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Source: Journal of the Arizona-Nevada Academy of Science, 41(1) : 16-23

Published By: The Arizona-Nevada Academy of Science

URL: https://doi.org/10.2181/036.041.0103

OBSERVATIONS OF BIRD NUMBERS AND SPECIES FOLLOWING A HISTORIC WILDFIRE IN ARIZONA PONDEROSA PINE FORESTS

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ABSTRACT

The Rodeo-Chediski Wildfire, the largest in Arizona's history, damaged or destroyed ecosystem resources or disrupted ecosystem functioning in a mostly mosaic pattern throughout the ponderosa pine (*Pinus ponderosa*) forests exposed to the burn. Impacts of the wildfire on the occurrence of birds and their diversities were studied on two watersheds in the area, one burned by a high severity (stand-replacing) fire, while the other was burned by a low severity (stand-modifying) fire. This paper reports on the results of a five-year (2002-2007) evaluation of this wildfire on the bird species and numbers observed on these two watersheds to provide a record of the impacts of the historic fire on avifauna communities.

INTRODUCTION

The Rodeo-Chediski Wildfire of 2002, the largest in Arizona's history, damaged or destroyed ecosystem resources or disrupted ecosystem functioning throughout the ponderosa pine forests exposed to the burn. Avifauna inhabiting the region represent a unique resource of main importance. An opportunity to study the impacts of this devastating wildfire on the occurrence of birds and their diversities presented itself on two watersheds burned by the wildfire. One watershed suffered a high severity (stand-replacing) fire, while the other watershed was burned by a low severity (stand-modifying) fire (Ffolliott and Neary 2003). The results of this five-year study of the post-fire occurrences of birds and their diversities are presented in this paper.

RODEO-CHEDISKI WILDFIRE

The Rodeo-Chediski Wildfire impacted 1,890 km^2 of chaparral shrub communities, pinyon-juniper (*Pinus-Juniperus)* woodlands, and ponderosa pine (*Pinus ponderosa*) forests in a mostly mosaic pattern of burned and unburned sites (Ffolliott and Neary 2003, Gottfried et al. 2003). The wildfire was started by two human ignitions that merged into one inferno to become the Rodeo-Chediski Wildfire. One-half of the ponderosa pine forests, the focus of this paper, was burned by a high-severity fire, other areas burned with a low- to medium-severity fire, and still other areas were largely unburned according to a Burned Area Emergency Rehabilitation (BAER) report and a fire severity map prepared shortly after the fire was extinguished (U.S. Forest Service, http://www.fs.fed.us/r3/asnf/salvage/).

STUDY AREAS

Two watersheds along Stermer Ridge on the Apache-Sitgreaves National Forest at the headwaters of the Little Colorado River in eastern Arizona, about 15 km southwest of Heber, were the study areas. The watersheds, each about 24.5 ha in size, were instrumented in 1972-1973 as a cooperative effort of the School of Natural Resources, University of Arizona, Tucson, and the Rocky Mountain Research Station, U.S. Forest Service, to obtain ecological and hydrologic information on ponderosa pine forests located on sedimentary soils (Ffolliott and Baker 1977). Tree overstories on the watersheds before the wildfire consisted of uneven-aged stands of ponderosa pine trees with intermingling Gambel oak (*Quercus gambelii*) and alligator juniper (*Juniperus deppeana*) trees. A diversity of grasses and grass-like plants, forbs, and shrubs commonly found in Arizona ponderosa pine forests (Clary 1975, Ffolliott and Baker 1977, Ffolliott and Gottfried 2008) characterized the pre-fire herbaceous plants.

Flat topographies with few slopes exceeding 10% characterize the watersheds. Elevations range from 2,075 to 2,135 m. Soils derived from the cretaceous materials lying beneath the watersheds are classified in the McVickers series (Hendricks 1985). The watersheds normally receive 500 to 635 mm of annual precipitation. Nearly 65% of this precipitation occurs from October to April, with the remainder falling mostly in high-intensity monsoonal storms from July to early September. However, a prolonged drought impacted the vicinity of the Stermer Ridge Watersheds throughout this study, with annual precipitation averaging about 400 mm in this nearly 10-year period.

