Response of an avifauna community to the La Tuna Fire in the Verdugo Mountains of Southern California

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Abstract

Fire regimes in coastal sage scrub and chaparral ecosystems have been found to reshape the distribution of vegetation and lead to changes in avian community composition. Although it is evident that these changes may be reflected in both community diversity and the structure of foraging guilds, the direction of response among habitats remains unclear. Here, patterns of change to an avifauna community were investigated in response to the 2017 La Tuna Fire at one monitoring site in the Verdugo Mountains of Southern California. Avian community diversity and evenness at this site were unaffected, however the structure of foraging guilds was significantly altered. There was a 44.2% increase in counts of insectivorous birds, a 69.6% increase in counts of generalist birds, and a 40.0% decrease in counts of granivorous birds. Principal component analysis suggests that this guild shift is explained by increases in the number of insectivorous and generalist birds present following the fire rather than by decreases in the number granivorous birds. Although post-fire distribution may be related to vegetation structure, interspecific interactions, and species unique adaptations to this habitat, results here suggest that patterns of avifauna community response to wildfire in these ecosystems do not always follow expected patterns and may be dictated by variable causes.

Background

The impact of wildfire upon Southern California flora and fauna is an ongoing area of interest in ecology. However, changes in avifauna communities occurring within disturbed coastal sage scrub (CSS) and chaparral habitats following wildfire have received limited attention and remain poorly understood. Some researchers have reported a decrease in avian species diversity in these habitats following fire (Moriarty et al. 1985; Stanton 1986; Newman et al. 2018), but others have reported an increase (Wirtz 1982; Mendelsohn et al. 2008). The effects upon avian community structure evident in the proportions of feeding guilds present have shown more consistent results across studies (Wirtz 1979, 1982; Newman et al. 2018), but are still not found to be totally uniform. For example, Newman et al. (2018) found that natural fire treatments had no effect on avian chaparral guilds, while mechanical treatments were associated with increased numbers of granivorous species. Additional study is needed to improve an understanding of the consequences that the CSS/chaparral fire regime has for avifauna distribution and community structure, especially as this regime is altered by novel environmental change.

Factors that might generate favorable conditions for avian communities following disturbance have been suggested. Longhurst (1978) hypothesized that heterogeneous seral plant communities provide better habitat for many bird species as well as the prey they often depend upon, and because fire stimulates an abundance of new seeds and shoots that may be more nutritious than older vegetative foods. Likewise, Knick et al. (2005). emphasized the importance of fire-mediated landscape heterogeneity for maintaining avian diversity in sagebrush dominated habitats. From these studies one might predict that wildfire will benefit avifauna. In addition, many birds could potentially favor the edge effects offered by disturbance

(Brawn et al. 2001). Research in these community types has shown that changes in vegetative cover can be predictors of avian community structure (Stanton 1986; Mendelsohn et al. 2008). In general, some species may demonstrate a mixed response to wildfire, which is likely due to differential habitat preference. Species that prefer open habitat for foraging may benefit whereas those that require cover may not. It is therefore expected that wildfire disturbance can reshape the diversity and guild structure of avifauna communities.

The effects of the 2017 La Tuna Fire provide an opportunity to study avifauna community response to environmental change that may be related to an altered disturbance regime. Results here seek to show (1) that diversity and evenness have changed following the fire, either by decreasing or increasing, and (2) that guild structure has changed as niche space has been altered. Because the outlook of the CSS/chaparral fire regime is likely to be affected by future climate change, monitoring avifauna response is an important component in understanding changes in biodiversity within this ecosystem. These effects could make these communities particularly sensitive as urbanization and environmental change encroach upon ecosystem processes (Brawn et al 2001). This may become critical if too frequent or intense fires drive type conversion of these ecosystems (Keeley 2005), especially as alien species are becoming rapidly naturalized in disturbed sites within Southern California chaparral-type ecosystems.

