CHANGES IN BREEDING BIRD ABUNDANCE AFTER THE KINCADE FIRE, SONOMA COUNTY, CALIFORNIA

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ABSTRACT: Birds' responses to wildfire have been well studied in southern California and the Sierra Nevada, but less attention has been paid to central and northern coastal California, a region with frequent high-intensity fires. Using a combination of data from a structured point-count survey and incidental community-science data (eBird.org), we compare bird species' abundance three years before and after the Kincade Fire, which burned 314.6 km^2, including along Pine Flat Road in Sonoma County, California, in October 2019. The point-count protocol consisted of a 5-minute count at 16 points repeated three times per season in April and May for three years both before and after the fire (except for just a single survey in 2016). Of 42 species modeled, 10 decreased in abundance following the fire, most notably the Band-tailed Pigeon (*Patagioenas fasciata*; 99% by both methods). The Western Meadowlark (*Sturnella neglecta*) colonized, and two, the Red-winged Blackbird (*Agelaius phoeniceus*) and Steller's Jay (*Cyanocitta stelleri*), increased according to both methods. As found in many studies of birds' response to fire, the Lazuli Bunting (*Passerina amoena*) increased sharply, though this was attested by the point counts only. For two species, the Bushtit (*Psaltriparus minimus*) and California Thrasher (*Toxostoma redivivum*), the trend per eBird data was a decline whereas the trend per point-count data was an increase. Trends in the abundances of the remaining 27 species were only weakly related (21 species) or unrelated (5 species) to the fire.

California has a history of frequent fires, resulting in many habitats and communities adapted to or dependent upon fire (Vogl 1973, Harvey et. al. 1980, Keeley 1987, Ostertag et al. 2023). Climate change, in conjunction with a legacy of fire suppression, is predicted to increase the number, size, types, and intensity of fires in the state (Williams et al. 2019, Schweizer et al. 2020, Keeley and Syphard 2021, Li and Banerjee 2021). From direct mortality to habitat alteration, fire affects wildlife in both negative and positive ways (Whelan 1995), depending on the species in question and type and severity of the fire (Fontaine and Kennedy 2012).

Birds' exceptional mobility allows them to respond quickly to disturbances like wildfires, making birds a convenient taxonomic group for assessing changes in habitat (Gregory and van Strien 2010). In landscapes that burn regularly, the availability of habitat for various bird species may be determined in part by the frequency and nature of recent fires (Fontaine et al. 2009), with abundances of some species peaking within a certain range of time post-fire (Hutto et al. 2015). Without high-intensity fire, habitats suitable for some bird species may not be maintained (Hutto et al. 2015). Pyrodiversity, the spatial and temporal variation of fires (Martin and Sapsis 1992), however, does not necessarily correspond to avian community diversity. Community richness can respond differently to fire depending on factors such as habitat type (Jones and Tingley 2022), patch size (Steel et al. 2022), and fire severity (Calhoun et al. 2025). How a fire alters resource availability can also depend on other factors such as rainfall, which can influence how rapidly plant communities regenerate or resprout (Moreno et al. 2011, Nolan et al. 2021), as well as their longer-term growth rates (Hope et al. 2007, Meng et al. 2015, Thomson et al. 2021, Dikshit and Evans 2024).

Bird communities' responses to fire have received more attention in southern California (Lawrence 1966, Mendelsohn et al. 2008, Van Mantgem et al. 2015, Hargrove and Unitt 2018) and the Sierra Nevada (Bock and Lynch 1970, Bock et al. 1978, Fogg et al. 2016, Ray et al. 2025) than in the San Francisco Bay area. Though the responses to fire of many bird species found in the San Francisco Bay area have been studied elsewhere, widespread species can occupy habitats that vary regionally and may respond to wildfire differently (Stillman et al. 2025).

Community-science data from sources such as eBird.org (Sullivan et al. 2009), used in conjunction with data recorded by standardized methods, can help mitigate biases in scientific data, which are not immune to observer variability and taxonomic bias (Binley and Bennett 2023). While the lack of standardized effort in eBird data can complicate accounting for spatial bias (Callaghan et al. 2019, Johnston et al. 2019, Binley and Bennett 2023), eBird hotspots, which are static (though often vague) locations, represent local datasets valuable for trend estimation across years (La Sorte et al. 2024), especially in heavily birded areas (Callaghan and Gawlik 2015).

We used point-count data and eBird observations from 3 years before and 3 years after a large wildfire to understand the response of breeding birds' abundance across a variety of habitats. As the response to fire varies even within species (Fontaine and Kennedy 2012, Rainsford et al. 2021, Stillman et al. 2025), and habitats within the study area vary as well, we present post-fire trends for each species as a case study without testing against explicit predictions of which species we expected to respond positively or negatively to this fire.

METHODS

Study Area

Pine Flat Road is in northeastern Sonoma County, California, in an ecoregion (central California foothills and coastal mountains) with a history of frequent large fires of high intensity (Green et al. 2020, Li and Banerjee 2021, Ostertag et al. 2023). From an elevation of ~67 m, Pine Flat Road climbs 19 km through or along grassland, riparian woodland, oak woodland, mixed evergreen and hardwood woodland, chaparral, and stands of knobcone pine (*Pinus attenuata*), ending at an elevation of 962 m. This area supports some breeding birds that are scarcer at lower elevations and in more developed parts of Sonoma County, such as the Mountain Quail (*Oreortyx pictus*), Northern Pygmy-Owl (*Glaucidium gnoma*), California Thrasher (*Toxostoma redivivum*), Rufous-crowned Sparrow (*Aimophila ruficeps*), and Bell's Sparrow (*Artemisiospiza belli*). Three birds listed as California Bird Species of Special Concern (Shuford and Gardali 2008), the Olive-sided Flycatcher (*Contopus cooperi*), Purple Martin (*Progne subis*), and Grasshopper Sparrow (*Ammodramus savannarum*), breed near Pine Flat Road. In October 2019, the Kincade Fire burned approximately 314.6 km^2 (www.fire.ca.gov/incidents/2019/10/23/kincade-fire/), including most of the habitat along Pine Flat Road (Figure 1), at mixed severity. The fire's severity was high in some areas, especially among dense plant communities susceptible to high-intensity fire such as knobcone pine stands or chaparral (Greene et al. 2024), resulting in the death of most of the canopy. More trees survived the fire in habitats with an open understory (Lumpkin pers. obs.) such as oak woodlands, which are less likely to suffer extensive canopy damage (Green et al. 2020). The Kincade Fire overlapped substantially with the footprint of the Geysers Fire of 2004 (gis.data.ca.gov/datasets/CALFIRE-Forestry::california-fire-perimeters-all), to which the bird community's response was addressed by Kelly (2010).

