

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. New trails have been added to Boulder County Open Space at Heil Ranch, which may impact the avian community present in these ponderosa pine forests. Additionally, specific stands of ponderosa pine on Boulder County Open Space have been thinned and further stands are slated for future prescribed thinning and burning to maintain or enhance native plant and animal species. During the summers of 1999- 2003 we gathered data on the distribution, abundance and breeding biology of bird populations on the Heil Ranch property. The data collected in 1999 and 2000 data were collected before the increase in human use associated with the opening of trails on this property. During the summer of 2001, we collected data following the opening of the parking/picnic areas and the hiking-only Lichen Trail. During the summer of 2002 and 2003 we collected data following the opening of the multi-use Wapiti trail and Ponderosa loop on the property. We present here data on how species have responded to the opening of new trails and the associated increase in human use.

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 migrant birds 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).

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).

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 ongoing 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.

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, 2002, and 2003 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, 2001, 2002 and 2003, 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 Ponderosa trail extending to the center of the property, and a no trail (NOTR) transect running to the west of the new Ponderosa trail in an area not slated for development.

Our transects for 2000, 2001, 2002 and 2003 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. See Map 1 for point count locations.

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 Ponderosa trail (Map 1). These sites were selected 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 m from the site, and percent of various ground cover types in a 5 m 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.

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.

Results for the 2003 Season

Avian Censusing: In 2003, we successfully censused birds at all 30 of our established point count locations. These points consist of 10 points in Ponderosa Pine forest, 9 in savannah-like Ponderosa Pine woodland, 8 in mixed Ponderosa Pine and Douglas Fir forest, and 3 in mixed Ponderosa Pine and Riparian woodland.

We detected a total of 32 bird species at our point count locations on Heil Ranch in 2003 (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 and 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 and Dark-eyed 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, Mourning Dove, American Robin, Broad-

tailed Hummingbird and Lesser Goldfinch. This supports our observations from other locations in Boulder County (pers. obs.). In contrast, Steller's Jay, and cavity-nesting species such as Mountain Chickadee and nuthatches, were in more even numbers across habitats.

A comparison of abundance data over the period 1999-2003 suggests that most birds had relatively similar numbers overall 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. Overall in 2002, abundance of many species were lower than in previous years. This trend seems to have been in response to the drought during 2002. During 2003, abundance of many species increased dramatically from 2002 and several species reached abundances higher than in any previous years of the study. These species include Chipping Sparrow, Lesser Goldfinch, Mourning Dove, Plumbeous Vireo, Pygmy Nuthatch, and Western Wood-Pewee.

To look for signs that the opening of the Heil Ranch property for public use is 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 Wapiti and Ponderosa multi-use loop trail. Over the period 1999- 2000, no consistent trends were found along the Lichen Trail (Table 1). Results from 2001-2003 (post-opening) show some interesting trends. Several species found along the trail during 1999-2000 have disappeared completely from censuses during 2001-2003. These species include Brown-headed Cowbird (Figure 1), Hammond's Flycatcher (Figure 2), Lark Sparrow (Figure 3), Mountain Chickadee (Figure 4) and Rock Wren (Figure 5). One common feature of these species is that they all are species that do not occur in high number anywhere on the Heil Ranch Property. Hammond's Flycatcher and Mountain Chickadee are found more frequently in mixed conifer forests at higher elevations throughout Boulder County. Abundance trends in non-trail sites were similar for Brown-headed Cowbird, Hammond's Flycatcher, Lark Sparrow and Rock Wren suggesting that the declines in these species are likely due to reasons other than recreational use (Table 3). However, Mountain Chickadees increased in non-trail sites lending some support to the hypothesis that Mountain Chickadees are not tolerating increased recreational use along the Lichen Trail (Figure 4). In contrast, several species that showed negative trends in 2002 including Chipping Sparrow, Western Tanager and Western-Wood Pewee showed a marked increase along the Lichen Trail as well as in non-trail areas. Presumably, the low numbers of these species in 2002 were due to variables other than recreational use.

Relative abundance of birds along the newly opened Wapiti and Ponderosa trails 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. During 2003, Broad-tailed Hummingbirds increased in abundance to a level commensurate with the average abundance during pre-opening years (Figure 6). However, two species, Stellar's Jay (Figure 7) and Lark Sparrow (Figure 8) disappeared from census points in 2003. This is surprising since both species showed increasing trends prior to 2003. Lark Sparrows showed similar trends in non-trail areas suggesting an overall decline in Lark Sparrows on the property. Stellar's Jays however increased in non-trail areas in contrast to the Wapiti/Ponderosa Trail.

Breeding Productivity: In 2003, we located and monitored 49 nests of 19 species (Appendix 2). Over the 3-year period we have located and monitored a total of 424 nests of 25 species (Appendix 3). Additionally we have confirmed nesting by 13 other species (Appendix 3), primarily cavity nesters; nests of which we did not monitor.

Overall, we found slightly fewer nests in 2003 than we did in 2002. In 2002, we found only 1 nest in the parking/picnic areas, which was directly contradictory to high numbers found in previous years. In 2003, this trend reversed and we found 13 nests of 7 species. These numbers are still lower than years prior to 2002 (18 nests in 2000 and 24 nests in 2002) but suggest that birds are again using this area for nesting (Table 5).

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 2003, we saw a drastic decrease in nesting success for three of the four species examined. American Robins, Mourning Doves, and Plumbeous Vireos showed the lowest nesting success since the beginning of this study (Figure 8).

Cowbirds detections were low for all years of the study. In 2003, the detections were lowest with only 3 detections for the entire summer (Appendix 3). Parasitism in 2003 was also at its lowest level of the 5 years studied with only 1 of 32 potential host nests parasitized (3.1%). 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, in 2001, at least 10 of 69 potential host nests (14.5%) were parasitized and in 2002, only 5 of 69 (7.2%) nests were parasitized.

Discussion

This year represented the second year that the full extent of the trail system on Heil Ranch was opened for use by the public. Use of the Wapiti Trail and Ponderosa Loop as well as the parking lot/picnic area increased greatly since it was first opened. Data from previous years hinted at possible negative responses of several species of birds both in abundance along trail areas and in breeding around the parking lot/picnic area. The data from 2003 contradict these findings for many of the species found to decrease in 2002. Several species increased dramatically across the property. This overall trend appears to be in response to the relatively wet spring and early summer, which led to a very productive year at Heil Ranch. Specifically, Chipping Sparrows reached very high numbers suggesting a high abundance of grass and other seeds as well as arthropods due to the early moisture.

