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GEOG 5563
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Critical Habitat Impacted by 2018 Wildfires in California: A Geospatial Analysis

SECTION 1: PROJECT SUMMARY

In terms of death and destruction, 2018 was a record-setting year for wildfires in California (Romero, 2019). More than 1.8 million acres went up in flames, claiming over 100 lives and consuming 17,133 homes (NICC, 2019). The 2018 fire season was clearly devastating to human residents, but many wildlife species also felt the effects as their habitat burned to ashes. These are fire-adapted ecosystems in California, and species have evolved in concert with the natural fire regimes there. However, due to a number of factors—including climate change and increased fuel loads resulting from fire suppression—wildfires are now more intense, more frequent, and more expansive than historical fires (Miller, Safford, Crimmins, and Thode, 2009).

This altered fire regime has implications for wildlife conservation in general, but those species already threatened with habitat loss and fragmentation are especially vulnerable to severe, large-scale wildfires like those seen in 2018. The Spotted Owl (*Strix occidentalis*), for example, is a federally-protected species dependent on old-growth forests in Pacific coastal states such as California. Given the long regeneration times for old-growth forests—on the order of centuries—high-intensity fires could spell disaster for Spotted Owl communities if they have nowhere to seek refuge (Tempel *et al.*, 2014). There are a number of imperiled wildlife species in California, aside from the Spotted Owl, that warrant our attention in the aftermath of last year's record-setting fire season.

I conducted a geospatial analysis to assess the impact of 2018 wildfires on critical wildlife habitat in California. Specifically, I was interested in answering the following questions:

- Which imperiled wildlife species were impacted?
- For each species, how much critical area was lost to fire? How much area remains?
- For each burn parcel, is there adjacent critical habitat remaining? If so, how many km^2?
- If no adjacent habitat, how far away is the nearest remnant habitat? How many km^2?

Through a series of overlays between the wildfire perimeters and critical habitat delineations, I determined which imperiled species were impacted and calculated species-specific areas of burned habitat and remnant habitat. For each individual burn parcel, I used a spatial analysis tool called Near By Group[1], which calculated—based on species—distance to the nearest remaining habitat. A table join allowed me to associate these distances with size (km^2) of the nearest remnant parcel.

The results of this analysis serve as a baseline assessment of 2018 wildfire impact on imperiled species in California, aiding in the direction of conservation efforts to those species most affected.

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[1] Documentation: https://www.esri.com/arcgis-blog/products/arcgis-desktop/analytics/finding-the-nearest-feature-with-the-same-attributes/

SECTION 2: TECHNICAL REPORT

SCENARIO

2018 was a record-setting year for wildfires in California, regarding both the severity and extent of land area impacted (NICC, 2019). Although fire is a natural ecosystem process with which species have adapted, both the frequency and intensity of wildfires has increased in recent decades due to compounding factors such as climate change and increased fuel loads (Miller *et al.*, 2009). Imperiled species, many already under threat from habitat loss and fragmentation, may be at increased risk of extinction in the wake of extreme fire behavior.

The United States Fish and Wildlife Service monitors threatened and endangered species for all 50 states, including California. They also maintain a spatial database of critical habitat for these species. Critical habitat as defined by the U.S. Fish and Wildlife Service includes:

> *"specific areas within the geographic area, occupied by the species at the time it was listed, that contain the physical or biological features that are essential to the conservation of endangered and threatened species and that may need special management or protection. Critical habitat may also include areas that were not occupied by the species at the time of listing but are essential to its conservation."* (USFWS, 2011)

DATASETS (citations in References section)

- California State Boundary
  - vector (polygon)
- Critical Habitat
  - vector (polygon)
  - extent: entire United States
- 2018 Fire Perimeters
  - vector (polygon)
  - extent: entire United States