Point-Count Surveys

Pre-fire, during April and May, 2016–2018, and post-fire, during May 2020–2022, Lumpkin made counts of 5 minutes each at 16 points along Pine Flat Road (Figure 1) for a total of 80 minutes per survey. The direct distances between points ranged from 641 to 1178 m. The transect began at the bottom of Pine Flat Road and spanned 18.2

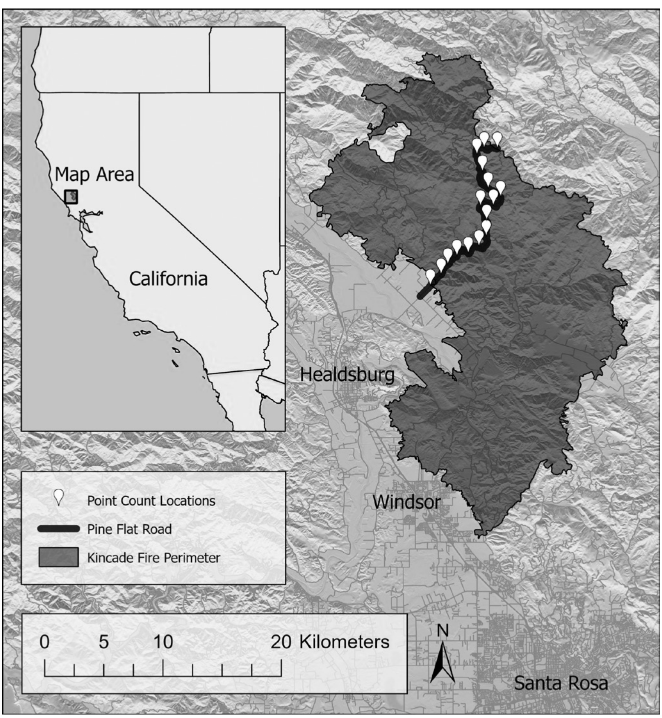

FIGURE 1. Footprint of the 2019 Kincade Fire with locations of point counts along Pine Flat Road, Sonoma Co., California.

km. Surveys began at 08:00 PST, with subsequent points counted at 15-minute intervals. Deviations from this schedule (due to construction or temporary noise interference) did not exceed 17 minutes, with surveys finished by 11:52. The route was run once in 2016, three times each in spring 2017, 2018, 2020, 2021, and 2022.

All birds detected by sight and/or sound within 400 m of each point were recorded and further categorized as being within or beyond 50 m of the point. As the road and the adjacent area that was mechanically cleared of vegetation post-fire made up a large portion of the circle of 50-m radius around each point, we included all detections within 400 m of each point. Because the transect traversed several habitats and had relatively few points per habitat, we summed the total individuals observed on each date across all points and used this value as the response variable in our analysis.

Data from eBird

Our sample of eBird data was restricted to the area around Pine Flat Road with reported locations ranging from 38.6757 to 38.7598° N and from 122.7441 to 122.8061° W. We referenced only checklists representing observations between 1 April and 1 June in the same years as our point-count surveys and only those marked as complete with abundance data (not just presence) for all species (Strimas-Mackey et al. 2023). Also, to parallel the point-count surveys, we used only checklists representing at least 80 minutes, initiated between 07:00 and 10:00 and ended between 08:00 and 12:00 (therefore not exceeding 300 minutes). When multiple suitable eBird checklists had been submitted per day (as occurred three times), we randomly selected one to avoid checklists that might have significant overlap. Checklists recorded by observers associated with the point-count surveys were excluded. We considered only checklists that indicated the "traveling" protocol, to avoid those more likely to represent efforts to find an individual bird or species (for which the "incidental" protocol might have been selected) or observations from one spot likely to represent a small portion of habitat types (for which the "stationary" protocol might have been selected).

Data Preparation

To account for how rainfall may have influenced trends in bird abundance, we calculated the prior year's rainfall by summing averaged monthly rainfall from the prior June through May estimated for the PRISM blocks (PRISM Climate Group, Oregon State University, prism.oregonstate.edu) covered by the study area. As Sonoma County receives most of its rain during the winter (www.weather.gov/wrh/climate?wfo=mtr), we concluded this would be more straightforward than using rainfall totals leading up to the date of a particular survey. Prior-year rainfall ranged from 0.4 to 1.86 m, being greatest in the year preceding 2017 surveys. The mean annual rainfall pre-fire (1.2 m) was double the mean annual rainfall post-fire (0.6 m).

To ensure species potentially undetected pre- or post-fire were included, as long as they were encountered at least a few times overall, we analyzed only those species encountered on at least 25% of survey dates both pre- and post-fire, and of which at least five had been detected on a single day. We considered only species suited to detection and analysis with point-count surveys (e.g., we omitted raptors, with home ranges large enough to overlap multiple points; see Ralph et al. 1993) that are expected to breed in the study area (per Burridge et al. 1995).

ANALYSIS

We treated each eBird checklist or point-count survey as a single instance of sampling of the bird community along the entire length of Pine Flat Road. Because Pine Flat Road is a dead-end road, the point count surveys and (we believe) the eBird checklists we included generally represent efforts spanning various habitats across a large portion of the road. Although we could have partitioned the point-count data by point to evaluate bird abundance at a finer spatial scale, our primary objective was to evaluate the degree of agreement in estimated response to the fire from the two independent sources (eBird and point counts), and we did not have a reliable way to apportion eBird checklists among the multiple sites to match subsets of the count points. We believe that the benefits of analyzing both datasets together, providing coefficients to compare the two approaches' abundance estimates, was a better fit for our objectives than analyzing the two datasets separately, even if different analysis methods might have been a better fit for each approach (e.g., N-mixture models for point counts per Goldstein and de Valpine 2022).

To estimate the total number of individuals per species encountered during a survey, either by point count or eBird, we used generalized linear models (GLM) with a Poisson error distribution. For all species, we constructed a candidate set of 12 models that included all additive combinations of year (to account for underlying trends related to factors we didn't measure), ordinal date (to account for intraseasonal variability in detection rates through the breeding season; Slagsvold 1977, Furnas and McGrann 2018), pre/post-fire (coded as a dummy variable set to 0 for 2016–2018 and 1 for 2020–2022), and prior year's rainfall. Because year and rainfall were correlated (Pearson correlation coefficient −0.61), we omitted models with both of these variables. This base candidate set also included the intercept-only model. For species detected on at least 25% of both kinds of surveys, we also wanted to evaluate the degree to which both overall estimated abundance and the estimated fire effect in the two datasets agreed. Therefore, for these species, we also included all the models described above plus an additive effect of dataset (eBird arbitrarily coded as the reference level), and the dataset × pre/post-fire interaction, for a total of 30 models for those species.

We evaluated the relative support for each model and for the individual predictor variables by comparing second-order values of Akaike's information criterion (AIC_c; Burnham and Anderson 2002). We considered the model with the lowest AIC_c value to be best supported and any models with AIC_c values within 2 units of the best model to be competitive with that top model (Burnham and Anderson 2002, Arnold 2010). Because our main interest was to assess evidence for a change in abundance following the fire from each type of survey, we calculated model-averaged estimates for each dataset at the average values of ordinal date and rainfall and transformed these predictions to percentage change relative to pre-fire modeled abundance. Model averaging by AIC_c weight adjusts each model's coefficients by the relative strength of AIC_c support for that model, so the resulting model-averaged estimates allow combining information from all models while accounting for differences in how well each model fits the data (Mazerolle 2023). For both the models' coefficients and model-averaged estimates, we evaluated the strength and importance of the effects of fire and type of survey by the direction and magnitude of the coefficient or prediction, the degree to which their 95% confidence intervals overlapped zero (Muff et al. 2022), and the degree of agreement between datasets. Good evidence for a species responding to the fire consisted of post-fire confidence intervals for model-averaged predictions not overlapping pre-fire estimates, as well as fire appearing as an informative parameter in the competitive models for the species. We regard support for effect of fire as limited where just one data source's model showed a response, or where post-fire abundance overlapped pre-fire values but fire appeared as a variable in competitive models.

For data management and analysis we used R version 4.4.0 (R Core Team 2021). We fitted generalized linear models with the function "glm" in the package "stats" and averaged the models' predictions by using the package "AICcmodavg" (Mazerolle 2023).

Point Count and eBird Survey Effort

We used data from 16 point-count surveys, of which 7 took place pre-fire and 9 post-fire. The survey's mean ordinal date post-fire was eight days later than pre-fire, because of the inclusion of two April surveys in 2017 and 2018 and surveys starting later than usual in 2020 during the covid-19 pandemic. We used data from 28 eBird checklists, 12 recorded pre-fire and 16 post-fire. The eBird checklists represented a mean observation time of 231.9 min (±standard deviation 50.8) and covered a reported average of 16.6 (±3.7) km of Pine Flat Road. Despite the lack of structured sampling effort, the eBird checklists' mean ordinal date pre-fire and post-fire differed by only 1.7 days.