Despite this overall lack of trends in response to recreation, a few species did show continued decreases along trail areas. American Robins and Mountain Chickadees showed a marked decrease from 2002 while remaining fairly stable across years at non-trail sites. Along the Wapiti trail Ponderosa Loop, Stellar's Jays showed decreased abundance while increasing in 2003 in non-trail areas. The decrease in these species seems to suggest that they may be responding negatively to recreational use along the trails.

Data overall in both the Lichen and Wapiti/Ponderosa Loop Trail areas suggests that most species do not appear to be showing a decline in use of these sites as recreational use increases.

Negative abundance trends that appeared along the trail areas during 2002 seem to be due either to the extreme drought of 2002, or may show an ability of many species to habituate to recreational use.

In 2002, we found a very low number of nesting birds around the parking lot/picnic area. However, in 2003, the number of nests around this area increased, not to levels found prior to opening, but to levels much higher than 2002. However, nesting success shows a drastic drop in several species including American Robin, Lark Sparrow, Mourning Dove and Plumbeous Vireo. This suggests a possible negative effect on reproductive output since the opening of the property to recreation. Despite decreased parasitism throughout the five years of the study, predation and abandonment increased as compared to other years of the study. This follows from previous studies that have found that 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. Although 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. In addition, we observed birds using and nesting within areas outside our designated study sites that were thinned during 2003. However, these findings are anecdotal and lack the necessary controls to adequately examine management impacts. 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. Future monitoring on the property would focus more specific attention on thinned and/or burned areas to provide more specific results evaluating the influence of recreation and thinning on bird abundance and nesting.

Overall, our data show that 2003 was a year with high abundances of most forest species at Heil Ranch. Recreational use does not seem to negatively influencing abundance of most species along trail areas. A few species do appear to be responding negatively to the increase in recreational activity. Birds continued to nest in recreational areas including the parking lot/picnic area. However, a disturbing result was the low overall nesting success seen in several focal species. These species may be experiencing an "ecological trap" where suitable habitat attracts the birds to nest, but influences such as recreation may lead to low reproductive success.

However, low sample sizes used to calculate nesting success for these species suggest that these results should be interpreted with caution.

Our study to date shows that recreation may be commensurate with a healthy bird community on Heil Ranch. However, nesting success as well as abundance should be closely monitored to ensure that the overall success of the bird community is not negatively affected by future human influences.

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Appendix 1. Relative Abundance of Bird Species on Heil Ranch Property, 2003.

Species	PIPO	PIPO/PSME	PIPO/RIPE	PIPO/SAVA
American Crow	0.28	0.00	0.00	0.00
American Robin	0.06	0.31	1.00	0.50
Brown-headed Cowbird	0.00	0.00	0.33	0.05
Broad-tailed Hummingbird	0.33	0.25	1.17	0.50
Canyon Wren	0.00	0.00	0.50	0.00
Chipping Sparrow	1.72	1.43	1.33	1.10
Common Nighthawk	0.06	0.00	0.33	0.20
Common Raven	#	#	#	#
Dark-eyed Junco	#	#	#	#
Hammond's Flycatcher	0.00	0.00	0.00	0.10
Hairy Woodpecker	0.00	0.00	0.00	0.05
Hermit Thrush	0.00	0.00	0.00	0.00
House Finch	0.11	0.13	0.17	0.10
House Wren	0.00	0.00	0.00	0.00
Lark Sparrow	0.00	0.00	0.00	0.00
Lazuli Bunting	0.00	0.00	0.00	0.00
Lesser Goldfinch	0.61	0.38	0.67	0.70
Mountain Chickadee	0.50	1.13	1.33	0.55
Mourning Dove	0.33	0.31	0.83	0.50
Northern Flicker	0.00	0.00	0.17	0.00
Plumbeous Vireo	0.17	0.19	0.5	0.45
Pygmy Nuthatch	0.78	0.5	0.33	0.90
Red-breasted Nuthatch	0.06	0.19	0.00	0.15
Red Crossbill	0.17	0.06	1.17	0.15
Rock Wren	0.00	0.00	0.00	0.00
Spotted Towhee	0.11	0.00	0.5	0.25
Stellar's Jay	0.44	0.25	0.83	0.40
Townsend's Solitaire	0.06	0.06	0.17	0.05
Violet-green Swallow	0.00	0.00	0.67	0.15
White-breasted Nuthatch	0.39	0.25	0.67	0.15
Western Meadowlark	0.00	0.00	0.00	0.00
Western Tanager	0.5	0.38	1.00	0.45
Western Wood-Pewee	0.39	0.19	1.00	1.25
Yellow-rumped Warbler	0.00	0.00	0.33	0.00

Appendix 2: Breeding biology of selected bird species on the Heil Ranch Property, 2003.

Species	# Nests	# Abandoned	# Depredated	# Parasitized	Mean Clutch Size	Mayfield Nest Success ^b
American Robin	6	0	1	0	3	0.07
Chipping Sparrow	8	0	0	0	3.2	--
Common Nighthawk	3	0	0	0	2	--
Lark Sparrow	2	0	1	0	5	0.06
Lesser Goldfinch	4	0	0	0	3	0.66
Mourning Dove	2	2	0	0	2	0.08
Plumbeous Vireo	2	0	1	1	3.5	0.17
Western Tanager	2	0	0	0	3	--
Western Wood-Pewee	3	0	0	0	2.75	--

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

b Mayfield (1975).

-- denotes species with too few nests to calculate Mayfield nesting success

Appendix 3: Breeding status of selected bird species on the Heil Ranch property, 1999 - 2003.

Species	Nest Type	Breeding Status	Reason for Status
American Robin	Open Cup	Confirmed	Nests Located (38)
Glue-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 (10)
Brown-headed Cowbird	Brood Parasite	Confirmed	Parasitized Nests
Canyon Wren	Cavity	Confirmed	Cavities Located
Cedar Waxwing	Open Cup	Confirmed	Nests Located (05)
Chipping Sparrow	Open Cup	Confirmed	Nests Located (39)
Common Bushtit	Hanging	Probably	Flocks
Common Poorwill	Ground	Confirmed	Nests Located (01)
Common Nighthawk	Ground	Confirmed	Nests Located (09)
Cordilleran Flycatcher	Open Cup	Confirmed	Nest Located (01)
Dark-eyed Junco	Open Cup	Confirmed	Fledged Young
Grace's Warbler	Open Cup	Confirmed	Nest Located (01)
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 (11)
Lazuli Bunting	Open Cup	Confirmed	Nests Located (03)
Lesser Goldfinch	Open Cup	Confirmed	Nests Located (39)
MacGillivray's Warbler	Open Cup	Confirmed	Fledged Young
Mountain Chickadee	Cavity	Confirmed	Cavities Located
Mourning Dove	Open Cup	Confirmed	Nests Located (30)
Pine Siskin	Open Cup	Confirmed	Nests Located (01)
Plumbeous Vireo	Open Cup	Confirmed	Nests Located (29)
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)
Stellar'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, 2003) relative abundance index (RAI) of bird species along the Lichen Trail.

