

**Effects of Forest Management and Trail Use on Ponderosa
Pine Forest Birds on Heil Ranch, Boulder County Open Space**

Alexander Cruz, Heather Swanson and John Prather
2002 Year End Report

Submitted to:
Mark Brennan, Wildlife Biology
Boulder County Open Space Department

Effects of Forest Management and Trail Use on Ponderosa Pine Forest Birds on Heil Ranch, Boulder County Open Space.

Abstract

The foothill ponderosa pine forests along the Colorado Front Range are an important, unique and understudied habitat. Specific stands of ponderosa pine on Boulder County Open Space are slated for prescribed thinning and burning to maintain or enhance native plant and animal species, their communities, and the ecological processes that sustain them. Additionally, new trails are being added to Boulder County Open Space at Heil Ranch, which may also impact the avian community. During the summers of 1999, 2000, 2001, and 2002 we gathered data on the distribution, abundance and breeding biology of bird populations on the Heil Ranch property. The data collected were taken prior to the implementation of forest management plans, and 1999, 2000, and 2001 data were collected before the increase in human use associated with the opening of trails on this property. During the summer of 2002, we collected the first year of data following the opening of a multi-use loop trail on the property. We present here our pre-disturbance findings, preliminary data on how species have responded to the opening of a new trail and associated increase in human use, and recommendations for further monitoring and research.

Introduction

Foothill ponderosa pine (*Pinus ponderosa*) along the east slope of the Colorado Front Range can be characterized by a park-like appearance of open canopy ponderosa pine, scattered Douglas fir (*Pseudotsuga menziesii*), and an understory composed of five major plant associations including shrubs, herbaceous plants, mixed grass and rock outcrops (Little, 1971; pers. obs.). A number of Neotropical migrants breed in ponderosa pine and adjacent montane riparian habitat of Boulder County, many of which are considered sensitive across their southwestern range. Among those species, the Broad-tailed hummingbird, Hammond's Flycatcher, Dusky Flycatcher, Cordilleran Flycatcher, Townsend's Solitaire, Plumbeous Vireo, Warbling Vireo, MacGillivray's Warbler, Virginia's Warbler, and Green-tailed Towhee are considered species of concern across Arizona, New Mexico and Colorado (Winternitz and Crumpacker, 1985; Rich and Breadmore, 1997; Hall et al., 1997).

Years of fire suppression in the foothills of Boulder County have had a pronounced effect on the forest-grassland interface, and on the forest ecosystem itself. The ponderosa pine forest occurs at a lower elevation than historically (Veblen and Lorenz, 1991), and the stand is overstocked with a high density of trees, making the forest more susceptible to catastrophic fires and pine beetle infestations (Finch et al., 1997; Veblen et al., 2000). The proposed prescribed thinning and burning of ponderosa pine forests on Boulder County Open Space should restore large-scale disturbance processes that will dramatically alter the age-structure of the ponderosa pine forest. In turn, these changes should support higher avian species diversity and maintain more stable populations of open-forest aerial insectivores, granivorous, and tree-drilling bird species (Hejl, 1994; Finch et al., 1997). However, there is some confusion in predicting how the proposed burning of ponderosa pine forest will affect the avian community because the literature is wrought with methodological problems (Dobkin, 1994; Hejl, 1994; Hutto, 1995; Finch et al., 1997). Furthermore, our work has shown that cowbirds are likely to respond positively to canopy openings created in the ponderosa pine forest (Chace and Cruz, 1999). Avian nest predators, e.g., Steller's Jays, may respond to canopy openings in a manner similar to cowbirds and may also negatively impact open-cup nesting songbirds.

Nonconsumptive recreational activities (e.g., hiking, nature study, biking, trail running) are generally thought to be inconsequential to wildlife. However, habitat modification and disturbance associated with trail use can negatively affect songbird productivity and survival, ultimately resulting in avian community changes (Knight and Cole, 1995; Anderson, 1995; Marzluff, 1997). Disturbance effects along trails are most significant during the early part of the nesting cycle (Gotmark, 1992), and recreationists may disturb nesting birds and inadvertently advertise nest locations to predators (Gutzwiller, 1995).

In our original proposal submitted in 1999 we outlined three major goals for our research on the Heil Ranch property. These goals were to:

- 1: Compare the response of bird species richness and abundance to thinning and/or prescribed burning during the breeding season. Compare breeding season parameters, such as density and reproductive success, between treatments and controls.

- 2: Compare the response of bird species richness and abundance at sites with and without trails. Establish pre-trail surveys to compare with post-trail building surveys conducted at a later date. Determine species-specific responses to trail effects during the breeding season.
- 3: Model, using a geographic information system, the effects of forest thinning and burning and trail construction on breeding bird populations in stands slated for future treatment.

