AVIAN COMMUNITY COMPOSITION IN RESPONSE TO RAPID VEGETATION CHANGES OVER TIME IN NORTHERN NEW MEXICO

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ABSTRACT.---Passerine populations and community composition were determined over a 16-year period (1997 through 2012) and over two major landscape changes within Los Alamos National Laboratory, New Mexico, USA. The Cerro Grande wildfire in 2000 and the drought-driven bark beetle (*Dendroctonus* spp.) infestation in 2002 altered the site from ponderosa pine (*Pinus ponderosa*) woodland to a more piñon pine (*Pinus edulis*.) and oneseed juniper (*Juniperus monosperma*.) woodland with some open grassland. With the completion of 170 mist-netting sessions, captured birds were identified, measured, and banded from May through August. A total of 2,341 captures and recaptures, representing 75 species, were banded. Overall, compared to avian population trends across North America, the avian populations at Los Alamos are not showing population reductions. However, the variability in bird populations seen during this monitoring project is likely driven by regional climatic factors and seasonal variation.

Keys words: *avian communities, drought, vegetation change, climate*, *habitat*

Increased environmental variability is a projected result of global climate change, and the associated effects on the biosphere are not yet well understood. Nonetheless, there is compelling evidence that recent climate change has already begun to impact wildlife populations (Melles et al. 2011; Cockrem 2013; Slobodnik et al. 2013). For bird populations, breeding phenology (Carey 2009), migratory patterns (Bridge et al. 2010), and increases in infectious diseases (Fuller et al 2012) are altered by increased variability in climatic conditions. However, empirical data for determining the specific population demographic consequences of such changes remain elusive (Jiguet et al. 2010) and most recent studies of the impacts of climate change on bird distributions depend largely on predictive modeling. These models require validation with long-term biologically relevant data (Forchhammer and Post 2004). For example, how do avian communities respond to rapid environmental and vegetation changes? Will this result in more productivity or higher survival rates? In order to answer these questions, we need to understand the community dynamics in response to environmental and habitat changes over time. Fitness in changing environments must balance the benefits and costs of all developmental, physiological, or behavioral attributes that a species or population exhibits.

Environmental conditions and rapid, large-scale environmental changes can limit populations. For example, regional droughts have far-reaching, substantial, and easily recognizable impacts on populations (George et al. 1992) and the environment (Allen and Breshears 1998). Based on current trends in tree mortality in the study area and the south western United States (McDowell et al 2010, 2011), in general, the change in general habitat at this study area and many areas essential to bird populations will likely increase more rapidly in the future. As climate change increases the frequency and severity of drought in many regions, there may be an increased vulnerability of populations to disease accompanied by more frequent disease

epidemics; emerging diseases have enormous potential to cause declines or localized extinction of populations.

Using standardized and widely-approved census methods to measure the abundance of wild birds is critical for estimating impacts of rapid environmental change on populations.

The Monitoring Avian Productivity and Survivorship (MAPS) program uses standardized procedures for measuring wild bird populations. Through a cooperative network of bird-banding stations operated throughout the United States, Canada, and Mexico, MAPS uses standardized procedures with analysis methodologies to estimate long-term trends in avian survivorship. All stations are operated during the summer breeding season with the principal purpose of documenting use of breeding habitat by birds throughout North America. The data are collected and analyzed by the Institute for Bird Populations (IBP). IBP then establishes a set of guidelines and protocol for all MAPS stations (DeSante et al. 2002). Data from all the stations are compared and long-term trends for many bird species are monitored on a continent-wide basis.

The MAPS program divides the continent into eight major regions based on bio-geographical and meteorological considerations. Los Alamos National Laboratory (LANL) falls into the Southwest region. During the early establishment of the MAPS program, the IBP designated which Neotropical migrants, based on expert opinion, were expected to be the most common (i.e., providing enough data to allow statistically robust inferences to be made) or of highest monitoring priority in this region. Over time, with many additional stations and improved statistical techniques, the IBP has been able to calculate survivorship estimates for 192 species, 91 of which are found in the Southwest region (DeSante and Kaschube 2009).

In 1999, LANL set up a MAPS station with the objective of the monitoring the possible effects on songbird population demographics in this general area.

METHODS

Study Area.---LANL is located in north-central New Mexico and encompasses approximately 112 km^2. The study site located within LANL consisted of 12 mist-nets deployed along the edge of Cañon de Valle in Los Alamos County, New Mexico. This netting area is currently comprised primarily of piñon pine (*Pinus edulis*) and oneseed juniper woodland (*Juniperus monosperma*) interspersed with shrubs 1 to 3 m tall with the majority being Gambel's oak (*Quercus gambelii*) and mountain mahogany (*Cercocarpus montanus*). The study site is located on the north side of Cañon de Valle, an east-west oriented canyon in the center of LANL. The banding station used 12 12-m-long mist-nets with 30 mm mesh. Net locations were placed strategically to maximize the number of birds captured (Bub 1996). A standard U. S. Geological Survey numbered band was put on each bird. The size of the band followed the requirements in the Bird Banding Manual (Gustafson et al. 1997). All birds were identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. The aging and sexing criteria were based on Pyle (1997). The times that nets were opened and closed were also recorded.

With few exceptions, all birds captured at LANL were identified to species, age, and sex. Effort data (i.e., the number and timing of net hours on each day of operation) were also collected in a standardized manner. To allow constant effort comparisons of data, the times of opening and closing the array of mist nets and of beginning each net check were recorded to the nearest 10 min. The breeding (summer residency) status (confirmed breeder, likely breeder, non-breeder) of each species captured at the station was determined. Several species that indicate changes in habitat like the Blue-gray Gnatcatcher (*Polioptila caerulea*), Rock Wren (*Salpinctes obsoletus*), and the white winged dove (*Zenaida asiatica*) have begun to be captured as the project continues.

The MAPS protocol requires stations to operate once during every 10-day period between May and August, for a total of 10 periods each year (De Sante et al. 2002). Banding operations took place on 10 mornings between 1 May and 8 August of each year. The nets were opened before local sunrise and closed between 11:30 a.m. and 12:00 p.m. for a period of 5.5 hr per netting session.

