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Authors: Ffolliott, Peter F., Chen, Hui, and Gottfried, Gerald J.

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BIRD SPECIES AND NUMBERS OF BIRDS IN OAK SAVANNAS OF THE SOUTHWESTERN BORDERLANDS REGION INCLUDING EFFECTS OF BURNING

PETER F. FFOLLIOTT, HUI CHEN, School of Natural Resources and the Environment, University of Arizona, Tucson, AZ 85721, and
GERALD J. GOTTFRIED, Rocky Mountain Research Station, U.S. Forest Service, Phoenix, AZ 85006; ffolpete@ag.arizona.edu

ABSTRACT

Oak savannas of the Southwestern Borderlands region provide food, cover, and sites for nesting, roosting, and perching for a diversity of bird species. The results of a five-year (2003-2007) study of bird species, numbers of birds, and their diversities in the naturally occurring (unburned) oak savannas of the region are reported in this paper. Effects of cool-season and warm-season prescribed burning treatments and a wildfire on bird species and numbers of birds sighted on the same study area after these burning events are also presented. These effects were difficult to isolate, however, because of the large variability in the tallies of bird species and numbers of birds obtained throughout the study.

INTRODUCTION

Oak savannas of the Southwestern Borderlands region provide food, cover, and sites for nesting, roosting, and perching for a diversity of bird species. Open oak savannas of scattered trees are situated between the higher-elevation and denser Mexican oak-pine and oak (encinal) woodlands and the lower-elevation grassland and desert-shrub communities (Ffolliott and Gottfried 2008). Therefore, many of the birds inhabiting these interfacing ecosystems are also observed in the oak savannas. The results of a five-year (2003-2007) study of the bird species, numbers of birds, and their diversities in the naturally occurring oak savannas of the Southwestern Borderlands region are reported in this paper. Effects of cool-season and warm-season prescribed burning treatments and a wildfire on the birds observed on the same study area after these burning events are also presented.

STUDY AREA

Twelve watersheds ranging from 20 to almost 60 acres in size located in the Peloncillo Mountains of southwestern New Mexico (Gottfried et al. 2007) collectively comprised the study area. The areal aggregation of these watersheds – the Cascabel Watersheds – is 451.3 acres. The watersheds are situated between 5,380 and 5,590 feet in elevation. The nearest long-term weather station indicates that annual precipitation averages 21.8±1.2 (mean ±standard error) inches with one-half of this precipitation occurring in the summer monsoonal season. However, the prolonged drought that was impacting the area from the middle of the 1990s continued past the burning events on the watersheds to the end of the study with the average precipitation in this drought period of 14.9 inches annually.

Emory oak (*Quercus emoryi*) was the dominant tree species in the overstories on the watersheds before the burning events followed by alligator juniper (*Juniperus deppeana*). Intermingling Arizona white (*Quercus arizonica*) and Toumey (*Q. toumeyi*) oak, redberry juniper (*Juniperus coahuilensis*), border pinyon (*Pinus discolor*), and the tree-form of mesquite (*Prosopis glandulosa* var. *torreyana*) were minor overstory components (Ffolliott et al. 2008). Perennial grasses in the understories included blue (*Bouteloua gracilis*), sideoats (*B. curtipendula*), slender (*B. repens*), and hairy (*B. hirsuta*) grama; and bullgrass (*Muhlenbergia emersleyi*), common wolfstail (*Lycurus pheoides*), and Texas bluestem (*Schizachyrium cirratum*). Forbs species of Mariposa lily (*Calochortus* spp.), verbena (*Verbena* spp.), and lupine (*Lupinus* spp.) were minor components of the understory plants. Beargrass (*Nolina microcarpa*), fairyduster (*Calliandra eriophylla*), common sotol (*Dasylirion wheeleri*), manzanita (*Arctostaphylos pungens*), Fendler's ceanothus (*Ceanothus fendleri*), and Mexican cliffrose (*Purshia mexicana*) were among the shrubs. Shrub forms of oak and mesquite were also present on many sites. Palmer's century plant (*Agave palmeri*) and banana yucca (*Yucca baccata*) were succulents scattered on rocky slopes. Annual plants were largely absent.