FFOLLIOTT, P. F., C. L. STROPKI, H. CHEN, AND D. G. NEARY. 2009. OBSERVATIONS OF BIRD NUMBERS AND SPECIES FOLLOWING A HISTORIC WILDFIRE IN ARIZONA PONDEROSA PINE FORESTS. *JOURNAL OF THE ARIZONA-NEVADA ACADEMY OF SCIENCE* 41(1):16-23.

It was determined by extrapolating a classification system relating fire severity to the soil-resources response to burning (Hungerford 1996) to a watershed-basis (Wells et al. 1979, DeBano et al. 1998) that one of the watersheds had experienced a high-severity fire while the other watershed was exposed to a low-severity fire.

METHODS

Bird Observations

On each of the watersheds, 30 sample plots were established along transects perpendicular to the main stream system and situated from ridge to ridge, with the intervals between the plots approximately 35 m. Bird sightings in a 5-minute observation period at each plot were recorded by species and numbers. These observations began shortly after the observer arrived at the plot to minimize disturbances caused by movement to the plot. Fall sightings were initiated in 2002, shortly after cessation of the wildfire, and continued in 2003, 2004, and 2005. Spring tallies were made from 2003 through 2007. All of the bird observations were obtained between 0800 and 1130 hours on clear or partly cloudy days with minimal wind movement.

Species Richness, Species Diversities, Evenness

Species richness (the number of species tallied) was determined for each of the watersheds and observation periods in the study. Additionally, knowledge of the bird species and numbers observed in studies of avifauna populations is often supplemented by a number representing species diversity (MacArthur and MacArthur 1961) as it was in this study. Species diversity (*H'*) (Shannon and Weaver 1948) was calculated by

$$H' = -\sum_{i=1}^{s} p_i \ln (p_i)$$

where p_i is the proportion of the *i*th species in a population of birds composed of *s* species. Larger values represent higher species diversities. Evenness (*E*) of the species tallied — that is, how equally abundant were the species — was calculated by

$$E = H'/\ln s$$

Larger values for (*E*) are equated with more equally abundant species on a site. Values approaching 1 represent higher levels of evenness.

RESULTS AND DISCUSSION

Bird species and their respective numbers tallied on the Stermer Ridge Watersheds in the fall and spring observation periods of the study are summarized in Tables 1 and 2, respectively. The summaries presented in these tables are a "snap-shot picture" of the birds on the two watersheds at the time of their observations. The species and numbers of birds sighted on both of the watersheds (combined) were less than the species and numbers of birds that have been generally reported in unburned ponderosa pine forests in the region (Szaro and Balda 1979, Brawn et al. 1987, Rosenstock 1996, Hurteau et al. 2008). It is likely that the widespread effects of the historic Rodeo-Chediski Wildfire, when coupled with the drought conditions prevailing before the wildfire and continuing throughout the study, contributed to the comparatively few species and small numbers of birds sighted on the two watersheds.

Impacts of Fire Severity

Comparing the impacts of the Rodeo-Chediski Wildfire on the numbers and diversities of birds on the two Stermer Ridge Watersheds exposed to different fire severities was the initial purpose of this study. It was anticipated that the wildfire might impact on bird numbers and diversities on the watershed burned by a high severity fire differently than on the watershed exposed to a low severity fire. However, the summaries in Tables 1 and 2 suggested that these comparisons were mostly insignificant or generally inclusive with a few exceptions.

Fewer birds were sighted on the watershed experiencing a high severity burn than on the watershed exposed to a low severity burn in the fall of 2002, shortly after cessation of the wildfire, and in both the spring and fall of the following year. The fewer birds tallied on this watershed was attributed to the devastating impacts of the wildfire on the watershed. Most of the trees were killed outright by the fire or died shortly thereafter (Ffolliott et al. 2008), with many of these trees and the pre-fire snags beginning to fall to the ground two years after the burn. The importance of snags to secondary cavity-nesting birds in Arizona ponderosa pine forests has been emphasized by Cunningham et al. (1980) and others. Fire-related damage to the tree overstory on the watershed exposed to a low-severity fire was significantly less. There was less tree mortality on this watershed and most of the pre-fire snags remained in place. Following the "initial shock" of the wildfire, however, differences in the numbers of birds sighted on either the two watersheds were mostly inconsistent with little meaningful trend. This finding contrasted (somewhat) with the statement of Smith (2000) that fire effects on