Data Entry and Verification.---All banding data were run through a series of verification programs by IBP biologists using custom data entry programs that cross-check all data and validity of all codes. Any discrepancies or suspicious data identified by any of these programs were examined manually and corrected if necessary. Wing chord, weight, station of capture, date, and any pertinent notes are used as supplementary information for the correct determination of species, age, and sex in all of these verification processes.

Adult Population Indices and Productivity Analyses.---The proofed, verified, and corrected banding data from all 16 years were run through a series of analysis programs that calculated for each species:

- The mean numbers and capture rates (per 600 net-hrs) of first captures (in a given year) of individual adult and young birds. Following the procedures pioneered by the British Trust for Ornithology in their constant effort site Scheme (Peach et al. 1996), we used the number of adult birds captured as an index of adult population size.
- The mean reproductive index (RI). For each species each year, we calculated a yearly reproductive index as the number of average young for that species divided by the number of adults. Years for which the reproductive index was undefined for a species, i.e., no adults of that species were captured in that year, are not included in the mean reproductive index for that species.

Analyses of Trends in Adult Population Size and Productivity.---We estimated trends in adult capture rates of adult and young birds and RI with linear regression. We report the slope of the regression (β – for capture rates this is an estimate of the change in numbers of birds per 600 net-hrs per year), standard error of β (*SE*), correlation coefficient (r), and significance of the correlation (*P*-value). Throughout this report, we use an alpha level of 0.05 for statistical significance and we use the term "near-significant" or "nearly significant" for 0.05 with a $P < 0.10$. Trends using constant effort "chain" indices, the typical method of analyzing trends in MAPS/constant effort data, could not be calculated because many species had zero captures in one of the 16 sampling years, which precludes using chained indices methodology. However, because of the consistency of sampling effort in all other years, it was reasonable to use the change in annual numbers of birds per 600 net-hrs to determine trends in adult population size. Trends in productivity are presented for those species for which a trend in adults was calculated.

Survivorship Analyses.---Using the computer program TMSURVIV (White 1983, Hines et al. 2003), we calculated, for each target species, maximum-likelihood estimates and *SEs* for adult survival probability, adult recapture probability, and the proportion of residents among newly-captured adults using a time-constant, between- and within-year transient model (Pradel et al. 1997, Nott et al. 2002, Hines et al. 2003). The use of the transient model accounts for the existence of transient adults (dispersing and floater individuals only captured once) in the sample of newly-captured birds, and provides survival estimates that are unbiased with respect to these transient individuals (Pradel et al. 1997).

Apparent survival rate is defined as the probability of a bird banded at a given station in a given year surviving to the next year and remaining at the same station. Recapture probability is defined as the conditional probability of recapturing a bird at a station in a subsequent year that

was banded at the station in a previous year, given that it survived and remained at the station at which it was originally banded. The presence of transient individuals (dispersing, 'floating', and late or early migrating individuals) in the sample of newly-captured birds tends to bias apparent survival rates and/or recapture probabilities low, because they are only captured once and never recaptured. We used a version of the Cormack-Jolly-Seber model (ad hoc robust design model) that reduces bias and increases precision of adult apparent survival-rate estimates by effectively eliminating these birds from the sample (Nott et al. 2002, Hines et al. 2003).

We considered 10 target species for which an average of 2.0 adult birds were captured over the 16 years of sampling (1997–2012—32 year-unique captures) and for which we recorded at least two between-year recaptures. Although 16 years of data would allow us to consider all possible combinations of both time-constant and time-dependent models for each of the two parameters estimated from the transient model, we limited our consideration to time-constant models that produced estimates for both survival and recapture probability that were neither 0 nor 1.

The Shannon's diversity index (*H*) (Shannon 1948) was used to examine species diversity by year. This diversity index is a popular measure in ecology that is used to describe both the species richness and relative abundance of each species in a community. The Shannon's *H* can range from 0.0 to 4.6, where larger values represent increasing diversity. *H* is calculated using the following formula:

$$H = -1\ (\mathrm{pi}\ (\ln\ (\mathrm{pi}))$$

Where pi is a percentage value of a specific species in the total population and ln is the natural log.

Another useful measure is the Shannon's equitability estimate (*EH*) which is a measure of evenness in the population. This measure ranges from 0 to 1 where one represents a

completely even community in which all of the species' abundances are equal. The Shannon's *EH* is calculated using the following formula:

$$EH = H/\ln S$$

Where S is species count, ln is the natural log, and *H* is the Shannon's diversity index.

The Shannon's indices between years were compared using bootstrapping techniques with a 1,000 sample permutation.

Each of the species banded in this project was categorized using Ehrlich et al. (1988) to determine the food preference, method of hunting, and nesting substrate. How each species makes its living can give insight to changes in habitat and general environmental changes. Birds were grouped into one of four diet classifications, primary habitat type used, type of foraging behavior, and nesting type, for further analysis. The classifications were based on the birders handbook (Ehrlich et al. 1988). The four diet classifications were 1) insectivores, where diet consists primarily of insects; 2) nectarivores, where diet consists primarily of nectar; 3) omnivores, where the diet is split evenly between the seed and insect eaters and; 4) granivores, where diet consists primarily of grains. The six primary habitat type classifications were 1) forest, primary area of activity in ponderosa/conifer forest; 2) grassland, primary area of activity in open grassy areas; 3) mountains, primary area of activity in cliffs and areas of bare rock; 4) open woodland, primary area of activity in areas such as piñon juniper woodland; 5) scrub, primary area of activity in scrub margins between woodlands and grasslands and; 6) town, primary area of activity around buildings and roads. The five foraging behavior classifications were 1) bark foraging, eating insects of the bark and branches of trees and bushes; 2) flycatching, eating insects while flying or capturing from a perch; 3) foliage forager, eats insects of the leaves of trees and shrubs and; 4) ground forager, eats insects and seeds off of the ground and between the roots of vegetation.

RESULTS

During the summer of 2000, a major fire, in addition to long-term drought conditions, had a major effect on the habitat at the netting location. A total of 1,564 conifer trees were recorded within 20 hectares of the net locations. Of those trees, 35.1% died between 2000 and 2013 primarily of bark beetle infestation related to the drought years in 2001 and 2002 (Fig. 1).