Our research during the summers of 1999 and 2000 has given us a large amount of data on the breeding bird community of the Heil Ranch property prior to extensive habitat modification and prior to high levels of disturbance associated with the opening of trails for human use on the property. We report here our analysis of these data and data collected during 2001 and 2002 following opening of the Lichen trail and the multi-use trail loop on the property. We also propose continuing research as trail use increases and management plans are implemented on Heil Ranch. These data may then be compared to data taken in the future to determine how the changes on Heil Ranch affect the bird community.

Methods

Point Count Station Establishment: In 1999 we established a total of 20 locations for point counts on the Heil Ranch property. In 2000 and 2001 and 2002, in accordance with our goals we increased this number to 30 stations, ten along each of 3 transects. These transects included a canyon (CANY) transect starting from the parking lot, running along the Lichen Trail and extending into Plumley Canyon, a proposed trail (PRTR) transect along the route of the new trail extending to the center of the property, and a no trail (NOTR) transect running to the west of the proposed trail in an area not slated for development.

Our transects for 2000 and 2001 and 2002 overlap broadly with our 1999 transects. All ten points on the CANY transect were represented in our GEER and PLUM transects in 1999. Our PRTR transect, while close to the HEIL transect of 1999 did not share any points. We changed the location of this transect and added more points so that they fell along the route of and extended coverage of the new trail. Comparisons of these two transects may be made, however, due to their proximity. The NOTR transect is an entirely new transect in an area not previously surveyed.

After July 16, each point location was pinpointed using a GPS unit, and the general habitat within 50 meters of each point was categorized. Our categories were; thick (often doghair) Ponderosa Pine (*Pinus ponderosa*) forest (PIPO), Ponderosa Pine/Douglas Fir (*Psuedotsuga menziesii*) forest (PIPO/PSME), Ponderosa Pine mixed with low elevation riparian woodland (PIPO/LERI) dominated by Chokecherry (*Prunus virginiana*), Willows (*Salix spp.*), Cottonwoods (*Populus spp.*), and Rocky Mountain Maple (*Acer montana*), and savannah like Ponderosa Pine woodland (PIPO/SAVA), with only scattered clumps of trees. In our 1999 preliminary report, we did not separate PIPO and PIPO/SAVA habitats, but do so here due to large differences in the relative abundance of some species in these two forest types.

Avian Censusing: From June 1 through July 15 we undertook point counts at the chosen locations along each of the transects above. Counts took place for 10 minutes and were performed 3 times at each location before July 15. During each count, all birds seen or heard within 50 meters were identified and recorded. Additional species within 150 meters were also noted. All counts took place between 0530 and 1000, with most counts being completed by 0900. For each point a Relative Abundance Index (RAI) was determined using the following formula:

Total Number of Independent Observations of Birds/Total Number of Census Periods

Each singing male, pair or family group of birds observed or heard was considered an independent observation for the purpose of this study. Only birds seen or heard within 50 meters of the point were tallied in the RAI.

Breeding Productivity: Through observations of nesting behavior (Ralph et al., 1993) and area searches, we located nests at three sites on the Heil Ranch property. These sites were the parking and picnic area and surroundings in Geer Canyon, the confluence of Plumley and Marietta Canyons, and a site along the east side of the loop of the new trail. These sites were used due to the high number of breeding birds using these areas and the opportunity to study the effects of disturbance, or lack thereof, on these breeding communities. Once found, nests locations were marked with flagging placed approximately 10 m from the nest. Nests were monitored at least once every three days from

the day they were found until the nest either failed or the young fledged. Contents were observed directly or with a 6-m mirror pole. Efforts were made not to influence natural rates of nest success using methods designed to prevent nest abandonment and the location of nests by predators (Picozzi, 1975; Westmoreland and Best, 1985; Major, 1989; Martin and Geupel, 1993).

We analyzed nesting success of species for which we found more than 6 nests using the Mayfield method (Mayfield, 1976) with suggested adjustments made by Manolis et al. (2000). This method gives an estimate of the proportion of nests of a species that will fledge at least 1 young based on actual observations from nests of that species. Note however, that this does not take into account cowbird parasitism.

Nest Site Selection: At the conclusion of the breeding season we measured the following vegetation variables at each nest site; nest height, nesting substrate, substrate height, average canopy height in an 11.3 m radius around the nest, number of trees (by size class and species) in an 11.3 m radius around the nest, number of woody stems (by species) in a 5 m radius around the nest, canopy cover at the nest site and at 4 locations 1 meter from the site, and percent of various ground cover types in a five meter radius around the nest. All vegetation variables were measured using standardized protocols (James and Shugart, 1970; Martin and Roppert, 1988).

We are currently in the process of analyzing all our nest site data and comparing it to data taken at random sites. This analysis should allow us to determine whether some species prefer specific microsite characteristics for their nests. We expect to complete this analysis over the next 6-9 months.

