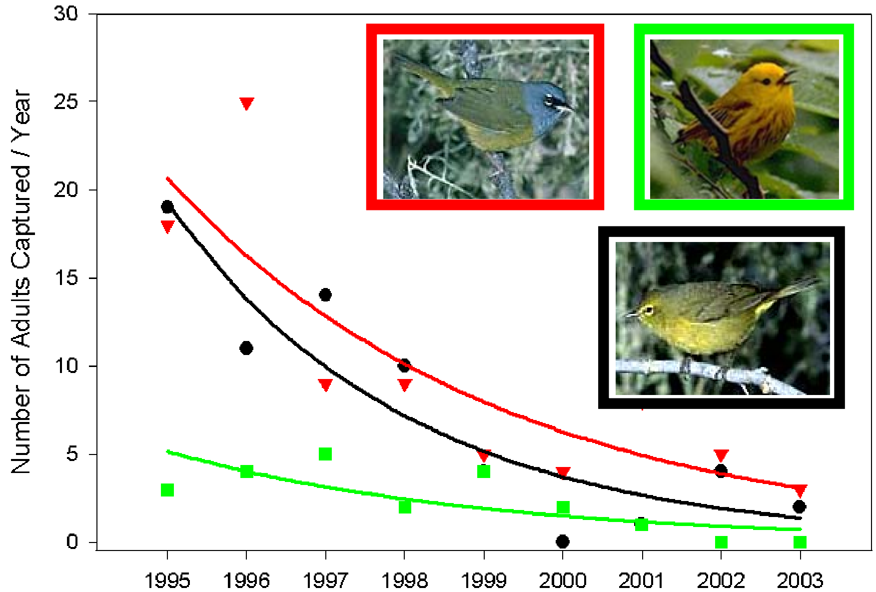
Local and Regional Trends in Breeding and Migratory Bird Populations in the Klamath and Rogue River Valleys: Monitoring Results for 1993-2003



A report by the Klamath Bird Observatory, April 2005

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Local and Regional Trends in Breeding and Migratory Bird Populations in the Klamath and Rogue River Valleys: Monitoring Results for 1993-2003

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John D. Alexander[1], Daniel C. Barton[1], and Nathaniel E. Seavy[1,2]

[1] *Klamath Bird Observatory*
Box 758
Ashland, OR 97520

[2] *Department of Zoology*
University of Florida
Gainesville, FL 32611-8029

Cover: Population trends of MacGillivray's Warblers (red triangles), Yellow Warblers (green squares), and Orange-crowned Warblers (black circles) at Wildlife Images on the Rogue River in Southern Oregon.

Abstract
We monitored bird populations using mist nets at two riparian banding stations, one on the Klamath River in northern California and the other on the Rogue River of southern Oregon from 1993-2003. We used these data to investigate population trends of 31 species of breeding and fall migrant birds and compared results with those from the Breeding Bird Survey (BBS) Southern Pacific Rainforest Physiographic Region for the same time period. For several species declining trends from mist-netting data corresponded with negative trends from BBS: Purple Finch (*Carpodacus purpureus*) declined at both stations during the breeding season and at the Rogue River station during fall migration; Swainson's Thrush (*Catharus ustulatus*) and Black-throated Gray Warbler (*Dendroica nigrescens*) at both stations during fall migration; and MacGillivray's Warbler (*Oporornis tolmei*) and Orange-crowned Warbler (*Vermivora celata*) during both seasons at the Rogue River station. BBS data showed a decreasing trend for Hermit Thrush, which increased at both sites during fall migration. BBS data showed an increasing trend for Black-headed Grosbeak, which declined at the Rogue River station during the breeding season and at the Klamath River station during migration. We found little correspondence between trends at the Rogue River site and Klamath River site during the breeding season, indicating that different population-level processes may be occurring at each site. We feel this type of strong cross-validation of regional and site-specific trends adds credibility to the validity of BBS results, and to the increasing evidence that regional population declines are occurring in songbirds. Accepting that real declines are occurring raises the question of the cause of these population declines. Further research into the possible weather, climactic, and anthropogenic causes of observed population trends and the demographic mechanisms of these trends are necessary to address the causes of these declines.

Introduction
Numerous studies have reported local and regional trends in breeding and migratory bird populations throughout North America (e.g., DeGraaf and Rappole 1995, Sauer et al. 2004). These studies suggest geographically widespread population declines that have provoked conservation concern for birds, particularly neotropical migrants (Askins et al. 1990, Terborgh 1989).

Several hypotheses have been advanced to explain regional or continent-wide trends in bird populations. Anthropogenic factors, in particular habitat change both on the breeding grounds and wintering grounds of migrant species, have been identified as an important causal factor (Terborgh 1989). Other studies have suggested that climactic variation and stochastic weather events might be the primary cause of many recent population trends (Nott et al. 2002, Sillett et al. 2000). The effects of habitat change and climate change on wildlife can be confounded (Pyke 2004) or there may be synergistic negative effects of weather and habitat loss on declining species (McLaughlin et al. 2002). As a result, declining populations warrant both conservation concern and additional research. Regardless of the proximate causes, recognition that decreasing bird populations may lead to regional extirpation or complete extinction of some bird species, the detection of trends has increasingly become a focus of bird monitoring programs using multiple methods such as mist-netting, surveys, and censuses (Bart et al. 2004).

Mist netting is frequently used to monitor migrant bird populations during the North American fall, when large numbers of birds move south from their breeding grounds (Dunn et al. 1997). Mist-netting has also been used to monitor changes in breeding bird populations (e.g. DeSante and O'Grady 2000, Nur et al. 2000, Silkey et al. 1999). Mist-netting provides information on the demographics of the populations that are monitored (Ralph et al. 1993). Count-based survey methods (Sauer et al. 2004) and census methods of finite study areas (Holmes and Sherry 1988) have been used more frequently than mist-netting to monitor changes in breeding populations.

The Breeding Bird Survey (BBS) is a roadside survey-based monitoring program designed to detect changes in bird abundance through time throughout southern Canada and the continental United States, and has been continuously collecting data since 1966 (Sauer et al. 2004). However, the BBS is limited to roadside habitats and is subject to numerous issues of observer variation. Count-based survey methods often inhibit accuracy and precision at finer scales, such as a single route or cluster of routes (Sauer et al. 2004). Because the argument can be made that when using count data to examine population trends of enough species or in enough locations some species will be seen to decline just be random chance (Hutto 1988), and because of the inherent problems of count-based surveys, the degree to which population changes detected by the BBS are consistent with trends detected using other methods and at other spatial scales is of interest to conservation biologists. Because the BBS is the only broad-scale long-term population monitoring program in North America, it provides a benchmark of comparison for other studies (e.g. Ballard et al. 2003, Holmes and Sherry 1988, Lloyd-Evans and Atwood 2004).

Using mist-nets, we have monitored bird populations since 1993 at two riparian sites, one on the Klamath River in northern California and the other on the Rogue River of southern Oregon. Here, we use these data to investigate ten-year population trends of songbirds breeding in and migrating through these sites. We then compare these trends to those from the breeding bird survey Pacific Rainforest Physiographic Region for the same time period (Sauer et al. 2004). We use these comparisons to evaluate the degree to which local trends generated from mist-netting data agree with those generated with different survey methods and at a much larger spatial scale.

Methods

Study Areas

We mist-netted birds at two stations: one on the Rogue River in southern Oregon and one on the Klamath River in northern California. The Rogue River (RORI) station is located approximately 5.8 km NE of Merlin, Oregon (Lat 42° 23' 29", Lon 123° 25' 48"; Fig. 1), in riparian habitat dominated by poplar (*Populus* sp.), willow (*Salix* spp.) and scattered relic fruit trees. Dominant understory plants include Himalayan blackberry (*Rubus discolor*) and poison hemlock (*Conium maculatum*). The site is 244 m above sea level, situated 4 meters above the river on a loamy floodplain substrate that was an historic homestead site. The Klamath River (KLRI) station is located approximately 1.3 km E of Seiad Valley, California (Lat 41° 23' 50", Lon 123° 36' 37"; Fig. 1) in riparian habitat dominated by willow and red alder (*Alnus rubra*). Dominant understory plants include Himalayan blackberry and poison hemlock. The site is 414 m above sea level, situated at river level on a substrate of granite dredge tailings.

Field Methods

Mist-nets were opened at each station within 15 min of local sunrise and were operated for 5 hours at the KLRI station and 6 hours at the RORI station. We did not operate nets during inclement weather conditions that might have affected capture rates or survivability of birds (i.e. high winds, rain, or extreme cold or heat). 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 metal leg bands issued by the Patuxent Wildlife Research Center Bird Banding Laboratory, and released. Because our mist-netting efforts we standardized, we refer to our method as constant-effort mist-netting (CEMN).

Station RORI was operated between 22 May and 31 October from 1995-2003, once during each 10-day period from late May to the end of August (breeding season banding protocol), and once during each 3-day period from the beginning of September to the end of October (migration season banding protocol).

Station KLRI was operated between 12 May and 4 November from 1993-2003, once during each 10-day period from mid-May to the end of August (breeding season banding protocol), and once during each 7-day period from the beginning of September to the beginning of November (migration season banding protocol). During 1993, KLRI was not operated consistently until the migration season, thus we excluded the 1993 breeding season from analyses.

Data Summary

We grouped netting efforts from both sites into 10-day periods beginning on 12 May, the earliest day we banded, and numbered these periods sequentially from 1 to 18 (Table 1). Because the start date at RORI was consistently later, we lacked data for the first 10-day period and thus excluded data from this period in analyses for that station. For each 10-day period we also summarized effort by total number of net-hours (1 net open for 1 hour). When defining breeding and migrant populations, we grouped data across years into ten-day periods. For analyses of trends, we summed captures and net-hours for each year within the periods defined as the breeding or migration seasons.

Local Trends in Breeding Populations

For migratory species, a consistent problem in the analysis of mist-netting data is that not all individuals captured are breeding locally. To limit our analyses to the local breeding population, we defined the period between the end of spring migration and the onset of fall migration as the breeding season. To determine the timing of spring and fall migration for each species, we examined the capture rates of resident birds (captured at least twice >7 days apart) and/or in 'high' breeding condition (defined as a large cloacal protuberance or a fully vascularized brood patch) during each 10-day period (Figs. 2-10). We considered the beginning of the breeding season to be the time period during which the proportion of birds captured that were resident and/or in high breeding condition first exceeded one third. We defined the onset of fall migration as the period during which signs of breeding condition (cloacal protuberances and brood patches) disappeared from captured birds (typically coinciding with an increase in capture rates, also signaling the onset of migration). After we defined the time period for the breeding season, all after-hatching year (AHY) birds captured during this time period were considered to be breeding or attempting to breed, in the immediate vicinity of the study area. In addition, we include birds that were captured twice > 7 days apart before the beginning of the breeding season because these individuals are almost certainly part of the local breeding population.

For year-round residents (Wrentit [*Chamaea fasciata*], Black-capped Chickadee [*Poecile atricapillus*], and Bushtit [*Psaltriparus minimus*]), we used data from the entire year to estimate trends in local populations, under the assumption that all captures regardless of season represent the local population. We present these data with breeding season data. Two species (Song Sparrow [*Melospiza melodia*] and Spotted Towhee [*Pipilo maculatus*]) had both individuals that were present for the entire study period (evidenced by recaptures of banded birds) and an apparent migratory/wintering population that breeds elsewhere. For these species we applied a similar criterion as we did to birds that were only migrants (see above) to separate the breeding population from the migratory/wintering population.

