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Prioritizing Lightning Ignitions in Yosemite National Park with a Biogeophysical and Sociopolitically Informed Decision Tool

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Abstract

Entering the 2014 fire season, managers in Yosemite National Park had cautious optimism while the rest of California had an exceptional drought on their minds. That, coupled with memories of the 2013 Rim fire, gave reason for cautiousness. However, optimism was due, in part, to the park's successful management of lightning ignitions since 1972, including 2012 and 2013 when large fires dotted the state. To identify risks and wildfire potential, Yosemite developed a decision tool (*sensu* Wildfire Management Go–No-Go) based on biophysical conditions, surrounding fuels, and sociopolitical "situation awareness." Three zones were identified. High-elevation areas presented the greatest opportunity for managing wildfires because they rarely burn in any but the driest years. Middle-elevation bands were "conditional" and would need extra scrutiny. Fires at lower elevations would be suppressed. We present the decision support tool using case studies to validate that there is an appropriate place for managing fires in Yosemite.

Introduction

Yosemite National Park covers 747,955 acres of the central Sierra Nevada in California and varies in elevation from 2,000 feet in the west to 13,000 feet in the east along the crest of the range. The elevation profile from east to west highlights distinct vegetation types. Lower montane forests (yellow pine–mixed conifer) occur between 2,000 feet and 6,000 feet, upper montane forests from 6,000 feet to 8,000 feet, and subalpine forests from 8,000 feet to tree line at 11,000 feet. The higher the elevation, the shorter the growing season and the more harsh the growing conditions, so the less fuel accumulates over time.

The Mediterranean climate of Yosemite is characterized by warm, dry summers and cool, wet winters with precipitation primarily occurring between November and April. However, during the summer, a monsoonal flow from the southeast, south, and southwest can create numerous thunderstorms responsible for lightning and occasional rain at the higher elevations. Studies of

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the distribution of lightning strikes show that at the lower elevations, where burnable vegetation is abundant, lightning is less frequent. Conversely, at higher elevations, lightning is abundant but vegetation is sparser (van Wagtendonk and Cayan 2008). In Yosemite and the Sierra Nevada, lightning ignited-fires will burn fire-adapted and fire-dependent vegetation every year.

Because the Sierra Nevada has an extensive history of lightning strikes and subsequent fires (van Wagtendonk et al. 2002; van Wagtendonk and Fites-Kaufman 2006), managers must consider factors in addition to ecology when deciding whether to manage a fire. In 1972, a Prescribed Natural Fire Program was established in Yosemite, establishing the opportunity to manage lightning-ignited fires so as to allow them to burn under prescribed conditions (van Wagtendonk 2007). Yosemite National Park's extensive fire records (1930 to the present) have facilitated studies of the spatial distribution of lightning fire ignitions (van Wagtendonk 1994; van Wagtendonk and Davis 2010; van Wagtendonk 2012). An understanding of the ignition patterns presents opportunities to manage fire in locations that frequently get lightning but few fires except in the driest years.

In 2014, the then three-year drought dominated discussions regarding the beginning of the fire season. Fire managers across the western US knew that a challenging fire season was coming. Additionally, managers in Yosemite were acutely aware that the 2013 Rim fire was still smoldering, not only on the landscape, but in the collective psyche of the region. Yosemite, therefore, found itself in a unique position, and under the microscope, for prioritizing the management of lightning ignitions. Could the park adhere to its mission of restoring fire as an ecosystem process in the face of exceptional drought on the heels of the largest fire in Sierra Nevada history? The park needed a science-based risk management tool to pick the successful starts from those that could cause partners and neighbors to lose our trust.

Lightning ignition patterns

An initial step in creating the decision tool was to identify where fires have historically burned in the park. Fire data from Yosemite National Park's GIS spatial database were used to assess when and where fire ignitions occurred. These data are updated annually and date back to 1930. In recent years, ignition point location data have been collected by fire personnel using GPS. However, for historic fires—with locations gleaned from reports, digitized, and integrated into the park GIS dataset—the center of each fire perimeter was calculated in GIS. The lightning-ignited point database was used for the spatial analysis of lightning fire ignition patterns (van Wagtendonk 1994; van Wagtendonk and Davis 2010; van Wagtendonk 2012).

