Understanding the Mechanisms for Fisher Declines in Areas of Mixed-Severity Wildfire

Final Performance Report

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A century of fire suppression and recent increases in fire frequency and severity in the western United States present an emerging suite of concerns for the sustainable management of forest resources and the conservation of forest-obligate wildlife species. The conservation of fishers (*Pekania pennanti*) epitomizes the challenges in considering various management alternatives. Previous research has indicated potential short- and long-term tradeoffs between fuels-management activities, fire severity, and fisher persistence (e.g., Scheller et al. 2011, Thompson et al. 2011, Sweitzer et al. 2016). These tradeoffs represent management alternatives that profoundly affect both human and biological communities, yet few studies have evaluated the response of forest-dependent carnivores to mixed-severity forest fires and associated management alternatives. Our history of monitoring fishers on the Klamath National Forest as part of the Klamath-Siskiyou Carnivore Project (hereafter, Klamath) (Green et al. 2018) provides sufficient long-term data needed to disentangle the effects of ecological and anthropogenic disturbances from naturally occurring variations on the landscape.

In the summer of 2014, two forest fires burned areas on and adjacent to Klamath (Figure 1): the Beaver Fire and Happy Camp Complex. The Beaver Fire burned 132 km^2 from July 30th to September 2nd and the Happy Camp Complex burned 543 km^2 from August 12th to October 31st. Both of these fires were ignited by lightning and burned at mixed-severity, with 47.5% and 27.7% of the Beaver Fire and Happy Camp Complex burning at high severity (i.e., $\geq$ 50% basal area mortality), respectively. Our recent results indicate significant declines in fisher density in areas where canopy cover declined by >50% following a mixed-severity fire and post-fire salvage logging (Green et al. In prep). We hypothesized that increases in predator abundance or decreases in prey availability may explain the observed declines in fisher density in a post-fire landscape.

Limited information is available on the responses of fisher predators and prey to forest fires and thus their influence on fisher density following a fire. Predation, primarily by bobcats and mountain lions, accounts for 70% of fisher mortalities in California (Wengert et al. 2014, Gabriel et al. 2015). In southern California, mountain lions used burned habitats opportunistically 2-5 years after a fire to take advantage of increased mule deer (*Odocoileus hemionus*) densities (Jennings et al. 2016). Fishers are described as dietary generalists that consume a variety of small and medium-sized mammals and birds, insects, reptiles, and amphibians (Lofroth et al. 2010). In central California, small mammal abundance was greater in unburned forests than in burned forests, largely reflecting the greater proportion of closed-canopy species such as northern flying squirrel (*Glaucomys sabrinus*; Roberts et al. 2015). Similar responses by fisher predators and prey to a post-fire landscape in the Klamath-Siskiyou Ecoregion could have important implications for fisher conservation and management.

Understanding the mechanisms driving population-level post-fire responses by fishers will inform post-fire decision-support tools for managers. Thus, we investigated the potential influences of predator (e.g., bobcats and mountain lions) and prey species (e.g., Douglas squirrels, western gray squirrels) as mechanistic hypotheses for changes in fisher density in the post-mixed-severity-fire landscape.

Task 1. Field surveys and estimate occupancy of large carnivores

We surveyed for carnivores, including fishers and their predators and competitors, in areas burned and unburned by the 2014 Beaver Fire using remote cameras throughout the Klamath-Siskiyou Carnivore Project study area (Figure 1). We paired one remote camera (Bushnell Aggressor, model 119876C, Bushnell Corporation, Overland Park, Kansas) with each of our 100 track plate stations. Each camera was deployed along a wildlife trail within 100 m of

the track-plate station (Figure 2). Twenty remote camera stations were located within the boundaries of the Beaver Fire and 80 were located in unburned areas. We estimated meso- and large carnivore occupancy and responses to fire throughout the study area using species detections at remote cameras collected between September and November 2019. Specifically, we estimated the effects of two variables on the occupancy of carnivores of interest: 1) the effect of a binary presence of wildfire (i.e., burned or unburned), and 2) the effect of distance to nearest burned area. Given these covariates are inherently correlated, we estimated their effects in two separate occupancy models and report the effects of each covariate on the probability of site occupancy estimated from remote camera detections.

