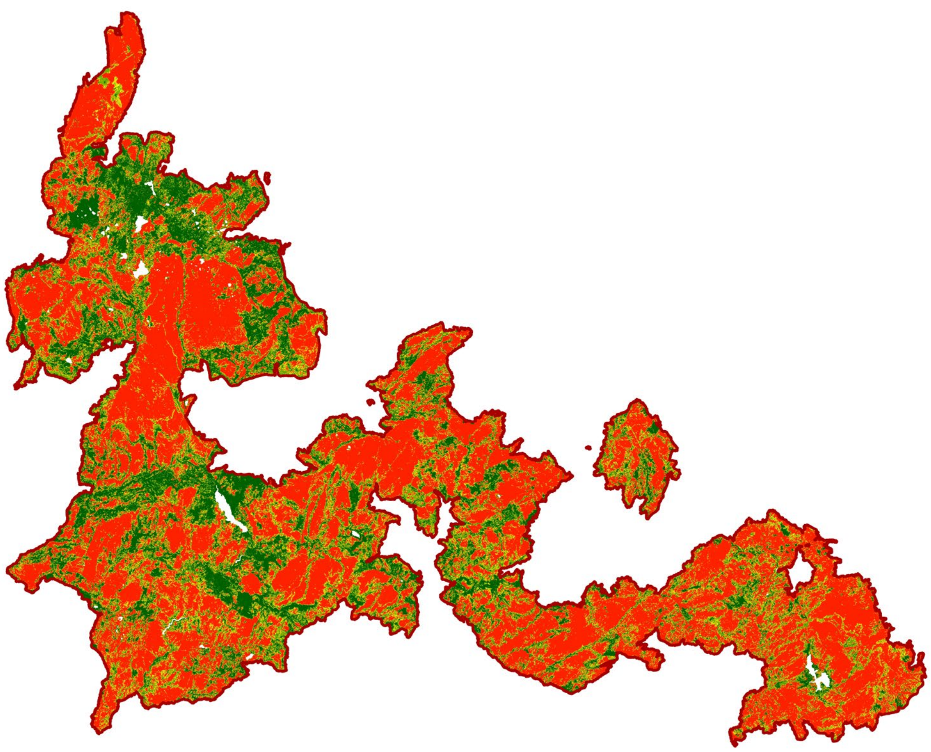
United States Department of Agriculture

USDA Forest Service
Region 5 Ecology Program
Sierra Cascade Province

Postfire Restoration Opportunities for California Spotted Owl in the 2021 Dixie and Sugar Fires

Plumas and Lassen National Forests



February 4, 2022

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Summary

We evaluated fire effects on California spotted owl (*Strix occidentalis occidentalis*) habitat from the 2021 Dixie and Sugar fires on the Plumas and Lassen National Forests using a science-based approach outlined in the "Postfire Restoration Framework for National Forests in California" (Meyer et al. 2021). Within these fires, we identify potential restoration opportunities and recommend potential management actions that can help promote and restore desired conditions for California spotted owls. Application of this framework can help guide site-specific project proposals and proposed actions. However, project proposals must be developed using an interdisciplinary team and include additional analysis, surveys, and ground-truthing.

Introduction

The California spotted owl (*Strix occidentalis occidentalis*) occurs across a large area of California, including the southern Cascade Range, the Sierra Nevada, the mountains of central coastal California, and the Peninsular and Transverse Ranges of southern California. Most of the current range of the California spotted owl occurs on public lands, primarily those managed by the USDA Forest Service (USFS). The California spotted owl (CSO) is considered a sensitive species and the USFS is directed to identify and assess information relevant to this species. Data from demographic studies conducted in the Sierra Nevada show that CSO populations have been declining over the past 20 years (e.g., Conner et al. 2013, Tempel et al. 2014) despite protected status designation around nests (Protected Activity Centers). As recent fire activity can degrade remaining owl habitat and decrease the probability of use by CSO (Jones et al. 2021), the need to maintain and restore CSO habitat throughout its range has become increasingly important.

The 2021 Dixie and Sugar fires burned 1,092,196 acres across a range of ownerships and vegetation types in the northern Sierra and southern Cascade regions, including 169 designated Protected Activity Centers (PACs) established to protect key nesting and roosting habitats for CSO (Figure 1). Although the Sugar Fire burned 108,348 acres, no PACs occurred within its perimeter. On the Plumas National Forest (PNF), 87 PACs were within the Dixie Fire perimeter (34% of all PACs on the PNF); on the Lassen National Forest (LNF) 82 PACs were within the Dixie Fire perimeter (53% of all PACs on the LNF). Most PACs experienced a range of fire severities, including low (<25% basal area mortality), moderate (25-75% basal area mortality), and high (>75% basal area mortality). However, the mean fire severity, averaged across the entire 300-acre PAC, was low in 58 PACs (34% of PACs within the fire perimeter), while only 31 PACs (18% of PACs within the fire perimeter) experienced greater than 75% basal area mortality. The percentage of PACs with mean severities in each fire severity category was similar on the

PNF and LNF (Table 1).

Table 1. Number of Protected Activity Centers (PACs) and percentage of PACs (in parentheses) on the Lassen National Forest (LNF), Plumas National Forest (PNF), and within the Dixie Fire as a whole, by fire severity category, calculated as a mean across the 300-acre PAC area.

Fire Severity Category	Number of PACs LNF (% of LNF PACs)	Number of PACs PNF (% of PNF PACs)	Number of PACs Total (% of Total PACs)
0-25%	29 (33%)	29 (35%)	58 (34%)
25-50%	19 (22%)	16 (19%)	35 (21%)
50-75%	22 (25%)	23 (28%)	45 (26%)
>75%	17 (20%)	14 (17%)	31 (18%)
Total	**87 (55%)**	**82 (34%)**	**169**

In addition to the 2021 Dixie and Sugar fires, several large fires with extensive high-severity fire effects have occurred on the LNF and PNF over the past several years with significant negative effects to CSO habitat. For example, of 145 CSO PACs on the Feather River Ranger District of PNF, 29 burned at high severity during the 2020 North Complex Fire and their protected designation was removed because the habitat was no longer considered viable for CSO. Given the cumulative impacts of this and other recent fires, as well as other stressors that have degraded CSO habitat, it is critical to determine where management actions can be taken to restore and maintain remaining CSO habitat on the LNF and PNF, as well as throughout the species range.

