Vegetation Trends and Cycles in the Fire-Prone Landscapes of Lake, Napa and Sonoma Counties

CALFIRE grant 19-FH-LNU-086

Baseline Consulting

Pepperwood Preserve
Inspiring conservation through science

CAL FIRE

Tukman Geospatial LLC
Digital Mapping

Thorne Environmental Landscape Analysis

STUDY AREAS

- **Where communities and/or natural resources are at risk**
- **Where long-term vegetation and fire records are available**

c. 1870 - 2020

125,000 acres / 190 sq. mi.

- **LAKE**
- **NAPA EAST**
- **SONOMA-NAPA**
- **SONOMA WEST**

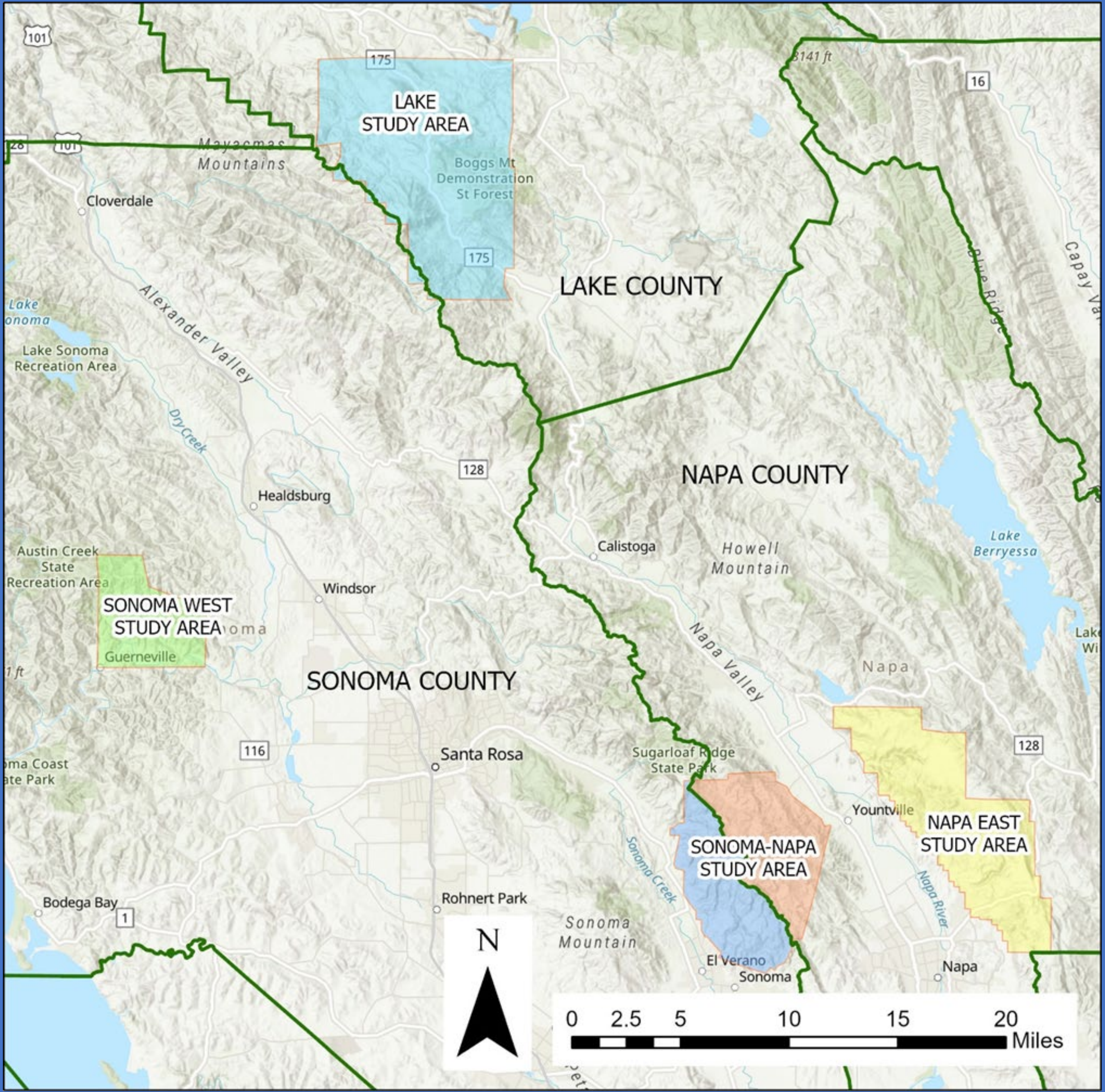
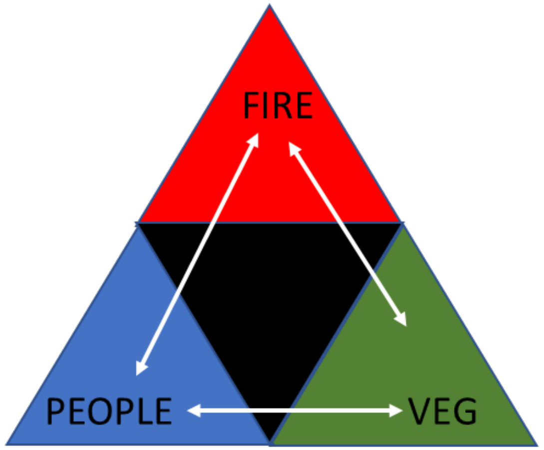


Table 1. Study Area Summary Characteristics

NAME	HUMAN IMPACTS	RECENT LARGE WILDFIRES	VEGETATION (≥2%, in order of abundance)
Napa East	Vineyards Rural development 16% footprint	Atlas fire 2017 Atlas fire 1981 Atlas fire 1965	Hardwoods Chaparral Grassland 2016
Sonoma-Napa	Vineyards Rural development 10% footprint	Nunns fire 2017 Nunns fire 1964	Hardwoods Conifers Chaparral Grasslands 2013/2016
Sonoma West	Past timber harvest Rural development 6% footprint	Walbridge fire 2020	Conifers Hardwoods Grassland Chaparral 2013
Lake	Past timber harvest Rural development 5% footprint	Valley fire 2015	Conifers Hardwoods Chaparral Grassland 1993

KEY QUESTIONS



How have vegetation patterns changed over time?

What is the history and pattern of fire on the landscape?

What is the relationship between vegetation, fire, and people?

What do the results suggest for:

- Improving ecological health?
- Lowering the chance of catastrophic fire?
- Maximizing C sequestration and minimizing emissions?

SOURCES

GENERAL LAND OFFICE:
GLO SURVEYS
c. 1870s

SOIL-VEG MAPS
c. 1950 - 1965

SONOMA & NAPA
VEG MAPS
2013 & 2016

EARLY NARRATIVES
1820s – 1850s

VEGETATION TYPE MAPS
(VTM)
1928 & 1932

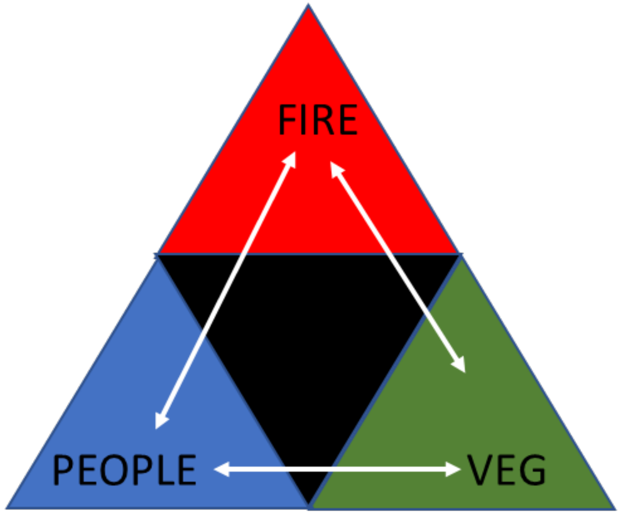
WILDLIFE HABITAT RELATIONSHIP
MAPS (WHR)
1993

Indigenous Wisdom ◆ Traditional Ecological Knowledge ◆ Local Knowledge

NARRATIVES
Newspapers & written accounts
1820s – 1940s

CALFIRE
PERIMETER MAPS
1940s - present

INDIGENOUS WISDOM



Clint McKay (Wappo, Pomo, Wintun)
Chair, Native Advisory Council, Pepperwood Preserve

Cultural burning at Pepperwood

The difference between cultural and controlled or prescriptive burning?

It comes down to who it's intended to benefit.

Just human beings?

Or all the living things on the land?


“We consider fire to be a member of the community,
one who is far wiser and more powerful than we are.”
--Sara Moncada, Director, Heron Shadow
(Yaqui/Irish)

What is our proper role as human beings?

Control?

or

Relationship?

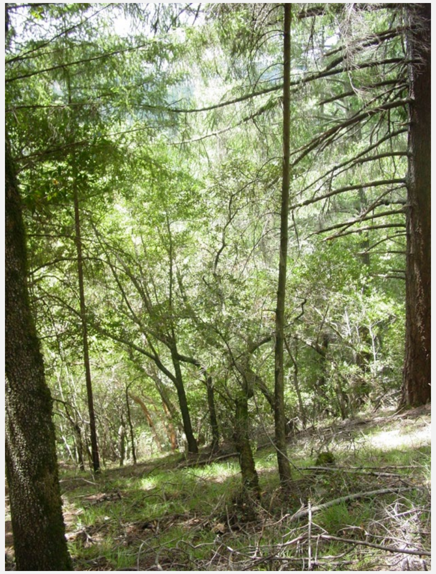
Tending and stewardship

Maintaining the balance

“This is how the land looks when it’s not being tended properly.”

--Redbird Willie, Stewardship Coordinator, Heron Shadow
(Pomo, Paiute, Wintu and Wailaki)






Survey line reported as “Covered with chemizal” in 1870

about 6-7 generations ago

VEGETATION DATA

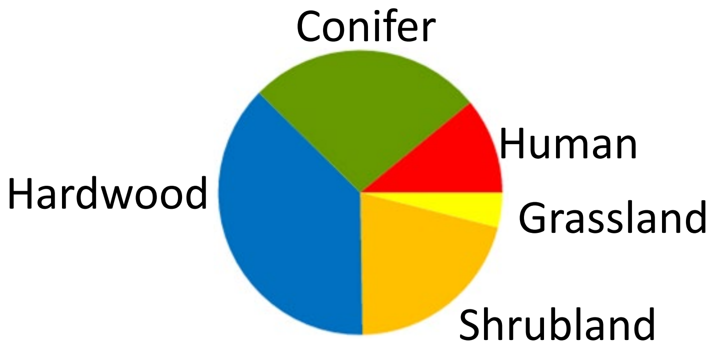
Historical Record

Occam's Razor: **Fewer categories = less chance for error**

All records: **'in order of abundance'**

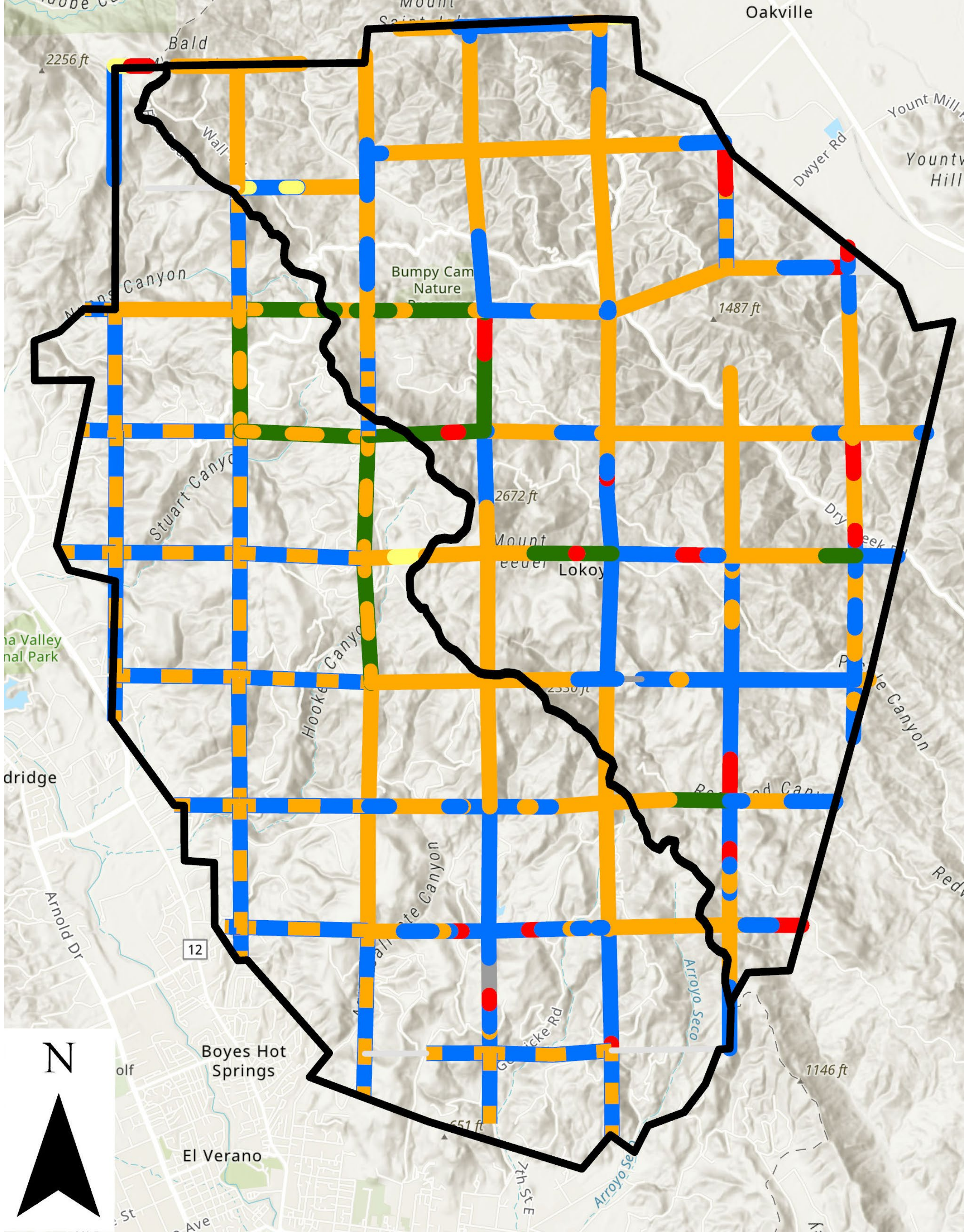
LIFEFORMS:

- Grasslands (Herbaceous)
- Shrublands (Chaparral)
- Woodlands (Forest)
    - Conifer
    - Hardwood
- Human
- Other (rock, water, barren etc.)



