Forest Fire Impact on Bird Habitat in a Mixed Oak-Pine Forest in Puebla, Mexico[1]

Laura P. Ponce-Calderón[2], Dante A. Rodríguez-Trejo[2], Beatriz C. Aguilar-Váldez[2], and Elvia López-Pérez[3]

Abstract

To assess the impact of different-severity wildfires on bird habitat, habitat quality was determined by analyzing the degree of richness association, abundance and diversity of bird species and vegetation structure (richness, abundance, diversity and coverage). These attributes were quantified with four sampling sites for birds and five for quadrant-centered points respectively, for each of three different conditions: oak forest burned years ago, and burned at low and high severity recently, in an oak-pine forest in Chignahuapan, Puebla, Mexico. More vegetation and birds were found in the first condition, while the lowest values correspond to the high-severity burn condition. No significant differences were found in terms of bird diversity between the low and high-severity burn areas ($t_{56(2)}$=0.39, P>0.05).The vegetation structure showed a different diversity between the burned years ago and high-severity burn conditions ($t_{250(2)}$=14.70, P<0.05). Only the correlation between bird and vegetation richness was associated, indicating that forest fires which occurred a year earlier can reduce plant richness and this, in turn, may represent an improvement in habitat quality for some birds. Such was the case with *Certhiaamericana*, a fire-adapted species that showed significant association with recent low-intensity burn sites.

Keywords: Association, birds, diversity, fire, vegetation

Introduction

Among the issues related to forest fires, fires within ecosystems have been mainly highlighted (Pantoja 2008). A fire is a change agent with negative effects; however, scientists are now recognizing fire's ecological role in creating a space in which new interactions occur between species (Pons 2005), as is the case with some birds that can colonize a burned area from nearby sites and which normally disappear years

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[2]Forestry Sciences Division, Universidad Autónoma Chapingo, Estado de México, México. Email:quautli_@hotmail.com; dantearturo@yahoo.com; cyrtonyxmontezumae@yahoo.com; loel50@hotmail.com

[3]Zootechnics Department, Universidad Autónoma Chapingo, Estado de México, México.

later with succession advance (Brotons and others 2005). Fire-maintained ecosystems provide habitat with an abundance and diversity of species, which respond differently depending on the frequency, intensity, severity and time of year that it was burned (Lyon 1978).The effect can be measured in different ways and withdifferent approaches;for this reason, the objective of this paper is to determine bird habitat quality, both in oak-pine forests burned several years ago and in those burned at low and high intensity recently, taking as a hypothesis that areas burned by low-intensity and relatively frequent surface fires help maintain bird habitat and diversity in the oak-pine forest in Chignahuapan, Puebla.

Materials and methods

The study area is located in Chignahuapan, Puebla state, and its geographical coordinates are: 19°48'29"north latitude and 97°59'35" west longitude. The predominant climate is temperate, with a mean annual temperature of 12.6 °C, and a mean annual rainfall of 1096.6 mm (García 1973). Species richness and diversity was determined by bird and vegetation sampling, making a comparison between three conditions with different damage levels: oak forests not recently burned by fire (more than five years after its occurrence) (C1), and those burned at low (C2) and high (C3) intensity in the previous year (2008).

The conditions burned at low and high intensity recently were burned in April 2008, whereas condition 1 was burned five years previously (CONAFOR 2008).

The fieldwork included three visits for vegetation and bird sampling in June, October and November 2009.

Bird sampling: A sample size of 500 m^2 was definedfor each condition, and directed sampling based on the degree of damage was established. Data collection for bird communities was performed by fixed-radius point count methods (Wunderle 1994) and mist nets. The points were distributed unevenly (zigzag) at 100-m intervals between each one, to give equal coverage to the area. The first method was to detect all the birds within a 25-m radius for a period of 15 minutes. Three fixed-radius points were located per condition in which the birds were observed with Bushnell 25x50m binoculars and identified using various field guides. Due to habitat conditions four mist nets, two 12 m and two 6 m in each condition, were operated to capture, identify and release the birds. Nets were placed alongside each fixed-radius point count and were hung where vegetation was thicker to go unnoticed by the birds. This activity was performed for each condition, from 7 to 12 and 16 to 19 hours, with reviews every 45-60 minutes, making a total of 288 reviews throughout the study.

