AVIAN POPULATION TRENDS IN THE PACIFIC NORTHWEST

by
Caimee Schoenbaechler
Dr. Dean Urban, Advisor
May 2009

Masters project submitted in partial fulfillment of the
requirements for the Master of Environmental Management degree in
the Nicholas School of the Environment of
Duke University
2009

Abstract

Land bird populations are facing a growing number of threats including habitat loss, climate change, loss of stratospheric ozone, and toxic pollution. In response to land bird monitoring needs by federal agencies, the High Cascades Ranger District in Prospect, OR, began implementation of mist-netting efforts as established by the Monitoring Avian Productivity and Survivorship (MAPS) program in 1994. Site specific population trends were analyzed using regression and non metric multi-dimensional scaling (NMS) ordination analysis over a fourteen year period, and then compared to regional trends using the MAPS web-based query. Of thirty eight species, four demonstrated significantly increasing trends, while two species demonstrated significantly decreasing trends in regression analysis. Site-specific trends were consistent with regional trends. Regression analysis also revealed a significant correlation between abundance and climate factors, specifically temperature and precipitation. The NMS ordination did not reveal clear ecological trends, but did show that species composition varies with net placement. Climate factors, life history strategy, productivity, and survivorship were factors used to interpret population trends. Continued MAPS monitoring will facilitate our understanding of shifts in avian populations and their ranges that will most likely occur in light of increased land use and climate change.

Acknowledgements

I am especially grateful to my advisor, Dr. Dean Urban, who offered enduring support and encouragement throughout this project. I thank Jeff Vonkienast and Norman Barrett, Wildlife Biologists at the High Cascades Ranger District of the U.S. Forest Service, for providing this amazing dataset, and special thanks goes to Norman Barrett, who answered countless questions along the way. I am particularly grateful to Sherry Kies, who patiently taught me the delicate art of bird banding. And finally, I am most grateful to my family and friends, for their undying love and support every step of the way!

Table of Contents

Introduction

History of Land Bird Population Management

Land bird populations are facing a growing number of threats including habitat loss, climate change, loss of stratospheric ozone, and toxic pollution (Brown 1991). The US 2009 State of the Birds Report affirmed that over the past forty years, nearly a third of the 800 bird species that occur in the United States are endangered, threatened, or are in significant decline. Furthermore, of the 310 forest-breeding birds nationwide, twenty-two percent are species of conservation concern, eleven of which are federally listed as endangered or threatened.

Avian communities are particularly affected by the alteration or removal of their preferred habitats through various management activities (Nott et al 2005). The USDA Forest Service is committed to avian conservation as outlined in their Land Bird Conservation Program, but these efforts must also be balanced with other, sometimes competing, multiple-use management goals such as timber production or recreation. Several plans have been developed to address the needs of avian conservation within the USDA Forest Service and beyond.

The Pacific Northwest Forest Plan emerged in 1993 with efforts to develop guidelines for managing federal forests, providing local economic aid to communities, and coordinating management actions with federal, state, local, and tribal governments in Oregon, Washington, and California. This plan developed strategies for adaptive forest management, conservation and restoration of riparian habitat, and the protection of sensitive species on nonfederal land.

As a result of the 2001 executive order 13186 and to further the purposes of the five conservation Acts of Congress, including the Migratory Bird Treaty Act, all federal agencies were mandated to protect migratory birds. This order emphasized the protection of "species of concern" as indicated in the Endangered Species Act. In response, the US Fish and Wildlife Service identified 131 "Birds of Conservation Concern" to guide research, monitoring, and management initiatives (Nott *et al* 2005).

The forests of the Pacific Northwest support some of the highest densities of breeding land birds, including many neotropical migrants. However, few of the species are listed as species of concern (Nott *et al* 2005). In fact, all species in this study are listed as "Species of Least Concern" by the International Union for Conservation of Nature and Natural Resources (IUCN) in 2008 (http://www.iucnredlist.org). In response to the clear need for more detailed regional guidelines, Partners in Flight, the Neotropical Migratory Bird Conservation Initiative, published the North American Land Bird Conservation Plan in 2004. This plan is organized by regional biome and "Bird Conservation Region" or BCR's. Each biome is further divided into sub-regions, thus providing the most detailed regional guidelines for land bird management. This study will examine the population trends of migratory, resident, and short-distance migrant birds on one National Forest in southern Oregon, while considering the potential underlying mechanisms that may be driving the observed trends.