CAVEATS

Sonoma-Napa Study Area, c. 1872



GRASSLAND

SHRUB

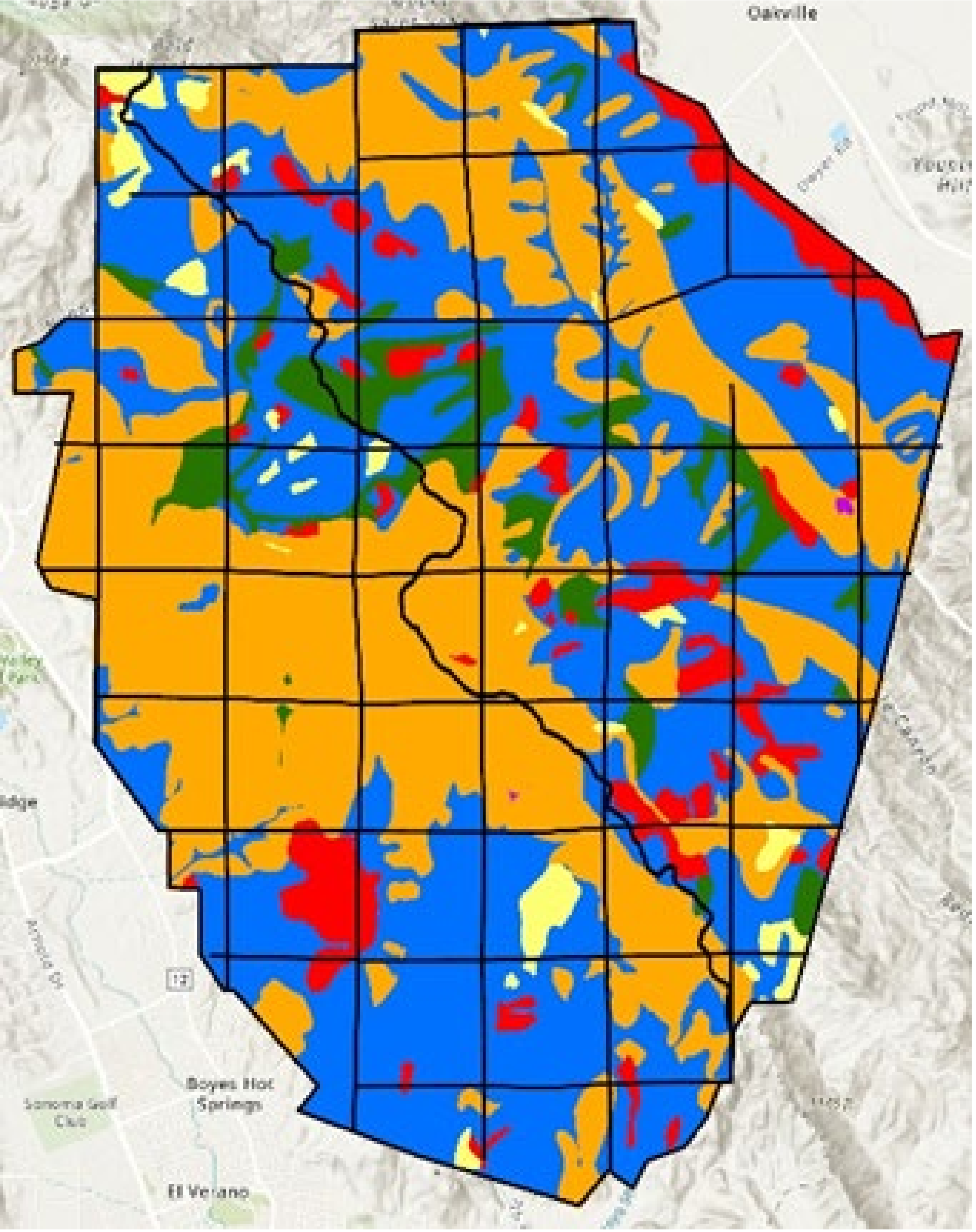
WOODLAND

Hardwood

Conifer

HUMAN

OTHER



Sonoma-Napa Study Area, 1932

GRASSLAND

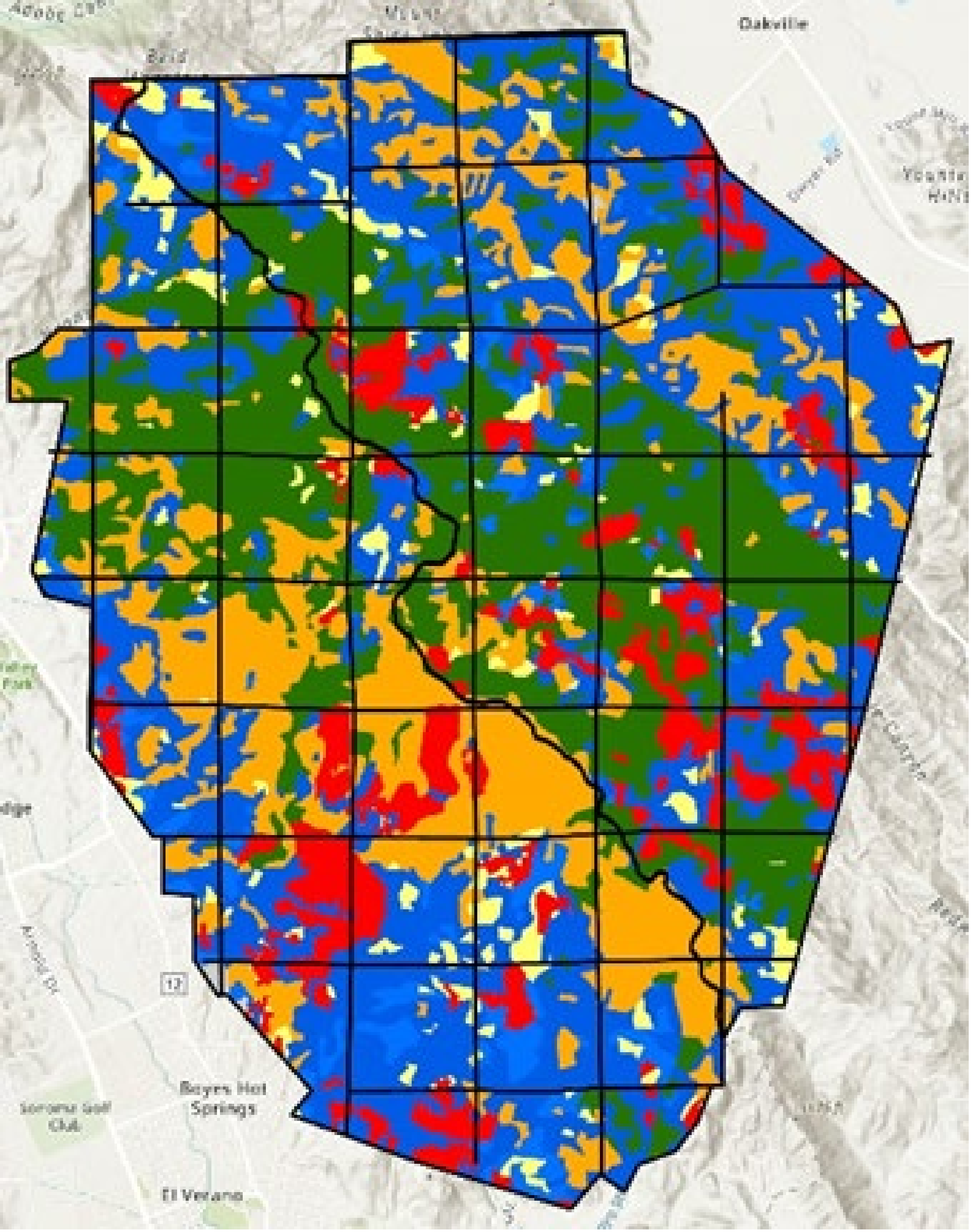
SHRUB

WOODLAND
- Hardwood
- Conifer

HUMAN

OTHER

Sonoma-Napa Study Area, 1993



GRASSLAND

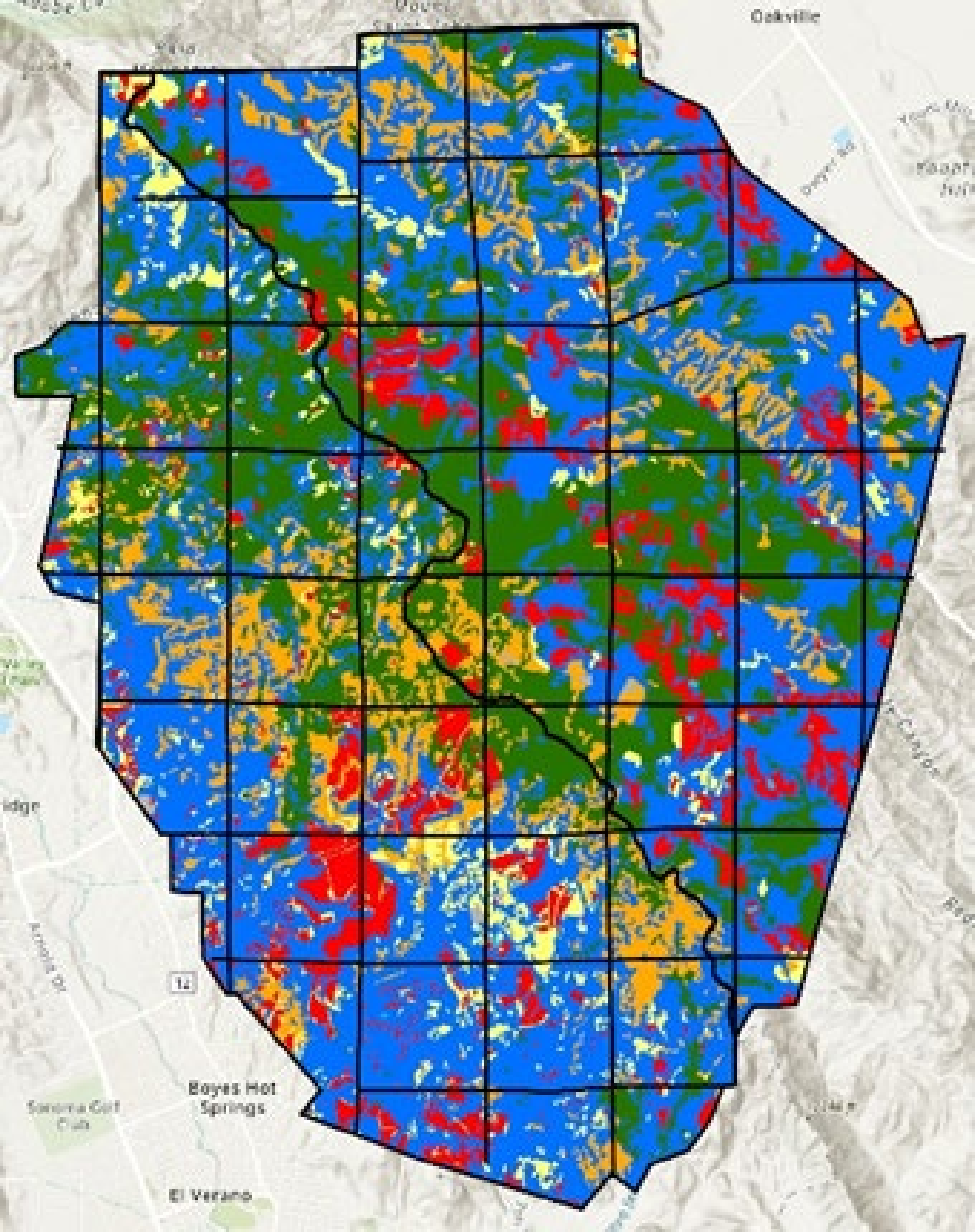
SHRUB

WOODLAND
- Hardwood
- Conifer

HUMAN

OTHER

Sonoma-Napa Study Area, 2013/16



GRASSLAND

SHRUB

WOODLAND

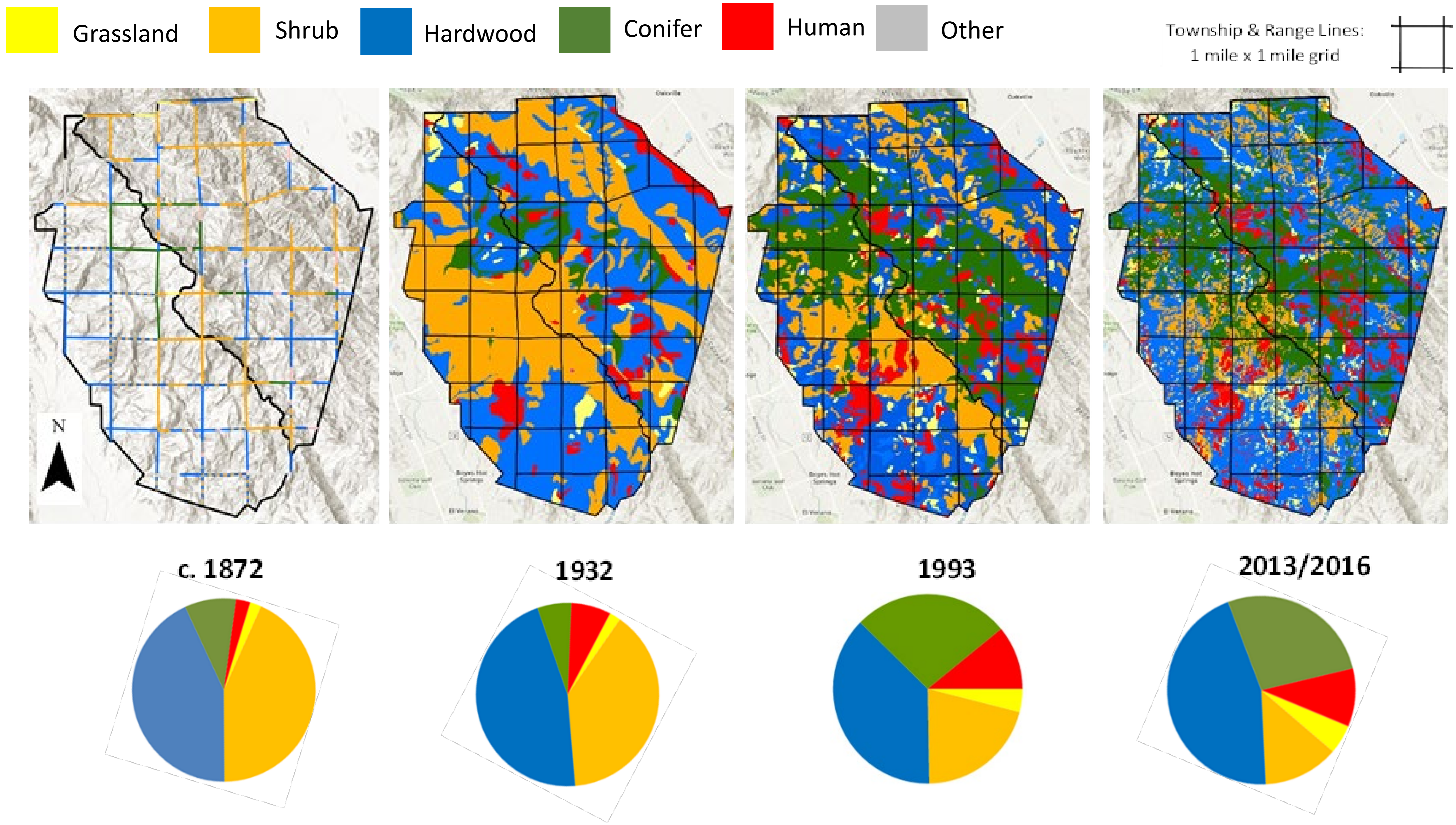
Hardwood

Conifer

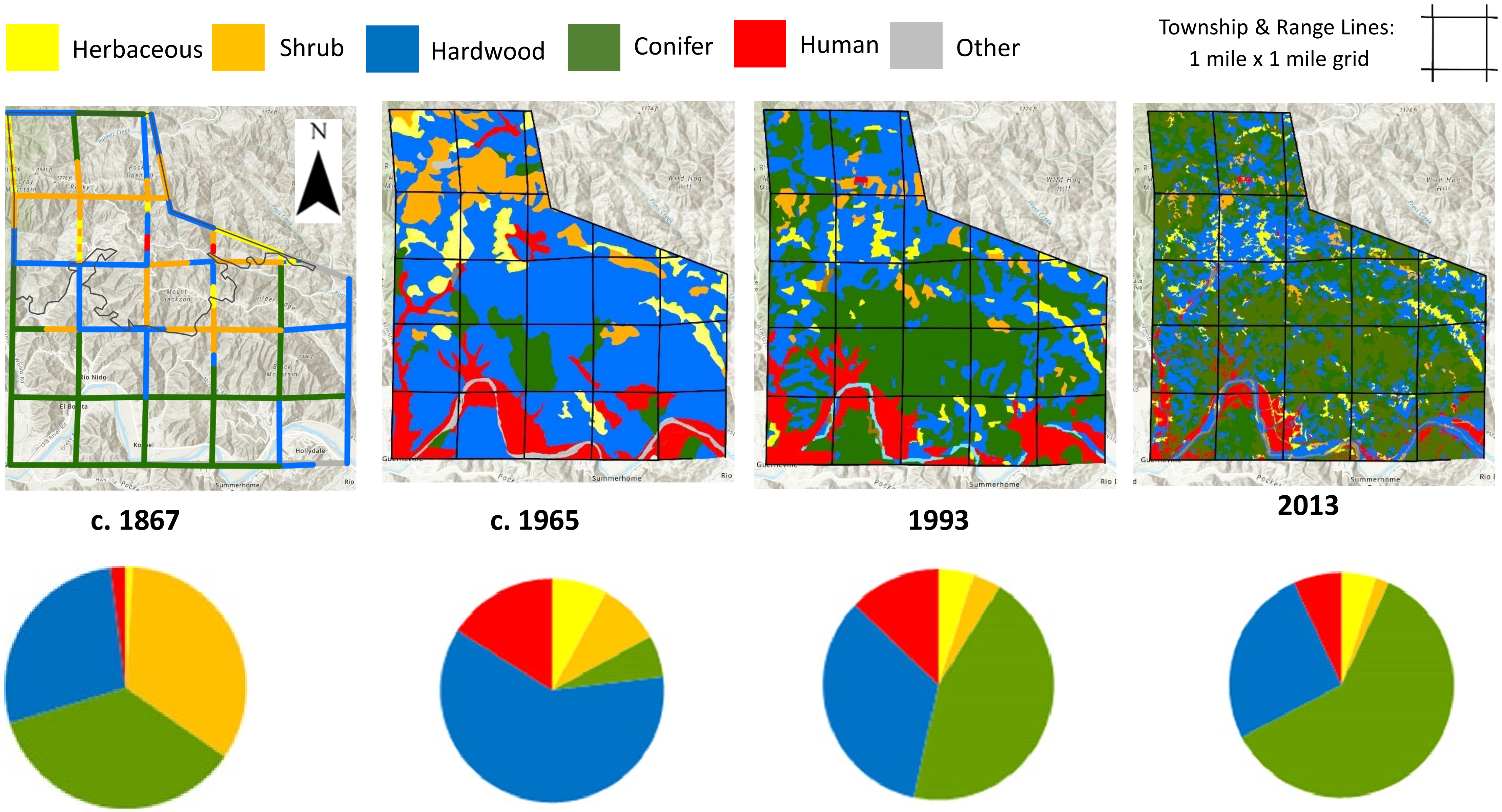
HUMAN

OTHER

Sonoma-Napa Study Area, Vegetation Lifeforms

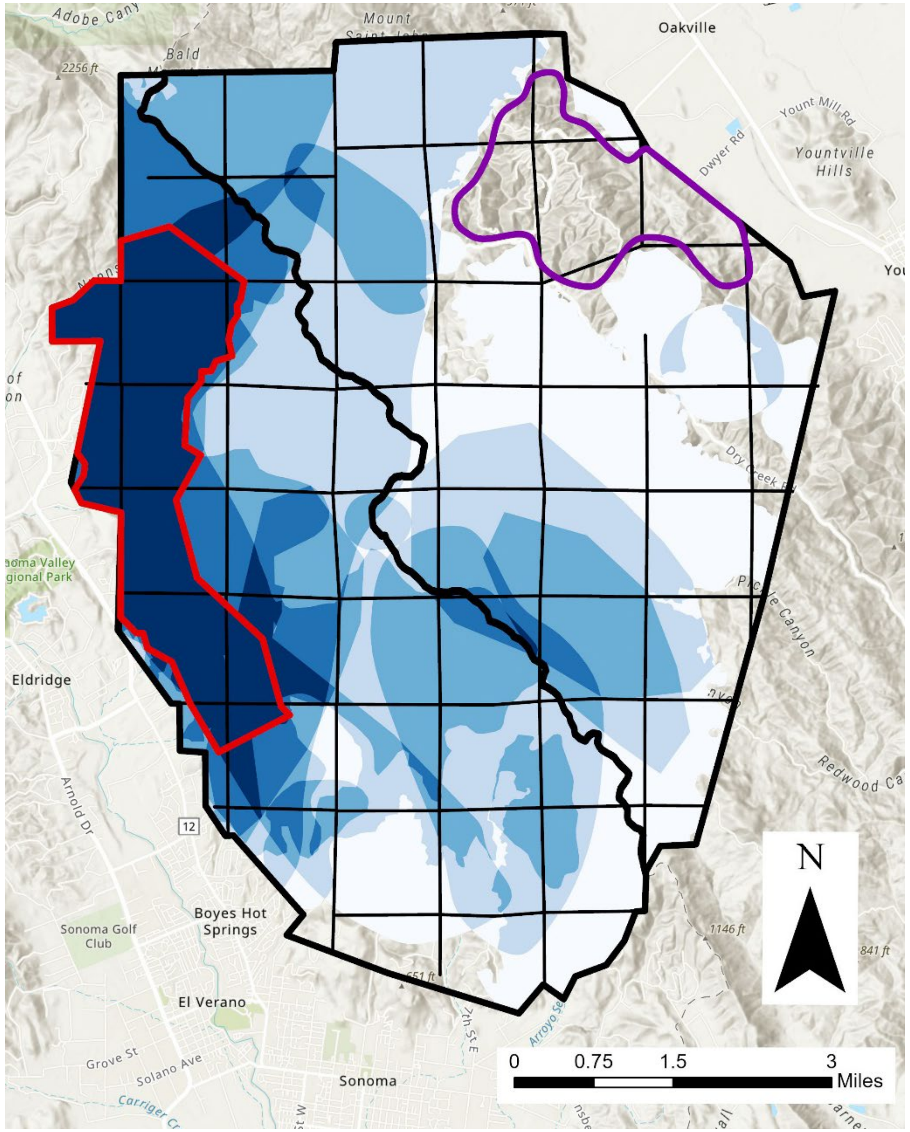


Sonoma-West Study Area, Vegetation Lifeforms



FIRE DATA

Historical Record



Township & Range Lines:
1 mile x 1 mile grid

SONOMA-NAPA STUDY AREA FIRE HISTORY

Documented Fires: 1870 - 2020

 # Fires, % of Study Area

1 22%
2 25%
3 20%
4 9%
-5 7%
-6 5%
-7 <1%

Frequent Burn Zone
4-7 Fires

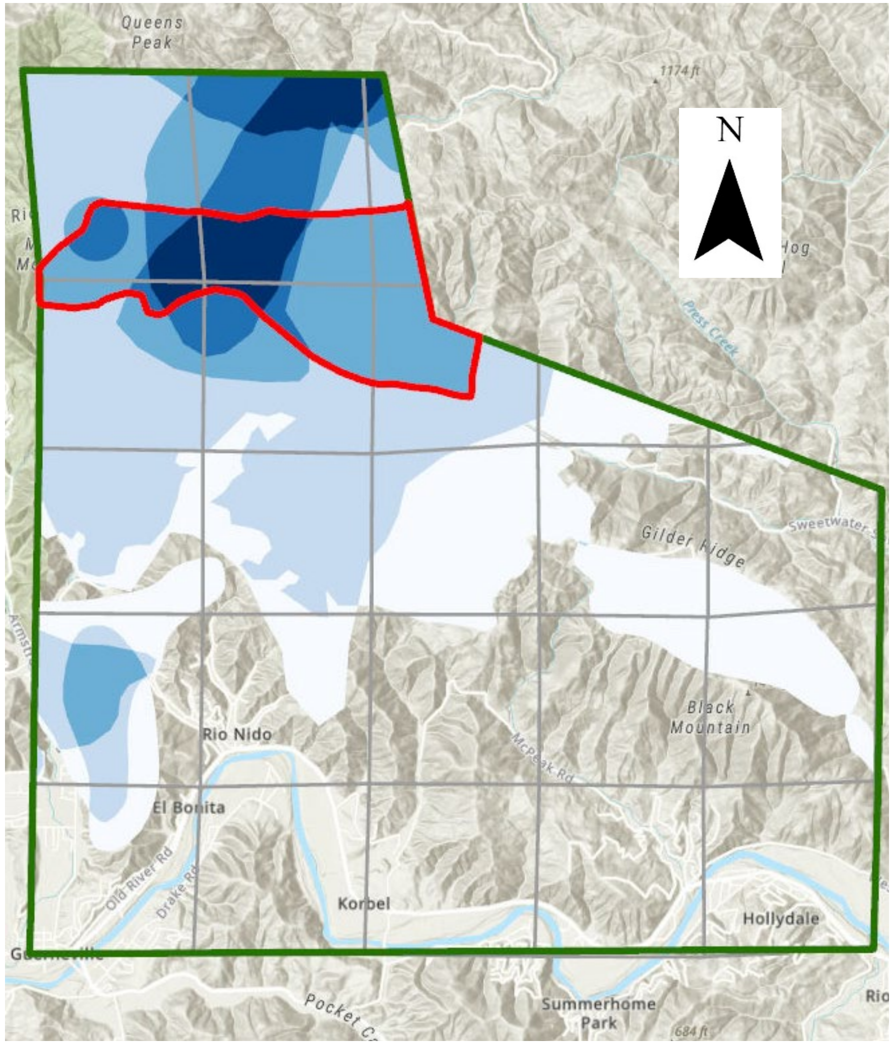
No documented burn:
13%

Average # fires:
1-2

Rare Burn Zone

SONOMA WEST STUDY AREA FIRE HISTORY

Documented Fires: 1902 -2020



Township & Range Lines:
1 mile x 1 mile grid

 # Fires, % of Study Area

1	16%
2	19%
3	8%
4	4%
5	3%

Frequent Burn Zone (FBZ)
3-5 Fires

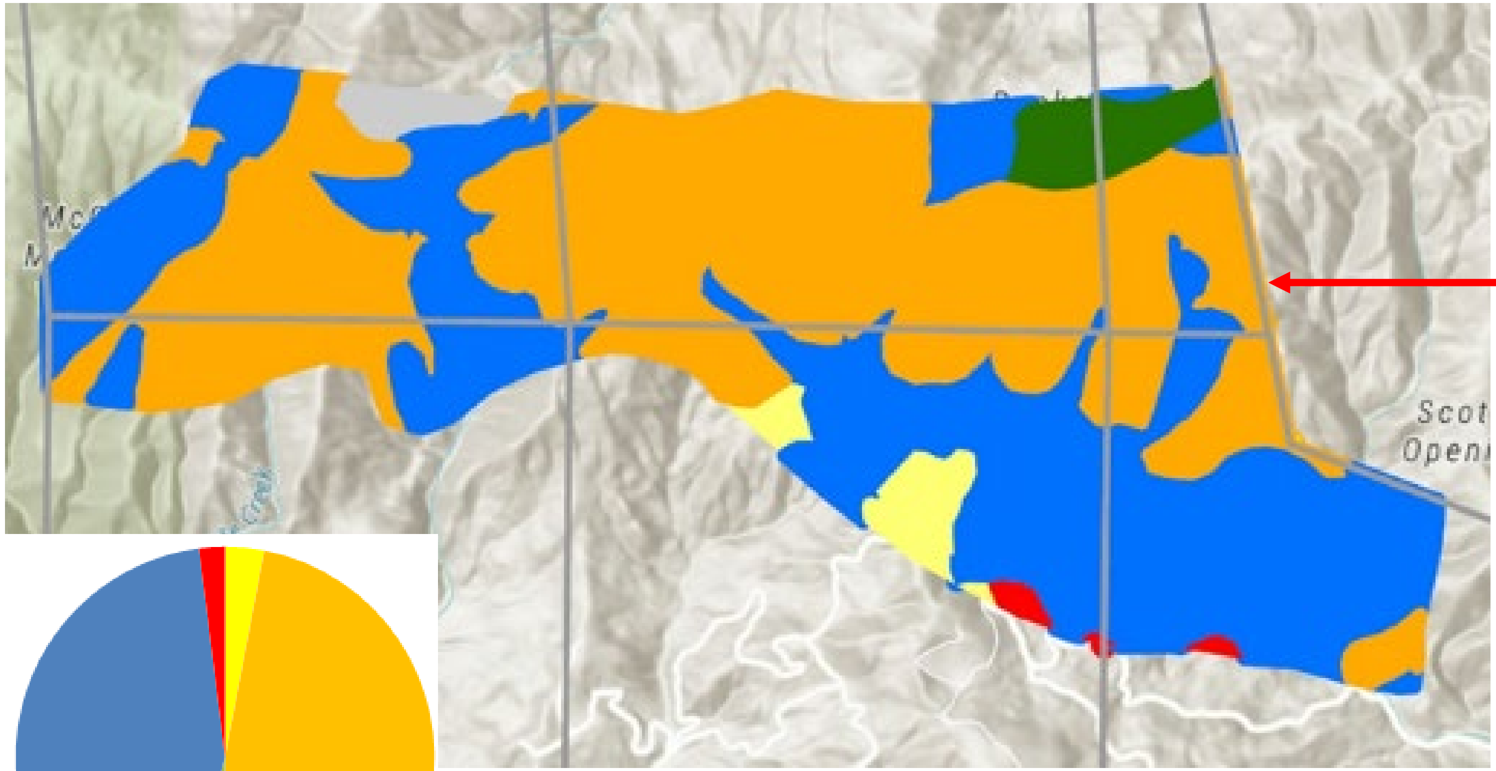
No documented burn:
50%

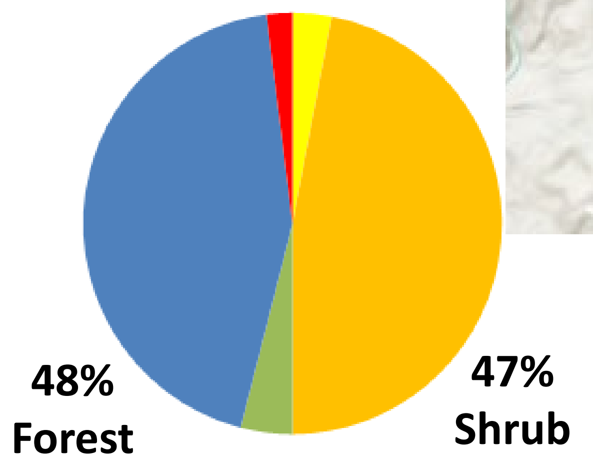
Average # Fires:
0-1

INTEGRATION

VEGETATION & FIRE DATA

POST-FIRE REVEGETATION
SONOMA WEST FREQUENT BURN ZONE (FBZ)





