Fire, Vegetation & Integrated Analysis
Bouverie Preserve and vicinity, Mayacamas Range
1858 - 2019

Funded by Audubon Canyon Ranch
Arthur Dawson, Baseline Consulting ● February 2020

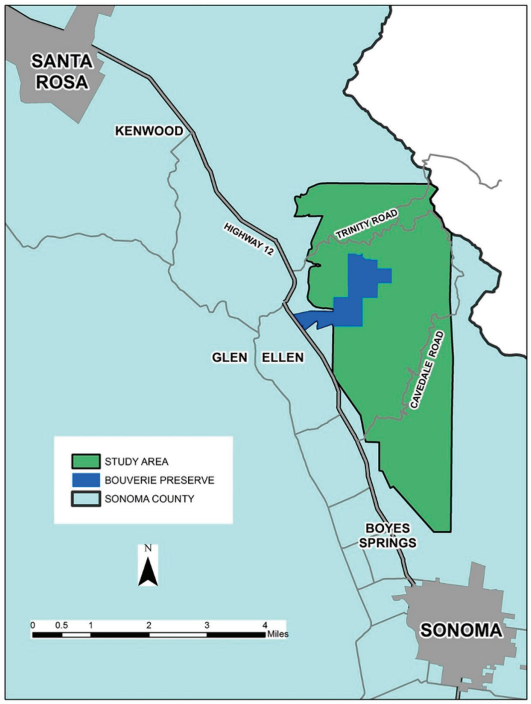
Executive Summary

OVERVIEW: This project examined the long-term relationship between vegetation and fire in a 6900-acre area which experienced one of California's most devastating wildfires in 2017. Recent and historical data were mapped and integrated to address the following questions:

- Do the vegetation patterns show long-term trends or cycles?
- Have fire return intervals varied across the landscape and over time?
- Is there a relationship between vegetation patterns and fire?

METHODS: Vegetation data (1858 – 2013) from four primary sources was compiled into tables and also mapped in GIS: **1858 & 1880 General Land Office surveys** (GLO); **1932 Vegetation Type Maps** (VTM) developed by the U.S. Forest Service under Alfred Weislander**; 1994 Wildlife-Habitat Relationship** (WHR) maps created by the CA Dept. of Fish and Wildlife; and the **2013 Sonoma County Vegetation and Habitat Mapping program** (Sonoma Veg Map; citations on pg. 7).

Created with differing methods, spatial resolutions and botanical detail over a broad time span, this data was initially distilled to its 'lowest common denominator'— the lifeform classifications used in the Manual of California Vegetation: Herbaceous; Shrub; and Forest or Woodland. Lifeform maps were created from each source. Finer-scale detail was also mapped and compiled into tables within the limits imposed by each individual source.