RESULTS

We modeled abundance for 42 species, 31 of which were represented in the data from both types of surveys, 8 just in the point-count data, and 3 in just the eBird data. Fire appeared as an informative predictor in one or more competitive models for 35 species. The type of survey appeared as relevant factor for all 31 species modeled on the basis of both datasets. The interaction between fire and type of survey was informative for 20 species. (Article with appendices, available at https://journal.westernfieldornithologists.org/index.php/westernbirds/article/view/2027.) Year was relevant in one or more competitive models for 25 species, ordinal date for 24 species, and prior year's rainfall for 10 species (Appendix 2).

Our models based on the two datasets combined showed good support for decreased abundance post-fire of 10 species (Table 1) and increased abundance post-fire for only three, the Red-winged Blackbird (*Agelaius phoeniceus*), Steller's Jay (*Cyanocitta stelleri*), and Western Meadowlark (*Sturnella neglecta*). The Western Meadowlark, however, was not detected on point counts pre-fire, leading to a complete separation of data, so we derive confidence intervals for its post-fire abundance from post-fire data only and do not present coefficients for competitive models in Appendix 1. Among species with good evidence for change in abundance post-fire, average decreases were 9.9 individuals (−70.2%, range −99% [for the Band-tailed Pigeon] to −33%), while average increases were 7.2 (602%, range 142% to 1062% [for the Red-winged Blackbird], Table 2).

We found limited support for the fire's having an effect on 21 species (Appendix 2), even though fire appeared as an informative parameter in a competitive model for 16 of these (Appendix 1). For two species, the Bushtit (*Psaltriparus minimus*) and California Towhee (*Melozone crissalis*), the change in abundance estimated according to the two types of surveys was in opposite directions (Table 1). Six species, the Ash-throated Flycatcher (*Myiarchus cinerascens*), Bullock's Oriole (*Icterus bullockii*), Cassin's Vireo (*Vireo cassinii*), European Starling (*Sturnus vulgaris*), Pileated Woodpecker (*Dryocopus pileatus*), and Violet-green Swallow (*Tachycineta thalassina*), showed no evidence for fire effects.

DISCUSSION

Overall Patterns

We found good evidence of a change in abundance of breeding birds after the Kincade Fire (including concurrence between the point-count and eBird data) for 13 of the 42 species we evaluated. Among these, only three species increased while the other 10 decreased. For the remaining 29 species we found either limited evidence of change (21 species), no evidence of change (six species), or the evidence of the two datasets conflicted (two species).

Many of the species showing strong evidence for response to the Kincade Fire were those associated with habitat types either particularly resilient or susceptible to severe fire. For instance, species associated with open grasslands, which regrow quickly after a fire (Green et al. 2020), such as the Red-winged Blackbird (Yasukawa and Searcy 2020) and Western Meadowlark (Davis and Lanyon 2008), increased post-fire. Several species with preference for greater shrub cover declined. These include the Blue-gray Gnatcatcher (*Polioptila caerulea*, Kershner and Ellison 2012), Orange-crowned Warbler (*Leiothlypis celata*, Gilbert et al. 2020), and Wrentit (*Chamaea fasciata*, Geupel and Ballard 2023), consistent with greater mortality of the canopy in habitats with a closed canopy and shorter vegetation—a result also reported in other studies (Kelly 2010, Fontaine and Kennedy 2012). The sharp increase of the Lazuli Bunting in our point-count data matches increases of this species after fire observed in other studies (Mendelsohn et al. 2008, Kelly 2010, Fontaine and Kennedy 2012, Hargrove and Unitt 2018). Not all species associated with chaparral, however, decreased dramatically. For instance, our data for the California Thrasher provided only weak support for decline in response to this particular fire.

Bird species with broad distributions inhabiting multiple ecoregions can respond either positively or negatively to fires in different regions or habitat types (Stillman et al. 2025), the difference driven by factors such as how plants regenerate after wildfire (Rainsford et al. 2021). For some widespread, adaptable species, such as the Bewick's Wren (*Thryomanes bewickii*), Northern Flicker (*Colaptes auratus*), and Western Bluebird (*Sialia mexicana*), our modeled responses differed from those observed in other studies (Table 1). The habitats along Pine Flat Road occupied by these species might have responded to or recovered from the Kincade fire differently from habitats occupied by those birds in other studies elsewhere in their ranges.

The variety of vegetation alliances along Pine Flat Road offers another potential explanation for responses we observed differing from results of other studies. Species may respond positively to low-severity fire but nega-

Table 1 Comparison of Responses of Birds to the Kincade Fire (2019) with Those to the Geysers Fire (2004), also in Sonoma Co., California, and a Meta-Analysis of 41 Fires[a]

	Kincade Fire		Geysers Fire[b]	Meta-analysis[c]	
Species	Per point counts	Per eBird	Post-fire trend	High severity	Low/moderate severity
Steller's Jay *Cyanocitta stelleri*	increase	increase	increase	decrease	increase
Red-winged Blackbird *Agelaius phoenicus*	increase	increase	no change		
Western Meadowlark *Sturnella neglecta*	increase		no change		
Lazuli Bunting *Passerina amoena*	increase	no change	increase	increase	increase
Mountain Quail *Oreortyx pictus*	increase	no change	increase		
Bushtit *Psaltriparus minimus*	increase	decrease	no change		
California Towhee *Melozone crissalis*	increase	decrease	decrease		
Blue-gray Gnatcatcher *Polioptila caerulea*	decrease	decrease	decrease	no change	decrease
Wrentit *Chamaea fasciata*	decrease	decrease	decrease		
Orange-crowned Warbler *Leiothlypis celata*	decrease	decrease	no change	decrease	decrease
Band-tailed Pigeon *Patagioenas fasciata*	decrease	decrease	no change		
Bewick's Wren *Thryomanes bewickii*	decrease	decrease	no change	increase	no change
Black-headed Grosbeak *Pheucticus melanocephalus*	decrease	decrease	increase	decrease	increase
Acorn Woodpecker *Melanerpes formicivorus*	decrease	decrease	increase	decrease	no change
California Quail *Callipepla californica*	decrease	decrease	increase		
Purple Martin *Progne subis*	decrease	decrease	increase		
Western Warbling-Vireo *Vireo swainsoni*	no change	decrease	no change	decrease	decrease
Western Tanager *Piranga ludoviciana*		decrease	increase	decrease	increase
Dark-eyed Junco *Junco hyemalis*	no change	decrease	no change	decrease	increase
Western Bluebird *Sialia mexicana*	no change	decrease	no change	increase	increase
Northern Flicker *Colaptes auratus*	no change	decrease	increase	increase	increase

(*continued*)

Species	Kincade Fire		Geysers Fire[b]	Meta-analysis[c]	
	Per point counts	Per eBird	Post-fire trend	High severity	Low/moderate severity
House Finch *Haemorhous mexicanus*	no change	decrease	no change		
Lesser Goldfinch *Spinus psaltria*	no change	decrease	no change		
Rufous-crowned Sparrow *Aimophila ruficeps*	no change	decrease	no change		
American Robin *Turdus migratorius*		no change	increase	increase	increase
Mourning Dove *Zenaida macroura*	no change	no change	increase	increase	increase
Northern House Wren *Troglodytes aedon*	no change	no change	increase	increase	increase
White-breasted Nuthatch *Sitta carolinensis*	no change		increase		increase
Violet-green Swallow *Tachycineta thalassina*	no change	no change	increase	increase	decrease
Oak Titmouse *Baeolophus inornatus*	no change	no change	increase		
Bullock's Oriole *Icterus bullockii*	no change		increase		
California Scrub-Jay *Aphelocoma californica*	no change	no change	decrease		
Hutton's Vireo *Vireo huttoni*	no change		decrease		
Pileated Woodpecker *Dryocopus pileatus*	no change		no change	no change	increase
Spotted Towhee *Pipilo maculatus*	no change	no change	no change	decrease	increase
Ash-throated Flycatcher *Myiarchus cinerascens*	no change	no change	no change	decrease	decrease
Cassin's Vireo *Vireo cassinii*	no change		no change	decrease	decrease
Anna's Hummingbird *Calypte anna*	no change	no change	no change		
Western Flycatcher *Empidonax difficilis*	no change	no change	no change		
California Thrasher *Toxostoma redivivum*		no change	no change		
Chestnut-backed Chickadee *Poecile rufescens*	no change		no change		
European Starling *Sturnus vulgaris*	no change		no change		

[a]Lack of an entry indicates species was not modeled on the basis of the dataset specified.