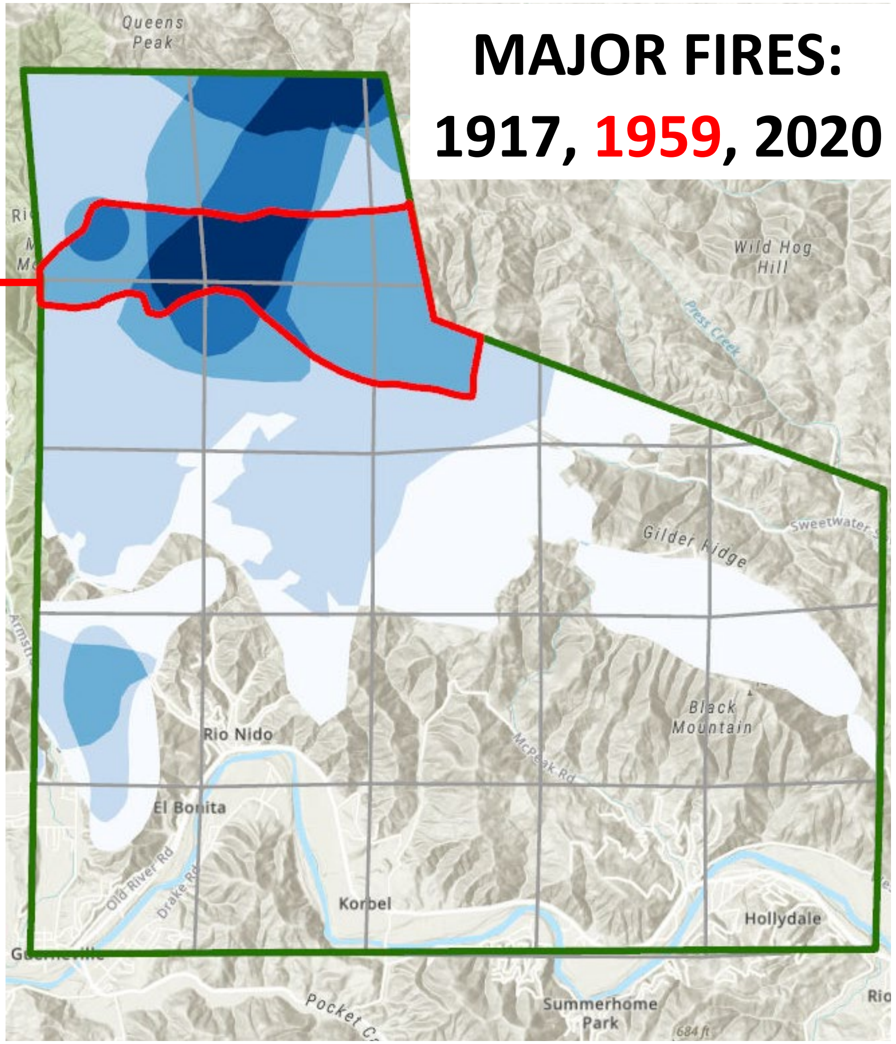
6 years post fire

c. 1965

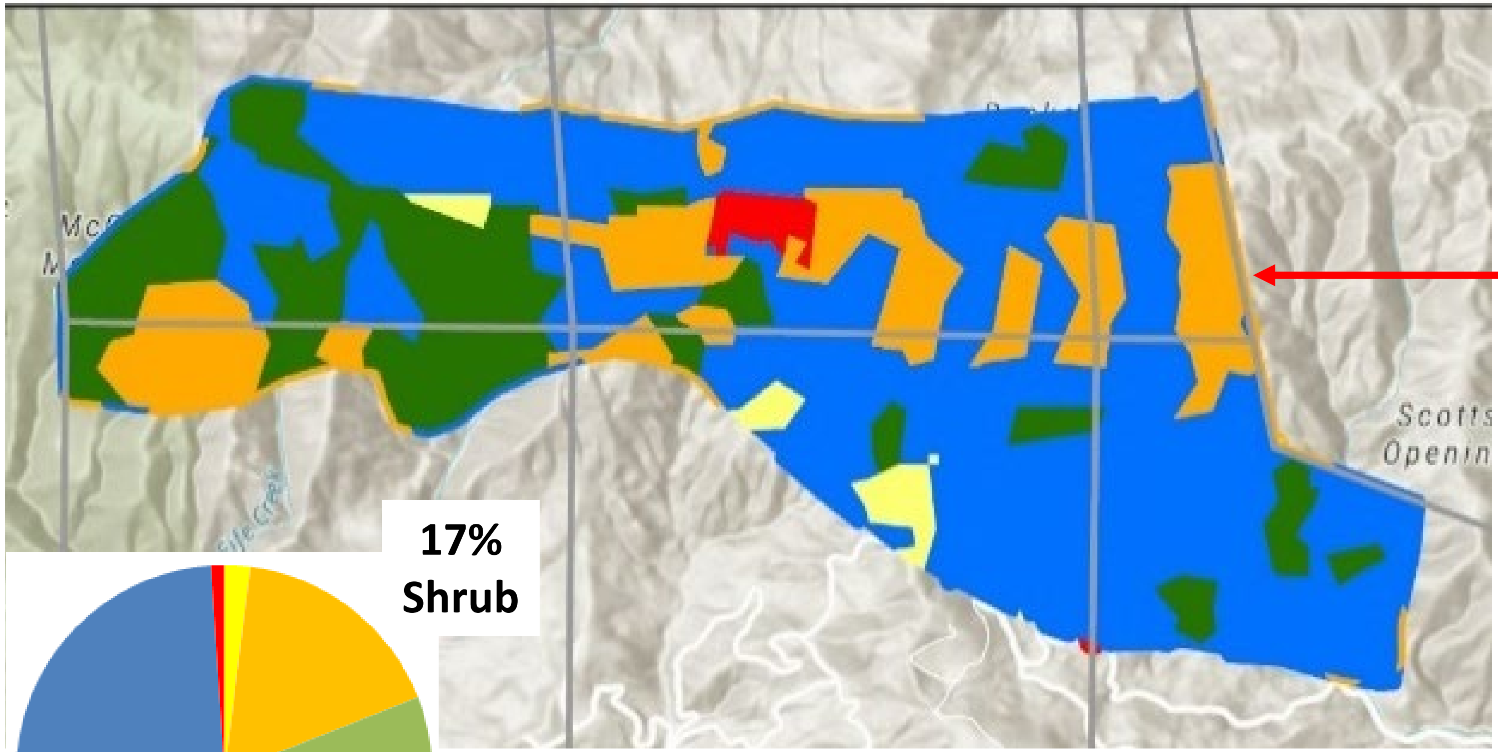
Herbaceous | Shrub | Hardwood | Conifer | Human

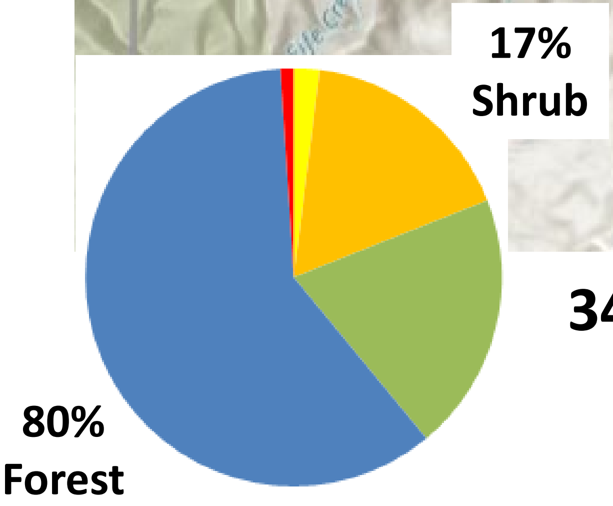
MAJOR FIRES:

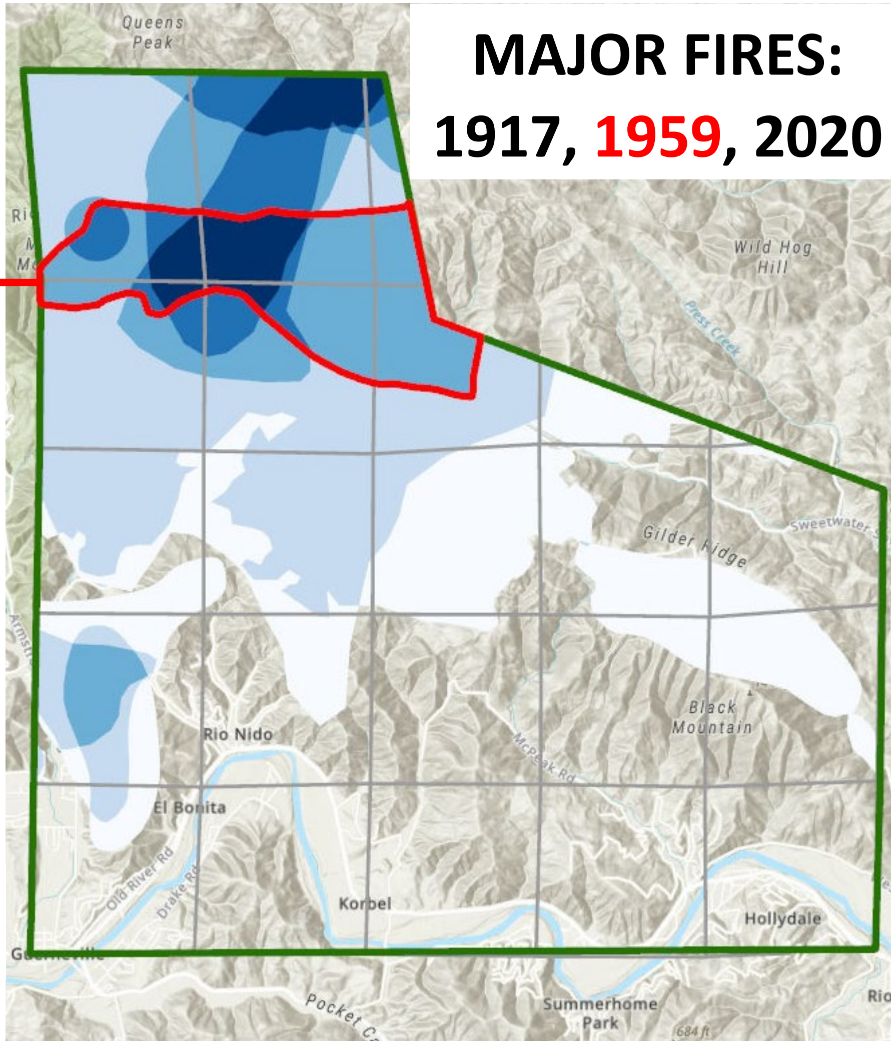
1917, 1959, 2020



POST-FIRE REVEGETATION
SONOMA WEST FREQUENT BURN ZONE (FBZ)







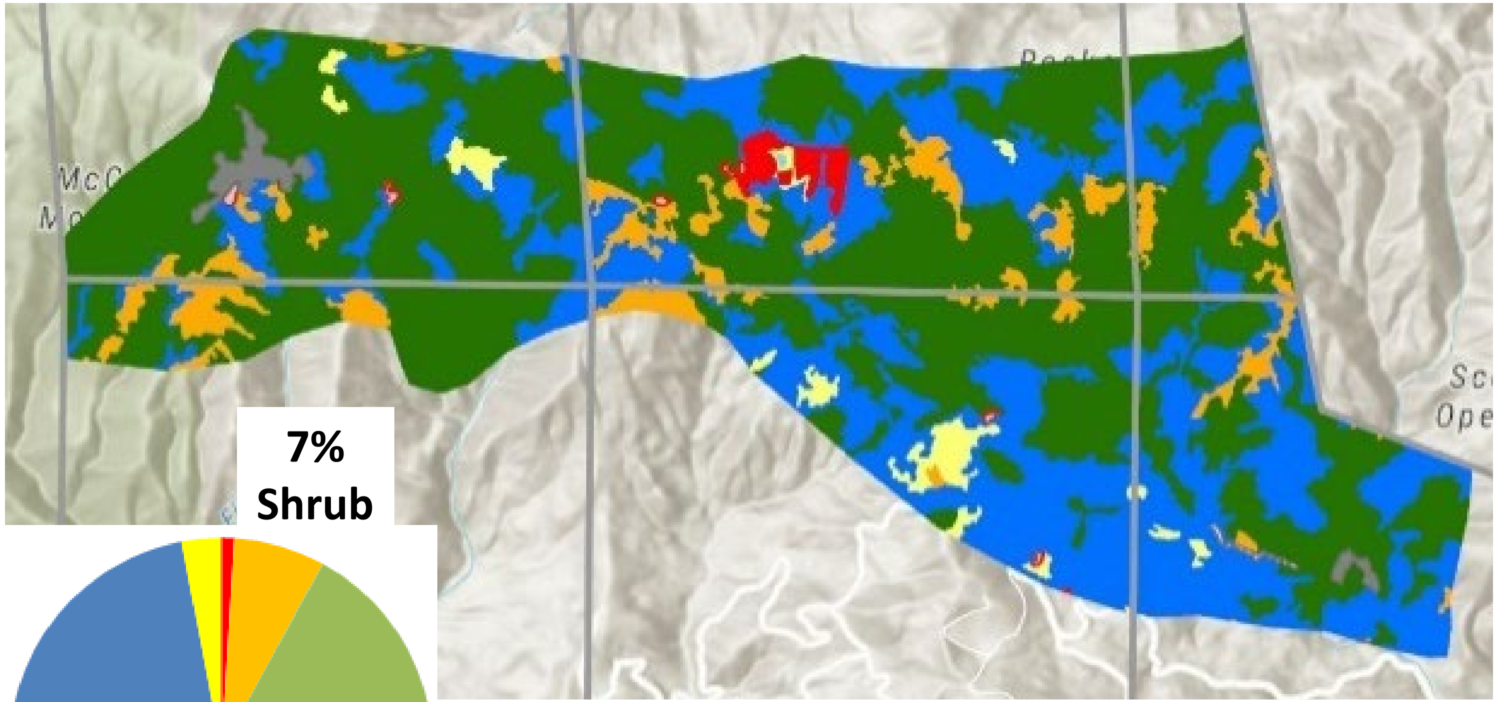
34 years post fire

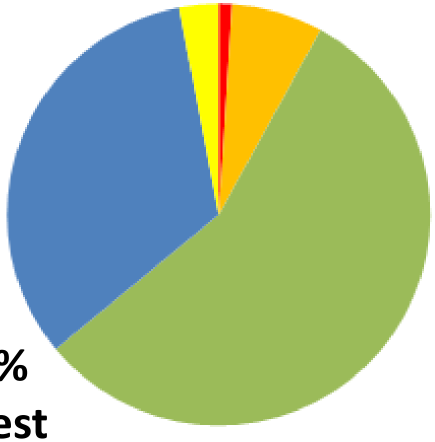
1993

Re-forestation rate
~1%/year

Herbaceous | Shrub | Hardwood | Conifer | Human

POST-FIRE REVEGETATION
SONOMA WEST FREQUENT BURN ZONE (FBZ)



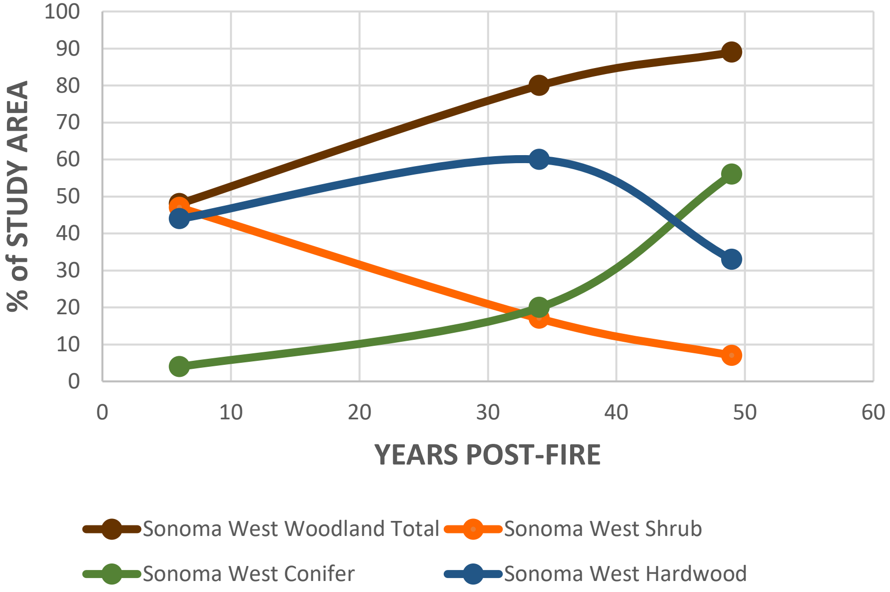


54 years post fire

2013

Herbaceous | Shrub | Hardwood | Conifer | Human

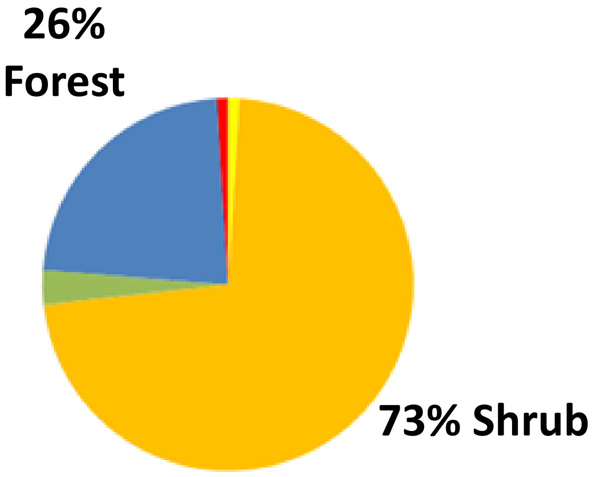
Figure 34. Sonoma West FBZ Lifeform Transitions
6-54 Years Post Fire

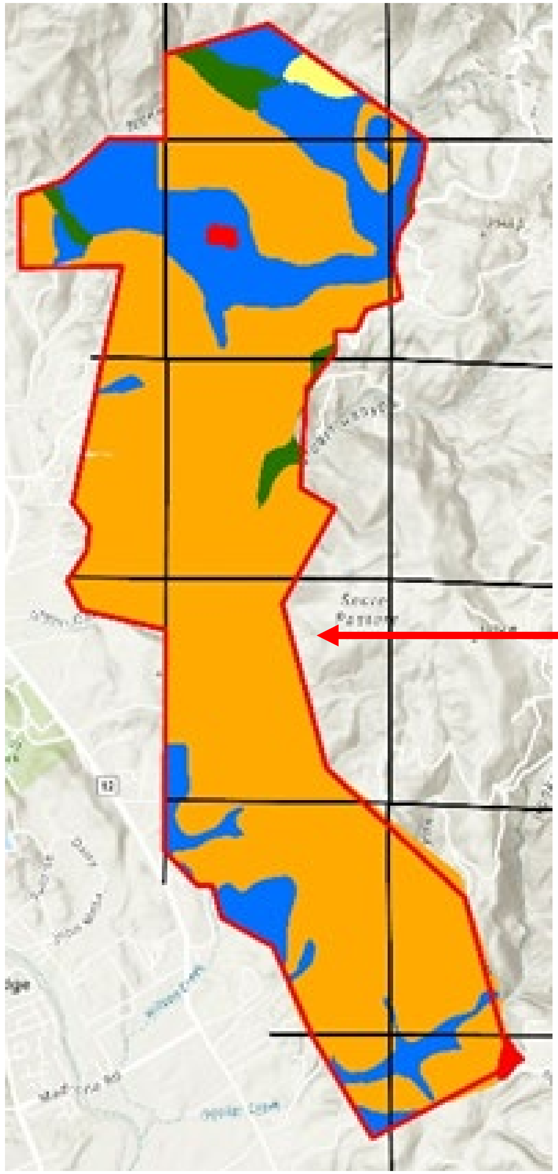


POST-FIRE REVEGETATION
SONOMA-NAPA FREQUENT BURN ZONE (FBZ)