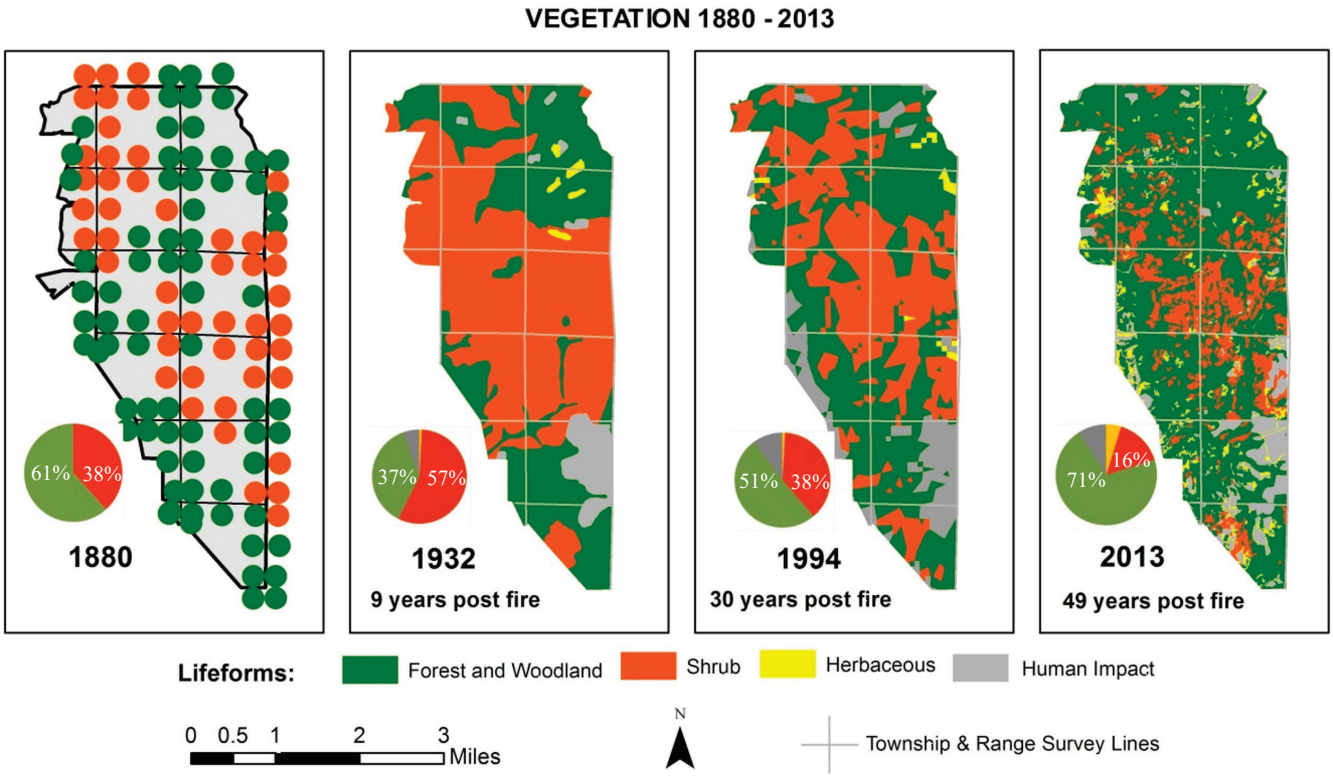


Study Area, Sonoma Valley, CA
(irregular shape due to availability of historical data)

Fire patterns over a similar period (1871– 2019) were established using **CALFIRE perimeter data** going back to 1945, and from narrative accounts before that date. In some cases, perimeters (polygons) could be estimated from the **narrative record**, in others, only points or lines could be drawn from the information. A total of thirteen fires, ranging from under 300 to 5773 acres within the study area were documented.

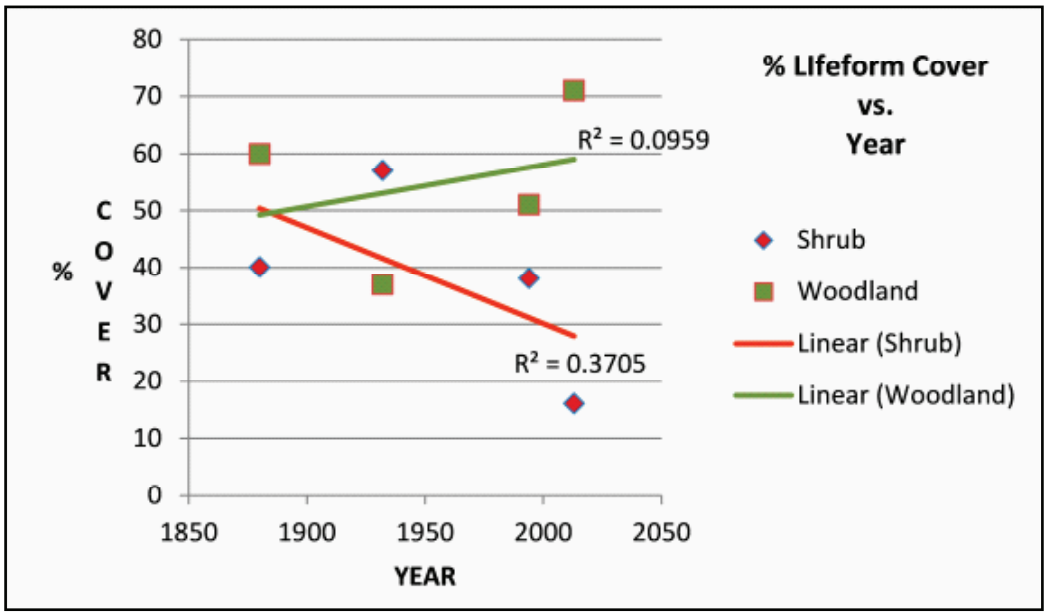
A fire history map was created with overlapping polygons, lines or points indicating locations experiencing fire return. This map indicated the presence of two distinct fire regimes, occupying separate locations and with markedly different return intervals. Vegetation layers were clipped to these areas and classed to "years post major fire," to further study the effects of fire on vegetation patterns.