A total of 2,341 captures of 75 species were made during the MAPS season at LANL between 1997 and 2012. There were 1,992 new bandings of individuals, 85% of the total captures.

Mean Indices of Adult Population Size and Post-fledging Productivity.---Mean annual numbers (per 600 net-hrs) of individual adult and young birds and the reproductive index for each species and for all species pooled, are presented in Table 1 for all years the station operated.

The most abundant species at the LANL station, with overall capture rates greater than 2.0 adults/600 net-hrs were, in descending order: Chipping Sparrow (*Spizella passerine*), Virginia's Warbler (*Oreothlypis virginiae*), Western Tanager (*Piranga ludoviciana*), Spotted Towhee (*Pipilo maculatus*), Western Bluebird (*Sialia Mexicana*), Rock Wren , Yellow-rumped Warbler (*Dendroica coronate*), Ash-throated Flycatcher (*Myiarchus cinerascens*), Bushtit (*Psaltriparus minimus*), and Gray Flycatcher (*Empidonax wrightii*). Total species richness for banded birds was 75 species, while the mean number of adults captured was 83.5 per 600 net-hrs, and the mean reproductive index was 0.28 young per adult over the entire period.

Multi-year Trends in Adult Population Size.---Sixteen-year (1997-2012) population trends for 10 species and all species pooled are shown in Fig. 2. Number of adult individuals captured per 600 net-hrs was used as the measure of population size for species which were regular or usual breeders and summer residents at the station. The slope of the linear regression

line was used as the measure of the population trend, and it and the standard error of the slope (in parentheses) are presented on each graph. The correlation coefficient (r), and the significance of the correlation (p), are included for each target species and for all species pooled on each graph.

There were no substantially declining species ($r \leq -0.3$) with significant ($P < 0.05$) trends. Ash-throated Flycatcher showed a substantially increasing trend ($r \geq 0.3$) that was non-significant and Spotted Towhee showed a substantially increasing trend ($r \geq 0.3$) that was highly significant ($P < 0.01$). Populations of Rock Wren showed a non-substantial (absolute $r < 0.3$) trend. All nine species showed substantially fluctuating trends (*SE* of the slope ≥ 0.021). The 16-year trend of all species pooled represented a nearly-substantial ($r = 0.277$), highly fluctuating but not significant ($P = 0.300$) increasing population trend. The year 2005 shows as an outlier, driven by extremely high capture rates of adult Western Tanagers, and with the removal of the Western Tanager data the population trend remains becomes substantial (r=0.398), but is still not significant (P=0.126).

Multi-year Trends in Productivity.---Sixteen-year (1997-2012) productivity trends for 10 species and all species pooled are shown in Fig. 3. The productivity index was defined as the number of young per adult in each year for species which were regular or usual breeders and summer residents at the station. The slope of the regression line was used as the measure of the productivity trend. The slope, the standard error of the slope (in parentheses), the correlation coefficient (r) and significance of the correlation coefficient (p) are shown on each graph.

No species showed a substantially declining productivity trend ($r \leq -0.3$). Western Wood-Pewee (*Contopus sordidulus*), White-breasted Nuthatch (*Sitta carolinensis*), Chipping Sparrow, and House Finch (*Carpodacus mexicanus*) showed substantially increasing trends ($r \geq 0.3$). The trend was significant for Chipping Sparrow ($p < 0.05$) and nearly significant ($0.05 < p < 0.10$) for

House Finch. Populations of Rock Wren, Western Bluebird, and Spotted Towhee showed non-substantial (absolute $r < 0.3$) and substantially fluctuating (*SE* of the slope ≥ 0.021) trends, while Ash-throated Flycatcher, Virginia's Warbler, and Western Tanager trends were not substantially fluctuating. The 16-year trend of all species pooled represented an average annual substantial ($r = 0.376$), not substantially fluctuating increase in productivity of 0.015 (*SE* = 0.010) per year.

Estimates of Adult Survivorship.---Estimates of adult survival and recapture probabilities were obtained for six target species breeding at LANL. Maximum-likelihood estimates of annual adult survival probability, recapture probability, and proportion of residents among newly-captured adults from the time-constant transient model are presented in Table 2. Annual adult survival-rate estimates ranged from a low of 0.274 for Western Tanager to a high of 0.709 for White-breasted Nuthatch, with a mean of 0.500 for the six species. The coefficient of variation (CV) for four of the six species at LANL were low (4 of the 6 species < 30% of which 2 species < 20%) indicating quite precise estimates. Furthermore, survival of land birds at LANL appears to be quite good, slightly better for the four well-estimated species than at other MAPS stations in the Southwest MAPS Region (DeSante et al. 2009).

The Shannon Diversity Index.---The Shannon diversity index showed diversity increasing over the years (Table 3). The Shannon's equitability showed that the evenness of the bird communities was similar across the all 16 years. Bootstrap permutations were used to compare the diversity indices between years. The diversity in 2001 was statistically different than 2002 ($p = 0.025$) and between 2008 and 2009 ($p = 0.053$). There were no significant differences between the other years.

DISCUSSION

Results from 16 years of MAPS monitoring at the LANL MAPS station suggest that over all land birds captured at Los Alamos may be faring somewhat better than land bird populations elsewhere in North America. Looking at all species pooled, the number of birds shows an increasing, but not significant, trend through time. Individually only two species, Ash-throated Flycatcher and Spotted Towhee, showed substantial or significantly increasing trends and no species showed significantly declining trends. The trends in productivity have also been generally increasing.

The survivorship values for the most abundant species were also generally higher than for the southwest MAPS region as a whole. For Western Tanager and Spotted Towhee, the survivorship values at Los Alamos were lower than in the region as a whole, but we feel they were not precisely estimated. More years of data could improve the precision of these estimates.

The site has transformed from more of ponderosa pine woodland in 1997 to a piñon juniper woodland with some open grassland following the 2000 Cerro Grande wildfire and sustained drought. This habitat change may have been the driving force behind the increasing population and productivity trends for many species which do well in a more open habitat. This change in habitat would explain the declining productivity estimates for Virginia's Warbler – a ponderosa pine woodland species. The population trend for this species is not yet declining possibly because the falling productivity is balanced by the relatively high survival rate for this species at this station compared to the region as whole.