Geologic, physiologic, and hydrologic characteristics of the Cascabel Watersheds have been described by Hendricks (1985), Vincent (1998), Osterkamp (1999), Youberg and Ferguson (2001), Robertson et al. (2002), Neary and Gottfried (2004), and Gottfried et al (2007). Bedrock geology of the watersheds is Tertiary rhyolite overlain by Oligocene-Miocene conglomerates and sandstone. Soils are classified as Lithic Argustolls, Lithic Haplustrolls, or Lithic Ustorthents. These shallow soils

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are generally <20 inches to bedrock. Streamflow originating on the watersheds is intermittent with the larger flows generated by storms of high-intensity rainfall (Gottfried et al. 2006).

PRESCRIBED BURNING TREATMENTS AND WILDFIRE

Land management agencies with support from their collaborators are interested in re-introducing a more natural fire regime into the Southwestern Borderlands region including the oak savannas. Natural fire frequencies, their burning characteristics, and their impacts on the ecosystem resources of the region have been altered since the late 1800s, largely because of past livestock grazing practices that removed significant portions of the fire-carrying herbaceous vegetation and past (often aggressive) fire suppression policies of the land management agencies (Fulé and Covington 1995, Edminster et al. 2000). A first step in the attempt to re-introduce a more natural fire regime was evaluating the effects of prescribed burning treatments on the ecosystem resources including bird species and numbers of birds. The original objective of the research program on the Cascabel Watersheds, therefore, was to evaluate the effects of cool-season (November through April) and warm-season (May through October) prescribed burning treatments on ecosystem resources of the oak savannas. These evaluations would be then compared to control (unburned) watersheds in determining the burning effects.

Following the required watershed calibration period, four of the watersheds were burned in the cool season in early March 2008. Three of the four watersheds to be burned in the warm season were burned on May 20, 2008 with burning of the fourth watershed delayed until at a later date because of shifting weather conditions. However, wind gusts up to 60 mph occurring on the morning of May 21, 2008 blew firebrands onto the remaining watershed scheduled for warm-season burning and the four control watersheds. The resulting wildfire – the Whitmire Wildfire – crossed the boundary lines among the Cascabel Watersheds and then spread beyond these watersheds to burn approximately 4,000 acres. As a consequence of this wildfire, the original objective of research on the Cascabel Watersheds had to be modified to evaluate the impacts of cool-season and warm-season prescribed burning treatments and the Whitmire Wildfire on the ecosystem resources.

FIRE SEVERITIES

A system that relates fire severity to the soil-resource response to burning (Hungerford 1996) was used to classify the resulting severities of the cool-season and warm-season prescribed burning treatments and the wildfire at sample plots on the watersheds (see below). This system relates the post-fire appearance of litter, duff, and woody material and soil conditions to discrete classes of fire severity ranging from low to medium to high. Details of the system are found in Wells et al. (1979), DeBano et al. (1998), and Neary et al. (2005). Classifications of fire severity at the sample plots were then extrapolated to a watershed-basis to determine the percentages of each of the watersheds that were unburned or burned at low, moderate, or high severities.

It was found that 85% of the four watersheds experiencing the cool-season prescribed burn had been exposed to a low severity fire; a moderate fire severity was observed on 5% of the watersheds; and the remaining 10% of the watersheds were unburned (Stropki et al. 2009). Distributions of the fire severities on the watershed exposed to the warm-season prescribed burn and wildfire were similar to the distributions of fire severities of the cool-season burn. It was concluded, therefore, that the Cascabel Watersheds (collectively) had been exposed to low severity fire by the three burning events. The low fire severities were attributed largely to the mostly small and scattered accumulations of flammable fuels before the burns (Ffolliott et al. 2006) and the relatively high windspeeds during burning (M. Harrington, pers. corresp., 2010).

STUDY PROTOCOLS

Sampling Basis

On each of the Cascabel Watersheds, between 35 and 45 sample plots have been located along transects perpendicular to the main stream system and situated from ridge to ridge to obtain data on the ecosystem resources. Intervals between the sample plots varied with the size and configuration of the watershed sampled. A total of 421 sample plots were established on the 12 watersheds. However, because of the small size of the individual watersheds, the short intervals (from 70 to 240 ft) between the plots, and the mobility of birds in the area, observations of bird species and numbers of birds were tallied at only every third sample plot (1, 4, 7, etc.) on the watersheds throughout the study.