Impetus for Monitoring Avian Productivity and Survivorship (MAPS) Program

Long term monitoring is a critical component to adaptive management strategies, especially when the goal is to respond to changing populations. Programs such as the Breeding Bird Survey, the Breeding Bird Census, the Winter Bird Population Study, and the Christmas

Count have produced results indicating serious population declines in many species including neotropical migrants (Terborgh 1989). These declining trends in bird populations initially prompted the establishment of the Neotropical Migratory Bird Conservation Initiative, "Partners in Flight" and the development of the Land Bird Conservation Plans. All of these monitoring efforts, however, fail to provide data on primary demographic parameters of land birds, which lead to information about productivity and survivorship. These data are important in understanding the mechanisms that may be driving observed population changes and at which stage in the life cycle the changes are occurring. Furthermore, presence/absence, relative abundance, or population size data may provide misleading information on indicators of habitat quality (Van Horne 1983). For example, high densities of adults may not be necessarily correlated with reproductive success unless the population conforms to an ideal free distribution (Sutherland 1983) where the number of individuals in an area is proportional to the resources available. However, many bird species conform to a despotic distribution in which competition for breeding habitat results in the presence of the fittest individuals that hold large territories (Nott *et al* 2005). Since environmental stressors and management actions affect primary demographic parameters without excessive time lags (Temple and Wiens 1989), primary demographic trends can facilitate in evaluating the effectiveness of management actions and conservation strategies (DeSante 1995) and may better indicate the quality of habitat at the local scale (Nott *et al* 2005).

In anticipation of this need, the Institute for Bird Populations (IBP) created the Monitoring Avian Productivity and Survivorship (MAPS) program in 1989. The MAPS program consists of a continent-wide network of constant effort mist netting (CEMN) stations in which

ornithologists can capture and band land birds during the breeding season. Since its inception in 1989, the MAPS program has expanded to over 1,000 banding stations in 2007 (IBP Annual Report 2008). Designing effective strategies to address declining population trends begin with understanding whether the declines are driven by low productivity, low survivorship, or both. This program allows researchers to address this very question.

The MAPS program maintains three main objectives relating to monitoring, research, and management. Monitoring objectives include 1) producing annual indices of adult population size and post-fledgling productivity and 2) producing annual estimates of adult survival rate, adult population size, proportion of residents in the adult population, and recruitment into the adult population. Research objectives include identifying and describing 1) the temporal and spatial patterns in the demographic indices and 2) the relationship between these patterns and life histories of target species, landscape-level habitat characteristics, and weather data. Management objectives include to 1) determine whether declining population trends are caused by low productivity or low survivorship, 2) identify landscape-level management actions and conservation strategies designed to reverse declining trends, and 3) evaluate the effectiveness of those actions and strategies that are implemented.

Forest Management in the Pacific Northwest

As a consequence of the Pacific Northwest's region of complex topographical diversity and patchiness superimposed by post settlement patterns of logging, development, managed fire history, and extensive pest outbreaks, the landscape is moderately to highly fragmented (Nott *et al* 2005). This heterogeneity creates patchy mosaics of sparse vegetation, grassland,

and shrub land distributed throughout extensive tracts of coniferous, deciduous, and mixed forests of varying canopy closure. High breeding season threats in the Pacific Northwest region are due to forest management effects, loss of riparian woodlands and wetlands, and urban/residential/agricultural encroachment into forested habitat (Rich *et al* 2004).

Riparian woodland and shrub habitats, including corridors and wet montane meadows, are critical habitats in the Pacific Northwest landscape because these areas support high species diversity, species richness, and reproductive success among breeding birds, and are essential to migratory species. Moist forests and shrubby habitats with deciduous canopies of cottonwood, ash, willow, and alder may act as "source habitats" of high productivity where the birth rate exceeds death rate in avian populations. Such habitats may drive meta-population dynamics, producing enough individuals to disperse to poorer quality habitats (Nott et al 2005). Many species such as MacGillivray's Warbler, Lincoln's Sparrow, and the Black-Headed Grosbeak depend on these types of habitat for survival. In fact, certain riparian species have been found to respond negatively to reductions in riparian buffer width in managed Douglas-Fir forests, including the Golden-Crowned Kinglet and Brown Creeper (Pearson and Manuwal 2001). Furthermore, abundances of the Chestnut Backed Chickadee, Pacific Slope Flycatcher, and Winter Wren all increased with increased riparian buffer width in western Oregon (Hagar 1999).