The MAPS station at LANL continues to provide station-specific indices of adult population size and post-fledging productivity, estimates of annual survival rates of adults, and

important information on annual changes and longer-term trends in these indices and estimates several target species.

After grouping birds into diet classifications, it was apparent that insectivores and granivores peaked in 2005; however, this was due to a highly unusual capture of a large number of Western Tanagers on a single day and has returned to similar levels after the spike. Analyzing foraging guilds during the study had a large spike in foliage and ground forages in 2005 and continued higher. When the birds are classified by habitat type, they have exhibited a slight decrease in number following the 2000 Cerro Grande wildfire; however, scrub habitat and open woodlands species have increased slightly in their use of the area because of the significant change in the habitat at the project location as indicated for the trends shown for the forest and open woodland. Ground foragers and foliage gleaners have been increasing since the 2000 Cerro Grande wildfire which is indicative of the habitat changes occurring at the banding site.

The Palmer Drought Severity Index (PDSI) uses a combination of temperature and precipitation data over several months as indicators of long-term meteorological drought. This index is determined using cumulative values, where negative numbers indicate overall drought stress (low precipitation and high temperature) and positive numbers indicate a lack of stress from drought (high precipitation and low temperatures). In New Mexico, the PDSI values based on a four-month average (May to August) for New Mexico in climate division 2 from 1997 to 2013 were mostly negative (NOAA 2013) (Fig. 4).

This drought severity would account for a large reduction in insects in 2002 and 2012, which would explain why insectivore species decreased in number more dramatically and did not recover as quickly as granivore species. Plants are also affected by drought; however, it takes a longer time for seed production to be affected by drought compared to the more immediate effect

on insects. Insect populations often respond rapidly and dramatically to changes in climatic condition (Rouault et al. 2006). Whether the driver is global or cyclic regional drought, the trend towards hotter, drier summers over the period of record is apparent. Population levels tend to follow the limited precipitation in this area. Corresponding with the PDSI, the average precipitation of 2.4 km from the banding site at a LANL meteorological tower was significantly lower (Fig. 5) that than the average of 48.13 cm (LANL 2013). The years with normal or near normal precipitation levels corresponded to an increase in bird capture rates.

Avian communities are dynamic and shift in response to the environment. A previous analysis of annual Christmas Bird Count data reveals both a 56 km northward trend of birds seen in North America and a positive statistical correlation between annual species location and temperature (Audubon 2009). As temperature increases on a continental scale, both northern latitudes and higher elevations have become warmer and thus more suitable for species that would have been deterred by cooler temperatures a century ago (Walther et al. 2002). In the case of birds, earlier onset of spring due to warmer temperatures can result in earlier breeding and arrival of migrants (Walther et al. 2002). However, if the increase in temperature is not coupled with an increase in precipitation, traditional food sources may not be available, causing birds to either leave or not breed in order to conserve energy. It is often assumed that sensitive species are likely to be impacted by rapid and abrupt environmental changes, despite adaptability, given that they were identified as sensitive at least in part because of attributes (e.g., rarity, endemism, declining populations, etc.) that may render them sensitive to climatic changes and environmental stress (Sala et al. 2000).

Increases in the frequency, duration, and/or severity of drought and heat stress associated with climate change could fundamentally alter the composition, structure and biogeography of

forests in many regions (Allen et al. 2010). The Jemez Mountains in particular are considered vulnerable to effects of ongoing climate change (Enquist et al. 2008).

The netting site at LANL is a microcosm of the changes that birds are undergoing due to drought effects in a micro habitat and is an indication of major environmental changes.

ACKNOWLEDGMENTS

We thank the following people for field help during this project: L. Hansen, A. Jacobs, M. Jankowski, H. Mahowald, L. Maestas, B. Norris, B. Panowski, R. Robinson, L. Marsh, M. Shendo, J. Ferenbaugh, G. Vigil, and K. Zemlick. This research was funded by the Environmental Stewardship Program through Los Alamos National Security, LLC, operator of the Los Alamos National Laboratory under Contract No. DE-AC52-06NA25396.

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TABLE 1. Mean numbers of aged individual birds captured per 600 net-hrs and reproductive index at the LANL MAPS station, during the MAPS season, averaged over the 16 years, 1997–2012. Data for each species is only included from a station that lies within the breeding range of the species and only from within the MAPS season.

Species[1]	Scientific Name	Adults	Young	Reproductive Index[2]
White-winged Dove	*Zenaida asiatica*	0.1	0.0	0.00
Mourning Dove	*Zenaida macroura*	0.2	0.0	0.00
Common Poorwill	*Phalaenoptilus nuttallii*	0.1	0.0	0.00
Acorn Woodpecker	*Melanerpes formicivorus*	0.7	0.0	0.00
Williamson's Sapsucker	*Sphyrapicus thyroideus*	0.1	0.0	0.00
Downy Woodpecker	*Picoides pubescens*	0.1	0.0	0.00
Hairy Woodpecker	*Picoides villosus*	1.6	0.1	0.06
Northern Flicker	*Colaptes auratus*	1.0	0.1	0.00
Western Wood-Pewee	*Contopus sordidulus*	1.8	0.3	0.20
Gray Flycatcher	*Empidonax wrightii*	2.1	0.0	0.00
Dusky Flycatcher	*Empidonax oberholseri*	0.8	0.1	0.11
Western Flycatcher	*Empidonax difficilis*	0.3	0.0	0.00
Say's Phoebe	*Sayornis saya*	0.6	0.3	0.33
Ash-throated Flycatcher	*Myiarchus cinerascens*	2.4	0.1	0.02
Cassin's Kingbird	*Tyrannus vociferans*	0.1	0.0	0.00
Western Kingbird	*Tyrannus verticalis*	0.1	0.0	0.00
Plumbeous Vireo	*Vireo plumbeus*	0.8	0.1	0.13