[b]From Kelly (2010).

[c]From Fontaine and Kennedy (2012), analyzing responses to fire across fire-prone habitats in the contiguous United States.

Table 2 Percentage Changes in Estimated Abundance of Each Bird Species Modeled from Point-Count and eBird Data Recorded on Pine Flat Road, Sonoma Co., California, before (2016–2018) and after (2020–2022) the Kincade Fire[a]

	Point Counts			eBird		
Species	% change	Pre-fire abundance	Post-fire abundance	% change	Pre-fire abundance	Post-fire abundance
Band-tailed Pigeon	-99	25.9 [16.4, 41.1]	0.2 [0.1, 0.4]	-99	22.4 [12.3, 39.9]	0.1 [0.1, 0.3]
Wrentit	-84	28.2 [19.6, 39.9]	4.6 [2.8, 7.2]	-84	14.5 [9.4, 22]	2.3 [1.5, 3.5]
Bewick's Wren	-64	11.2 [6.8, 18.1]	4 [2.2, 7.2]	-93	7.6 [4.2, 13.4]	0.5 [0.3, 1.1]
Black-headed Grosbeak	-62	14.6 [10.1, 21.1]	5.6 [3.6, 8.5]	-88	8.9 [5.8, 13.5]	1.1 [0.6, 1.8]
Blue-gray Gnatcatcher	-62	8.4 [5.3, 12.8]	3.2 [1.8, 5.4]	-67	4.7 [2.8, 7.7]	1.6 [0.9, 2.6]
Purple Martin	-61	13.6 [9.1, 20.1]	5.3 [3.3, 8.4]	-73	10.7 [6.7, 16.7]	2.9 [1.7, 4.6]
Rufous-crowned Sparrow	-50	3.9 [1.9, 7.8]	1.9 [0.9, 4.1]	-79	3.1 [1.2, 7.5]	0.7 [0.3, 1.5]
Orange-crowned Warbler	-40	14.7 [11.6, 18.6]	8.9 [6.7, 11.7]	-67	7.4 [5.5, 9.8]	2.4 [1.6, 3.5]
Dark-eyed Junco	-35	5.3 [3.5, 7.9]	3.4 [2.2, 5.3]	-53	4.2 [2.5, 6.6]	2 [1.2, 3.1]
California Quail	-33	16.3 [12.1, 21.9]	10.9 [8, 14.8]	-67	15.7 [11.5, 21.4]	5.1 [3.8, 6.9]
Western Bluebird	-30	3 [1.4, 6.2]	2.1 [1, 4.2]	-87	7.1 [3.5, 14.1]	0.9 [0.4, 1.8]
Northern Flicker	-20	6.2 [4.3, 8.9]	4.9 [3.2, 7.4]	-43	3.6 [2.2, 5.8]	2 [1.2, 3.4]
Spotted Towhee	-19	13.1 [10.3, 16.6]	10.6 [8.2, 13.6]	-23	6 [4.5, 7.9]	4.6 [3.5, 6.1]
Hutton's Vireo	-18	2 [1.1, 3.4]	1.6 [0.8, 3]			
California Scrub-Jay	-17	15.4 [11.9, 19.8]	12.7 [9.6, 16.7]	-18	7.7 [5.8, 10.3]	6.4 [4.9, 8.2]
Oak Titmouse	-15	15.2 [10.4, 21.8]	13 [8.5, 19.3]	-18	2.9 [1.7, 4.6]	2.4 [1.5, 3.6]
Anna's Hummingbird	-12	7.5 [5.2, 10.7]	6.6 [4.5, 9.6]	-37	3.2 [1.9, 5.3]	2.1 [1.2, 3.4]
Violet-green Swallow	-12	4.7 [3.1, 6.9]	4.1 [2.7, 6.3]	-15	2.6 [1.6, 4]	2.2 [1.5, 3.3]
Acorn Woodpecker	-10	57.4 [51.5, 64.1]	51.5 [46.6, 57]	-56	23.2 [20.2, 26.7]	10.2 [8.7, 11.9]
European Starling	-8	4 [2.8, 5.7]	3.7 [2.5, 5.4]			
Western Flycatcher	-3	6.2 [4.2, 8.8]	6 [4, 8.7]	-7	2.2 [1.4, 3.3]	2 [1.3, 3]

(*continued*)

tively when fire kills much of the canopy, as with the Black-headed Grosbeak (Fontaine and Kennedy 2012), which decreased in abundance after the Kincade Fire. While the Kincade Fire would be classified as moderate under the criteria of the Fontaine and Kennedy study, those authors acknowledged an insufficiency of studies describing fires of mixed severity, which more accurately describes the Kincade Fire. The decrease we saw in the Black-headed Grosbeak might be explained by a preference for particular habitat types along Pine Flat Road that experienced high canopy mortality after the Kincade Fire.

While differing representation of habitat types may offer an explanation for the different responses to fire across different regions, the reasons for the differences between trends of birds observed after the Geysers Fire (Kelly 2010) and the Kincade Fire aren't

Species	Point Counts			eBird		
	% change	Pre-fire abundance	Post-fire abundance	% change	Pre-fire abundance	Post-fire abundance
Bullock's Oriole	2	2.1 [1.1, 3.8]	2.1 [1, 4.1]			
Ash-throated Flycatcher	3	3.6 [2.6, 5]	3.7 [2.7, 5.1]	2	2.7 [2, 3.7]	2.8 [2.1, 3.7]
Cassin's Vireo	7	2.8 [1.8, 4.4]	3 [1.9, 4.8]			
Pileated Woodpecker	7	2 [0.9, 4]	2.1 [1, 4.4]			
Northern House Wren	9	7.6 [5, 11.3]	8.2 [5.1, 12.8]	-20	3.3 [1.9, 5.5]	2.7 [1.5, 4.5]
Lesser Goldfinch	13	10.7 [8.3, 13.8]	12.1 [9.9, 14.8]	-67	7.4 [5.6, 9.6]	2.4 [1.8, 3.3]
Chestnut-backed Chickadee	18	3.1 [2, 4.9]	3.7 [2.4, 5.5]			
Mourning Dove	29	9 [6.3, 12.5]	11.5 [8.6, 15.4]	-17	3.6 [2.4, 5.3]	3 [2.1, 4.2]
White-breasted Nuthatch	38	2.3 [1.2, 4.2]	3.2 [1.8, 5.6]			
House Finch	48	2.3 [1, 5]	3.4 [1.6, 6.9]	-72	3.6 [1.7, 7.3]	1 [0.5, 2.1]
Western Warbling-Vireo	61	2.7 [1.4, 4.8]	4.3 [2.5, 7.3]	-75	3.5 [2, 6]	0.9 [0.4, 1.7]
Bushtit	65	4.1 [2.7, 6.2]	6.7 [4.8, 9.2]	-81	3.3 [2.2, 4.9]	0.6 [0.3, 1.2]
California Towhee	100	4.2 [2.6, 6.7]	8.5 [5.6, 12.6]	-38	5.9 [3.7, 9.1]	3.6 [2.4, 5.4]
Steller's Jay	143	4.1 [2.2, 7.4]	10.1 [5.1, 18.7]	142	1.6 [0.7, 3.2]	3.9 [2.2, 6.8]
Mountain Quail	149	2 [1, 3.6]	4.9 [3.3, 7.3]	-19	2.9 [2, 4.4]	2.4 [1.6, 3.5]
Lazuli Bunting	684	1.6 [0.8, 3.2]	12.9 [8.1, 19.9]	18	2.6 [1.5, 4.6]	3.1 [1.9, 5]
Red-winged Blackbird	1,109	1.5 [0.8, 2.7]	17.7 [10.8, 28.5]	1,016	0.4 [0.2, 0.9]	4.8 [2.9, 7.9]
Western Meadowlark[b]		0	3.5 [2.4, 5.1]			
Western Tanager				-97	7 [2.6, 18.6]	0.2 [0.1, 0.6]
American Robin				-38	2.9 [1.5, 5]	1.8 [1, 3.1]
California Thrasher				-37	2.7 [1.5, 4.6]	1.7 [1, 2.9]

[a]Numbers in parentheses specify confidence intervals.