Methods

The La Tuna Fire affected 7194 acres within the Verdugo Mountains during September 2017 (Fig 1). Prior to this event, a climax mixed coastal sage scrub (CSS) and chaparral plant community existed within the study area, characterized by a high density of shrubs mostly 2-3 meters tall (personal observation). Dominant plant species included California Sagebrush (*Artemisia californica*), California Buckwheat (*Eriogonum fasciculatum*), Laurel Sumac (*Malosma laurina*), Black Sage (*Salvia mellifera*), Elderberry (*Sambucus cerulea*), and Lemonade Berry (*Rhus integrifolia*). As a result of the fire, vegetation was significantly impacted. In the spring of 2019, there were few new shoots found greater than 1 meter tall in the study area (personal observation). Emergent vegetation following the fire included a few recovering native shrubs such as *A. californica*, *M. laurina*, and *S. cerulea*. However, the most abundant plant species found were Deerweed (*Acmispon glaber*), alien grasses such as *Bromus rubens*, and the alien forb *Brassica nigra*.

In 2016, a site in the Verdugo Mountains was selected for monitoring avifauna communities in the mixed CSS and chaparral habitat. Observations were recorded along a 1.5 km transect on a ridge above La Tuna Canyon, at an average elevation of 410 meters (Fig. 1a). An area-search method was used to determine richness and estimate the abundance of bird species observed. All birds that could be identified by sound and/or sight within approximately 25 meters of the transect were recorded as present. In the spring of 2016, 14 hours of surveys were conducted between 19 April and 6 June, for approximately 2.5 hours preceding twilight (6 surveys total). Following the La Tuna Fire in September 2017, interest in change within this avifauna community prompted additional surveys. Subsequently, 14.5 hours of post-fire surveys were similarly conducted in the spring of 2019 along the same transect, from 26 March to 2 May

(6 surveys total). Many bird species common in CSS and chaparral habitats were initially observed in this area. These include Anna's Hummingbird (*Calypte anna*), Mourning Dove (*Zenaida macroura*), Red-tailed Hawk (*Buteo jamaicensis*), Turkey Vulture (*Cathartes aura*), Western Scrub Jay (*Aphelocoma californica*), Spotted Towhee (*Pipilo maculatus*), and Wrentit (*Chamaea fasciata*). Such species were probably pre-fire residents of this avian community in the Verdugo Mountains, along with migratory visitors such as Phainopepla (*Phainopepla nitens*) and Yellow-rumped Warbler (*Setophaga coronata*).

Remote sensing data provided specific information on the magnitude of vegetation change due to the 2017 La Tuna Fire along the survey transect. Normalized Difference Vegetation Index (NDVI) based on spectral reflectance was used to quantify vegetation cover; values greater than 0.3 indicate canopy presence while values near zero indicate bare soil. Mean NDVI values within the study site changed from 0.3527 before the fire to 0.1668, one month following the fire (paired t-test: $t = 43.4$, $df = 124$, $p < 0.0001$; Fig. 1c). Following the fire, Difference Normalized Burn Ratio values (dNBR) of plots within the study site ranged from 0.20 to 0.58; 6.4% scorched, 59.5% low, 34.1% medium (Fig. 1a, 1b). dNBR estimates burn severity based on changes in spectral reflectance in a landscape after wildfire. The fire perimeter data for the La Tuna Fire was gathered from Monitoring Trends in Burn Severity (U.S. Department of the Interior and Department of Agriculture, 2018; https://www.mtbs.gov/). The satellite imagery used to calculate the dNBR and NDVI was Landsat8 30x30 meters (United States Geological Survey, 2018; https://www.usgs.gov/core-science-systems/nli/landsat). The formulas for dNBR are *NBR = (Band 5 – Band 7) / (Band 5 + Band 7)* before and after the fire, and NDVI is *NDVI = (Band 5 – Band 4) / (Band 5 + Band 4)*. The data was manipulated in Imagine (ERDAS, 2020) and the maps were generated in ArcMap using Esri base maps (Esri, 2020).