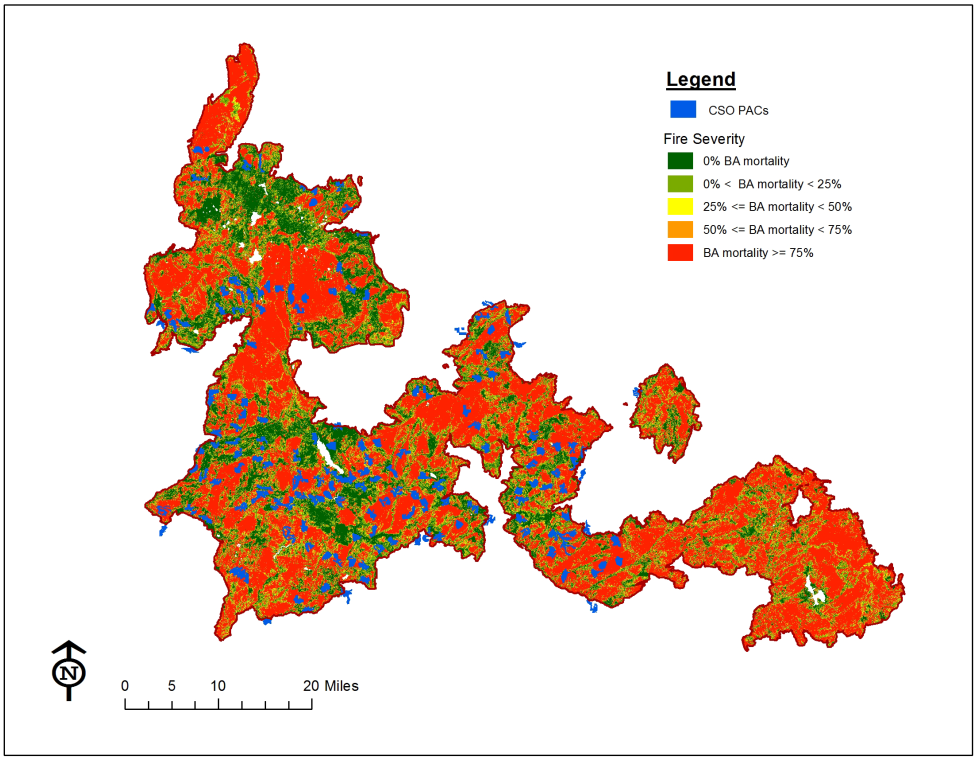

Figure 1. Protected Activity Centers (PACs) mapped within the perimeter of the Dixie (169 PACs) and Sugar (0 PACs) fire perimeters.

The first task wildlife biologists and other land managers often assess after a fire is to evaluate if PACs will be retained, retired, or re-mapped based on availability of remaining suitable habitat. Protected Activity Centers should be retired or removed from the network when disturbance events change their conditions so significantly as to make their contribution to the CSO population unlikely. After a stand-replacing event, the USFS is directed to evaluate habitat conditions for CSO within a 1.5-mile radius around the PAC to identify opportunities for re-mapping the PAC (USDA 2004). If there is insufficient suitable habitat for designating a PAC within the 1.5-mile radius, the PAC may be removed from the network. In this document, we provide a framework for making this evaluation. However, we also present a rationale for taking additional actions to manage PACs and surrounding habitat areas (e.g., core areas, territories, home ranges) after fires, including restoration opportunities in areas where the fire may have improved or maintained desired conditions for CSO.

Postfire Restoration Assessment Process

To evaluate fire effects on CSO habitat, we used the process outlined in the "Postfire Restoration Framework for National Forests in California" (Meyer et al. 2021). This strategy provides a science-based, postfire ecological restoration framework for national forests in California. The framework is rooted in the following ecological principles designed to enhance or recover ecological integrity after a large-scale disturbance such as fire: 1) Restore key ecological processes; 2) Consider landscape context; 3) Promote regional native biodiversity; 4) Sustain diverse ecosystem services; 5) Establish a prioritization approach for management interventions; and 6) Incorporate adaptation to agents of change. The framework outlines a five-step process that leads to the development of a restoration portfolio that can inform project planning and monitoring. The five steps we followed to conduct this assessment are outlined in Figure 2 and described in more detail below.

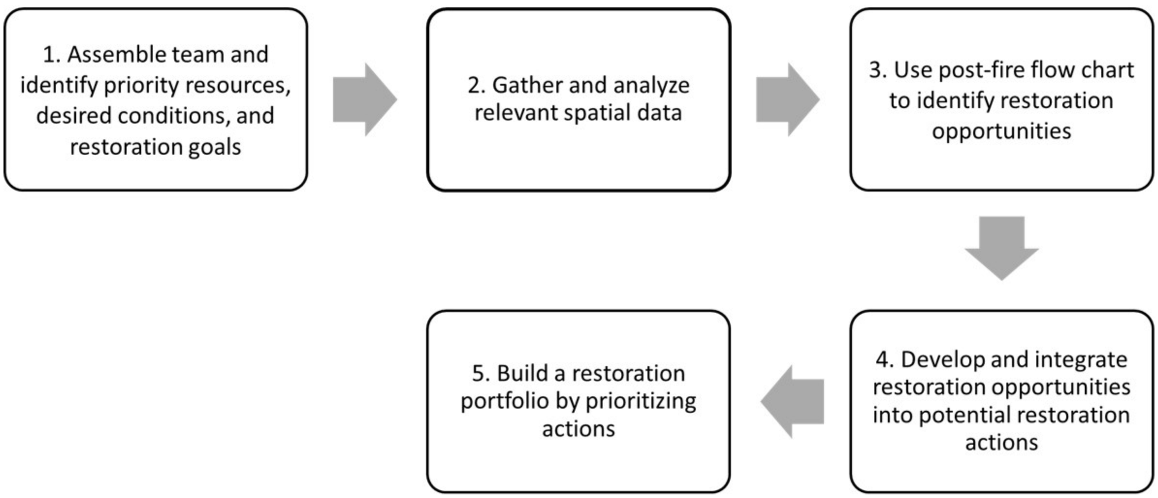

Figure 2. Five step process used to develop the postfire restoration framework.

