



Bird Population Trends from Constant Effort Mist Netting in Oregon Caves National Monument and Preserve

Natural Resource Report NPS/KLMN/NRR—2016/1311



**ON THIS PAGE**

Riparian habitat and moist meadows at the Oregon Caves banding station surrounded by mature coniferous forest
Photograph by: Robert Frey

ON THE COVER

Male MacGillivray's Warbler (*Geothlypis tolmiei*) in breeding plumage
Photograph © James Livaudais

Bird Population Trends from Constant Effort Mist Netting in Oregon Caves National Monument and Preserve

Natural Resource Report NPS/KLMN/NRR—2016/1311

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Abstract

As part of the NPS Klamath Network Inventory and Monitoring program, we monitored bird populations from 2002-2013 in a high elevation riparian habitat surrounded by mature coniferous forest at Oregon Caves National Monument and Preserve (ORCA), using standard mist netting and banding methods. We investigated trends in abundance of adults and young for 10 species of breeding, fall migrant, and year-round resident birds. We then compared population change at ORCA with estimates derived from the Breeding Bird Survey (BBS) Northern Pacific Rainforest region, and examined productivity as a possible cause of population change. We found the strongest evidence for declines in adults and/or young for MacGillivray's Warbler (*Geothlypis tolmei*), followed by Western (Pacific-Slope) Flycatcher (*Empidonax difficilis*). MacGillivray's Warbler was the only species where declines in both the local breeding population of adults and young were revealed, with corresponding declines in the regional BBS data. We further assessed that species' regional status by examining patterns at nine additional banding stations, and found a decreasing trend in breeding adults for just one other site, also at high elevation. Fall populations of Wilson's Warbler (*Cardellina pusilla*) adults remained stable and abundance of young increased, contrasting with a negative trend found for breeding adults in the BBS data. Adult populations of other fall migrants and all year-round residents studied remained relatively stable during this period, despite significant declines in Golden-crowned Kinglet (*Regulus satrapa*) in the BBS data. Capture rates of local young Western Flycatcher declined over the study period, while regionally produced Oregon Junco (*Junco hyemalis oregonus*) young increased. Capture rates of young in one year were not associated with adult abundance in the following year for any species; thus, we found little evidence that local productivity is the driver of population change at ORCA. A greater understanding of the conservation biology of these species is needed, because some may be undergoing declines that we do not have sufficient sample sizes to detect. Further research into the potential climatic and anthropogenic causes of observed population trends and their proximate demographic mechanisms in all phases of the annual cycle are needed to understand and address causes of declines.

Acknowledgments

We thank John Roth of ORCA for his vision in starting this monitoring station and consistent support for this work. We want to especially acknowledge the contributions of the late Daniel Sarr, who was instrumental during the formative years of the NPS Klamath Network and development of the long-term landbird monitoring protocol. We would like to acknowledge additional NPS partners Alice Chung-MacCoubrey, Sean Mohren, and Eric Dinger for their contributions to this work. This report was greatly improved by comments from Alice Chung-MacCoubrey, Sean Mohren, C.J. Ralph, John Roth, and Rodney Siegel. This work was made possible by numerous student volunteer interns who contributed their time in the field over this 12-year period. This project is part of the Klamath Network Inventory and Monitoring program and was funded by the National Park Service.

Introduction

Much attention has been given recently to declines observed in North American landbird populations (e.g., DeGraaf and Rappole 1995, Sauer et al. 2008, Sauer et al. 2013), spurring new research into the possible sources of these declines. Previous studies have attributed declines to various causes, including tropical deforestation (Robbins et al. 1989, Rappole and MacDonald 1994), poor conditions at migratory stopover sites (Moore et al. 2005), stochastic climatic events (Silllett et al. 2000), and persistent climate change (Both et al. 2006). Other studies have highlighted the effects of forest fragmentation on breeding grounds (Bayne and Hobson 2002), nest predation and parasitism (Donovan et al. 1995, Robinson et al. 1995, Rodewald and Yahner 2001), and the impact of summer food limitation on reproductive success (Rodenhouse and Holmes 1992, Holmes et al. 1996, Nagy and Holmes 2005) and survival (Martin 1987). Identifying limiting factors for migratory birds is particularly challenging, due to the wide range of habitats on which they depend throughout the annual cycle. The need for an increased understanding of birds' full life cycle ecology in identifying sources of mortality that limit bird populations has recently been emphasized (Berlanga et al. 2010).

Constant effort mist netting provides one tool to potentially understand demographic factors that may drive population trends in bird species, such as survival rates and productivity (DeSante et al. 1995, DeSante et al. 1999, Saracco et al. 2008, Saracco et al. 2010). The National Park Service (NPS) and Klamath Bird Observatory (KBO) have collaborated to conduct this type of avian monitoring within the Oregon Caves National Monument and Preserve (ORCA) since 2002 (Stephens et al. 2010), as part of the NPS Klamath Network Inventory and Monitoring Program (KLMN I&M). The KLMN I&M Program is one of 32 NPS I&M Networks that have been established nationwide to improve collaboration and data sharing among NPS units, in order to better achieve the NPS mission of preserving natural resources. The KLMN includes six NPS units located in southern Oregon and northern California; landbird monitoring in these units contributes to the vital signs monitoring program developed by the KLMN (Sarr et al. 2007). KBO, in partnership with KLMN, developed a landbird monitoring protocol designed to yield important information about avian community composition, status of landbirds in a given year, and long-term population trends of specific species for each KLMN park unit (Stephens et al. 2010). The objectives of the Klamath Network Landbird Monitoring Protocol are to: 1) monitor breeding landbird richness, relative abundance, and density, 2) co-sample habitat parameters and integrate bird and vegetation monitoring to aid in interpretation of landbird status and trends, and 3) determine status and trends in demographic parameters for selected landbird species in mixed-conifer and riparian habitat at ORCA. This report focuses primarily on objective 3.

The ORCA monitoring station is also part of a larger bird and habitat monitoring network coordinated by KBO and the U.S. Forest Service's Redwood Sciences Laboratory that includes long-term constant effort bird monitoring stations extending throughout the Klamath-Siskiyou Bioregion (Alexander et al. 2004). This landbird monitoring effort is informed by and contributes to the Partners in Flight (PIF) landbird conservation initiative. Regional and continental PIF habitat-based bird conservation plans and state wildlife conservation strategies provide a framework for understanding landbird status in our region, and in the parks (Rich et al. 2004, Altman and Alexander

2012). Avian data from ORCA also contribute to the Monitoring Avian Survival and Productivity (MAPS) program, a continent-wide collaborative effort to assist the conservation of birds and their habitats through demographic monitoring (DeSante et al. 2016). The objectives of this bird monitoring effort include providing information useful in describing and determining potential causes of long-term trends in the composition and abundance of Western landbirds.

Twelve years of monitoring at ORCA (2002-2013) have resulted in a dataset that provides information on the presence, abundance, and productivity of bird species. Here we present data useful for analyses of species' vital signs, including productivity and population trends. This report provides an examination of trends in abundance for 10 species during the breeding season (local populations) or fall migration (regional populations), and potential demographic causes of those trends. These 10 study species were the most commonly captured birds at ORCA, and thus had the greatest sample sizes for statistical analysis. Four of our study species (Fox Sparrow, Oregon Junco, Pacific-slope Flycatcher, and Wilson's Warbler) have been identified as conservation focal species in either the Oregon/Washington or continental Partners in Flight plans (Rich et al. 2004, Altman and Alexander 2012). We compare trends at ORCA to trends derived from the Breeding Bird Survey (BBS), which provides data for bird populations on a larger geographic scale (Sauer et al. 2014), placing our results in a regional context. We used the BBS Northern Pacific Rainforest region for comparison, which encompasses western portions of California, Oregon, and Washington. Such cross-validation of trends derived from multiple types of data (in this case, mist netting and point counts) at multiple spatial scales increases strength of inference (Lloyd-Evans and Atwood 2004, Alexander et al. 2007). We predicted that trends from BBS data would be more similar to ORCA's fall migration (regional) trends than ORCA's breeding (local) trends due to its larger scale. No *a priori* hypotheses regarding the direction of trends in abundance or productivity for each species were made; our objectives were primarily to identify any species that may be undergoing local population change, and to interpret any trends within a regional context.

Capture rate of young birds, or a ratio of young to adult captures, are commonly used as indices of avian productivity (Nur and Geupel 1993, Johnson and Geupel 1996, Bart et al. 1999). Young are defined here as hatch-year birds born during the current breeding season, while adults are birds greater than one year old, in their second summer or beyond. For some species in previous studies, annual abundance of adults was related to productivity, as measured by the capture rate of young in the previous year (Johnson and Geupel 1996, Chase et al. 1997, Gardali et al. 2000, Saracco et al. 2008), an indication that productivity may be a driver of population change. Here we include an analysis of the relationship between productivity of our study species and adult abundance in the following year.