Regional Trends of Migratory Populations
When migrating birds are captured in the fall, AHY and HY birds represent unknown populations, and may include some locally produced birds as well migrants. Thus, we assume the majority of birds captured during the fall are produced somewhere in northwestern North America and refer to these trends as regional. We examined regional trends of migratory species that occur only during fall migration and species that breed at the study sites and also stopover during fall migration. For species that did not breed at our study sites, we simply defined fall migration as July 15-November 3. For species that did breed locally, we defined the beginning of fall migration as the time period in which cloacal protuberances and brood patches disappeared from the captured population, which also defined the end of the breeding season (see above). Some species both stopover during fall migration at these study sites as well as winter at them (e.g. Fox Sparrow [*Paserella illiaca*], Ruby-crowned Kinglet [*Regulus strapa*]). We included data from all captures for these species, and recognize that trends in fall capture rates may represent either declines in local wintering birds or in migrants.

General Trends of Non-specific Population
For several species we lacked sufficient data during the breeding or migratory periods to estimate changes in their abundance. For these species, we used capture rates from the entire study period as our unit of analysis. We refer to these populations as non-specific populations, and their trends as general trends. These analyses are meant to simply to examine whether species that are difficult to monitor with mist-nets might be declining, in order to suggest additional research if they are found to be declining.

Trend Modeling
We used annual capture totals within our defined periods to estimate local, regional, and general trends. We estimated local trends for 9 migratory and 3 resident species that breed at the sites, regional trends for 21 species that use the sites during migration, general trends for 5 uncommon species. We analyzed trends in AHY captures of breeding and resident populations, except in the case of Bushtit, where we combined AHY and HY captures, and analyzed combined AHY and HY captures for fall migrant and general populations.

Analyzing the number of birds captured at a station each year presents the challenge of count data; the distribution of captures and non-zero measurements are always positive integers. When number of captures is low, a frequency distribution of capture totals is likely to be highly non-normal (left-skewed, with a majority of observations at or near zero). Instead of employing nonparametric statistics or data transformations, we chose to use generalized linear models (GLMs; Crawley, 1997; Seavy et al., In press) that allow for non-normal random components that accommodate the distributional properties of count data.

To estimate trends in captures, we fit GLMs specifying a Poisson distribution and log-link, where annual capture total for a particular period was the response variable and year was the explanatory variable. When the annual capture total for each period was correlated with effort (net-hours) for the same period at $P < 0.10$, we corrected the model for effort variation using the number of net-hours as a linear offset on a log scale. These offsets were necessary for only 11 of 93 trend estimates. Significance was determined using z-tests and we defined significance as $P < 0.05$. We also report trends for $0.05 < P < 0.10$ because their results are suggestive that a trend may be occurring, but that we lack the statistical power to detect it. We then calculated percent annual population change using the antilog of the slope coefficient.

BBS Trends and Comparisons
We calculated BBS trends for the Southern Pacific Rainforest Physiographic Strata for the period 1993-2003 with the estimating equations method from Sauer et al. (2004). We then examined correlation between BBS trends and our trend results using ordinary least squares linear regression. All analyses were conducted using Stata 8.0 (StataCorp 2003).

Results

Definition of Breeding, Migratory, Resident, and General Populations
The 31 species for which we analyzed trends are listed in Table 2 with mean annual capture totals by analysis period, number of years with no captures, and definition of the breeding season used for each breeding migratory species. Data used for the definition of breeding season in the 9 species for which we analyzed trends in breeding season abundance are graphed in Figures 2-10. Some migratory species completed spring migration before the study period began each spring, and for these we did not need to use our data on recaptures and breeding condition to determine the end of spring migration (e.g. Black-headed Grosbeak; Fig. 9). Other migratory species appeared to arrive before the study period, but with large numbers of migrants continuing to stopover into June

(e.g. Yellow Warbler; Fig. 3) and still others appeared to first arrive well into the study period (e.g. Western Tanager; Fig 6). To avoid undercounting the local summer population, we included the *resident* birds present prior to the end of spring migration in our summer count for species whose migration continued past the beginning of the local breeding season (Yellow Warbler, Orange-crowned Warbler, and MacGillivray's Warbler).

Breeding and Resident Population Trends from CEMN
Linear trend and annual percentage change in 9 breeding and 3 resident bird populations as estimated by generalized linear models of CEMN data is presented in Table 3. Annual percentage change as estimated by estimating equations models of BBS data (Sauer et al. 2004) for the Southern Pacific Rainforest BBS strata 1993-2003 is also presented in Table 3 for comparison purposes.

At station RORI, we estimated breeding and resident trends for 11 species. AHY captures of 6 species declined significantly ($P < 0.05$) from 1995-2003 (Table 3). Bushtit lacked sufficient capture totals to allow analysis of AHY and HY captures separately, and we combined captures for this species; it declined significantly at RORI from 1995-2003 ($P = 0.039$; Table 3).

At station KLRI, we estimate breeding and resident population trends for 10 species (one of which differed from station RORI; see Table 3). AHY captures of 1 species declined significantly and for 1 species increased significantly from 1994-2003. Again, Bushtit lacked sufficient capture totals to allow analysis of AHY captures; we combined AHY and HY captures for analysis, and at KLRI this total did not increase or decline significantly from 1994-2003 ($P = 0.323$; Table 3).

Migratory and General Population Trends from CEMN
Linear trend and annual percentage in migratory and general bird populations as estimated by generalized linear models of CEMN data is presented in Table 4. Annual percentage change as estimated by estimating equations models of BBS data for the Southern Pacific Rainforest BBS strata 1993-2003 is also presented in Table 4 for comparison purposes.

At station RORI, we estimated migratory and general population trends for 28 species. From 1995-2003, 13 species declined significantly and 6 increased significantly (Table 4). At station KLRI, we estimated migratory and general population trends for 25 species, 2 of which declined significantly and 4 of which increased significantly from 1993-2003 (Table 4). One species also showed a suggestive negative trend and 1 species showed a suggestive positive trend over the same time period (Table 4).

Correspondence between CEMN and BBS trends
Correspondence between significant or suggestive (both methods with $P < 0.10$) CEMN and BBS trends from this study is shown in Table 5. Species showing a significant or suggestive trend on both CEMN and BBS are shown in Table 6. We use $P < 0.10$ for comparing correspondence of trends because the probability of occurrence of $P < 0.10$ for

two separate trends by chance is actually equivalent to $P < 0.01$ (0.10^2). The relationship between CEMN and BBS trends for both sites and in both seasons (breeding and fall) is shown in Figures 11 – 16. Figures 11 and 14 graph the correspondence between significant trends at each site and the BBS, showing trends that are corroborated (lower left and upper right quadrants) and trends that are in opposing directions (upper left and lower right quadrants).

Comparing breeding and resident population trends from our mist-netting data with declining BBS trends, BBS trends correspond with trends measured for 4 species at the RORI station (Table 4, Table 6, Fig.11), and trends measured for 1 of these species at the KLRI station (Purple Finch) also corresponded with the BBS trend (Table 4, Fig.11). Increasing BBS trends correspond with breeding and resident population trends measured for 1 species at the KLRI station (Table 4, Table 6, Fig.11). Two species that showed declining trends at the RORI station, did not correspond with increasing BBS trends (Table 4, Table 6, Fig.11).

Comparing migratory and general population trends from our data with declining BBS trends, BBS trends correspond with measured for 8 species at the RORI station (Table 5, Table 6, Fig.14), and trends measured for 2 of these species at the KLRI station (Swainson's Thrush and Black-throated Gray Warbler) also corresponded with the BBS trend (Table 5, Fig.14). Increasing BBS trends correspond with migratory and general population trends measured for one species at the RORI station and a different species at the KLRI Station (Table 5, Table 6, Fig.14). One species that showed declining trends at the RORI station, did not correspond with increasing BBS trends. Decreasing BBS trends did not correspond with increasing trends for 1 species at the RORI site, and 2 species at the KLRI site; increasing trends at both the RORI and KLRI station for 1 of these species (Hermit Thrush) showed correspondence (Table 5, Fig.14)

Discussion

Our constant-effort mist netting results indicate significant ($P < 0.05$) declines in numerous species while showing significant increases in relatively few (Tables 3, 4, 6). In particular, numerous species are declining at the RORI station during the breeding season (7 species; Table 3) and during fall migration (13 species; Table 4), many more than at the Klamath River banding station during breeding (1 species; Table 3) and fall migration (2 species; Table 4).

Correspondence between CEMN and the BBS reveals that 3 species are declining at both the RORI and KLRI stations and on the BBS during 1993-2003: Purple Finch, Black-throated Gray Warbler, and Swainson's Thrush (Table 6). Both breeding and migratory populations of Purple Finch, MacGillivray's Warbler, and Orange-crowned Warbler are declining at the Rogue River site as well as on the BBS. No species increased at both sites and on the BBS, or during both seasons and on the BBS. Only Western Tanager, Song Sparrow, and Lesser Goldfinch showed congruent increasing trends between one of the CEMN sites and the BBS (Table 6). Black-headed Grosbeaks showed declines during both seasons at the RORI station, while BBS data revealed increasing trends (Table 5, Fig. 14). During migration Hermit Thrushes increased at both the RORI and

KLRI stations, while BBS data revealed decreasing trends (Table 5, Fig. 14). Many of the trends we have observed in CEMN are much stronger than BBS trends (i.e. up to a factor of 10 times greater annual % change, as in Purple Finch; Table 3).

The causes of observed trends in CEMN captures could be several. Local habitat succession or net avoidance could be causing apparent trends at each site by reducing capture probabilities (Remsen and Good 1996). Local habitat change could also be reducing the suitability of the CEMN stations as breeding or migratory stopover habitat for certain species, thus reducing local breeding and migratory populations (Soule et al. 1988, Yong et al. 1998). Alternatively, this may be occurring at a landscape-level scale, which could influence habitat suitability with no apparent local change at each site (Drolet et al. 1999). Finally, some or all of the observed population trends in CEMN data could be real. All of these hypotheses warrant further investigation.

Local habitat succession at each site has been relatively minor during the study period; additionally, landscape-level influences are unlikely to have significantly affected local habitat suitability over the study period because the changes have been relatively minor (J. Alexander, pers. obs.). Although net avoidance is a possibility, we suggest that this has not significantly influenced our results because a very large proportion of each year's captures are of previously unbanded birds at both sites (KBO, unpublished data), especially during fall, when a large proportion of our annual count consists of hatching-year birds. We therefore suggest that our results indicate actual population declines and increases in both local breeding populations and regional migratory populations. We suggest that negative trends that correspond between CEMN and BBS, especially trends occurring at both CEMN sites, have the strongest inference.

Of particular interest to us is the lack of correspondence between trends occurring at the Rogue River site and at the Klamath River site. This would tend to indicate, if the trends observed at the Rogue River that correspond with the BBS are indeed real population changes, that very different things are occurring at each site during the breeding season. Further research is needed at scales larger than each CEMN station but smaller than the Southern Pacific Rainforest BBS strata to determine if there is a larger-scale difference between each site, or if the Klamath River site is just an island of stable populations in a sea of declines.

During fall migration, we suggest that because of the low effort (1 day / week) at the Klamath River site the results from that site have very low statistical power (Thomas et al. 2004). Nonetheless, migratory or general population trends correspond at both the Rogue and Klamath sites and on the BBS for two species: Black-throated Gray Warbler and Swainson's Thrush. Significant migratory and general population trends at the Rogue River site correspond very well with significant BBS trends: 8 species declined and 1 species increased according to both survey methods, and only 1 significant trend did not correspond (Hermit Thrush, which is decreasing on the BBS and increasing during migration at the Rogue River site and the Klamath River site).

Another study within the same physical BBS strata, but located on the central California coast approximately 350 km SSW of our study sites, also found that Black-throated Gray Warbler, Purple Finch, Orange-crowned Warbler, and Wilson's Warbler were declining during fall migration from the period 1979-1999, which corresponded with west-wide regional BBS trends over the same time period for Orange-crowned Warbler and Wilson's Warbler (Ballard et al. 2003). We feel this type of strong cross-validation of regional results adds to the credibility of both studies (Ballard et al. 2003 and ours), to the validity of BBS results (Sauer et al. 2004), and to the increasing evidence that regional population declines are occurring in songbirds.