Step 1: Assemble Team and Identify Priority Resources

Interdisciplinary Team

Kyle Merriam (Province Ecologist), Angela White (PSW Research Wildlife Biologist), Chris Kane (Plumas NF Wildlife Program Manager), Jessica Mcmullen (Natural Resource Staff Officer, Lassen NF), Tom Rickman (Wildlife Biologist, Eagle Lake Ranger District, Lassen NF), Colin Dillingham (Wildlife Biologist, Mt. Hough Ranger District, Plumas NF), Kelly Mosinski (Wildlife Biologist, Almanor Ranger District, Lassen NF), Rachel Bauer (Wildlife Biologist, Beckwourth Ranger District, Plumas NF), and Jeannine Sibley (Wildlife Biologist, Hat Creek Ranger District, Lassen NF).

Priority Resources

California spotted owl habitat.

Desired Conditions

As described in the Conservation Strategy for the California Spotted Owl in the Sierra Nevada (USDA 2019) and the Sierra Nevada Forest Plan Amendment – Final Supplemental Environmental Impact Statement Record of Decision (USDA 2004), desired conditions for CSO include high-quality nesting and roosting habitat that will likely enhance occupancy and demographic performance. These areas are generally characterized by structurally complex conifer forests with large trees and high canopy cover, including a hardwood component.

Restoration goals

- Maintain California spotted owl habitat so that it continues to support reproduction of California spotted owls.
- Promote California spotted owl persistence on the landscape by increasing the resiliency of existing habitat and facilitating the development of additional, high-quality habitat.

Step 2: Gather and Analyze Relevant Spatial Data

Data sources

Table 2. Spatial data used in Dixie fire analysis.

Data type	**Dataset**	**Description/Source**
CSO PACs	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_PACs	Compiled by LNF and PNF Wildlife Biologists.
CSO Territories	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_territiories	Generated using a 1,100 m (1,100 m) circular buffer around each PAC.
RAVG Fire Severity	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Severity\DixieSugar_Severity_5class	Remote Sensing Lab's Rapid Assessment of Vegetation Condition after Wildfire (RAVG) program.
CSO_SeveritySummary	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_SeveritySummary	A summary of fire severity in each PAC and surrounding territory, including mean severity, and percentage of PAC and territory in each of five severity classes.

Data type	Dataset	Description/Source
CSO Restoration opportunities	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_severitymetrics	CSO PACs attributed with fire severity metrics at both the PAC and territory scale used to assign probability of occupancy (high, medium, low) and restoration opportunities (maintain, restore, reevaluate).
Pre-fire Vegetation (Eveg)	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Vegetation\DixieSugar_Fire_Eveg	USFS Region 5 Existing Vegetation data layer.
CSO Potential habitat	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_PotentialHabitat	Areas within the Dixie and Sugar Fires that could provide CSO habitat based on California Wildlife Habitat Relationship (CWHR) classifications for vegetation type, density and size classes described in USDA (2019). Does not include delineated PACs or territories.
Wildland Urban InterMix	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\WUI\SN_WUI	USFS Region 5 data layer available at: https://www.fs.usda.gov/detail/r5/landmanagement/gis/?cid=fsbdev3_048299
Spotted owl predicted climatic niche	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Climate\CSO_predictedclimate	Predicted future climate niche of spotted owls using HADCM2 model and A1B emissions scenario for 2080 available at: https://databasin.org/datasets/602952a97e7841b881166e9d7f196954
CSO Priority	T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_Priority	An example of how a ranking system using wildland and urban intermix, climate and occupancy could be applied to prioritize restoration opportunities.

Scale

- Plumas and Lassen National Forests
- Dixie Fire and Sugar Fire footprints

Step 3. Use Postfire Flow Chart to Identify Restoration Opportunities

As described in (Meyer et al. 2021), we used the postfire flowchart (Figure 3) to identify different restoration opportunities in response to the range of effects caused by the Dixie and Sugar fires. The actions described in boxes I and II are generic examples and not intended to specifically address desired conditions for CSO; specific actions related to CSO are described in **Step 4. Develop a Restoration Portfolio.**