GIS Analysis: We intend to use data layers from Arcview to determine landscape level patterns of bird distribution, abundance, and nesting success on the Heil Ranch property. Specific variables used will include vegetation type, slope, aspect, canopy cover, and distance from trails and/or roads. As above, this analysis is to be performed over the next 6-9 months.

Results for the 2002 Season

Avian Censusing: In 2002 we successfully censused birds at all 30 of our established point count locations. Previous habitat classification of these points revealed we had 10 points in Ponderosa Pine forest, 9 in savannah-like Ponderosa Pine woodland, 8 in mixed Ponderosa Pine and Douglas Fir forest, and three in mixed Ponderosa Pine and Riparian woodland.

We detected a total of 34 bird species at our point count locations on Heil Ranch in 2002 (Appendix 1). Our 4 years of point counts indicate that species typical of riparian areas (e.g. Warbling Vireo, Black-headed Grosbeak) and foothills scrub habitat (e.g. Blue-Gray Gnatcatcher, Spotted Towhee) are generally uncommon on Heil Ranch, as there are few extensive patches of these vegetation types. Species typical of grasslands (e.g. Western Meadowlark, Lark Sparrow) are also present in low numbers in open meadows and savannah-like ponderosa areas. Species typical of Ponderosa Pine forests are widespread on the Heil Ranch property, and a few species typical of higher montane coniferous forests (e.g. Townsend's Solitaire, Gray-headed Junco) are present, especially near the western edge of the property. The avian community on Heil Ranch appears to be similar to that of other Ponderosa Pine dominated open space properties in Boulder County (pers. obs.).

One of the most interesting results is that there is a suite of species that are widespread on the property, but reach highest relative abundance in the savannah-like ponderosa pine habitat and areas where Ponderosa Pines are mixed with riparian vegetation. These species include Western Wood-Pewee, Plumbeous Vireo, Western Tanager, and Lesser Goldfinch. This supports our observations from other locations in Boulder County (pers. obs.). In contrast, Steller's Jay, Mourning Dove, and cavity-nesting species such as Mountain Chickadees and nuthatches, were in more even numbers across habitats.

A comparison of abundance data over the period 1999-2002 suggests that most birds had relatively similar numbers between years. There was a significant production of cones by the ponderosa pines in 2001, resulting in dramatically increased numbers of Red Crossbills and Pygmy Nuthatches. However, Mountain Chickadees were in lower numbers, perhaps as a result of competition with Pygmy Nuthatches for nest sites. Additionally, numbers of Townsend's Solitaires and Broad-tailed Hummingbirds were greatly increased for unknown reasons, a trend that was apparent across all of our study sites in Boulder County. In general, numbers of other species appeared to be lower than in previous years, but none of these species showed dramatic changes in abundance.

To look for signs that the opening of the Heil Ranch property for public use was already impacting the breeding bird community, we compared the relative abundance of birds at 6 point counts located near the recently opened parking lot and Lichen Trail and 10 point counts along the newly opened multi-use loop trail. Over the period 1999- 2001, no consistent trends were found along the Lichen Trail (Table 1). However, in 2002, several

species which showed unclear trends in 2001, including Chipping Sparrows, Lark Sparrows, Rock Wrens, Western Tanagers and Western Wood-Pewees, showed obvious negative trends in abundance along the Lichen Trail in 2002. In 2001, more species seemed to show negative trends than positive trends and this continued in 2002 with 9 out of 16 species showing negative abundance trends when pre-opening (1999, 2000) and post-opening (2001, 2002) data are compared in this area. Three of these 9 species showed negative trends across the same time period at non-trail control sites (Table 3). This suggests that these species, Chipping Sparrow, Rock Wren and Western Tanager may be responding to variables other than trail use. However, since the opening of the Lichen Trail, Hammond's Flycatcher, Lark Sparrows, Western Tanagers, and Western Wood-Pewees have disappeared altogether from this area with no detections in 2002 point count censuses. This seems to suggest that there may be reduced use of this area by several species of songbirds, including those that are usually common species in ponderosa pine forests. This may be due to increased recreational use of this area.

In comparisons, relative abundance of birds along the newly opened multi-use loop trail, does not show strong trends towards reduced use by forest birds following opening of the trail (Table 2). In 2002, only 1 species, Broad-tailed Hummingbirds showed reduced abundance in 2002 as compared to 1999-2001. Comparisons with non-trail sites did not show a similar trend in Broad-tailed Hummingbird abundance away from the trail suggesting that this species may be responding negatively to the use of the trail (Table 3). The lack of negative trends in other species may suggest that the use of this trail is not impacting abundance in most species. However, in examining the Lichen Trail data, it is evident that two years post-opening, negative trends are evident that were not seen the first year. This suggests that further monitoring is necessary to establish whether songbird abundance is influenced by the opening of this trail.