Accepting that real declines are occurring raises the question of the cause of these population declines. Further research into the possible weather, climactic, and anthropogenic causes of observed population trends and the demographic mechanisms of these trends are necessary to address the causes of these declines. We suggest a raised concern for understanding the conservation biology of species we have found to be declining locally and regionally, and the strong negative strength of these declines indicates the problem may be urgent.

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Literature Cited

Askins R. A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Current Ornithology 11:1-34.

Ballard, G., G. R. Geupel, N. Nur, and T. Gardali. 2003. Long term declines and decadal patterns in population trends of songbirds in Western North America, 1979 - 1999. Condor 105:737-755.

Bart, J., K.P. Burnham, E.H. Dunn, C.M. Francis, and C.J. Ralph. 2004. Goals and strategies for estimating trends in landbird abundance. Journal of Wildlife Management 68:611-626.

Crawley, M.J. 1997. GLIM for Ecologists. Blackwell Science, Oxford, United Kingdom.

DeGraaf, R. M., and J. H. Rappole. 1995. Neotropical migratory birds: natural history, distribution and population change. Cornell University Press, New York, USA.

DeSante, D.F., and O'Grady, D.R. 2000. The Monitoring Avian Productivity and Survivorship (MAPS) Program 1997 and 1998 report. Bird Populations 5:49-101.

Drolet, B., A. Desrochers, and M. J. Fortin. 1999. Effects of landscape structure on nesting songbird distribution in a harvested boreal forest. Condor 101:699-704.

Dunn, EH, DT Hussell, and RJ Andams. 1997. Monitoring songbird population change with autumn mist netting. Journal of Wildlife Management 61:389-396
Holmes, R. T., and T. W. Sherry. 1988. Assessing population trends of New Hampshire forest birds: local vs regional patterns. Auk 105:756-768.
Hutto, R. L. 1988. Is tropical deforestation responsible for the reported declines in Neotropical migrant populations? American Birds 42:375-359.
Lloyd-Evans, T. L., and J. L. Atwood. 2004. 32 years of changes in passerine numbers during spring and fall migrations in coastal Massachusetts. Wilson Bulletin 116:1-16.
McLaughlin, J. F., J. J. Hellmann, C. L. Boggs, and P. R. Ehrlich. 2002. Climate change hastens population extinctions. Proceedings of the National Academy of Sciences 99:6070-6074.
Nott, M.P., DeSante, D.F., Siegel, R.B., and P. Pyle. 2002. Influences of the El Niño/Southern Oscillation and the North Atlantic Oscillation on avian productivity in forests of the Pacific Northwest of North America. Global Ecology and Biogeography 11:333-342.
Nur, N., G. R. Geupel, and G. Ballard. 2000. The use of constant-effort mist-netting to monitor demographic processes in passerine birds: annual variation in survival, productivity, and floaters. In: R. Bonney, D. N. Pashley, R. J. Cooper, and L. Niles (Eds.), Proceedings of the 3rd Partners in Flight workshop. USDA Publication RMRS-P-16.
Pyke, C. R. 2004. Habitat loss confounds climate change impacts. Frontiers in Ecology and the Environment 2:178-182.
Pyle, P. Identification guide to North American birds. 1997. Part I. Slate Creek Press, Bolinas, CA.
Ralph, C.J., G.R. Geupel, P. Pyle, T.E. Martin & D.F. DeSante. 1993. Handbook of field methods for monitoring landbirds. USDA General Technical Report PSW-GTR-144.
Remsen, J. V. and D. A. Good. 1996. Misuse of data from mist-net captures to assess relative abundance in bird populations. Auk 113:381-398.
Sauer, J. R., J. E. Hines, and J. Fallon. 2004. The North American Breeding Bird Survey, Results and Analysis 1966 - 2003. Version 2004.1. USGS Patuxent Wildlife Center Laurel, Maryland.
Seavy, N. E., S. Quader, J. D. Alexander, and C. J. Ralph. In Press. Generalized linear models and point count data: Statistical considerations for the design and analysis of monitoring studies. In: Ralph, C.J. and T. D. Rich (Eds.), Bird Conservation Implementation and Integration in the Americas. USDA General Technical Report PSW-GTR-191.
Silkey, M., N. Nur, and G. R. Geupel. 1999. The use of mist-net capture rates to monitor variation in abundance: a validation study. Condor 101:288-298.
Sillett, T. S., R. T. Holmes, and T. W. Sherry. 2000. Impacts of a global climate cycle on population dynamics of a migratory songbird. Science 288:2040-2042.
Soule, M. E., D. T. Bolger, A. C. Alberts, R. M. Sauvajot, J. Wright, M. Sorice, and S. Hill. 1998. Reconstructed dynamics of rapid extinctions of chaparral-requiring birds in urban habitat islands. Conservation Biology 2:75–92.
StataCorp. 2003. Stata Statistical Software: Release 8. Stata Corporation, College Station, TX.
Terborgh, J. 1989. Where have all the birds gone? Princeton University Press, Princeton, NJ.
Thomas, L., G. Geupel, N. Nur & G. Ballard. 2004. Optimizing the allocation of count days in a migration monitoring program. Studies in Avian Biology 29:97-111.
Yong, W., D. M. Finch, F. R. Moore, and J. F. Kelly. Stopover ecology and habitat use of migratory Wilson's Warblers. Auk 115:829-842.

Tables

Figures

Table 1. First day of each 10-day period used for determination of breeding and fall migration periods, and for all analyses. KLRI had data for all 18 periods, 1994-2003, and RORI had data for periods 2-18, 1995-2003. Additionally, KLRI had data for periods 6-18 in 1993.

	10-day Period																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
First Day of Period	12-May	22-May	1-Jun	11-Jun	21-Jun	1-Jul	11-Jul	21-Jul	31-Jul	10-Aug	20-Aug	30-Aug	9-Sep	19-Sep	29-Sep	9-Oct	19-Oct	29-Oct

Table 2. Mean annual capture totals and number of years with no captures for each population (in parenthesis) for which we modeled trends, and the defined local breeding season period for breeding migratory species used in separating breeding populations from migratory populations.

		Rogue River				Klamath River			
Common Name	Standard Name	Breeding AHY	Breeding HY	Migratory	Time Periods	Breeding AHY	Breeding HY	Migratory	Time Periods
Downy Woodpecker†	*Picoides pubescens*			8 (0)				4 (0)	
Western Flycatcher	*Empidonax difficilis*			16 (0)				6 (0)	
Willow Flycatcher	*E. trailli*			54 (0)				22 (0)	
Warbling Vireo	*Vireo gilvus*			9 (0)					
Black-capped Chickadee‡	*Poecile atricapillus*	5 (0)	23 (0)			3 (1)	7 (0)		
Bushtit‡	*Psaltriparus minimus*	7 (1)				14 (0)			
Bewick's Wren†	*Thryomanes bewickii*			3 (2)				11 (1)	
Ruby-crowned Kinglet	*Regulus calendula*			12 (0)				14 (0)	
Swainson's Thrush	*Catharus ustulatus*			106 (0)				24 (0)	
Hermit Thrush	*C. guttatus*								
American Robin	*Turdus migratorius*			63 (0)				7 (0)	
Wrentit‡	*Chamaea fasciata*	9 (0)	25 (0)			7 (0)			
Cedar Waxwing	*Bombycilla cedrorum*			31 (0)				2 (0)	
Orange-crowned Warbler	*Vermivora celata*	7 (1)	6 (0)	30 (0)	2-9*			4 (0)	
Nashville Warbler†	*V. ruficapilla*			2 (3)				8 (1)	
Yellow Warbler	*Dendroica petechia*	2 (2)	5 (0)	71 (0)	4-10*	12 (0)	10 (0)	25 (0)	3-10*
Myrtle Warbler	*D. coronata*			21 (0)				6 (3)	
Black-throated Gray Warbler†	*D. nigrescens*			5 (0)				7 (0)	
MacGillivray's Warbler	*Oporornis tolmei*	9 (0)	8 (1)	14 (0)		16 (0)	9 (0)	7 (0)	2-8*
Common Yellowthroat	*Geothlypis trichas*			7 (1)				8 (1)	
Wilson's Warbler	*Wilsonia pusilla*			13 (0)				4 (0)	
Yellow-breasted Chat	*Icteria virens*	10 (0)	5 (0)		2-8	22 (0)	12 (0)		1-9
Western Tanager	*Piranga ludoviciana*			18 (0)		4 (2)		6 (1)	4-10
Spotted Towhee	*Pipilo maculatus*	7 (0)	18 (0)	79 (0)	2-10	13 (0)	26 (0)	36 (0)	1-10
Fox Sparrow	*Passerella iliaca*			18 (0)				24 (0)	
Song Sparrow	*Melospiza melodia*	29 (0)	58 (0)	117 (0)	2-10	16 (0)	33 (0)	33 (0)	1-10
Lincoln's Sparrow	*M. lincolnii*			13 (0)				4 (1)	
Golden-crowned Sparrow	*Zonotrichia atricapilla*			67 (0)				69 (0)	
Black-headed Grosbeak	*Pheucticus melanocephalus*	11 (0)	19 (0)	11 (0)	2-9	6 (0)	5 (0)	5 (2)	1-9
Purple Finch	*Carpodacus purpureus*	4 (4)	19 (0)	11 (1)	2-12	13 (0)	9 (0)	12 (0)	2-12
Lesser Goldfinch†	*Carduelis psaltria*			2 (1)				11 (0)	

†Rare species for which we calculated general trends, using the total number of captures of all age classes throughout the entire study period.
‡Year-round resident species; breeding captures for these species are the total for the entire study period. For Bushtit at both sites and Wrentit at the Klamath River site, we lumped all age classes for analysis.
*Species for which we included birds in the breeding season capture total that were resident (captured > 7 days apart) before the beginning of the defined period.

Table 3. Breeding and year-round resident population trends from the Rogue River (RORI) and Klamath River (KLRI) constant-effort mist-netting stations as estimated by poisson-family GLM and regional population trends from the South Pacific Rainforest Strata of the BBS as estimated by estimating equations models (Sauer et al. 2004). Significant models ($P < 0.05$) are shown in bold type.

	BBS South Pacific Rainforest Strata 1993-2003			RORI AHY Trend 1995-2003			KLRI AHY Trend 1994-2003		
Species	% Change	*P*	*n*	β (SE)	% Change	*P*	β (SE)	% Change	*P*
Black-capped Chickadee†	3.47	0.056	43	-0.032 (0.057)		0.572	-0.041 (0.063)		0.512
Bushtit†	**-7.20**	**0.009**	42	**-0.102 (0.049)**	**-9.72**	**0.039**	-0.029 (0.030)		0.323
Wrentit†	0.01	0.997	41	0.069 (0.045)		0.124			
Orange-crowned Warbler	**-4.86**	**< 0.001**	65	**-0.329 (0.059)**	**-28.01**	**< 0.001**			
Yellow Warbler	1.67	0.466	36	**-0.247 (0.095)**	**-21.89**	**0.009**	0.036 (0.032)		0.272
MacGillivray's Warbler	**-2.88**	**0.046**	51	**-0.238 (0.047)**	**-21.19**	**< 0.001**	0.042 (0.027)		0.126
Yellow-breasted Chat	-0.93	0.491	27	-0.059 (0.041)		0.154	0.016 (0.023)		0.492
Western Tanager	**3.79**	**< 0.001**	67				**0.223 (0.066)**	**24.94**	**0.001**
Spotted Towhee	0.90	0.314	67	0.067 (0.050)		0.182	-0.009 (0.035)		0.806
Song Sparrow	**1.73**	**< 0.001**	65	**-0.066 (0.024)**	**-6.39**	**0.006**	0.017 (0.027)		0.529
Black-headed Grosbeak	**2.39**	**0.029**	69	**-0.192 (0.042)**	**-17.50**	**< 0.001**	-0.073 (0.046)		0.107
Purple Finch	**-2.18**	**0.035**	65	**-0.618 (0.110)**	**-46.09**	**< 0.001**	**-0.143 (0.033)**	**-13.31**	**< 0.001**

†Year-round resident populations for which we used all captures through the study period.