[b]To generate valid confidence intervals for the Western Meadowlark, because of a complete separation of data, we estimated that species' abundance from post-fire detections only.

obvious. The footprints of these fires overlapped, and both would be appropriately classified as of mixed severity (MTBS.gov). The spatial distribution of bird-counting effort after the Geysers fire differed from ours, likely biasing surveyed habitat types and sampling of canopy mortality in a way that might have changed how the local bird community appeared to respond to each. Regardless of the mechanism, this difference suggests caution is warranted in forecasting how birds will respond to fire across their ranges.

Differences between Results from Point Counts and eBird

We found generally good agreement in estimated fire effects between our point counts and eBird data, with the direction of the fire's effect agreeing for about twice as many species for which it disagreed. Birds' abundance, however, was consistently lower when estimated from eBird data than from point-count data (mean across all years of eBird data was 55.6% of point-count abundance, range 18.7–158.5%; see mostly positive dataset coefficients in Appendix 1). For the 11 species for which the fire's effects according to the two datasets differed, the post-fire change was generally less negative when estimated from the point-count data than from the eBird data (Table 2). For both species according to which the fire's effects ran in opposite directions (the Bushtit and California Towhee), the point-count data implied a positive effect but the eBird data implied a negative effect.

The consistency of this difference across species associated with a variety of habitats and belonging to a variety of guilds suggests no obvious single ecological explanation for its cause. Rather, we suspect that some unaccounted-for difference in sampling style between the two field methods could be responsible for the differences in estimated abundance and fire effects. Point-count surveys entailed stopping at 16 locations along Pine Flat Road. It's likely that eBird users averaged fewer stops, resulting in fewer individuals being recorded per visit, thus implying lower overall abundance. For species such as the Lazuli Bunting, which was evenly distributed along Pine Flat Road after the fire (Lumpkin pers. obs.), eBird users making fewer stops and not walking long distances along the road would likely encounter proportionally fewer individuals. Additionally, some eBird contributors may have been focused on seeing particular species (Rosenblatt et al. 2022) or searching certain habitats, potentially obscuring declines of species concentrated in those habitats (which we suspect may have been the case with the California Thrasher). These birders may have consequently sampled the range of habitats along Pine Flat Road less evenly, thus depressing the total number of birds encountered within and across species.

Other Factors

Birds may be more easily detected in burned habitats where the vegetation is sparse (Einoder et al. 2018, Lee et al. 2023). Post-fire increases of flocking species (as we observed in the point-count data for the Bushtit) may be due in part to increased detectability of more individuals in each flock. Nevertheless, we opted to keep flocking species in our analysis because we were interested in evaluating changes to the full bird community. The broader landscape may also have influenced bird populations both pre- and post-fire. Pine Flat Road meets the eastern edge of the Kincade Fire's footprint (Figure 1), beyond which unburned chaparral is likely to have served as refuge for species such as the California Thrasher associated with that habitat.

As well-studied as birds and fire seem to be, inconsistent agreement between some of our results and those other studies, particularly of the overlapping Geysers Fire, highlights the importance of continued evaluation of local ecological consequences of fire. Effective stewardship of habitat for biodiversity and resilience calls for particular attention to factors influencing a fire's behavior.

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Appendix 1 Coefficients and their 95% confidence intervals from competitive ($\Delta AIC_c \leq 2$) models for bird species detected in the footprint of the Kincade Fire of 2019 along Pine Flat Road, Sonoma Co., California[a]