Predicted site occupancy varied among species. Fishers occupied approximately 39 sites and the remaining six carnivore species occupied between 14 and 73 sites (Table 1). Preliminary results indicate varied responses of the carnivore community to the presence of burned areas on the landscape. The results of our first model indicated that fishers were significantly less likely to occupy sites within burned areas, whereas gray foxes were significantly more likely to occupy sites within burned areas (Table 1, Figure 3). Conversely, site occupancy of all other carnivores was largely unrelated to whether a site had burned (Table 1, Figure 3). The results of our second model showed that there was no evidence that distance to fire was positively associated with site occupancy of carnivores outside the boundaries of the Beaver Fire (Table 1, Figure 4). For three carnivores—gray fox, black bear, and ringtail—distance to fire was negatively associated with site occupancy (Table 1, Figure 4). For these carnivores, the probability of occupying a site decreased as distance to the boundary of the Beaver Fire increased, suggesting they were more likely to occupy sites proximal to the fire boundary.

These results support recent research demonstrating the varied effects of wildfire on the ecology of the carnivore guild in the Klamath-Siskyou Carnivore Project study area (Green et al. In prep). In particular, we found that fishers are still unlikely to use sites affected by wildfire ≥4 years post-fire, whereas gray foxes are still likely to occupy burned sites. Interestingly, we found there was virtually no effect of distance to fire edge on the probability of fishers occupying a site outside of the fire footprint. Though these findings are preliminary, if such patterns of fisher space use are consistent over time, managers may be able to offset the negative effects of wildfire on fisher space use by maintaining a landscape mosaic that includes access to forest patches with dense forest cover, multiple canopy layers, and large down wood.

Task 2. Estimate occupancy of small mammals

We estimated occupancy and responses to wildfire of a subset of small mammal species likely to be prey for fishers (Table 1) using species detections collected via remote cameras throughout the Klamath-Siskiyou Carnivore Project study area (Figure 1). Following our approach with carnivore species, we used remote camera detections collected between September and November 2019 to estimate occupancy and responses to fire of a subset of small mammal species or species groups that may be important prey for fishers in the Klamath-Siskiyou Carnivore Project study area. Specifically, we estimated the effects of two variables on the occupancy of small mammals of interest, 1) the effect of binary presence of wildfire (i.e., burned or unburned), and 2) the effect of distance to nearest burned area.

Site occupancy varied among species. Douglas' squirrels occuyied approximately 68 sites and the remaining six small mammal species occupied 5 to 33 stations (Table 1). Preliminary analyses suggest that Douglas' squirrels were significantly less likely to occupy sites within burned areas, whereas California ground squirrels were significantly more likely to occupy sites

within burned areas (Table 1, Figure 5). Site occupancy of all other small mammal species included in this preliminary analysis was largely unrelated to whether a site had burned (Table 1, Figure 5). There was no evidence that distance to fire was negatively associated with site occupancy of small mammals—that is, no species exhibited a higher probability of occupying sites closer to the boundary of the Beaver Fire. For golden-mantled ground squirrels and chipmunks distance to fire was positively associated with site occupancy (Table 1, Figure 6). That is, for these species, the probability of occupying a site increased as distance to the boundary of the Beaver Fire increased.