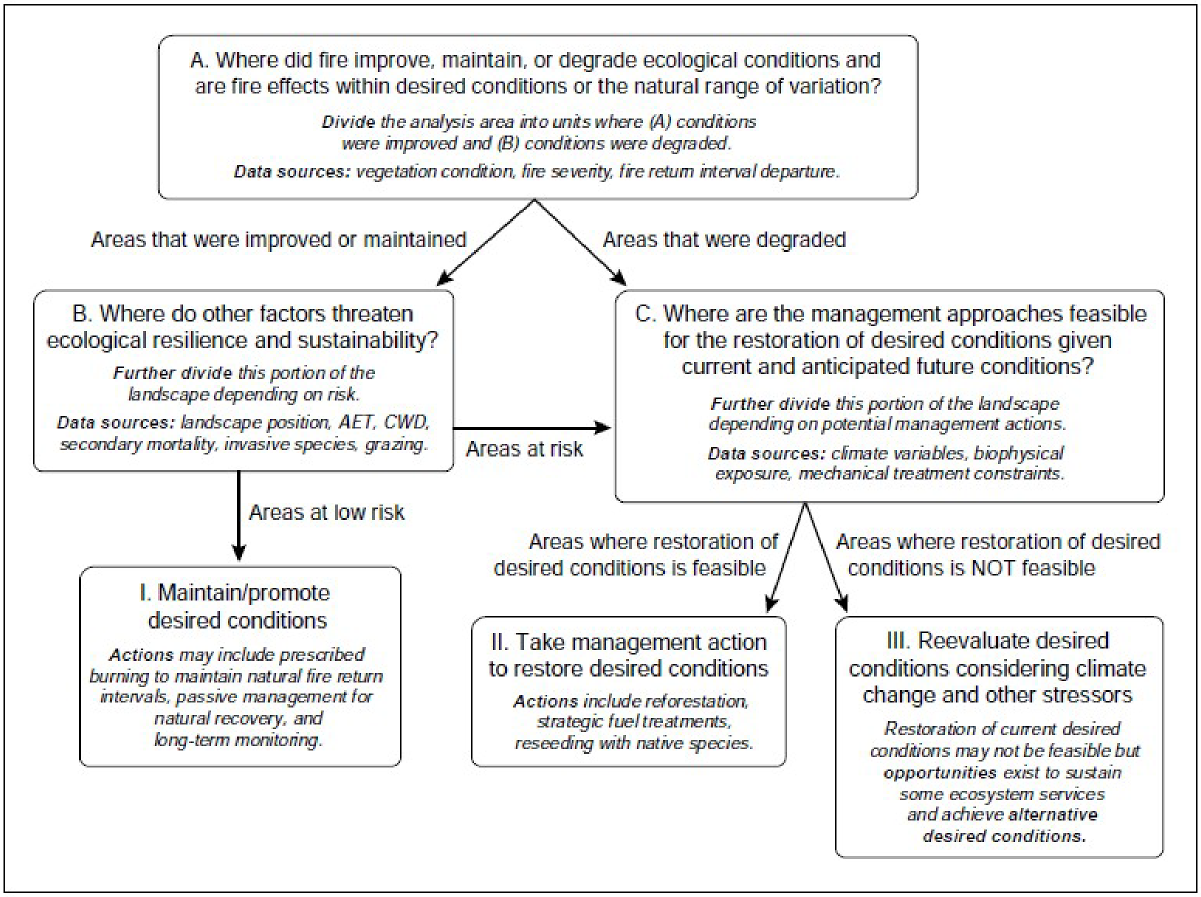

Figure 3. The postfire flow chart is based on three questions (A, B, and C) for the identification of management responses or “restoration opportunities” (I, II and III) that support the overarching restoration goals in different portions of the postfire landscape. The actions described in boxes I and II are generic examples and not intended to specifically address desired conditions for CSO.

We evaluated areas that were known to support California spotted owls prior to the fire (occupied habitat) including PACs and their surrounding territories. This analysis was limited to the Dixie Fire because no PACs were delineated within the Sugar Fire perimeter. We also evaluated restoration opportunities in areas within both the Dixie and Sugar fire perimeters that might be considered suitable habitat for CSO, as indicated by the California Wildlife Habitat Relationship (CWHR) classification system for canopy cover and tree size (USDA 2019), but where PACs had not been delineated (potential habitat).

Delineated PACs

We identified opportunities to 1) promote and maintain desired conditions, 2) restore desired conditions, and 3) reevaluate desired conditions in the Dixie Fire based on an estimation of the probability that areas delineated as CSO PACs prior to the fire would be likely to be occupied by CSO after the fire. For this analysis we choose to evaluate delineated PACs because forest-level mapping of PACs represents the best available data indicating where owls have been known to occur. Although CSO use various sized areas for nesting, roosting and foraging, and the size of these areas differ greatly depending on individual, sex, season and habitat quality (Blakey et al. 2019), we elected to use a standardized territory area to be consistent with previous studies of fire effects on CSO for this analysis. We followed the example provided in Jones and others (2021), who defined a territory as an area within a 1,100 m (3,609-foot) radius from the PAC (approximately 988 acres). Although we could have evaluated a wide range of other areas around the PAC, Jones and others (2021) found that patterns of fire severity within the 1,100 m (3,609-foot) radius area from the PAC was representative of effects seen at other spatial scales (e.g, nest sites and home ranges). Therefore, we believe our analysis approach using a 1,100 m (3,609-foot) radius territory area may sufficiently capture the effects of the fire on CSO outside of the PAC area. However, an analysis of fire effects at other spatial scales would also be appropriate and informative.

Using severity data provided by the USFS Remote Sensing Lab's Rapid Assessment of Vegetation Condition after Wildfire(RAVG) program, we calculated the area that burned in each of four severity categories (0-25% basal area mortality, 25-50% basal area mortality, 50-75% basal area mortality and >75% basal area mortality) in both the PAC and the surrounding territory (using our standardized definition), as well as the mean severity across the entire PAC and territory for each of the 169 PACs found within the Dixie Fire perimeter (available at: T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_SeveritySummary).

We then used the percent of each PAC and territory that burned at high severity, as well as the largest patch size of high severity effects (>75% basal mortality) in each PAC and surrounding territory to evaluate the likelihood that CSO would continue to utilize these habitat areas after the fires. Each PAC was then attributed with these severity metrics, including metrics that apply to the surrounding territory area. Attribute fields and definitions for this data set are shown in Table 3.

Table 3. Attributes and description of Severity Metric dataset used in our fire effects analysis. Data available at: T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_severitymetrics)

Attribute Name	Description	Notes
GOULDNUM	Identity field for PACs on the LNF	Missing values for 4 PACs on the LNF
LOCAL_ID	Identity field for PACs on the PNF	
PAC_NAME	Name of PAC	Only attributed for LNF PACs
Forest	LNF or PNF	
PAC_ID	Unique ID for all PACs included in analysis	Autogenerated in GIS
P_High	Proportion of PAC that burned w/ >75% basal area mortality	Based on area classified as grid code 4 in RAVG dataset. Note that 1 = 100%
T_High	Proportion of territory that burned w/ >75% basal area mortality	Based on area classified as grid code 4 in RAVG dataset. Note that 1 = 100%
PAC_PS	Largest patch of high severity in the PAC (acres with >75% basal area mortality)	Based on contiguous area classified as grid code 4 in RAVG dataset.
T_PS	Largest patch of high severity in the territory (acres with >75% basal area mortality)	Based on contiguous area classified as grid code 4 in RAVG dataset.

Using these metrics of fire effects within each PAC and surrounding territory, we classified the potential probability that each PAC and surrounding territory would be used by CSO after the Dixie Fire as either high, moderate, or low (Table 4). However, occupancy status can only be determined based on surveys conducted after the fire during which these assumptions can be tested and refined.

Table 4. Criteria used to classify the potential probability of occupancy of PACs by California spotted owl after the Dixie Fire.

PAC % High Severity	Territory % High Severity	PAC High Severity Patch Size	Territory High Severity Patch Size	Probability of Occupancy
<50% **and**	<50% **and**	<89 acres **or**	<250 acres	High
<50% **and**	<50% **and**	>89 **or**	>250	Moderate
>50% **or**	>50%	ANY	ANY	Low

Our rationale for these classifications were as follows:

- **High**: Areas considered to potentially have a high probability of occupancy after the fire are those where less than half of the PAC and less than half of the territory experienced high severity fire effects. This determination is based on recent research of CSO occupancy and recolonization after fires (USDA 2019, Jones et al. 2021). Although there is considerable variation in the size and configuration of high severity patches that will continue to be used by CSO after a fire (e.g., Kramer et al. 2021), we chose a conservative estimate of less than 89 acres of high severity patch sizes within the PAC to indicate where CSO may be likely to persist (Eyes 2014, Eyes et al. 2017). Within the territory area, we applied a criteria of less than 250 acres of high severity fire effects to indicate where fire effects were still within the Natural Range of Variation for mixed conifer forest types (Safford and Stevens 2017).
- **Moderate:** Areas where probability of occupancy might be considered moderate included areas where less than 50% of both the PAC and the territory experienced high severity fire effects, but where high severity patch sizes were either greater than 89 acres in the PAC, or greater than 250 acres in the territory. This designation differs from High in that additional management actions could help restore desired conditions and potentially increase the probability of use in these areas.
- **Low**: In cases where high severity fire effects occurred in greater than 50% of the PAC or greater than 50% the territory, the probability of occupancy or recolonization is likely to be low. However, CSO may continue to use some portion of these areas if the surrounding landscape continues to support suitable habitat characteristics for owls. The persistence of CSO at these sites can only be determined by surveys conducted after the fire, as described in (USDA 2004).