Because observations were limited to one site, bird abundance values from each transect were treated as replicate samples. Diversity was quantified using Shannon's index (*H'*) and compared between pre-fire and post-fire surveys using a two-sample t-test. Evenness was then calculated (*H'/ln s*, where *s* = species richness) and likewise compared using a two-sample t-test. The assumptions of a general linear model were met for both variables. Following De Graf and Anderson (1985), feeding guilds were classified into five categories: (1) granivores, (2) insectivores, (3) nectarivores, (4) meat or carrion feeding (hereafter referred to as carrion feeding) and (5) generalists. Classification of observed species into a particular guild was based on the designations provided by the Cornell Lab of Ornithology database (https://www.birds.cornell.edu/home/). A goodness of fit (G^2) test was used to analyze the difference in the total counts of species within each guild present between pre-fire and post-fire surveys. Principal Component Analysis (PCA) was then used to show which guilds might explain the difference between pre-fire and post-fire transects. PCA axes explaining variance relative to these guilds were tested using separate one-way ANOVAs.

Results

There was a non-significant difference in diversity between pre-fire and post-fire surveys ($t = -0.73$, $df = 10$, $P = 0.48$; Fig. 2a), and a non-significant difference in evenness between pre-fire and post-fire surveys (t =

0.24, df = 10, P = 0.82; Fig. 2b). There was, however a highly significant difference in the counts of species within different guilds (G^2 = 153.4, df = 4, P < 0.0001; Fig. 3). There were fewer counts of seed eating species (130 pre-fire vs. 78 post-fire; a 40.0% decrease), more counts of insect eating species (104 pre-fire vs. 150 post-fire; a 44.2% increase), and more counts of generalists (56 pre-fire vs. 95 post-fire; a 69.6% increase). Counts of nectar (9 pre-fire vs. 16 post-fire; a 77.8% increase) and carrion (9 pre-fire vs. 11 post fire; a 33.3% increase) foraging guilds increased, however changes in counts within both guilds were comparatively fewer.

The first two principal components combined to explain 91.3% of the variance and reflect the results of the G^2 test (Fig. 4). Insect eating and generalist guilds were correlated in post-fire transects and mostly associated with PC2. In contrast, seed eating guilds were correlated with pre-fire transects and mostly associated with PC1. Nectar and carrion guilds were not well represented in the PCA. PC1 explained 58.5% of the variance, however these scores were not related to a difference between pre-fire and post-fire transects ($F_{1,10}$ = 0.24, P = 0.64). Although PC2 explained just 32.8% of the variance, it appears to be driving the difference between pre-fire and post-fire transects ($F_{1, 10}$ = 11.0, P = 0.008).

Discussion

Previous studies have reported significant changes in community diversity following wildfire (Wirtz 1982; Moriarty et al. 1985; Stanton 1986; Mendelsohn et al. 2008: Newman et al. 2018), however no such changes were observed here. Mendelsohn et al. (2008) proposed that variable habitat preference among species is likely to drive patterns of post-fire bird distribution. In addition, these authors speculated that vegetation structure can be highly variable following wildfire and is likely to determine such patterns of distribution. Other studies similarly postulated that avian communities may benefit from habitat heterogeneity caused by wildfire (e.g., Longhurst 1978; Brawn et al. 2001; Bock 2005). In the present study, it may be that unique patterns of vegetation response due to heterogenous burn intensity (Fig. 1) have generated a habitat mosaic with variable influence on avian diversity. In addition, Moriarty et al. (1985) demonstrated that avian diversity may be predicted to increase gradually within one year of wildfire disturbance as habitats are subsequently recolonized. Post-fire surveys here were conducted 18 months after the study site had burned, thus it may follow that the level of diversity observed was due to colonization following subsequent periods of low diversity immediately after the fire. Wirtz (1982) reported a gradual increase in avian diversity 42 months following wildfire in chaparral communities. It might be that avian diversity has been increasing since the 2017 La Tuna Fire, reflecting how the process of recolonization depends upon time (Smucker et al. 2005) and species (Winchell and Doherty 2014). On the other hand, non-significant differences in diversity observed here could indicate that burn severity along this transect was not sufficient to alter the relative abundance of species (e.g. Smucker et al. 2005). Because 65.9% of dNBR values represent scorched or low severity plots along the transect (Fig. 1), it is possible that avian habitat quality was not sufficiently altered to impact community diversity.