An assessment of ignition points and final fire perimeters was done to see where Yosemite experienced lightning starts and their subsequent growth. Elevation was a major indicator in this spatial pattern due, in part, to the changing vegetation types with elevation and the duration of snow pack on the landscape. Other factors such as slope, aspect, and soil moisture capacity relate to how wet or dry the landscape is and are measured by water deficit and the actual evapotranspiration of the vegetation. These factors all play a role in where and when ignitions occur in Yosemite and how large they become.

The majority of ignitions and acres burned in the park occur between 6,000 feet and 9,000 feet (2,327 ignitions for a total of 131,709 acres). Of those, the largest number of ignitions and acres burned are between 7,000 feet and 8,000 feet (921 ignitions for 72,079 acres). The 8,000 foot contour is a threshold where strikes and ignitions are prevalent, but acres burned are low (639 fires for 13,941 acres). Hence, not all lightning strikes produce ignitions and the park has identified these areas as fire shadows (van Wagtendonk 2012). Fire shadows are important because they do not burn very often but present opportunities for accomplishing resources objectives under dry conditions. In fact it may be only in drought years that fires can burn in high-elevation upper montane and subalpine landscapes with longer fire return intervals than in the lower-elevation montane forests.

2012 and 2013 fire seasons

Two thousand twelve marked the first year of California's drought and, when the lightning came, provided Yosemite with the opportunity to begin to understand how to manage fires in a drier climate. The Cascade fire started in the fire shadow at 7,880 feet and burned largely unnoticed by visitors under prescribed conditions for four months for a total of 1,705 acres. It is during dry years that fires will burn in places with longer return intervals or that typically have snow on the ground well into June despite northern California experiencing large and expensive fires.

Two thousand thirteen was a significant year for the region. Its winter was the second in a row with less than average precipitation, which helped intensify California's drought. Additionally, the Rim fire burned over 257,000 acres of the Stanislaus National Forest and Yosemite National Park from mid-August through mid-September. That May the park received lightning strikes, one of which ignited the Forbidden Fire at 7,383 feet. This slow growing fire was re-burning a managed lightning ignition from the mid-1980s in red fir and Jeffrey pine. It burned for four months for a total of 198 acres. During its final month, which coincided with the month that the Rim was active, the Forbidden grew by 28 acres.

Identification of 2014 fire management units

Yosemite's Fire Management program is guided by the 2004 Fire Management Plan/Environmental Impact Statement (FMP). The plan identifies two management units: Suppression and Managed Fire (NPS 2004). All wildfire ignitions in the Suppression Unit are immediately suppressed using the 2009 Guidance for Implementation of Federal Wildland Fire Management Policy (2009). In the Managed Fire Unit, lightning-ignited fires are used to meet ecological target conditions (NPS 2004). In 2012 Yosemite developed a prioritization decision tool that incorporated the knowledge of ignition patterns along with other biological, physical, and sociopolitical factors for fires that ignited in the Managed Fire Unit.

For the 2014 fire season, the park used knowledge gained from assessing the historic patterns of lightning ignitions and the lessons learned from the Cascade and Forbidden fires. Because these fires burned in the fire shadow, they were used by the park to craft new fire management units. Three distinct units were created (Figure 1). All areas above 8,000 feet were placed into the Managed Fire Unit where ignitions are considered for management. The fire shadow areas between 7,000 feet and 8,000 feet and areas within the Rim footprint were considered to be in the Conditional Unit. The Suppression Unit was made up of areas below 7,000 feet outside of the Rim footprint and areas in the Suppression Unit in the 2004 FMP.