Selected Results

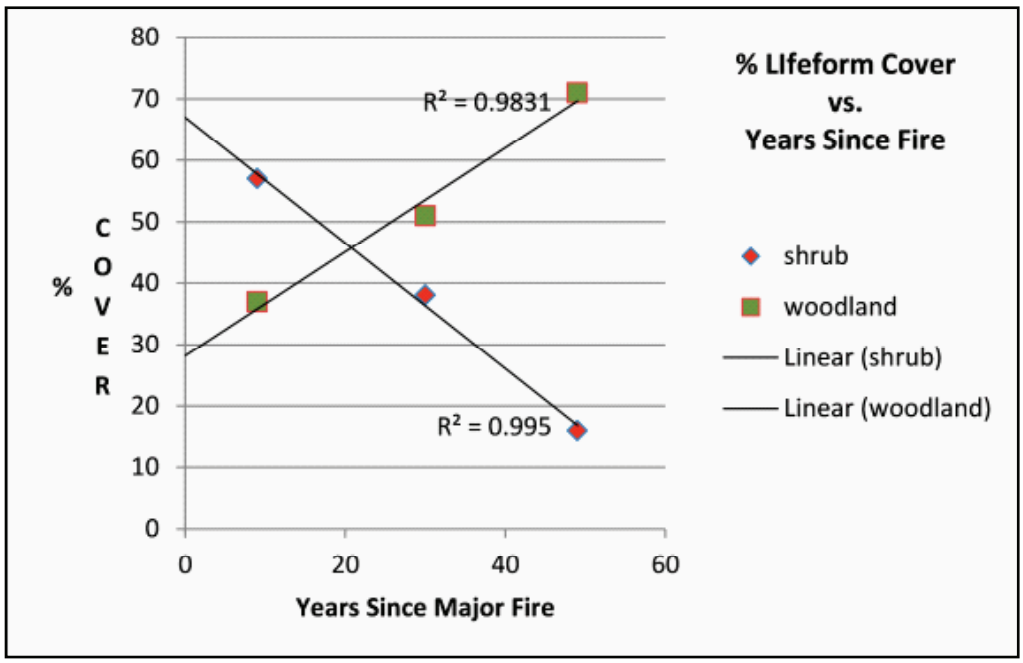


(NOTE: Because 1858 GLO data only covers a small part of the study area, it is not depicted here)

The maps above show changes in lifeform extent over time, with pie charts indicating percentages of each. Plotting these percent values against the calendar year (figure below) indicates a weak relationship or effect size (r^2 well below the commonly accepted threshold of 0.5) between lifeform extent and the passage of time. Thus neither the extent of woodland nor shrub lifeforms exhibit a distinct trend over the study period:

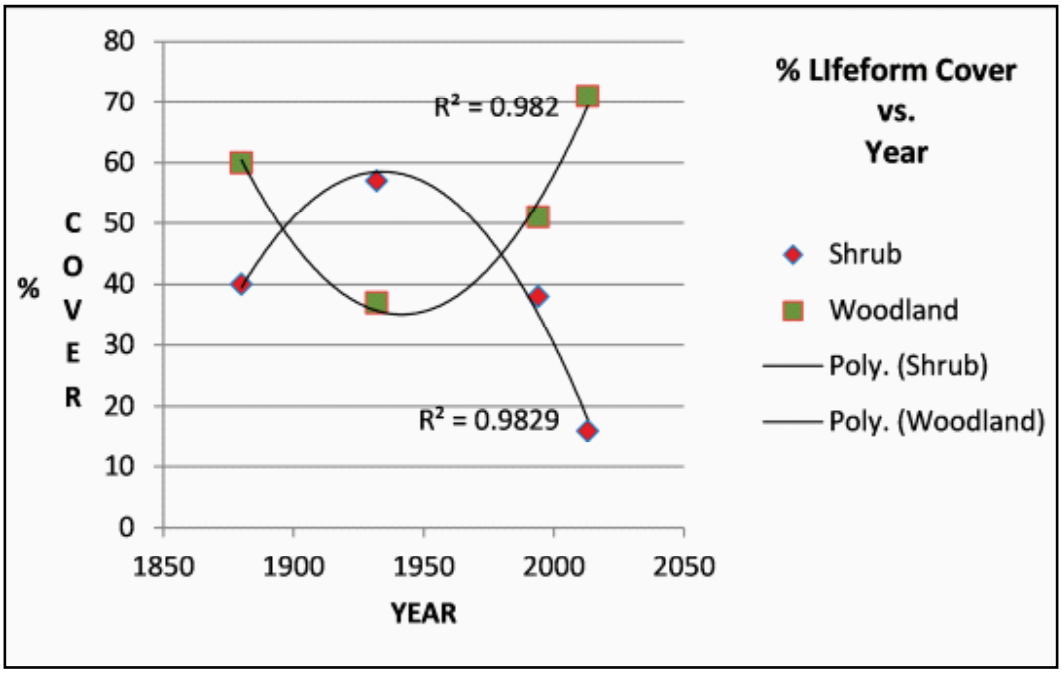


While little or no overall trend can be demonstrated, plotting lifeform extent against "years since fire" demonstrates a strong relationship or effect size between these variables (r^2>0.98, well above the commonly accepted threshold of 0.75). Extending the trendline backwards in time indicates that shrub cover is expected to be highest and woodland lowest immediately after a fire. As time passes, this condition gradually reverses to one of high woodland and low shrub cover, until the next fire occurs.