9 years post fire

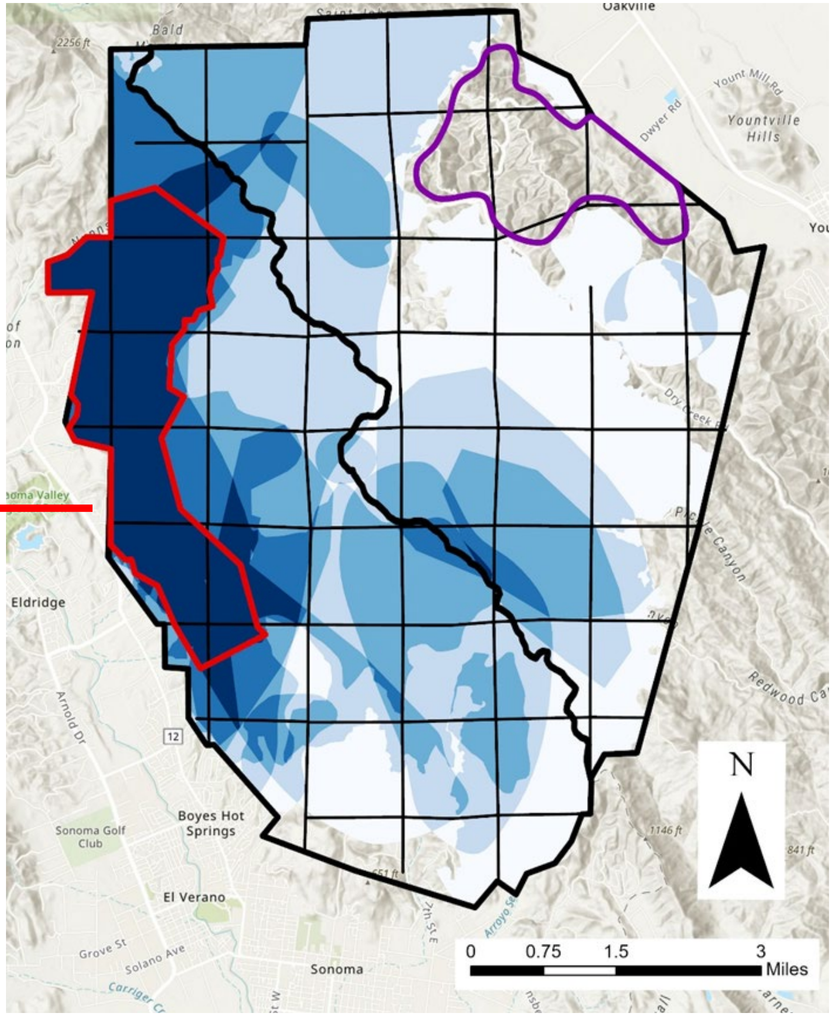
1932





MAJOR FIRES:

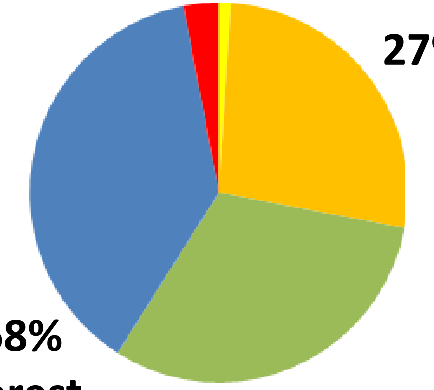
1880, 1923, 1964, 2017

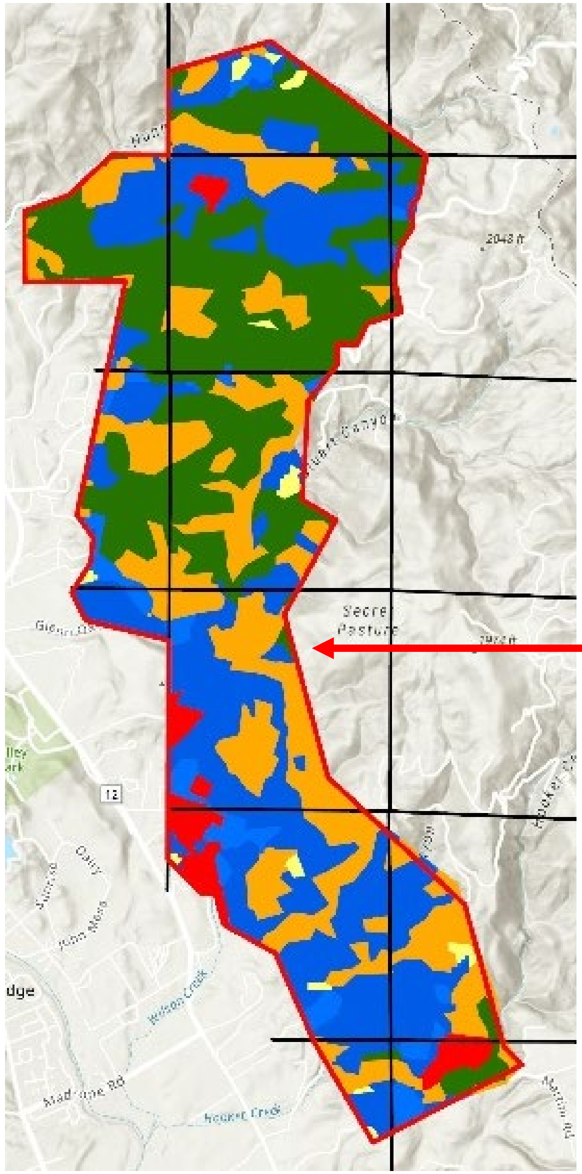


POST-FIRE REVEGETATION
SONOMA-NAPA FREQUENT BURN ZONE (FBZ)

29 years post fire

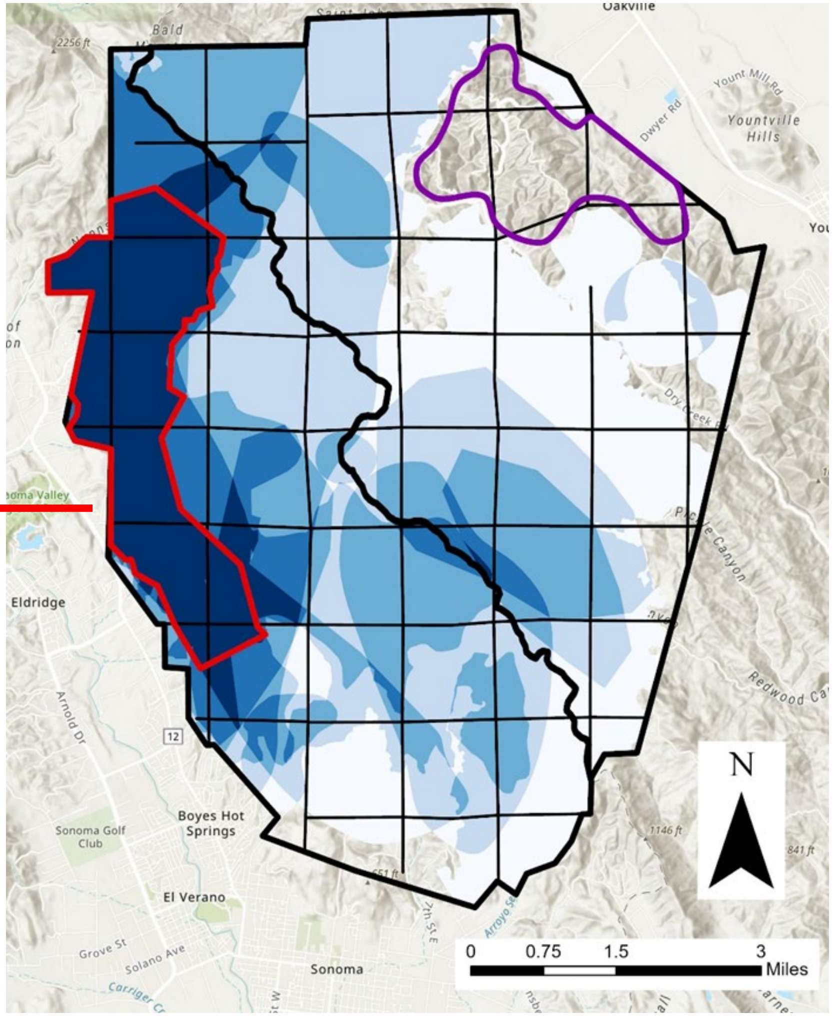
1993





MAJOR FIRES:

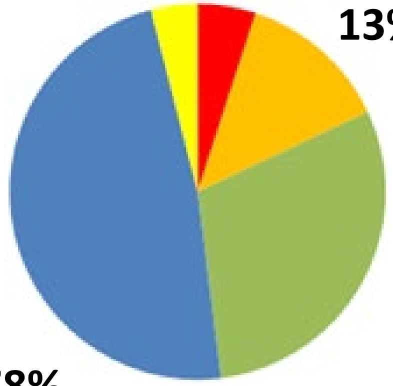
1880, 1923, 1964, 2017



POST-FIRE REVEGETATION
SONOMA-NAPA FREQUENT BURN ZONE (FBZ)

49 years post fire
2013

13% Shrub



78% Forest

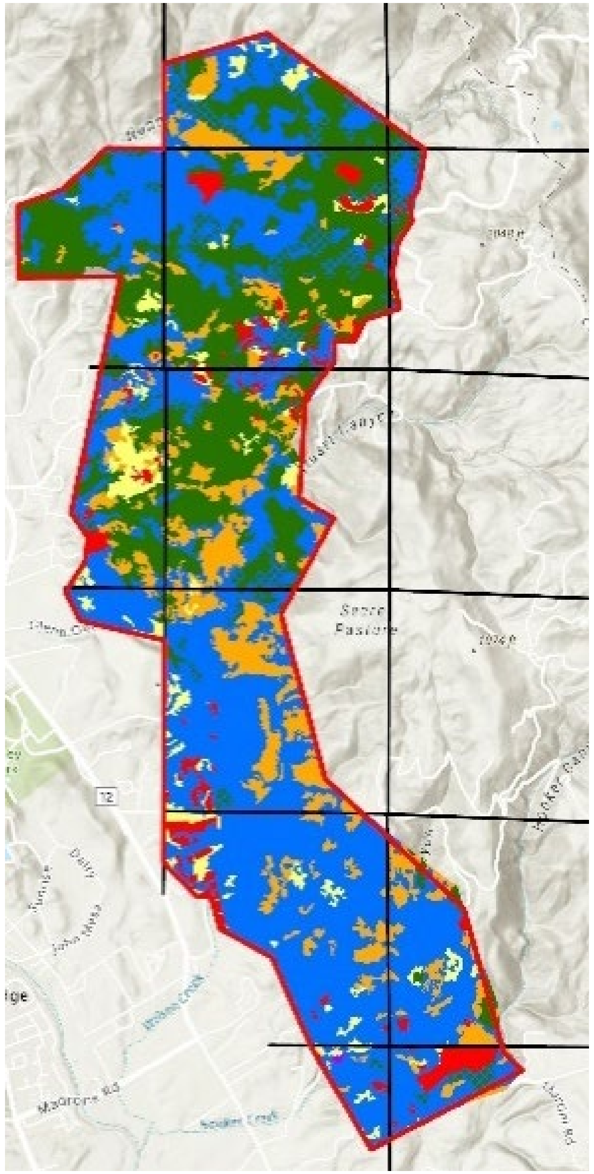


Figure 33. Sonoma-Napa FBZ Lifeform Transitions
9-49 Years Post Fire

50 YEARS Post-fire

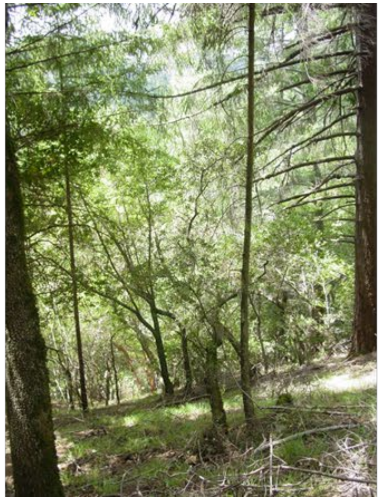
1964 >> 2014

Secret Pasture

3 YEARS Pre-Fire

2014 << 2017

Secret Pasture



1830s cultural burning (est.)

1880

1923

(1936)

1964

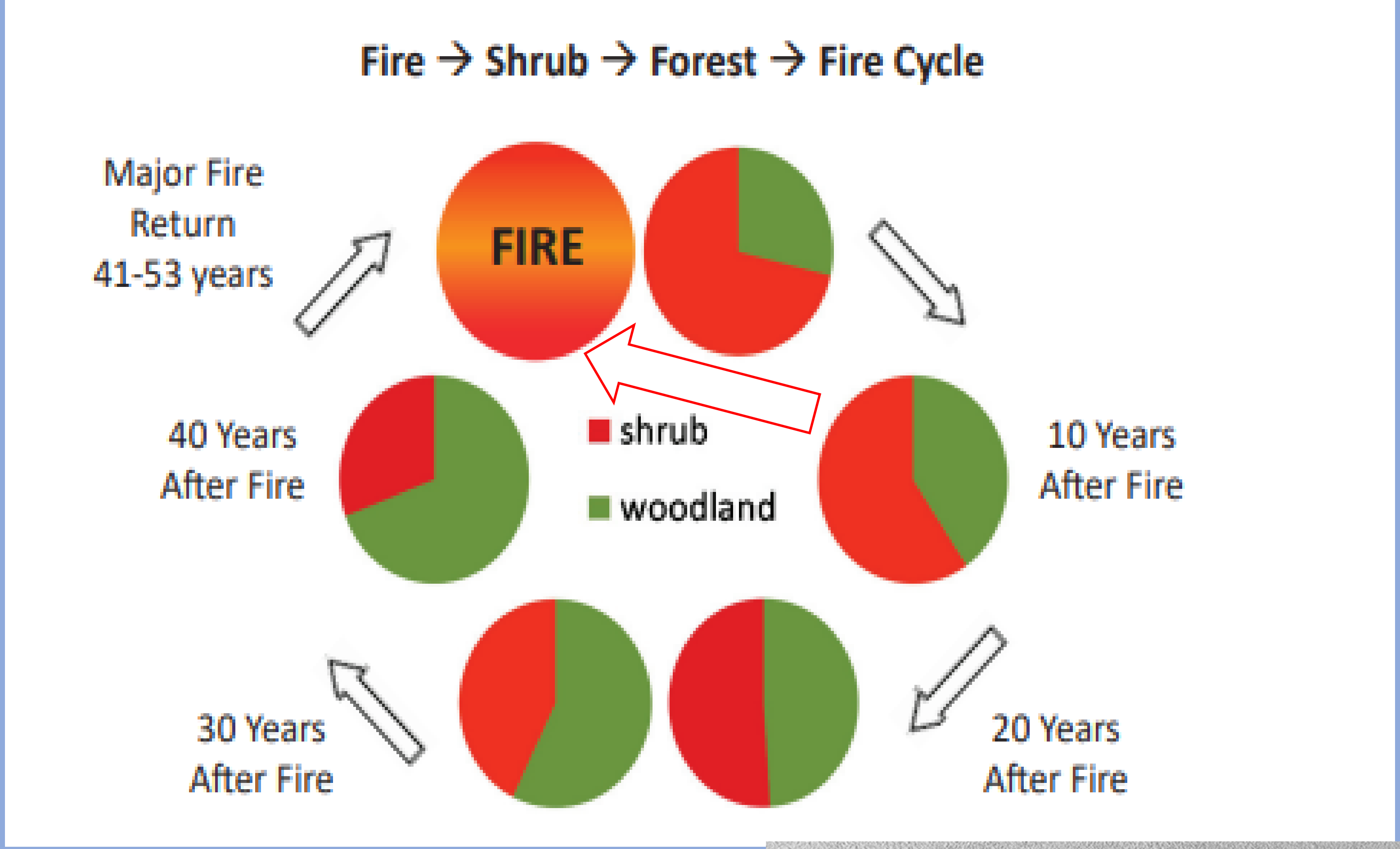
2017

“We had a fire thirty years ago [1964], burned that whole ridge down to Sonoma. The second year the grass is there, fourth year the brush is back.

…it’s pretty quick.”

—Bill Basileu, 2000

Photos from Glen Oaks Ranch, Spring 2018.
6 months after the Nunns Fire.
(Sonoma-Napa Study Area)



'Untended' cycle

Cultural burning cycle

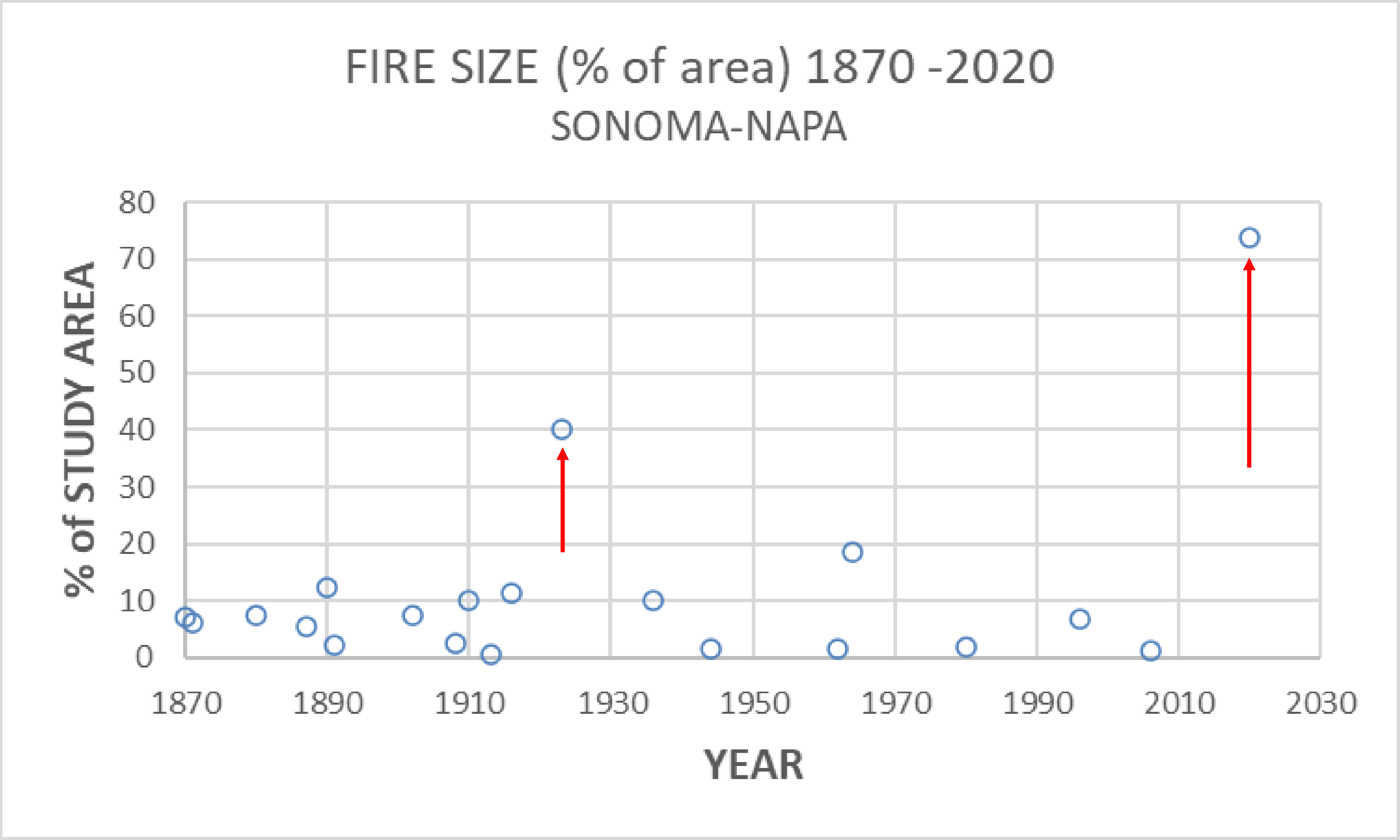
"The Douglas fir timber they say **has always encroached on the open prairies** and crowded out the other timber. They have continuously burned it and have done all they could to keep it from covering all the open lands.