Species richness was determined by adding the total number of species in each plot with two sampling methods (mist nets and point counts). Abundance was obtained by adding up the number of individuals of species i (Chi 2007). Diversity was estimated for each condition using the Shannon-Wiener index (H '). The values obtained were subjected to Hutchenson t tests (Zar 1999).

The similarity of bird species between conditions was determined using the Jaccard Coefficient of Community (Magurran 1988); this coefficient considers qualitative data for comparing communities (Mostacedo and Fredericksen 2000).

Vegetation sampling.The quadrant-centered point method was used for arboreal vegetation and Ossting embedded squares were used for herbaceous vegetation, in a one-square-meter sampling area, whereas shrub vegetation was sampled in a 16-square-meter area (Müeller-Dombois and Ellenberg 1974). In each plot a 500-m zig-zag transect was established and a sampling point was located every 100 m, because the study area showed homogeneity in vegetation. For woody vegetation the variables were: species, distance from the centralsampling point to the tree and canopy cover. For herbaceous and shrub vegetation, the variables were: species, number of plants and percent coverage.

The importance value (IV), which is an estimate of the ecological significance of a species in a community (Franco 1989), was determined. Species richness, abundance and the Shannon-Wiener diversity index (H') were obtained in each plot. The diversity values obtained between fire-damage conditions were compared with Hutchenson t tests (Zar 1999). To determine the similarity of species richness, the Jaccard Coefficient of Community was used (Magurran 1988).

Whether there was an association between condition and the presence of some common species in burned areas was analyzed through a X2 test that is applicable to a number of situations where counts are made and where the data do not follow a normal distribution (SAS 1999).

To determine the degree of association between bird variables (richness, abundance and diversity of species) and vegetation structure variables (cover, richness, abundance and diversity of vegetation), the relationship between the two sets of variables was explained using Pearson correlation analysis (SAS 1999).

Results and Discussion

During field observations 30 species of birds, belonging to 6 orders and 20 families, were recorded. The predominant families were Fringillidae (finches) with 8, Turdidae (thrushes) with 3 and Caprimulgidae (nightjars) with 2. In total, 23 individuals belonging to 19 species were caught in the nets in the three conditions (12 in the burned years ago condition, and 7 and 4 in the low- and high-intensity conditions, respectively).

Species diversity estimated in the mixed forest burned years ago differs from the diversity of both the forest burned at low intensity ($t_{50(2)}$=3.51, P<0.05) and the mixed forest burned at high intensity ($t_{50(2)}$ =3.88 , P<0.05). However, the diversity in these forests burned at low and high intensity showed no statistically significant differences ($t_{56(2)}$=0.39, P> 0.05) between each other. The Jaccard similarity index indicates that for low- and high-intensity burn areas, there is a greater similarity of bird species, as they share six of the 16 species that were detected in both conditions.

Differences in richness and diversity of bird species between conditions may be because in burned areas habitats become more diverse and open plant communities and, after a fire, these habitats recover, thus benefiting wildlife populations by providing the food and structural components they require (Main and Tanner 2003). Fire also creates mosaics and patches of vegetation in which many species, especially granivorous, find food and, as a result, there is an increase in their abundance after a fire (Whelan 1995). Studies like that of Castrale (1982) demonstrate the tolerance of birds to burns, a quality that could be better studied to know the frequency with which the habitat is naturally burned (Society for Range Management 1996).

Conner *and others* (2001) comment that the reason why some species decline is due to their biological and physical interaction with the ecosystem. The recovery process of an area and its wildlife after a fire varies depending on the intensity of the fire, habitat type, precipitation patterns and the time of year that it burned.