Breeding Productivity: In 2002, we located and monitored 96 nests of 12 species (Appendix 2). Over the 3-year period we have located and monitored 375 nests of 22 species (Appendix 3). Additionally we have confirmed nesting by 14 other species (Appendix 3), primarily cavity nesters; nests of which we did not monitor.

Overall, we found slightly fewer nests in 2002 than we did in 2001. Specifically, despite significant searching efforts, we found only one nest in the parking lot and surrounding areas. This is in direct contrast with previous years where the parking lot has been the site of many nests including 21 nests of 8 species in 2001 (Table 5). This is most likely due to the greatly increased use of the parking area this year.

Analysis of nesting success using the Mayfield method (Mayfield, 1976) shows that there is a large amount of annual variation in nesting success of the various avian taxa on Heil Ranch (Table 4). In 2002, nesting success of Chipping Sparrows, Lesser Goldfinches, Mourning Doves, Western Tanagers, and Western Wood-Pewees was higher than in previous years. This is surprising given the expectation that the dry conditions during the summer of 2002 would lead to decreased nest success. In any case, due to the large amount of annual variation in nesting success of the different species, changes in nesting success found in later studies should be interpreted with caution.

Cowbirds were detected more often in 2002 (6 detections) than in 2001 (2 detections) or 2000 (4 detections), but fewer times than in 1999 (10 detections). Brood parasitism by cowbirds, did decrease in 2002 (Appendix 3). In 1999, at least 5 of 48 potential host nests (10.4%) were parasitized, in 2000, at least 14 of 82 potential host nests (17.1%) were parasitized, and in 2001, at least 10 of 69 potential host nests (14.5%) were parasitized. In comparison, in 2002, only 5 of 69 (7.2%) nests were parasitized. The reasons for this are not clear; perhaps the dry weather and low amount of resources caused the reproductive output of the female cowbirds to decrease.

Discussion

A large portion of the Heil Ranch property was opened for public use this season, and work continued on thinning operations while the breeding season was progressing, although these operations did not directly affect our study areas. Point count data from the 6 points along the Lichen Trail as well as nesting data from around the parking lot, suggest that the bird community structure may be changing due to recreation use. Use during the 2001 season hinted at possible negative trends in the abundance of bird species, but showed little difference in breeding use or success. However, in 2002, this area showed strong negative trends in abundance of several species of birds including the complete absence of several species. This combined with the steep drop in nesting birds in the parking lot area suggests that use of these areas is strongly influencing the bird community present.

Along the new multi-use loop trail, changes in the bird community appeared to be minimal. However, as demonstrated by the parking lot and Lichen Trail area, the first year of use may not show the trends that develop as use continues to increase.

Increased use of the parking lot and trail system will undoubtedly cause increased disturbance near these areas. Monitoring of breeding birds will, therefore, be very important in the immediate future and again 3-5 years in the future in order to assess impacts. We believe that effects on songbird communities may become more evident as the time since trail opening increases.

An additional effect of increased human use may be the attraction of higher numbers of predators, such as squirrels and corvids, to the picnic area and surrounding habitat. Both squirrels and jays are known to respond positively to human disturbance (Craig, 1997; Knight and Cole, 1995), probably because they take advantage of the additional food left by hikers and picnickers, and both are common nest predators around Boulder County. We believe there may be an increase in the predation rate of nests around "high-use" areas, such as the picnic area, in future years. Cowbird parasitism is also often, but not always linked to human disturbance (Tewksbury et al., 1998). However, we feel that the removal of cattle from the Heil Ranch property in 1999 has probably resulted in the observed decrease in cowbird activity on the property. In ponderosa ecosystems cowbird abundance has been shown to decrease dramatically with distance from areas grazed by cattle (Goguen and Mathews, 2000), which are the primary feeding areas of cowbirds. Nevertheless, cowbird activity should be monitored closely in the future.

Finally, our data suggest that the thinning and burning of the Heil Ranch property to restore a more "savannah-like" aspect to the forest structure will positively impact a small suite of species, most notably the Western Wood-Pewee, Plumbeous Vireo, Western Tanager, and Lark Sparrow. Indeed, there is a small amount of evidence that thinning associated with the construction of the trail has resulted in new territories of some of the above species in areas where we did not previously detect them. However, these data are tentative, as thinning operations have mostly been remote from our study areas. Furthermore, thinning of forest will make it much more open, which could produce negative effects, such as an increase in cowbird brood-parasitism (e.g. Chace and Cruz, 1999), and reduce numbers of species that like thicker woodlands, such as Townsend's Solitaire. Again continued monitoring will give us the chance to assess changes in nesting success and breeding bird abundance and allow us to analyze the effects of changing vegetation structure on the forest bird community.