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	2003 RAI
American Robin	0.61	0.56	0.27	0.67	0.33
Brown-headed Cowbird	0.17	0.11	0.00	0.00	0.00
Broad-tailed Hummingbird	0.17	0.39	0.11	0.33	0.83
Chipping Sparrow	0.61	0.22	0.33	0.11	0.83
Hammond's Flycatcher	0.17	0.06	0.00	0.00	0.00
Lark Sparrow	0.28	0.17	0.11	0.00	0.00
Lesser Goldfinch	0.06	0.33	0.11	0.44	0.67
Mountain Chickadee	0.28	0.22	0.00	0.11	0.00
Mourning Dove	0.11	0.20	0.17	0.11	0.33
Plumbeous Vireo	0.28	0.17	0.22	0.33	0.33
Pygmy Nuthatch	0.00	0.17	0.50	0.11	0.17
Rock Wren	0.11	0.22	0.11	0.00	0.00
Spotted Towhee	0.33	0.11	0.27	0.22	0.67
Stellar's Jay	0.17	0.17	0.33	0.55	1.33
Western Tanager	0.41	0.41	0.22	0.00	1.33
Western Wood-Pewee	0.22	0.39	0.27	0.00	0.33

Table 2: A comparison of the pre-opening (1999, 2000, 2001) and post-opening (2002, 2003) relative abundance index (RAI) of bird species along the Ponderosa Loop Trail

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	2003 RAI
American Robin	0.29	0.20	0.30	0.37	0.20
Brown-headed Cowbird	0.00	0.00	0.00	0.00	0.00
Broad-tailed Hummingbird	0.42	0.03	0.07	0.00	0.25
Chipping Sparrow	0.04	0.50	0.50	0.53	1.55
Hammond's Flycatcher	0.00	0.00	0.00	0.00	0.00
Lark Sparrow	0.13	0.03	0.17	0.17	0.00
Lesser Goldfinch	0.04	0.17	0.13	0.30	0.85
Mountain Chickadee	0.00	0.33	0.23	0.20	0.40
Mourning Dove	0.00	0.30	0.13	0.17	0.40
Plumbeous Vireo	0.00	0.07	0.10	0.20	0.30
Pygmy Nuthatch	0.21	0.37	0.47	0.77	1.30
Rock Wren	0.00	0.03	0.00	0.00	0.00
Spotted Towhee	0.13	0.00	0.00	0.00	0.05
Stellar's Jay	0.08	0.17	0.03	0.23	0.00
Western Tanager	0.50	0.30	0.23	0.33	0.35
Western Wood-Pewee	0.29	0.17	0.20	0.30	1.10

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	2003 RAI
American Robin	N/A	0.61	0.45	0.49	0.47
Brown-headed Cowbird	N/A	0.06	0.04	0.19	0.09
Broad-tailed Hummingbird	N/A	0.22	0.18	0.22	0.5
Chipping Sparrow	N/A	0.59	0.63	0.31	1.41
Hammond's Flycatcher	N/A	0.12	0.12	0.10	0.06
Lark Sparrow	N/A	0.02	0.00	0.02	0.00
Lesser Goldfinch	N/A	0.24	0.08	0.10	0.41
Mountain Chickadee	N/A	0.24	0.39	0.30	1.11
Mourning Dove	N/A	0.18	0.08	0.20	0.47
Plumbeous Vireo	N/A	0.16	0.12	0.07	0.29
Pygmy Nuthatch	N/A	0.27	0.27	0.25	0.44
Rock Wren	N/A	0.24	0.04	0.04	0.00
Spotted Towhee	N/A	0.12	0.08	0.16	0.15
Stellar's Jay	N/A	0.12	0.24	0.27	0.5
Western Tanager	N/A	0.49	0.41	0.27	0.44
Western Wood-Pewee	N/A	0.14	0.12	0.12	0.5

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	2003 MNS
American Robin	---	0.58	0.77	0.53	0.07
Chipping Sparrow	0.16	0.49	0.25	0.53	--
Lesser Goldfinch	---	0.72	0.44	0.90	0.66
Mourning Dove	0.32	0.28	0.15	0.85	0.08
Plumbeous Vireo	0.24	0.70	0.52	0.50	0.17
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.

-- denotes species with too few nests to calculate Mayfield estimate

Table 5: A comparison of the pre-opening (1999/2000) and post-opening (2001, 2002, 2003) nesting success of birds at the Heil Ranch parking and picnic area.

Species	Year	# Nests	% Depredated	% Parasitized
American Robin	1999	1	0	0
	2000	3	33	0
	2001	6	13	0
	2002	0	--	--
	2003	3	33	0
Broad-tailed Hummingbird	1999	1	0	0
	2000	0	--	--
	2001	2	50	0
	2002	0	--	--
	2003	3	33	0
Chipping Sparrow	1999	3	100	0
	2000	3	67	33
	2001	2	50	0
	2002	0	--	--
	2003	1	0	0
Hammond's Flycatcher	1999	1	0	0
	2000	1	100	0
	2001	1	0	100
	2002	0	--	--
	2003	0	--	--
Lesser Goldfinch	1999	0	--	--
	2000	2	50	0
	2001	5	40	0
	2002	0	--	--
	2003	3	0	0
Mourning Dove	1999	1	0	0
	2000	1	0	0
	2001	0	--	--
	2002	0	--	--
	2003	1	0	0
Plumbeous Vireo	1999	4	75	75
	2000	2	50	50
	2001	2	50	50
	2002	0	--	--
	2003	0	--	--
Western Tanager	1999	1	0	0
	2000	2	50	0
	2001	2	0	50
	2002	0	--	--
	2003	1	0	0
Western Wood-Pewee	1999	4	0	0
	2000	4	25	25
	2001	4	25	0
	2002	1	0	0
	2003	1	0	0