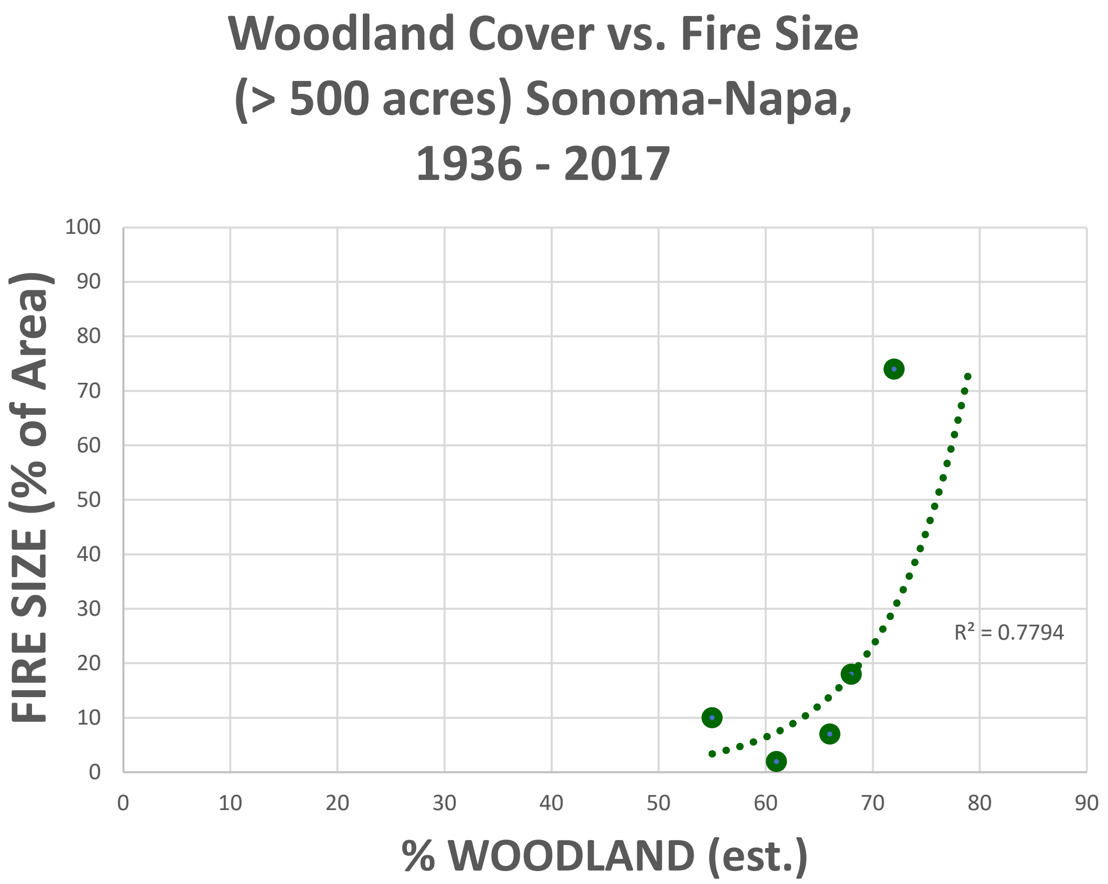
"Our legends tell when they arrived in the Klamath River country that **there were thousands of acres of prairie lands, and with all the burning** that they could do, **the country has been growing up to timber more and more.**"

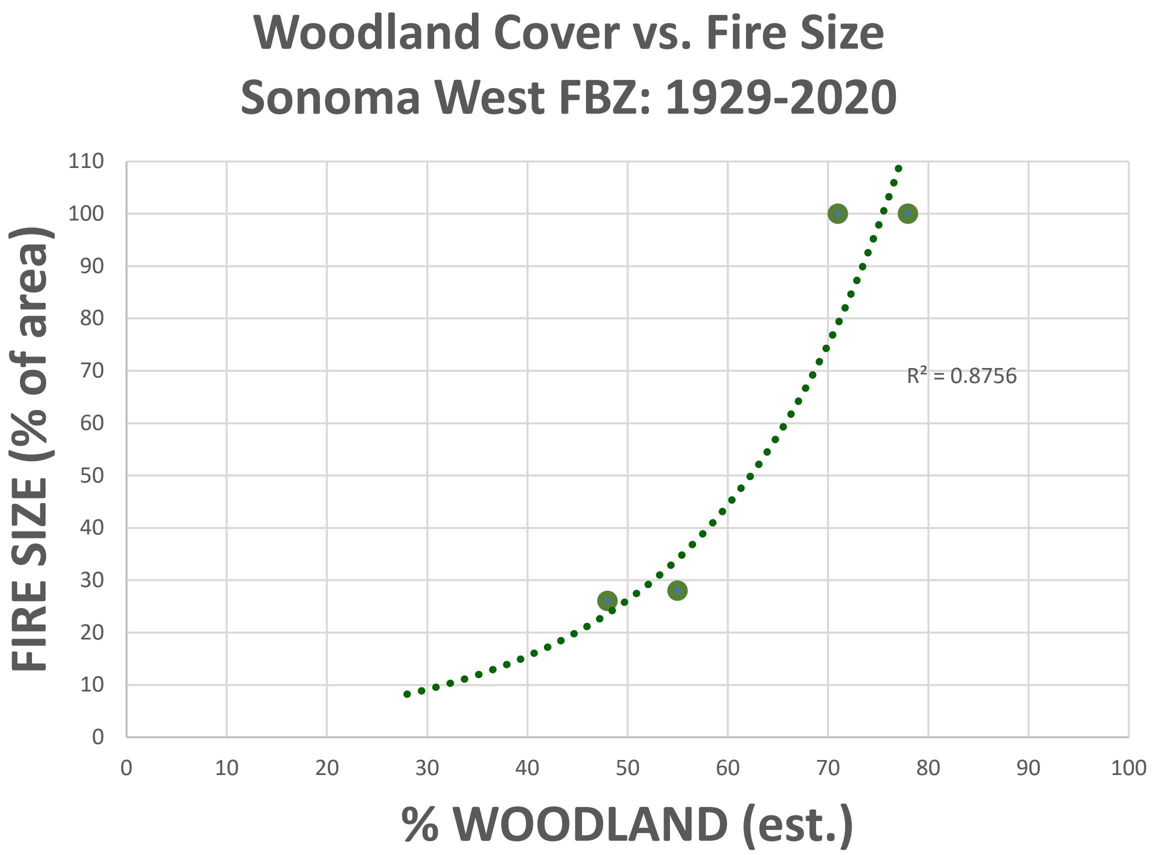
--Lucy Thompson, 1916

IS THERE A TIPPING POINT FOR CATASTROPHIC FIRE?

A small change in conditions which leads to a large change in the outcome?



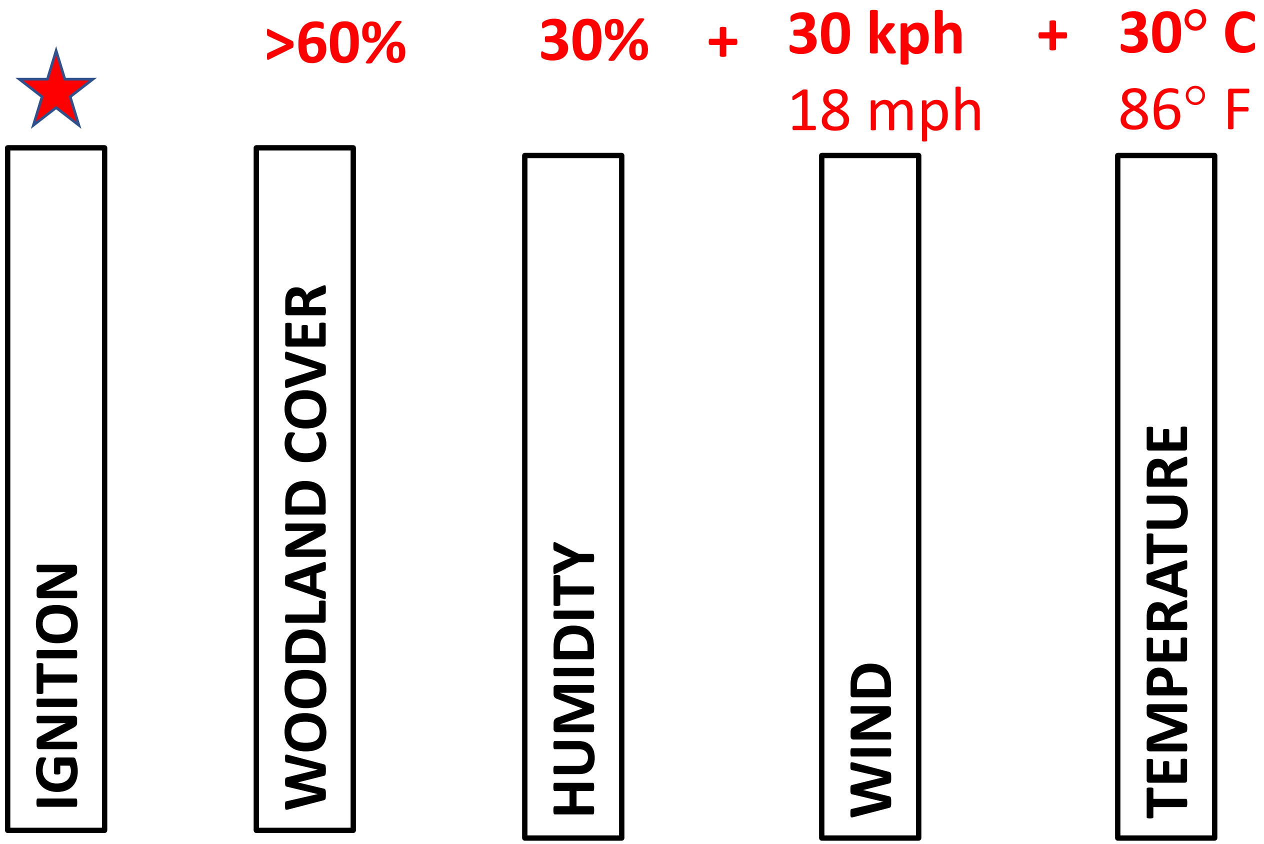

Woodland Cover vs. Fire Size (> 500 acres) Sonoma-Napa, 1936 - 2017
FIRE SIZE (% of Area)
% WOODLAND (est.)
$R^2 = 0.7794$
0
10
20
30
40
50
60
70
80
90
100
0
10
20
30
40
50
60
70
80
90


Woodland Cover vs. Fire Size Sonoma West FBZ: 1929-2020
FIRE SIZE (% of area)
% WOODLAND (est.)
$R^2 = 0.8756$
0
10
20
30
40
50
60
70
80
90
100
110
0
10
20
30
40
50
60
70
80
90
100

Possible Tipping Points

“30 - 30 - 30”

= ‘extreme fire behavior’



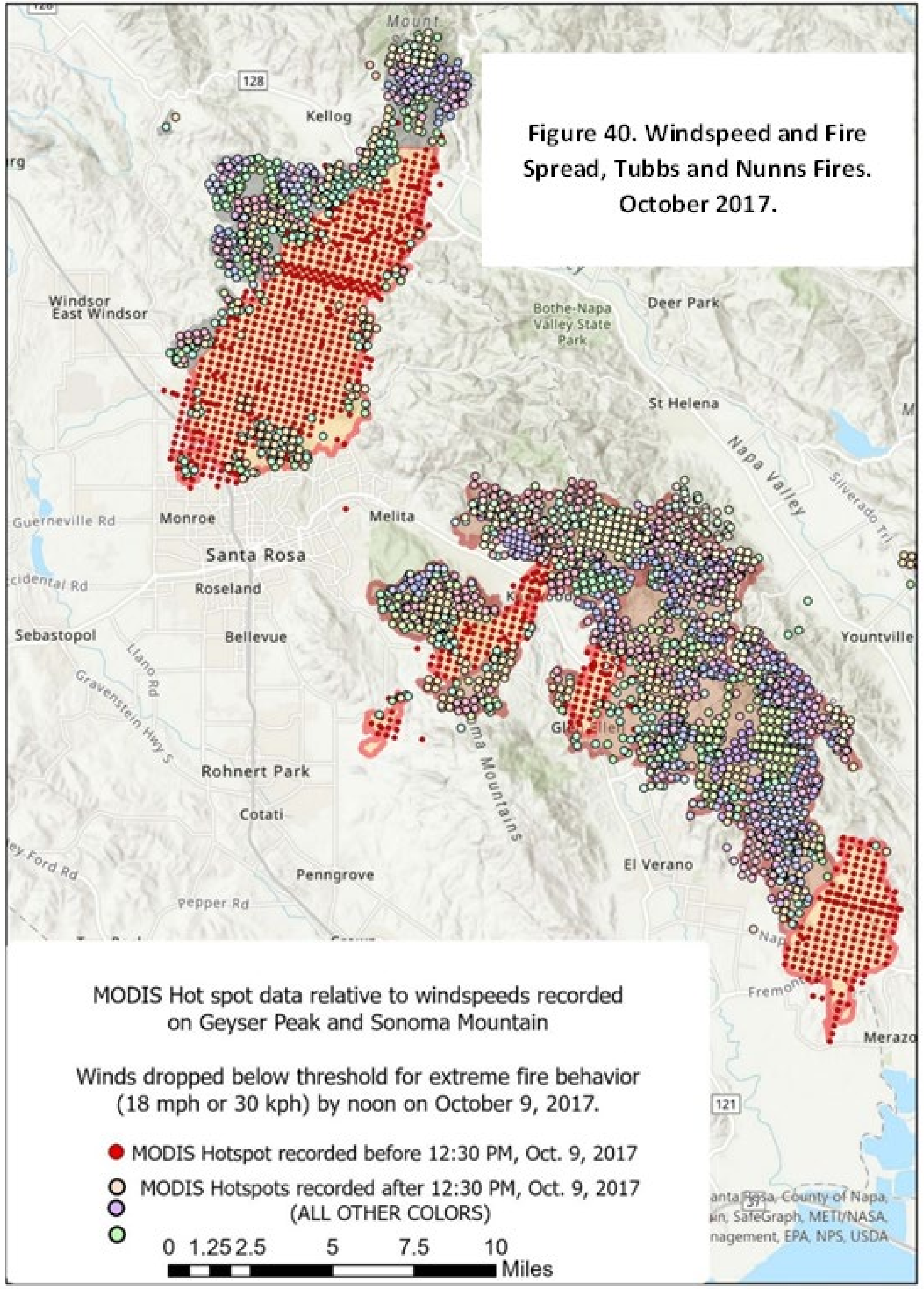


Figure 40. Windspeed and Fire Spread, Tubbs and Nunns Fires. October 2017.

Wind-driven vs. Fuel-driven Phases. ‘Sonoma Complex Fires’ October 2017			
	Wind-driven Phase	**Fuel-driven Phase**	**TOTAL**
Nunns Fire	**23%** 12,586 acres	**77%** 42,260 acres	**100%** 54,846 acres
Tubbs Fire	**68%** 24,740 acres	**32%** 11,748 acres	**100%** 36,488 acres
TOTAL	**41%** 37,326 acres	**59%** 54,008 acres	**100%** 91,334 acres

Estimated Woodland Cover on the Eve of Catastrophic Fires

		Within perimeter in 1993:
GLASS, 2020:	**76%**	62%
WAHLBRIDGE, 2020:	**86%**	72%
KINCAID, 2019:	58%	45%
NUNNS, 2017	**69%**	57%
TUBBS, 2017	**66%**	54%
VALLEY, 2015	**88%**	79%

The relationship between woodland cover and fire size suggests a tipping point for very large, potentially catastrophic fires at around 60 – 75 % woodland cover.

A few takeaways

- **Vegetation patterns are dynamic and repeat over time**
  Woodland and shrub proportions shift rapidly

- **The fastest vegetation changes occur in the most fire-prone places**

- **Douglas fir has vastly expanded in area and elevation range**

- **A possible tipping point for catastrophic fires at ~60% woodland cover**

In appreciation, (a very incomplete list):

INDIVIDUALS

120+ General Land Office surveyors & assistants
Alfred Wieslander & Vegetation Type Map teams
Amber Manfree
Clint McKay
Danny Franco
David Ackerly
Edward Redbird Willie
Jeanne Wirka
Jim Thorne
Judy Talaugon
Kim Batchelder
Lisa Micheli
Journalists (many)
Mark Tukman
Monica Delmartini
Morgan Gray
Penny Sirota
Rand Evett
Sara Moncada
Sasha Berleman
Sherry Adams
Soil-Veg surveyors & cartographers
Steve Barnhart
Steven Swain
Tosha Comendant

CAL FIRE

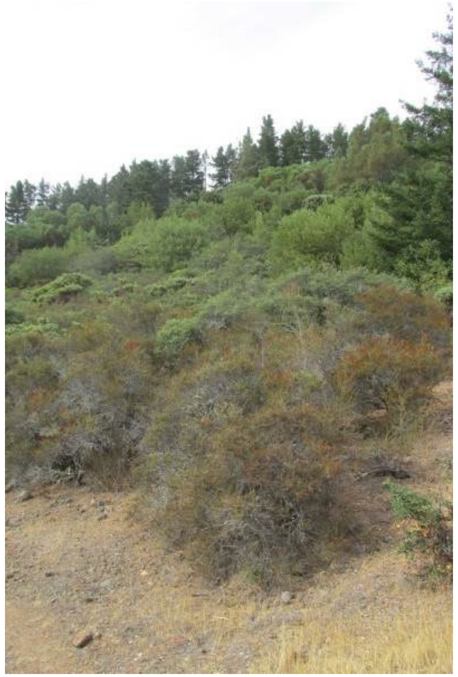
Pepperwood Preserve
Inspiring conservation through science

Tukman Geospatial LLC
Digital Mapping

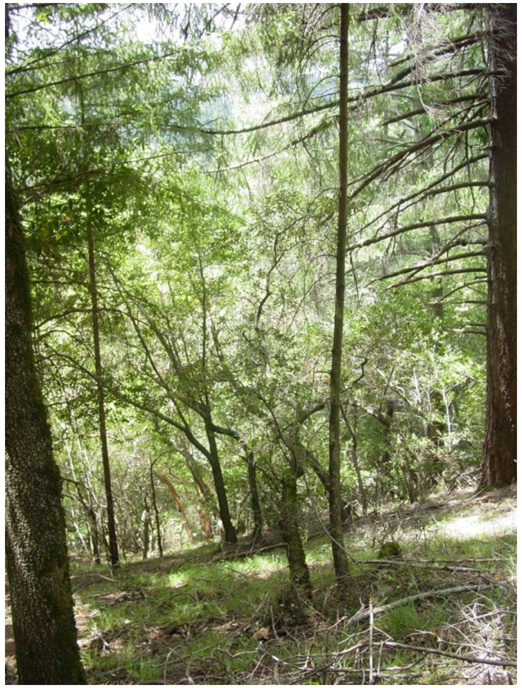
Thorne Environmental Landscape Analysis

INSTITUTIONS & ORGANIZATIONS

Audubon Canyon Ranch
Bureau of Land Management
California Department of Fish & Wildlife
County of Sonoma
Golden Gate National Parks Conservancy
Heron Shadow
Pepperwood Preserve
Sonoma County Forest Conservation Working Group
Sonoma Ecology Center
U.S. Forest Service
U.S. Soil Service
University of California, Berkeley
University of California, Davis



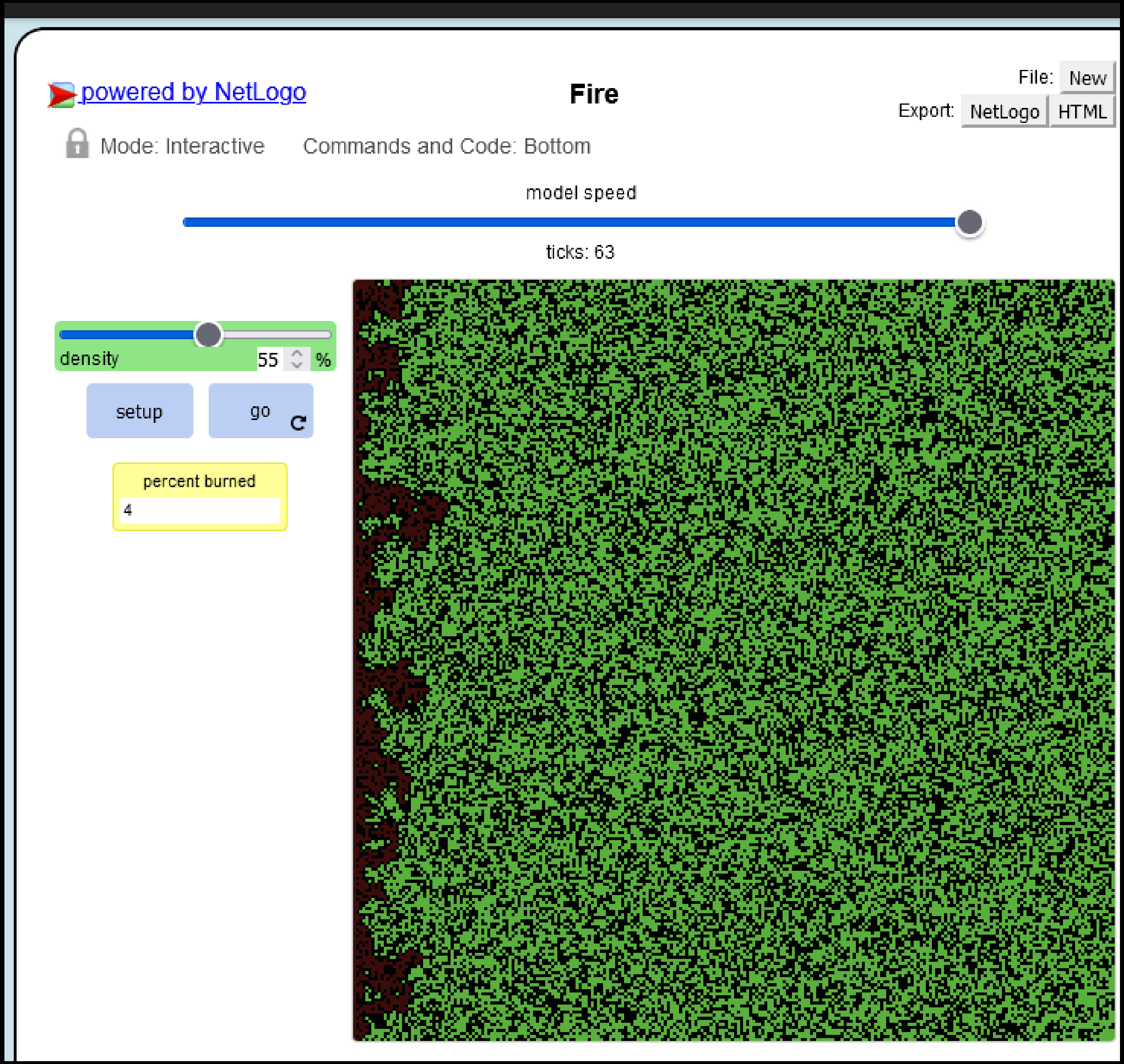
How does the land look when it's well tended?