Species and model[b]	Fire	Rain	Dataset	Fire × dataset	Year	Ordinal date	Deviance explained
Acorn Woodpecker							
odate + rain + fire.data	−0.82 (−1.04, −0.6)	−0.36 (−0.52, −0.21)	0.9 (0.74, 1.07)	0.71 (0.48, 0.95)	—	0.01 (0, 0.01)	0.81
American Robin							
year	—	—	—	—	−0.2 (−0.32, −0.08)	—	0.14
fire	−0.87 (−1.39, −0.36)	—	—	—	—	—	0.14
year + odate	—	—	—	—	−0.2 (−0.32, −0.09)	0.01 (−0.01, 0.02)	0.15
Anna's Hummingbird							
odate + fire.data	−0.58 (−1.06, −0.12)	—	0.7 (0.29, 1.13)	0.62 (0.03, 1.22)	—	0.02 (0.01, 0.03)	0.55
year + odate + fire.data	−1.12 (−2, −0.24)	—	0.65 (0.23, 1.08)	0.67 (0.08, 1.27)	0.13 (−0.05, 0.31)	0.02 (0.01, 0.03)	0.56
odate + data	—	—	1.03 (0.73, 1.33)	—	—	0.02 (0.01, 0.03)	0.50
odate + fire + data	−0.19 (−0.48, 0.1)	—	1.02 (0.73, 1.32)	—	—	0.02 (0.01, 0.03)	0.51
Ash-throated Flycatcher							
odate + data	—	—	0.37 (0.04, 0.69)	—	—	0.02 (0.01, 0.04)	0.29
odate + rain + data	—	0.15 (−0.2, 0.48)	0.37 (0.04, 0.7)	—	—	0.03 (0.01, 0.04)	0.30
Bewick's Wren							
year + fire.data	−2.77 (−3.81, −1.77)	—	0.38 (−0.02, 0.77)	1.62 (0.94, 2.35)	0.27 (0.08, 0.48)	—	0.46
Blue-gray Gnatcatcher							
fire + data	−0.83 (−1.15, −0.51)	—	0.65 (0.34, 0.96)	—	—	—	0.31
year + fire + data	−1.4 (−2.29, −0.54)	—	0.61 (0.29, 0.92)	—	0.15 (−0.06, 0.36)	—	0.32
fire.data	−1.02 (−1.51, −0.55)	—	0.52 (0.13, 0.91)	0.36 (−0.28, 1.01)	—	—	0.32
year + fire.data	−1.7 (−2.7, −0.72)	—	0.44 (0.05, 0.84)	0.43 (−0.22, 1.08)	0.17 (−0.04, 0.38)	—	0.33
fire + rain + data	−0.71 (−1.14, −0.28)	0.15 (−0.22, 0.52)	0.66 (0.35, 0.98)	—	—	—	0.31
Black-headed Grosbeak							
year + odate + fire.data	−2.13 (−2.92, −1.35)	—	0.5 (0.15, 0.85)	1.14 (0.61, 1.69)	0.26 (0.1, 0.42)	0.02 (0.01, 0.03)	0.65
Band-tailed Pigeon							
year + odate + fire	−5.29 (−6.51, −4.13)	—	—	—	0.83 (0.57, 1.11)	−0.02 (−0.03, −0.01)	0.30
year + odate + fire + data	−4.93 (−6.21, −3.72)	—	0.29 (−0.07, 0.64)	—	0.76 (0.48, 1.04)	−0.02 (−0.03, −0.01)	0.30
Bullock's Oriole							
year	—	—	—	—	0.2 (0.03, 0.38)	—	0.23
Bushtit							
odate + fire.data	−1.53 (−2.25, −0.89)	—	0.24 (−0.26, 0.73)	2.12 (1.35, 2.96)	—	0.02 (0.01, 0.03)	0.36
odate + rain + fire.data	−1.78 (−2.56, −1.06)	−0.38 (−0.88, 0.1)	0.2 (−0.3, 0.7)	2.17 (1.39, 3.01)	—	0.02 (0, 0.03)	0.37
California Towhee							
fire.data	−0.35 (−0.7, 0)	—	−0.32 (−0.78, 0.11)	1.15 (0.6, 1.71)	—	—	0.31
year + fire.data	−0.87 (−1.64, −0.11)	—	−0.38 (−0.84, 0.06)	1.2 (0.65, 1.77)	0.13 (−0.04, 0.29)	—	0.33
odate + fire.data	−0.34 (−0.69, 0.01)	—	−0.3 (−0.76, 0.13)	1.19 (0.64, 1.76)	—	−0.01 (−0.01, 0)	0.33
rain + fire.data	−0.15 (−0.62, 0.33)	0.24 (−0.14, 0.62)	−0.29 (−0.75, 0.15)	1.12 (0.57, 1.68)	—	—	0.33
year + odate + fire.data	−0.83 (−1.62, −0.06)	—	−0.36 (−0.83, 0.08)	1.23 (0.68, 1.8)	0.12 (−0.05, 0.29)	−0.01 (−0.01, 0)	0.35
California Quail							
year + odate + fire.data	−1.12 (−1.68, −0.57)	—	0.04 (−0.27, 0.33)	0.72 (0.35, 1.1)	0.28 (0.16, 0.4)	−0.01 (−0.02, −0.01)	0.32
California Scrub-Jay							
odate + fire + data	−0.2 (−0.39, 0)	—	0.68 (0.49, 0.88)	—	—	0.01 (0, 0.01)	0.45
year + odate + fire + data	−0.53 (−1.05, −0.01)	—	0.66 (0.47, 0.86)	—	0.08 (−0.04, 0.21)	0.01 (0, 0.01)	0.46
fire + data	−0.17 (−0.36, 0.02)	—	0.72 (0.52, 0.91)	—	—	—	0.42
odate + data	—	—	0.69 (0.49, 0.88)	—	—	0.01 (0, 0.01)	0.42
California Thrasher							
fire	−0.79 (−1.32, −0.28)	—	—	—	—	—	0.20
rain	—	0.65 (0.21, 1.08)	—	—	—	—	0.18
year	—	—	—	—	−0.17 (−0.29, −0.05)	—	0.17
fire + rain	−0.54 (−1.29, 0.26)	0.3 (−0.34, 0.98)	—	—	—	—	0.22
odate + fire	−0.78 (−1.31, −0.27)	—	—	—	—	−0.01 (−0.02, 0.01)	0.21
Cassin's Vireo							
odate	—	—	—	—	—	0.03 (0, 0.05)	0.40

Species and model[b]	Fire	Rain	Dataset	Fire × dataset	Year	Ordinal date	Deviance explained
Chestnut-backed Chickadee							
year	—	—	—	—	0.14 (0, 0.28)	—	0.25
fire	0.52 (–0.02, 1.1)	—	—	—	—	—	0.22
rain	—	–0.51 (–1.18, 0.07)	—	—	—	—	0.19
intercept	—	—	—	—	—	—	0.00
Dark-eyed Junco							
rain + fire.data	–1.04 (–1.59, –0.49)	–0.67 (–1.13, –0.22)	0.11 (–0.37, 0.57)	0.63 (–0.02, 1.3)	—	—	0.13
fire + rain + data	–0.71 (–1.12, –0.28)	–0.61 (–1.07, –0.18)	0.43 (0.1, 0.75)	—	—	—	0.11
odate + rain + fire.data	–1 (–1.55, –0.45)	–0.61 (–1.09, –0.15)	0.11 (–0.37, 0.57)	0.59 (–0.07, 1.26)	—	0 (–0.01, 0.02)	0.14
European Starling							
intercept	—	—	—	—	—	—	0.00
rain	—	–0.34 (–0.94, 0.18)	—	—	—	—	0.03
House Finch							
year + odate + fire.data	–1.59 (–2.71, –0.48)	—	–0.47 (–1.22, 0.22)	1.64 (0.81, 2.53)	0.3 (0.07, 0.54)	0.01 (0, 0.03)	0.30
year + fire.data	–1.47 (–2.63, –0.34)	—	–0.45 (–1.2, 0.24)	1.7 (0.86, 2.59)	0.28 (0.04, 0.52)	—	0.28
Hutton's Vireo							
rain	—	0.86 (0.22, 1.47)	—	—	—	—	0.27
year + odate	—	—	—	—	–0.18 (–0.39, 0.01)	–0.02 (–0.04, 0)	0.36
odate	—	—	—	—	—	–0.03 (–0.05, –0.01)	0.22
odate + rain	—	0.64 (–0.09, 1.33)	—	—	—	–0.02 (–0.04, 0.01)	0.34
fire	–0.89 (–1.7, –0.15)	—	—	—	—	—	0.22
year	—	—	—	—	–0.22 (–0.41, –0.03)	—	0.21
odate + fire	–0.68 (–1.53, 0.14)	—	—	—	—	–0.02 (–0.04, 0)	0.33
Lazuli Bunting							
odate + rain + fire.data	–0.02 (–0.55, 0.55)	–0.74 (–1.3, –0.2)	–0.49 (–1.24, 0.19)	1.91 (1.17, 2.71)	—	0.02 (0.01, 0.03)	0.65
Lesser Goldfinch							
rain + fire.data	–1.12 (–1.55, –0.69)	–0.74 (–1.08, –0.4)	0.38 (0.03, 0.73)	1.24 (0.77, 1.72)	—	—	0.42
Mourning Dove							
odate + rain + fire.data	–0.34 (–0.83, 0.15)	–0.36 (–0.74, 0.02)	0.77 (0.36, 1.18)	0.67 (0.14, 1.2)	—	0.01 (0, 0.02)	0.64
odate + fire.data	–0.09 (–0.51, 0.33)	—	0.81 (0.4, 1.23)	0.62 (0.1, 1.15)	—	0.01 (0, 0.02)	0.62
odate + rain + data	—	–0.39 (–0.68, –0.12)	1.19 (0.93, 1.45)	—	—	0.01 (0, 0.02)	0.61
year + odate + fire.data	–0.53 (–1.28, 0.23)	—	0.77 (0.36, 1.19)	0.66 (0.13, 1.18)	0.11 (–0.05, 0.26)	0.01 (0, 0.02)	0.63
Mountain Quail							
fire.data	–0.21 (–0.67, 0.26)	—	–0.45 (–1.13, 0.16)	1.22 (0.47, 2.01)	—	—	0.13
Northern House Wren							
year + odate + data	—	—	0.94 (0.67, 1.22)	—	–0.16 (–0.22, –0.09)	0.01 (0, 0.02)	0.42
year + odate + fire.data	–0.24 (–1.1, 0.62)	—	0.71 (0.34, 1.08)	0.59 (0.02, 1.17)	–0.18 (–0.36, 0)	0.01 (0, 0.02)	0.45
year + fire.data	–0.09 (–0.96, 0.76)	—	0.75 (0.38, 1.12)	0.61 (0.05, 1.19)	–0.21 (–0.39, –0.03)	—	0.43
year + data	—	—	0.99 (0.72, 1.27)	—	–0.15 (–0.22, –0.08)	—	0.40
odate + fire.data	–0.97 (–1.43, –0.53)	—	0.63 (0.27, 1)	0.65 (0.08, 1.22)	—	0.01 (0, 0.02)	0.43
Northern Flicker							
odate + fire.data	–0.93 (–1.41, –0.48)	—	0.42 (0.02, 0.82)	0.68 (0.05, 1.32)	—	–0.01 (–0.02, 0)	0.42
year + odate + data	—	—	0.74 (0.43, 1.05)	—	–0.14 (–0.22, –0.07)	–0.01 (–0.02, 0)	0.38
fire.data	–0.94 (–1.42, –0.49)	—	0.39 (–0.01, 0.79)	0.6 (–0.03, 1.23)	—	—	0.37
odate + fire + data	–0.58 (–0.9, –0.27)	—	0.69 (0.38, 1)	—	—	–0.01 (–0.02, 0)	0.37
year + odate + fire.data	–0.54 (–1.53, 0.44)	—	0.47 (0.05, 0.88)	0.64 (0.01, 1.29)	–0.09 (–0.31, 0.12)	–0.01 (–0.02, 0)	0.42
Oak Titmouse							
odate + fire + rain + data	–0.47 (–0.76, –0.18)	–0.38 (–0.7, –0.06)	1.65 (1.38, 1.92)	—	—	0.01 (0, 0.02)	0.67
year + odate + data	—	—	1.68 (1.42, 1.96)	—	–0.08 (–0.13, –0.02)	0.01 (0, 0.02)	0.66
fire + rain + data	–0.47 (–0.75, –0.17)	–0.44 (–0.75, –0.13)	1.68 (1.42, 1.96)	—	—	—	0.65
year + odate + fire + data	0.32 (–0.31, 0.96)	—	1.71 (1.44, 1.99)	—	–0.15 (–0.3, 0)	0.01 (0, 0.02)	0.66
Orange-crowned Warbler							
fire.data	–1.2 (–1.59, –0.83)	—	0.66 (0.38, 0.94)	0.66 (0.18, 1.15)	—	—	0.51
odate + fire.data	–1.19 (–1.58, –0.82)	—	0.67 (0.39, 0.96)	0.69 (0.22, 1.19)	—	0 (–0.01, 0)	0.51
rain + fire.data	–1.1 (–1.54, –0.66)	0.12 (–0.14, 0.39)	0.68 (0.4, 0.96)	0.64 (0.16, 1.13)	—	—	0.51