Table 4. Migratory and general population trends from the Rogue River (RORI) and Klamath River (KLRI) constant-effort mist-netting stations as estimated by poisson-family GLM and regional population trends from the South Pacific Rainforest Strata of the BBS as estimated by estimating equations models (Sauer et al. 2004). Significant models ($P < 0.05$) are shown in bold type.

	BBS South Pacific Rainforest 1993-2003			RORI Total Fall Captures 1995-2003			KLRI Total Fall Captures 1993-2003		
	% Change	*P*	*n*	β (SE)	% Change	*P*	β (SE)	% Change	*P*
Downy Woodpecker‡	**-5.13**	**0.011**	**45**	-0.010 (0.046)	-1.04	0.819	0.020 (0.050)	2.02	0.689
Western Flycatcher	**-3.58**	**< 0.001**	**65**	-0.029 (0.033)	-2.81	0.38	0.024 (0.038)	2.43	0.524
Willow Flycatcher	1.88	0.167	40	**-0.039 (0.028)**	**-3.79**	**0.028**	0.001 (0.020)	0.13	0.951
Warbling Vireo	-0.89	0.316	65	0.041 (0.043)	4.22	0.341			
Bewick's Wren‡	1.8	0.467	48	0.092 (0.082)	9.68	0.261	**0.092 (0.029)**	**9.63**	**0.002**
Ruby-crowned Kinglet	-9.203	0.187	***8***	-0.051 (0.038)	-4.94	0.185	-0.033 (0.025)	-3.31	0.187
Swainson's Thrush	-1.22	0.071	61	**-0.029 (0.013)**	**-2.87**	**0.02**	**-0.088 (0.020) †**	**-8.40**	**< 0.001**
Hermit Thrush	**-3.97**	**< 0.001**	**37**	**0.138 (0.050)**	**14.74**	**0.005**	**0.042 (0.015)**	**4.33**	**0.004**
American Robin	0.61	0.295	69	**0.172 (0.017)**	**18.77**	**< 0.001**	-0.042 (0.036)	-4.16	0.238
Cedar Waxwing	0.66	0.694	41	**-0.080 (0.023)**	**-7.73**	**0.001**			
Orange-crowned Warbler	**-4.86**	**< 0.001**	**65**	**-0.176 (0.025)**	**-16.10**	**< 0.001**	0.008 (0.046)	0.84	0.855
Nashville Warbler‡	-2.4	0.08	27	**-0.204 (0.092)**	**-18.42**	**0.026**	0.025 (0.035)	2.57	0.466
Yellow Warbler	1.67	0.466	36	**-0.089 (0.015)**	**-8.47**	**< 0.001**	0.036 (0.019)	3.68	0.059
Myrtle Warbler			0	**-0.097 (0.029)**	**-9.25**	**< 0.001**			
Black-throated Gray Warbler‡	**-2.32**	**0.017**	**62**	**-0.188 (0.065)**	**-17.12**	**0.004**	**-0.092 (0.037)**	**-8.84**	**0.012**
MacGillivray's Warbler	**-2.88**	**0.046**	**51**	**-0.180 (0.036)**	**-16.45**	**< 0.001**	0.024 (0.037)	2.39	0.527
Common Yellowthroat	-1.43	0.087	39	**-0.279 (0.056)**	**-24.34**	**< 0.001**	**0.159 (0.037)**	**17.20**	**< 0.001**
Wilson's Warbler	**-2.08**	**0.002**	**61**	**-0.120 (0.038)**	**-11.35**	**0.001**	0.019 (0.046)	1.89	0.681
Yellow-breasted Chat	-0.94	0.489	27	-0.005 (0.031)	-0.47	0.878	-0.030 (0.033) †	-2.98	0.361
Western Tanager	**3.79**	**< 0.001**	**67**	-0.035 (0.031)	-3.42	0.135	-0.050 (0.039)	-4.83	0.203
Spotted Towhee	0.9	0.314	67	**0.073 (0.015)**	**7.60**	**< 0.001**	0.010 (0.016)	0.95	0.548
Fox Sparrow	-1.91	0.890	***4***	**0.075 (0.017) †**	**7.82**	**< 0.001**	0.016 (0.023)	1.60	0.484
Song Sparrow	**1.73**	**< 0.001**	**65**	**0.032 (0.012)**	**3.25**	**0.008**	0.022 (0.167)	2.20	0.193
Lincoln's Sparrow			0	**-0.118 (0.037)**	**-11.16**	**< 0.001**	0.056 (0.049)	5.78	0.249
Golden-crowned Sparrow			0	**0.049 (0.016)**	**5.06**	**0.002**	0.005 (0.012)	0.54	0.637
Black-headed Grosbeak	**2.39**	**0.029**	**69**	-0.013 (0.038)	-1.30	0.731	-0.085 (0.044) †	-8.11	0.054
Purple Finch	**-2.18**	**0.035**	**65**	**-0.207 (0.042)**	**-18.68**	**< 0.001**	0.045 (0.028)	4.63	0.104
Lesser Goldfinch‡	**3.76**	**0.031**	**33**	-0.130 (0.090)	-12.23	0.146	**0.074 (0.029)**	**7.65**	**0.011**

†Poisson GLMs for which we included a log-based offset to account for positive correlations ($P < 0.10$) between effort and capture totals.
‡General population trends of all captures through the entire study period are reported for these species.

Table 5. Correspondence in significant or suggestive (both methods with $P < 0.10$) trends between the Rogue River and Klamath River CEMN stations and the Breeding Bird Survey (Southern Pacific Rainforest strata, 1993-2003).

			Rogue River		Klamath River	
Summer Correspondence			Increasing	Decreasing	Increasing	Decreasing
	BBS	Increasing	0	2	1	0
		Decreasing	0	4	0	1

			Rogue River		Klamath River	
Fall Correspondence			Increasing	Decreasing	Increasing	Decreasing
	BBS	Increasing	1	0	1	1
		Decreasing	1	8	2	2

Table 6. Species that are significantly ($P < 0.05$) or suggestively ($0.05 < P < 0.10$) decreasing or increasing both on the BBS (Southern Pacific Rainforest strata 1993-2003) and at the Rogue River and/or Klamath River CEMN stations.

	Species	CEMN station(s) showing trend
Breeding/Resident Decreasing	Bushtit	Rogue
	Orange-crowned Warbler	Rogue
	MacGillivray's Warbler	Rogue
	Purple Finch	Rogue / Klamath
Breeding/Resident Increasing	Western Tanager	Klamath
Migratory/General Decreasing	Swainson's Thrush†	Rogue / Klamath
	Orange-crowned Warbler	Rogue
	Nashville Warbler†	Rogue
	Black-throated Gray Warbler	Rogue / Klamath
	Wilson's Warbler	Rogue
	Common Yellowthroat†‡	Rogue
	MacGillivray's Warbler	Rogue
	Purple Finch	Rogue
Migratory/General Increasing	Song Sparrow	Rogue
	Lesser Goldfinch	Klamath

†Species for which the BBS trend has $0.05 < P < 0.10$.
‡Common Yellowthroat is significantly increasing during fall at the Klamath River site.

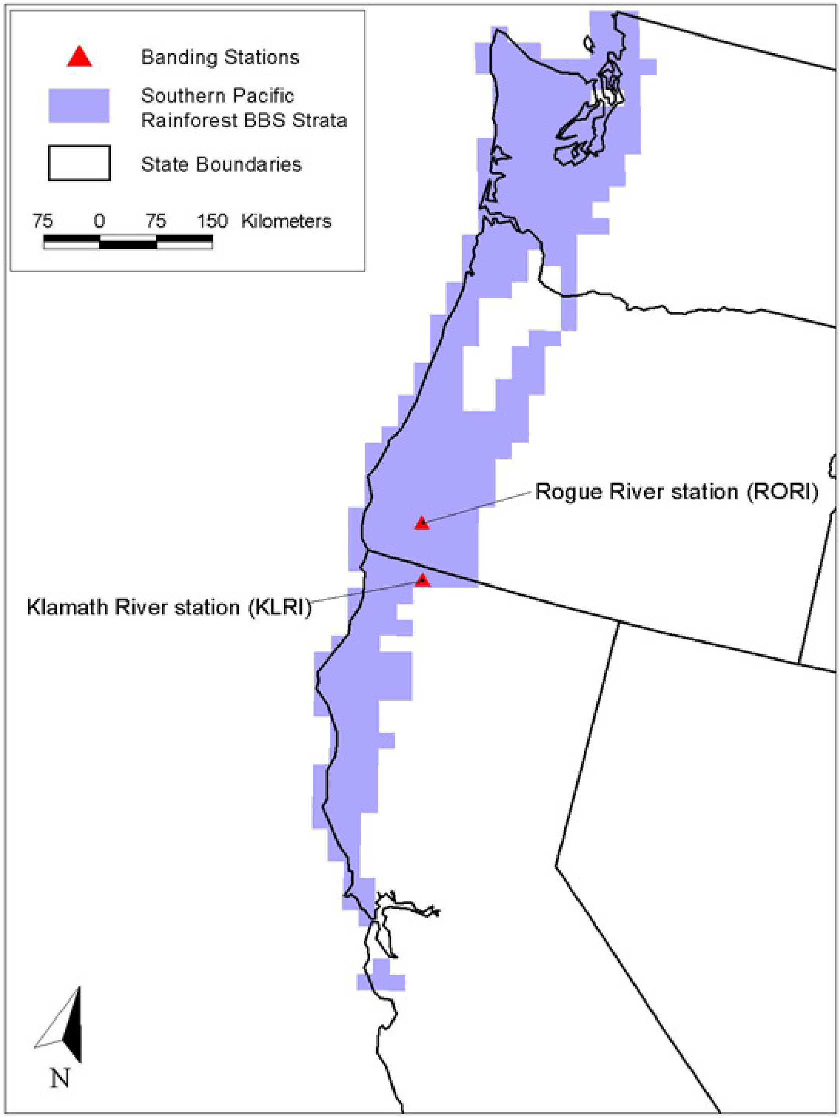


Figure 1. Locations of the Rogue River and Klamath River banding stations as well as the Southern Pacific Rainforest physiographic strata in Oregon and California.