Figure 1. Relative Abundance of Brown-headed Cowbirds at Lichen Trail and Non-Trail Sites

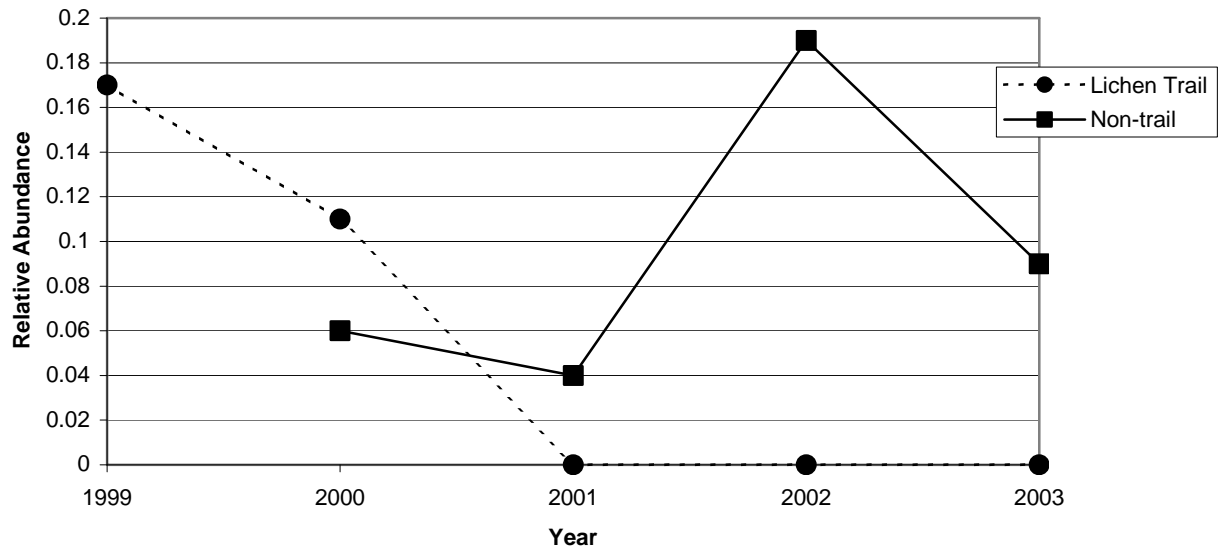


Figure 2. Hammond's Flycatcher Relative Abundance at Lichen Trail and Non-trail Sites

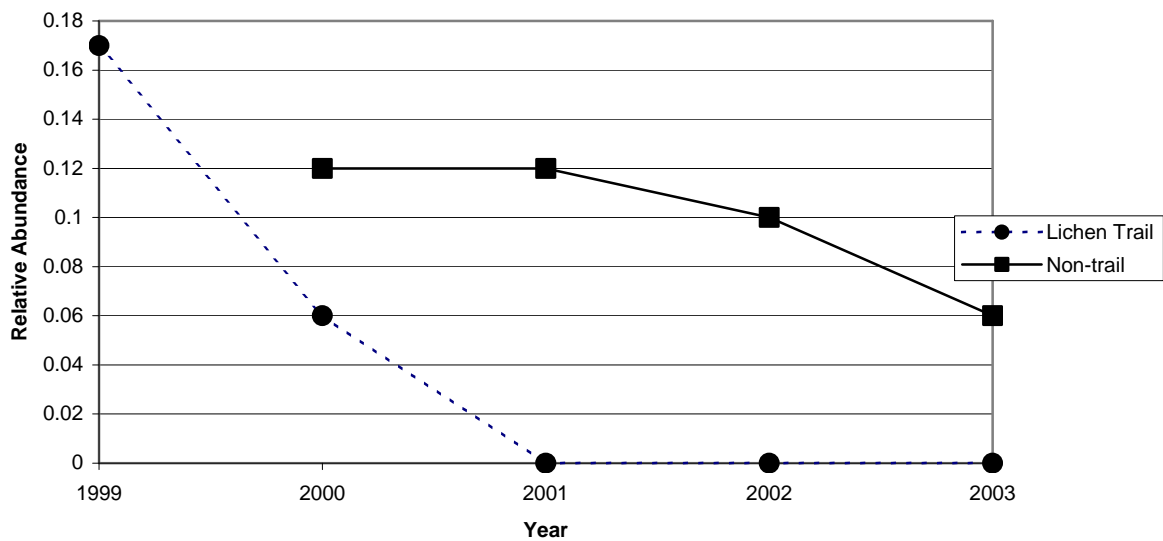


Figure 3. Lark Sparrow Relative Abundance at Lichen Trail and Non-trail Sites

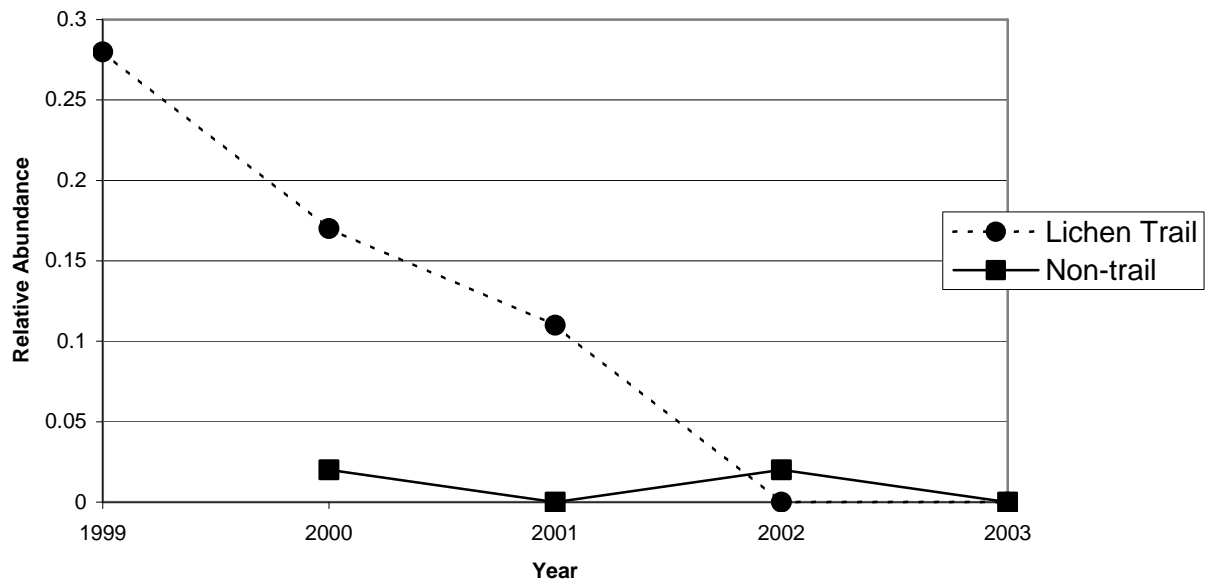


Figure 4. Relative Abundance of Mountain Chickadees at Lichen Trail and Non-trail Sites