To examine local and regional population change, and productivity as a potential causal factor, we address four major questions: 1) are capture rates of adults at ORCA increasing, decreasing, or remaining stable, 2) are capture rates of young at ORCA (productivity) increasing, decreasing, or remaining stable, 3) are any observed trends in adult abundance related to changes in productivity, and 4) are population trends at ORCA similar to those in the larger Pacific Northwest Rainforest region?

Methods

Study site and species

In collaboration with ORCA, and as part of the NPS KLMN I&M Program, KBO has operated a mist netting and banding station at this site since 2002. ORCA was a 480-acre park unit until an expansion approved in 2014 added 3520 acres, intended to help protect a greater portion of the watershed. KBO's banding station is located within the five acres surrounding the Big Tree at 42° 05' 37" latitude, 123° 23' 47" longitude, at an elevation of approximately 1495 meters above sea level (Figure 1). The banding station location is within a small riparian forest patch dominated by mountain alder (*Alnus incana*) and small moist meadows, surrounded by late-seral mixed conifer forest. The surrounding landscape of the Rogue River-Siskiyou National Forest has an extensive history of timber management.

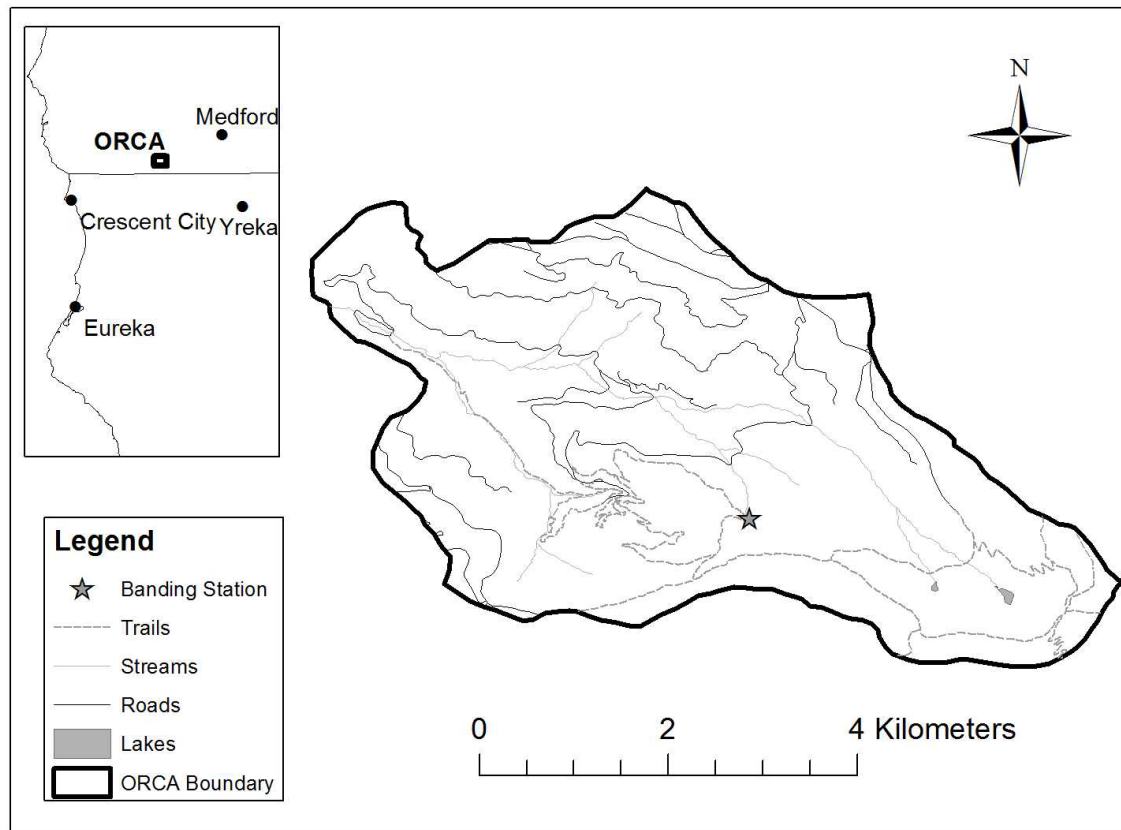


Figure 1. Location of Oregon Caves National Monument and Preserve in southern Oregon (inset map), and location of the KBO banding station at Big Tree within the ORCA boundary.

We chose 10 species for analysis based on their abundance at the study site, including species that represent a variety of life histories (Table 2). Three of these species are migratory birds that breed at ORCA (MacGillivray's Warbler, *Geothlypis tolmei*; Nashville Warbler, *Oreothlypis ruficapilla*; and Pacific-slope Flycatcher, *Empidonax difficilis*), three of them pass through ORCA during fall migration (Fox Sparrow, *Passerella iliaca*; Hermit Thrush, *Catharus guttatus*; and Wilson's Warbler, *Cardellina pusilla*), one species has both breeding and migrating individuals present at ORCA at different times of the year (Dark-eyed Junco, Oregon race; *Junco hyemalis oregonus*), and three species are year-round residents that both breed and overwinter at the site (Chestnut-backed Chickadee, *Poecile rufescens*; Golden-crowned Kinglet, *Regulus satrapa*; and Red-breasted Nuthatch, *Sitta canadensis*). It is noted that Pacific-slope Flycatcher cannot be visually distinguished from Cordilleran Flycatcher when captured, but it is unlikely to find Cordilleran Flycatcher in this area. We hereafter refer to these two species together, as Western Flycatcher, and believe this is unlikely to be a confounding factor in our analysis.

Field Methods

The protocols implemented at this study site included mist netting and banding using standardized methods described in the Klamath Network Landbird Monitoring Protocol (Stephens et al. 2010). Methods used during the breeding season are also consistent with the continent-wide MAPS program (DeSante et al. 2016). Banding at ORCA began each year at the onset of songbird breeding, typically in early June (exact date determined by snow cover at this high-elevation location). Efforts continued into mid-October (exact date determined by winter weather conditions), which included the fall migration period. Visits were scheduled every 10 days through August of each year, and beginning on 1 September, visits were scheduled every seven days. A mist net array of 10 nets was situated within riparian vegetation. Nets were opened 15 minutes before local sunrise, and operated for five hours, weather conditions permitting. Captured birds were aged and sexed when possible using standard methods (Pyle 1997), checked for signs of breeding condition (i.e., cloacal protuberances and brood patches), marked with individually numbered aluminum leg bands, and released. We grouped netting efforts into 10-day periods beginning on 1 June, the most typical starting date for mist netting at ORCA, and numbered these periods using the Julian date of the center of each period (155 = 4 June, 165 = 14 June, etc., ending with 295 = 22 October).

Trends in Local Breeding Populations

For migratory species, a consistent problem in the analysis of mist netting data is that not all individuals captured are local breeders (e.g., Johnson and Geupel 1996, Nur et al. 1999). To limit our analyses to the local breeding populations of interest, we included only adults that had either been recaptured within-season or across seasons, and/or were in high breeding condition (defined as a medium to large cloacal protuberance [males], or a fully vascularized or wrinkled brood patch [females]). Individuals recaptured within-season (at least 7 days apart) are likely to be residents, because stopover duration for Neotropical migrants tends to be less than a week (Morris et al. 1996, Gardali et al. 2000). We also included those adults that returned to the study site in multiple years because adult birds typically show high breeding site fidelity (Baker 1978), but individuals that use ORCA as a migratory stopover site are far less likely to be recaptured between years (e.g., Catry et al. 2004). In addition, adults captured in high breeding condition are likely to be breeding or

attempting to breed in the vicinity of the study area. Hatch-year birds (young born in the current breeding season) do not breed and were not often recaptured within or between seasons, so we were unable to use the same definition as for adults. Instead, we examined distributions of hatch-year abundance across the breeding season for each species, and chose 8 September as the point which appeared to include all locally produced young, yet exclude any second peaks in abundance indicating young migrating through in fall (see example in Figure 2). In a further attempt to restrict the analysis to birds born at or near the study site, we only included hatch-year birds with <66% skull ossification and/or >50% juvenal plumage.