We associated the probability of occupancy with different restoration opportunities for CSO habitat following the example flowchart (Figure 3). In areas where probability of occupancy is high, desired conditions for CSO likely have been maintained or improved. These areas provide opportunities for management actions to promote and maintain desired conditions. In areas where probability of occupancy is moderate, desired conditions for CSO may have been degraded, but opportunities to take management actions that can restore these conditions are likely to be possible. Finally, in areas where probability of occupancy is low, desired conditions for CSO may have been degraded and management actions to restore these conditions may not be successful. In these areas, a reevaluation of desired conditions may be warranted, including remapping or retiring the PAC. The relationship between probability of occupancy, the effect of the Dixie Fire on desired conditions for CSO, and the corresponding restoration opportunity for management actions are shown in Table 5.

Table 5. Relationship between probability of occupancy, effect of the Dixie Fire on desired conditions for CSO, and corresponding restoration opportunity, and number of PACs in each category on the LNF, PNF and across the Dixie Fire as a whole. Percentage of PACs shown in parenthesis.

Probability of Occupancy	Desired Conditions	Restoration Opportunity	Number of PACs LNF (% on LNF)	Number of PACs PNF (% on PNF)	Number of PACs Total (% of Total)
High	Maintained or Improved	Maintain/Promote Desired Conditions	18 (21%)	23 (28%)	41 (25%)
Moderate	Degraded - Restoration Possible	Restore Desired Conditions	30 (34%)	21 (26%)	51 (30%)
Low	Degraded- Restoration Unlikely	Reevaluate Desired Conditions	39 (45%)	38 (46%)	77 (46%)

The spatial locations of probability of occupancy and the corresponding restoration opportunity are shown in Figure 4. Although Figure 4 depicts these opportunities at the scale of the PAC, they apply to the surrounding territory area as well.

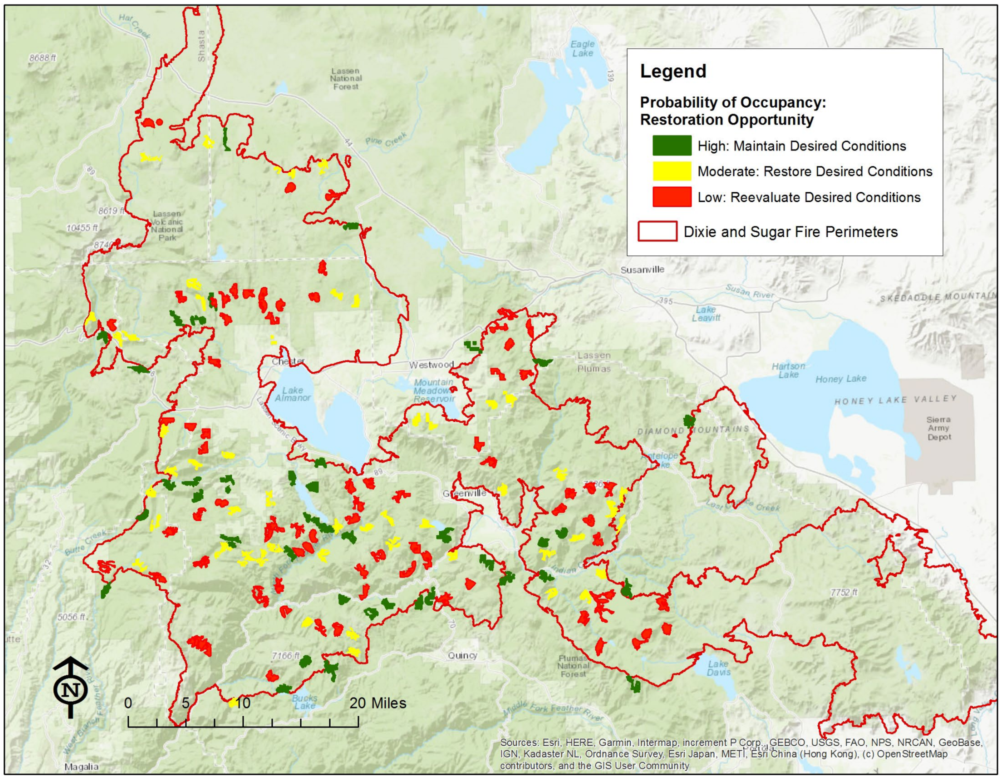

Figure 4. Potential restoration opportunities for California spotted owl habitat affected by the Dixie Fire. Although these are depicted according to PAC boundaries, the opportunities apply to the surrounding territory area as well. Data available at: T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_severitymetrics.

Potential Habitat

Throughout the Dixie and Sugar fire footprints, we also evaluated restoration opportunities in burned areas that may provide suitable habitat conditions for CSO, but where PACs have not been delineated. We refer to these areas as "potential habitat". We used the CWHR classification system to provide a rough estimation of where these potential habitat areas for CSO are located, according to definitions provided in USDA (2019) shown in Table 6.

Table 6. Suitable habitat for the CSO using the California Wildlife Habitat Relationships[1]

CWHR Classification	Tree Size QMD	CWHR Canopy Class	Canopy Cover	Vegetation Types
4D	11 to 24"	Dense cover	60 to 100 percent	DFR, MHC, MHW, MRI, PPN, RFR, SMC, WFR
4M	11 to 24"	Moderate cover	40 to 59 percent	
5D	more than 24"	Dense cover	60 to 100 percent	DFR, EPN, JPN, LPN, MHC, MHW, MRI, PPN, RFR, SMC, WFR
5M	more than 24"	Moderate cover	40 to 59 percent	
6		Multilayered canopy with dense cover		

[1] CWHR habitat types for CSO include Douglas fir (DFR), eastside pine (EPN), Jeffrey pine (JPN), lodgepole pine (LPN) montane hardwood-conifer (MHC), montane hardwood (MHW), montane riparian (MRI), ponderosa pine (PPN), red fir (RFR), Sierran mixed conifer (SMC), white fir (WFR).