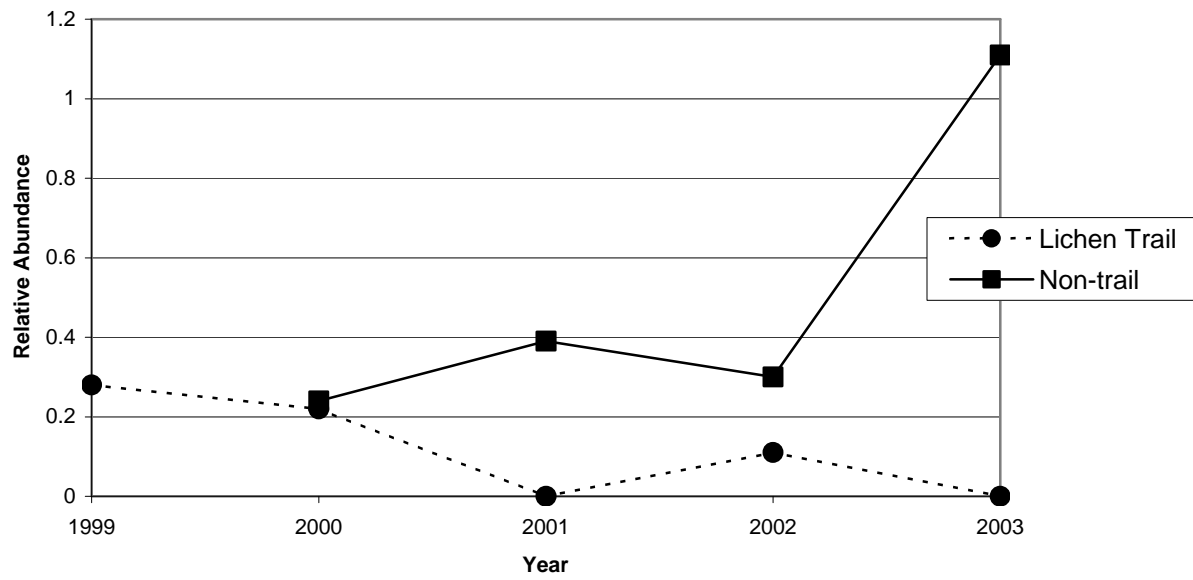


Figure 5. Rock Wren Relative Abundance of Lark Sparrows at Lichen Trail and Non-trail Sites

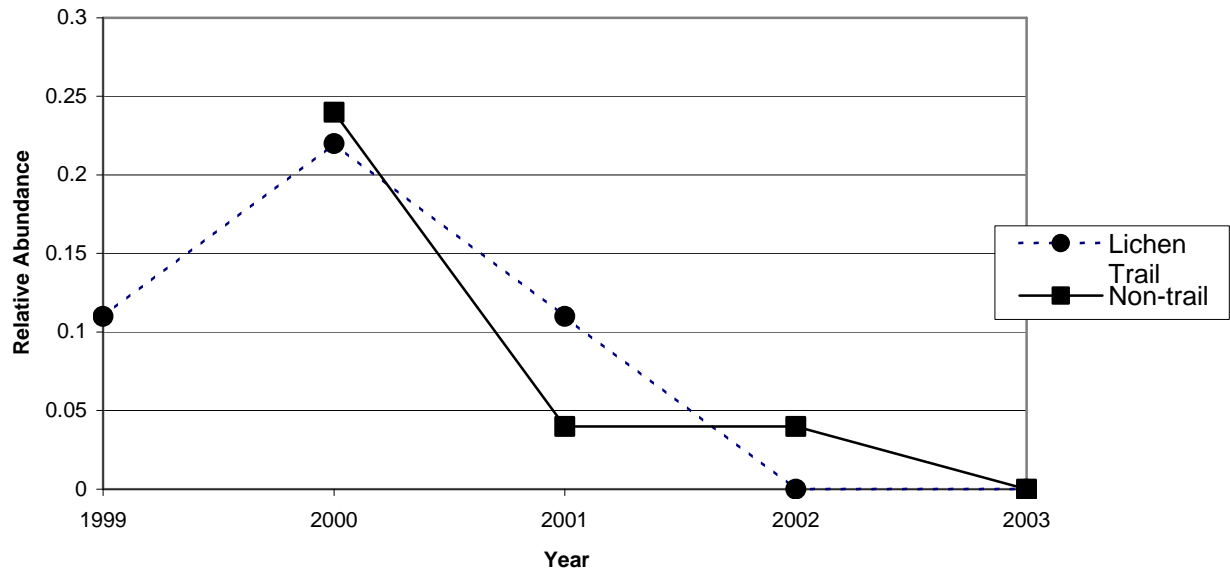


Figure 6. Broad-tailed Hummingbird Relative Abundance at Wapiti/Ponderosa Trail and Non-trail Sites