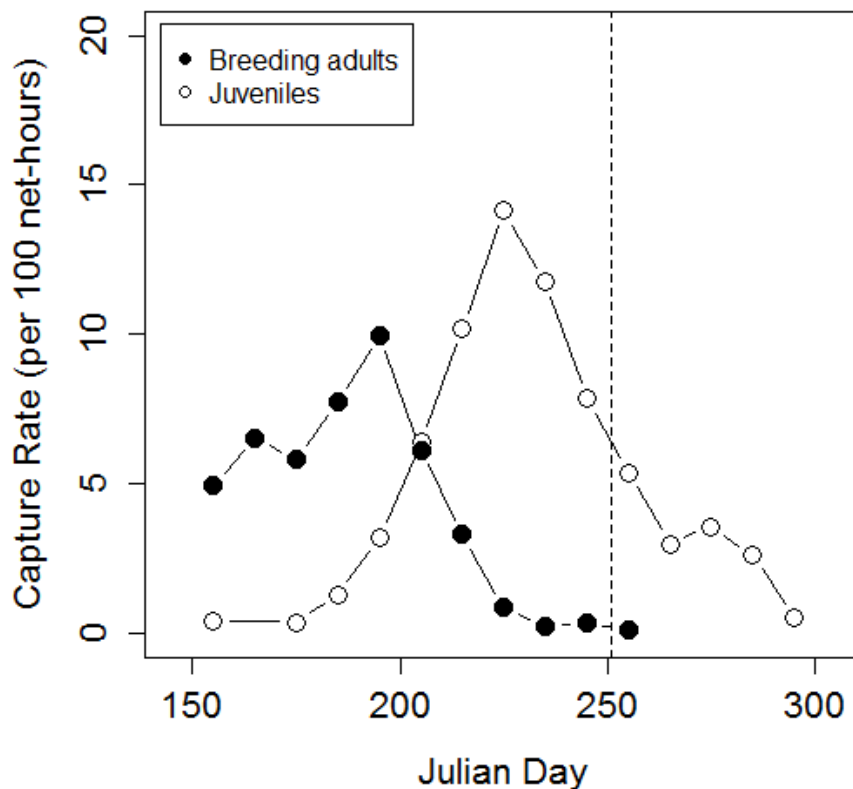


Figure 2. Capture rates of breeding adult and juvenile Oregon Juncos in 10-day time bins over the mist netting season (years 2002-2013 pooled). Using visual inspection of similar distributions for all species, we determined 8 September (Julian day = 251; dotted line) as the dividing point between locally produced young and young beginning to migrate through ORCA in fall. This method includes juveniles captured within a ~3-week lag time after the cessation of adult breeding, but excludes later peaks in juvenile capture rates.

Regional Trends in Migratory Populations

When migrating birds are captured in fall while moving south from their breeding grounds, adults and young represent populations from a wider catchment area than just the study site (Dunn et al. 1997). Thus, we assume the majority of birds captured in fall are produced somewhere in northwestern North America and refer to these trends as regional (Alexander et al. 2007). For species that did not breed at the study site, we defined fall migration as 10 July– 23 October, based on the

phenology of first arrivals of migrants and the end of the mist netting season at ORCA. For species that also breed locally, we defined the beginning of fall migration as the 10-day time period in which the percent of adults in high breeding condition first fell below 5%. For example, for Oregon Junco this was the time period from 8-17 September, so we considered all Oregon Juncos captured after 7 September to be part of the migratory population rather than the breeding population.

Trends in Year-round Populations

For species that are year-round residents, both breeding and overwintering at the study site (Chestnut-backed Chickadee, Golden-crowned Kinglet, and Red-breasted Nuthatch), we used capture data from the entire year (effectively 1 June to 23 October) to estimate trends in local populations.

Statistical Analysis

We used annual capture totals of adults and young that fit our inclusion rules to estimate trends from 2002-2013 in four breeding, four migrating, and three year-round resident study species, separating each species into two age classes. To account for varying effort in different years, we calculated annual capture rates by dividing the total number of individuals captured meeting the criteria listed above by the total net-hours within the period of interest, and multiplying by 100. Thus, results are presented as the yearly change in the number of captures per 100 net-hours. We used linear models with year as the independent variable and capture rate of adult birds as the dependent variable to estimate trends for each species. Capture rates for most species and age classes approximated normal distributions, and for those that did not, we used square root transformations to improve normality of the residuals. We used the same method to estimate trends in capture rates of young over time, with year as the independent variable. Linear regression, with square root transformations of variables where needed, was also used to assess the relationship between both productivity indices (capture rates of young, and ratio of adult:young capture rates) in year n and adult capture rates in year $n+1$. We considered trends to be significant if $p \leq 0.05$, but also identified species where data suggest a trend (i.e., $0.05 < p \leq 0.10$).

For species that exhibited significantly negative trends in both adult abundance and productivity at ORCA, and in the BBS data, we further assessed regional status by examining patterns at additional banding stations. We estimated trends in capture rates for adults and young at all other KBO banding stations that were operated during the same time period, 2002-2013. This amounted to nine other sites in the Klamath-Siskiyou Bioregion, including a range of elevations and habitats (Figure 3). Trends were analyzed in the same manner as above for each site, with year as the independent variable and captures per 100 net-hours as the dependent variable.

Comparison to BBS Trends

We obtained BBS trends for the Northern Pacific Rainforest region, including California, Oregon, and Washington states (<http://www.mbr-pwrc.usgs.gov/bbs/trend/tf13.html>; Sauer et al. 2014), over the period 2002-2012 (2013 results were not available online at the time of writing). The BBS measures an index of the adult population during the breeding season only. Results were generated from online analysis tools and are based on hierarchical models for population change, as described in Link and Sauer (2002).

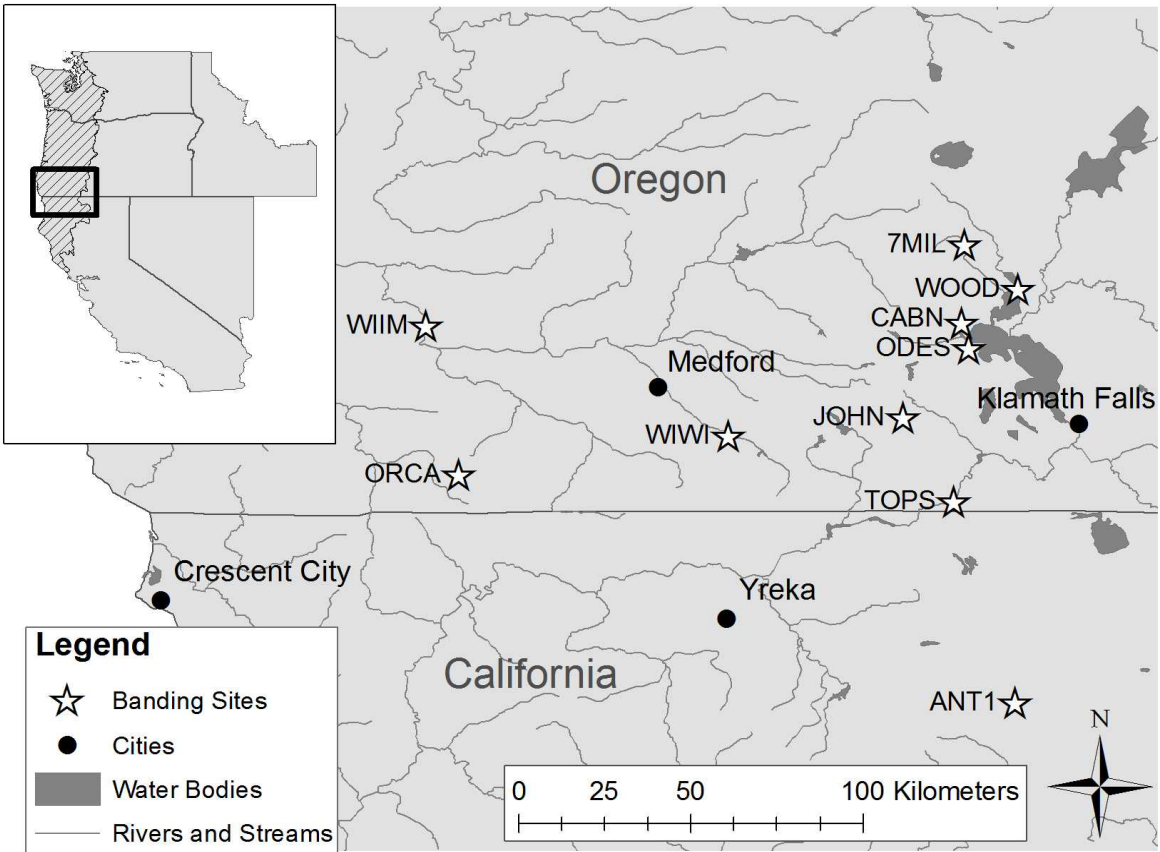


Figure 3. Location of 10 Klamath Bird Observatory banding stations in southern Oregon and northern California. Inset map shows location of study area inside black square, and the region of BBS analysis (Bird Conservation Region 6/ Northern Pacific Rainforest – California, Oregon, and Washington only) in hash lines. ANT1, JOHN, and ORCA are high elevation sites (1500-1700m); 7MIL, CABN, ODES and WOOD are mid-elevation sites (1200-1300m); and TOPS, WIIM, and WIWI are lower elevation sites (<1000m).