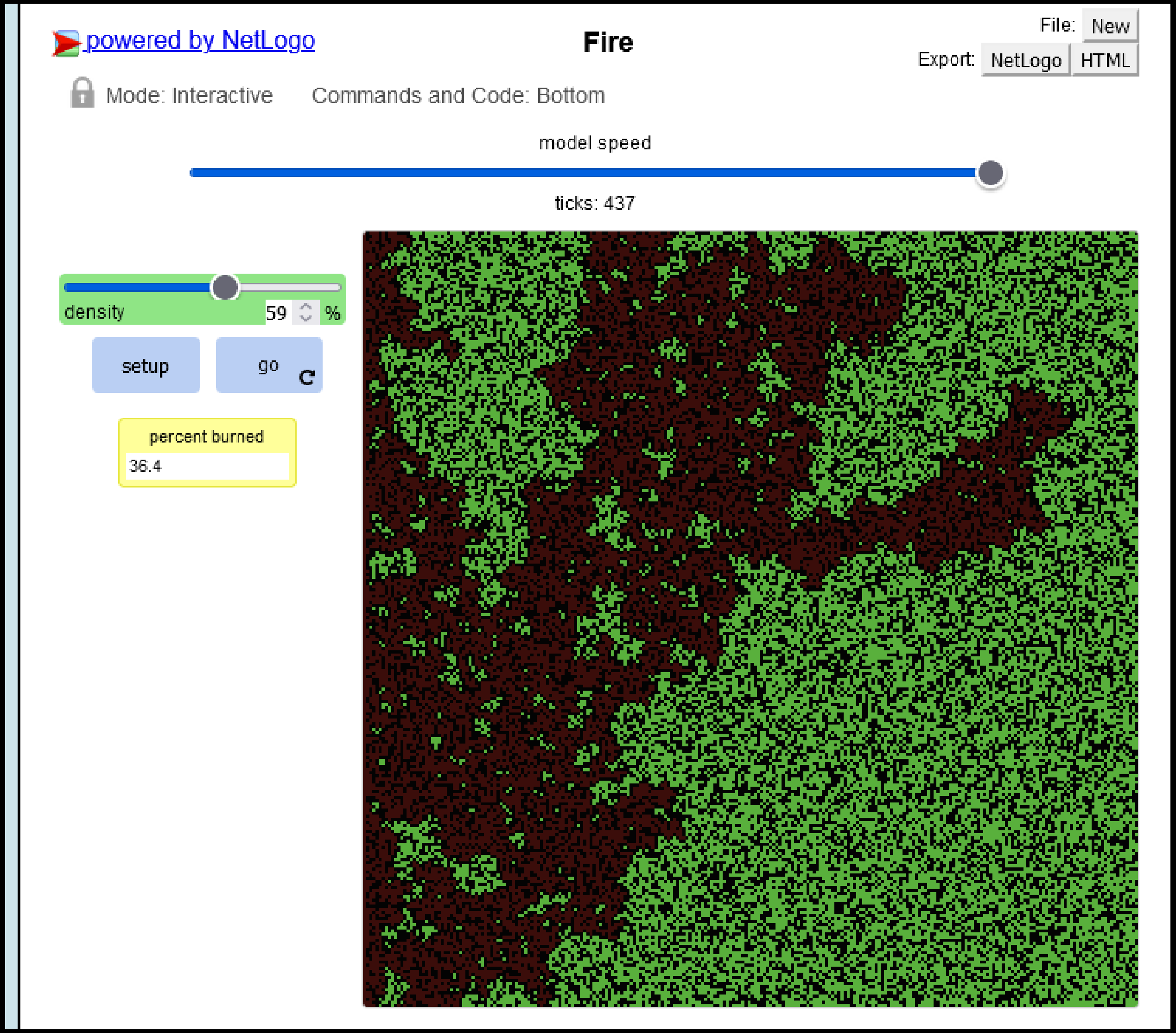


Arthur Dawson, baseline@vom.com
(707) 996-9967

Baseline Consulting

55%


powered by NetLogo
Fire
File: New
Export: NetLogo HTML
Mode: Interactive
Commands and Code: Bottom
model speed
ticks: 63
density 55 %
setup
go
percent burned
4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Fire
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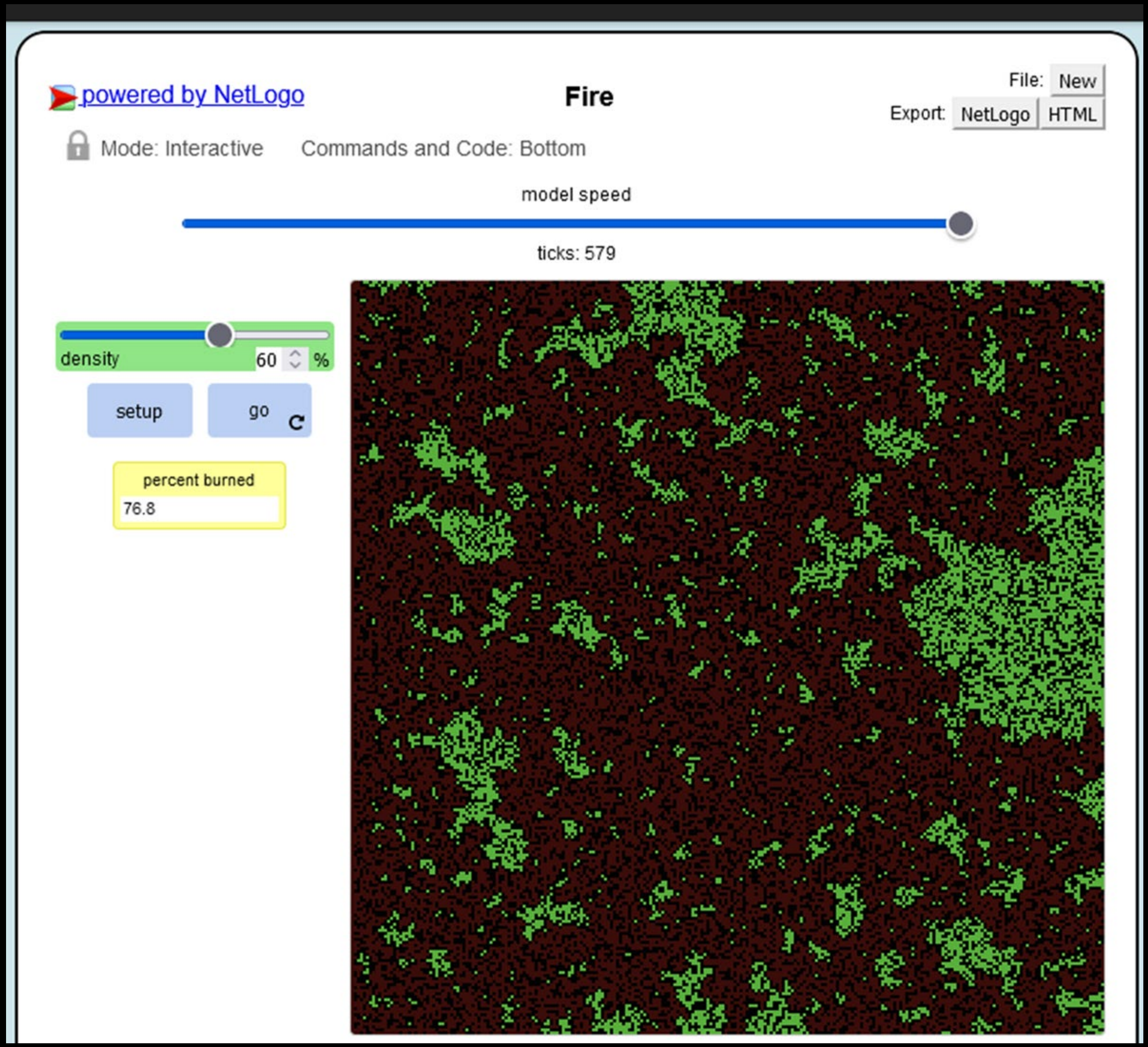
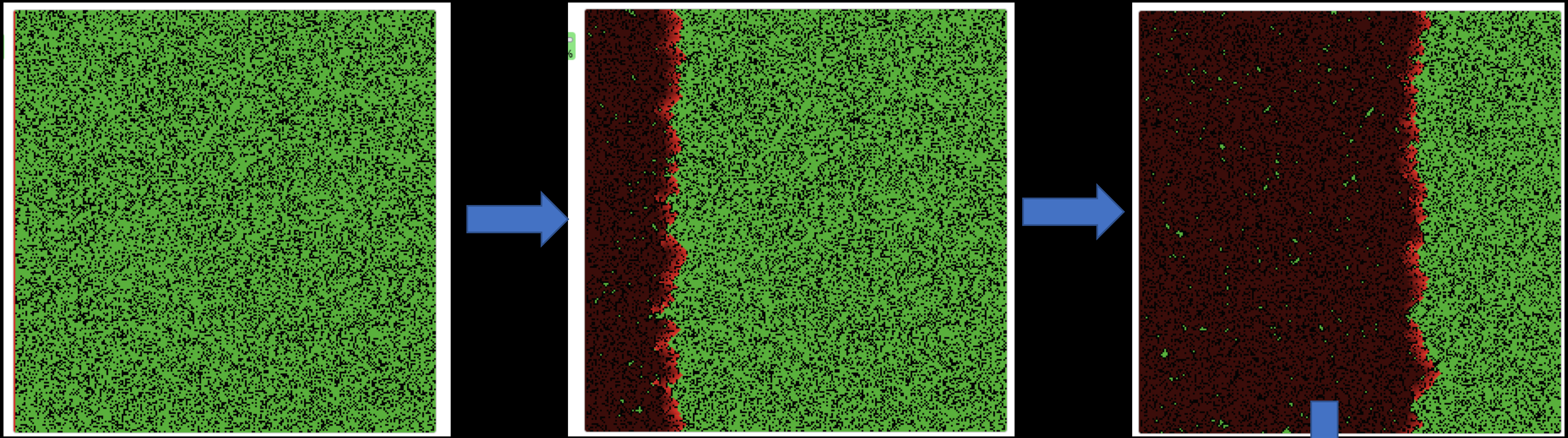
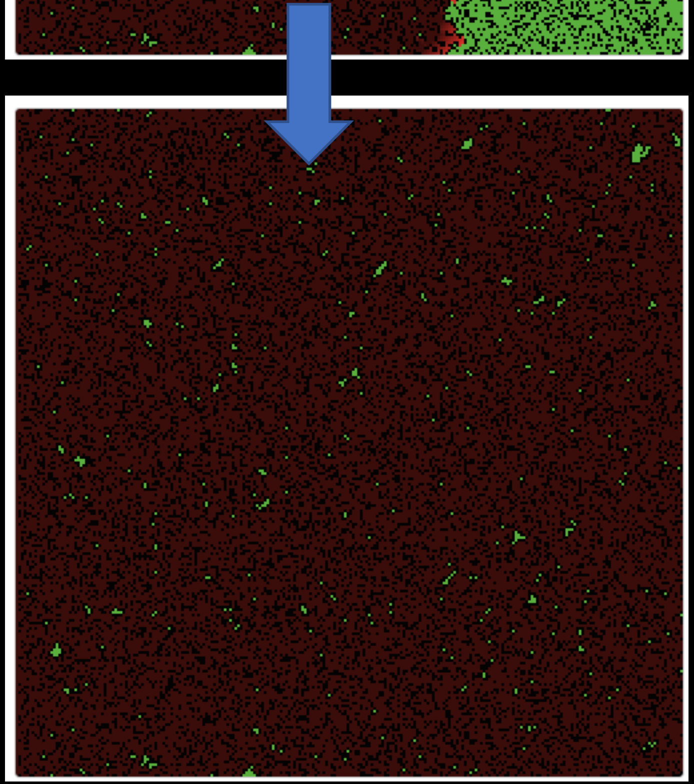
model speed
ticks: 437
density
59
%
setup
go
percent burned
36.4


powered by NetLogo
Fire
File: New
Export: NetLogo HTML
Mode: Interactive
Commands and Code: Bottom
model speed
ticks: 579
density
60
%
setup
go
percent burned
76.8

59%

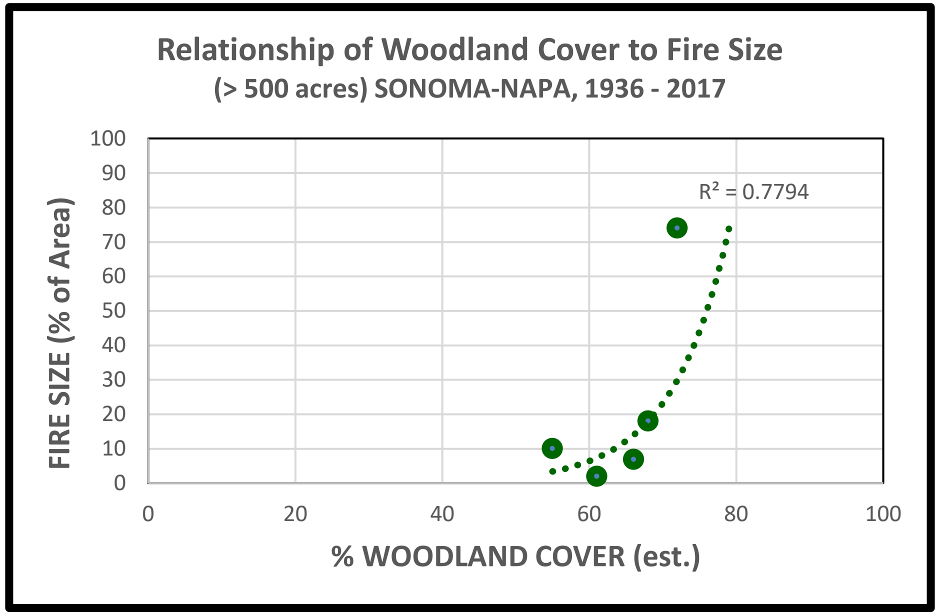
60%

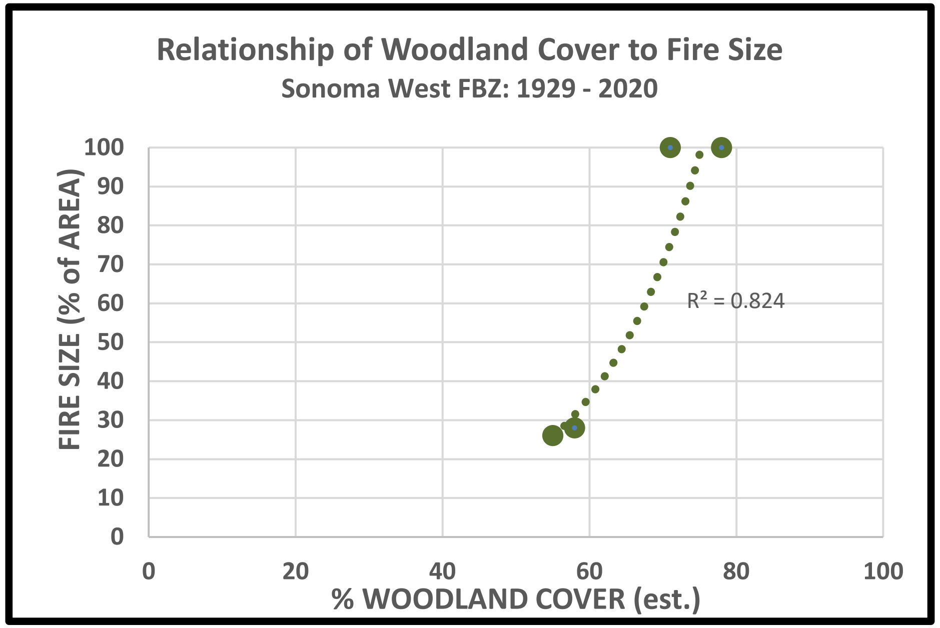


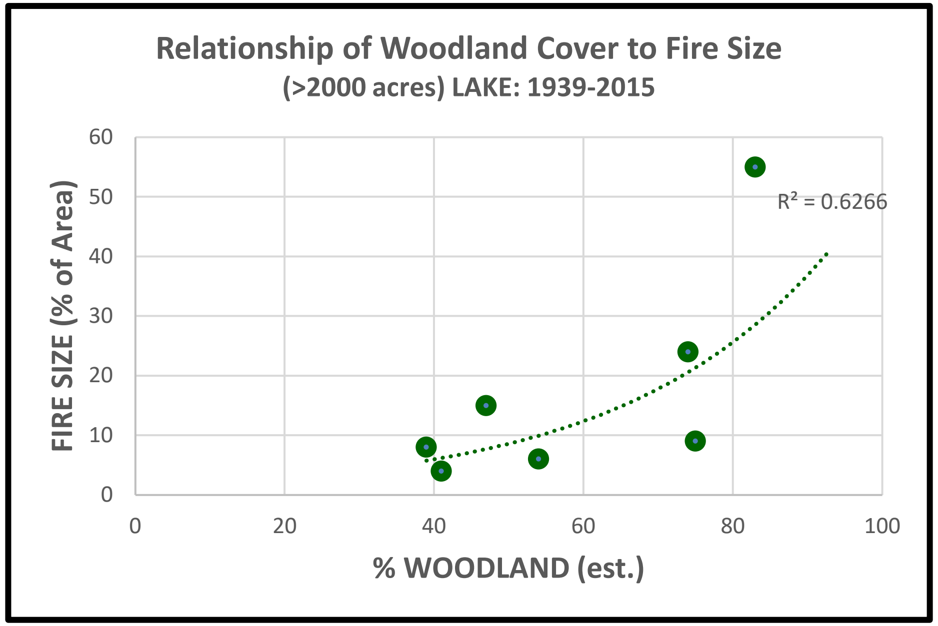


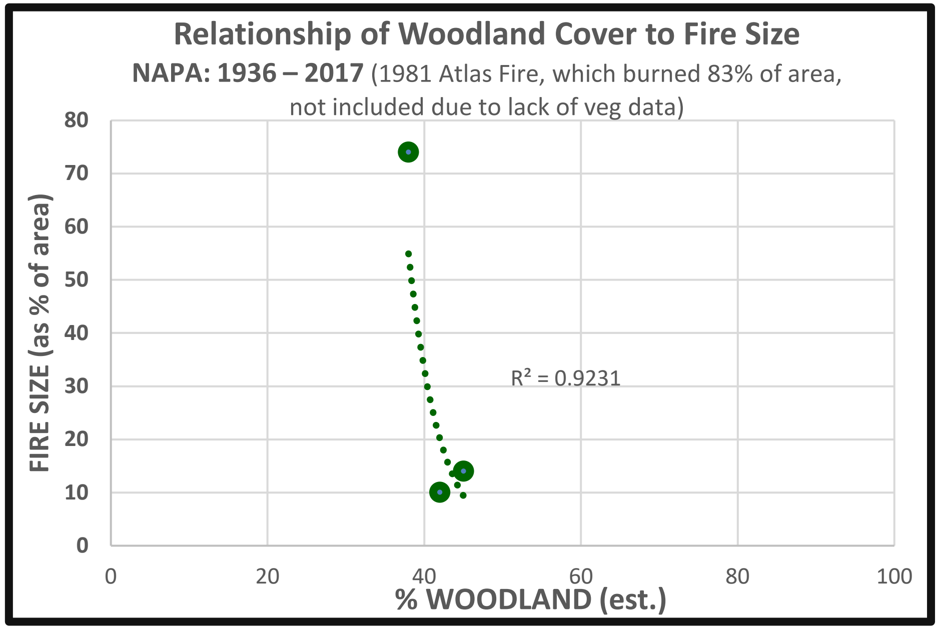
69%

% Woodland = a Possible Tipping Point for Catastrophic Fire







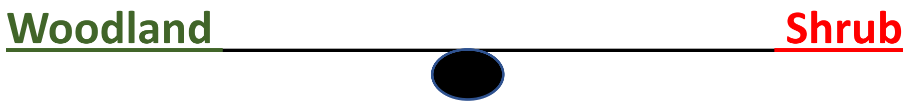


Except in Napa!

“Percolation theory can provide new insights into fire prevention measures that may ultimately help to control the spread of wildfires across the landscape.”

Duane et. al. 2021. “Forest connectivity percolation thresholds for fire spread under different weather conditions.” *Forest Ecology and Management*

POST-DISTURBANCE VEGETATION CHANGE
Long-term Annual Averages



	Woodland	Shrub
SONOMA WEST FBZ	+0.9%	-0.8%
SONOMA-NAPA FBZ	+1.3%	-1.5%
SONOMA WEST LOGGING	+0.3%	0%
LAKE FBZ	+0.8%	-0.7%
NAPA FBZ	+0.04%	+0.04%

“[the hills] were soon to be burned of the long grass by the Indians we met . . . **the place is bare of thick woods**.”