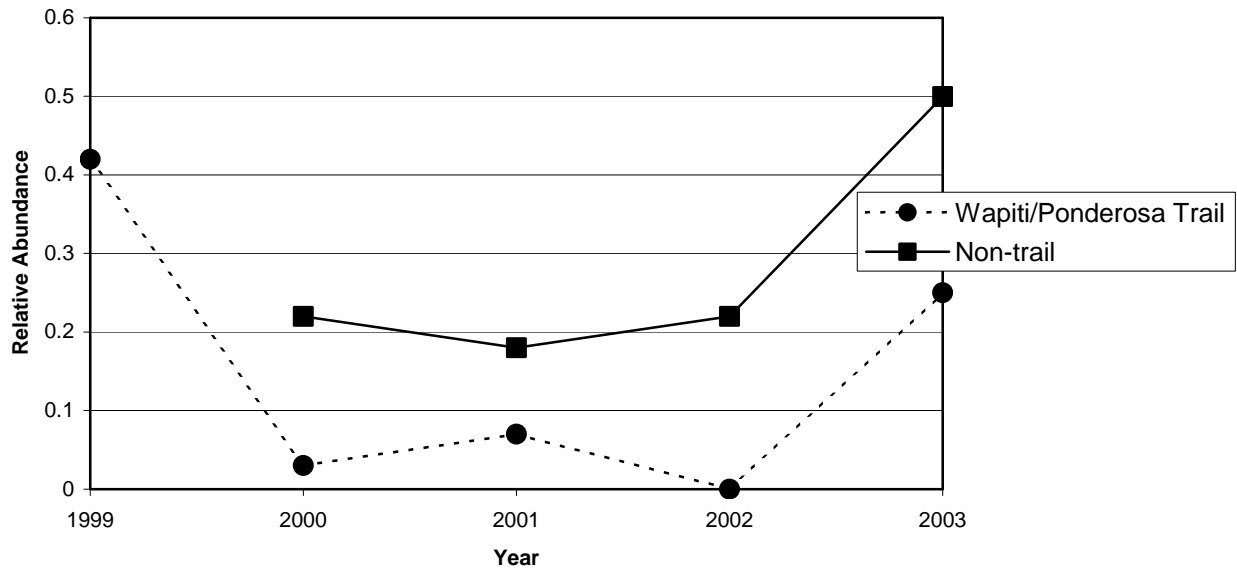


Figure 7. Stellar's Jay Relative Abundance at Wapiti/Ponderosa Trail and Non-trail Sites

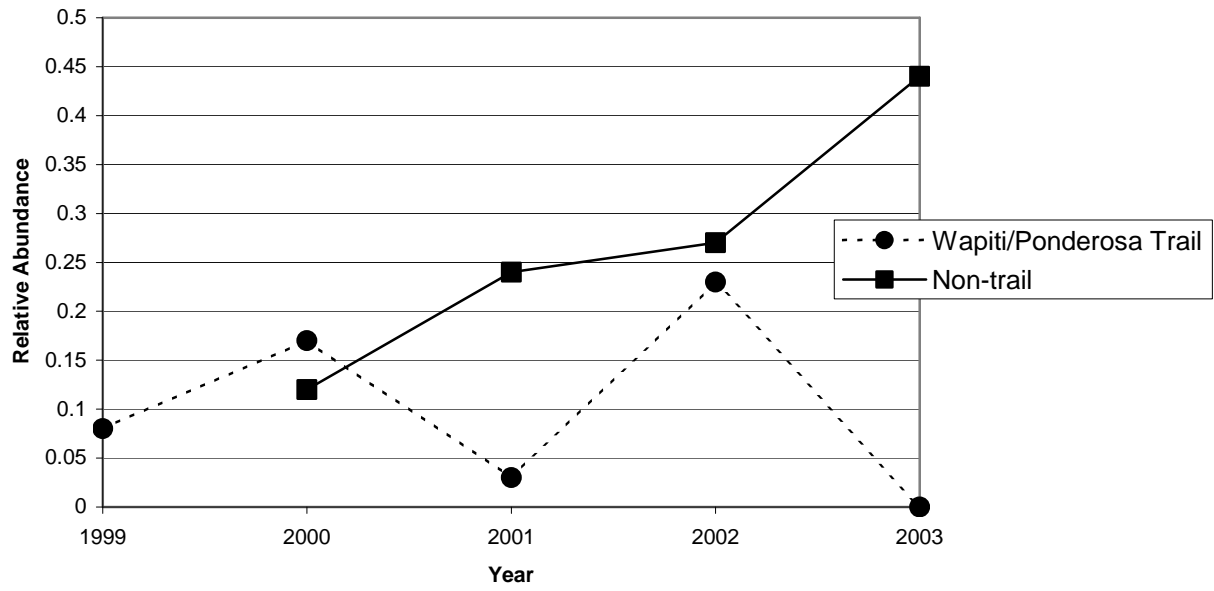


Figure 8. Lark Sparrow Relative Abundance at Wapiti/Ponderosa Trail and Non-trail Site

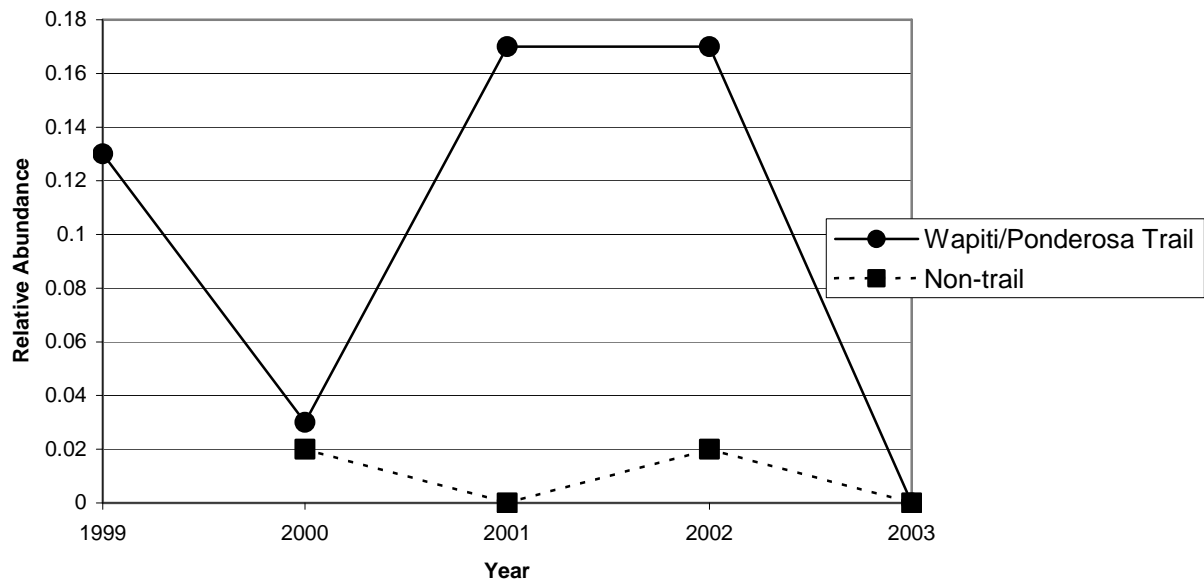
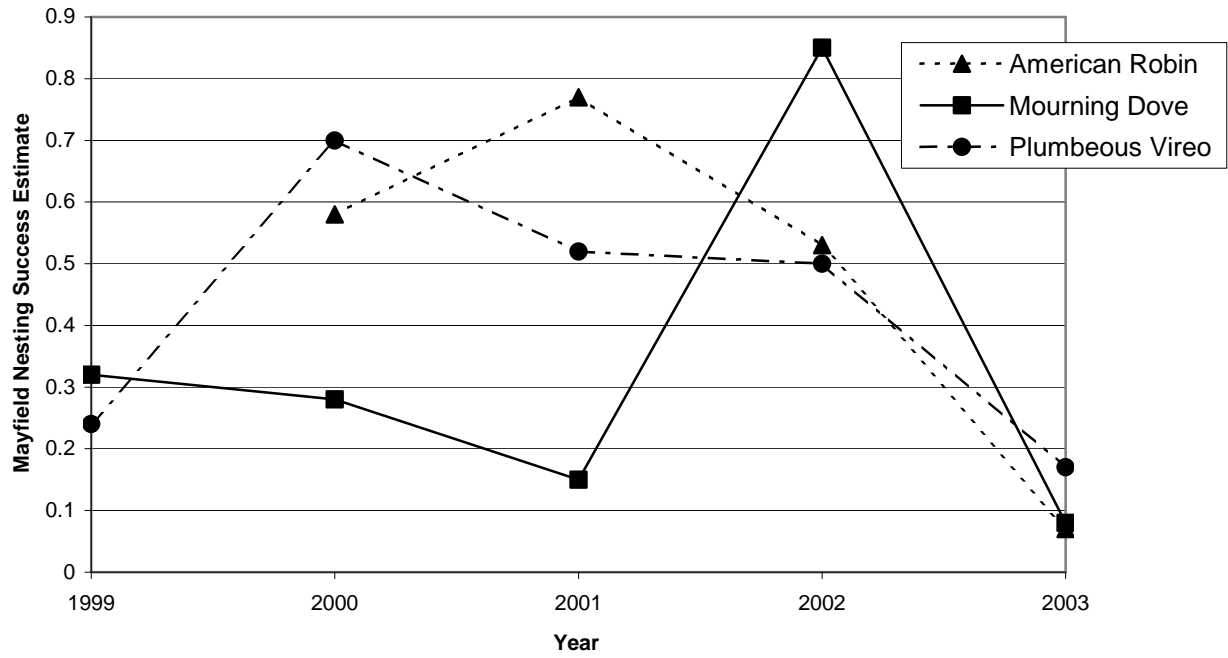