Species[1]	Scientific Name	Adults	Young	Reproductive Index[2]
Warbling Vireo	*Vireo gilvus*	0.7	0.1	0.00
Steller's Jay	*Cyanocitta stelleri*	0.2	0.1	0.00
Western Scrub-Jay	*Aphelocoma californica*	0.7	0.3	0.44
Clark's Nutcracker	*Nucifraga columbiana*	0.1	0.0	0.00
Violet-green Swallow	*Tachycineta thalassina*	0.8	0.0	0.00
Mountain Chickadee	*Poecile gambeli*	1.6	1.0	0.33
Juniper Titmouse	*Baeolophus ridgwayi*	0.8	0.3	0.31
Bushtit	*Psaltriparus minimus*	2.3	0.7	0.30
Red-breasted Nuthatch	*Sitta canadensis*	0.1	0.0	0.00
White-breasted Nuthatch	*Sitta carolinensis*	1.8	0.3	0.18
Pygmy Nuthatch	*Sitta pygmaea*	0.8	0.4	0.20
Brown Creeper	*Certhia americana*	0.1	0.0	0.00
Rock Wren	*Salpinctes obsoletus*	3.1	1.5	0.51
Canyon Wren	*Catherpes mexicanus*	0.1	0.2	0.00
Bewick's Wren	*Thryomanes bewickii*	0.1	0.2	0.00
House Wren	*Troglodytes aedon*	0.2	0.4	0.75
Ruby-crowned Kinglet	*Regulus calendula*	0.2	0.0	0.00
Blue-gray Gnatcatcher	*Polioptila caerulea*	1.8	1.2	0.76
Western Bluebird	*Sialia mexicana*	3.8	5.2	1.55
Mountain Bluebird	*Sialia currucoides*	0.3	0.7	2.00
Townsend's Solitaire	*Myadestes townsendi*	0.6	0.5	0.42

Species[1]	Scientific Name	Adults	Young	Reproductive Index[2]
Hermit Thrush	*Catharus guttatus*	1.2	0.0	0.00
American Robin	*Turdus migratorius*	0.5	0.0	0.00
Northern Mockingbird	*Mimus polyglottos*	0.3	0.0	0.00
Orange-crowned Warbler	*Vermivora celata*	0.1	0.0	0.00
Virginia's Warbler	*Oreothlypis virginiae*	12.4	2.1	0.17
Yellow Warbler	*Dendroica petechia*	0.1	0.0	0.00
Yellow-rumped Warbler	*Dendroica coronata*	2.7	0.2	0.01
Black-throated Gray Warbler	*Dendroica nigrescens*	0.1	0.0	0.00
Grace's Warbler	*Dendroica graciae*	0.1	0.1	0.50
MacGillivray's Warbler	*Oporornis tolmiei*	1.0	0.0	0.00
Hepatic Tanager	*Piranga flava*	0.4	0.1	0.25
Western Tanager	*Piranga ludoviciana*	8.5	0.1	0.06
Green-tailed Towhee	*Pipilo chlorurus*	0.7	0.1	0.00
Spotted Towhee	*Pipilo maculatus*	3.8	1.1	0.28
Canyon Towhee	*Melozone fusca*	0.1	0.0	0.00
Chipping Sparrow	*Spizella passerina*	12.8	3.3	0.38
Brewer's Sparrow	*Spizella breweri*	0.2	0.2	0.25
Vesper Sparrow	*Pooecetes gramineus*	0.1	0.1	0.00
Lark Sparrow	*Chondestes grammacus*	0.3	0.0	0.00
Savannah Sparrow	*Passerculus sandwichensis*	0.0	0.3	und.[3]
Dark-eyed Junco	*Junco hyemalis*	0.5	0.4	1.00

Species[1]	Scientific Name	Adults	Young	Reproductive Index[2]
Black-headed Grosbeak	*Pheucticus melanocephalus*	1.5	0.1	0.03
Lazuli Bunting	*Passerina amoena*	0.1	0.0	0.00
Brown-headed Cowbird	*Molothrus ater*	0.2	0.1	0.17
Bullock's Oriole	*Icterus bullockii*	0.1	0.0	0.00
House Finch	*Carpodacus mexicanus*	1.8	0.4	0.27
Pine Siskin	*Carduelis pinus*	0.5	0.1	0.00
Lesser Goldfinch	*Carduelis psaltria*	0.9	0.1	0.00
ALL SPECIES POOLED		83.6	22.7	0.28
Number of Species		65	40	
Total Number of Species			66	

[1] Hummingbirds, gallinaceous birds, and species for which there are no aged individuals are not included in this table.

[2] Years for which the reproductive index was undefined (no adult birds were captured in the year) are not included in the mean reproductive index.

[3] The reproductive index is undefined at this station because no young individual of the species was ever captured in the same year as an adult individual of the species.

TABLE 2. Estimates of adult annual survival and recapture probabilities and proportion of residents among newly-captured adults using a time-constant model for 6 species breeding at the MAPS stations on the LANL obtained from 16 years[1] (1997–2012) of mark-recapture data.

Species	Num. ind.[1]	Num. caps.[2]	Num. ret.[3]	Survival probability[4]	Surv. C.V.[5]	Recapture probability[6]	Proportion of residents[7]
Ash-throated Flycatcher	36	45	7	0.627 (0.149)	23.7	0.371 (0.185)	0.326 (0.213)
White-breasted Nuthatch[8]	28	37	4	0.709 (0.172)	24.2	0.206 (0.148)	0.270 (0.242)
Virginia's Warbler	177	289	43	0.535 (0.059)	11.0	0.403 (0.080)	0.492 (0.132)
Western Tanager[8,9]	146	149	3	0.274 (0.229)	83.7	0.055 (0.218)	1.000 (4.048)
Spotted Towhee[9]	60	82	8	0.326 (0.143)	44.0	0.306 (0.215)	1.000 (0.737)
Chipping Sparrow	216	241	13	0.550 (0.108)	19.6	0.089 (0.065)	0.587 (0.431)

[1] Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).

[2] Total number of captures of adult birds of the species at stations where the species was a regular or usual breeder.

[3] Total number of returns. A return is the first recapture in a given year of a bird originally banded at the same station in a previous year.