Not all land birds require closed canopy forested habitats. For example, some species such as Cassin's Vireo and Purple Finch are "edge specialists," and rely on disturbed, fragmented habitats. Other species may breed in the forest interior, but forage in the edges, where invertebrate diversity is high (Nott *et al* 2005). Suitability of nesting habitat and

consequently reproductive success for many species of land birds may depend on the availability of matrix and edge habitat. As forest fragmentation increases, "edge-avoiding" species will decrease, while "edge-specialists" will increase (Nott *et al* 2005).

Maintaining ecosystem function while balancing multiple land management goals such as agricultural diversion, watercourse alteration, logging, grazing, and recreation is one of the major issues that agencies face in managing the forests of the Pacific Northwest (Nott *et al* 2005). The complexity of these issues is exacerbated in light of climate change. As habitats are altered and climate change continues, species will respond with changing behaviors. As these changing behaviors can sometimes be predicted, no one can know for certain what the responses will be.

Avian Productivity and Climate Change

Short term climate variability is associated with oceanic and atmospheric phenomena including the El Niño/Southern Oscillation (ENSO) of the tropical Pacific Ocean, and the North Atlantic Oscillation (NAO) (Nott 2002). ENSO and NAO induced weather conditions can affect primary productivity (Wiles *et al* 2001) and insect abundance (Kemp et al 1985), which in turn may affect avian reproductive success (Nott 2002). Nott *et al* (2002) found that annual reproductive indices for neotropical-wintering species increased significantly with springtime ENSO Precipitation Index (ESPI) and annual reproductive indices for temperate-wintering species increased significantly with springtime North Atlantic Oscillation index (NAOI). One mechanism that may explain this effect, is that prey biomass on the wintering grounds is probably greater in the wetter El Niño years, which may enhance the ability of birds to survive

the winter and the rigors of spring migration. These factors most likely affect the physical condition of migrating birds, as well as the timing of their arrival to the breeding grounds and the potential length of the breeding season. The correlations with NAOI and defoliation caused by insect outbreaks, suggest that the temperate wintering species that are already on the breeding grounds before neotropical migrants arrive, are positioned to take advantage of abundant insects during these warmer periods (Nott *et al* 2002). Understanding the response of land birds to short-term climate variation may help predict what the response to long-term climate change will be. Changing spatial patterns of suitable breeding and wintering habitat, due to habitat loss and degradation and climate change, will likely cause shifts in the geographical ranges of many land bird species.

Rogue-River/Siskiyou National Forest MAPS Monitoring Efforts

The Partners in Flight Land Bird Conservation Plan has identified several Species of Continental Importance in the Pacific Avifaunal Biome and Intermountain West Avifaunal Biome, which include the Watch List Species of greatest conservation concern, and Stewardship Species which are umbrella species characteristic of the biome. Several of these species occur at the SKSW banding station, and are listed in Tables A.1 and A.2 of the Appendix.

In response to land bird monitoring needs by federal agencies, particularly for the species listed in the PIF Land Bird Conservation Plan, the High Cascades Ranger District of the Rogue River/Siskiyou National Forest began implementation of the MAPS program in 1994. The Rogue River/Siskiyou National Forest has been collecting banding data since 1994 at their Skeeter Swamp (SKSW) banding station in southwest Oregon.

Study Objectives

Although CEMN can suffer from problems when trying to analyze trends at one local site, managers need to understand what is happening at the local level, and how their own management actions may affect broader population dynamics. IBP maintains a searchable web-based query for regional estimates of productivity and survivorship (Michel *et al* 2006). Requests for these MAPS data intended for use in research with clearly defined objectives may be submitted to IBP for review. However, many banding sites and the agencies maintaining them, do not receive site specific consultation regarding data results or management recommendations. Therefore, the purpose of my research is to provide site specific analysis for the SKSW banding station through the following objectives:

(1) Analyze fourteen years of banding data for population trends and reproductive indices of each species.

(2) Compare site-specific trends to MAPS regional trends.

(3) Conduct a non-metric multi-dimensional scaling (NMS) ordination to identify ecological patterns in abundance and composition, and how they may relate to climate.