METHODOLOGY

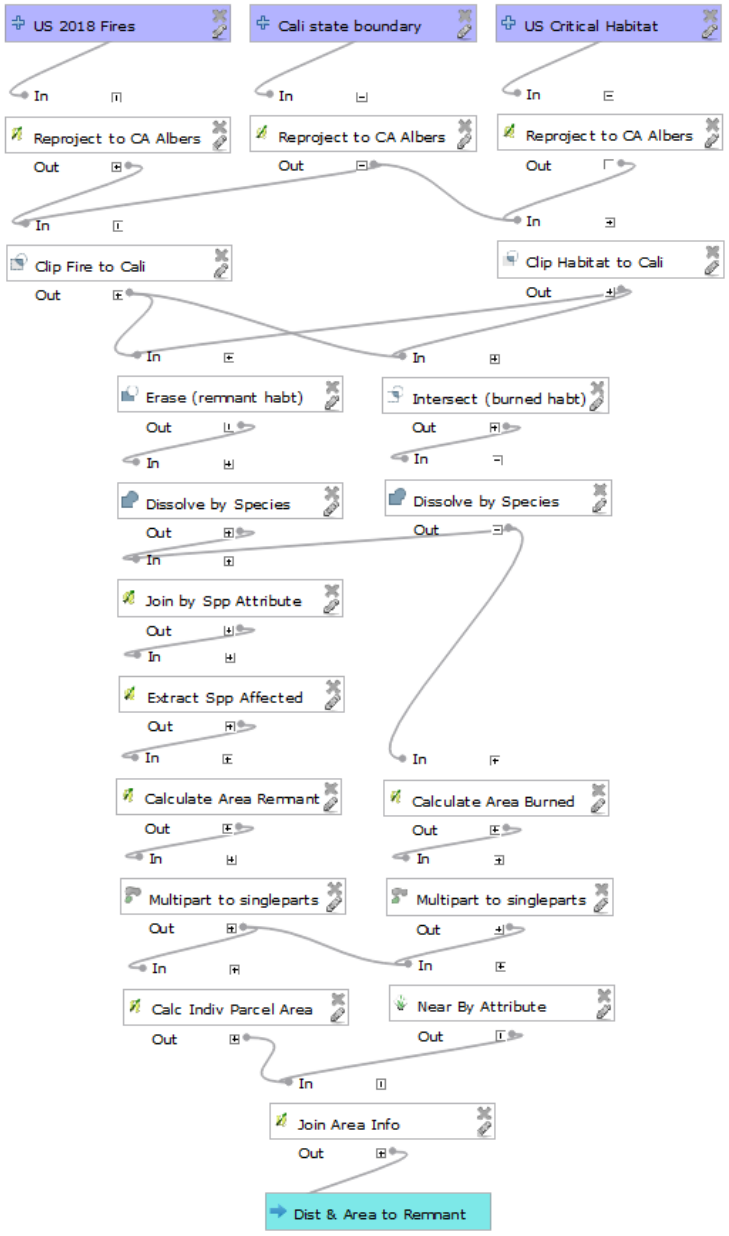
All spatial analyses were performed using ArcMap version 10.6.1 (ESRI, 2018), as well the production of one map. A model flowchart was created using QGIS version 2.18.28 (QGIS, 2019).

The 3 shapefiles downloaded for this analysis were provided in different coordinate reference systems. Prior to conducting spatial analyses, each shapefile was reprojected into an equal-area projection appropriate for this study. I chose NAD83 (NSRS2007) / California Albers—EPSG: 3488. Both the fire and habitat polygon layers were then clipped to the extent of California's state boundary.

Habitat lost to fire was identified by an intersection with the fire layer, whereas remnant habitat that survived the wildfires was identified with an erase. After dissolving each resulting habitat layer by species (creating multipart features), the total area of habitat lost/remaining for each species was easily calculated using the field calculator. However, since we were only interested in species affected by fire, I extracted only those species from the remnant habitat layer using a table join with the burnt habitat layer.

To address matters of adjacency and proximity between burned areas and remaining habitat parcels, I converted from multipart to singlepart features. Then I used the field calculator to compute area (in square kilometers) of each individual remnant habitat parcel. I downloaded and used a tool called Near By Group (Flater, 2015), which allows the user to specify an attribute constraint when determining the nearest feature between layers. In this case, I specified that the nearest remnant habitat parcel belong to the same species associated with the burn parcel. This produced a layer of burn parcels with species information and appended attributes for distance-to-nearest remnant habitat, which I then joined to the remnant habitat layer containing area of each individual habitat parcel.

