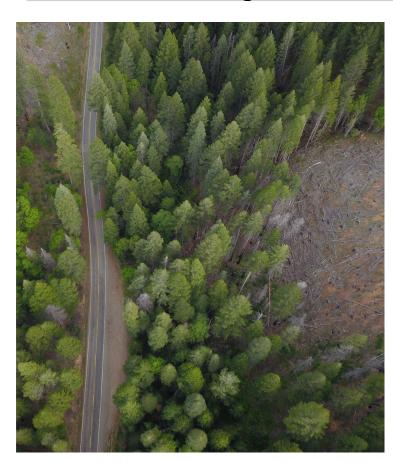


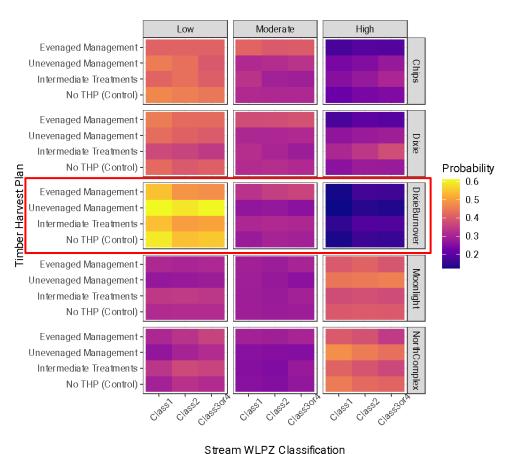


Stream WLPZ Classification

Results: Partial Dependence Probability







Discussion





Burn severity patterns

- Class I & II WLPZs show a consistent buffering effect severity is lower at the channel and increases with distance upslope.
- Class III & IV WLPZs don't show the same clear signal; outcomes are scattered.



Timber harvest history

- Treatments do influence outcomes, but the effect depends on fire context: intermediate treatments moderate severity in highintensity fires, while uneven aged and control areas perform better in lower-intensity fires.
- Treated WLPZs often show better outcomes than untreated, suggesting active forest management matters.



Physical context of WLPZs

- Streams sit at low points in the landscape, where cooler air, higher humidity, and fuel moisture create natural insulation.
- Roads along riparian corridors complicate the signal they act as fire breaks and provide access for crews, but they also
 confound attribution to WLPZ effects.



Limitations and noise

- Sample sizes are uneven across treatments and fire events.
- Results are messy, with multiple interacting drivers (climate, topography, fire event, management).

Recommendations





Reconsider WLPZ rules with fire in mind

- Current rules protect streams for water/fish/high canopy values but don't necessarily support wildfire resilience.
- Evidence suggests benefits from intermediate thinning and uneven-aged management in riparian areas when timed appropriately.



Layered buffer concept (site/timing specific)

- Allow graduated treatments: e.g., thinning in outer riparian buffer zones, with increasing restriction closer to the stream.
- This could maintain ecological protections while reducing severe fire risk.



Restocking standards

How post-fire areas are replanted will heavily shape future fire risk. Dense, even-aged plantations can increase hazard; more heterogeneous, lower-density restocking may improve resilience.



Incorporate fire and fuels management

Evidence from Dixie burnover areas shows that prior lower severity fire dramatically lowers high-severity risk. Prescribed fire or managed wildfire, combined with elimination of residual slash, log decks, and fuel concentrations after harvest, could strengthen WLPZ resilience.



Develop a Statewide Classified WLPZ dataset

 Develop a unified, classified (Class I–IV) layer for streams and lakes with consistent buffers, reconciled across TA83 and CA-NHD, to enable reproducible statewide analysis and support policy decisions

Future Research





North Coast anomalies

Particularly in Trinity County, large riparian acreages are within fire scars, but most are unburned or low severity. Why? Data, fuels, suppression tactics, timing of burning (night/day), or geography? Needs closer study.



Management vs. no management

Treated riparian zones often show better outcomes, but we need more systematic comparison to controls.



Roads and edge effects

Roads are nearly ubiquitous along streams; future analysis should explicitly model their role as barriers to fire spread, use(s)
during suppression, and as potential sources of ignitions.



Treatment timing

 How long do the fire resilience benefits of reduced density (thinning from below) last in riparian areas compared with upland areas (10-20 years?) is critical for regulatory guidance.



Post-fire trajectories

 Restocking and recovery strategies should be linked to long-term hazard modeling — how today's decisions shape severity risks in 20–40 years.