These results represent an initial exploration of the distribution of small mammals and their responses to wildfire in the study area. We anticipate that the lack of response to distance to fire by some small mammal species may be due to the spacing or scale of the survey design. These surveys were designed to be effective at detecting fishers and larger carnivores, with the spacing and distribution of stations determined by the average home range of female fishers. Thus, we may be unable to capture more nuanced or fine-scale spatial responses of small mammal species to wildfire with stations deployed at this broader scale. Nonetheless, we were still able to demonstrate that some small mammal species, such as Douglas' squirrels and California ground squirrels exhibit varied responses to the presence of wildfire. In particular, California ground squirrels, a species typically associated with early-successional forest or open landscape patches, were more likely to occupy burned areas than the average response of the small mammal community. Conversely, Douglas' squirrels, a species typically associated with closed canopy forest patches, were less likely to use sites burned by the Beaver Fire.

Next Steps

To further explore the distribution of carnivores and small mammals, inter-specific interactions, and the effects of temporal and spatial heterogeneity in the Klamath-Siskiyou Carnivore Project study area on the ecology of the mammal community, we will incorporate additional remote camera data collected in 2019 and long-term detection data (i.e., 2006 – 2019) collected from sooted track plates. By incorporating long-term detection data, spanning the period before and after the Beaver Fire, we may be able to quantify broader spatial and temporal patterns of distribution and co-occurrence of carnivores and their prey, and quantify how such relationships may vary due to wildfire.

Task 3. Evaluate the influence of large carnivore and small mammal occupancy on fisher density

Results from preliminary occupancy analyses indicate that the occupancy patterns of potential predators and prey of fishers four years post-fire do not provide evidence to explain patterns of fisher density (e.g., declines) in and around the 2014 Beaver Fire footprint (Green et al. In prep). The occupancy patterns of mountain lions and bobcats were not influenced by whether a site was burned or the distance to the fire boundary. Grey fox occupancy did increase in the fire footprint and in unburned areas in closer proximity to the fire boundary. We suspect, however, the response of grey fox is a function of the absence of fisher in and around the fire footprint. Green et al. (2018) found fishers negatively affected grey fox site persistence, indicating in areas where fishers are present they are able to outcompete grey foxes.

Fishers are dietary generalists that forage on a diverse array of mammals, birds, reptiles, insects, and vegetation (e.g., Golightly et al. 2006, Slauson et al. 2011). On the Shasta-Trinity National Forest, an area with similar forest and species composition to our study area, Douglas'

squirrel and ground squirrel were a relatively small component of fisher diet (Golightly et al. 2006); remains were found in 1 (0.7%) and 3 (2.0%) of 148 scats, respectively. Our results indicate Douglas' squirrels were significantly less likely to occupy sites within burned areas, whereas California ground squirrels were significantly more likely to occupy sites within burned areas. Additionally, site occupancy of all other small mammal species included in this preliminary analysis was largely unrelated to whether a site had burned. Although no pre- or post-fire diet data are available for fisher on our study area, we suspect the patterns in small mammal occupancy we observed relative to the 2014 Beaver Fire likely had little effect on the decline of fisher following the fire.

Next Steps

A single year of occupancy patterns of fisher predators and prey relative to the 2014 Beaver Fire do not explain demographic responses of fishers post-fire. In upcoming analyses, we will quantify the influence of large carnivores and small mammal occupancy on fisher density using spatial mark-recapture methods. We will make comparisons between areas burned during the 2014 Beaver Fire and adjacent unburned areas.

Table 1. Sites occupied and responses to fire of mammalian species of interest in the Klamath-Siskyou Carnivore Project study area. For each species, we display estimates of the number of stations occupied, the effect of presence of wildfire (i.e., burned vs. unburned) on probability of site occupancy, and the effect of distance to fire on the probability of site occupancy outside of the fire footprint. For each response we report the mean estimate and lower and upper 95% credible intervals. Statistically significant parameters are indicated in bold (i.e., their 95% credible interval did not overlap 0).