(4) Identify site - specific interpretation of the observed trends based on life history traits, productivity, survivorship, and climate factors.

Methods

Site Description

The High Cascades Ranger District of the Rogue River/Siskiyou National Forest (Region 6) maintains a banding station at Skeeter Swamp (SKSW), which is located near Butte Falls in Jackson County at latitude 42 27 50 and longitude -122 23 50 (in degrees, minutes, seconds). The site is a riparian, mixed conifer stand with a dominant habitat of sub-polar evergreen forest

typically dominated by Douglas Fir (MAPS code = IA8na), and a subdominant habitat of temperate, cold-deciduous shrub land (MAPS code = IIIB2Na). SKSW is designated as a Special Interest Area by the Rogue River National Forest Plan. The goal of this designation is to "manage and interpret special geological, botanical, zoological, cultural, and scenic areas for educational, scientific, and public enjoyment purposes" (USDA 1990); thus, management is limited in this area. For example, there is to be no scheduled volume of timber removed (unless it benefits the special interest area) or mineral aggregate source development in this area. If endangered, threatened, or sensitive species are found in a special interest area, consultation requirements with the USDI Fish and Wildlife Service will be met in accordance with the Endangered Species Act. Management practices for selected species are outlined in the Rogue River National Forest Plan; cavity-nesting woodpeckers are one example. This site provides a unique opportunity to monitor avian population trends in a relatively undisturbed forest, an attribute that may be important in understanding observed trends.

MAPS Protocol

A standardized method of collecting banding data has been established by the MAPS program, a strictly breeding season survey. The starting date for data collection depends largely on latitude, and thus the timing of the breeding season; migrants breeding farther north must have the chance to pass through (Figure 1). Skeeter Swamp operates once every ten-day period starting 21 May (period three) and ending 8 August. Nets are opened at local sunrise, operated for six hours, and are checked every half hour. Ten 12-meter, 30-mm, nylon mist nets are established uniformly yet opportunistically (where birds will actually be caught) in a core area of roughly 8 hectares along a riparian corridor (Figure 2). Once birds are retrieved from

the mist nests, they are brought back to the banding tent where they are aged, sexed, weighed, measured for wing cord, checked for signs of breeding and molt, banded, and released.

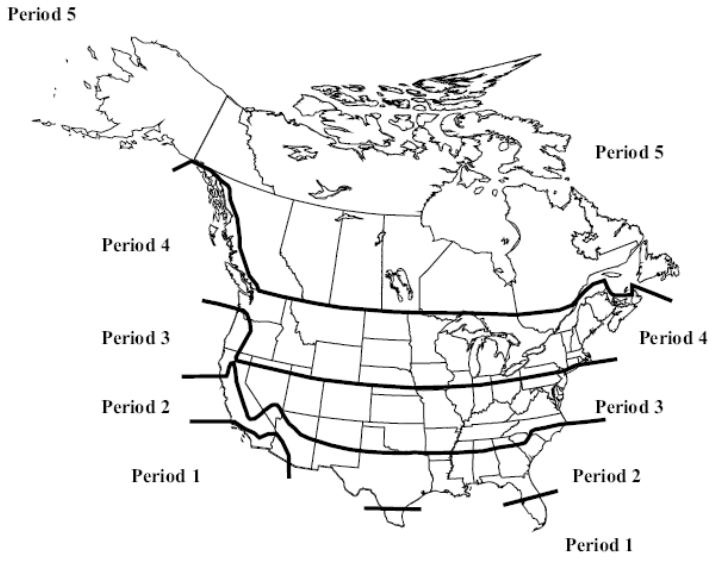

Figure 1: Starting Periods for MAPS Stations (2007 MAPS Manual)