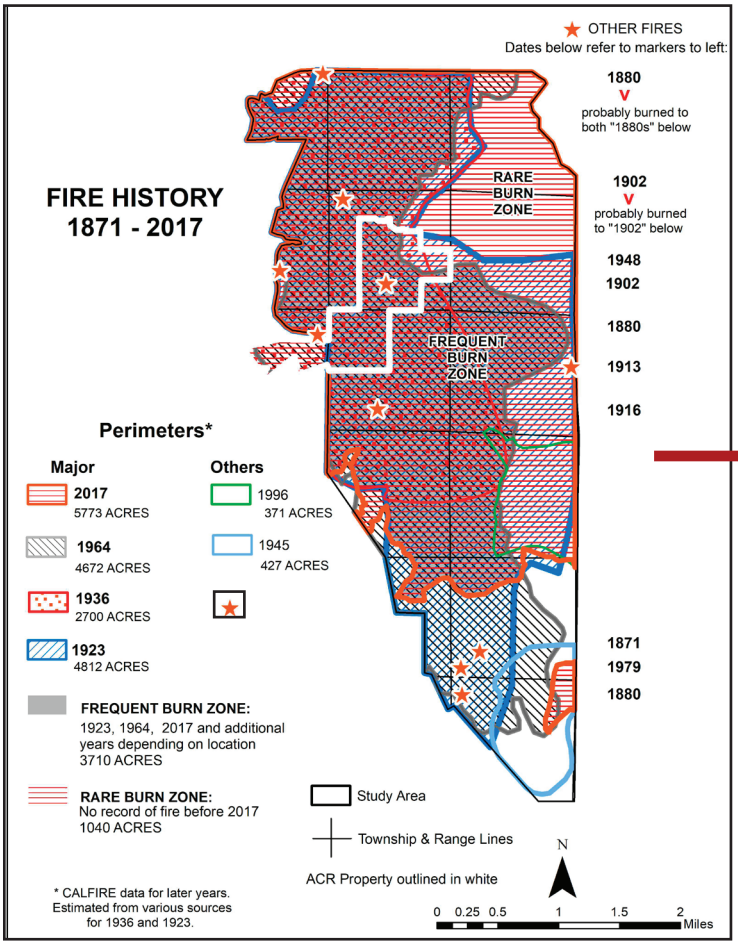


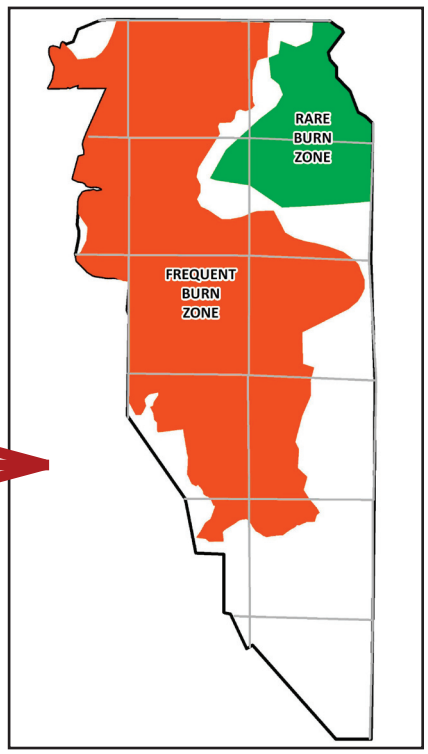
(Note: this graph does not include the 1880 data. Fire history before that date is poorly documented, making it difficult to assign a "years since fire" to the 1880 vegetation data)

To test whether the proportions of woodland and shrub lifeforms are cyclical, second-order polynomial trend lines were plotted for each life form against the calendar year. These proved to be a good fit (r^2>0.98), demonstrating that proportion of each lifeform is cyclical over time and has an inverse relationship with the other (e.g. as one increases, the other decreases).



FIRE HISTORY 1871 - 2019





Geographical Patterns

- Nearly the entire study area (98%) burned at least once since 1871. Some locations burned six times or possibly more.
- A "Frequent Burn Zone," covering 54% of the study area (3710 acres), consistently burned in every major fire. It is largely mid-elevation, west-facing slopes.
- A "Rare Burn Zone," covering about 15% of the area (1040 acres), saw no fires before 2017. At the headwaters of Stuart Creek, this zone is probably cooler and moister than elsewhere. Its position in relation to wind and slope aspect may also hamper the spread of fire.

Seasonal Timing

- With possible minor exceptions (small fires with no established ignition date) all fires began between August 2 and November 30. Sixty percent (60%) began between mid-September and mid-October. Two-thirds of the major fires also started within this window.

Causes & Drivers

- At least 7 of the 13 documented fires were caused by humans. Known causes include: brush burning (2x); railroad embers; a smudge stick used by bee hunters; and PG&E equipment (3x). Causes of the remaining fires are unknown.
- At least 8 fires were accompanied by strong winds. North or northeast was recorded as the direction 5 times; no other directions were mentioned.