Species	Estimated Occupancy	Fire
Fisher	0.45 (0.41, 0.50)	**-2.05 (-4.07, -0.44)**
Coyote	0.27 (0.14, 0.56)	0.34 (-1.05, 1.67)
Puma	0.38 (0.20, 0.71)	0.39 (-0.84, 1.67)
Gray fox	0.28 (0.26, 0.33)	**0.91 (0.01, 2.05)**
Black bear	0.71 (0.68, 0.75)	0.43 (-0.55, 1.47)
Ringtail	0.14 (0.11, 0.20)	0.19 (-1.25, 1.18)
Bobcat	0.41 (0.24, 0.71)	0.57 (-0.54, 1.74)
Bushy-tailed woodrat	0.05 (0.04, 0.08)	-0.15 (-2.32, 1.85)
California ground squirrel	0.10 (0.02, 0.14)	**2.07 (0.90, 3.33)**
Douglas' squirrel	0.77 (0.75, 0.79)	**-1.82 (-2.95, -0.76)**
Golden-mantled ground squirrel	0.06 (0.05, 0.09)	-1.69 (-5.40, 0.75)
Northern flying squirrel	0.15 (0.14, 0.18)	-0.46 (-2.10, 0.92)
Chipmunk specie(s)	0.34 (0.33, 0.36)	-0.16 (-1.28, 0.87)
Grey squirrel	0.27 (0.26, 0.30)	0.53 (-0.45, 1.53)