[4] Survival probability (φ) presented as the maximum likelihood estimate (standard error of the estimate).

[5] The coefficient of variation for survival probability, CV(φ).

[6] Recapture probability (p) presented as the maximum likelihood estimate (standard error of the estimate).

[7] The proportion of residents among newly-captured adults (τ) presented as the maximum likelihood estimate (standard error of the estimate).

[8] The estimate for recapture probability (and possibly survival probability as well) may be biased low because the estimate for τ was 1.000.

[9] The estimate for survival probability should be viewed with caution because it is based on fewer than five between-year recaptures or the estimate is very imprecise ($SE(\varphi) \geq 0.200$ or $CV(\varphi) \geq 50.0\%$).

TABLE 3. Shannon's diversity index and Shannon's equitability estimate at the Dual-Axis Radiographic Hydrodynamic Test Facility banding site for all captures that extend beyond the standard MAPS sessions in some years.

Year	Number of Species	Total Number of Birds	Shannon's Diversity Index	Shannon's Equitability
1997	27	143	2.675	0.8116
1998	30	163	2.587	0.7606
1999	28	127	2.864	0.8596
2000	29	135	2.904	0.8624
2001	23	91	2.556	0.8153
2002	18	54	2.612	0.9036
2003	28	139	2.938	0.8818
2004	27	143	2.828	0.8581
2005	45	456	2.875	0.7553
2006	39	181	3.045	0.8311
2007	37	226	2.972	0.8231
2008	36	191	3.079	0.8593
2009	43	210	3.291	0.8751
2010	45	226	3.22	0.8458
2011	32	132	3.123	0.901
2012	36	98	3.157	0.8809
2013	29	107	3.049	0.7275

FIG. 1. Orthophoto of the project location in 1991(left) and 2011.

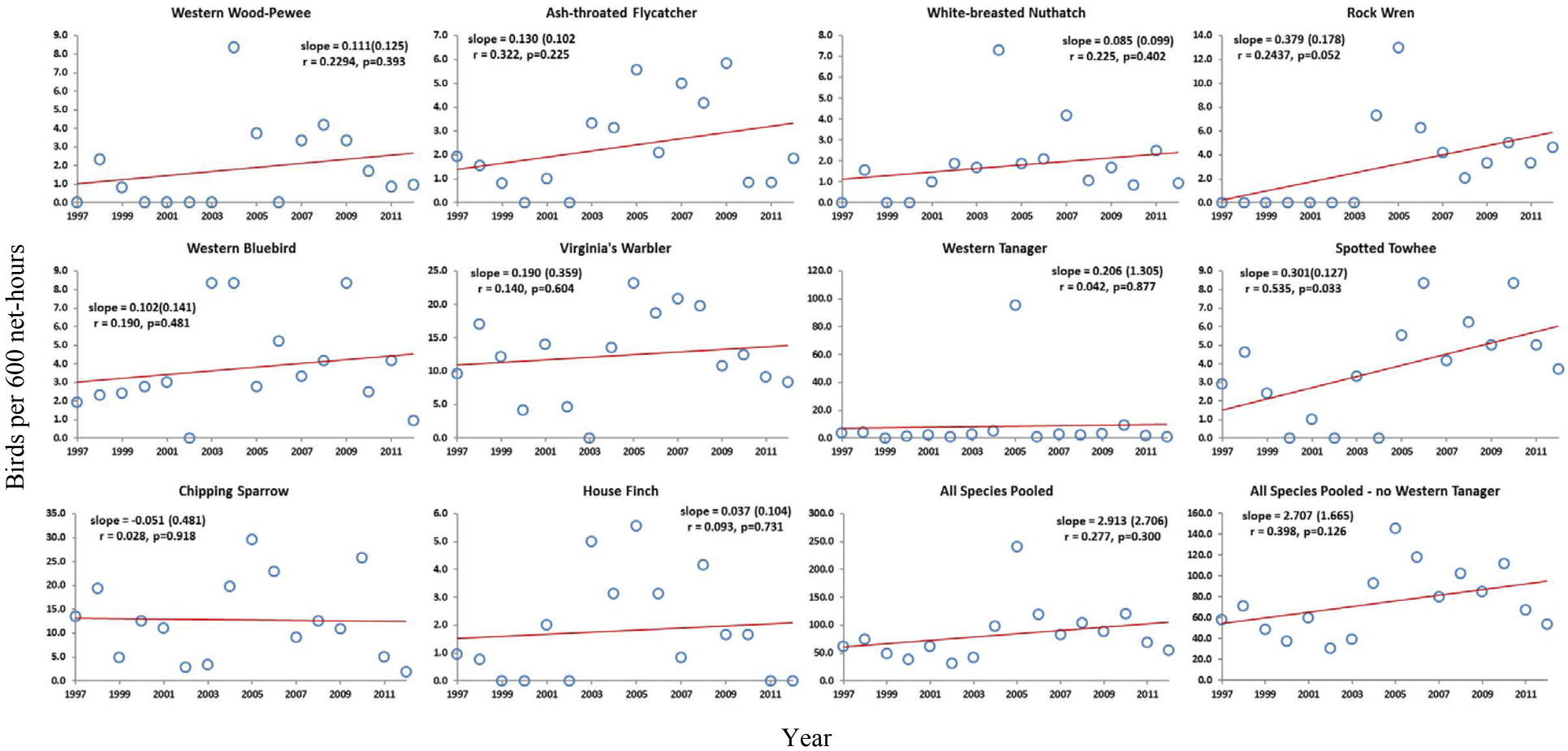
FIG. 2. Population trends for 10 species and all species pooled at LANL from 1997–2012. Also presented is the population trend for all species pooled but without Western Tanager. The number of adult individuals captured per 600 net-hrs was used as the measure of population size for species which were regular or usual breeders and summer residents at the station. The slope of the linear regression line was used as the measure of the population trend and is presented on each graph with the standard error of the slope in parentheses. The correlation coefficient (r) and significance of the correlation coefficient (p) are also shown on each graph.