The high-intensity burn area shows a significant difference in diversity and richness. This could be because the severity of the burn temporarily eliminated several plant species and it can therefore reduce or delay the repopulation of wildlife in the burned site (Main and Tanner 2003). Bock and Bock (1983) observed that during the first year after a fire, species such as *Certhia americana* and *Zenaida macroura*se are attracted to burned areas. The results obtained in terms of species similarity between conditions were low, which may indicate that each condition has attributes that cause some species to be present and others absent, as is the case with *Certhia americana* which was limited to burned areas and showed preference for the low-intensity burn area; this supports Imbeau *and others* (1999), who claim that the extinction of fires affect this species, while Hobson (1999) shows that the density of *Certhia Americana* and *Turdusmigratorius* increases after a fire. Main and Tanner (2003) note that fire has a positive effect on some wildlife populations because it stimulates fruit production, resulting in increased availability of seeds and berries that provide food for many species; this means that the eating habits of species must be considered in order to better understand this influence.

Conner *and others* (2001) mention species such as *Pipiloerythrophalmus* and *Otusasio* as common species in fire-dependent communities; the latter often uses woodpecker cavities for nesting, and both were recorded in this study. The *Pipiloerythrophalmus* has been shown to be twice as frequent and three times more abundant in fire-dependent sites (Beachy *and others* 2008).

For vegetation, a total of 58 species were obtained in the three conditions.

Generally, in the oak forest burned years ago, there was a diversity of 2.648 and a richness of 25, representing the highest diversity found for the three conditions studied. For the oak forest burned at low intensity, a diversity of 2,438 and a richness of 24 were obtained.

In the oak forest burned at high intensity, a richness of 29 species and a diversity of 1.6305 were obtained, meaning it is the least diverse of the three conditions.

When comparing the three conditions it was observed that the area burned years ago shows the same diversity as the low-intensity burn area ($t_{250(2)}$=1.92, P>0.05), just as the low- and high-intensity burn areas showed no differences in diversity ($t_{150(2)}$ =0.33, P> 0.05), but for the area burned years ago and the high-intensity burn area ($t_{250(2)}$=14.70, P <0.05) diversity differed.

The Jaccard similarity index indicates that the area burned years ago and the low-intensity burn area had 14 species in common, the area burned years ago and the high-intensity burn area shared 13 species, and the high- and low-intensity burn areas had 12 species in common.

In conducting the vegetation and avifauna association, a low negative correlation was found between richness of vegetation and richness, abundance and diversity of bird species; on the contrary**,** abundance, diversity and coverage were not associated with avifauna (Table 1), which may be mainly due to the samples not being statistically representative enough in order to have an association between vegetation structure and the structure of birds.

Table 1— *Pearson correlation coefficients between the bird and vegetation variables with a significance of P<0.05.*

Vegetation	**Avifauna**		
	Richness	Abundance	Diversity
Richness	**-0.46139***	**-0.48535***	**-0.45126***
Abundance	-0.22573	-0.17915	-0.22895
Diversity	-0.11977	-0.28593	-0.02882
Coverage	-0.22377	-0.26465	-0.22248

The results indicate that a decrease in vegetation leads to an increase in the richness, abundance and diversity of bird species. This may be because the condition will have a greater richness of plant species that will provide shelter and roosting sites for birds. However, plants that are indispensable to their particular requirements may not be present. An example of this is that in recently burned conditions, a greater number of hummingbirds, possibly due to the presence of *Bouvardiaternifolia*, a species with tubular flowers suitable for these birds, whose beak is adapted to take nectar from flowers like this, was found. Furthermore, this study found no association between tree cover and understory vegetation, but Chi (2007) found that tree density affects the abundance of birds, since when tree density increases, the abundance of bird species decreases. On the other hand, authors like Pons and Prodon (1996) mention that birds never leave areas burned by fire, returning any time from the day after the fire up to a year later.

The relationship between species and vegetation richness shows that by reducing the latter element, habitat quality for some birds can improve because they use these areas since they have a vegetation structure suitable for feeding, nesting and breeding, as shown in similar studies where unburned areas have a greater abundance of birds, but less richness (García-Ruiz *and others* 1996). Similarly, Jansen *and others* (1999) indicate that due to the abundance of grasses, it has a negative effect on the richness and demographics of birds. There are fire-adapted species that depend on this factor to maintain their habitat and which benefit from low intensity fires, as was the case with *Certhia americana*.

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