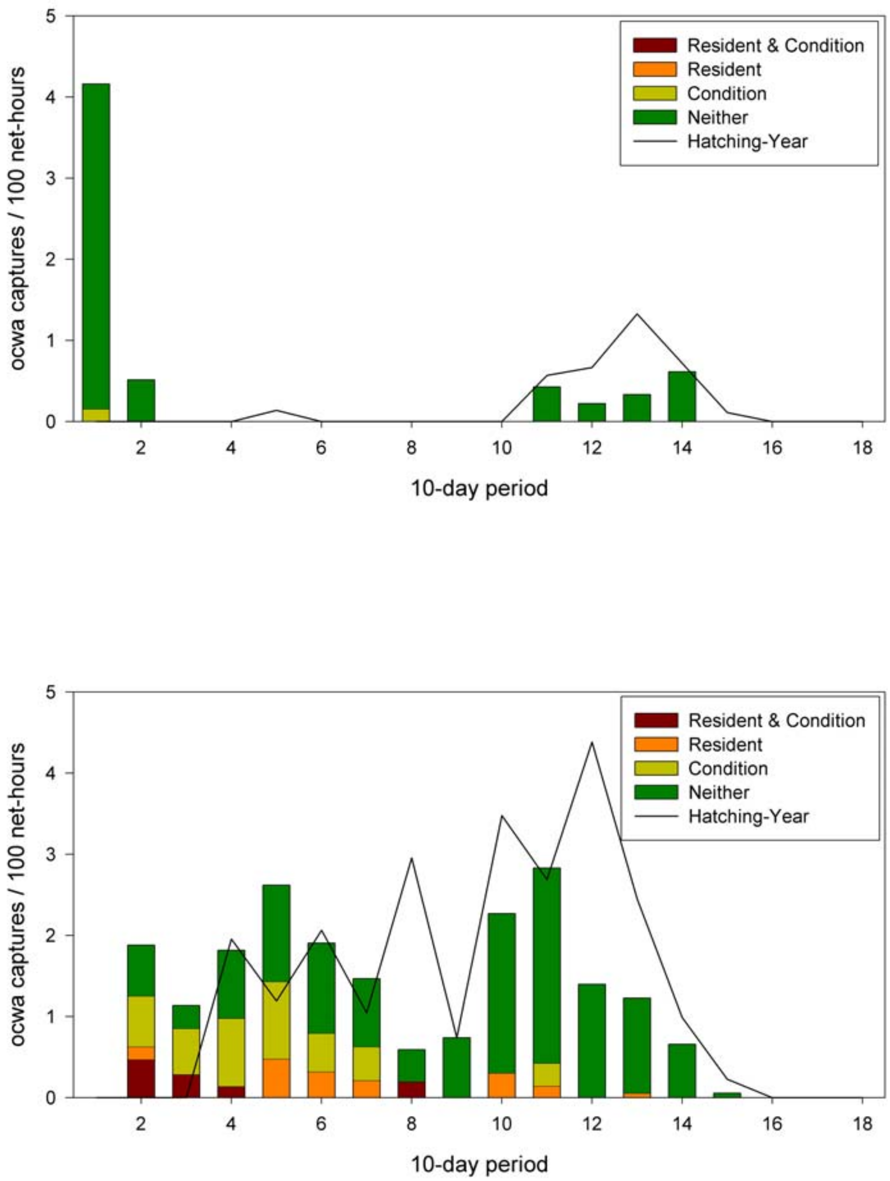
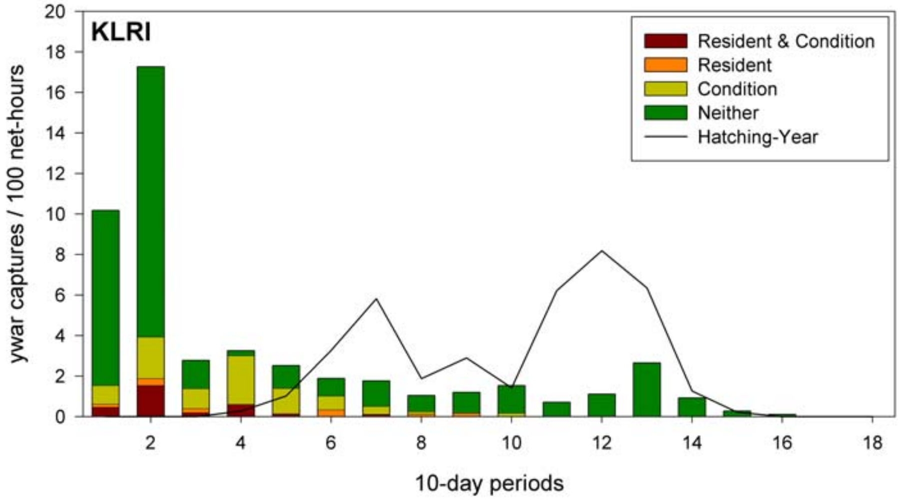


Figure 2. Capture rates of Orange-crowned Warbler for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



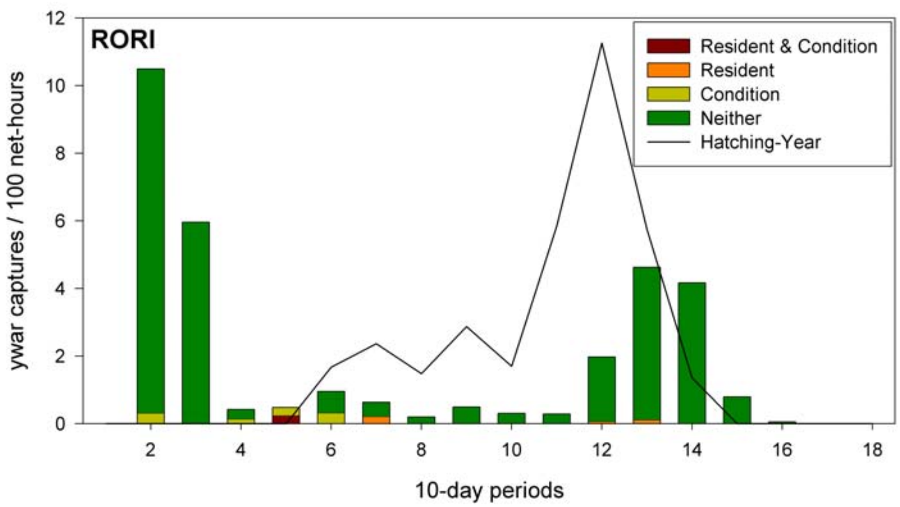
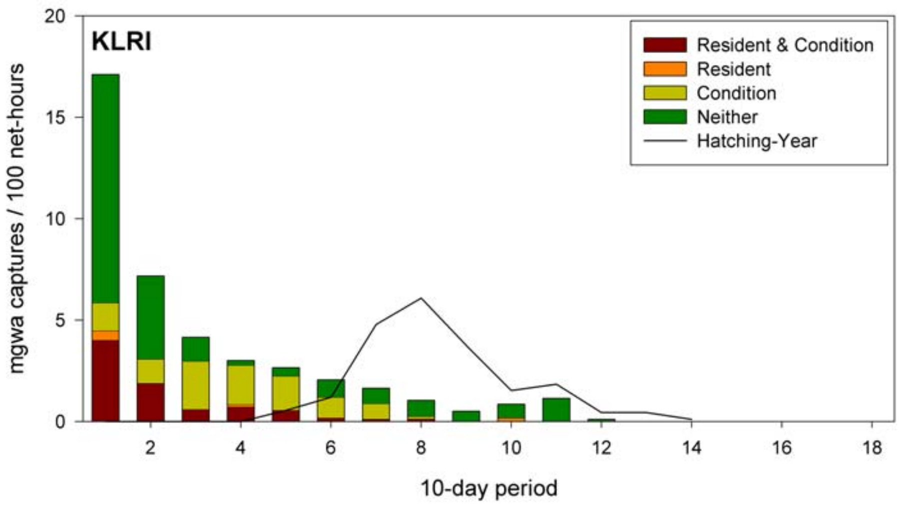


Figure 3. Capture rates of Yellow Warbler for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



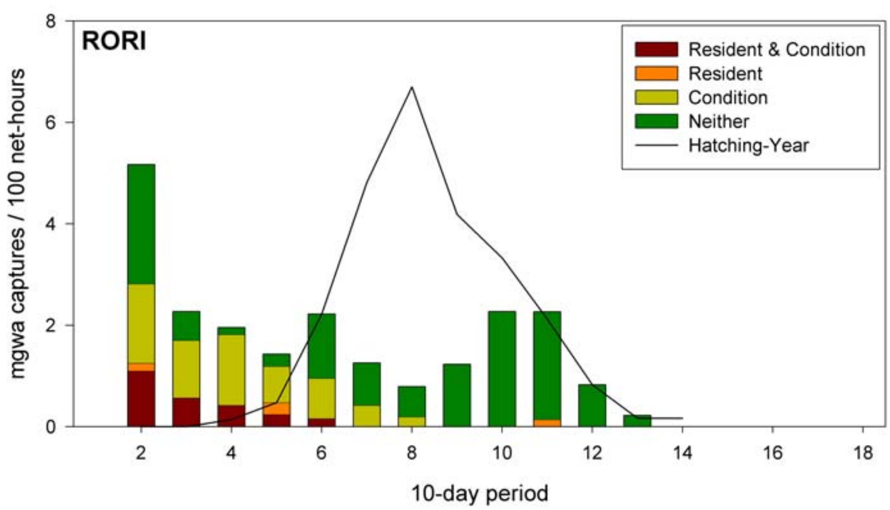
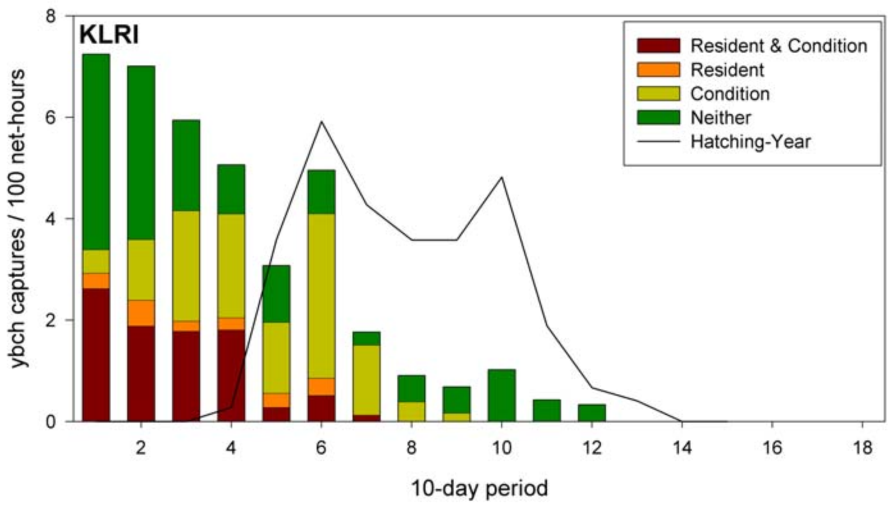


Figure 4. Capture rates of MacGillivray's Warbler for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



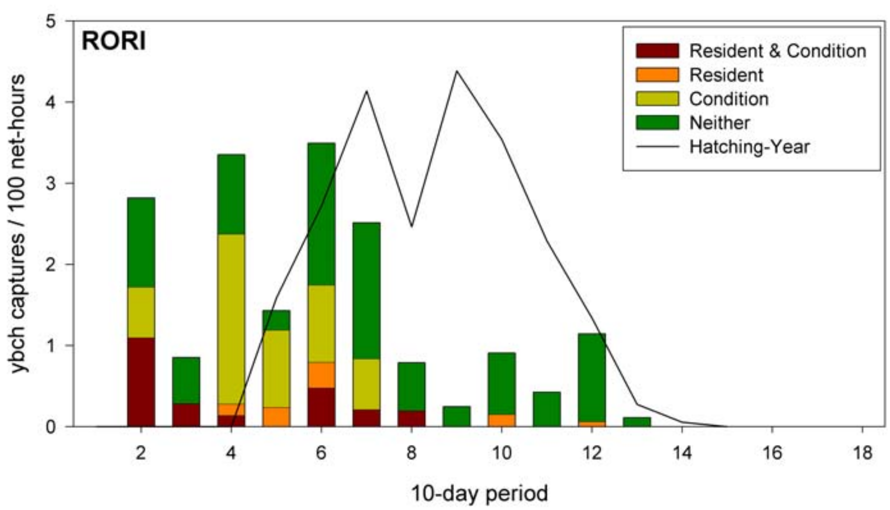
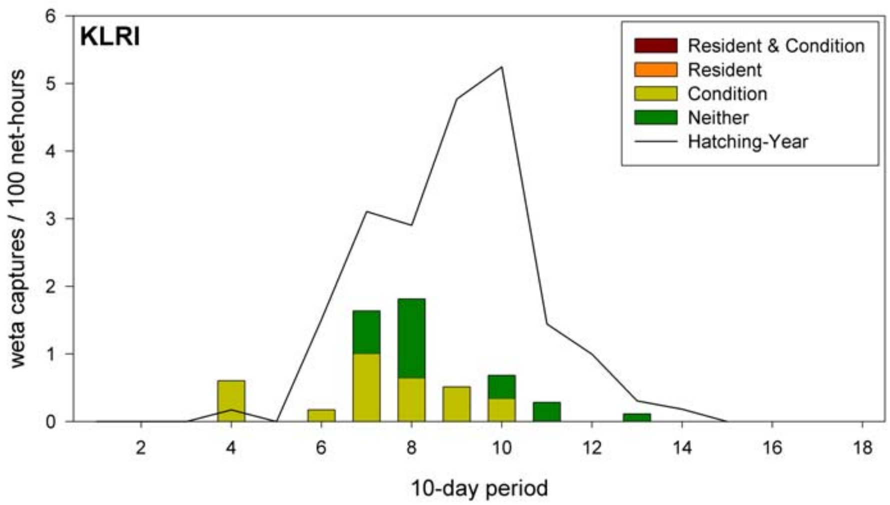