Burn parcels adjacent to remnant habitat were identified as those with a distance-to-nearest value of zero.



RESULTS

Of the 112 imperiled species represented in the critical habitat dataset for California, 26 were impacted by the 2018 wildfires, 20 wildlife species and 6 plant species. 65% of the affected species were listed as endangered, with the remaining 35% listed as threatened (Fig. 1).

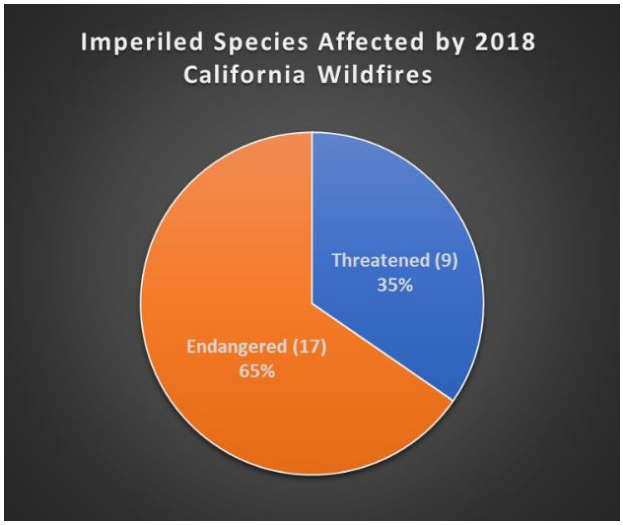


Figure 1. A total of 26 imperiled species were impacted by California wildfires in 2018.

A summary of how many square kilometers of habitat burned and how much habitat remained for each species is listed in Table 1, along with percent of area burned. Overall, 2 species saw a significant loss of habitat due to fire, both of which were plants; the Lyon's Pentachaeta and Braunton's Milk-vetch experienced 45% and 47% range loss, respectively. All other species had less than 5% of their total habitat lost to fire in 2018. These statistics from Table 1 are summarized graphically in Figures 2 and 3.

Considering the 226 parcels of contiguous habitat that burned, almost 83% were adjacent to remnant habitat (Fig. 4). Three endangered plant species, however, accounted for the greatest distance to remaining habitat, which was over 37 km away. The size of remnant habitat parcels varied, with 57.5% of them less than 25 km^2 in size, and the 3 largest parcels—all associated with the Northern Spotted Owl—greater than 700 km^2 (Fig. 5). An overview of Spotted Owl habitat in relation to two major 2018 wildfires in northern California, the Ranch and River Fires, shows burn parcels alongside adjacent surviving habitat, as well as isolated burn parcels 9-21 km from remnant habitat (Map 1).

Table 1, Map 1, and Figures 2-5 can be found at the end of this report.

GoogleDrive (link to project materials):

https://drive.google.com/drive/folders/14HmCjjvAB8j-nEk0GS1E-WZClOGJa8BW?usp=sharing

SECTION 3: CONCLUSION

Overall, I was pleasantly surprised by the small percentage of habitat burned for most species, even despite the relatively large cumulative totals of burned habitat. For example, the Northern Spotted Owl lost over 371 km^2 of habitat, but this paled in comparison to its 8,100 km^2 of remaining habitat (Table 1).

While this geospatial analysis investigated adjacency, proximity, and size of remnant habitat in relation to burned habitat, there are still additional factors that warrant consideration when assessing the full impact of wildfires on imperiled species. For instance, the carrying capacity of remnant habitat parcels is of utmost importance. In the event that a large swath of habitat is destroyed and surviving habitat is restricted to a small area, a species may struggle to recover if they are not able to sustain a viable population.

Many of the habitat parcels adjacent to burned habitat were small and possibly a manifestation of error in the overlapping boundaries between the fire perimeters and critical habitat (leaving slivers), since neither layer was produced for fine-scale assessment. If I were to conduct a similar analysis in the future, I might try to account for this error by only including adjacent habitat that is above a certain size threshold.