Results

Total Captures

From 2002-2013, we operated mist nets at ORCA for 176 days, totaling over 8600 net hours (Table 1). During this time, we captured 191 MacGillivray's Warblers, 194 Nashville Warblers, 567 Oregon Juncos, and 58 Western Flycatchers that fit our breeding criteria. For species that use ORCA during fall migration, we captured 103 Fox Sparrows, 106 Hermit Thrushes, 250 Oregon Juncos, and 253 Wilson's Warblers. For year-round residents at the site, we captured 169 Chestnut-backed Chickadees, 167 Golden-crowned Kinglets, and 97 Red-breasted Nuthatches.

Table 1. Total net hours (number of nets open x hours of operation) and total number of days that ORCA was visited by KBO personnel per year.

Year	Net Hours	Visits
2002	750.6	16
2003	823.2	18
2004	641.1	13
2005	742.0	15
2006	746.9	15
2007	679.0	14
2008	749.7	15
2009	684.2	14
2010	701.2	14
2011	696.9	14
2012	776.3	15
2013	640.7	13

Trends in Abundance (adult capture rates)

Adult capture rates of MacGillivray's Warbler declined significantly during the study period ($\beta = -0.12 \pm 0.04$, $p = 0.009$) from 2002-2013. This is the equivalent of losing approximately 0.6 breeding adults in the area sampled by our mist nets per year (given a typical 500 hours of netting during the breeding season), or going from a modeled 8.5 breeding adults captured in 2002 to 2 breeding adults in 2013. No species showed a significant or near-significant increase in adult captures (Table 2; Figure 4). Breeding populations of Nashville Warbler and Western Flycatcher, and both populations of Oregon Juncos remained relatively stable (Figures 4 and 5). Populations of the other three fall migrants (Table 2; Figure 5), and all three species of year-round residents exhibited no significant trends either (Table 2; Figure 6).

Table 2. Trends in abundance of 10 study species derived from mist netting and banding data at Oregon Caves National Monument and Preserve, from 2002-2013. Slopes are estimates of the yearly change in number of adults or young captured per 100 net-hours from linear models. Species with results in grey boxes indicate that a square root transformation was used, and the slope represents yearly change in the square root of capture rates. Species and age classes with significant ($p \leq 0.05$) trends are in bold and near-significant ($0.05 < p \leq 0.10$) trends are in bold italics.

Species	Status*	Adult			Young		
		Slope	SE	<i>p</i>	slope	SE	<i>p</i>
MacGillivray's Warbler	B	-0.120	0.037	0.01	-0.13	0.03	< 0.01
Nashville Warbler	B	-0.108	0.091	0.26	-0.01	0.08	0.87
Western Flycatcher	B	-0.053	0.033	0.14	-0.05	0.03	0.10
Oregon Junco (local)	B	-0.101	0.089	0.29	0.11	0.20	0.60
Oregon Junco (regional)	M	-0.170	0.102	0.13	0.12	0.05	0.04
Fox Sparrow	M	0.012	0.025	0.64	-0.02	0.03	0.58
Hermit Thrush	M	0.004	0.030	0.90	-0.05	0.03	0.16
Wilson's Warbler	M	0.078	0.052	0.17	0.23	0.10	0.05
Chestnut-backed Chickadee	R	-0.013	0.023	0.59	-0.06	0.04	0.18
Golden-crowned Kinglet	R	0.017	0.020	0.42	0.02	0.05	0.61
Red-breasted Nuthatch	R	-0.026	0.024	0.30	-0.04	0.04	0.42

*B = breeding, M = migrating, and R = resident populations

Breeding Species

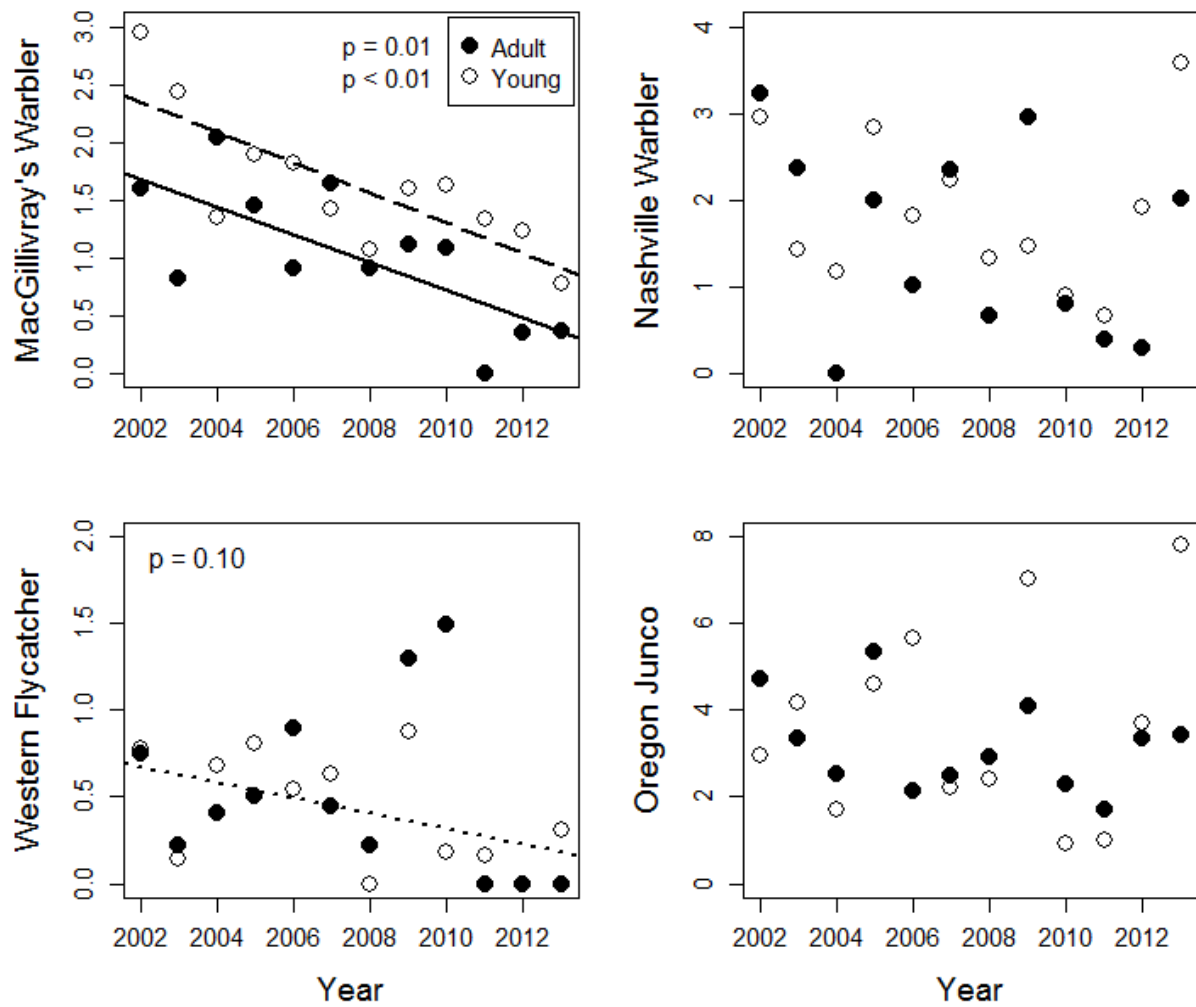


Figure 4. Trends in abundance of adults and young, measured in captures per 100 net-hours, for four species that breed at Oregon Caves National Monument and Preserve. For adults, solid lines represent significant trends ($p \leq 0.05$). For capture rates of young, dashed lines represent significant trends ($p \leq 0.05$), and dotted lines represent suggested trends ($0.05 < p \leq 0.10$). Species that were given square root transformations are presented on the original scale.