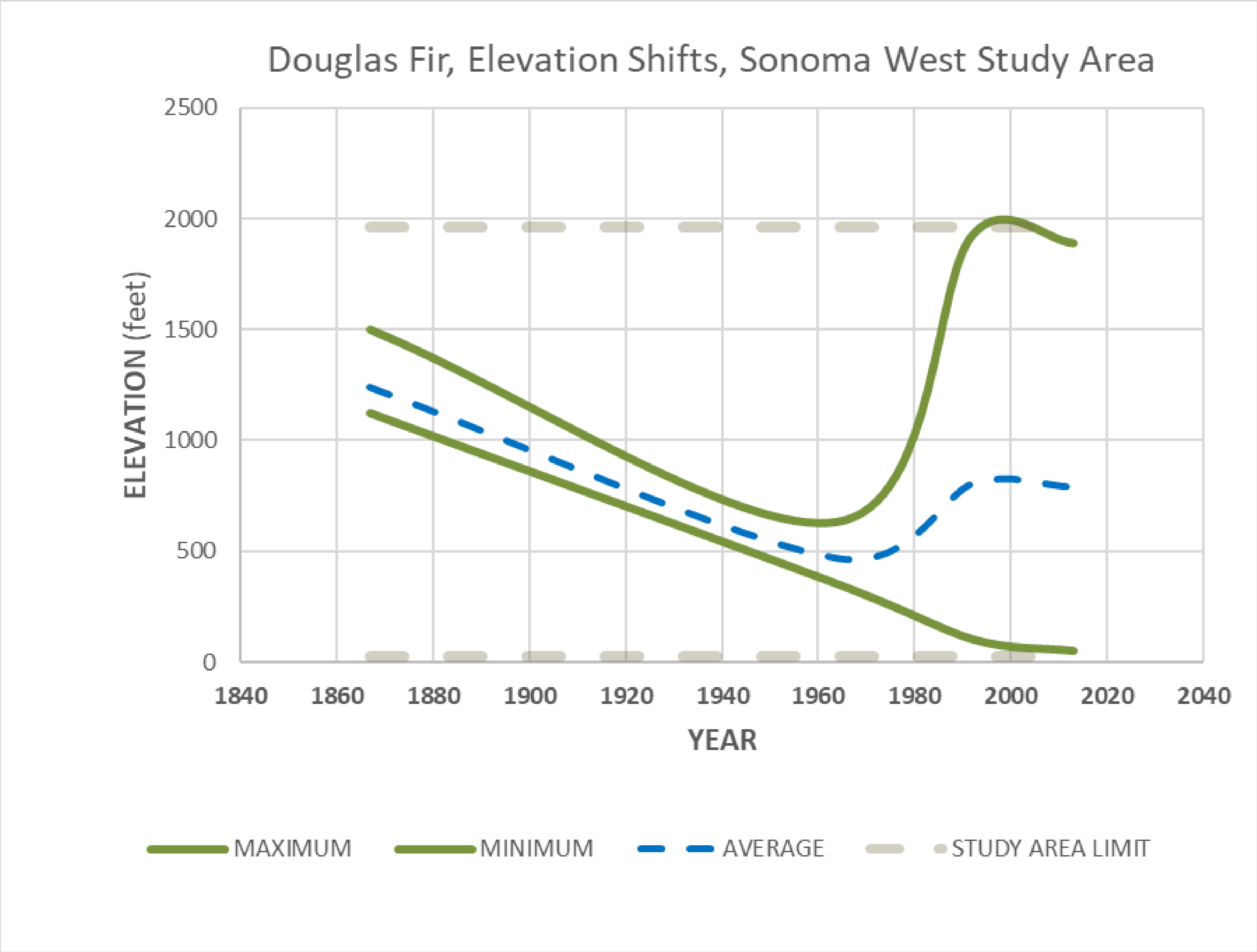
Father Jose Altimira, 1823

CALFIRE PERIMETER MAPS: 1940s - 2020

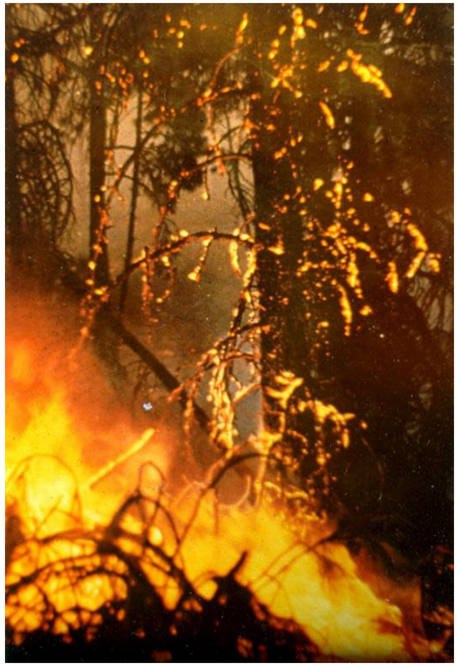
NEWSPAPERS & OTHER NARRATIVES: 1870s – 1940s

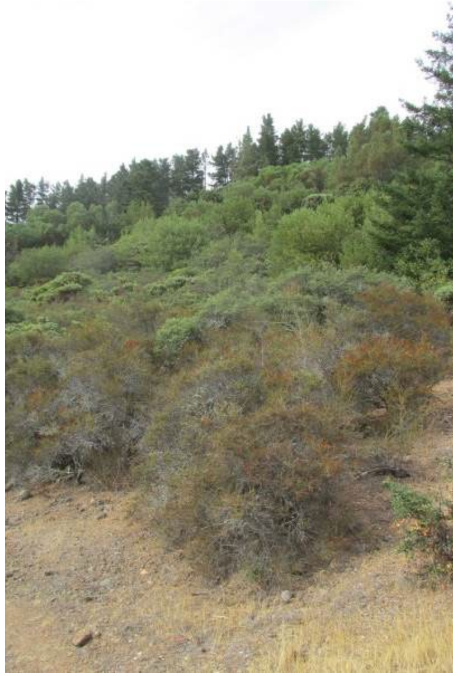
COUNTY MAPS: 1870s – 1930s

CONFIDENCE LEVELS: High, Medium, Low
for Location & Extent for each mapped fire



Douglas Fir, Elevation Shifts, Sonoma West Study Area
ELEVATION (feet)
2500
2000
1500
1000
500
0
1840
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040
YEAR
MAXIMUM
MINIMUM
AVERAGE
STUDY AREA LIMIT



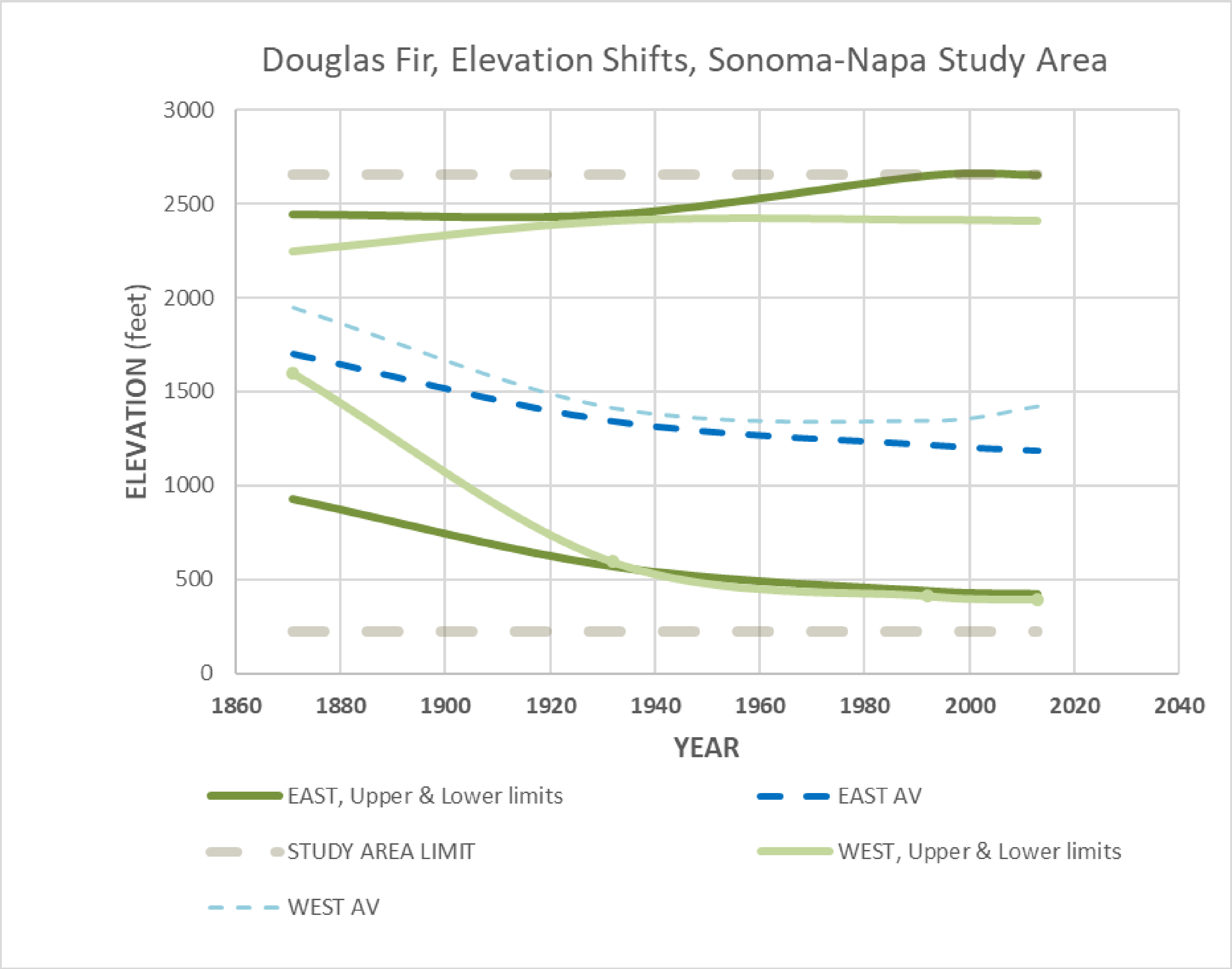


1880

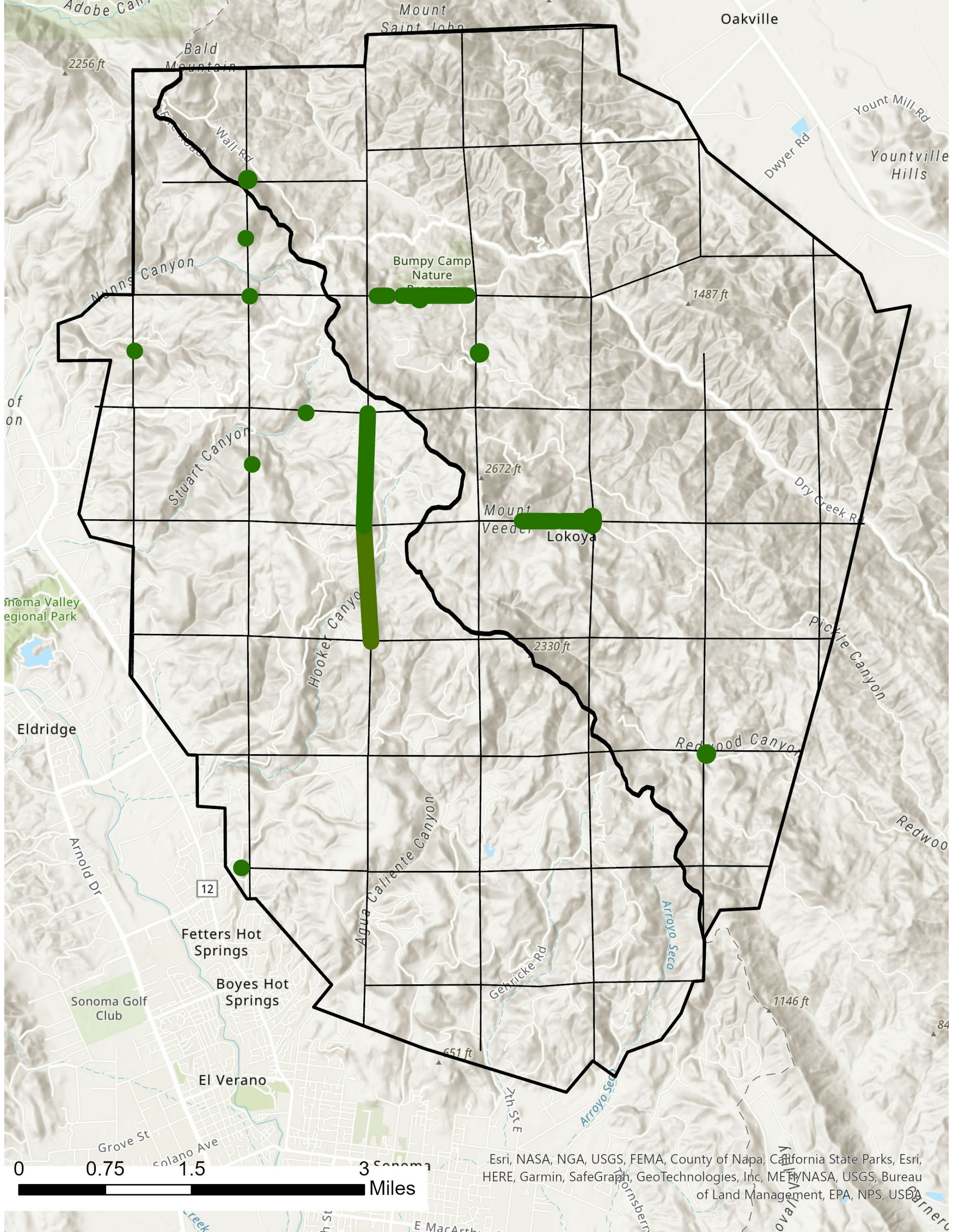
1923

1964

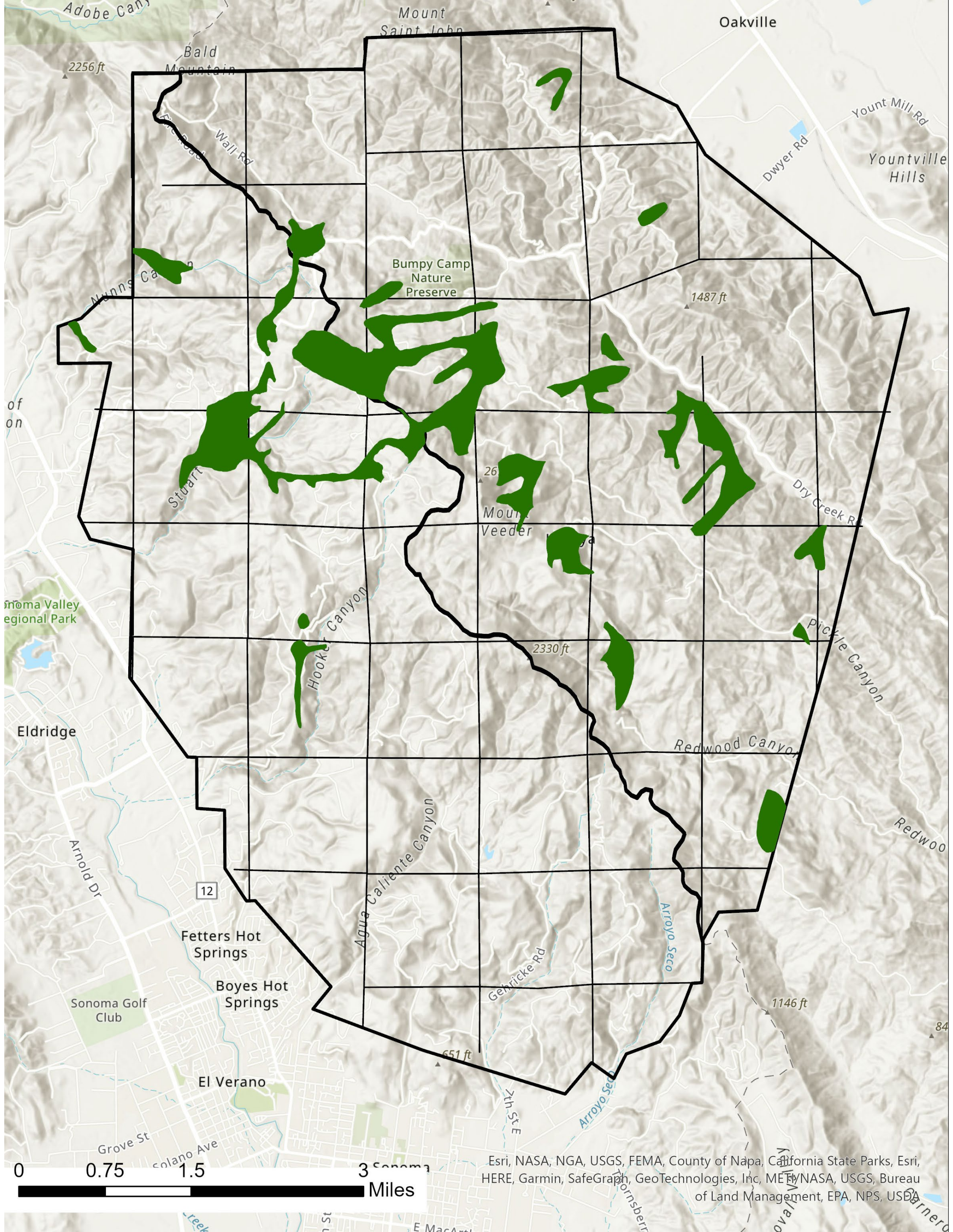
?



Douglas Fir, Elevation Shifts, Sonoma-Napa Study Area
3000
2500
2000
1500
1000
500
0
ELEVATION (feet)
1860
1880
1900
1920
1940
1960
1980
2000
2020
2040
YEAR
EAST, Upper & Lower limits
EAST AV
STUDY AREA LIMIT
WEST, Upper & Lower limits
WEST AV


Oakville
Mount Saint John
Bald Mountain
2256 ft
Yount Mill Rd
Dwyer Rd
Yountville Hills
Nunns Canyon
Bumpy Camp Nature
1487 ft
Stuart Canyon
2672 ft
Mount Veeder
Lokoya
Dry Creek Rd
Sonoma Valley Regional Park
Hooker Canyon
2330 ft
Pickle Canyon
Eldridge
Redwood Canyon
Agua Caliente Canyon
Arroyo Seco
12
Fetters Hot Springs
Boyes Hot Springs
Sonoma Golf Club
Gehricke Rd
1146 ft
651 ft
El Verano
Grove St
Solano Ave
7th St E
0 0.75 1.5 3 Miles
Esri, NASA, NGA, USGS, FEMA, County of Napa, California State Parks, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

c. 1872


Oakville
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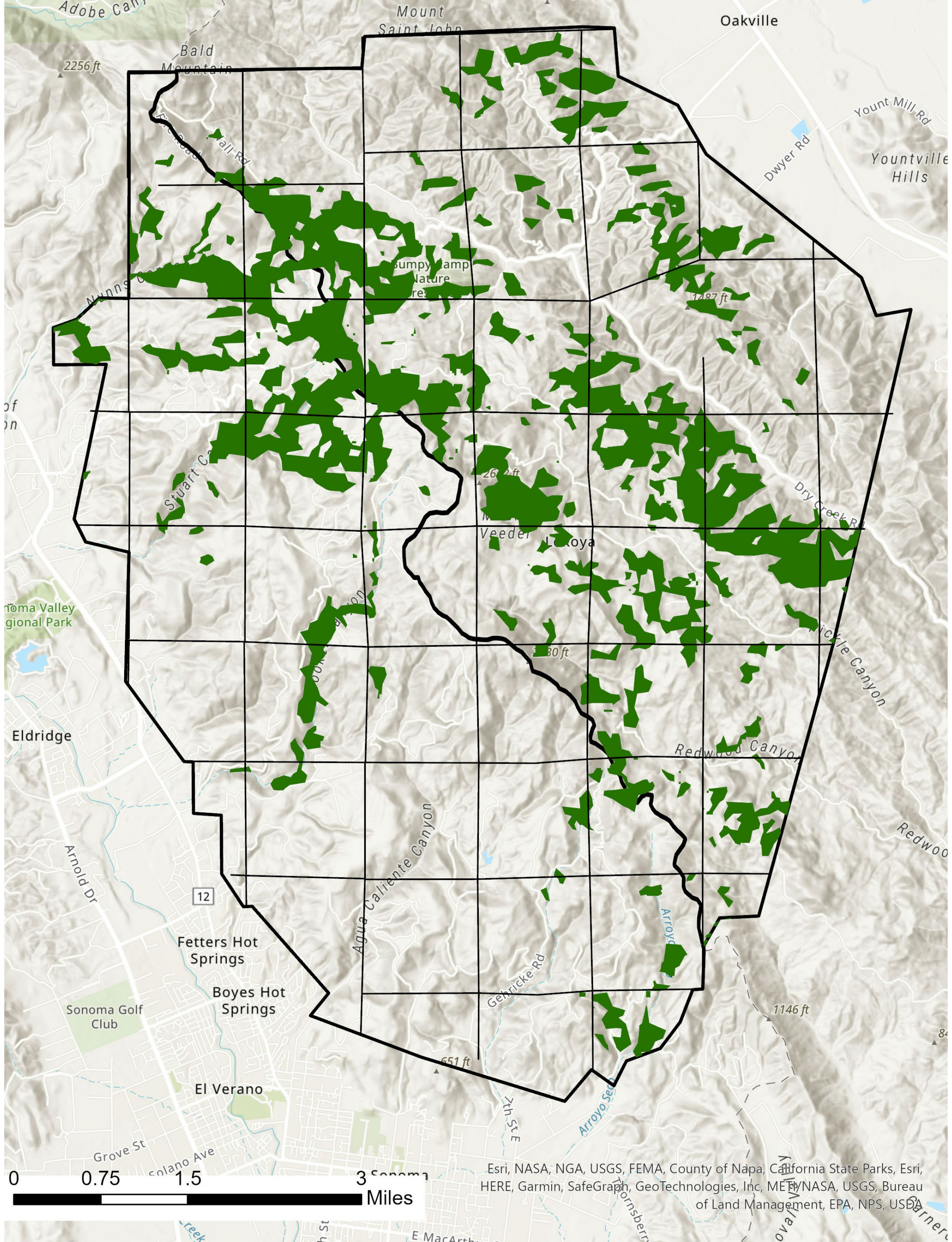
1932



Oakville
Yountville Hills
Bald Mountain
Mount Saint John
Eldridge
Fetters Hot Springs
Boyes Hot Springs
El Verano
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Redwood Canyon
Dry Creek Rd
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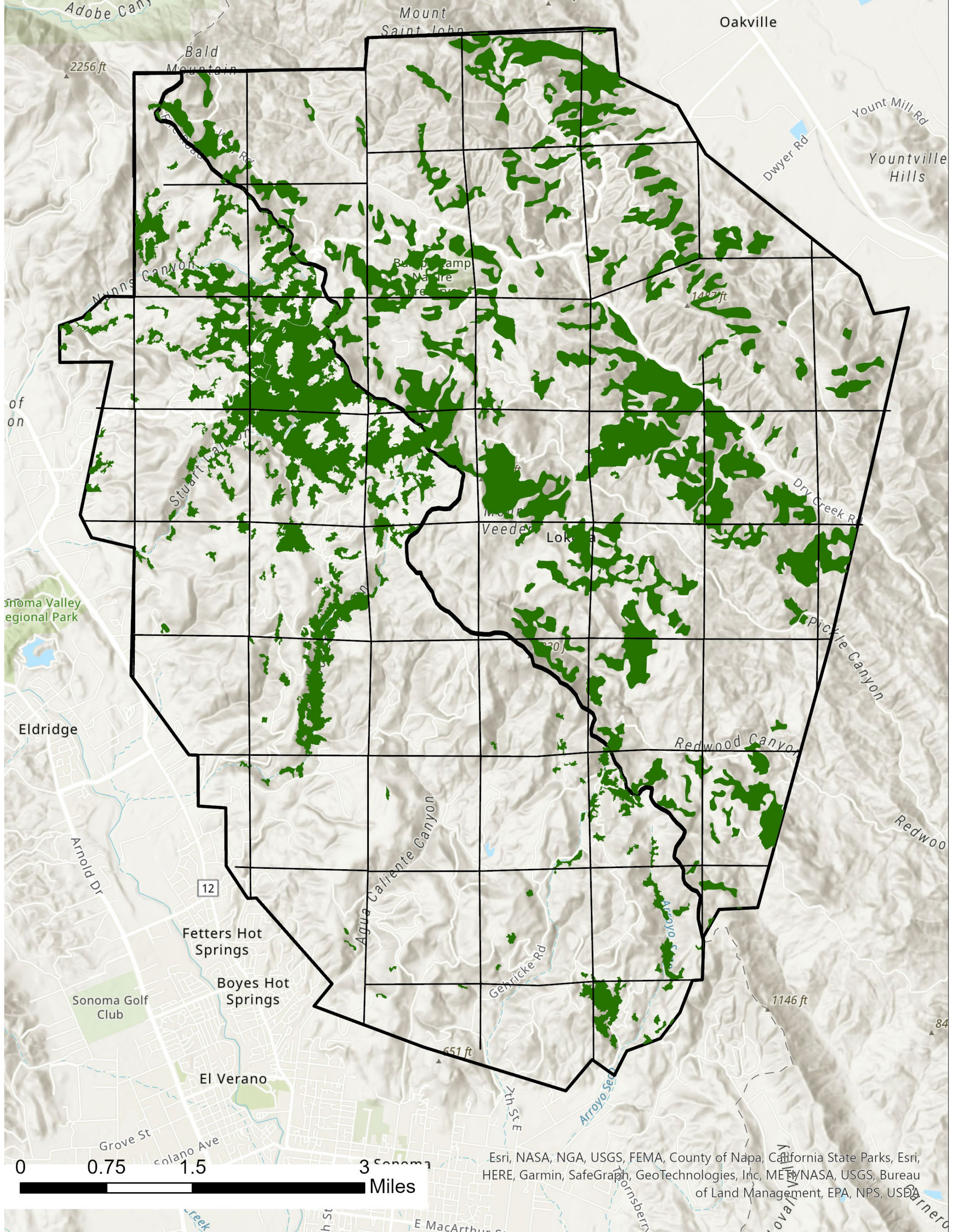
Esri, NASA, NGA, USGS, FEMA, County of Napa, California State Parks, Esri, HERE, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA

1993



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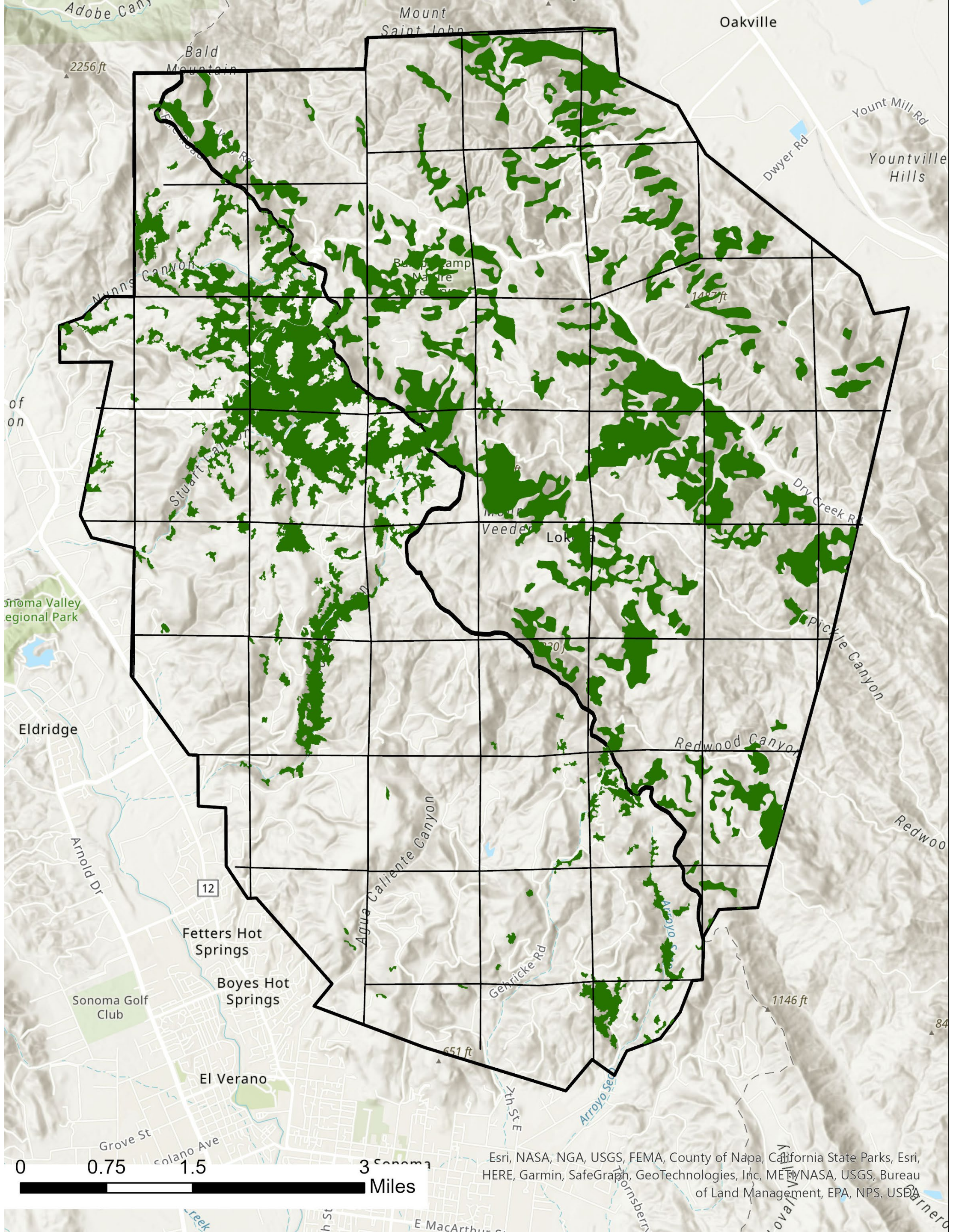
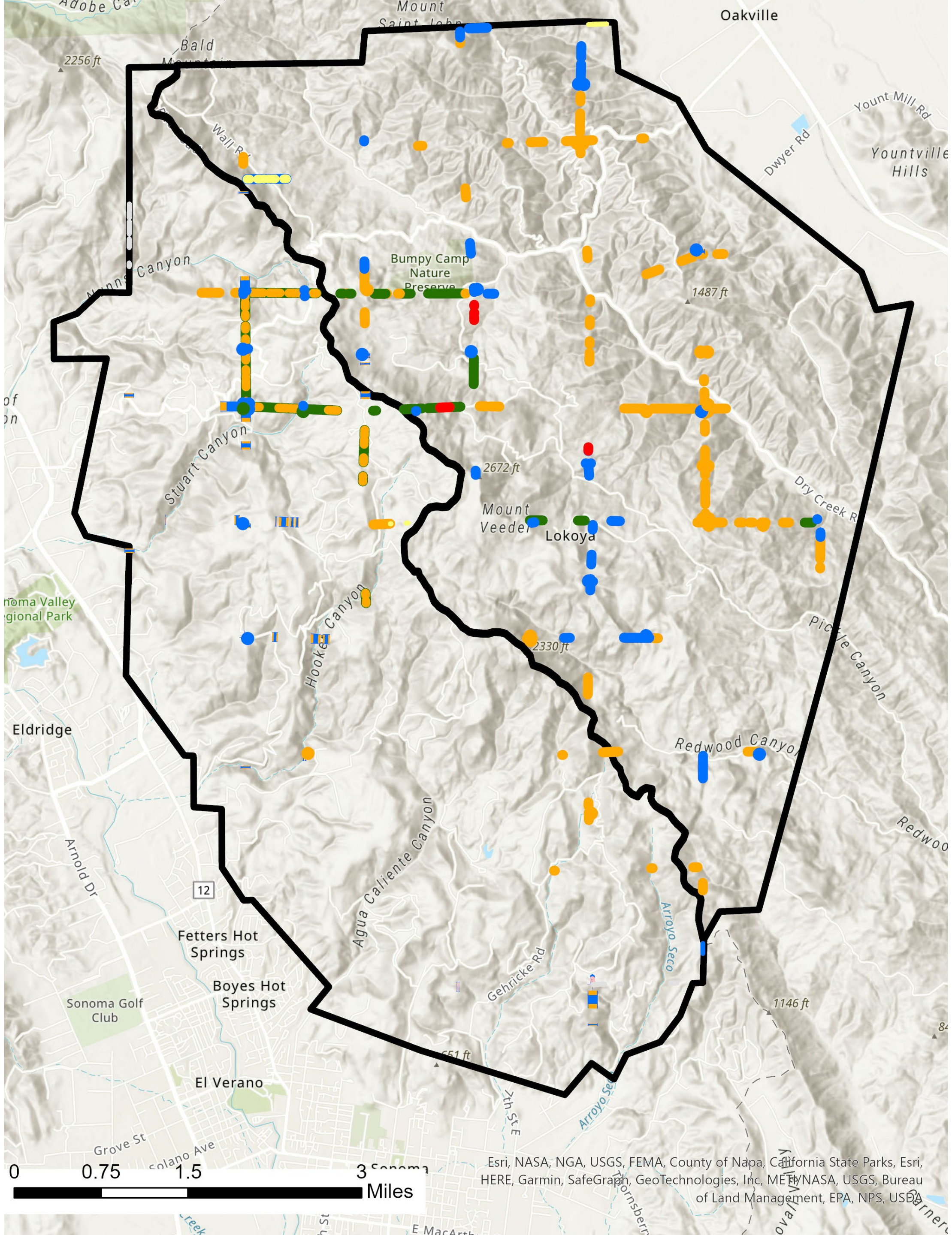
2013/2016



2013/2016

What did the Douglas fir replace?



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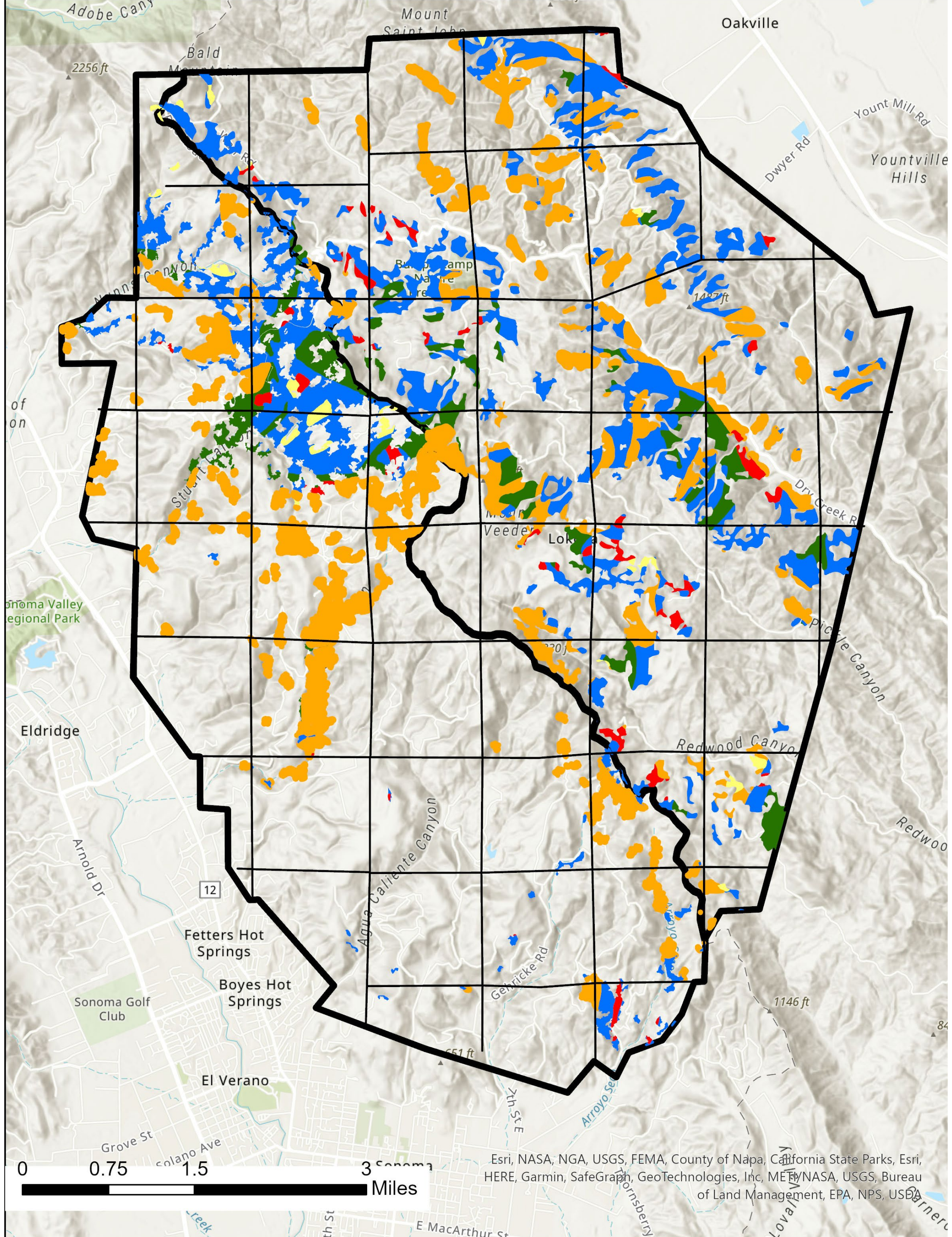
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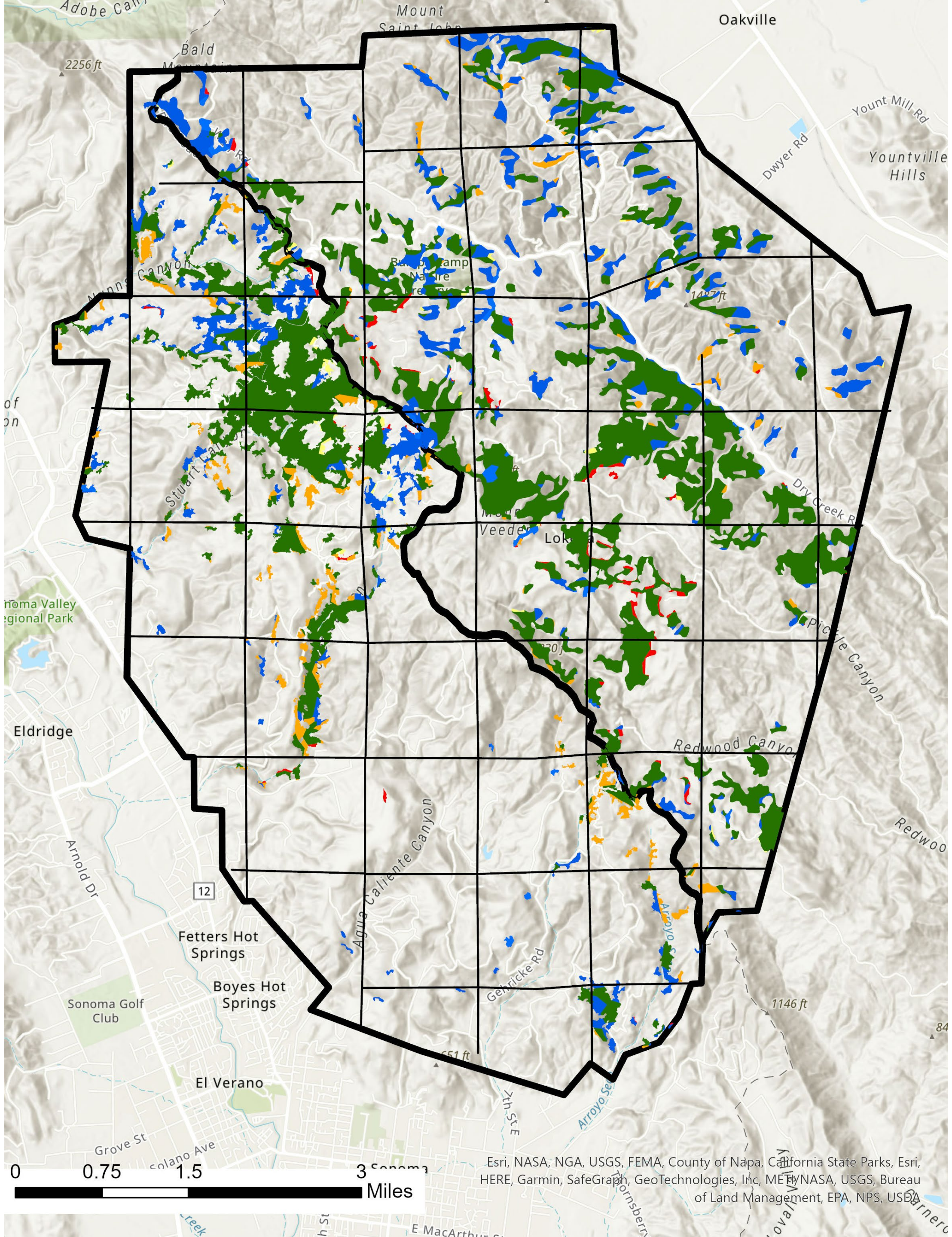
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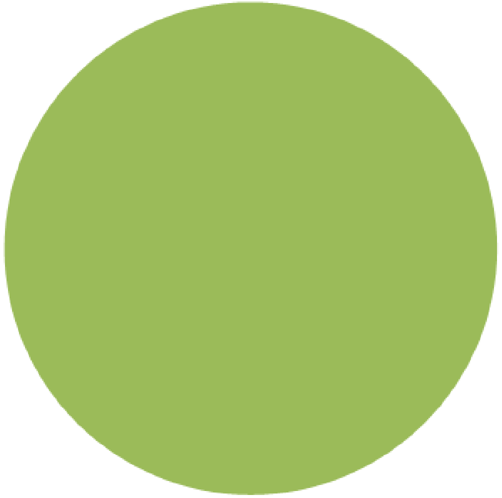
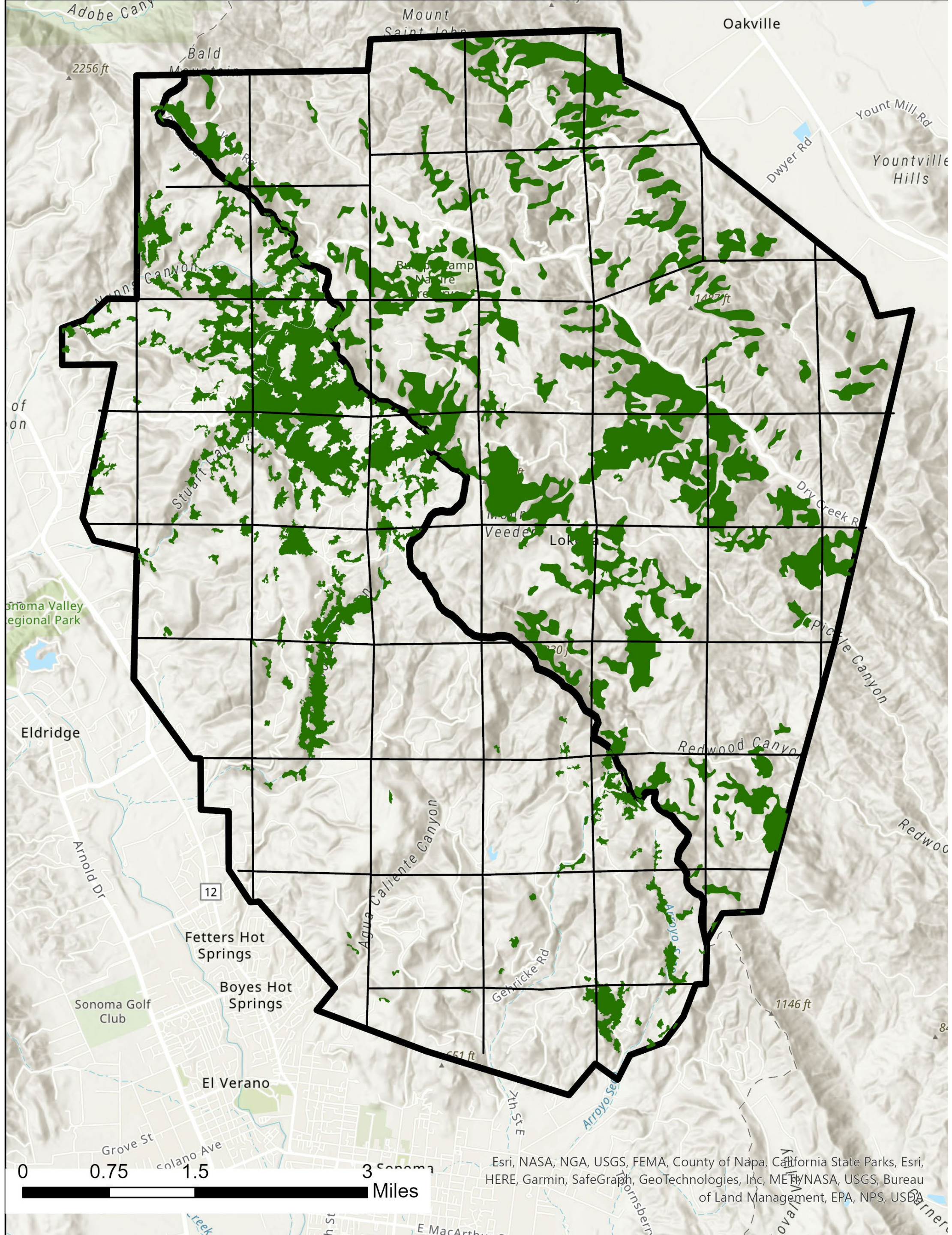


100% Douglas fir Alliance

Increased:

2x in 20 years
7x in 80 years
13x in 140 years

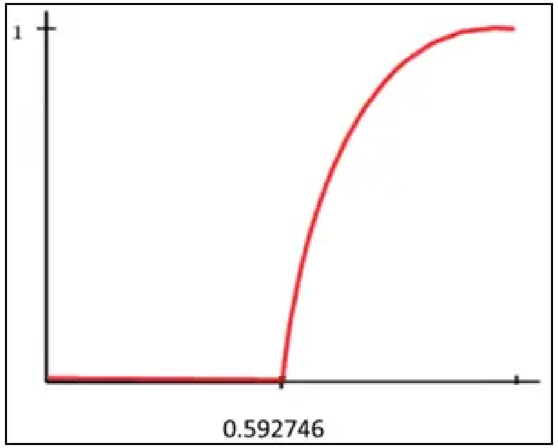


2013/2016

Glass Fire Impacts

- Human community impacts
- **Extensive tree mortality in Douglas-fir dominated areas**
- Ladder-fuel-driven mortality
- Compounded stress due to drought
- Invasive species response

Woodland cover increases linearly as Fire size increases exponentially



Percolation Theory

"The risk of catastrophic fire does not increase in a linear relationship with the density of the forest. Instead there is a tipping point at about 59% density."

- Tipping points are **not easily predictable.**
- Once triggered, **there is no way to reverse them.**
- Events that occur when a system passes through a tipping point are **usually dramatic, proceed at a high rate, and have no forewarning.**
- **Understanding the actual causes behind tipping points is important for designing preventive measures.**

Adapted from: 'Growth, Delays and Tipping Points' by Mark Fedkin, College of Earth and Mineral Sciences, Pennsylvania State University