To identify potential habitat areas, we selected these CWHR vegetation type, tree size and canopy cover classes from within the Dixie and Sugar fire perimeters that did not intersect a delineated owl PAC or surrounding standardized territory area. Of 411,802 acres mapped as potentially suitable for CSO, 236,394 acres were within a CSO PAC and surrounding territory area (57%) and 175,408 acres (43%) were outside of delineated PACs and surrounding territories. We then identified potential restoration opportunities for CSO as those areas with less than 50% basal area mortality in patch sizes of at least 300 acres, to approximate the area required to sustain a CSO PAC. We excluded areas on private land. Based on these criteria, we identified 17 patches occupying a total of 9,877 acres as potential habitat for CSO where management actions to restore or maintain desired conditions could occur. These areas are shown in Figure 5.

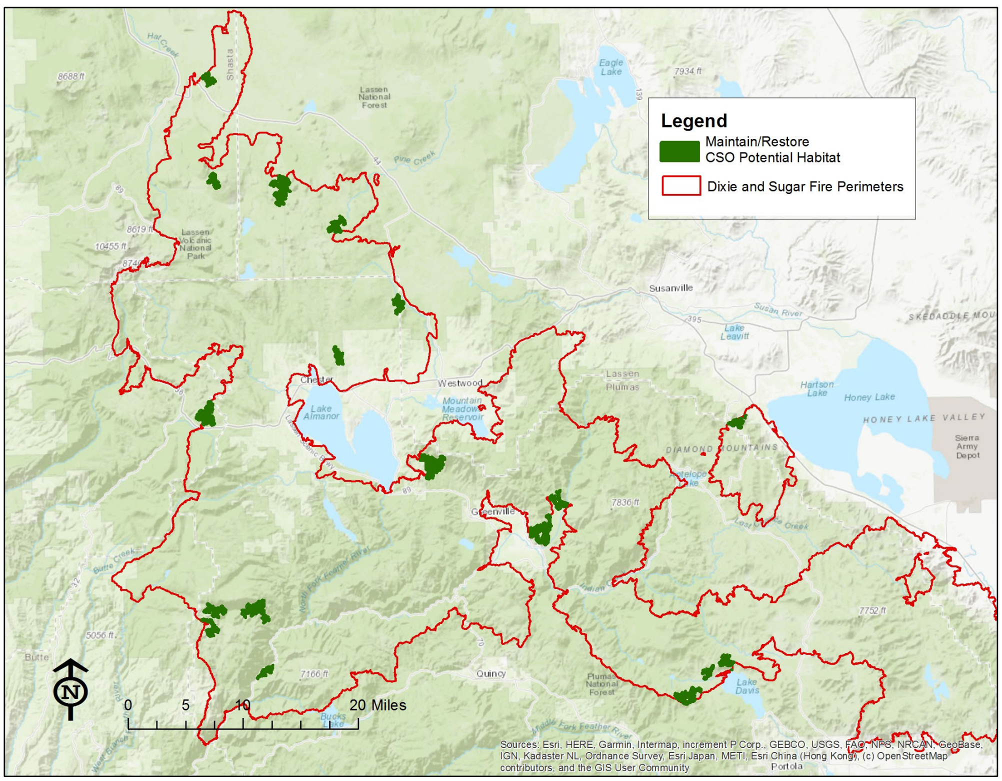

Figure 5. Restoration opportunities for CSO potential habitat areas within the Dixie and Sugar fire perimeters. Data available at: [T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_potential]().

Step 4. Develop a Restoration Portfolio

<u>List of Potential Management Actions</u>

There is a suite of potential management actions that could both maintain and promote desired conditions for CSO habitat as well as restore those habitat areas where conditions were degraded. These actions include targeted and strategic fuels management designed to meet the dual objectives of conserving California spotted owl habitat and promoting resilience of Sierra Nevada forests by retaining large trees, reducing surface fuels and small tree densities, and promoting fire regimes within the natural range of variation for Sierra Nevada forests (USDA 2019). Specific management actions might include:

- *Prescribed burning and hand thinning.* These treatments could both promote and restore desired conditions in CSO habitat areas.
- *Mechanical thinning and dead tree removal.* These treatments may be appropriate in some areas to reduce the risk of high severity fire and allow for subsequent actions such as prescribed burning to restore natural fire regimes and desired conditions for CSO.
- *Reforestation.* This management intervention may be warranted to restore desired conditions in areas with large patch sizes of high severity fire effects. Reforestation in these areas may consider planting preferred species by CSO, such as Douglas-fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), and red fir (*A. magnifica*). Hardwoods are also an important component of CSO habitat and these species should be protected and maintained during site preparation and other postfire management activities. Although reforested areas may not serve as CSO habitat in the short-term, they may provide habitat for CSO over longer time frames, particularly when managed to promote desired conditions for CSO, such as through repeated prescribed burning.

Heterogeneity

Management approaches will be most effective at restoring desired conditions for CSO if they can be designed to promote and maintain heterogeneity. Creating a dynamic mosaic of tree clumps and openings of variable sizes, shapes, spatial configurations, and seral stages can enhance forest resilience to fire and other disturbances and protect existing stands of mature, multi-canopied forest preferred by CSO (Kane et al. 2013). Maintaining or restoring heterogeneity can also be accomplished by varying management approaches across different spatial scales. For example, actions that are taken within the territory or the home range may differ from those employed within the PAC because habitat elements that promote foraging are different from those associated with nesting and roosting. By considering spatial scale when implementing management actions, multiple restoration goals might be achieved, including promoting both structural and compositional heterogeneity across the landscape.

Monitoring and Adaptive Management

Monitoring is a critical component of any restoration strategy for CSO to test assumptions regarding postfire use. For example, monitoring in areas that we predicted would differ in occupancy could help refine our definitions and prioritization. In addition, potential habitat areas outside of existing PACs should be monitored to evaluate if this habitat is utilized by CSO in the future. In addition, the success of any management action taken will need to be evaluated through a well-maintained feedback loop between science and management in an adaptive management context.