No research endeavor is without challenges, and this analysis was unfortunately no exception to that rule. I learned that pre-written tools in both ArcGIS and QGIS are not all-inclusive, and sometimes it is necessary to invoke geoprocessing models that can automate certain workflows. This is especially true when iteration over many inputs is required, which was the case when I needed to search for near features based on specific attributes in both the input layer and target layer. Thankfully, after many hours of attempting to create my own model, I discovered that someone else had already created this tool and kindly made it available for download on ArcGIS Online (Flater, 2015).

SECTION 4: REFERENCES

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DATA SOURCES

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SOFTWARE AND TOOLS

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Flater, D. (2015). Near By Group Tool. Available at https://umn.maps.arcgis.com/home/item.html?id=37dbbaa29baa467d9da8e27d87d8ad45

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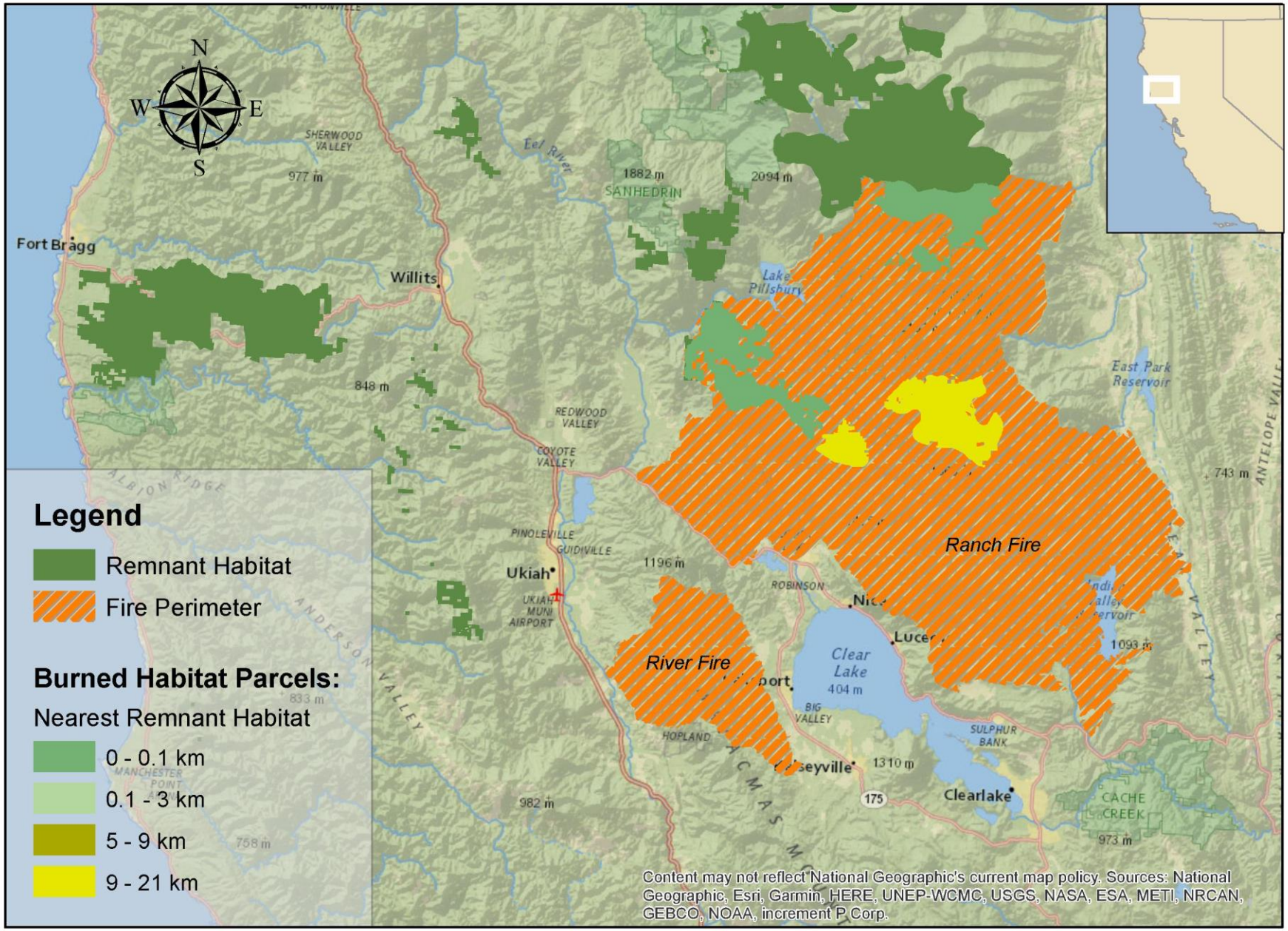
Northern Spotted Owl Habitat
Impacted by 2018 California Wildfires