Figure 5. Capture rates of Yellow-breasted Chat for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



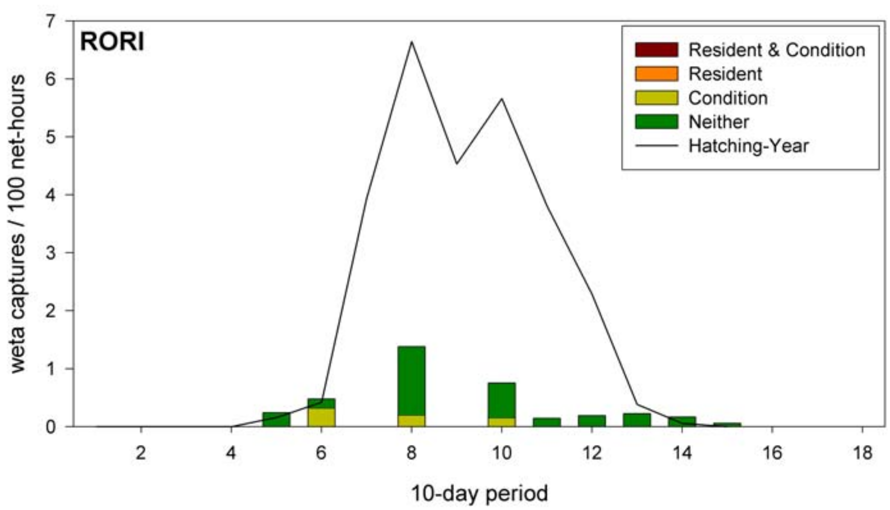
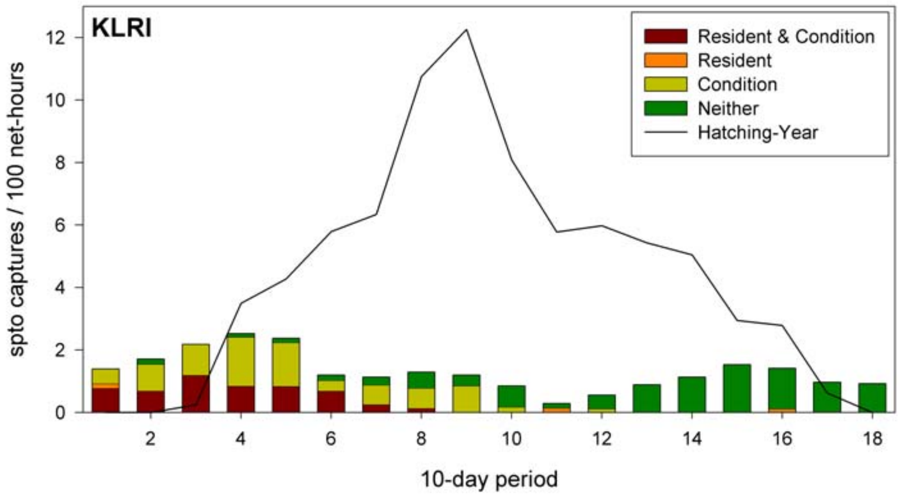


Figure 6. Capture rates of Western Tanager for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



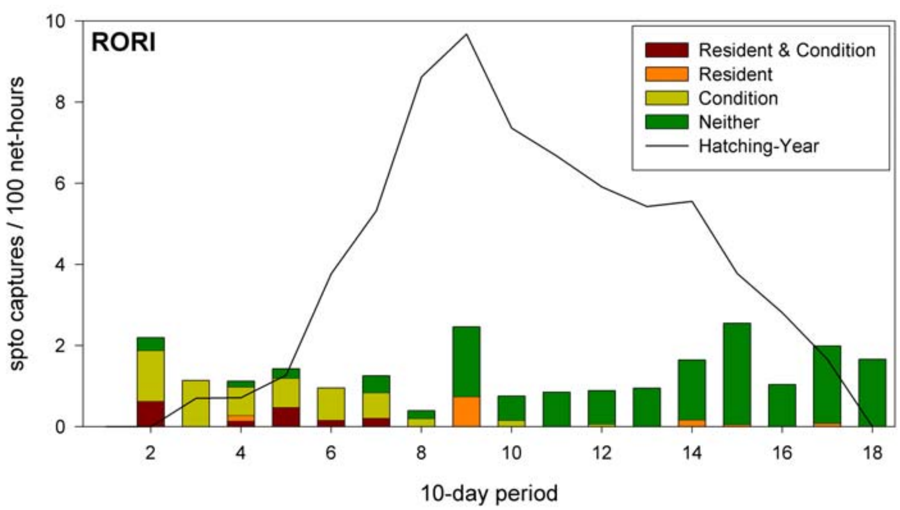


Figure 7. Capture rates of Spotted Towhee for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.

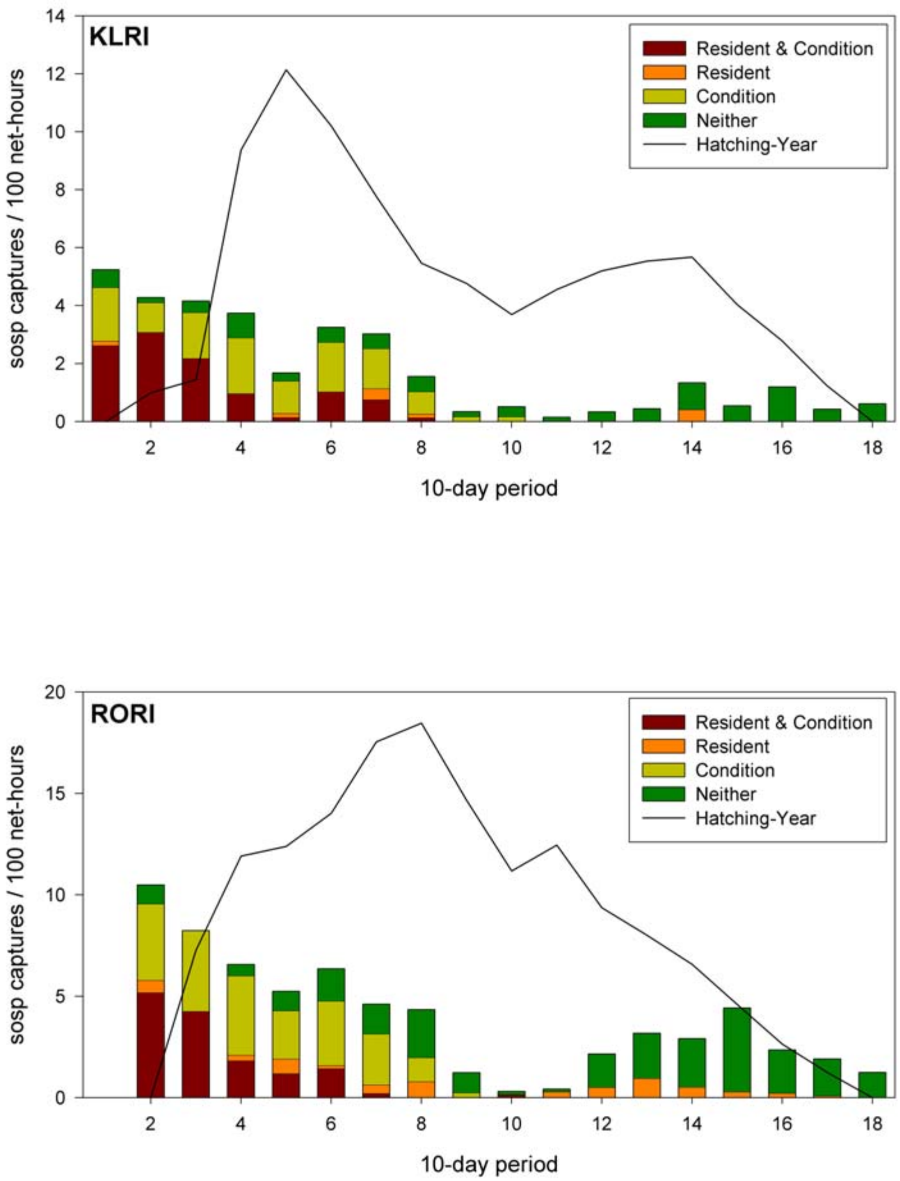
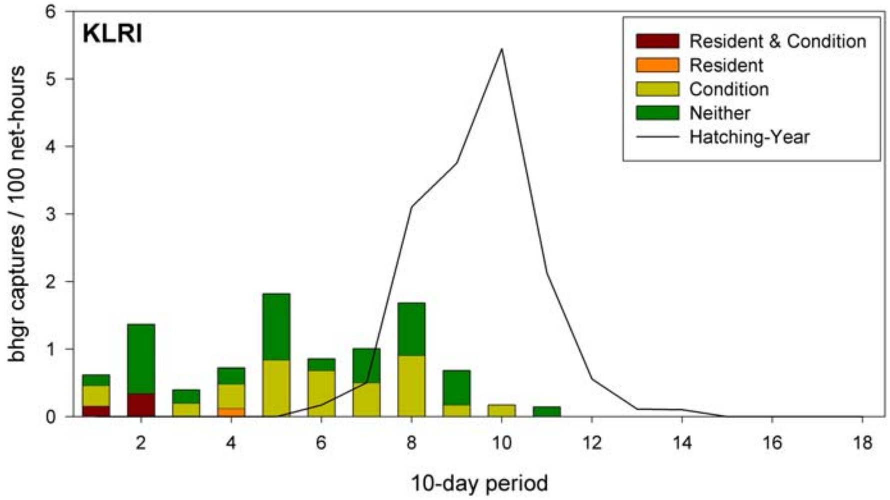


Figure 8. Capture rates of Song Sparrow for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



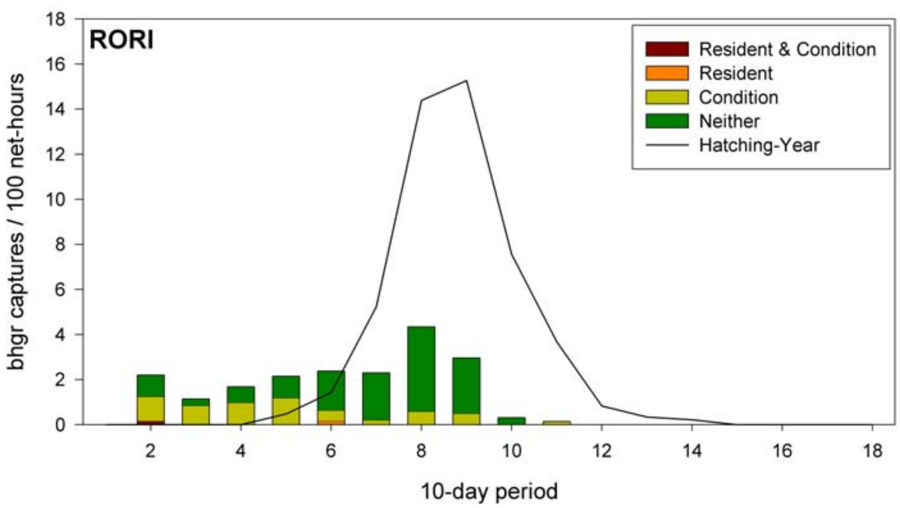
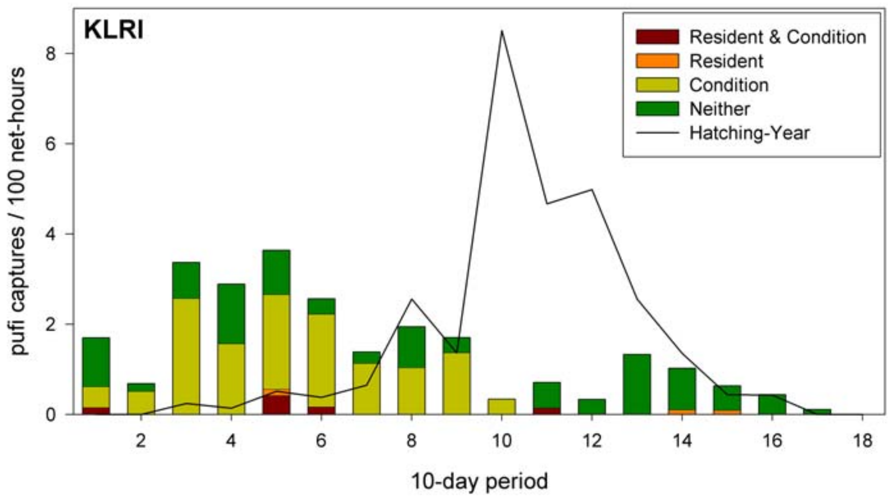


Figure 9. Capture rates of Black-headed Grosbeak for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.