Whereas changes in avian community evenness were not discussed in previous research, species abundance may reflect patterns of adaptation to disturbance regimes. It might be postulated that sufficient niche space has allowed avian CSS and chaparral bird species to occupy the variable habitats created by wildfire. Longhurst (1978) suggested that such species may be adapted to heterogeneous vegetation presumably because it offers better habitat for the prey they depend upon. It may follow that burning will allow evenness to be maintained as different species are able to utilize resources across a broader range of niches following wildfire. In addition, the timing of wildfires may be related to community level response from avian species. Newman et al. (2018) suggested that avian populations in chaparral are adapted to fall wildfires, which is the usual time for fires to affect their habitat. Because the 2017 La Tuna Fire was a fall wildfire, perhaps the avian community maintained evenness as a behavioral response in concert with the historic fire regime.

The prediction that this fire prompted a change in feeding guilds due to a change in vegetation structure was supported (Fig. 3; Fig. 4). Although previous studies had not detected a significant change in guild structures following wildfire in Southern California chaparral (e.g., Wirtz 1979, 1982), here results showed that such a change is possible. In addition, studies that found a significant change in guild structure following fire in chaparral (e.g. Newman et al. 2018) instead recorded higher numbers of seed eating species and lower numbers of insect eating species, contrary to the results here. The association of insect eating and generalist species with negative PC2 scores suggests that increases in these guilds were driving the difference between pre-fire and post-fire surveys. These disparities further illustrate that the response of avian communities to wildfire in CSS/chaparral habitats may not always follow specific patterns. In the case of the 2017 La Tuna Fire, vegetation shifted from mature perennial shrubs to mostly herbaceous annuals. It may follow that seed eating species had a stronger association with perennials, whereas insect feeding species had a stronger association with annuals that proliferate rapidly, attracting abundant prey for birds to feed on. Force (1981) suggested that insect diversity was expected to increase substantially in response to the emergence of pioneer plant species immediately following wildfire in California chaparral communities. van Mantgem et al. (2015) specifically pointed to increases in ground dwelling harvester ants immediately following wildfire in CSS/chaparral and other taxa that may survive below ground or disperse from adjacent unburned areas. Force (1982) provided detailed reports of conspicuous post-fire colonization by flower visiting hymenopterans, non-flower phytophagous aphids and acridid grasshoppers, and more predator-like syrphid, asilid and bomyliid flies and coccinnelid beetles. An increase in generalist bird species may indicate patterns of territoriality associated with residents that were able to shift resource usage in order to avoid local extirpation from their home range; they may have turned to these insects for food in sympatry with emergent insectivorous species.

Patterns of species turnover seem to present additional questions about what may cause shifts in avian community structure. Insectivorous bird species such as the Western Kingbird (*Tyrannus verticalis*) and Lazuli Bunting (*Passerina amoena*) observed following the fire were never observed in the study site previously. However, other insectivorous species such as Bushtits (*Psaltriparus minimus*) and Bewick’s Wren (*Thryomanes bewickii*) that were observed before the fire were absent in all post-fire surveys. Very similar responses in bird abundance were observed in mechanical treatments within chaparral communities designed to simulate the effects of fire on the landscape (Seavy et al. 2008) and in burned CSS (Stanton 1986). In contrast, all seed eating species observed before the fire, except for the House

Finch (*Haemorhous mexicanus*), were also observed in post-fire surveys. These results may suggest that stronger post-fire competition exists among insectivorous species. Granivorous species may instead be able to utilize similar resources in sympatry even when those resources are limited, shift to a more generalist strategy, or may be less territorial than insectivorous species.

Changes to avifauna community diversity and structure in response to fire regimes in CSS and chaparral remain uncertain. Across studies, contrasting results have been found, illustrating that these communities may not always follow specific patterns. Underlying variables such as vegetation structure, burn intensity, season, and periods of post-fire colonization each have potential to influence species distribution. A unique history of adaptations in CSS and chaparral bird species may allow these avian communities to coexist with a natural fire regime and maintain diversity in light of disturbance. Although it seems likely that guild structure will change following wildfire, the direction of change remains unclear. CSS and chaparral ecosystems are facing novel environmental pressures that may lead to extirpation in areas of localized diversity such as the Verdugo Mountains. As fire regimes in CSS and chaparral habitats become altered due to climate change and anthropogenic influence, long term monitoring of avian community response will become increasingly important for conservation interests. If widespread type conversion of historic habitat becomes prevalent, this information may guide management decisions and be useful for predicting how bird species ranges are likely to shift.