Figure 9. Nesting Success of 3 Common Species on Heil Ranch



Appendix 1. Relative Abundance of Bird Species on Heil Ranch Property, 2003.

Species	PIPO	PIPO/PSME	PIPO/RIPE	PIPO/SAVA
American Crow	0.28	0.00	0.00	0.00
American Robin	0.06	0.31	1.00	0.50
Brown-headed Cowbird	0.00	0.00	0.33	0.05
Broad-tailed Hummingbird	0.33	0.25	1.17	0.50
Canyon Wren	0.00	0.00	0.50	0.00
Chipping Sparrow	1.72	1.43	1.33	1.10
Common Nighthawk	0.06	0.00	0.33	0.20
Common Raven	#	#	#	#
Dark-eyed Junco	#	#	#	#
Hammond's Flycatcher	0.00	0.00	0.00	0.10
Hairy Woodpecker	0.00	0.00	0.00	0.05
Hermit Thrush	0.00	0.00	0.00	0.00
House Finch	0.11	0.13	0.17	0.10
House Wren	0.00	0.00	0.00	0.00
Lark Sparrow	0.00	0.00	0.00	0.00
Lazuli Bunting	0.00	0.00	0.00	0.00
Lesser Goldfinch	0.61	0.38	0.67	0.70
Mountain Chickadee	0.50	1.13	1.33	0.55
Mourning Dove	0.33	0.31	0.83	0.50
Northern Flicker	0.00	0.00	0.17	0.00
Plumbeous Vireo	0.17	0.19	0.5	0.45
Pygmy Nuthatch	0.78	0.5	0.33	0.90
Red-breasted Nuthatch	0.06	0.19	0.00	0.15
Red Crossbill	0.17	0.06	1.17	0.15
Rock Wren	0.00	0.00	0.00	0.00
Spotted Towhee	0.11	0.00	0.5	0.25
Stellar's Jay	0.44	0.25	0.83	0.40
Townsend's Solitaire	0.06	0.06	0.17	0.05
Violet-green Swallow	0.00	0.00	0.67	0.15
White-breasted Nuthatch	0.39	0.25	0.67	0.15
Western Meadowlark	0.00	0.00	0.00	0.00
Western Tanager	0.5	0.38	1.00	0.45
Western Wood-Pewee	0.39	0.19	1.00	1.25
Yellow-rumped Warbler	0.00	0.00	0.33	0.00

Appendix 2: Breeding biology of selected bird species on the Heil Ranch Property, 2003.

Species	# Nests	# Abandoned	# Depredated	# Parasitized	Mean Clutch Size	Mayfield Nest Success ^b
American Robin	6	0	1	0	3	0.07
Chipping Sparrow	8	0	0	0	3.2	--
Common Nighthawk	3	0	0	0	2	--
Lark Sparrow	2	0	1	0	5	0.06
Lesser Goldfinch	4	0	0	0	3	0.66
Mourning Dove	2	2	0	0	2	0.08
Plumbeous Vireo	2	0	1	1	3.5	0.17
Western Tanager	2	0	0	0	3	--
Western Wood-Pewee	3	0	0	0	2.75	--

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

b Mayfield (1975).

-- denotes species with too few nests to calculate Mayfield nesting success

Appendix 3: Breeding status of selected bird species on the Heil Ranch property, 1999 - 2003.

Species	Nest Type	Breeding Status	Reason for Status
American Robin	Open Cup	Confirmed	Nests Located (38)
Glue-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 (10)
Brown-headed Cowbird	Brood Parasite	Confirmed	Parasitized Nests
Canyon Wren	Cavity	Confirmed	Cavities Located
Cedar Waxwing	Open Cup	Confirmed	Nests Located (05)
Chipping Sparrow	Open Cup	Confirmed	Nests Located (39)
Common Bushtit	Hanging	Probably	Flocks
Common Poorwill	Ground	Confirmed	Nests Located (01)
Common Nighthawk	Ground	Confirmed	Nests Located (09)
Cordilleran Flycatcher	Open Cup	Confirmed	Nest Located (01)
Dark-eyed Junco	Open Cup	Confirmed	Fledged Young
Grace's Warbler	Open Cup	Confirmed	Nest Located (01)
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 (11)
Lazuli Bunting	Open Cup	Confirmed	Nests Located (03)
Lesser Goldfinch	Open Cup	Confirmed	Nests Located (39)
MacGillivray's Warbler	Open Cup	Confirmed	Fledged Young
Mountain Chickadee	Cavity	Confirmed	Cavities Located
Mourning Dove	Open Cup	Confirmed	Nests Located (30)
Pine Siskin	Open Cup	Confirmed	Nests Located (01)
Plumbeous Vireo	Open Cup	Confirmed	Nests Located (29)
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)
Stellar'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, 2003) relative abundance index (RAI) of bird species along the Lichen Trail.