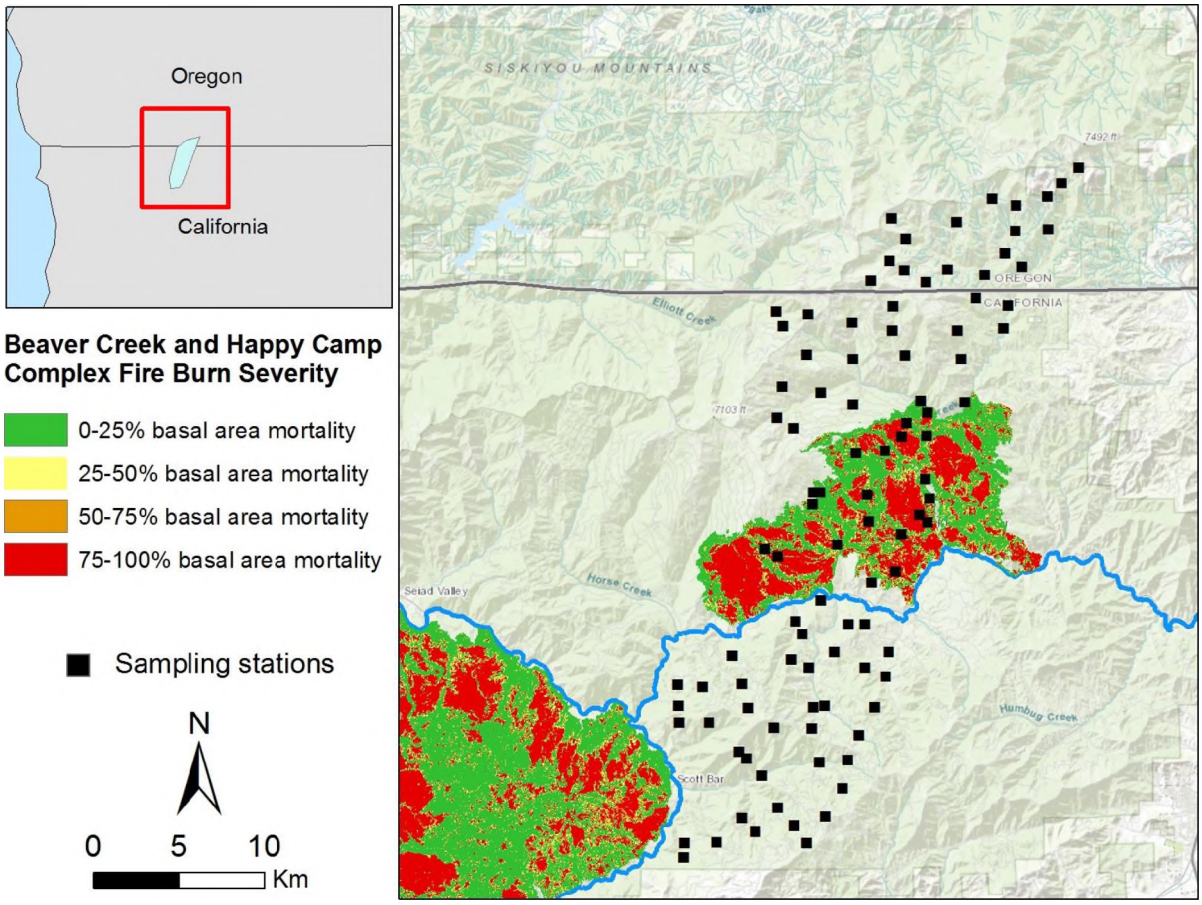

Figure 1. Survey sites (n = 100, black squares) and 2014 wildfires on and adjacent to the Klamath-Siskiyou Carnivore Project in the Klamath-Siskiyou Ecoregion of northern California and southern Oregon. Wildfires are depicted by categorical burn severity based on basal area tree mortality evaluated by the Rapid Assessment of Vegetation Condition after Wildfire (RAVG) program. The Beaver Fire is the northern fire and the Happy Camp Complex is the southern fire.

Figure 2. Placement of a remote camera deployed along a wildlife trail within 100 m of a track-plate station on the Klamath-Siskiyou Carnivore Project in 2018.

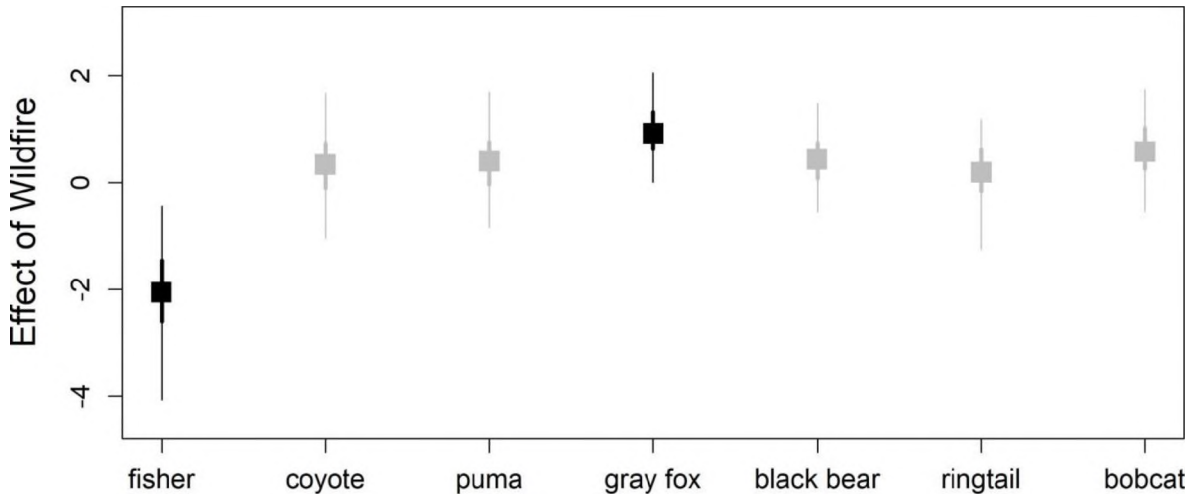

Figure 3. Effect of wildfire (i.e., burned vs. unburned) on site occupancy of meso- and large carnivores in the study area in the Klamath-Siskiyou Carnivore Project study area. For each species, mean values are indicated by squares and 50% and 95% credible intervals (CIs) are shown with thick and thin vertical bars, respectively. Black shapes indicate a relationship that was significant at the 95% CIs, whereas gray shapes indicate non-significant relationships. Fishers were less likely to occupy sites within burned areas, whereas gray foxes were more likely to occupy sites within burned areas. Conversely, site occupancy of all other carnivores was largely unrelated to whether a site had burned.