Bird Observations

Bird species and numbers of birds sighted in 5-min observations at each sample plot were tallied by established procedures (Ralph et al. 1995, Braun 2005). The counts began a few minutes after the observer arrived at a plot to minimize the effects of disturbances caused by the observer moving to the

plot. Most of the observations were made between 0800 and 1130 hours on consecutive days of clear or partly cloudy conditions with a minimum of wind movement. One exception to this protocol occurred in the spring of 2009 when recurring rainstorms and accompanying cloudy and windy conditions continuously disrupted the tallying of birds on the watersheds. These tallies were obtained intermittently within a 3-week period as a consequence.

Observations of birds before the prescribed burns treatments and wildfire occurred were made in the spring and fall from 2003 through 2007. Effects of these burning events on bird species and number of birds were determined by tallies obtained in the fall of 2008 (approximately 6 and 4 months after the cool-season burn and the warm-season burn and the wildfire, respectively.) and in the spring and fall of 2009. Tallies of birds were not obtained in the spring of 2008 because of the warm-season prescribed burning treatment and wildfire.

Ecological Diversity

Ecological diversity has become a central theme of ecology with measures of ecological diversity also serving as indicators of the "well being" of an ecosystem (Magurran 1988). No matter how it is measured, however, ecological diversity embodies two fundamental indices that are species richness (the number of species) and species evenness (how equally abundant the species are). High species evenness, that is, when the species of an area are virtually equal in abundance, is equated with high ecological diversity.

Species richness of the birds tallied on the Cascabel Watersheds was determined for each of the observation periods in the study. Knowledge of species richness was supplemented by calculating a number representing species diversity (MacArthur and MacArthur 1961). This number (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 comprised of *s* species. Larger (H') values represent higher species diversities.

Evenness (E) of the bird species tallied was calculated by

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

Larger (E) values are equated with more equally abundant species on a site with values approaching 1 representing higher levels of evenness and, therefore, higher ecological diversity on the watersheds.

RESULTS AND DISCUSSION

Bird Species and Numbers of Birds

Bird species and numbers of birds tallied in the spring and fall observations before the prescribed burning treatments and wildfire and the observations of following these burning events occurred are summarized in Tables 1 and 2, respectively. These summaries represent a "snap-shot picture" of the birds on the Cascabel Watersheds at the time of their observation. Grouping the observed bird species by guilds (associations) based on their exploitation of available habitat resources (Ehrlich et al. 1988) was not meaningful because of the large variability in their observations throughout the study.

Some of the species tallied in the study were neotropical migratory birds that typically breed in temperate climates and winter in tropical environments (Block et al. 1992). These birds use a diversity of habitats along their migration routes to obtain the resources needed for reproduction and survival. The oak savannas provide many of these habitats.

Some of the bird species were tallied only occasionally in few numbers throughout the study, while other species were observed more frequently in larger numbers. Tallies of the bird species in larger numbers were attributed mainly to the large flocks of birds that had flown onto the watersheds before their observation. These birds were concentrated mostly in the vicinity of a few closely clustered sample plots with no discernible pattern in their location on the watersheds.

Before the Burning Events

Bird species tallied infrequently and sighted in only few numbers (< 10 counts of the species on the watersheds in an observation period) before the prescribed burning treatments and wildfire included (but not limited to) the Acorn Woodpecker (*Melanerpes Formicivorus*), Barn Swallow (*Hirundo rustica*), Eastern Meadowlark (*Sturnella magna*), Northern Harrier (*Circus Cyaneus*), Prairie Falcon (*Falco mexicanus*), and Yellow Warbler (*Dendroica petechia*). These tallies suggest the transient nature of many of the bird species on the watersheds.