Species and model[b]	Fire	Rain	Dataset	Fire × dataset	Year	Ordinal date	Deviance explained
Pileated Woodpecker							
year	—	—	—	—	–0.35 (–0.55, –0.17)	—	0.54
Purple Martin							
year + odate + fire.data	–1.56 (–2.24, –0.89)	—	0.17 (–0.14, 0.48)	0.53 (0.07, 0.99)	0.19 (0.04, 0.33)	0.02 (0.01, 0.02)	0.34
Rufous-crowned Sparrow							
year + fire.data	–1.87 (–3.18, –0.58)	—	0.07 (–0.68, 0.8)	1.1 (0.21, 2.01)	0.44 (0.18, 0.72)	—	0.35
Red-winged Blackbird							
year + fire + data	2.53 (1.68, 3.39)	—	1.28 (0.96, 1.62)	—	–0.31 (–0.5, –0.11)	—	0.61
Spotted Towhee							
odate + fire + data	–0.32 (–0.54, –0.11)	—	0.8 (0.58, 1.01)	—	—	0.02 (0.01, 0.02)	0.53
year + odate + data	—	—	0.81 (0.6, 1.03)	—	–0.07 (–0.13, –0.02)	0.01 (0.01, 0.02)	0.53
odate + fire.data	–0.43 (–0.76, –0.11)	—	0.7 (0.4, 1.01)	0.19 (–0.23, 0.62)	—	0.02 (0.01, 0.02)	0.53
Steller's Jay							
year + odate + fire + data	1.22 (0.36, 2.09)	—	1 (0.67, 1.32)	—	–0.33 (–0.54, –0.12)	–0.01 (–0.02, 0)	0.31
year + fire + data	1.01 (0.19, 1.82)	—	0.91 (0.61, 1.22)	—	–0.29 (–0.49, –0.09)	—	0.29
Violet-green Swallow							
year + data	—	—	0.64 (0.3, 0.97)	—	–0.13 (–0.21, –0.05)	—	0.17
year + odate + data	—	—	0.6 (0.26, 0.94)	—	–0.14 (–0.22, –0.06)	0.01 (0, 0.02)	0.19
White-breasted Nuthatch							
year	—	—	—	—	0.19 (0.05, 0.35)	—	0.35
fire	0.74 (0.13, 1.41)	—	—	—	—	—	0.30
Western Bluebird							
year + odate + fire.data	–2.15 (–3.3, –1.03)	—	–0.87 (–1.57, –0.25)	1.72 (0.94, 2.55)	0.44 (0.2, 0.69)	–0.03 (–0.04, –0.02)	0.46
Western Flycatcher							
year + odate + data	—	—	1.07 (0.75, 1.4)	—	–0.09 (–0.16, –0.01)	0.02 (0.01, 0.03)	0.37
odate + fire + data	–0.29 (–0.61, 0.02)	—	1.05 (0.73, 1.38)	—	—	0.02 (0.01, 0.03)	0.36
year + odate + fire + data	0.32 (–0.52, 1.17)	—	1.09 (0.76, 1.42)	—	–0.16 (–0.36, 0.04)	0.02 (0, 0.03)	0.37
Western Tanager							
year + fire	–3.65 (–5.79, –1.69)	—	—	—	1.06 (0.63, 1.54)	—	0.21
Western Warbling-Vireo							
odate + fire.data	–1.14 (–1.76, –0.57)	—	–0.25 (–0.85, 0.31)	1.84 (1.05, 2.67)	—	0.02 (0, 0.03)	0.45
year + odate + fire.data	–1.84 (–2.96, –0.74)	—	–0.31 (–0.92, 0.25)	1.9 (1.11, 2.73)	0.17 (–0.06, 0.4)	0.02 (0.01, 0.03)	0.47
Wrentit							
year + fire + data	–2.02 (–2.6, –1.44)	—	0.66 (0.46, 0.86)	—	0.16 (0.02, 0.29)	—	0.79

[a]Based on data from point counts and eBird from 2016 to 2018 (pre-fire) and 2020 to 2022 (post-fire). For the dataset variable, eBird was coded as the reference level, such that positive coefficients indicate higher abundance of a species in point count data.

[b]Variables tested for contribution to the model: dataset (point counts or eBird), fire (before/after), ordinal date ("odate"), rain (annual total from June to May in season preceding survey), and year (total of 6).