FIG. 3. Trend in productivity for 10 species and all species pooled at LANL from 1997–2012. The productivity index was defined as the number of young per adult in each year for species which were regular or usual breeders and summer residents at the station. The slope of the regression line was used as the measure of the productivity trend. The slope, the standard error of the slope (in parentheses), the correlation coefficient (r) and significance of the correlation coefficient (p) are shown on each graph.

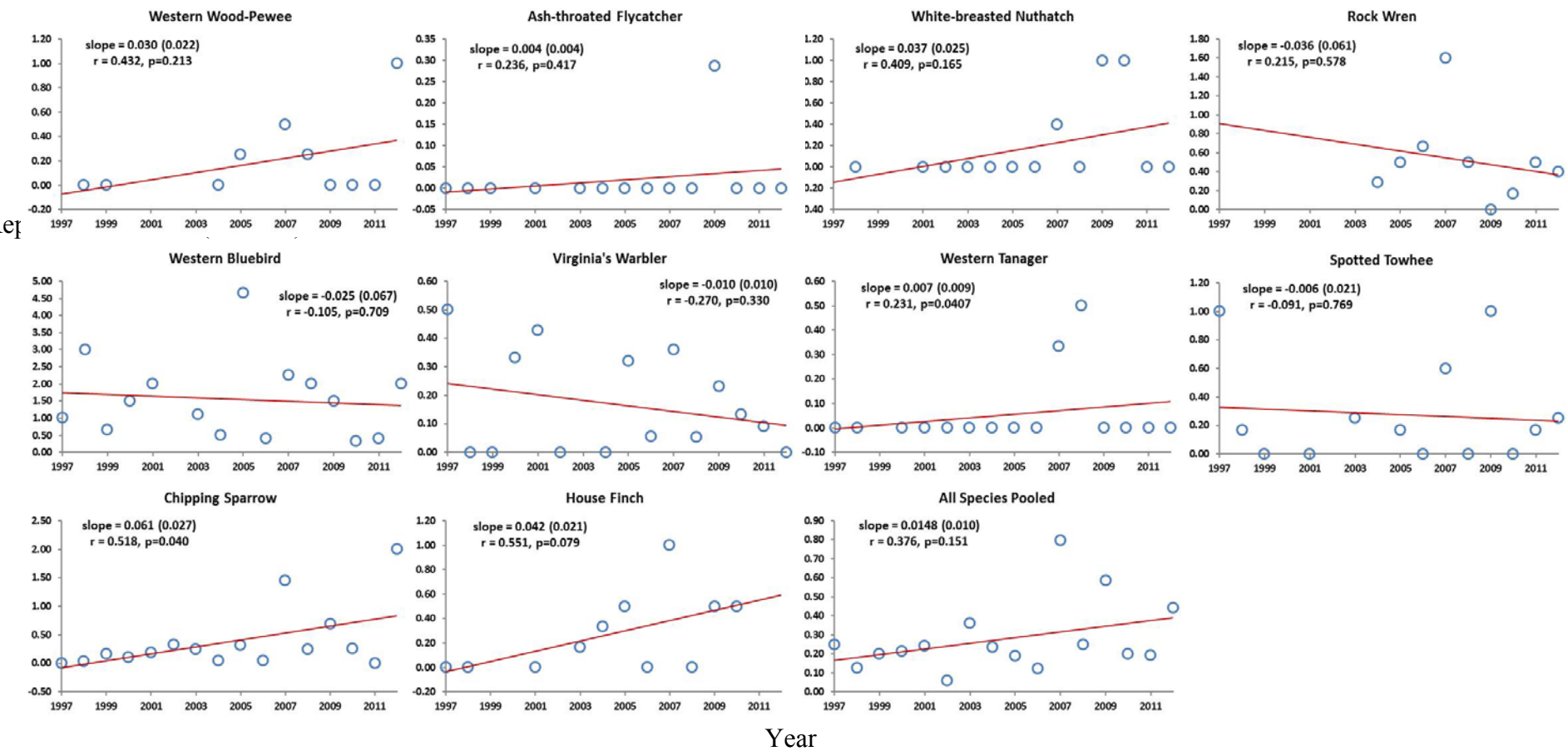
FIG. 4: Palmer drought severity index for division 2 in New Mexico.

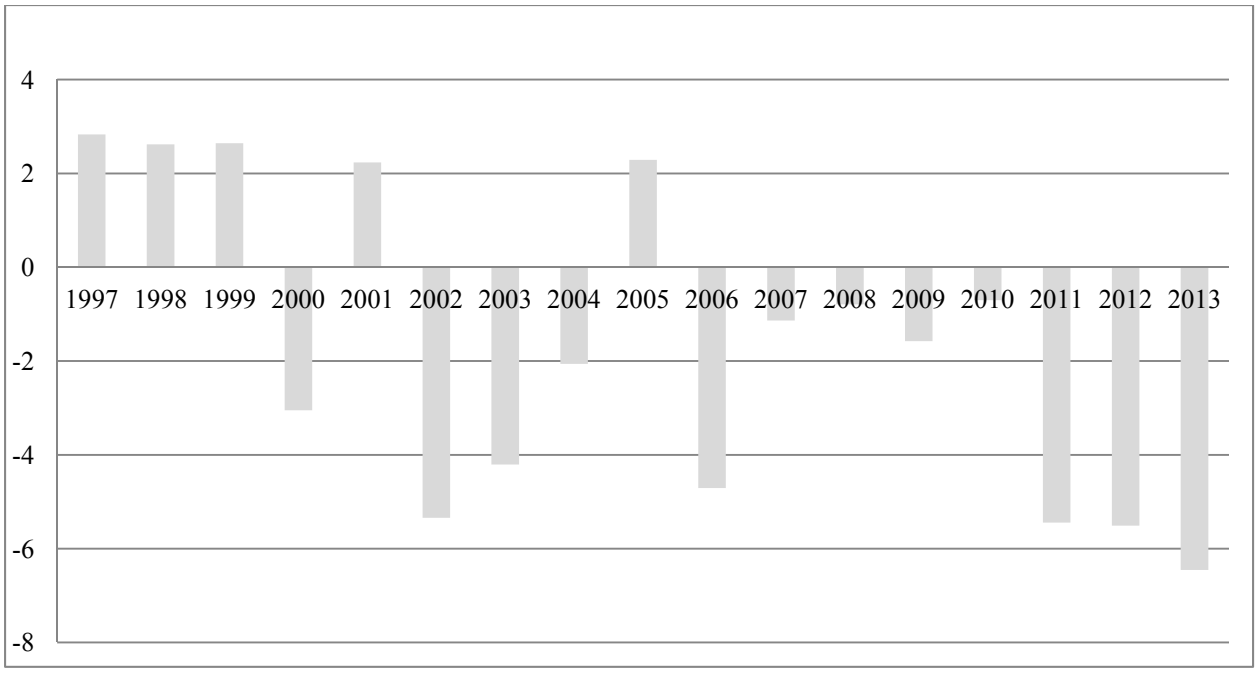
FIG. 5: Precipitation near the banding site.