Several bird species were tallied in larger numbers only once in either the spring, fall, or both seasons before the burning events with fewer or no observations of the species at other times. Included in these tallies were the House Finch (*Carpodacus mexicanus*), Lesser Goldfinch (*Carduelis psaltria*), Oregon Junco *(Junco hyemalis* var. *thurberi*), Spotted Towhee (*Pipilo maculatus*), and Violet-green Swallow (*Tachycineta thalassina*). Other bird species were observed in larger numbers several

Table 1. *Species (according to Sibley 2000) and bird numbers sighted on the Cascabel Watersheds in the spring observations of 2003-2007 and 2009. Counts of birds of unknown species are excluded from the table.*

		Number of observations					
ID	Species name	2003	2004	2005	2006	2007	2009
1	Arizona Woodpecker (*Picoides arizonae*)	0	0	1	0	0	0
2	Ash-throated Flycatcher (*Myiarchus cinerascens*)	0	7	17	11	1	0
3	Barn Swallow (*Hirundo rustica*)	0	0	1	0	0	0
4	Brown-crested Flycatcher (*Myiarchus tyrannulus*)	0	0	2	0	0	0
5	Bewick's Wren (*Thryomanes bewickii)*	0	0	11	0	0	11
6	Black Phoebe (*Sayornis nigricans)*	0	0	0	4	0	0
7	Bridled Titmouse (*Baeolophus wollweberi*)	0	0	9	1	0	0
8	Bushtit (*Psaltriparus minimus*)	33	0	4	9	0	0
9	Canyon Towhee (*Pipilo fuscus*)	0	0	1	4	0	0
10	Chihuahuan Raven (*Corvus cryptoleucus*)	0	0	0	0	8	7
11	Chipping Sparrow (*Spizella passerina*)	0	0	1	0	0	0
12	Cooper's Hawk (*Accipiter cooperii*)	0	0	1	0	0	0
13	Common Nighthawk (*Chordeiles minor*)	8	3	0	0	0	0
14	Common Raven (*Corvus corax*)	1	1	6	8	0	0
15	Dusky-capped Flycatcher (*Myiarchus tuberculifer*)	8	0	1	0	0	0
16	Gambel's Quail (*Callipepla gambelii*)	2	0	0	0	0	0
17	Gould's Turkey (*Melaeagris gallopavo mexicanas*)	10	0	0	0	0	0
18	Hawfinch (*Coccothraustes coccothraustes*)	0	0	0	0	1	0
19	House Finch (*Carpodacus mexicanus*)	0	0	3	0	0	0
20	Juniper Titmice (Baceolophus ridgwayi)	21	0	0	0	48	1
21	Lesser Goldfinch (*Carduelis psaltria*)	0	0	2	1	0	0
22	Mexican Jay (*Aphelocoma ultramarina*)	24	24	40	12	20	10
23	Mourning Dove (*Zenaida macroura*)	17	26	13	4	1	0
24	Northern Cardinal (*Cardinalis cardinalis*)	2	5	0	0	0	0
25	Northern Mockingbird (*Mimus polyglottos*)	10	1	1	18	2	0
26	Phainopepla (*Phainopepla nitens*)	1	0	0	0	0	0
27	Prairie Falcon (*Falco mexicanus*)	0	0	1	1	0	0
28	Rufous-crowned Sparrow (*Aimophila ruficeps*)	0	0	3	0	0	0
29	Rock Wren (*Salpinces obsoletus*)	0	0	6	0	0	0
30	Red-tailed Hawk (*Buteo jamaicensis*)	6	3	1	1	0	0
31	Say's Phoebe (*Sayornis saya*)	1	1	0	4	0	0
32	Scott's Oriole (*Icterus parisorum*)	0	3	4	0	3	2
33	Scaled Quail (*Callipepla squamata*)	20	0	0	0	0	1
34	Spotted Towhee (*Pipilo maculatus*)	0	0	3	2	0	0
35	Turkey Vulture (*Cathartes aura*)	6	34	42	20	20	27
36	Violet-green Swallow (*Tachycineta thalassina*)	0	0	1	0	0	0
37	White-throated Swift (*Aeronautes saxatalis*)	0	0	1	0	0	0
Total		170	108	176	100	104	59

times in either the spring, fall, or both seasons before the burns. Among these species were the Ash-throated Flycatcher (*Mylarchus cinerascens*), Common Raven (*Corvus corax*), Bridled Titmouse (*Baceolophus wollweberi*), Bushtit (*Psaltriparus minimus*), Bewick's Wren (*Thryomanes bewickii*), Chipping Sparrow (*Spizella passerina*), Cassin's Kingbird (*Tyrannus vociferans*), Gray-headed Junco (*Junco hyemalis* var. *dorsalis*), Mourning Dove (*Zenaida macroura*), Mexican Jay (*Aphelocoma Ultramarina*), Northern Flicker (*Colaptes auratus*), Red-tailed Hawk (*Buteo jamaicensis*), Northern Mockingbird (*Mimus polyglottos*),Scaled Quail (*Callipepla squamata*), Turkey Vulture (*Cathartes aura*) and Rufous-crowned Sparrow (*Aimophila ruficeps*).