Declarations

Competing interests: The authors declare no competing interests.

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Figures

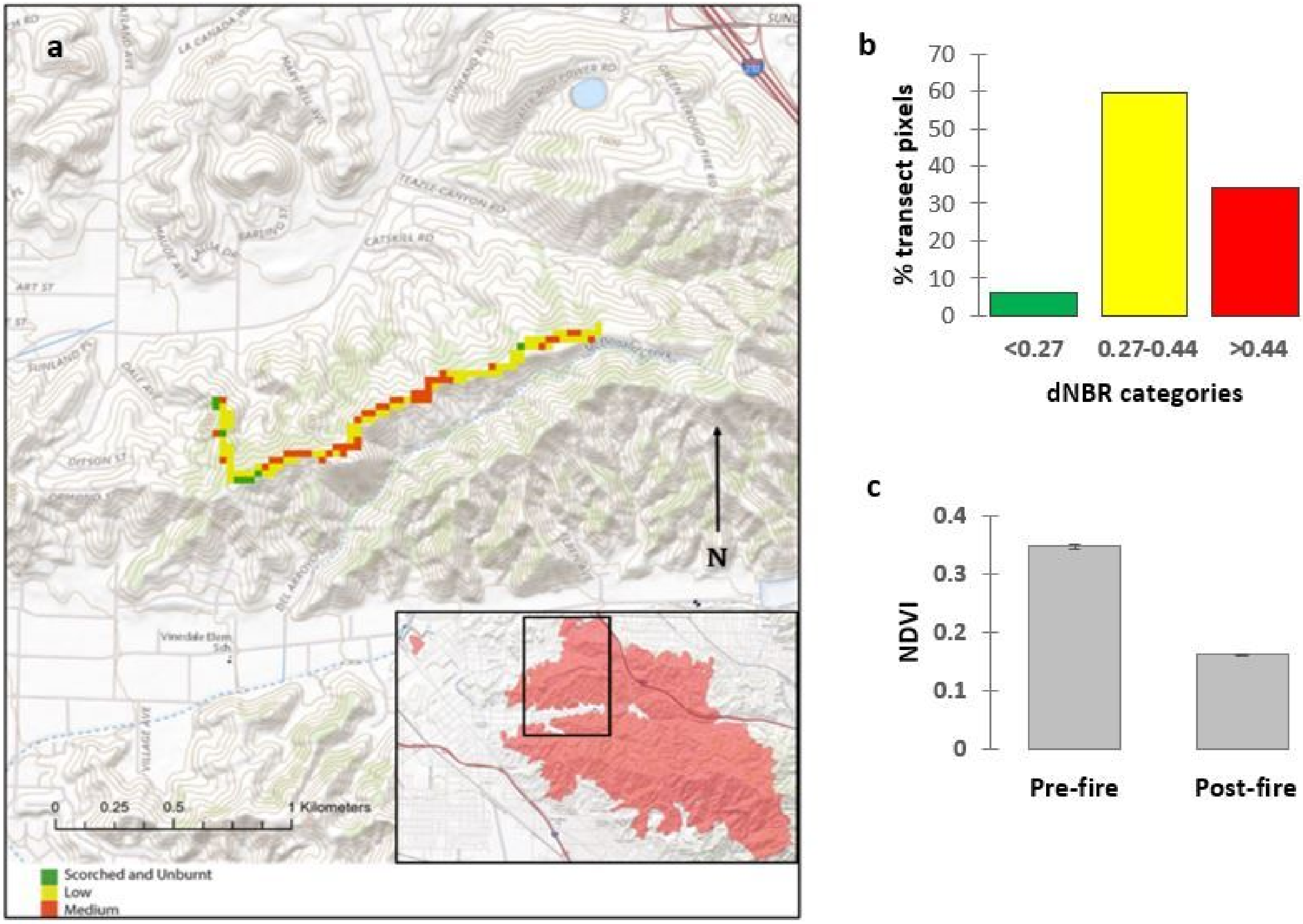

Figure 1

(a) Map showing sampling location in the Verdugo Mountains with dNBR ranks for 30 x 30 m pixel quadrats along the transect. Map at lower right shows 2017 La Tuna Fire perimeter with an inset showing the location of the monitoring transect. (b) Plot showing % of transect pixels in three dNBR categories. (c) Plot of means +/- SEM showing NDVI values in pre-fire and post-fire surveys (n = 126 for each level).