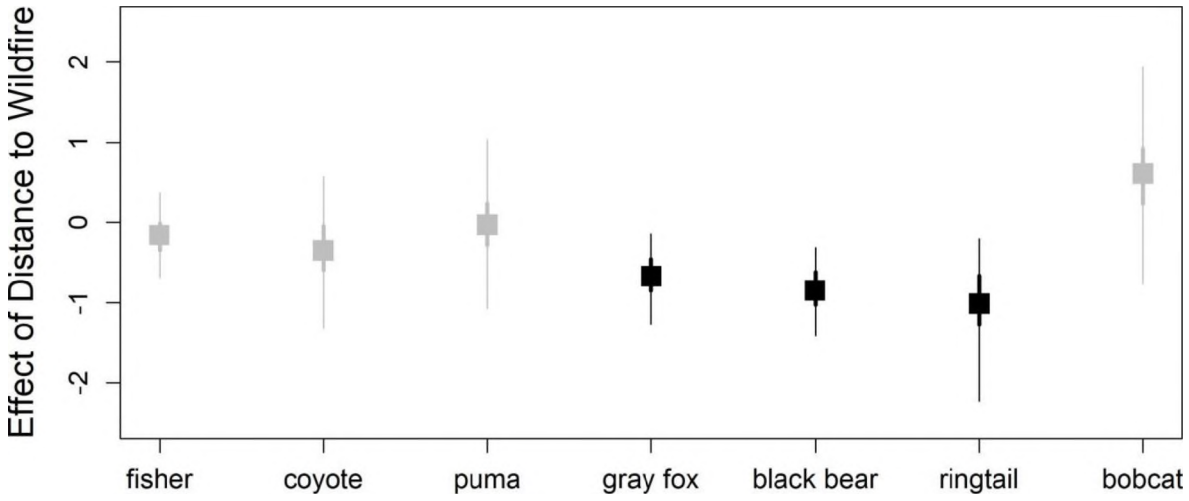

Figure 4. Effect of distance to wildfire on site occupancy of meso- and large carnivores detected outside of the Beaver Fire boundary in the Klamath-Siskiyou Carnivore Project study area. For each species, mean values are indicated by squares and 50% and 95% credible intervals are shown with thick and thin vertical bars, respectively. Black shapes indicate a relationship that was significant at the 95% CIs, whereas gray shapes indicate non-significant relationships. There was no evidence that distance to fire was positively associated with site occupancy of carnivores. For three carnivores—gray fox, black bear, and ringtail—distance to fire was negatively associated with site occupancy.