Fall Migrant Species

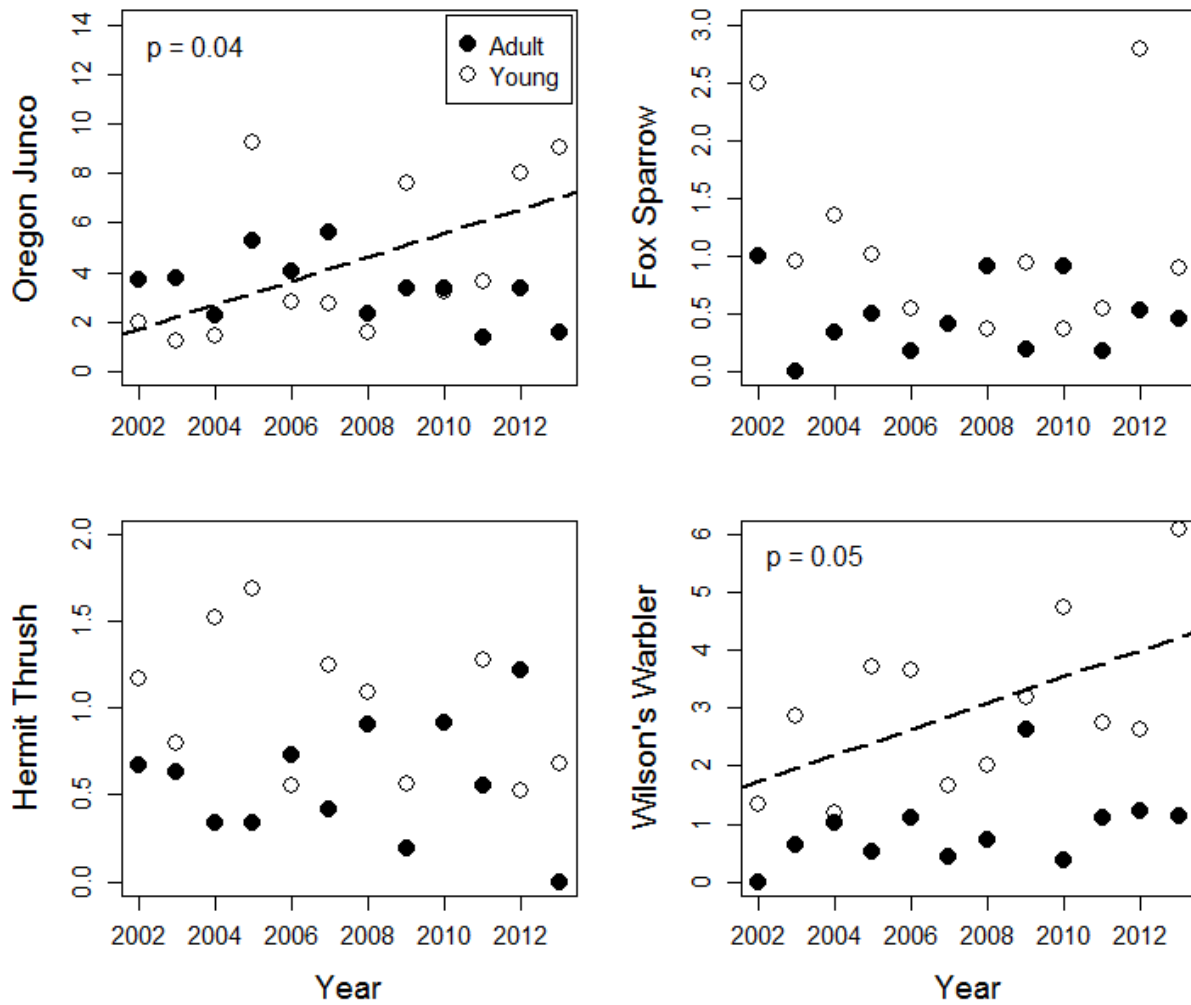


Figure 5. Trends in abundance of adults and young (productivity), measured in captures per 100 net-hours, for four species that migrate through Oregon Caves National Monument and Preserve in fall. For adults, there were no significant trends. For capture rates of young, dashed lines represent significant trends ($p \leq 0.05$). Species that were given square root transformations are presented on the original scale.

Resident Species

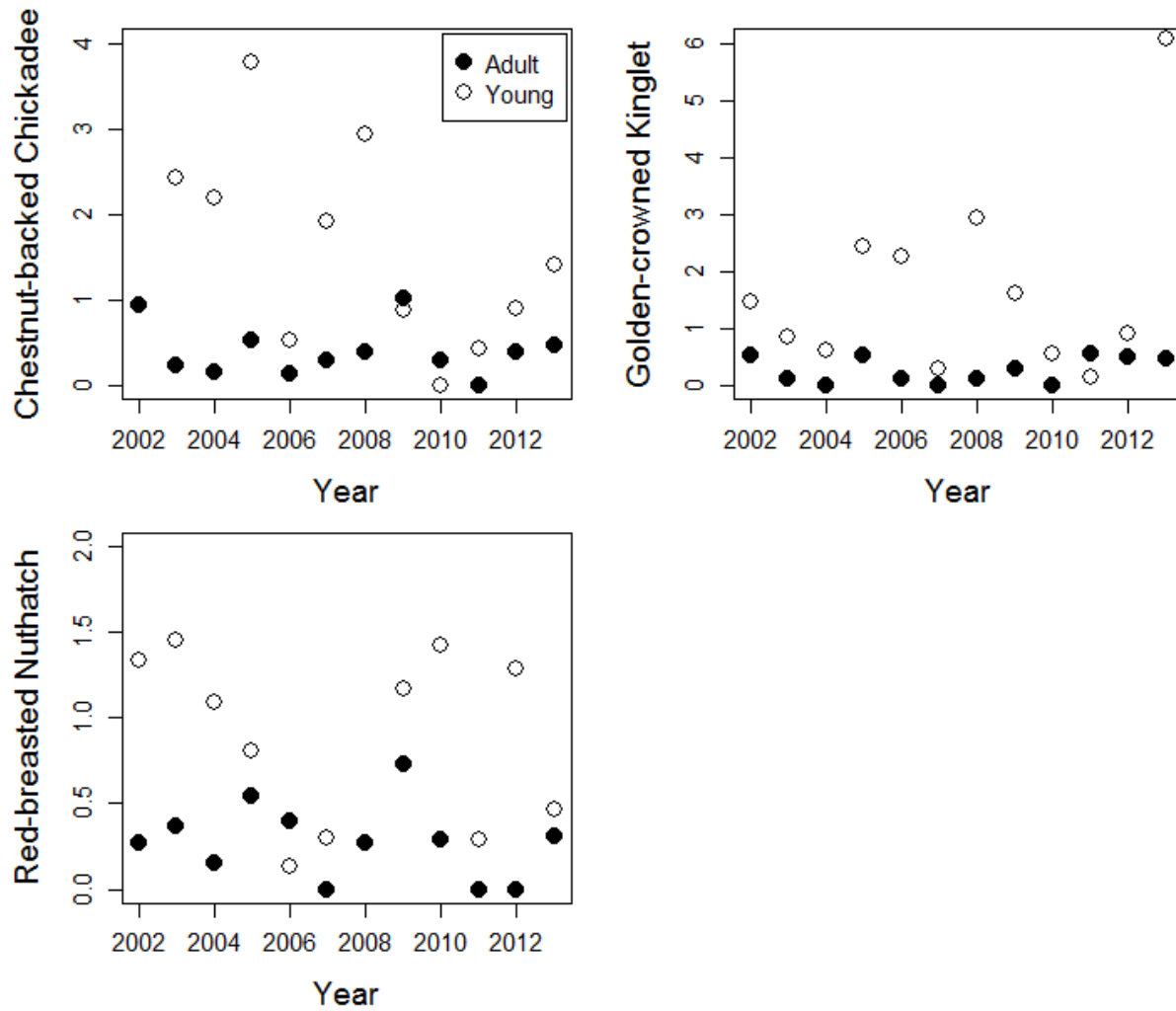


Figure 6. Trends in abundance of adults and young, measured in captures per 100 net-hours, for three resident species that are present at Oregon Caves National Monument and Preserve year-round. No trends were significant at the $p \leq 0.10$ level. Species that were given square root transformations are presented on the original scale.

Trends in Productivity (capture rates of young)

Capture rates of young birds decreased significantly or near-significantly for two of 10 study species, and increased for two species over the period 2002-2013 (Table 2). Capture rates of young MacGillivray's Warbler at ORCA declined at a rate similar to that of adults ($\beta = -0.13 \pm 0.03$, $p = 0.002$). Western Flycatcher capture rates ($\beta = -0.05 \pm 0.03$, $p = 0.10$) showed a suggested decline over the course of the study, while capture rates of young Nashville Warbler and local young Oregon Junco remained relatively stable (Figure 4). Regional productivity, as measured by capture rates of migrating young in fall, of Oregon Junco (square root of capture rate: $\beta = 0.12 \pm 0.05$, $p = 0.04$) and Wilson's Warbler ($\beta = 0.23 \pm 0.10$, $p = 0.05$) increased significantly (Figure 5). There was no evidence for a change in capture rates of young for regional populations of Fox Sparrow or Hermit Thrush (Figure 5). Resident Chestnut-backed Chickadee, Golden-crowned Kinglet, and Red-breasted Nuthatch populations maintained stable levels of locally produced young over time (Figure 6).