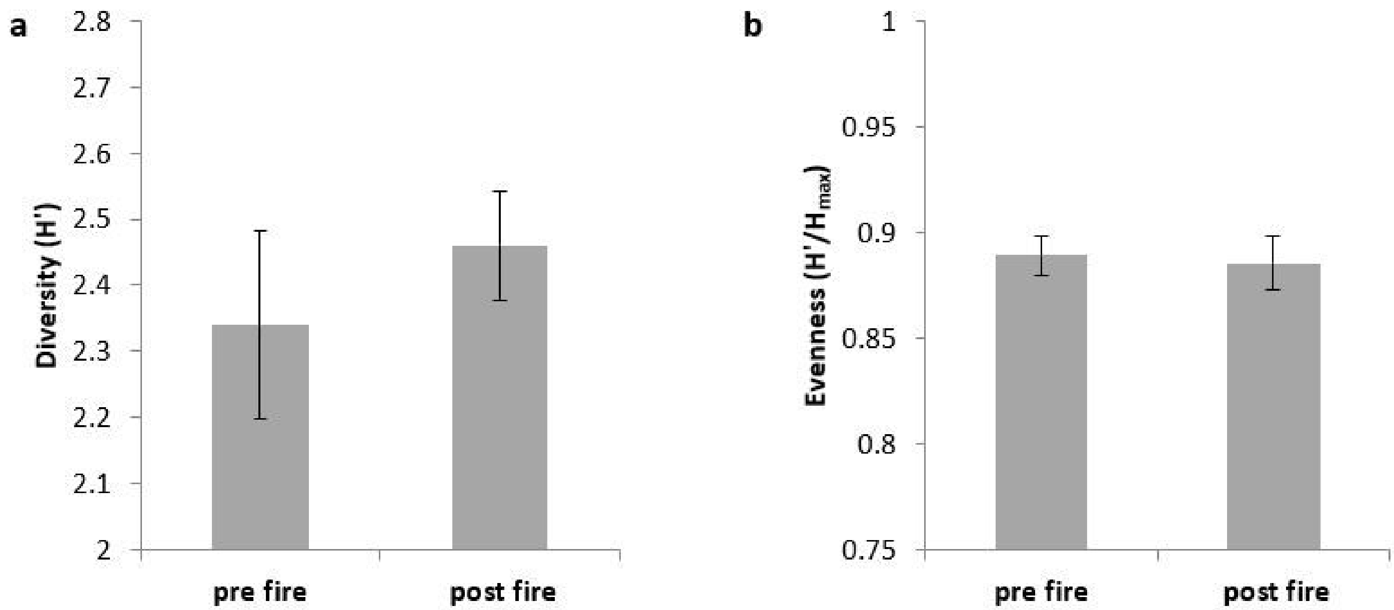

Figure 2

Plots of means +/- SEM for (a) diversity and (b) evenness between pre-fire (n = 6) and post-fire (n = 6) surveys.