Appendix 2 Competitive Models ($\Delta AIC_c \leq 2$) for Patterns of Abundance of Bird Species Detected on Pine Flat Road, Sonoma Co., California, before (2016–2018) and after (2020–2022) the Kincade Fire[a]

Species and model[b]	K[c]	ΔAIC_c	Weight	Log likelihood
Acorn Woodpecker				
Ordinal date + Rain + Fire × Dataset	6	0.000	0.920	–181.003
American Robin				
Year	2	0.000	0.274	–64.649
Fire	2	0.068	0.265	–64.683
Year + Ordinal date	3	1.801	0.111	–64.289
Anna's Hummingbird				
Ordinal date + Fire × Dataset	5	0.000	0.253	–94.280
Year + Ordinal date + Fire × Dataset	6	0.690	0.179	–93.279
Ordinal date + Dataset	3	1.054	0.149	–97.296
Ordinal date + Fire + Dataset	4	1.753	0.105	–96.433
Ash-throated Flycatcher				
Ordinal date + Dataset	3	0.000	0.315	–91.706
Ordinal date + Rain + Dataset	4	1.706	0.134	–91.346
Band-tailed Pigeon				
Year + Ordinal date + Fire	4	0.000	0.446	–209.536
Year + Ordinal date + Fire + Dataset	5	0.045	0.436	–208.282
Bewick's Wren				
Year + Fire × Dataset	5	0.000	0.687	–107.791
Black-headed Grosbeak				
Year + Ordinal date + Fire × Dataset	6	0.000	0.976	–100.452
Blue-gray Gnatcatcher				
Fire + Dataset	3	0.000	0.222	–105.015
Year + Fire + Dataset	4	0.461	0.177	–104.033
Fire × Dataset	4	1.199	0.122	–104.401
Year + Fire × Dataset	5	1.339	0.114	–103.195
Fire + Rain + Dataset	4	1.778	0.091	–104.691
Bullock's Oriole				
Year	2	0.000	0.371	–27.629
Bushtit				
Ordinal date + Fire × Dataset	5	0.000	0.449	–133.784
Ordinal date + Rain + Fire × Dataset	6	0.327	0.382	–132.601
California Quail				
Year + Ordinal date + Fire × Dataset	6	0.000	0.996	–178.797
California Scrub-Jay				
Ordinal date + Fire + Dataset	4	0.000	0.179	–123.636
Year + Ordinal date + Fire + Dataset	5	0.772	0.122	–122.745
Fire + Dataset	3	1.417	0.088	–125.557
Ordinal date + Dataset	3	1.572	0.082	–125.635
California Thrasher				
Fire	2	0.000	0.260	–49.380
Rain	2	0.975	0.160	–49.868
Year	2	1.355	0.132	–50.057
Fire + Rain	3	1.690	0.112	–48.965
Ordinal date + Fire	3	1.962	0.098	–49.101
California Towhee				
Fire × Dataset	4	0.000	0.254	–103.039
Year + Fire × Dataset	5	0.281	0.220	–101.903
Ordinal date + Fire × Dataset	5	0.702	0.179	–102.113
Rain + Fire × Dataset	5	1.024	0.152	–102.274
Year + Ordinal date + Fire × Dataset	6	1.465	0.122	–101.149
Cassin's Vireo				
Ordinal date	2	0.000	0.399	–27.547

Species and model[b]	K^c	ΔAIC_c	Weight	Log likelihood
Chestnut-backed Chickadee				
Year	2	0.000	0.237	–30.164
Fire	2	0.406	0.194	–30.367
Rain	2	1.011	0.143	–30.670
Intercept only	1	1.311	0.123	–32.138
Dark-eyed Junco				
Rain + Fire × Dataset	5	0.000	0.330	–126.422
Fire + Rain + Dataset	4	1.047	0.196	–128.223
Ordinal date + Rain + Fire × Dataset	6	1.900	0.128	–126.027
European Starling				
Intercept only	1	0.000	0.298	–47.650
Rain	2	1.067	0.175	–46.865
House Finch				
Year + Ordinal date + Fire × Dataset	6	0.000	0.453	–94.269
Year + Fire × Dataset	5	0.868	0.293	–96.049
Hutton's Vireo				
Rain	2	0.000	0.205	–25.123
Year + Ordinal date	3	0.986	0.125	–24.078
Ordinal date	2	1.224	0.111	–25.736
Ordinal date + Rain	3	1.293	0.108	–24.231
Fire	2	1.315	0.106	–25.781
Year	2	1.510	0.097	–25.878
Ordinal date + Fire	3	1.640	0.090	–24.405
Lazuli Bunting				
Ordinal date + Rain + Fire × Dataset	6	0.000	0.788	–124.415
Lesser Goldfinch				
Rain + Fire × Dataset	5	0.000	0.788	–164.066
Mountain Quail				
Fire × Dataset	4	0.000	0.434	–106.218
Mourning Dove				
Ordinal date + Rain + Fire × Dataset	6	0.000	0.254	–105.864
Ordinal date + Fire × Dataset	5	0.742	0.175	–107.580
Ordinal date + Rain + Dataset	4	1.472	0.122	–109.222
Year + Ordinal date + Fire × Dataset	6	1.588	0.115	–106.657
Northern Flicker				
Ordinal date + Fire × Dataset	5	0.000	0.213	–91.666
Year + Ordinal date + Dataset	4	0.677	0.152	–93.281
Fire × Dataset	4	1.508	0.100	–93.696
Ordinal date + Fire + Dataset	4	1.883	0.083	–93.884
Year + Ordinal date + Fire × Dataset	6	1.919	0.082	–91.279
Northern House Wren				
Year + Ordinal date + Dataset	4	0.000	0.253	–111.596
Year + Ordinal date + Fire × Dataset	6	0.889	0.162	–109.418
Year + Fire × Dataset	5	1.275	0.134	–110.957
Year + Dataset	3	1.785	0.104	–113.701
Ordinal date + Fire × Dataset	5	1.970	0.094	–111.304
Oak Titmouse				
Ordinal date + Fire + Rain + Dataset	5	0.000	0.229	–116.707
Year + Ordinal date + Dataset	4	0.376	0.190	–118.172
Fire + Rain + Dataset	4	1.253	0.122	–118.611
Year + Ordinal date + Fire + Dataset	5	1.934	0.087	–117.674
Orange-crowned Warbler				
Fire × Dataset	4	0.000	0.325	–128.153
Ordinal date + Fire × Dataset	5	0.713	0.227	–127.232
Rain + Fire × Dataset	5	1.714	0.138	–127.733

Species and model[b]	K^c	ΔAIC_c	Weight	Log likelihood
Pileated Woodpecker				
Year	2	0.000	0.574	–23.659
Purple Martin				
Year + Ordinal date + Fire × Dataset	6	0.000	0.597	–134.149
Red-winged Blackbird				
Year + Fire + Dataset	4	0.000	0.558	–91.836
Rufous-crowned Sparrow				
Year + Fire × Dataset	5	0.000	0.590	–77.210
Spotted Towhee				
Ordinal date + Fire + Dataset	4	0.000	0.322	–116.908
Year + Ordinal date + Dataset	4	0.561	0.243	–117.189
Ordinal date + Fire × Dataset	5	1.768	0.133	–116.516
Steller's Jay				
Year + Ordinal date + Fire + Dataset	5	0.000	0.367	–105.222
Year + Fire + Dataset	4	0.772	0.249	–106.885
Violet-green Swallow				
Year + Dataset	3	0.000	0.277	–104.371
Year + Ordinal date + Dataset	4	0.765	0.189	–103.541
Western Bluebird				
Year + Ordinal date + Fire × Dataset	6	0.000	0.975	–84.376
Western Flycatcher				
Year + Ordinal date + Dataset	4	0.000	0.362	–106.411
Ordinal date + Fire + Dataset	4	1.835	0.145	–107.328
Year + Ordinal date + Fire + Dataset	5	1.998	0.133	–106.133
Western Meadowlark				
Fire + Rain	3	0.000	0.497	–15.671
Fire	2	1.234	0.268	–17.827
Western Tanager				
Year + Fire	3	0.000	0.778	–72.384
Western Warbling-Vireo				
Ordinal date + Fire × Dataset	5	0.000	0.446	–78.442
Year + Ordinal date + Fire × Dataset	6	0.533	0.341	–77.363
White-breasted Nuthatch				
Year	2	0.000	0.346	–28.100
Fire	2	0.939	0.216	–28.569
Wrentit				
Year + Fire + Dataset	4	0.000	0.417	–108.885

[a]According to a combination of data from 16 repeated point counts and reports via eBird.
[b]Variables tested for contribution to the model: dataset (point counts or eBird), fire (before/after), ordinal date, rain (annual total from June to May in season preceding survey), and year (total of 6).
[c]Number of parameters.