Table 1. *Bird species (according to Sibley 2000) and their numbers sighted on the Stermer Ridge Watersheds in fall observations of 2002-2005 (high = high-severity fire, low = low-severity fire).*

		Number of observations								
		Fall 2002		Fall 2003		Fall 2004		Fall 2005		
ID	Species name	High	Low	High	Low	High	Low	High	Low	Total
1	Acorn woodpecker (*Melanerpes formicivorus*)	0	0	0	3	0	0	2	0	5
2	Brown creeper (*Certhia americana*)	0	0	0	0	0	0	2	0	2
3	Bushtit (*Psaltriparus minimus*)	2	20	0	0	0	0	0	0	22
4	Chipping sparrow (*Spizella passerina*)	0	0	0	0	0	1	0	0	1
5	Common raven (*Corvus corax*)	1	5	0	0	6	0	0	0	12
6	Gray-headed junco (*Junco hyemalis*)	0	0	0	0	0	1	150	1	152
7	Hammond's flycatcher (*Empidonax hammondii*)	0	0	0	1	0	0	0	0	1
8	Hairy woodpecker (*Picoides villosus*)	0	0	3	1	4	0	4	0	12
9	Mexican jay (*Aphelocoma ultramarina*)	0	0	2	0	0	0	0	0	2
10	Mountain chickadee (*Poecile gambeli*)	0	0	0	0	1	0	0	1	2
11	Northern cardinal (*Cardinalis cardinalis*)	0	0	0	1	0	0	0	0	1
12	Northern flicker (*Colaptes auratus*)	0	0	1	0	0	2	6	0	9
13	Northern harrier (*Circus cyaneus*)	0	0	0	0	0	0	1	0	1
14	Pine siskin (*Carduelis pinus*)	0	0	0	0	0	0	8	0	8
15	Pygmy nuthatch (*Sitta pygmaea*)	0	0	0	0	0	0	0	18	18
16	Red-tailed hawk (*Buteo jamaicensis*)	0	0	0	0	0	0	1	0	1
17	Sharp-shinned hawk (*Accipiter striatus*)	0	0	0	0	0	0	0	1	1
18	Steller's jay (*Cyanocitta stelleri*)	1	2	0	2	4	2	4	5	20
19	Townsend's solitaire (*Myadestes townsendi*)	0	0	0	1	0	0	0	0	1
20	Turkey vulture (*Cathartes aura*)	0	0	0	0	1	0	0	0	1
21	White-breasted nuthatch (*Sitta carolinensis*)	0	0	5	15	4	1	4	3	32
22	Western bluebird (*Sialia mexicana*)	0	0	0	9	28	52	12	0	101
23	Williamson's sapsucker (*Sphyrapicus thyroideus*)	0	0	0	0	0	1	0	0	1
24	Yellow-rumped warbler (*Dendroica cornata*)	0	0	0	0	2	3	0	0	5
Totals		4	27	11	33	50	63	194	29	411

Table 2. *Bird species (according to Sibley 2000) and their numbers sighted on the Stermer Ridge Watersheds in spring observations of 2003-2007 (high = high-severity fire, low = low-severity fire).*