<u>Prioritization Scheme</u>

After developing a list of potential restoration opportunities as described above, the following information could be used to prioritize CSO habitat areas for management actions. Areas that may warrant higher priority might include:

1. *Occupancy status.* PACs that continue to have the highest likely contribution to owl productivity as confirmed by postfire monitoring efforts should be given the highest priority for maintaining or restoring desired conditions. Occupancy status is likely the most important factor in any restoration strategy for CSO.
2. *Wildland Urban intermix.* Management of wildland urban intermix (WUI) areas is currently a high priority for the USFS, and fuel treatments within the WUI may be more likely to be implemented than treatments in remote wildland areas. However, these treatments must be carefully designed and implemented to maintain and promote desired conditions for CSO.
3. *Climate suitability.* Areas that are predicted to continue to provide suitable habitat conditions for CSO in both the near- and longer-term may warrant a higher priority for management than areas where only short-term restoration may be possible. However, given the uncertainty in these models and the difficulty in predicting emissions scenarios, these models may not necessarily be weighted as heavily as other known factors such as CSO occupancy. In addition, maintaining suitable CSO habitat in the short term may be critical for longer term survival of this species.
4. *Proposed project areas*. CSO habitat that is within an area currently proposed for treatments (e.g., fuels reduction, timber sales, vegetation management) may require an expedited assessment of restoration opportunities and potential management actions.

An example of a prioritization scheme using wildland and urban intermix zones, predicted future climate niches for spotted owls, and delineated PACs versus potential habitat areas is provided in **Appendix 1**.

Benefits of Maintaining and Restoring CSO habitat

Our analysis suggests that areas occupied by CSO may be less susceptible to high severity fire effects than areas not used by CSO. We found that CSO PACs experienced lower severity fire effects than those observed across the Dixie and Sugar fires as a whole (Figure 6). High severity fire effects (over 75% basal area mortality) occurred in 50% of all vegetation types, and 50% of mixed conifer vegetation types, while only 24% of PACs experienced high severity fire effects. In addition, the percent of PACs that experienced more moderate severities (between 25 and 75% basal area mortality) was higher than that found in conifer forest vegetation types, and across all vegetation types combined.

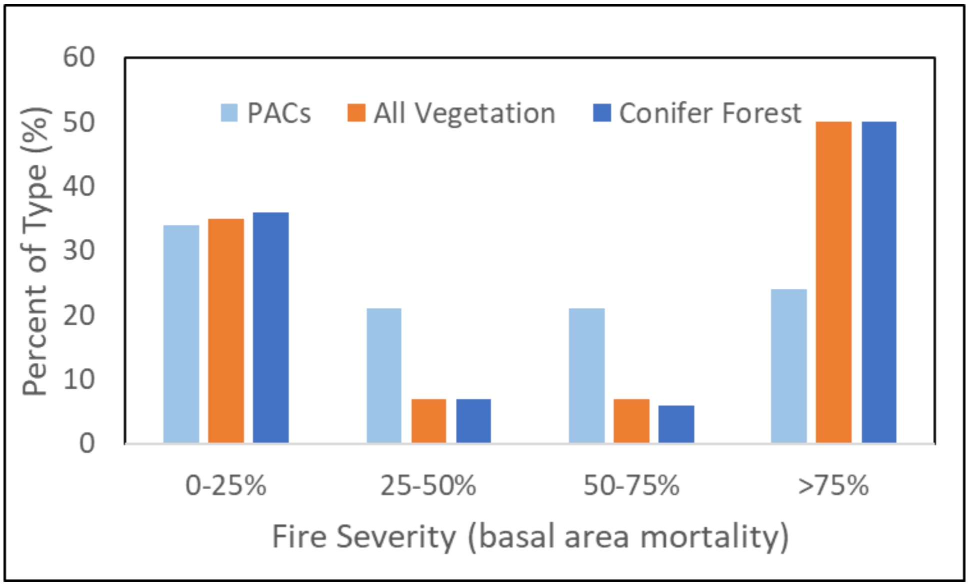

Figure 6. Patterns of fire severity in CSO PACs, across all vegetation types, and in mixed conifer forest vegetation types, within the Dixie and Sugar fire perimeters.

Other studies have also found that fire severity can be lower in areas used by spotted owls for nesting compared with the surrounding forest (Lesmeister et al. 2019, Lesmeister et al. 2021). This may be related to the habitat requirements of CSO, including late-successional, multistoried, closed-canopy forests characterized by large trees. Closed-canopy older forests are less likely to burn at high severity compared to younger and more open-canopied forest cover types (Zald and Dunn 2018), even during drought years with high-fire weather conditions (Lesmeister et al. 2019). Late-successional forests create moister and cooler microclimates (Rambo and North 2009) that may moderate fire behavior, and large trees are more resistant to fire than smaller trees. Large trees are also important for structural heterogeneity, carbon sequestration (Stephenson et al. 2014), and seed production, which is critical for forest recovery after large fires. In addition to contributing to spotted owl conservation, restoring and maintaining late-successional forest habitats can also support ecosystem resilience to disturbances and promote postfire ecosystem recovery.

Literature Cited

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Appendix 1. Example prioritization scheme for CSO restoration opportunities after the Dixie and Sugar fires.

To provide an example prioritization scheme, we used data identifying wildland and urban intermix zones developed by the Region 5 of the USFS for the Sierra Nevada (see Table 2). We also included predicted future climatic niches for spotted owls developed by Brandt (2012) using the modeling algorithm Maxent and the Worldclim predictor set. For this exercise, we used a model of climatic suitability in 2080 based on the A1B emission scenario and the HADCM3 general circulation model. We chose the selected dataset only as an example. Other datasets, including different modeling algorithms, timeframes, circulation models and emissions scenarios are available. In addition, we differentiated between areas delineated as PACs prior to the Dixie Fire and those where CWHR vegetation, canopy and tree size classes suggested suitable habitat conditions for CSO (potential habitat). We did not include areas identified as potentially needing to be reevaluated in this prioritization scenario because factors important for prioritizing these areas may differ from those presented here. An example of the spatial combination of these datasets is shown in Figure 7.