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	2003 RAI
American Robin	0.61	0.56	0.27	0.67	0.33
Brown-headed Cowbird	0.17	0.11	0.00	0.00	0.00
Broad-tailed Hummingbird	0.17	0.39	0.11	0.33	0.83
Chipping Sparrow	0.61	0.22	0.33	0.11	0.83
Hammond's Flycatcher	0.17	0.06	0.00	0.00	0.00
Lark Sparrow	0.28	0.17	0.11	0.00	0.00
Lesser Goldfinch	0.06	0.33	0.11	0.44	0.67
Mountain Chickadee	0.28	0.22	0.00	0.11	0.00
Mourning Dove	0.11	0.20	0.17	0.11	0.33
Plumbeous Vireo	0.28	0.17	0.22	0.33	0.33
Pygmy Nuthatch	0.00	0.17	0.50	0.11	0.17
Rock Wren	0.11	0.22	0.11	0.00	0.00
Spotted Towhee	0.33	0.11	0.27	0.22	0.67
Stellar's Jay	0.17	0.17	0.33	0.55	1.33
Western Tanager	0.41	0.41	0.22	0.00	1.33
Western Wood-Pewee	0.22	0.39	0.27	0.00	0.33

Table 2: A comparison of the pre-opening (1999, 2000, 2001) and post-opening (2002, 2003) relative abundance index (RAI) of bird species along the Ponderosa Loop Trail

Species	1999 RAI	2000 RAI	2001 RAI	2002 RAI	2003 RAI
American Robin	0.29	0.20	0.30	0.37	0.20
Brown-headed Cowbird	0.00	0.00	0.00	0.00	0.00
Broad-tailed Hummingbird	0.42	0.03	0.07	0.00	0.25
Chipping Sparrow	0.04	0.50	0.50	0.53	1.55
Hammond's Flycatcher	0.00	0.00	0.00	0.00	0.00
Lark Sparrow	0.13	0.03	0.17	0.17	0.00
Lesser Goldfinch	0.04	0.17	0.13	0.30	0.85
Mountain Chickadee	0.00	0.33	0.23	0.20	0.40
Mourning Dove	0.00	0.30	0.13	0.17	0.40
Plumbeous Vireo	0.00	0.07	0.10	0.20	0.30
Pygmy Nuthatch	0.21	0.37	0.47	0.77	1.30
Rock Wren	0.00	0.03	0.00	0.00	0.00
Spotted Towhee	0.13	0.00	0.00	0.00	0.05
Stellar's Jay	0.08	0.17	0.03	0.23	0.00
Western Tanager	0.50	0.30	0.23	0.33	0.35
Western Wood-Pewee	0.29	0.17	0.20	0.30	1.10

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	2003 RAI
American Robin	N/A	0.61	0.45	0.49	0.47
Brown-headed Cowbird	N/A	0.06	0.04	0.19	0.09
Broad-tailed Hummingbird	N/A	0.22	0.18	0.22	0.5
Chipping Sparrow	N/A	0.59	0.63	0.31	1.41
Hammond's Flycatcher	N/A	0.12	0.12	0.10	0.06
Lark Sparrow	N/A	0.02	0.00	0.02	0.00
Lesser Goldfinch	N/A	0.24	0.08	0.10	0.41
Mountain Chickadee	N/A	0.24	0.39	0.30	1.11
Mourning Dove	N/A	0.18	0.08	0.20	0.47
Plumbeous Vireo	N/A	0.16	0.12	0.07	0.29
Pygmy Nuthatch	N/A	0.27	0.27	0.25	0.44
Rock Wren	N/A	0.24	0.04	0.04	0.00
Spotted Towhee	N/A	0.12	0.08	0.16	0.15
Stellar's Jay	N/A	0.12	0.24	0.27	0.5
Western Tanager	N/A	0.49	0.41	0.27	0.44
Western Wood-Pewee	N/A	0.14	0.12	0.12	0.5

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	2003 MNS
American Robin	---	0.58	0.77	0.53	0.07
Chipping Sparrow	0.16	0.49	0.25	0.53	--
Lesser Goldfinch	---	0.72	0.44	0.90	0.66
Mourning Dove	0.32	0.28	0.15	0.85	0.08
Plumbeous Vireo	0.24	0.70	0.52	0.50	0.17
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.

-- denotes species with too few nests to calculate Mayfield estimate

Table 5: A comparison of the pre-opening (1999/2000) and post-opening (2001, 2002, 2003) nesting success of birds at the Heil Ranch parking and picnic area.

Species	Year	# Nests	% Depredated	% Parasitized
American Robin	1999	1	0	0
	2000	3	33	0
	2001	6	13	0
	2002	0	--	--
	2003	3	33	0
Broad-tailed Hummingbird	1999	1	0	0
	2000	0	--	--
	2001	2	50	0
	2002	0	--	--
	2003	3	33	0
Chipping Sparrow	1999	3	100	0
	2000	3	67	33
	2001	2	50	0
	2002	0	--	--
	2003	1	0	0
Hammond's Flycatcher	1999	1	0	0
	2000	1	100	0
	2001	1	0	100
	2002	0	--	--
	2003	0	--	--
Lesser Goldfinch	1999	0	--	--
	2000	2	50	0
	2001	5	40	0
	2002	0	--	--
	2003	3	0	0
Mourning Dove	1999	1	0	0
	2000	1	0	0
	2001	0	--	--
	2002	0	--	--
	2003	1	0	0
Plumbeous Vireo	1999	4	75	75
	2000	2	50	50
	2001	2	50	50
	2002	0	--	--
	2003	0	--	--
Western Tanager	1999	1	0	0
	2000	2	50	0
	2001	2	0	50
	2002	0	--	--
	2003	1	0	0
Western Wood-Pewee	1999	4	0	0
	2000	4	25	25
	2001	4	25	0
	2002	1	0	0
	2003	1	0	0