NAD83 (NSRS2007) / California Albers

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0 5 10 20 30 40 Kilometers

Data Sources: USFWS Critical Habitat & USGS GeoMAC Fire Perimeters

Common Name	Scientific Name	Listing Status	Total Habitat (sq-km)	Remnant Habitat (sq-km)	Burned Habitat (sq-km)	Percent Burned (%)
Santa Ana sucker	*Catostomus santaanae*	Threatened	37.7903	37.79	0.0003	0.0
Hoover's spurge	*Chamaesyce hooveri*	Threatened	464.85	464.82	0.03	0.0
Yosemite toad	*Anaxyrus canorus*	Threatened	3032.91	3032.59	0.32	0.0
Western snowy plover	*Charadrius nivosus nivosus*	Threatened	67.45	67.44	0.01	0.0
Coastal California gnatcatcher	*Polioptila californica californica*	Threatened	798.93	797.63	1.3	0.2
Vernal pool fairy shrimp	*Branchinecta lynchi*	Threatened	2387.67	2377.67	10	0.4
Little Kern golden trout	*Oncorhynchus aguabonita whitei*	Threatened	333.19	329.44	3.75	1.1
California red-legged frog	*Rana draytonii*	Threatened	6640.23	6469.53	170.7	2.6
Northern spotted owl	*Strix occidentalis caurina*	Threatened	8506.09	8134.72	371.37	4.4
Sierra Nevada Yellow-legged Frog	*Rana sierrae*	Endangered	4406.42	4406.32	0.1	0.0
Tidewater goby	*Eucyclogobius newberryi*	Endangered	49.1719	49.17	0.0019	0.0
Greene's tuctoria	*Tuctoria greenei*	Endangered	587	586.97	0.03	0.0
Mountain yellow-legged frog	*Rana muscosa*	Endangered	926.96	926.91	0.05	0.0
California tiger Salamander	*Ambystoma californiense*	Endangered	1042.73	1042.66	0.07	0.0
Hairy Orcutt grass	*Orcuttia pilosa*	Endangered	321.95	321.92	0.03	0.0
San Bernardino Merriam's kangaroo rat	*Dipodomys merriami parvus*	Endangered	134.83	134.81	0.02	0.0
Quino checkerspot butterfly	*Euphydryas editha quino*	Endangered	251.61	251.56	0.05	0.0
Sierra Nevada bighorn sheep	*Ovis canadensis sierrae*	Endangered	1691.46	1688.27	3.19	0.2
Southwestern willow flycatcher	*Empidonax traillii extimus*	Endangered	158.65	157.98	0.67	0.4
Vernal pool tadpole shrimp	*Lepidurus packardi*	Endangered	925.85	921.06	4.79	0.5
Butte County meadowfoam	*Limnanthes floccosa californica*	Endangered	67.35	66.99	0.36	0.5
Arroyo toad	*Anaxyrus californicus*	Endangered	398.28	395.89	2.39	0.6
Least Bell's vireo	*Vireo bellii pusillus*	Endangered	149.68	144.48	5.2	3.5
California condor	*Gymnogyps californianus*	Endangered	2449.06	2348.73	100.33	4.1
Lyon's pentachaeta	*Pentachaeta lyonii*	Endangered	13.74	7.61	6.13	44.6
Braunton's milk-vetch	*Astragalus brauntonii*	Endangered	13.35	7.11	6.24	46.7

Table 1. A summary of total habitat, cumulative habitat burned, and cumulative habitat remaining for each imperiled species, along with percent of habitat area burned. The largest 3 instances are highlighted in each numeric column.