Relating Adult Abundance to Productivity

No study species exhibited a relationship between adult abundance (captures per 100 net-hours) and productivity (captures of young per 100 net-hours) in the previous year (Figures 7-9). Since annual abundance of adults is often positively related to productivity, we were somewhat surprised by these results, and chose to further examine the relationship between an alternate index of productivity (ratio of young:adult capture rates) and adult abundance in the subsequent year. Both of the indices we used provide information about the production of young on a population level, rather than per pair (Nur et al. 1999). We did not originally elect to use this ratio as our index of productivity because the catchment area of adult and young birds can be quite different, which complicates interpretation (Nur and Geupel 1993). However, one previous study found that the ratio of young:adult captures was better correlated to the number of young known to have fledged locally than the capture rate of young alone (Nur and Geupel 1993). Regardless, results were very similar to the original analyses; no significant correlations were found between the ratio of young:adult capture rates in one year and adult capture rates in the next.

Breeding Species

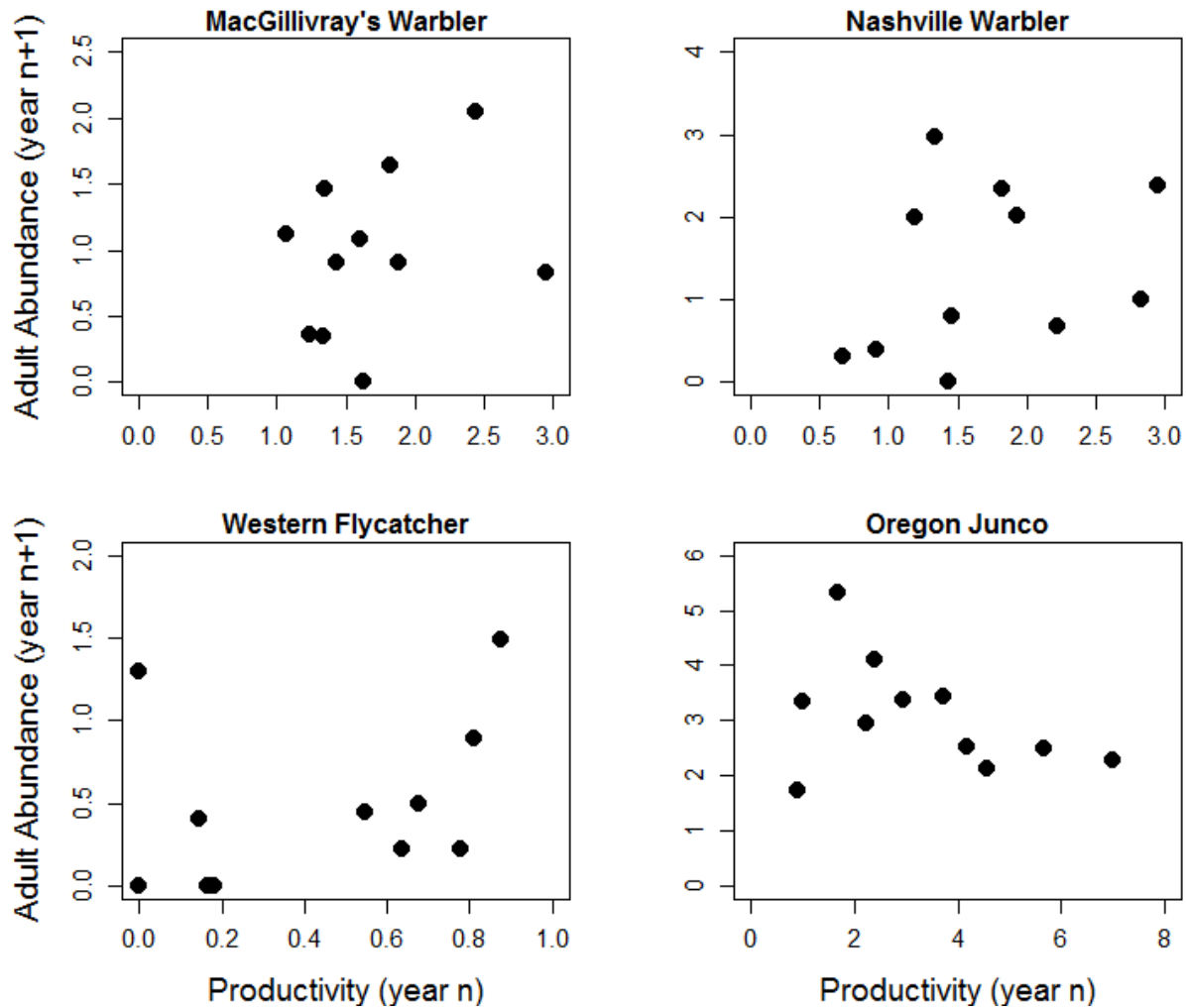


Figure 7. Relationship between adult abundance (captures per 100 net-hours) and productivity (captures of young per 100 net-hours) in the previous year for species that breed at Oregon Caves National Monument and Preserve. No trends were significant. Species that were given square root transformations are presented on the original scale.

Fall Migrant Species

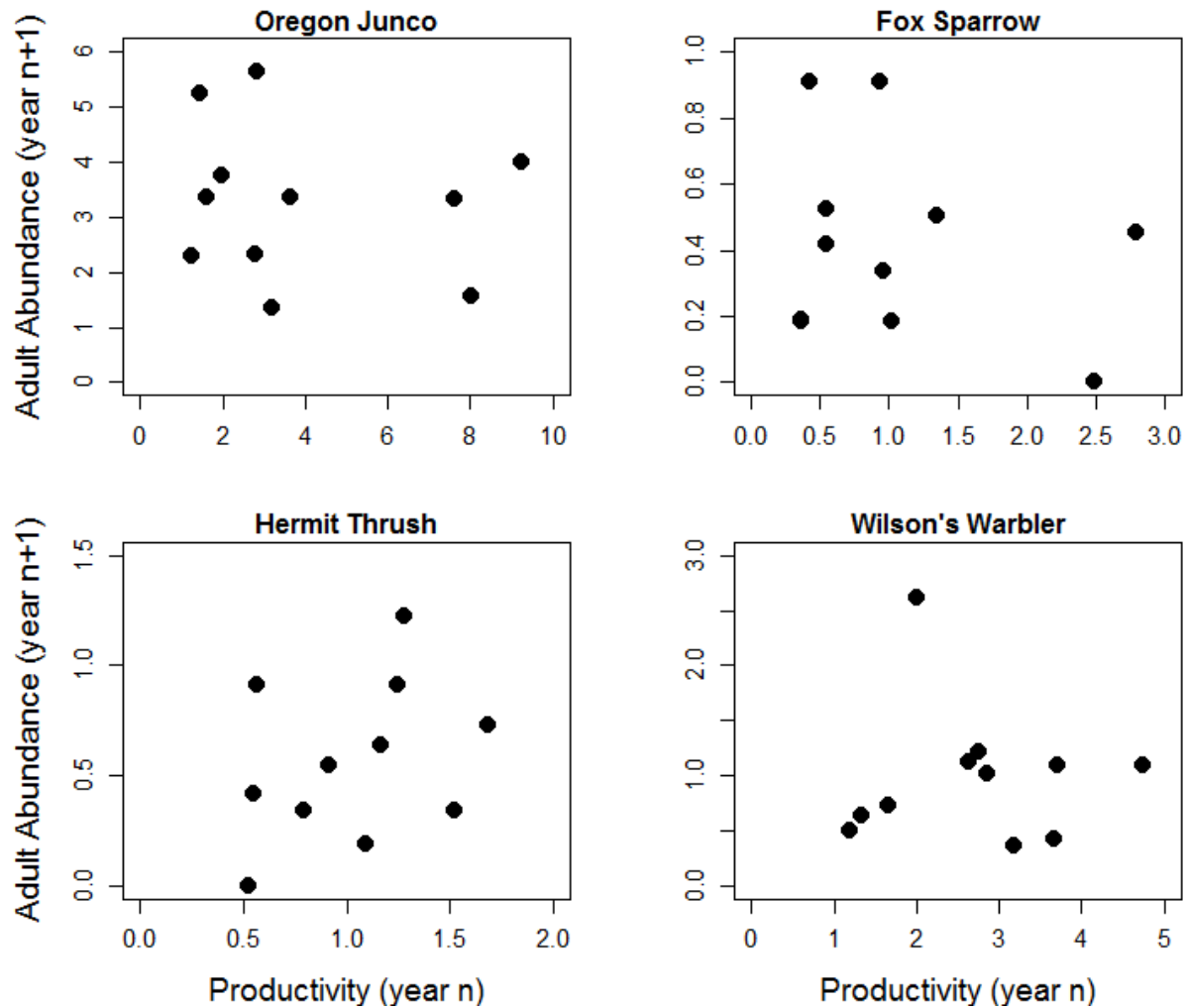


Figure 8. Relationship between adult abundance (captures per 100 net-hours) and productivity (captures of young per 100 net-hours) in the previous year for species that migrate through Oregon Caves National Monument and Preserve in fall. No trends were significant. Species that were given square root transformations are presented on the original scale.