		Number of observations										
		Spring 2003		Spring 2004		Spring 2005		Spring 2006		Spring 2007		
ID	Species name	High	Low	High	Low	High	Low	High	Low	High	Low	Total
1	Acorn woodpecker	0	3	0	0	0	0	0	0	0	0	3
2	American robin (*Turdus migratorius*)	0	0	0	1	0	0	1	0	0	0	2
3	Broad-tailed hummingbird (*Selasphorus platycercus*)	0	0	0	1	0	1	2	0	0	0	4
4	Brown creeper	0	0	0	0	3	2	0	0	0	0	5
5	Bushtit	3	6	0	0	0	0	0	0	0	0	9
6	Chipping sparrow	0	0	0	1	6	0	3	1	0	0	11
7	Common raven	1	0	0	3	2	0	6	0	2	2	16
8	Gray-headed junco	0	0	0	0	11	0	5	2	0	0	18
9	Grace's warbler (*Dendroica graciae*)	0	0	2	2	0	9	0	0	0	0	13
10	Hammond's flycatcher	0	0	0	1	0	0	0	0	0	1	2
11	Hairy woodpecker	0	0	6	0	0	0	0	3	3	1	33
12	Juniper titmouse (*Baeolophus ridgwayi*)	0	0	0	0	0	0	0	0	0	28	28
13	Mexican jay	1	0	0	0	0	0	0	0	0	0	1
14	Mountain chickadee	0	0	0	1	0	0	0	0	0	0	1
15	Mourning dove (*Zenaida macroura*)	0	0	2	0	0	0	0	0	0	0	2
16	Northern cardinal	0	1	0	0	0	0	0	0	0	0	1
17	Northern flicker	1	0	0	0	1	2	0	0	4	0	8
18	Plumbeous vireo (*Vireo plumbeus*)	0	0	0	0	1	0	1	0	0	0	2
19	Sharp-shinned hawk	0	0	0	0	0	0	0	0	1	0	1
20	Steller's jay	1	5	2	0	5	0	2	2	9	12	38
21	Townsend's solitaire	0	0	0	0	0	0	0	1	0	0	1
22	Turkey vulture	0	0	1	0	0	0	0	0	0	2	3
23	Violet-green swallow (*Tachycineta thalassina*)	0	0	0	1	6	4	0	1	2	2	40
24	White-breasted nuthatch	0	3	18	5	5	4	0	1	2	2	40
25	Western bluebird	0	4	0	0	17	8	8	2	6	2	47
26	Western tanager (*Piranga ludoviciana*)	0	0	0	0	0	1	0	0	0	0	1
Totals		7	22	31	16	57	31	28	15	52	50	309

bird communities depended largely on fire severity. There also were little discernible trends in tallies of the individual species or number of species observed on the two watersheds throughout most of the study period. The general effects of the mosaic burning pattern of the Rodeo-Chediski Wildfire in creating a diversity of bird habitats in the vicinity of the Stermer Ridge Watersheds contributed to the minimal impacts of fire severity on the birds tallied on these relatively small watersheds or their habitats.

A salvage cutting and fuel reduction treatments implemented on the watershed burned by a high severity fire in the summer of 2005 removed much of the surviving tree overstory (U.S. Forest Service, http://www.fs.fed.us/r3/asnf/salvage/). It was not possible, therefore, to isolate the impacts of the wildfire itself on bird numbers and diversities from the effects of these post-fire treatments. Even with this difficulty in mind, however, impacts of the differing fire severities studied were minimal. That the two Stermer Ridge Watersheds were relatively small in area, and that some of the birds sighted in the study flew onto the watersheds from adjacent areas of differing fire severities and habitat conditions, probably contributed to the lack of significant differences in bird numbers and species on the two watersheds.

Species and Numbers

Bird species tallied on the two watersheds were few in number and infrequent in their occurrence. Of the 24 species observed on the two watersheds (combined) in the fall observation periods of the study, 17 species were sighted only once or twice, while 15 of the 26 species sighted on these watersheds in the spring were tallied only once or twice (Tables 1 and 2). A few of the bird species were observed in "comparatively large numbers" only once on either one or the other of the watersheds. The eight pine siskin (*Carduelis pinus*) sighted in the fall 2005, on the watershed exposed to a high-severity fire, were the only observations of this species in the study. The only observations of pygmy nuthatch (*Sitta pygmaea*) occurred on the watershed burned by a low-severity fire in the fall of 2005, when 18 birds were sighted. The 28 juniper titmice (*Baeolophus ridgwayi*) tallied on the watershed experiencing a low-severity fire in spring 2007, were the only observations of this species throughout the study. Sightings of these three species were concentrated on a few closely clustered plots.