Overall, our data show that recreational use may be having a distinct and negative effect on both breeding productivity and abundance of forest songbirds. However, these effects may not be apparent during the first season following the opening of a trail system. As a result, the current trail system and parking lot area should continue to be monitored to determine if negative effects do continue along the Lichen Trail or become evident along the multi-use loop trail.

Literature Cited

- Anderson, S. H. 1995. Recreational disturbance and wildlife populations. Pp. 157-168 in R. L. Knight and K. J. Gutzwiller (eds.) *Wildlife and Recreationists: coexistence through management and research*. Island Press, Wash. D. C.
- Chace, J. F. and A. Cruz. 1999. The influence of landscape and cowbird parasitism on the reproductive success of Plumbeous Vireos breeding in Colorado. *Studies in Avian Biology* 19: 200-204.
- Craig, D. P. 1997. An experimental analysis of nest predation in western coniferous forests: a focus on the role of corvids. Unpublished PhD. Dissertation. University of Colorado, Boulder.
- Dobkin, D. S. 1994. Conservation and management of Neotropical migrant landbirds in the northern Rockies and Great Plains. Univ. of Idaho Press. Moscow, ID.
- Finch, D. M., J. L. Ganey, W. Yong, R. T. Kimball, and R. Sallabanks. 1997. Effects and interactions of fire, logging, and grazing. Pp. 103-136 in W. M. Block and D. M. Finch (eds.), *Songbird ecology in southwestern ponderosa pine forests: a literature review*. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. of Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Goguen, C. B. and N. E. Mathews. 2000. Local gradients of cowbird abundance and parasitism relative to livestock grazing in a western landscape. *Conservation Biology* 14: 1862-1869.
- Gotmark, F. 1992. The effects of investigator disturbance on nesting birds. *Current Ornithology* 9: 63-104.

- Gutzwiller, K. J. 1995. Recreational disturbance and wildlife communities. Pp. 169-181 in R. L. Knight and K. J. Gutzwiller (eds.) *Wildlife and Recreationists: coexistence through management and research*. Island Press, Wash. D. C.
- Hall, L. S., M. L. Morrison, and W. M. Block. 1997. Songbird status and roles. Pp. 69-88 in, W. M. Block and D. M. Finch (eds.), *Songbird ecology in southwestern ponderosa pine forests: a literature review*. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Hejl, S. J. 1994. Human-induced changes in bird populations in coniferous forests in western North America during the past 100 years. *Studies in Avian Biology* 15: 232-246.
- Hutto, R. L. 1995. Composition of bird communities following stand-replacement fires in northern Rocky Mountain conifer forests. *Conservation Biology* 9: 1041-1058.
- James, F.C., and H. H. Shugart Jr. 1970. A quantitative method of habitat description. *Audubon Field Notes* 24: 727-736.
- Knight, R. L. and D. N. Cole. 1995. Factors that influence wildlife responses to recreationists. Pp. 71-79 in R. L. Knight and K. J. Gutzwiller (eds.) *Wildlife and Recreationists: coexistence through management and research*. Island Press, Washington, D. C.
- Little, E. L. 1971. *Atlas of United States Trees. Volume 1. Conifers and important hardwoods*. Misc. Pub. 1146. Washington DC: U.S. Department of Agriculture, Forest Service.
- Manolis, J. C., D. E. Anderson, and F. J. Cuthbert. 2000. Uncertain nest fates in songbird studies and variation in Mayfield estimation. *Auk* 117: 615-626.
- Martin, T. E. and G. R. Geupel. 1993. Nest-monitoring plots: methods for locating nests and monitoring success. *Journal of Field Ornithology* 64: 507-519.
- Martin, T. E. and J. J. Roppert. 1988. Nest predation and nest-site selection of a western population of the Hermit Thrush. *Condor* 90: 51-57.
- Major, R. E. 1989. The effect of human observers on the intensity of nest predation. *Ibis* 132: 608-612.
- Marzluff, J. M. 1997. Effects of urbanization and recreation on songbirds. Pp. 89-102 in, W. M. Block and D. M. Finch (eds.), *Songbird ecology in southwestern ponderosa pine forests: a literature review*. Gen. Tech. Rep. RM-GTR-292. Fort Collins, CO: US Dept. Agric., Forest Service, Rocky Mountain Forest and Range Experiment Station.
- Picozzi, N. 1975. Crow predation on marked nests. *J. of Wildlife Manage.* 39: 151-155.
- Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. *Handbook of field methods for monitoring landbirds*. Gen. Tech. Rep. PSW-GTR-144, Albany, CA, Southwest Research Station, Forest Service, US Dept. Agric.
- Rich, T., and C. Breadmore. 1997. *Priority bird species by state in the western US: 1997 status report*. Unpubl. Rep., Partners-in-Flight, Western Working Group.
- Tewksbury, J. J., S. J. Hejl, and T. E. Martin. 1998. Breeding productivity does not decline with increasing fragmentation in a western landscape. *Ecology* 79: 2890-2903.
- Veblen, T. T. and D. C. Lorenz. 1991. *The Colorado Front Range, a Century of Ecological Change*. University of Utah Press, Salt Lake City, Utah.