2014 decision support tool

The 2014 version of the decision support tool varied slightly from the previous two years in that it addresses the idea of a seasonally dry fire season and introduces the Conditional Unit. "Seasonally dry" equates to the April 1st Tuolumne Meadows (elevation 8,600 feet) Snow Water Equivalent being 40 cm or less (Lutz et. al, 2009). Generally, Yosemite fires burn more acres in years that average more than 40 cm of snow water equivalent, so this decision tool is used as a "Go–No-Go" when conditions are dry. Once an ignition is detected, the first step is to determine if it occurred above 8,000 feet, which is the threshold for the Managed Fire Unit. If that ignition fell outside of the Suppression Unit while the National Preparedness Level is less than four, the fire would be considered for management. However, if that ignition occurred within the Suppression Unit, in

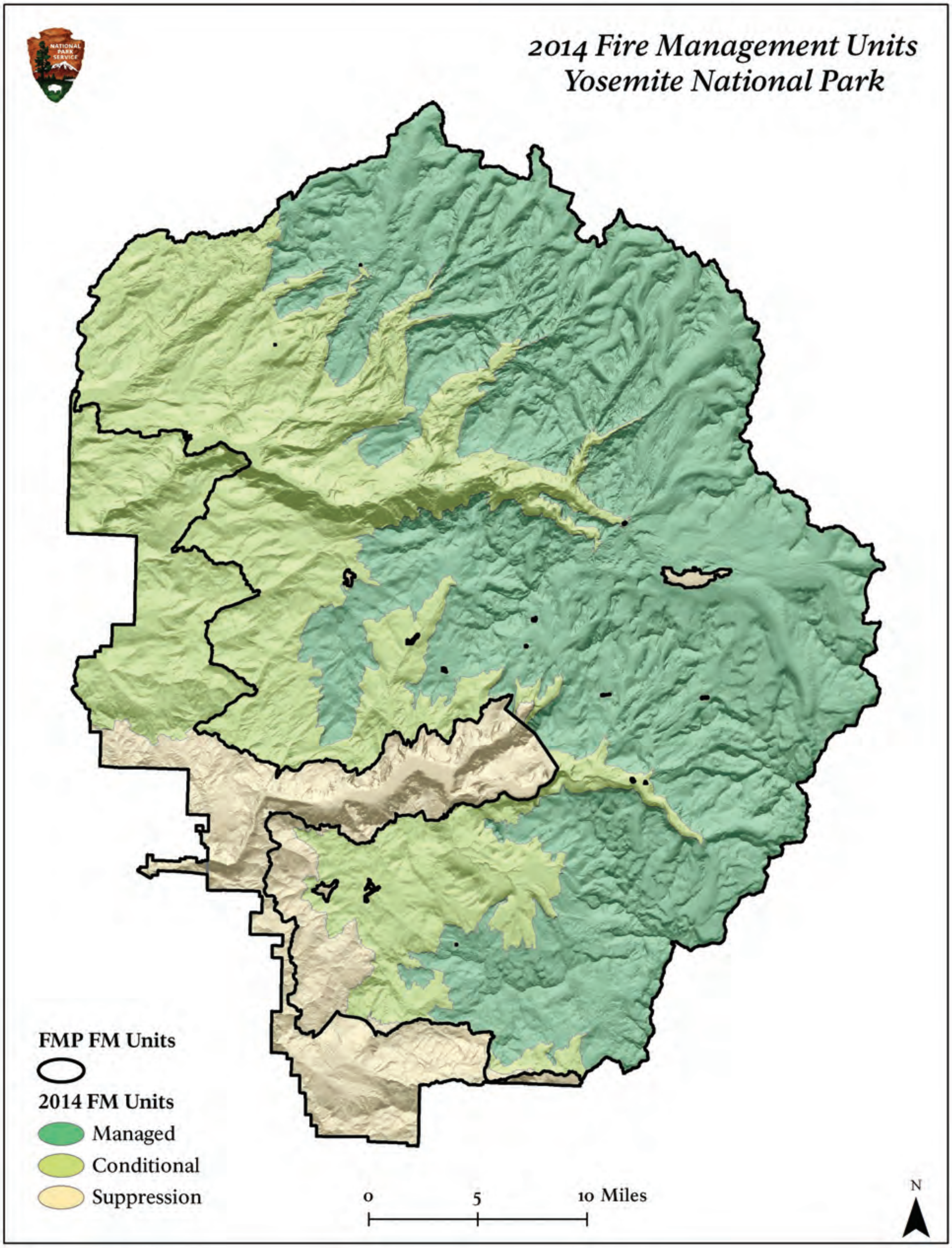

Figure 1. Map of the 2014 Fire Management Units for Yosemite National Park. The Managed Fire Unit is dark green, the Conditional Unit light green, and the Suppression Unit is tan. The black lines represent the Fire Management Units as identified in the 2004 Fire Management Plan for reference to show how the Units were altered for 2014.

Tuolumne Meadows, for example, the fire would be suppressed. If the fire occurred when the National Preparedness Level was above three, the park would consult with the National Park Service Pacific West Regional Office before management of that fire began.