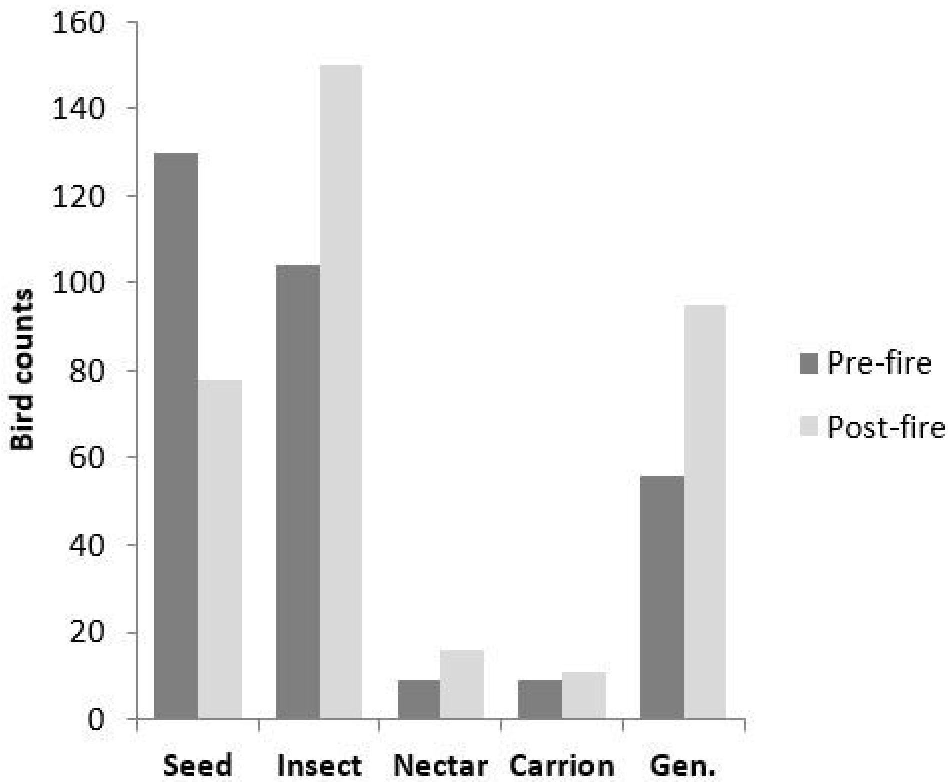

Figure 3

Change in counts for individual birds within five guild classes (seed, insect, nectar, carrion, and generalist) between pre-fire and post-fire surveys.

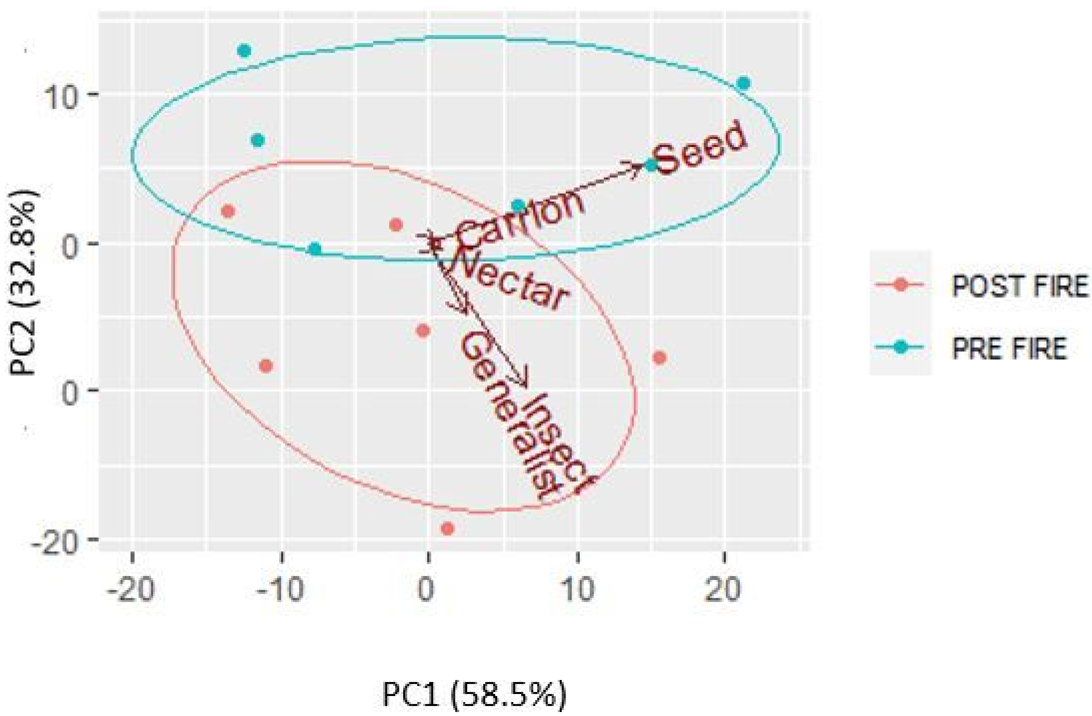

Figure 4

PCA association of guilds with pre-fire (blue) and post-fire (red) transects. % variance explained by each axis is given in parenthesis.