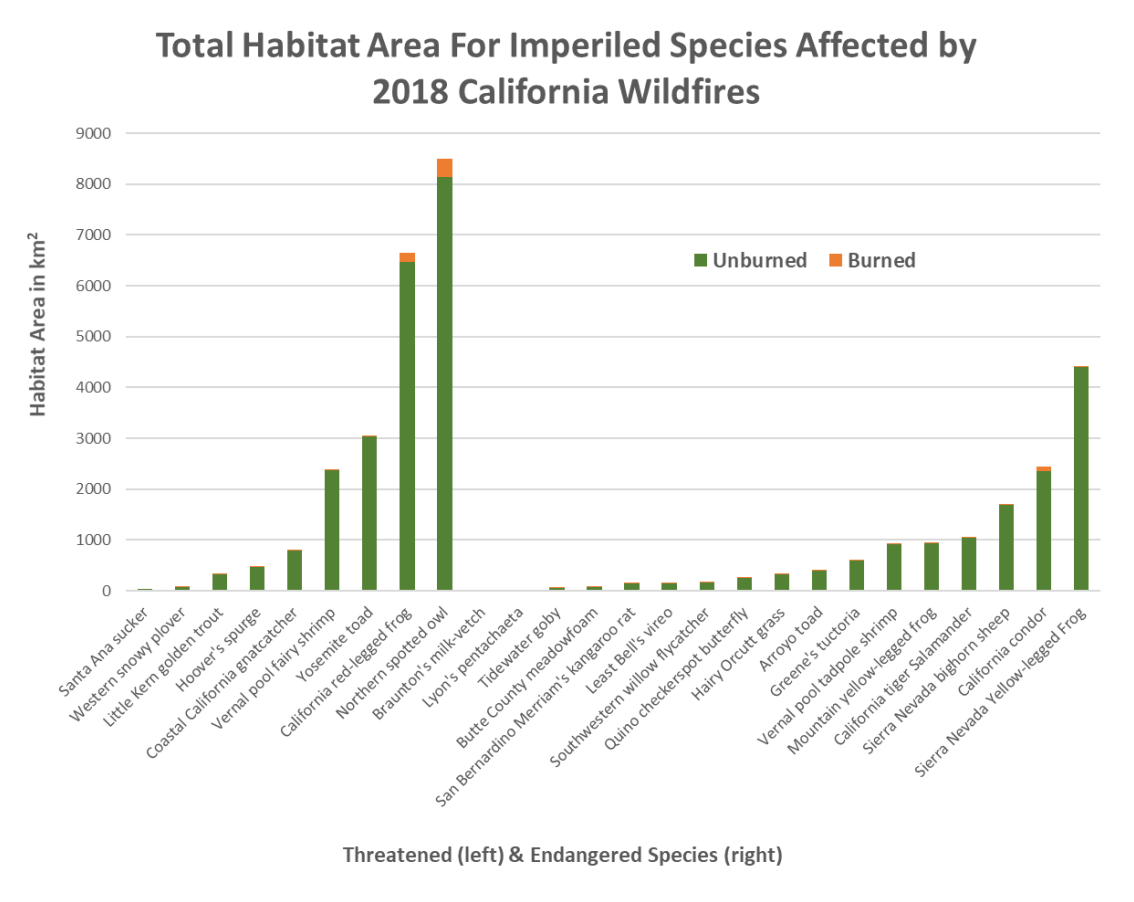

Figure 2. Total habitat area for all 26 species, shown as a sum of burned and unburned habitat. The 9 species on the left are threatened, while the 17 species on the right are endangered.