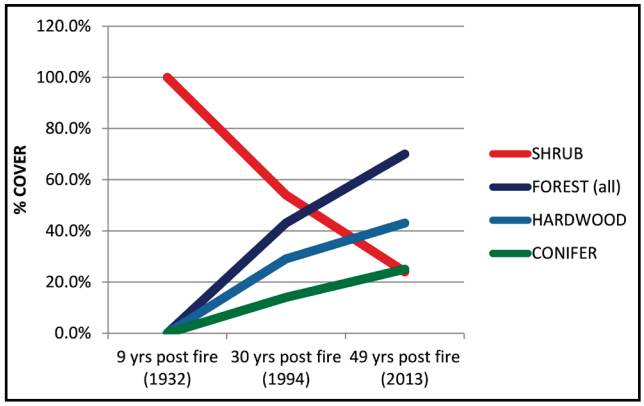
Return Intervals

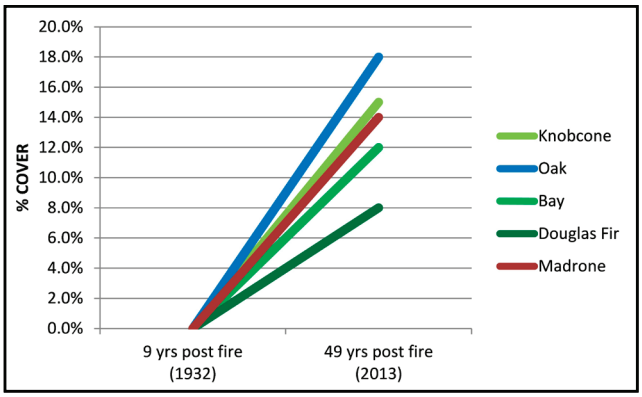
- Fire return intervals varied from 7 years to over 100 years.
- The longest was in the 'Rare Burn Zone', which had no recorded fire before 2017.
  The shortest was in the 'Frequent Burn Zone,' with an average of 25.3 years.
- The fire return interval more than doubled (+133%) between the Early Era (1871 – 1948) and the Recent Era (1949 – 2019).
- For areas that burned in 2017, the average return interval was 64 years (median = 72), triple the return interval in the Early Era (before 1948).

INTEGRATED CHANGE ANALYSIS

The fire history suggested that there might be significant differences in vegetation depending on the fire regime at a particular location. To explore the sequence of post-fire revegetation in the Frequent Burn Zone, areas within that zone that were mapped as shrubs in 1932 were clipped and assessed for vegetation cover later in the fire/vegetation cycle:

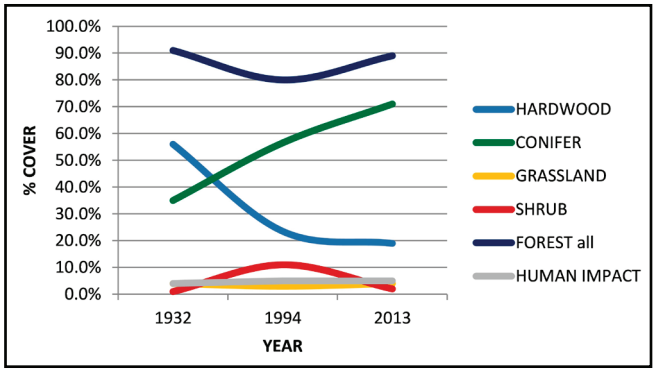
Post fire Revegetation on Shrublands
in the Frequent Burn Zone
(1994 not shown on the right because species were combined into 'Montane Hardwoods.')

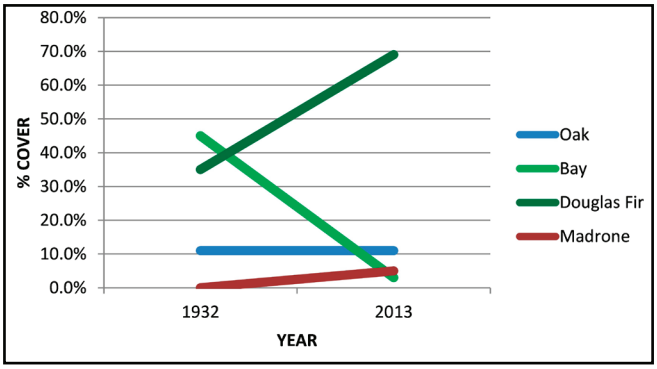




For comparison, vegetation in the Rare Burn Zone was also tracked over time:

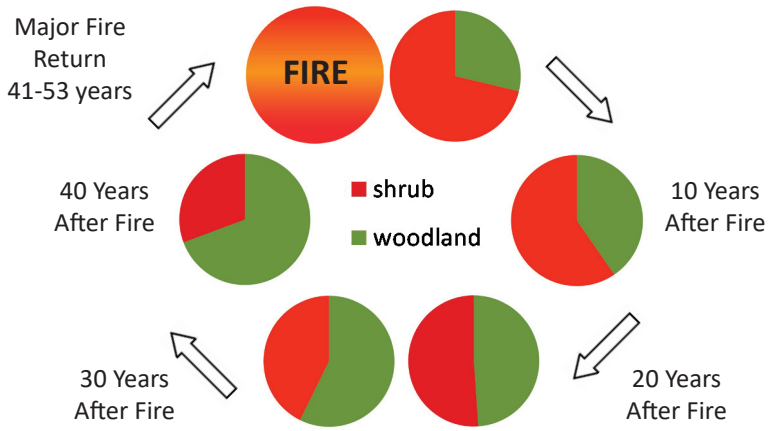
Vegetation Changes in the Absence of Fire
(Rare Burn Zone)
(1994 not shown on the right because species were combined into 'Montane Hardwoods.')