Resident Species

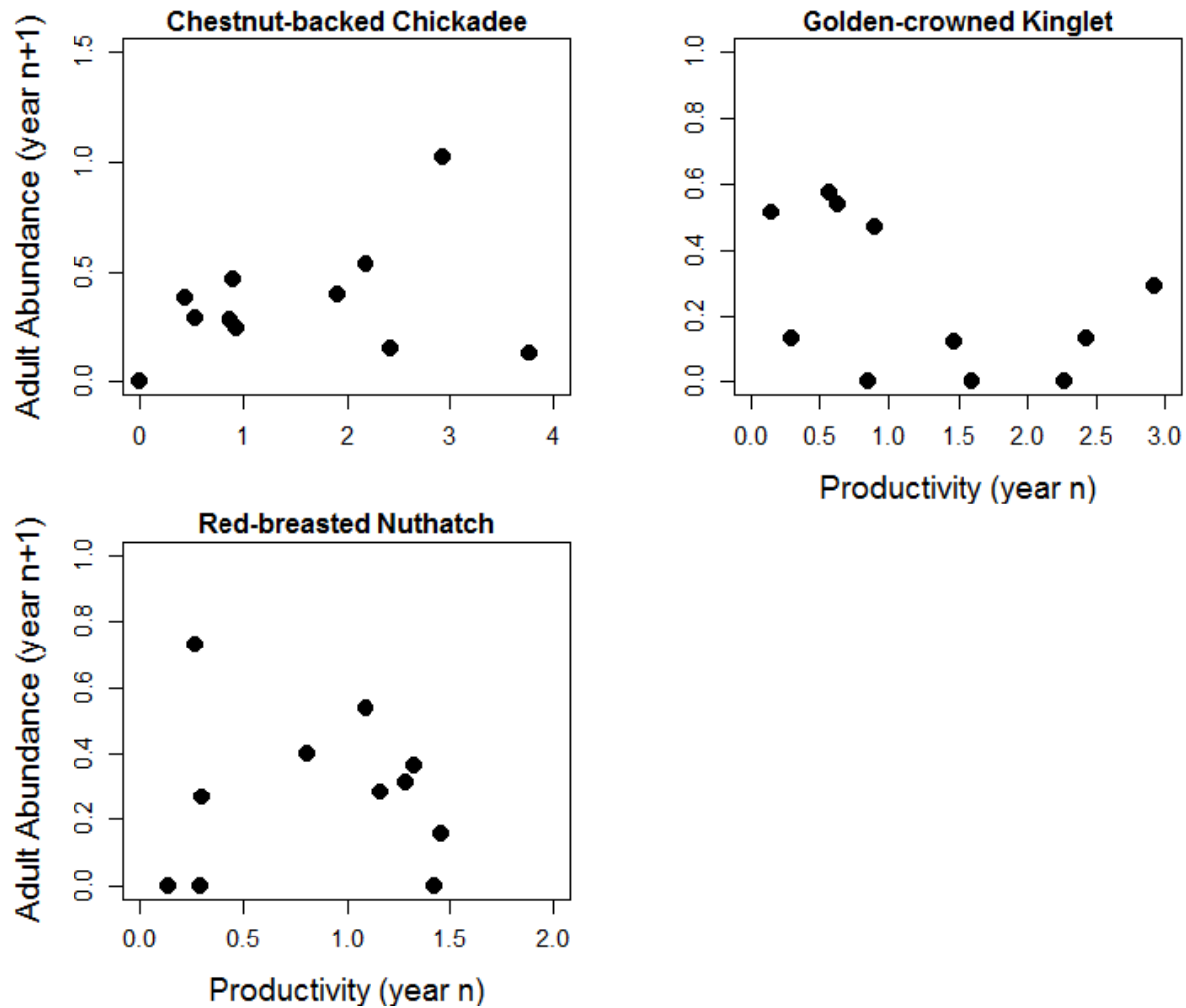


Figure 9. Relationship between adult abundance (captures per 100 net-hours) and productivity (captures of young per 100 net-hours) in the previous year for resident species of Oregon Caves National Monument and Preserve. No trends were significant. Species that were given square root transformations are presented on the original scale.

Correspondence between ORCA and BBS Trends

We compared trends in adult abundance derived from Breeding Bird Survey data for the Northern Pacific Rainforest region with trends from our mist netting data in direction and significance (a direct comparison of slopes was not possible given the difference in units). Four of our 10 study species (MacGillivray's Warbler, Wilson's Warbler, Dark-eyed Junco [BBS does not distinguish between Junco races, but Oregon Junco is the only one breeding in this area], and Golden-crowned Kinglet) had significant negative trend estimates for adult breeding populations during the period 2002-2012 (Sauer et al. 2014; Table 3). These BBS estimates corroborate the negative trends we found at ORCA in breeding populations of adult MacGillivray's Warbler. In contrast, we did not detect a trend at ORCA for the other three species showing regional declines in BBS data (Tables 2 and 3).

Table 3. Trends in abundance of 10 study species derived from Breeding Bird Survey data in the Northern Pacific Rainforest region, including western portions of California, Oregon, and Washington. Trend estimates are the ratios of the annual abundance indices for 2012 to 2002, produced by a hierarchical model that aggregates all BBS routes within the region (Link and Sauer 2002, Sauer et al. 2014). Species in bold are significant at the $p < 0.05$ level (i.e., 95% confidence intervals do not overlap zero). Asterisks (*) indicate that the trend matches a significant trend at ORCA.

Species	Trend	2.5% CI	97.5% CI
MacGillivray's Warbler	-2.39*	-4.28	-0.52
Nashville Warbler	-1.69	-3.89	0.36
Western Flycatcher	-1.48	-3.03	0.08
Oregon Junco	-1.36	-2.77	-0.14
Fox Sparrow	-1.63	-5.31	1.21
Hermit Thrush	-0.77	-2.76	0.98
Wilson's Warbler	-1.65	-2.81	-0.18
Chestnut-backed Chickadee	-1.94	-4.06	0.18
Golden-crowned Kinglet	-2.25	-3.99	-0.47
Red-breasted Nuthatch	0.13	-2.08	2.46

MacGillivray's Warbler: a closer look

MacGillivray's Warbler was the only species to exhibit significant negative trends in both adults and young at ORCA, and in the BBS data. We further assessed the regional status of this species by calculating trends in capture rates at nine additional KBO banding stations (Figure 3). MacGillivray's Warbler breeding adults exhibited a significant negative trend at only one other station (Table 4): a high elevation site along Johnson Creek on the Cascades Mountain ridge, about 25 miles northeast of Ashland, Oregon (JOHN). No stations showed a significant increase in adult abundance over this time period. In contrast to the negative trend in capture rates of young MacGillivray's Warbler found at ORCA, there was a significant increase in hatch-year capture rates at a lower elevation site along the Rogue River near Merlin, Oregon (WIIM) (Table 4).

Table 4. Trends in abundance of MacGillivray's Warblers derived from mist netting and banding data at nine additional KBO banding stations scattered throughout the Klamath-Siskiyou Bioregion, from 2002-2013 (see Figure 3 for site locations). Slopes are estimates of the yearly change in number of adults or young captured per 100 net-hours from linear models. SE represents standard error of the slope estimate, and n is the sample size. Sites and age classes with significant ($p \leq 0.05$) trends are in bold. There were no near-significant ($0.05 < p \leq 0.10$) trends. Slope estimates are not available for adults at sites WOOD or WIWI because they were not captured in sufficient numbers.