- Veblen, T. T., T. Kitzberger, and J. Donnegan. 2000. Climatic and human influences on fire regimes in ponderosa pine forests in the Colorado Front Range. *Ecological Applications* 10: 1178-1195.
- Westmoreland, D. and L. B. Best. 1985. The effect of disturbance on Mourning Dove nesting success. *Auk* 102: 774-780.
- Winternitz, B. L., and D. W. Crumpacker (eds.). 1985. Species of special concern. Unpubl. Rep., Colorado Wildlife Workshop.

Appendix 1: Relative abundance of bird species on the Heil Ranch property, 2002.

Species	PIPO	PIPO / PSME	PIPO / RIPE	PIPO / SAVA
American Crow	.22 ± .15	#	#	#
American Robin	.33 ± .12	.50 ± .17	.66 ± .37	.50 ± .19
Brown-headed Cowbird	#	#	.66 ± .47	.10 ± .07
Broad-tailed Hummingbird	.03 ± .03	.08 ± .06	.55 ± .38	.20 ± .10
Canyon Wren	#	#	.22 ± .22	.03 ± .03
Chipping Sparrow	.26 ± .14	.54 ± .19	.11 ± .11	.40 ± .19
Common Nighthawk	.03 ± .03	.08 ± .06	#	.06 ± .05
Common Raven	#	.13 ± .09	#	.07 ± .07
Dark-eyed Junco	#	.50 ± .18	#	#
Hammond's Flycatcher	#	#	.22 ± .15	.10 ± .06
Hairy Woodpecker	.03 ± .03	#	#	#
Hermit Thrush	#	.04 ± .04	#	#
House Finch	#	.04 ± .04	#	#
House Wren	#	#	.33 ± .24	.07 ± .07
Lark Sparrow	#	#	#	.20 ± .12
Lazuli Bunting	#	#	.22 ± .22	.10 ± .07
Lesser Goldfinch	.03 ± .03	.04 ± .04	.22 ± .22	.48 ± .22
Mountain Chickadee	.18 ± .09	.33 ± .13	.22 ± .15	.24 ± .09
Mourning Dove	.18 ± .07	.17 ± .08	.33 ± .23	.13 ± .07
Northern Flicker	#	#	#	.03 ± .03
Plumbeous Vireo	.07 ± .05	.17 ± .10	#	.23 ± .12
Pygmy Nuthatch	.48 ± .23	.54 ± .26	#	.37 ± .21
Red-breasted Nuthatch	#	.04 ± .04	#	#
Red Crossbill	.55 ± .55	#	#	#
Rock Wren	#	#	#	.07 ± .07
Spotted Towhee	#	.04 ± .04	.77 ± .40	.07 ± .07
Stellar's Jay	.30 ± .17	.16 ± .08	.67 ± .44	.27 ± .13
Townsend's Solitaire	.18 ± .09	.25 ± .12	#	.13 ± .06
Violet-green Swallow	.03 ± .03	.08 ± .08	.22 ± .22	.06 ± .05
White-breasted Nuthatch	#	.50 ± .20	#	.10 ± .07
Western Meadowlark	.03 ± .03	#	#	.17 ± .08
Western Tanager	.18 ± .11	.20 ± .08	.56 ± .38	.30 ± .12
Western Wood-Pewee	.07 ± .07	#	.44 ± .34	.30 ± .17
Yellow-rumped Warbler	#	#	.56 ± .29	.06 ± .06

Indicates that the species was not detected

Appendix 2: Breeding biology of selected bird species on the Heil Ranch Property, 2002.

Species	# Nests	# Abandoned	# Predated	# Parasitized	Mean a Clutch Size	Mayfield b Nest Success
American Robin	15	0	3	0	3.2 (n= 20)	0.53
Chipping Sparrow	19	0	4	2	3.1 (n= 10)	0.53
Common Nighthawk	4	0	1	0	4 (n= 4)	
Lark Sparrow	3	0	1	0	3.7 (n= 3)	
Lesser Goldfinch	14	0	1	0	3 (n= 17)	0.90
Mourning Dove	10	1	0	0	2 (n= 17)	0.85
Plumbeous Vireo	3	0	1	3	3.3 (n= 6)	0.50
Spotted Towhee	3	0	0	0	3 (n= 3)	
Western Tanager	5	1	0	0	3.7 (n= 3)	0.66
Western Wood-Pewee	13	1	1	0	2.8 (n= 21)	0.76

a Includes only non-parasitized nests found before egg-hatching.

b Mayfield (1975).