Following the Burning Events

Several species tallied in larger numbers more than once before the prescribed burning treatments and wildfire continued to be sighted in large numbers after the burning events. Included with this group of species were the Bewick's Wren, Bridled Titmouse, Bushtit, Common Raven, Chipping Sparrow, Gray-headed Junco, Lesser Goldfinch,

***Table 2**. Species (according to Sibley 2000) and bird numbers sighted on the Cascabel Watersheds in the fall observations of 2003-2009. Counts of birds of unknown species are excluded from the table.*

		Number of observations						
ID	Species name	2003	2004	2005	2006	2007	2008	2009
1	Acorn Woodpecker (*Melanerpes formicivorus*)	0	0	0	1	2	2	0
2	American Kestrel (*Falco sparverius*)	0	0	0	6	6	7	3
3	American Robin (*Turdus migratorius*)	0	0	0	0	0	0	1
4	Arizona Woodpecker (*Picoides arizonae*)	0	2	0	9	14	9	30
5	Audubon's Warbler *(Dendroica coronata audubonì*)	0	0	0	0	0	0	8
6	Barn Swallow (*Hirundo rustica*)	0	0	0	0	2	0	0
7	Bewick's Wren (*Thryomanes bewickii*)	0	0	5	83	26	48	34
8	Blue-gray Gnatcatcher (*Polioptila caerulea*)	0	0	0	4	0	4	0
9	Black Vulture (*Coragyps atratus*)	0	0	0	0	1	0	0
10	Brewer's Blackbird (*Euphagus cyanocephalus*)	0	0	0	0	0	0	1
11	Brewer's Sparrow (*Spizella breweri*)	0	0	0	0	0	3	2
12	Bridled Titmouse (*Baeolophus wollweberi*)	0	0	4	20	51	32	20
13	Broad-tailed Hummingbird (*Selasphorus platycercus*)	0	0	0	0	2	0	0
14	Band-tailed Pigeon (*Patagioenas fasciata*)	0	0	0	0	0	2	0
15	Black-throated Gray Warbler (*Dendroica nigrescens*)	0	0	0	1	3	1	0
16	Bushtit (*Psaltriparus minimus*)	84	0	0	79	50	30	0
17	Cassin's Kingbird (*Tyrannus vociferans*)	0	4	8	15	23	2	1
18	Canyon Towhee *(Pipilo fuscus*)	0	0	0	5	4	6	19
19	Canyon Wren (*Catherpes mexicanus*)	0	0	0	0	0	0	6
20	Cassin's Sparrow (*Aimophila cassinii*)	0	0	0	1	0	0	0
21	Cassin's Vireo (*Vireo cassinii*)	0	0	0	1	0	0	0
22	Cedar Waxwing (*Bombycilla cedrorum*)	0	32	0	0	0	0	0
23	Chihuahuan Raven (*Corvus cryptoleucus*)	0	0	0	4	3	11	0
24	Chipping Sparrow (*Spizella passerina*)	0	104	269	355	446	476	400
25	Cooper's Hawk (*Accipiter cooperii*)	0	0	0	0	0	2	2
26	Common Nighthawk (*Chordeiles minor*)	4	0	0	0	0	0	0
27	Common Poorwill (*Phalaenoptilus nuttallii*)	0	0	0	1	0	0	0
28	Common Raven (*Corvus corax*)	8	24	32	9	28	46	53
29	Crissal Thrasher (*Toxostoma crissale*)	0	0	0	3	0	0	9
30	Dark-eyed Junco (*Junco hyemalis*)	0	0	0	0	0	0	18
31	Eastern Bluebird (*Sialia sialis*)	0	0	0	0	0	3	0
32	Eastern Meadowlark (*Sturnella magna*)	0	0	0	2	0	0	0
33	Gambel's Quail (*Callipepla gambelii*)	0	0	0	0	1	0	0
34	Gray-headed Junco (*Junco hyemalis var. dorsalis*)	0	214	28	0	0	0	252
35	Great Horned Owl (*Bubo virginianus*)	0	0	0	2	0	0	0
36	Gila Woodpecker (*Melanerpes uropygialus*)	1	0	0	0	0	0	0
37	Golden Eagle (*Aquila chrysaetos*)	0	0	0	0	0	0	1
38	Grasshopper Sparrow (*Ammodramus savannarum*)	0	0	0	1	0	0	1
39	Green-tailed Towhee (*Pipilo chlorurus*)	0	0	0	2	0	0	0
40	Gambel's White-crowned Sparrow (*Zonotrichia leucophrys*)	0	0	0	0	0	0	2
41	Hepatic Tanager (*Piranga flava*)	0	0	0	1	0	0	0
42	House Finch (*Carpodacus mexicanus*)	0	3	2	13	2	10	25
43	Horned Lark (*Eremophila alpestris*)	0	0	0	0	0	0	3
44	Hutton's Vireo (*Vireo huttoni*)	0	0	0	1	0	1	0
45	Juniper Titmice (*Baceolophus ridgwayi*)	16	0	3	5	2	3	6
46	Lazuli Bunting (*Passerina amoena*)	0	0	0	0	0	1	0
47	Lesser Goldfinch (*Carduelis psaltria*)	0	0	0	11	4	39	6
48	Lincoln's Sparrow (*Melospiza lincolnii*)	0	0	0	0	0	3	0
49	Mexican Chickadee (*Poecile sclateri*)	0	0	0	0	0	1	0
50	Mexican Jay (*Aphelocoma ultramarina*)	27	34	55	71	111	56	67
51	MacGillivray's Warbler (*Oporornis tolmiei*)	0	0	0	0	2	0	0
52	Mourning Dove (*Zenaida macroura*)	1	5	2	13	11	98	0
53	Montezuma's Quail (*Cyrtonyx montezumae*)	2	0	0	0	4	0	0
54	Northern Cardinal (*Cardinalis cardinalis*)	0	0	0	0	0	0	1