CONCLUSIONS

Fire → Shrub → Forest → Fire Cycle



For much of the study area, fire appears to be the driver of a decades-long cycle in which the extent of shrubland and forest shifts back and forth over time. In the years immediately after a fire, shrubs, particularly chamise, are the dominant lifeform, covering about two-thirds of the landscape (57% at 9 years after the 1923 fire).

As years pass without fire, trees begin to replace the shrubs. After two to three decades, woodlands and shrublands cover roughly equal areas. After this, woodlands dominate. In 2013, forty-nine years after the fire of 1964, woodlands covered 71% of the study area. Four years later, the 2017 Nuns Fire burned this landscape and beyond, presumably "resetting the clock" back to shrublands, and thus beginning another cycle (limited GLO survey data from 1858 supports this scenario; post-2017 vegetation data not yet available).

The long-term data also suggests that:

- Hardwoods (oaks, madrone and bay, in order of abundance) revegetate shrublands about twice as fast as conifers. Of conifers, Knobcone pine revegetates at nearly twice the rate of Douglas fir.
- In the absence of fire (Rare Burn Zone) Douglas fir outcompetes hardwoods.
- The abundance of California Bay is a relatively recent occurrence (no record in 19th-century data).

PRACTICAL APPLICATIONS

The results of this study suggest a number of avenues for further research and actionable steps with the potential to reduce fire hazards and threats to human safety while also improving the ecological health of this landscape. This study points to the highly variable history of fire and vegetation in this relatively small area and that effectively deploying limited resources requires a site-specific approach. Input from fire ecologists, fire fighters and local land managers would be valuable to address the following questions:

- What is the best timing in the fire/vegetation cycle for fuel reduction? Is there a point in the cycle after which catastrophic fire becomes more likely?
- Does the transition from shrublands to forest contribute to the spread of fire in high winds through "ember cast?" Is there a critical vegetation height above which embers are cast substantially further downwind?
- How might differences in fire return intervals within this landscape inform, on a small scale, the size of defensible space and the schedule of fuel reduction efforts?
- Are there differences in fire intensity between the Rare Burn Zone and the Frequent Burn Zone?
- How might topographic, wind or other patterns account for the different burn regimes? Are these useful for identifying other high risk and low risk locations outisde the study area? (The orientation of the Rare Burn Zone may contribute to its relative safety from fire. Upper Mark West watershed has also escaped nearby large fires and appears to have similar characteristics.)

Acknowledgements

This analysis relied on a wealth of previous research, mapping and survey data. It leveraged more than a century of records created by government agencies, private organizations and publications. Knowledge of where to find this data, and the expertise to carefully interpret and integrate the disparate pieces into a coherent whole was developed over the course of several previous projects:

Experience working with 19th-century vegetation data collected by U.S. General Land Office Surveyors (Benson 1880; Tracy 1858) was largely gained through the "Grassy Ridges" project funded by Pepperwood Preserve (Dawson 2008; Evett et. al 2013), the "Modini-Mayacamas Preserve" study funded by Audubon Canyon Ranch (Dawson 2014a), and the "Upland Pilot Project" funded by Sonoma Ag + Open Space (Dawson 2014b). My work as historical ecologist for the Sonoma Ecology Center was also an important foundation for this effort.

This project benefited greatly from the work of Dr. James Thorne of UC Davis, who digitized the U.S. Forest Service 1932 Weislander Vegetation Type Maps. Also from the work of the California Department of Fish & Wildlife in creating the Wildlife-Habitat-Relationship maps in the 1990s, which built on fire-risk mapping done by CALFIRE. Battalion Chief Marshall Turbeville and other CALFIRE staff contributed more than seventy years of fire perimeter data. The Sonoma County Ag + Open Space District and its partners, through the Sonoma Veg Map effort led by Mark Tukman of Tukman Geospatial, provided high-resolution vegetation data from 2013. Finally, the narrative account by James Frazier of the 1923 fire, as well as those written by journalists between 1871 and 1936, contributed the information needed to draw estimated pre-1945 perimeters and locations.

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