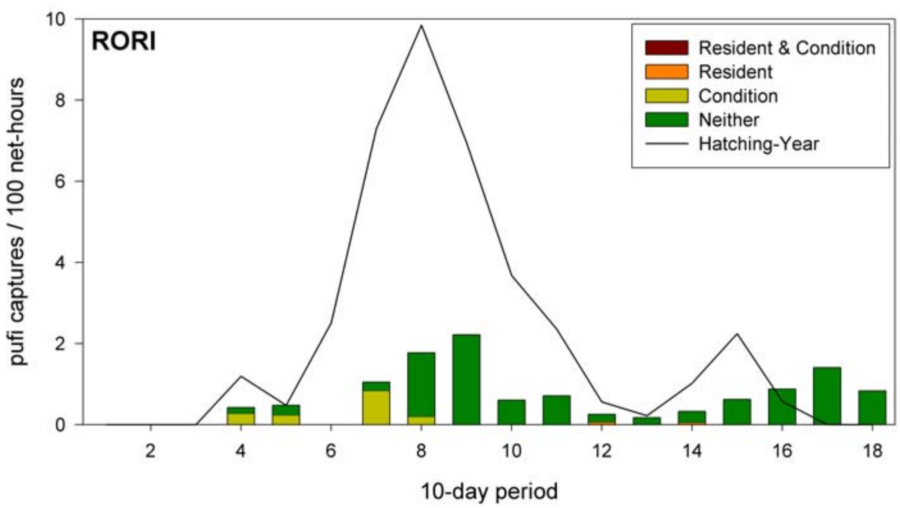


Figure 10. Capture rates of Purple Finch for each 10-day period (see Table 1 for corresponding dates) at the Klamath River (KLRI) and Rogue River (RORI) banding stations. The stacked color bars represent capture rates of birds that were: resident (captured > 7 days apart), in high breeding condition, both, or neither. The graphed line represents capture rates of hatching-year birds.

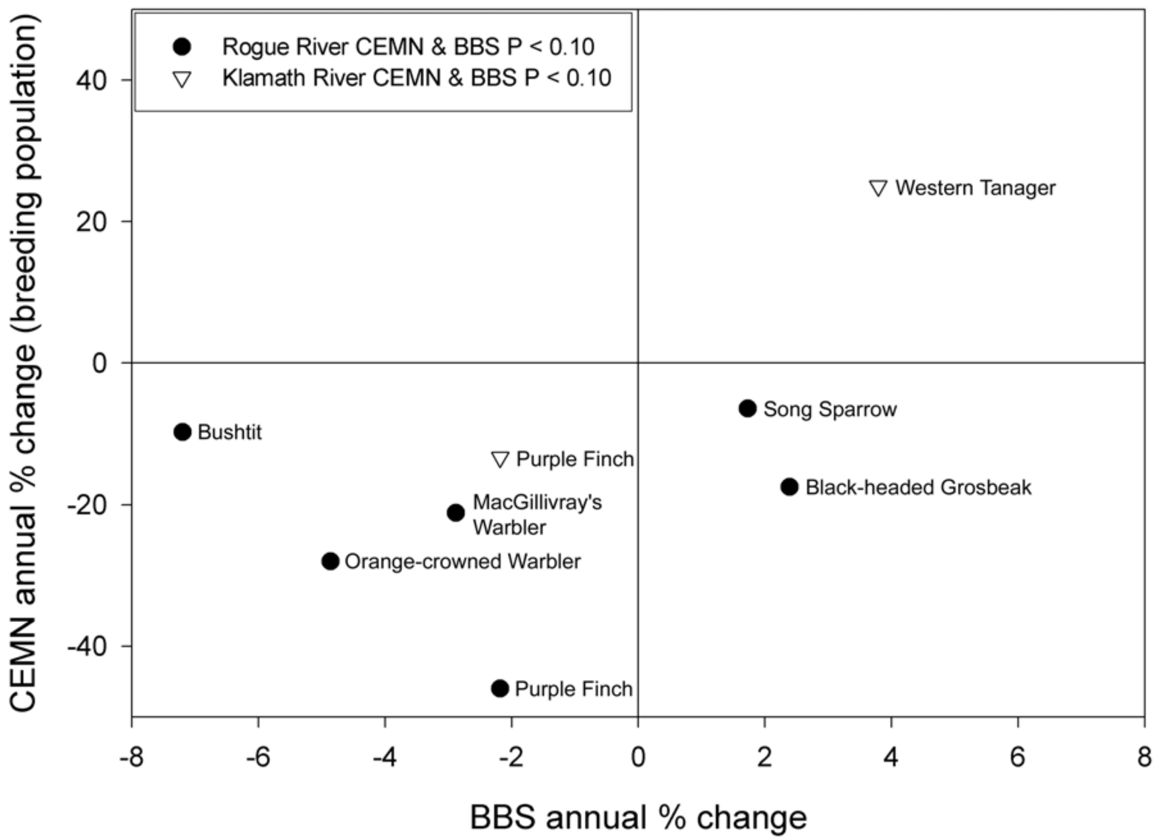


Figure 11. Correspondence of significant and suggestive ($P < 0.10$) trends in breeding populations from constant-effort mist netting (CEMN) at the Rogue River and Klamath River banding stations (Table 3) with Breeding Bird Survey (BBS) for the Southern Pacific Rainforest (1993-2003).

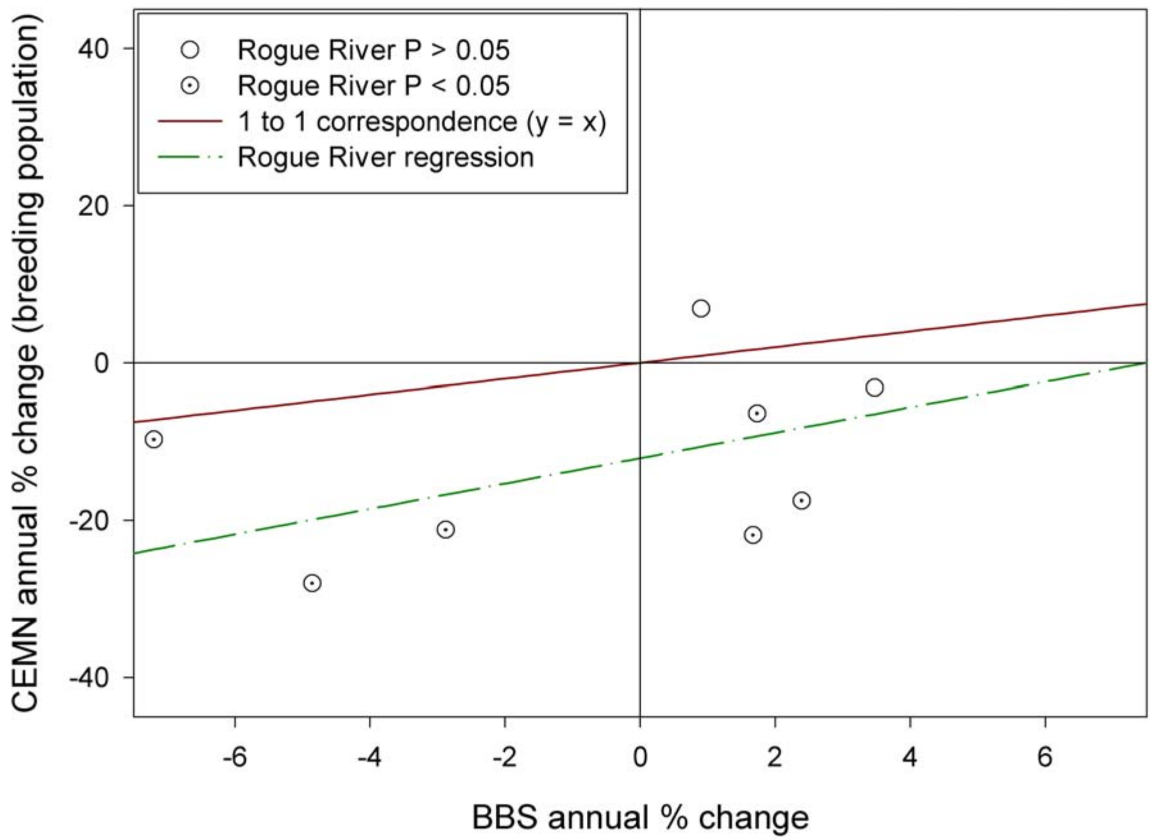


Figure 12. Correspondence of trends in breeding populations at the Rogue River banding station (Table 3) with BBS trends for the Southern Pacific Rainforest (1993-2003). The red line represents 1 to 1 correspondence (y = x). Rogue River regression statistics: $F_{1,9} = 1.15$, $R^2 = 0.113$, $P = 0.3117$.

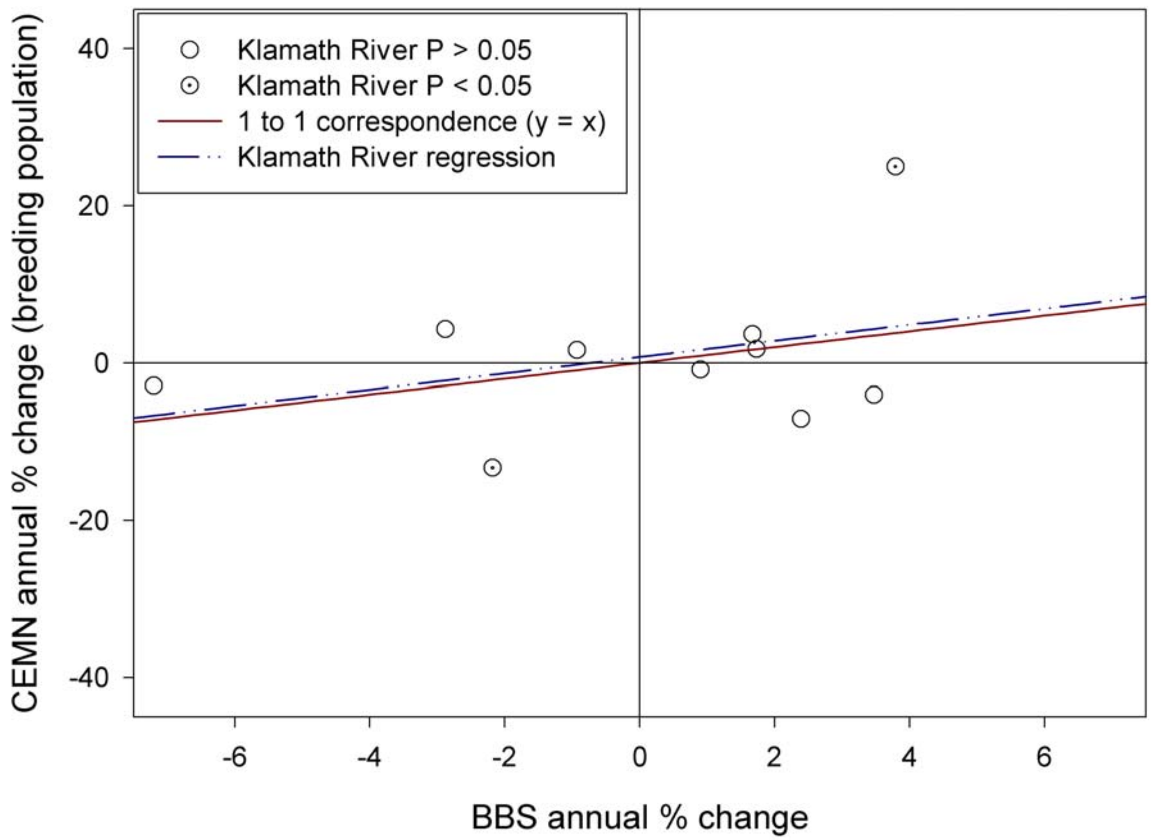


Figure 13. Correspondence of trends in breeding populations at the Klamath River banding station (Table 3) with BBS trends for the Southern Pacific Rainforest (1993-2003). The red line represents 1 to 1 correspondence. Klamath River regression statistics: $F_{1,9} = 1.11$, $R^2 = 0.1216$, $P = 0.3234$.