A few other bird species were tallied in "comparatively large numbers" in one of the observation periods, with a fewer number of these species sighted at least once on either of the watersheds at other times (Tables 1 and 2). A large number of hairy woodpeckers (*Picoides villosus*) was tallied on the watershed experiencing a high-severity fire in the spring 2007, with fewer tallied at any time on either watershed either before or after. Most large numbers of gray-headed junco (*Junco hyemalis*) observed in the study were tallied on the watershed exposed to a low-severity burn in the spring 2005 and then on the watershed burned by a high-severity fire in the fall of that year. Bushtit (*Psaltriparus minimus*) was observed on both of the watersheds in the fall immediately after the Rodeo-Chediski Wildfire and in the spring thereafter, with the 20 sightings on the watershed experiencing a low-severity wildfire in the fall 2002 representing the largest tally of the species. This species was not tallied on either of the watersheds for the remainder of the study.

Some bird species were tallied in "comparatively large numbers" several times throughout the study. Western bluebird (*Sialia mexicana*) was sighted frequently on either or both of the watersheds at varying times in more than one observation period (Tables 1 and 2). White-breasted nuthatch (*Sitta carolinensis*) and Steller's jay (*Cyanocitta stelleri*) were also tallied in relatively large numbers at varying times on the watersheds more than once. The "comparatively large numbers" of the species sighted on the Stermer Ridge Watersheds throughout the study were attributed largely to movements of flocks onto the watersheds at the time of recordings.

Seasonal Patterns

A comparison of seasonal patterns of the species and numbers of birds observed on the watersheds was possible only in 2003, 2004, and 2005, when tallies of birds were obtained in both the spring and fall of those years (Tables 1 and 2). That more species and numbers of birds were tallied in the fall than in the spring in each of those years possibly reflected a more abundant food supply for the birds during the summer months (as indicated by fall tallies) than in the winter (signified by spring sightings). Increasing numbers of birds were sighted in both seasons as the watersheds began to recover from the initial impacts of the wildfire.

Most of the individual species observed in the study were tallied on the watersheds in both fall and spring at least once in the study. There were a few exceptions, however, when a species was sighted in only one of the two seasons. For example, pygmy nuthatch and yellow-rumped warbler (*Dendroica coronata*) were tallied in the fall but not the spring on either of the watersheds. Included in spring but not the fall sightings were Grace's warbler (*D. graciae*), juniper titmouse, and violet-green swallow (*Tachycineta thalassina*).

Whether the seasonal patterns in species and numbers observed were a response to impacts of the Rodeo-Chediski Wildfire or reflected the relatively few post-fire observations of these birds is not known. It is also possible that the drought conditions prevailing throughout the study period influenced the seasonal behavior of the bird numbers and species observed.

Species Richness, Species Diversities, and Eveness

Species richness, diversities, and evenness in the fall and spring tallies of birds are presented in Tables 3 and 4, respectively. While varying (somewhat) by years and seasons, species richness of birds on both of the watersheds was largely similar in the fall and spring observations, especially in the latter stages of the study. However, the post-fire species richness on the two Stermer Ridge Watersheds was generally less than that reported by Szaro and Balda (1979) in their study of bird communities in unburned ponderosa pine forests on the Beaver Creek watersheds in north-central Arizona (Baker and Ffolliott 1999).

The individual watersheds studied on Beaver Creek were managed (at the time of the study) by a uniform thinning of the tree overstory to a "light level" of stocking suitable for even-aged management; alternating cut and thinned strips in irregular elongated openings; a silvicultural cutting combining seed tree-strip cuttings; and a control watershed on which the merchantable timber had been selectively harvested earlier (Szaro and Balda 1979), with the last harvesting of timber on this watershed in the early 1950s. However, species richness on the both of the Stermer Ridge Watersheds in the early part of this study was similar to that on a Beaver Creek watershed where all of the trees had been removed in a clearcutting operation.

Species diversities were variable on both of the Stermer Ridge Watersheds with no consistent pattern in the diversities between the two watersheds (Tables 3 and 4). This finding further supports the lack of significant differences in the occurrence of bird species on the watersheds. However, species diversities were lower in the fall than in the spring on both of the watersheds. Species diversities on the Stermer Ridge Watersheds (combined) were generally lower than those on the unburned Beaver Creek watersheds (Szaro and Balda 1979), with the exception of the clearcut-watershed. A variety of herbaceous plants and a few Gambel oak stump-sprouts had become reestablished on this latter watershed since the clearing treatment almost 10 years earlier.