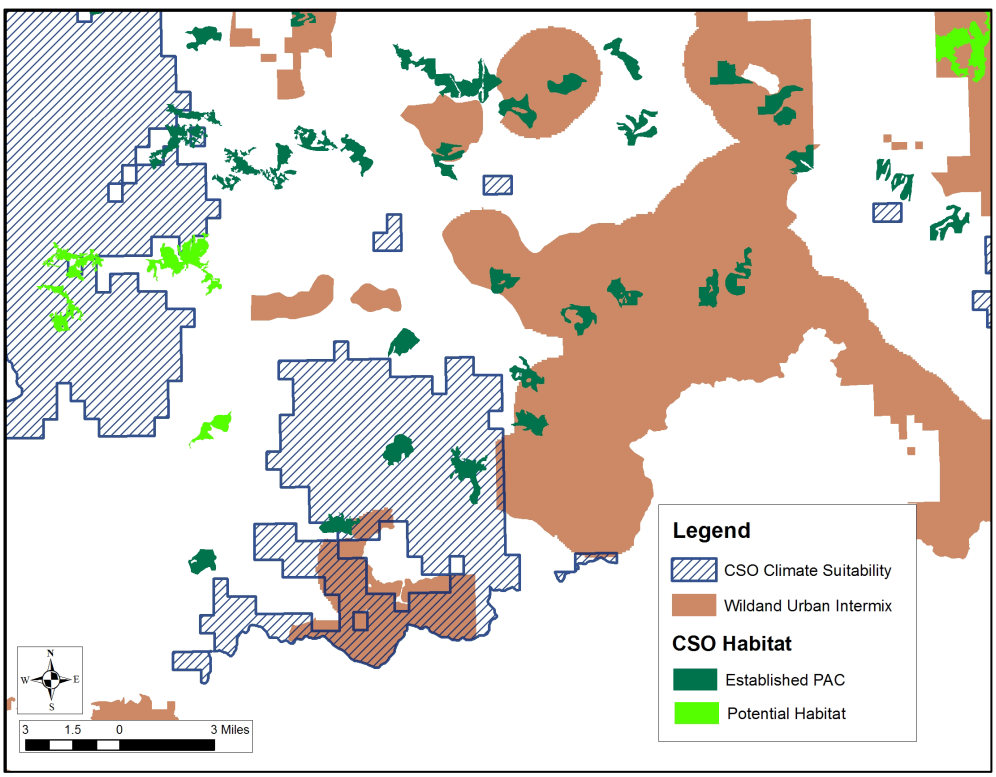

Figure 7. Example data sets that could be used to prioritize potential management actions for CSO, such as wildland urban intermix zones, climate suitability models, and established PACs vs. potential habitat areas.

In this example, we gave each data layer equal weight by assigning each of the following a value of one if present and a value of zero if absent: 1) areas that were within delineated PACs; 2) areas within a wildland urban intermix zone; and 3) areas predicted to support a suitable climate for CSO in 2080. More sophisticated prioritization schemes, including weighting factors, could be considered. We combined values from all three datasets to develop a final ranking system, where areas that met none of these criteria received a final rank of zero, and those that met all three criteria (within a PAC, within a WUI, and within an area predicted to have a suitable climate for CSO) would receive a final ranking of three.

Of 119 areas identified as opportunities to restore or promote desired conditions (excluding areas where desired conditions may need to be reevaluated), 11 areas met all three criteria and were given a rank of three. These are areas located within the WUI, may support climatic conditions suitable for spotted owls in 2080, and were within delineated PACs prior to the Dixie Fire. Conversely, 11 areas did not meet any of these criteria. The number of areas in each combination of the three ranking factors is shown in Table 7, and the spatial locations of each area with the combined ranking is shown in Figure 8.

Table 7. Count of areas identified as having opportunities to restore or promote desired conditions in each combination of prioritization factors (WUI = wildland urban intermix, Climate = suitable habitat conditions in 2080, Occupied = delineated as a PAC prior to the Dixie Fire).

	WUI	Climate	Occupied
WUI	53	12	42
Climate	12	34	28
Occupied	42	28	92

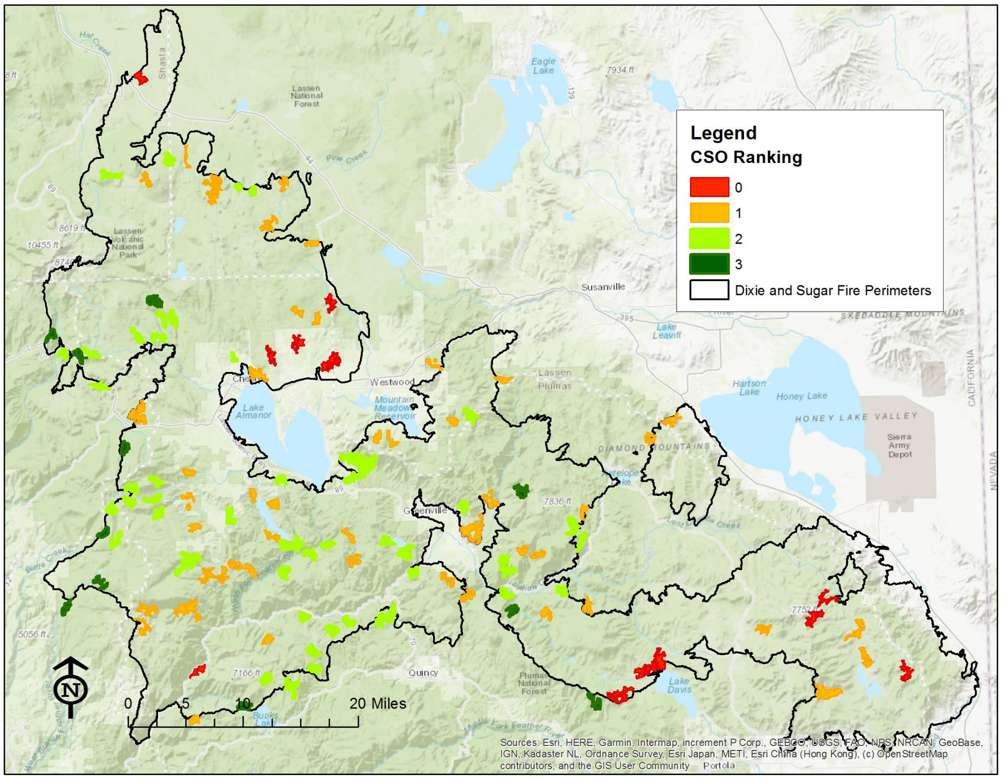

Figure 8. Example prioritization of areas with restoration opportunities for CSO of maintain or restore ranked according to occupancy, location within a WUI, and overlap with climatic niche modeling for 2080. A rank of zero means none of these criteria where met, a rank of three means the area meets all three criteria. Data available at: [T:\FS\NFS\Plumas\Project\SO\DixieFire_LandscapeAssessment\GIS\MasterData\Dixie_RestorationStrategy.gdb\Wildlife\CSO_Priority]().