If the fire was below 8,000 feet, the Conditional Fire Unit assessment criteria are evaluated. In order to be a managed fire, the ignition must occur within the 2013 Rim fire footprint. If it did not fall within the Rim footprint, the fire would have to be between 7,000 and 8,000 feet to be considered. In both cases the risks and benefits of managing the fire are weighed with internal and external factors as posed in the final assessment. If the natural ignitions did not meet the Conditional Fire Unit criteria, that is, if it was outside of the Rim footprint and below 7,000 feet, the fire would be suppressed (Figure 2).

Once the candidate fire for management is assessed, a final evaluation, or secondary situational awareness and risk analysis, is undertaken using biogeophysical, sociopolitical, and management factors (Figure 3). The biogeophysical factors of Fire Return Interval Departure (van Wagtendonk et al. 2002), lightning ignition density (van Wagtendonk 2012), barriers to spread, and seasonality of the fire help to identify how the fire may grow and spread. More nuanced and less scientific sociopolitical factors, such as impacts on visitors and infrastructure, impacts on hol-

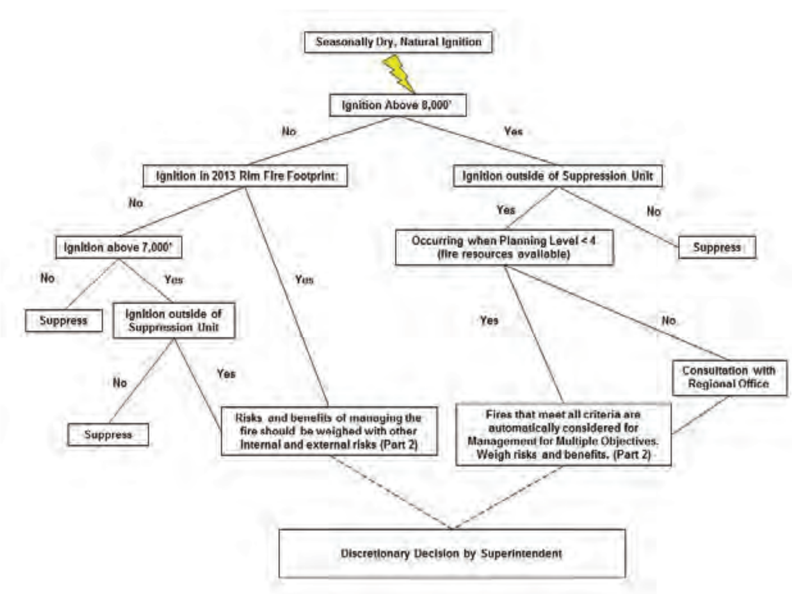

Figure 2. Natural Ignition Decision Support Tree. This diagram can walk managers through the decision making process when evaluating candidate fires for management for multiple objectives.