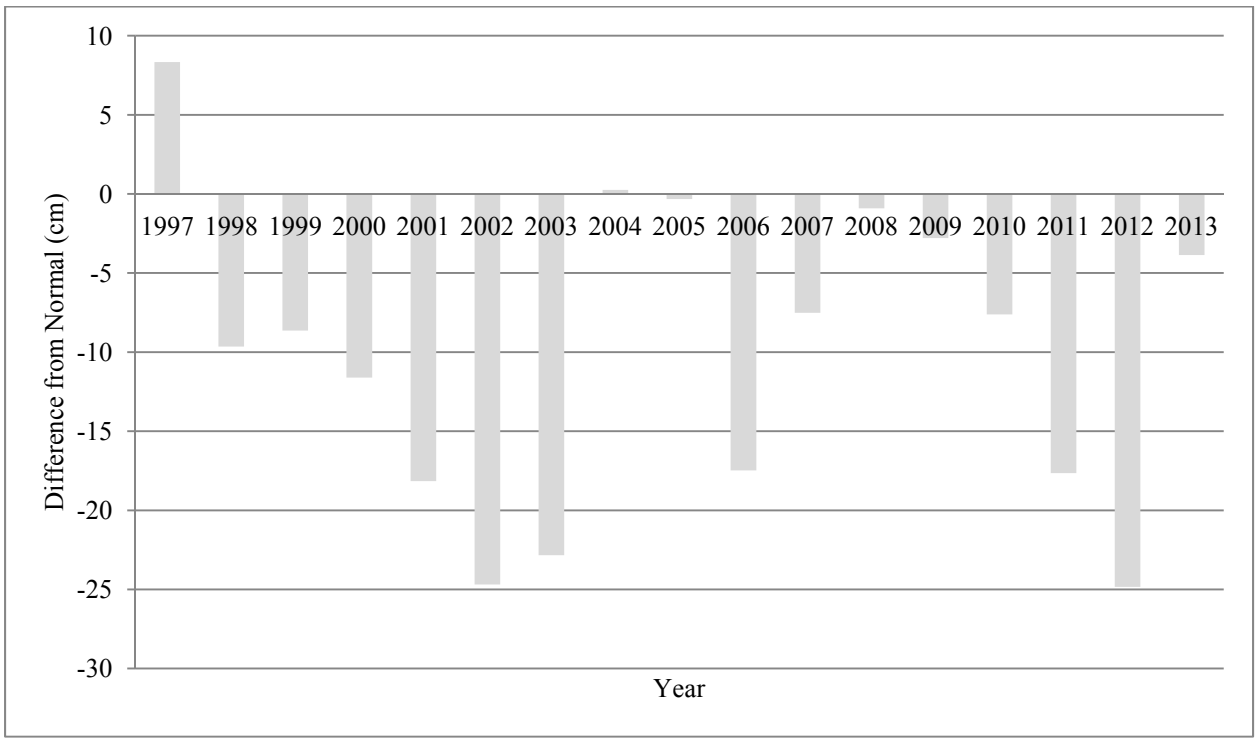
Cañon de Valle
Cañon de Valle


Western Wood-Pewee
slope = 0.111(0.125)
r = 0.2294, p=0.393
Ash-throated Flycatcher
slope = 0.130 (0.102
r = 0.322, p=0.225
White-breasted Nuthatch
slope = 0.085 (0.099)
r = 0.225, p=0.402
Rock Wren
slope = 0.379 (0.178)
r = 0.2437, p=0.052
Western Bluebird
slope = 0.102(0.141)
r = 0.190, p=0.481
Virginia's Warbler
slope = 0.190 (0.359)
r = 0.140, p=0.604
Western Tanager
slope = 0.206 (1.305)
r = 0.042, p=0.877
Spotted Towhee
slope = 0.301(0.127)
r = 0.535, p=0.033
Chipping Sparrow
slope = -0.051 (0.481)
r = 0.028, p=0.918
House Finch
slope = 0.037 (0.104)
r = 0.093, p=0.731
All Species Pooled
slope = 2.913 (2.706)
r = 0.277, p=0.300
All Species Pooled - no Western Tanager
slope = 2.707 (1.665)
r = 0.398, p=0.126
Birds per 600 net-hours
Year

Rep


Western Wood-Pewee
slope = 0.030 (0.022)
r = 0.432, p=0.213
Ash-throated Flycatcher
slope = 0.004 (0.004)
r = 0.236, p=0.417
White-breasted Nuthatch
slope = 0.037 (0.025)
r = 0.409, p=0.165
Rock Wren
slope = -0.036 (0.061)
r = 0.215, p=0.578
Western Bluebird
slope = -0.025 (0.067)
r = -0.105, p=0.709
Virginia's Warbler
slope = -0.010 (0.010)
r = -0.270, p=0.330
Western Tanager
slope = 0.007 (0.009)
r = 0.231, p=0.0407
Spotted Towhee
slope = -0.006 (0.021)
r = -0.091, p=0.769
Chipping Sparrow
slope = 0.061 (0.027)
r = 0.518, p=0.040
House Finch
slope = 0.042 (0.021)
r = 0.551, p=0.079
All Species Pooled
slope = 0.0148 (0.010)
r = 0.376, p=0.151
Year


4
2
0
-2
-4
-6
-8
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013


10
5
0
-5
-10
-15
-20
-25
-30
Difference from Normal (cm)
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013
Year