Appendix 3: Breeding status of selected bird species on the Heil Ranch property, 1999 - 2002.

Species	Nest Type	Breeding Status	Reason for Status
American Robin	Open Cup	Confirmed	Nests Located (33)
Blue-gray Gnatcatcher	Open Cup	Confirmed	Nests Located (03)
Black-headed Grosbeak	Open Cup	Confirmed	Nests Located (05)
Broad-tailed Hummingbird	Open Cup	Confirmed	Nests Located (07)
Brown-headed Cowbird	Brood Parasite	Confirmed	Parasitized Nests
Canyon Wren	Cavity	Confirmed	Cavities Located
Cedar Waxwing	Open Cup	Confirmed	Nests Located (03)
Chipping Sparrow	Open Cup	Confirmed	Nests Located (31)
Common Bushtit	Hanging	Probable	Flocks
Common Poorwill	Ground	Confirmed	Nests Located (01)
Common Nighthawk	Ground	Confirmed	Nests Located (06)
Cordilleran Flycatcher	Open Cup	Confirmed	Fledged Young
Dark-eyed Junco	Open Cup	Confirmed	Fledged Young
Hairy Woodpecker	Cavity	Probable	Cavities Located
Hammond's Flycatcher	Open Cup	Confirmed	Nests Located (04)
House Finch	Open Cup	Confirmed	Nests Located (01)
House Wren	Cavity	Confirmed	Fledged Young
Lark Sparrow	Open Cup	Confirmed	Nests Located (09)
Lazuli Bunting	Open Cup	Confirmed	Nests Located (03)
Lesser Goldfinch	Open Cup	Confirmed	Nests Located (35)
MacGillivray's Warbler	Open Cup	Confirmed	Fledged Young
Mountain Chickadee	Cavity	Confirmed	Cavities Located
Mourning Dove	Open Cup	Confirmed	Nests Located (28)
Pine Siskin	Open Cup	Confirmed	Nests Located (01)
Plumbeous Vireo	Open Cup	Confirmed	Nests Located (26)
Pygmy Nuthatch	Cavity	Confirmed	Cavities Located
Red-breasted Nuthatch	Cavity	Probable	Pairs
Red Crossbill	Open Cup	Confirmed	Nests Located (01)
Rock Wren	Cavity	Confirmed	Cavities Located
Spotted Towhee	Open Cup	Confirmed	Nests Located (02)
Steller's Jay	Open Cup	Confirmed	Fledged Young
Townsend's Solitaire	Open Cup	Confirmed	Nests Located (04)
Vesper Sparrow	Open Cup	Confirmed	Nests Located (01)
Violet-Green Swallow	Cavity	Confirmed	Cavities Located
Virginia's Warbler	Open Cup	Confirmed	Fledged Young
Warbling Vireo	Open Cup	Confirmed	Nests Located (02)
Western Tanager	Open Cup	Confirmed	Nests Located (26)
Western Wood-Pewee	Open Cup	Confirmed	Nests Located (44)
White-breasted Nuthatch	Cavity	Confirmed	Cavities Located
Yellow-rumped Warbler	Open Cup	Confirmed	Fledged Young

Table 1: A comparison of the pre-opening (1999) and post-opening (2000, 2001, 2002) relative abundance index (RAI) ^a of bird species along the Lichen Trail.

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	Trend ^a
American Robin	0.61	0.56	0.27	0.67	?
Brown-headed Cowbird	0.17	0.11	0.00	0.00	-
Broad-tailed Hummingbird	0.17	0.39	0.11	0.33	?
Chipping Sparrow	0.61	0.22	0.33	0.11	-
Hammond's Flycatcher	0.17	0.06	0.00	0.00	-
Lark Sparrow	0.28	0.17	0.11	0.00	-
Lesser Goldfinch	0.06	0.33	0.11	0.44	+
Mountain Chickadee	0.28	0.22	0.00	0.11	-
Mourning Dove	0.11	0.20	0.17	0.11	=
Plumbeous Vireo	0.28	0.17	0.22	0.33	=
Pygmy Nuthatch	0.00	0.17	0.50	0.11	+
Rock Wren	0.11	0.22	0.11	0.00	-
Spotted Towhee	0.33	0.11	0.27	0.22	-
Steller's Jay	0.17	0.17	0.33	0.55	+
Western Tanager	0.41	0.41	0.22	0.00	-
Western Wood-Pewee	0.22	0.39	0.27	0.00	-

^a Increasing (+), Stable (=), Decreasing (-), No Trend or Unclear Trend (?)