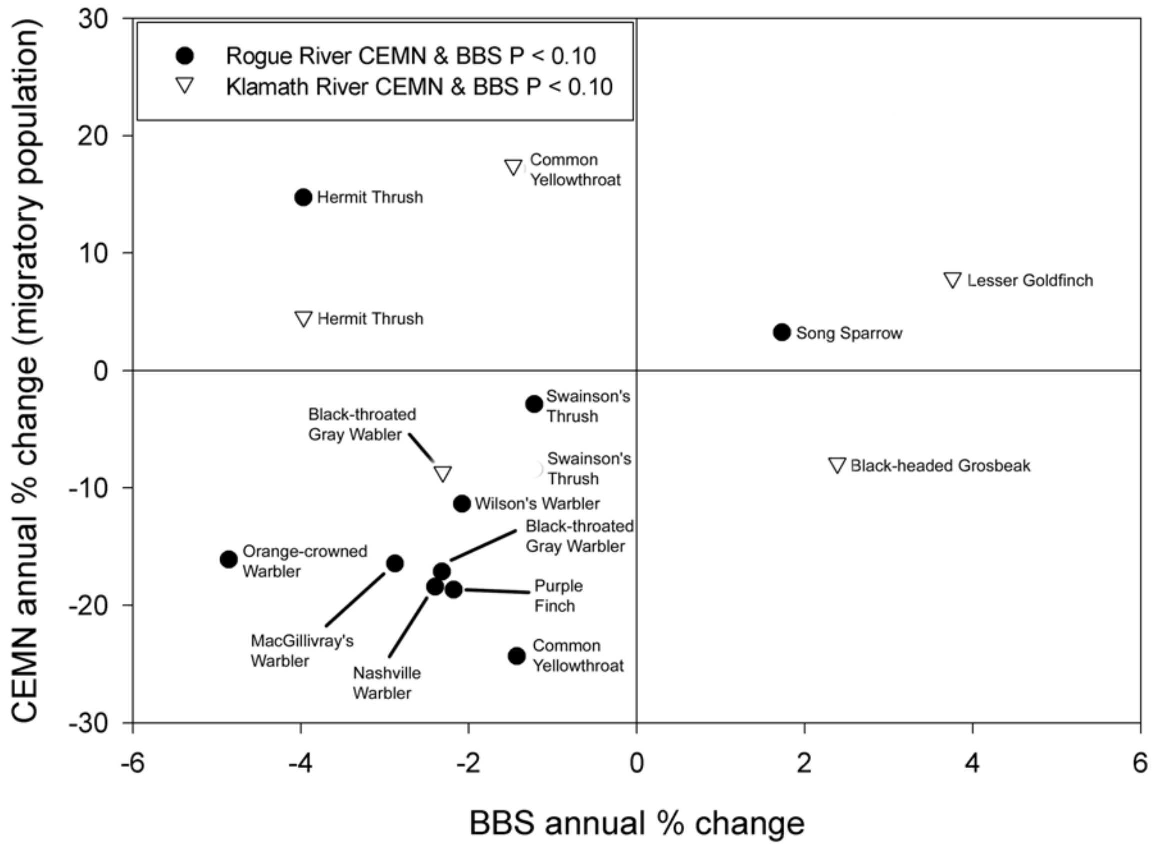


Figure 14. Correspondence of significant and suggestive ($P < 0.10$) trends in migratory populations from constant-effort mist netting (CEMN) at the Rogue River and Klamath River banding stations (Table 4) with Breeding Bird Survey (BBS) trends for the Southern Pacific Rainforest (1993-2003).

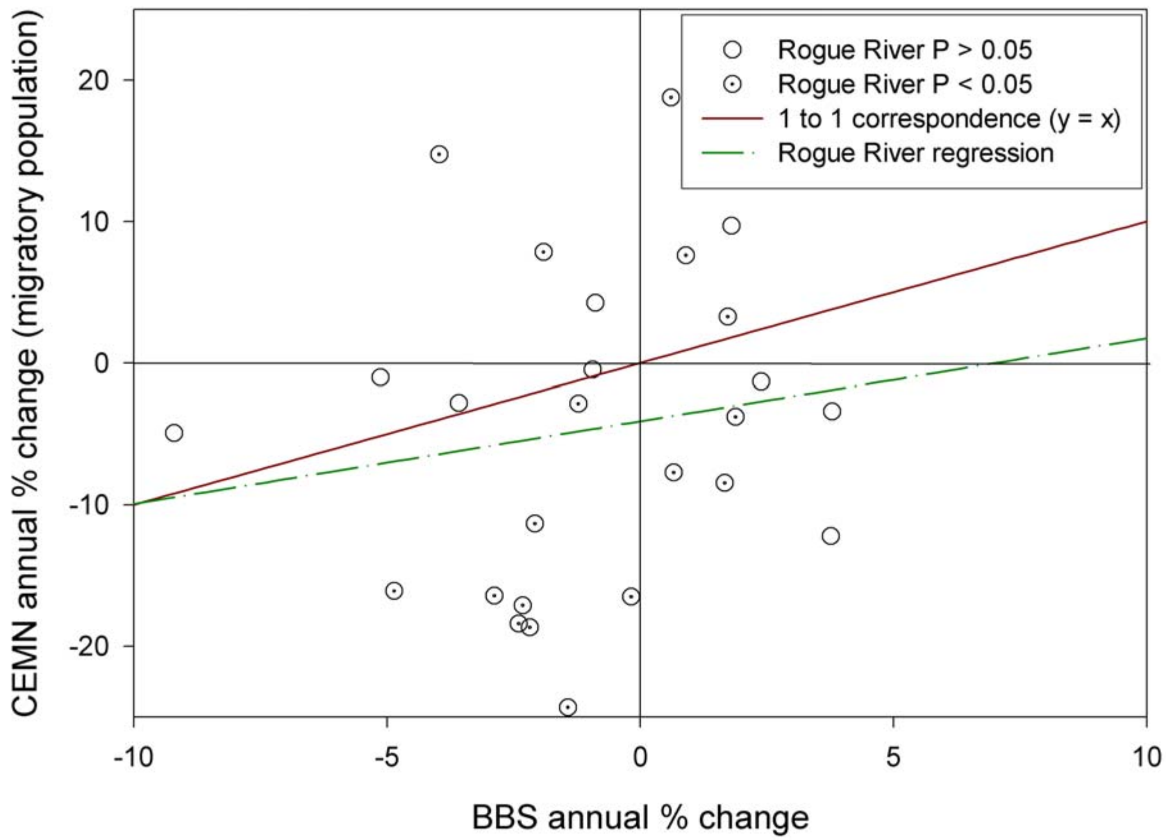


Figure 15. Correspondence of trends in fall total captures of bird species at the Rogue River banding station (Table 4) with BBS trends for the Southern Pacific Rainforest (1993-2003). The red line represents 1 to 1 correspondence. Rogue River regression statistics: $F_{1,24} = 0.60$, $R^2 = 0.0246$, $P = 0.4444$.

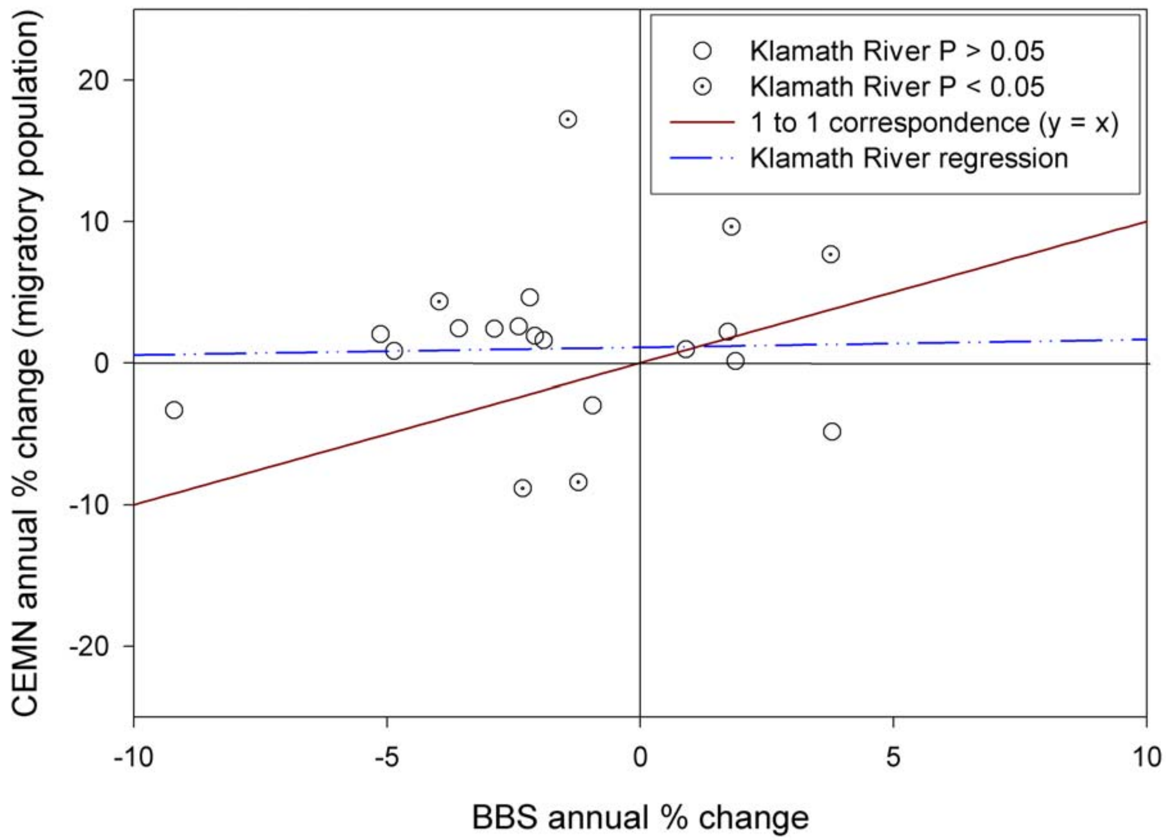


Figure 16. Correspondence of trends in fall total captures of bird species at the Klamath River banding station (Table 4) with BBS trends for the Southern Pacific Rainforest (1993-2003). The red line represents 1 to 1 correspondence. Klamath River regression statistics: $F_{1,23} = 0.02$, $R^2 = 0.0008$, $P = 0.8959$.