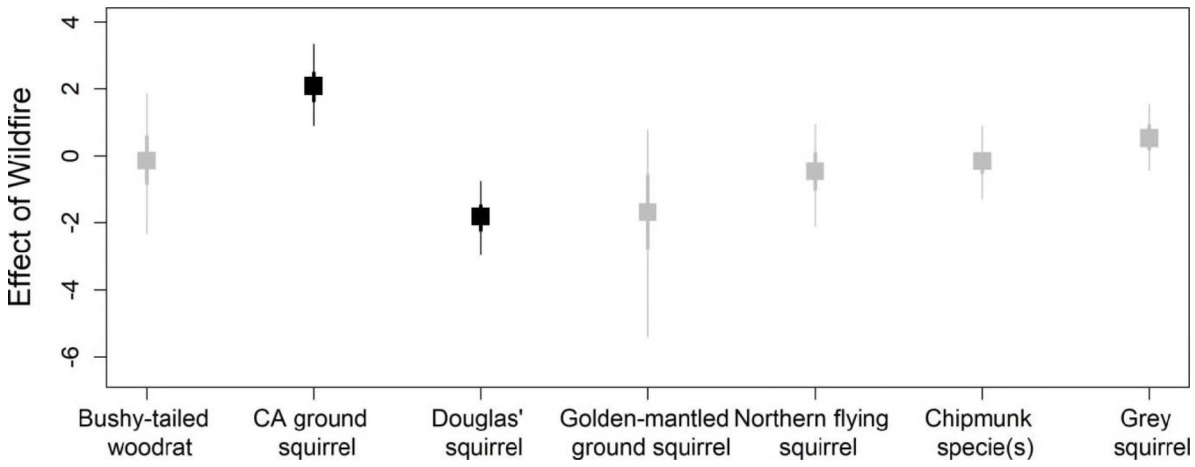

Figure 5. Effect of wildfire (i.e., burned vs. unburned) on site occupancy of a subset of small mammal species or species groups in the Klamath-Siskiyou Carnivore Project study area. For each species, mean values are indicated by squares and 50% and 95% credible intervals are shown with thick and thin vertical bars, respectively. Black shapes indicate a relationship that was significant at the 95% CIs, whereas gray shapes indicate non-significant relationships. Douglas' squirrels were less likely to occupy sites within burned areas, whereas California ground squirrels were more likely to occupy sites within burned areas. Site occupancy of all other small mammal species included in this preliminary analysis was largely unrelated to whether a site had burned.

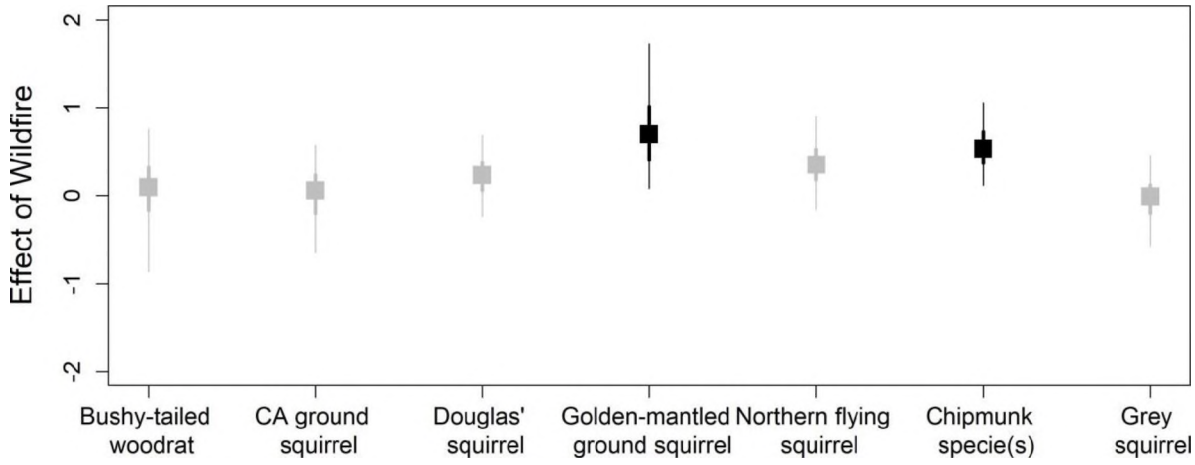

Figure 6. Effect of distance to wildfire on site occupancy of a subset of small mammal species or species groups in the Klamath-Siskiyou Carnivore Project study area outside of the boundary of the Beaver Fire. For each species, mean values are indicated by squares and 50% and 95% credible intervals are shown with thick and thin vertical bars, respectively. Black shapes indicate a relationship that was significant at the 95% CIs, whereas gray shapes indicate non-significant relationships. There was no evidence that distance to fire was negatively associated with site occupancy of small mammals. For two small mammal species or species groups—golden-mantled ground squirrels and chipmunks—site occupancy increased as distance from burn areas increased.

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