ID	Species name	Number of observations						
		2003	2004	2005	2006	2007	2008	2009
55	Northern Flicker (*Colaptes auratus*)	0	5	10	88	45	9	18
56	Northern Goshawk (*Accipiter gentilis*)	0	0	0	0	0	2	0
57	Northern Harrier (*Circus cyaneus*)	0	0	1	1	2	3	0
58	Oak Titmouse (*Baeolophus inornatus*)	0	0	0	0	0	0	1
59	Orange-crowned Warbler (*Vermivora celata*)	0	0	0	0	0	2	0
60	Oregon Junco (*Junco hyemalis var. thurberi*)	0	3	10	0	0	0	25
61	Osprey (*Pandion haliaetus*)	0	0	0	0	0	1	0
62	Peregrine Falcon (*Falco peregrinus*)	0	0	0	1	0	0	0
63	Phainopepla (*Phainopepla nitens*)	4	3	4	3	0	0	6
64	Pine Siskin (*Carduelis pinus*)	0	0	0	0	0	0	8
65	Prairie Falcon (*Falco mexicanus*)	0	0	2	0	0	0	2
66	Pyrrhuloxia (*Cardinalis sinuatus*)	0	0	0	0	15	0	0
67	Ruby-crowned Kinglet (*Regulus calendula*)	0	0	0	8	5	1	20
68	Rufous-crowned Sparrow (*Aimophila ruficeps*)	0	0	3	29	118	32	43
69	Red-naped Sapsucker (*Sphyrapicus nuchalis*)	0	1	1	2	0	2	3
70	Rock Wren (*Salpinces obsoletus*)	0	0	3	9	10	7	3
71	Red-shafted Flicker (*Colaptes auratus cafer*)	0	0	0	0	0	0	45
72	Red-tailed Hawk (*Buteo jamaicensis*)	0	3	9	13	14	5	5
73	Red winged Blackbird (*Agelaius phoeniceus*)	0	0	0	4	0	0	0
74	Say's Phoebe (*Sayornis saya*)	0	0	0	1	0	1	0
75	Scott's Oriole (*Icterus parisorum*)	0	0	0	8	1	0	0
76	Scaled Quail (*Callipepla squamata*)	10	0	0	0	0	0	0
77	Spotted Towhee (*Pipilo maculatus*)	0	0	0	20	4	0	7
78	Sharp-shinned Hawk (*Accipiter striatus*)	0	0	0	1	0	4	3
79	Swainson's Hawk (*Buteo swainsoni*)	0	0	0	0	0	2	0
80	Townsend's Solitaire (*Myadestes townsendi*)	0	0	0	0	0	0	2
81	Townsend's Warbler (*Dendroica townsendi*)	0	0	0	0	1	0	0
82	Tufted Titmouse (*Parus bicolor*)	0	0	0	1	0	0	0
83	Turkey Vulture (*Cathartes aura*)	0	0	0	33	37	25	0
84	Vesper Sparrow (*Pooecetes gramineus*)	0	0	0	4	0	7	1
85	Violet-green Swallow (*Tachycineta thalassina*)	0	0	0	0	23	3	0
86	Warbling Vireo (*Vireo gilvus*)	0	0	0	1	3	0	0
87	White-breasted Nuthatch (*Sitta carolinensis*)	0	0	0	0	0	3	1
88	White-crowned Sparrow (*Zonotrichia leucophrys*)	0	0	0	0	0	26	0
89	Western Bluebird (*Sialia mexicana*)	0	4	0	0	0	0	61
90	Western Kingbird (*Tyrannus verticalis*)	0	0	0	0	0	19	0
91	Western Meadowlark (*Sturnella neglecta*)	0	0	0	0	0	0	80
92	Wild Turkey (*Meleagris gallopavo*)	0	0	0	0	1	8	8
93	Wilson's Warbler (*Wilsonia pusilla*)	0	0	0	0	1	0	0
94	Yellow-rumped Warbler (*Dendroica coronata*)	0	0	0	6	2	35	0
95	Yellow Warbler (*Dendroica petechia*)	0	0	0	0	2	0	0
96	Zone-tailed Hawk (*Buteo albonotatus*)	0	0	0	0	4	0	0
Totals		157	441	451	952	1086	1093	1313