	Fire Situation	Meadow
Biogeophysical	Fire Management unit (If suppression, stop here)	Outside the Suppression unit
	Lightning density	Low
	Fire Return Interval Departure	2 (30 FRI)
	Seasonality (ERCs increasing or decreasing)	Probably decreasing
	Barriers to fire spread	Some, moderate
Socio-political	Visitor disturbance (smoke, traffic, closures)	Smoke in Yosemite Valley
	Impact to holiday visitation	Labor Day
	Values at risk	Air quality
	Regional smoke impacts from other fires	No
	Gateway events that could be impacted	Labor Day, Wilderness celebration
	County	Mariposa
	Potential to impact boundary	No
Managerial	Number of resources needed to manage fire	TBD
	Are there fires in neighboring Federal units creating local demand on resources?	No
	Other fuels projects or wildfires in the park	Yes
	Likelihood of meeting objectives with prescribed fire	No

Figure 3. Part 2 of the Decision Support Tool. These are the internal and external factors that are assessed when determining whether a fire will be managed for multiple objectives. These factors fall into three categories: biological and physical, socio-political, and managerial. The 2014 Meadow Fire is being used as an example.

iday visitation and gateway community events, air quality, proximity to the park boundary, and the county in which the fire is burning are also considered. These factors could ultimately swing the decision from managing a fire to suppressing it, but not vice versa. Additional management factors such as number of fires burning in Yosemite or on neighboring federal lands or whether the park could utilize a prescribed burn in lieu of the natural ignition would also need to be assessed when prioritizing these ignitions.

Another key component of the tool is the risk management gained from fire spread models after ignition. This could also begin the validation process behind the decision to suppress or manage. The final part of this decision-making process requires a rationale signed by and at the discretion of the Superintendent. The rationale would include all of the factors evaluated in the decision support tool.

2014 fire season

In 2014, Yosemite had 36 lightning-ignited fires. Therefore, park had many fires to evaluate through the prioritization process. Eighteen fires were within the Managed Fire Unit of the 2014 Yosemite Fire Management Units (Figure 1). Of those, five were suppressed, 11 went out naturally and two were managed for multiple objectives. These two fires were both above 9,000 feet and burned from mid-July until the end of fire season in November. Combined they burned about 25 acres. In the Conditional Unit, there were 17 ignitions: 11 were suppressed, five were extinguished naturally, and one was managed for multiple objectives and burned about 1,070 acres. The Suppression Unit had one ignition, a low-elevation 3 acre fire that started when lightning struck a power line.

Conclusion

The decision support tool developed by Yosemite takes into account fire history, biogeophysical, and sociopolitical factors unique to the park. However, this tool can be adapted for use by any Land Management Unit (LMU) where fire is part of the fabric of the landscape, as is the case in Yosemite. By integrating issues and factors pertinent not only to the LMU, but for the fire season, managers are equipped with the best available science and data to make informed decisions on which fires could be managed for multiple objectives.

In Yosemite, there are areas that can have fire in any given year. By understanding the fire history and some of the other biogeophysical and sociopolitical factors, park managers can identify those areas that can burn even in drought years. Drought years present the opportunity to accomplish resource benefits that might not be possible at other times. The park learned many things from the 2014 fire season with respect to ignitions occurring above 8,000 feet. Many fires went out naturally, thus reducing the risk to firefighter safety. Additionally, the fires that did make it to the end of the season only burned 25 acres. This showed that the park should manage fires at higher elevations even in drought years.

In an era of longer, hotter, and drier fire seasons, park managers are faced with the tough tasks of trying to preserve and protect the landscape knowing that fires will ignite each and every year. Fire is a natural process that Yosemite has committed to returning to the ecosystem. It is a vital part of a healthy forest and may be one of the few tools that managers can use right now to build resiliency in a changing climate. This is not to be undertaken lightly. By developing a prioritization/decision support tool, the park has integrated many different and varying factors to assist and document its process. This is paramount for a science-based program to operate.

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