Table 2: A comparison of the pre-opening (1999, 2000, 2001) and post-opening (2002) relative abundance index (RAI) a of bird species along the Multi- use Loop Trail

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	Trend a
American Robin	0.29	0.20	0.30	0.37	+
Brown-headed Cowbird	0.00	0.00	0.00	0.00	=
Broad-tailed Hummingbird	0.42	0.03	0.07	0.00	-
Chipping Sparrow	0.04	0.50	0.50	0.53	+
Hammond's Flycatcher	0.00	0.00	0.00	0.00	=
Lark Sparrow	0.13	0.03	0.17	0.17	?
Lesser Goldfinch	0.04	0.17	0.13	0.30	+
Mountain Chickadee	0.00	0.33	0.23	0.20	?
Mourning Dove	0.00	0.30	0.13	0.17	?
Plumbeous Vireo	0.00	0.07	0.10	0.20	+
Pygmy Nuthatch	0.21	0.37	0.47	0.77	+
Rock Wren	0.00	0.03	0.00	0.00	=
Spotted Towhee	0.13	0.00	0.00	0.00	-
Steller's Jay	0.08	0.17	0.03	0.23	+
Western Tanager	0.50	0.30	0.23	0.33	?
Western Wood-Pewee	0.29	0.17	0.20	0.30	=

a Increasing (+), Stable (=), Decreasing (-), No Trend or Unclear Trend (?)

Table 3: A comparison of 4-year relative abundance index (RAI) ^a of bird species along the non-trail census sites

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	Trend ^b
American Robin	N/A	0.61	0.45	0.49	=
Brown-headed Cowbird	N/A	0.06	0.04	0.19	+
Broad-tailed Hummingbird	N/A	0.22	0.18	0.22	=
Chipping Sparrow	N/A	0.59	0.63	0.31	-
Hammond's Flycatcher	N/A	0.12	0.12	0.10	=
Lark Sparrow	N/A	0.02	0.00	0.02	=
Lesser Goldfinch	N/A	0.24	0.08	0.10	-
Mountain Chickadee	N/A	0.24	0.39	0.30	?
Mourning Dove	N/A	0.18	0.08	0.20	?
Plumbeous Vireo	N/A	0.16	0.12	0.07	-
Pygmy Nuthatch	N/A	0.27	0.27	0.25	=
Rock Wren	N/A	0.24	0.04	0.04	-
Spotted Towhee	N/A	0.12	0.08	0.16	+
Steller's Jay	N/A	0.12	0.24	0.27	+
Western Tanager	N/A	0.49	0.41	0.27	-
Western Wood-Pewee	N/A	0.14	0.12	0.12	=

^a Increasing (+), Stable (=), Decreasing (-), No Trend or Unclear Trend (?)

Table 4: Annual variation in Mayfield Nest Success (MNS)^a calculations for selected species on the Heil Ranch Property.

Species	1999 MNS	2000 MNS	2001 MNS	2002 MNS
American Robin	---	0.58	0.77	0.53
Chipping Sparrow	0.16	0.49	0.25	0.53
Lesser Goldfinch	---	0.72	0.44	0.90
Mourning Dove	0.32	0.28	0.15	0.85
Plumbeous Vireo	0.24	0.70	0.52	0.50
Western Tanager	0.38	0.36	0.52	0.66
Western Wood-Pewee	0.68	0.62	0.33	0.76

^a Proportion of nests successfully fledging young as estimated by the Mayfield (1976) method.

Table 5: A comparison of the pre-opening (1999/2000) and post-opening (2001/2002) nesting success of birds at the Heil Ranch parking and picnic area.

Species	Year	# Nests	% Predated	% Parasitized
American Robin	1999	1	0	0
	2000	3	33	0
	2001	6	13	0
	2002	0	-	-
Broad-tailed Hummingbird	1999	1	0	0
	2000	0	-	-
	2001	2	50	0
	2002	0	-	-
Chipping Sparrow	1999	3	100	0
	2000	3	67	33
	2001	2	50	0
	2002	0	-	-
Hammond's Flycatcher	1999	1	0	0
	2000	1	100	0
	2001	1	0	100
	2002	0	-	-
Lesser Goldfinch	1999	0	-	-
	2000	2	50	0
	2001	5	40	0
	2002	0	-	-
Mourning Dove	1999	1	0	0
	2000	1	0	0
	2001	0	-	-
	2002	0	-	-
Plumbeous Vireo	1999	4	75	75
	2000	2	50	50
	2001	2	50	50
	2002	0	-	-
Western Tanager	1999	1	0	0
	2000	2	50	0
	2001	2	0	50
	2002	0	-	-
Western Wood-Pewee	1999	4	0	0
	2000	4	25	25
	2001	4	25	0
	2002	1	0	0