Mexican Jay, Mourning Dove, Northern Flicker, Rufous-crowned Sparrow, and Turkey Vulture.

Some bird species not observed before burning events were tallied in few numbers after the burns. These species included the American Robin (*Turdus migratorius*), Mexican Chickadee (*Poecile sclateri*), Oak Titmouse (*Baceolophus inormatus*), Brewer's Blackbird (*Euphagus breweri*), and Osprey (*Pandion haliaetus*). Other species not tallied before the burning events were observed in larger numbers after the burns. Among these species were the Dark-eyed Junco (*Junco hyemalis*), Pine Siskin (*Carduelis pinus*), Red-shafted Flicker (*Colaptes auratus cafer*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Western Kingbird (*Tyrannus verticalis*).

Effects of Burning Events

Whether the sightings of bird species only after the prescribed burning treatments and wildfire were a response to these burning events is unknown. The large variability in the tallies of bird species and numbers of birds obtained throughout the study

could have "masked" the effects of the burns. Furthermore, movements of birds onto the Cascabel Watersheds following the burning events in relation to their movements before the burns might not have been significantly altered because of the low fire severities of the burning events. The burns, for example, had little effect on the initial survival, crown damage, and basal sprouting of trees in the overstory (Ffolliott et al. 2011). There were no meaningful relationships between the tallies of bird species and numbers of birds either before or after the burns and the habitats conditions (vegetation, physiography, ground cover, etc.) surrounding the sample points. The authors of this paper concluded, therefore, that the prescribed burning treatments and wildfire on the Cascabel Watersheds had relatively little effect on the bird species or numbers of birds on the watersheds.

Seasonal Patterns

More bird species and numbers of birds were tallied in the fall observations than the spring both before and after the burning events with the exception of 2003, when there was little difference in the seasonal tallies. The few birds tallied in the spring of 2009 was attributed to the recurring rainstorms and cloudy conditions encountered when movements of birds onto and away from the Cascabel Watersheds was probably erratic. These adverse conditions also hindered identification of some of the species of birds sighted at this time.