Evenness of the bird species observed on the Stermer Ridge Watersheds was also variable, with inconsistent differences in the values on the two watersheds (Tables 3 and 4). Similar to the seasonal patterns for species diversities, however, evenness

Table 3. *Species richness, species diversities, and evenness of birds observed on the Stermer Ridge Watersheds in the fall 2002-2005. High - high-severity fire; low= low-severity fire.*

	Fall 2002		Fall 2003		Fall 2004		Fall 2005	
	High	Low	High	Low	High	Low	High	Low
Species richness	3	3	4	8	8	8	11	6
Species diversity	1.040	0.727	1.241	1.524	1.471	0.785	0.999	1.182
Species evenness	0.946	0.662	0.895	0.733	0.707	0.378	0.417	0.660

Table 4. *Species richness, species diversities, and evenness of birds observed on the Stermer Ridge Watersheds in the spring 2003-2007. High - high-severity fire; low= low-severity fire.*

	Spring 2003		Spring 2004		Spring 2005		Spring 2006		Spring 2007	
	High	Low	High	Low	High	Low	High	Low	High	Low
Species richness	5	6	6	9	10	8	8	8	8	8
Species diversity	1.475	1.685	1.275	1.977	1.994	1.812	1.850	1.991	1.663	1.339
Species evenness	0.917	0.940	0.711	0.900	0.866	0.872	0.890	0.958	0.800	0.644

values were lower in the fall than spring. The higher evenness values in Tables 3 and 4 were similar to the values found by Szaro and Balda (1979) in their study of bird communities on unburned sites on the Beaver Creek Watersheds.

CONCLUSIONS

This paper presents "baseline interpretations" of data sets reflecting the impacts of the historic Rodeo-Chediski Wildfire on the occurrences of birds species and numbers. While structure of the bird communities in the general vicinity of the Stermer Ridge Watersheds before the Rodeo-Chediski Wildfire was unknown, it is likely that the wildfire resulted in species in some bird guilds becoming "winners," while species in other bird guilds were "losers" following the burn. Bird guilds (associations) are group of bird species that exploit the same habitat resources (foods, nesting materials, etc.) in a similar manner (Ehrlich et al. 1988). However, the birds within a guild are not necessarily closely related taxonomically.

On the watershed burned by a high-severity fire, for example, species in the cavity-nesting guild of birds benefitted from the retainment of some of the larger trees killed by the burn but continuing to stand until the salvage and fuel reduction treatments were initiated. Because dead and fire-damaged trees on both of the watersheds became hosts for the bark and wood-boring insects that are the main prey for birds in the bark-gleaning guild, food for these birds increased following the wildfire. On the other hand, species in the foliage-gleaning guild probably declined in numbers on severely burned sites within both of the watersheds because of the post-fire loss of foliage and branches. A mosaic of habitat conditions on a "landscape-scale" would be necessary to maintain a "full suite of species" following the wildfire because of these variable responses. Such a diversity of habitats was probably created by the varying burning patterns of the Rodeo-Chediski Wildfire on a scale larger than on the two watersheds studied.

The results obtained from this study should be helpful to managers in anticipating the impacts of future large-scale wildfire events on bird communities. Similar to other studies on the effects of wildfire on bird communities (Finch et al. 1997), however, this study was limited because of methodological problems. There were neither "replications" of the two watersheds studied nor unburned control sites, and, because of this limitation, the information presented in this paper should be considered a case study. Once again, not knowing the structure of the bird communities on the Stermer Ridge Watersheds before the Rodeo-Chediski Wildfire prevented comparison of pre- and post-fire species and numbers. As already mentioned, because the watersheds studied were relatively small in area, it is likely that some of the birds tallied in the study flew onto the one or both of the watersheds from sites of differing fire severities or unburned areas. The data obtained in this study have been interpreted in terms of "summary statistics" that tend to mask information on the post-fire compositions of bird community. It is necessary, therefore, that the results presented be interpreted within the context of these limitations.

ACKNOWLEDGMENTS

This study was funded by the by the Southwest Watershed Team, Air, Water and Aquatics Science Program, Rocky Mountain Research Station, U.S. Forest Service, Flagstaff, Arizona, and the Arizona Agricultural Experiment Station, University of Arizona, Tucson.

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