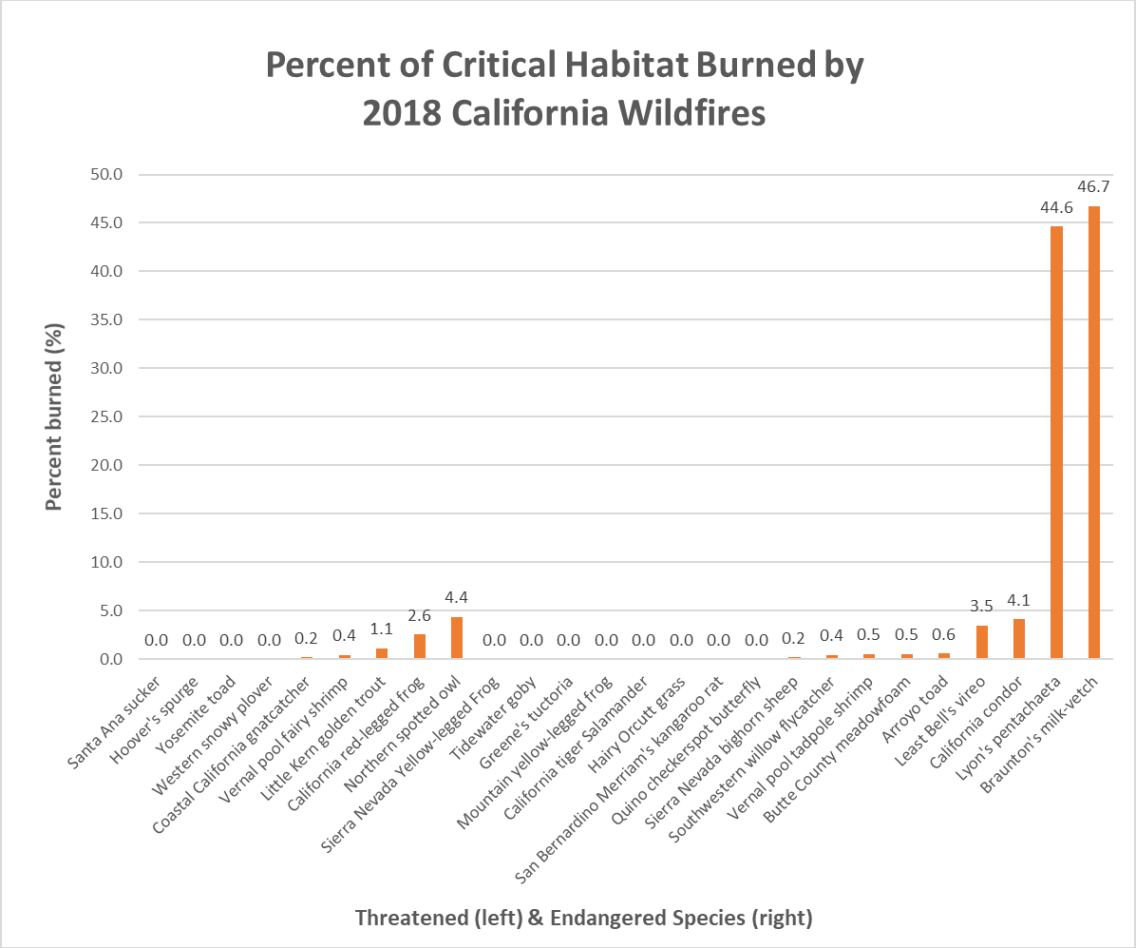

Figure 3. Percent of total habitat burned for each of 26 imperiled species in California. The 9 species on the left are threatened, while the 17 species on the right are endangered. Two plant species saw almost half of their habitat lost to fire.