That more bird species and numbers of birds were tallied in the fall than in the spring was likely the result of a more abundant food supply in the summer months (as indicated by the fall tallies) than in the winter months (as signified by the spring counts). The reason for the increasing numbers of birds observed in the fall as the study progress is unknown. Some of the bird species that were tallied in the fall were not seen in the spring and vice versa.

Species Richness, Species Diversities and Evenness

Species richness, species diversities, and evenness of the birds tallied in the spring and fall observations are presented in Tables 3 and 4, respectively. The values presented in these tables suggest that prescribed burning treatments and wildfire has little consistent effect of the ecological diversity of the Cascabel Watersheds (as measured by species richness and species evenness) or species diversities.

Species richness in both the spring and fall observation before the burning events was variable with little seasonal or annual pattern in the numbers of species sighted. However, the numbers of species tallied in the spring were less than the average counts of bird species obtained in the Mexican oak-pine and oak woodlands of southeastern Arizona by Block et al. (1992) in the breeding seasons (March through June) of 1986, 1987, and 1988. Trees in the oak ecosystems studied by Block and his colleagues are denser (closer together) than trees in the oak savannas on the Cascabel Watersheds and the average precipitation amounts at the time of their study were closer to the normal conditions for the borderland region.

The large numbers of species tallied in the fall of 2006, about 18 months before the cool-season burn, and continuing in the counts after the burning events to the end of the study was the only difference of note in the numbers of species in the fall tallies either before or after the burning events. The reason for these large numbers of tallied species is unknown. Earlier tallies of the numbers of species in the fall were smaller.

The only spring tally of the number of bird species following the burning events in 2009 was less than the numbers of species in all of the spring tallies before the burns. The small number of species that were observed in the spring of 2009

***Table 3**. Species richness, species diversities, and evenness of birds observed on the Cascabel Watersheds in the spring observations of 2003-2007 and 2009.*

	2003	2004	2005	2006	2007	2009
Species richness	16	11	26	15	9	7
Species diversity	2.387	1.789	2.458	2.324	1.501	1.478
Species evenness	0.861	0.746	0.754	0.858	0.683	0.759

***Table 4.** Species richness, species diversities, and evenness of birds observed on the Cascabel Watersheds in the fall observations of 2003-2009.*

	2003	2004	2005	2006	2007	2008	2009
Species richness	10	15	19	47	41	48	46
Species diversity	1.504	1.599	1.577	2.491	2.329	2.431	2.582
Species evenness	0.653	0.590	0.535	0.647	0.627	0.628	0.674

was a likely consequence of the adverse conditions encountered when these tallies were made. The numbers of species in the fall tallies after the burning events were similar to the numbers obtained before the burns in the fall of 2007 and 2006. Moreover, the tallies of species in these fall observations were all larger than the fall counts prior to 2006.

Species diversities of birds in both the spring and fall were variable before and after the burning events with the following exception. Species diversities in the fall observations after the burns were largely the same as species diversities before the burning events in the fall of 2007 and 2006. The reason for this similarity is unknown. Parenthetically, the general pattern of species diversities was similar to the pattern of species richness in this same time period. Evenness of bird species tallied before and after the burns was also variable. Moreover, the values of evenness when coupled with the values for species richness suggest little change in ecological diversity as a result of the burning events.

CONCLUSIONS

This paper presents "snap-shot" summaries of the bird species, numbers of birds, and their diversities in the oak savannas on the Cascabel Watersheds before and after cool-season and warm-season prescribed burning treatments and a wildfire. The tallies before the burning events are assumed to be indicative of the occurrences of birds in naturally occurring oak savannas of the Southwestern Borderland region within the drought conditions encountered. While the effects of the burns on these birds were difficult to isolate, the authors of this paper concluded that the burning events on the Cascabel Watersheds had relatively little effect on the bird species or numbers of birds observed on the watersheds. The Cascabel Watersheds are small both individually and (collectively) in aggregate, and, therefore, it is likely that some of the birds sighted throughout the study had flown into the watersheds from the surrounding oak savannas and other ecosystems in the vicinity. Nevertheless, the results obtained in this study provide a case study of the bird species, numbers of birds, and their diversities before and after cool-season and warm-season prescribed burning treatments and a wildfire in the oak savannas of the region.

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