Site	Adults				Young (productivity)			
	Slope	SE	n	<i>p</i>	slope	SE	n	<i>P</i>
7MIL	0.080	0.061	240	0.22	-0.102	0.128	191	0.45
ANT1	0.009	0.034	77	0.80	-0.015	0.410	74	0.97
CABN	0.056	0.035	21	0.14	-0.006	0.045	164	0.90
JOHN	-0.094	0.035	125	0.02	0.090	0.155	156	0.57
ODES	0.065	0.051	62	0.23	0.037	0.108	73	0.74
TOPS	-0.047	0.068	14	0.51	0.097	0.081	50	0.26
WIIM	-0.011	0.043	44	0.80	0.149	0.046	80	0.01
WIWI	NA	NA	3	NA	0.131	0.074	24	0.11
WOOD	NA	NA	1	NA	-0.049	0.126	42	0.71

Discussion

Results from 12 years of mist netting and banding at ORCA revealed declining trends for adults of just one of four breeding season species analyzed (MacGillivray's Warbler), and none of four species present during fall migration. Populations of all three year-round resident species analyzed remained stable during this time period. The capture rate of young birds, an index of productivity, decreased for two species that breed at ORCA; this decline was significant for MacGillivray's Warbler and near-significant for Western Flycatcher. Regional populations of young Oregon Junco and Wilson's Warbler during fall migration were the only species and age classes to experience significant increases in capture rates. Productivity in one year was not related to adult abundance in the subsequent year for any species. Regional BBS trends were significantly negative for four of 10 species, and were consistent with declining adult MacGillivray's Warbler trends at ORCA.

Our findings suggest that ORCA provides important habitat for mature coniferous forest species which are widely in decline (Altman 2005). Resident populations of Chestnut-backed Chickadee, Golden-crowned Kinglet, and Red-breasted Nuthatch at ORCA all appeared to be relatively stable, despite evidence of regionally declining populations of kinglets as indicated by significantly negative BBS trends. A previous study of bird populations at ORCA that examined trends using point count data reported a near-significant decline in Golden-crowned Kinglets from 2000-2010 (Bennett and Gray 2011), but our results did not corroborate this conclusion. That study sampled a much larger area of ORCA, and included more mature coniferous habitat, but still had weak evidence for a decline in this species (Bennett and Gray 2011). While our capture rates of adult kinglets were relatively low (<1 bird per 100 net-hrs), our total sample size of 167 captures was not much less than their total of 194 point count detections, and we suggest that our conclusion is robust for the area around Big Tree sampled by our mist nets. ORCA is a relatively small remaining patch of intact habitat within a landscape of managed forest, and as such may provide an important refuge for these resident species – especially Red-breasted Nuthatch, which is an old-growth forest obligate. All seral stages are important to maintain healthy bird communities, and ORCA has important conservation value for mature coniferous forest species.

Western Flycatcher may warrant some concern, having experienced near-significant declines in young ($p = 0.10$) at ORCA during the study period, consistent with regional declines in adults from BBS data and with results from a study at a banding station on the central California coast (Ballard et al. 2003). The prior point count study conducted at ORCA found no change in adult populations of Pacific-slope Flycatcher (i.e., Western Flycatcher) over a similar time period, 2000-2010 (Bennett and Gray 2011). Western Flycatcher is a coniferous forest focal species in the Oregon-Washington Partners in Flight conservation plan, and it depends on deciduous canopy and subcanopy trees within a mature coniferous forest (Altman and Alexander 2012). Due to small sample sizes at ORCA, the near-significant decline in young may be a warning sign of a decreasing population trend that we simply do not have the power to detect, especially because the direction of the trend is supported by several other sources. Future monitoring at ORCA, as well as analysis at other banding stations, will provide additional information for this species.

While adult populations of Oregon Junco did not show a local trend at ORCA, BBS data demonstrated a significant regional decline. The previous study in ORCA based on point count data found a local negative trend for this species, but it was only significant with a highly influential outlier included (Bennett and Gray 2011). One other study also found a non-significant decline in adult Oregon Juncos migrating through the central California coast in fall during an earlier time period (Ballard et al. 2003). In contrast, we found that capture rates of young migrating through ORCA in fall increased significantly over the same time period while the population of adult migrants remained stable. Further work is needed to understand how migratory pathways and overwinter survival may be contributing to regional declines in this species.

Wilson's Warbler, which uses ORCA during fall migration, exhibited a significant increase in young from 2002-2013. This is in contrast to other studies which have found either no trends in Wilson's Warbler (Chase et al. 1997), or significant declines in breeding populations (BBS data presented here) or fall migrants (Ballard et al. 2003). Wilson's Warbler in our study area often disperse altitudinally during the post-breeding season, moving their young to higher elevations (J. Alexander, pers. obs.). These more local adult dispersers often retain remnants of a brood patch, indicating that they may have bred relatively close by, and thus may represent a smaller catchment area of fall migrants than the entire BBS region. Further regional analysis of this species' population trends will help elucidate the status of Wilson's Warbler in different parts of the Klamath-Siskiyou Bioregion. Several other fall migrant species (Nashville Warbler, Fox Sparrow, and Hermit Thrush) showed no evidence of population change over time, either at ORCA or in the regional BBS analysis, or in a previous study on the central California coast (Ballard et al. 2003).

Declining trends of MacGillivray's Warbler at ORCA and across the Pacific Northwest region are concerning. This was the only study species found to be declining in both local breeding adult abundance and local hatch-year abundance at ORCA, and also in the larger regional population represented by the BBS data. Given a typical 500 hours of netting during the breeding season at ORCA, MacGillivray's Warbler adult captures decreased at a rate of -0.6 breeding individuals per year, from a modeled 8.5 captures in the 2002 breeding season to only 2 captures in 2013. The numbers of young captured each year declined at a similar rate. Further examination of other KBO stations in the Klamath-Siskiyou Bioregion revealed a patchwork of sites where MacGillivray's Warbler populations are largely stable. The only other station where this species declined significantly was at Johnson Creek, a high elevation site with habitat similar to ORCA. The previous bird trend study at ORCA found no significant change in MacGillivray's Warblers during a slightly earlier period, 2000-2010 (Bennett and Gray 2011). The authors noted that this species' abundance appeared to follow a roughly parabolic curve over time, peaking in 2005-2006 and then decreasing again (Bennett and Gray 2011). Comparisons between these two studies should be undertaken with caution, due to widely differing methodologies, but we may be detecting a continuing downward trend consistent with (and persisting after) the latter half of this parabola. However, we did not detect a similar peak in abundance in 2005-2006.

MacGillivray's Warblers are associated with early successional hardwoods and shrubs, especially in southwestern Oregon (Betts et al. 2010). Species most closely associated with this habitat type have

declined in our region at the greatest rates (Betts et al. 2010). The interruption of natural successional cycles, via actions such as intensive forest management and fire suppression, has resulted in the widespread loss of early-seral broadleaf forest cover (Betts et al. 2010). Recent expansion of the park into the 4000-acre Oregon Caves National Monument and Preserve may provide an opportunity to protect additional forest habitat in various successional stages. If portions of these newly acquired lands are allowed to undergo natural forest regeneration, the maintenance of early-seral broadleaf vegetation across the landscape could be beneficial for this species. However, local productivity did not appear to be a limiting factor driving population change, and MacGillivray's Warblers at ORCA are faring no worse than the species is regionally. Analysis of trends at this single banding site provides a useful snapshot of the species' status in southern Oregon, but further work that combines multiple sites in a more in-depth regional analysis is warranted.

Conclusion

We have presented evidence for declines in one migratory species breeding at ORCA (MacGillivray's Warbler), and potential cause for regional concern for another (Western Flycatcher), raising the question of the possible factor(s) driving negative trends. We assessed the time-lagged effect of the abundance of young birds in one year on adult abundance in the subsequent year, and found that they were poorly correlated for all study species. This suggests that local productivity is not the cause of observed declines in MacGillivray's Warbler, or that we have insufficient data to answer this question at this time. Little is known about adult survival in different portions of the annual cycle, or the effect of conditions at migratory stopover and overwintering sites on migratory bird populations. Future studies should examine these as potential limiting factors. MacGillivray's Warblers are associated with early-successional hardwoods and shrubs, and the maintenance of early-seral broadleaf vegetation across the landscape could be beneficial for this species. Our findings further suggest that ORCA supports stable populations of resident mature coniferous forest species which are widely in decline, such as Chestnut-backed Chickadee, Golden-crowned Kinglet, and Red-breasted Nuthatch. We recommend a raised concern for understanding the conservation biology of species we found to be experiencing significant or suggestive population decreases either locally or regionally, including limiting factors that may operate in the breeding or non-breeding seasons.

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