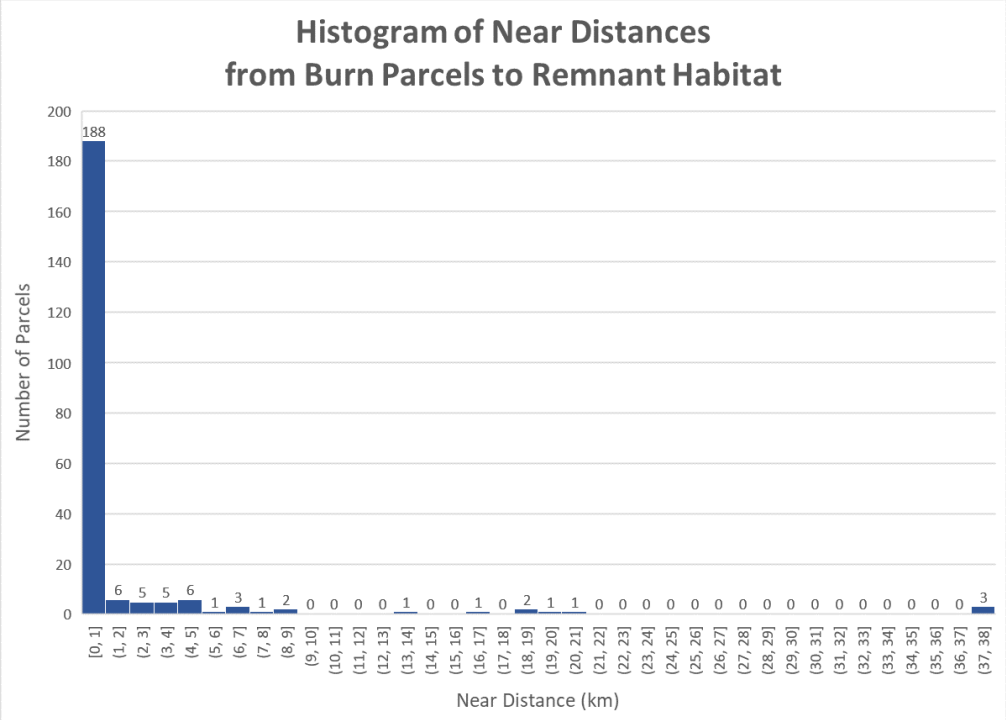

Figure 4. Shortest distances between burn parcels and remnant habitat for the same species. Histogram shows all 226 burn parcels with 1-km bins. Adjacent habitat is included in the 0-1 km bin.

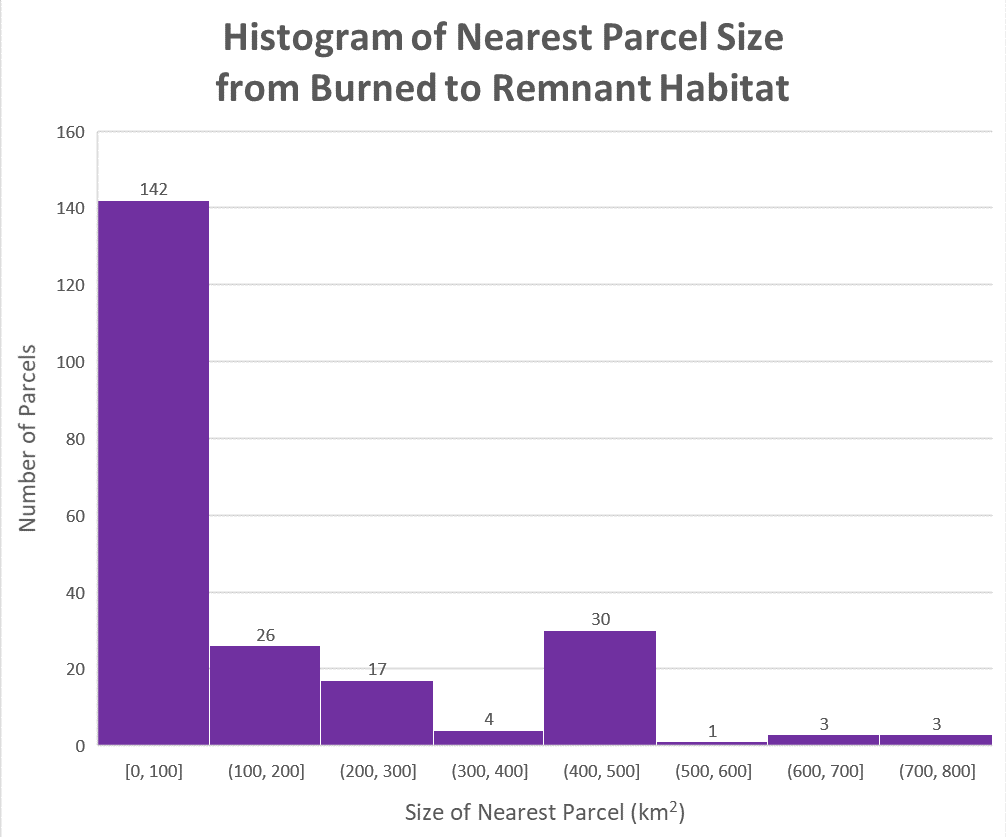

Figure 5. Size of closest remnant habitat parcel from 226 burn parcels. Histogram shows 100-km² bins, but 130 parcels were less than 25 km². Adjacent habitat is included in the 0-1 km bin.