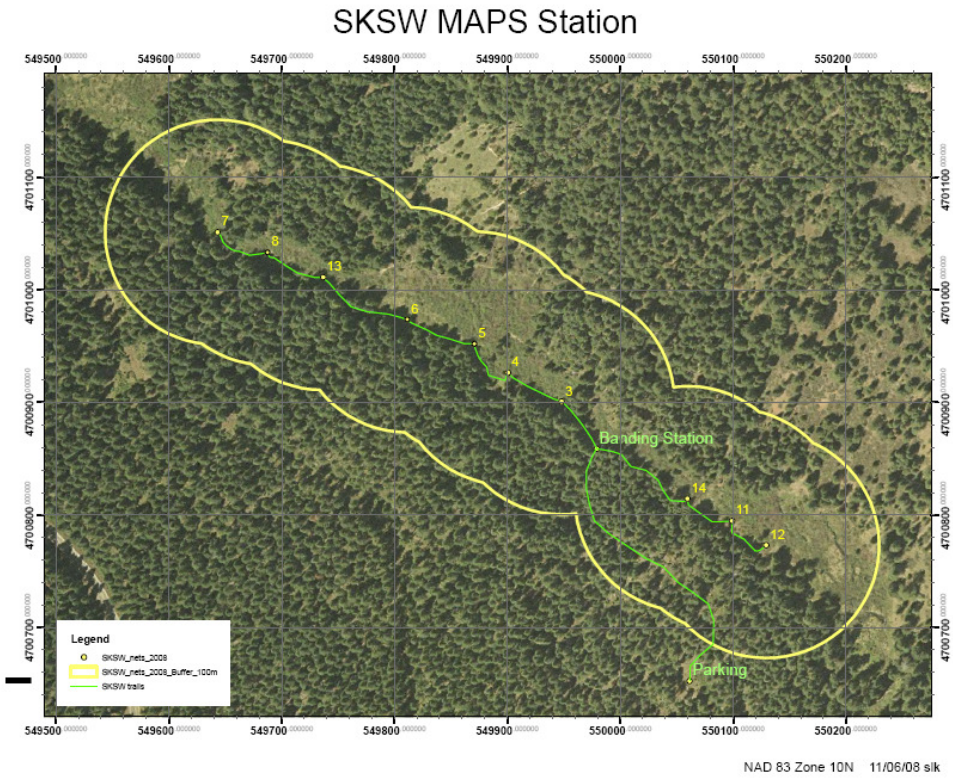

Figure 2: Configuration of SKSW Banding Station

Statistical Analysis

Exploratory analysis consisted of basic summaries of the data including the number of species and individuals caught over time, net performance, and percentage of species in the fourteen year catch. Life history traits, including feeding, nesting, and migratory strategies, in addition to breeding status, were identified and summarized for the species caught at SKSW (Appendix A.4 and A.5).

Population trends were determined through regression analysis on "After Hatch Year" (AHY = adults) and "Hatch Year" (HY = young) birds separately for each species over fourteen years, from 1994 to 2007. Although sixty species were actually netted at the SKSW banding station over fourteen years, regression analysis was only performed on species for which there

was adequate data, which included thirty nine species of adults and thirty five species of young. Trends were analyzed using unique band numbers so that multiple catches of the same bird do not skew population trends. Regressions were not performed on some species because there were not enough data points to conduct a regression (birds that were only caught once in fourteen years). The species omitted from the analyses are shown in Table 1. Given that hummingbirds are not banded, it is impossible to determine unique birds which, if over-counted, may skew population trends and reproductive index, and thus were removed from the analysis. Birds that were not aged or banded were also removed from the analysis.

Table 1: Species Omitted from Regression Analysis

Adults	Young
Black-Capped Chickadee	American Robin
Cedar Waxwing	Audubon's Warbler
Chipping Sparrow	Broad-Tailed Hummingbird
Cooper's Hawk	Calliope Hummingbird
Fox Sparrow	Cedar Waxwing
House Finch	Chipping Sparrow
House Wren	Common Yellowthroat
Lincoln's Sparrow	Dusky Flycatcher
Northern Pygmy Owl	Mountain Chickadee
Red-Winged Blackbird	Ruffed Grouse
Ruby-Crowned Kinglet	Townsend's Solitaire
Ruffed Grouse	Townsend's Warbler
Spotted Towhee	Western Wood Pewee
Townsend's Solitaire	
Townsend's Warbler	
Western Flycatcher	
Western Wood Peewee	

Annual reproductive indices were calculated for each species as the ratio of young to adults captured. These estimates, in addition to percent changes in population, were compared to regional MAPS data from the web-based query interface. These comparisons were made from the years 1994 – 2003, since this is what is available in the MAPS database at this time. Survival probabilities for each species across the Pacific Northwest region are also reported for a twelve year period, from 1992-2003 from the MAPS web-based query interface.

Mean annual temperature and precipitation data were gathered from the National Climatic Data Center of the National Oceanic and Atmospheric Administration. Data from the closest cooperative weather station to the banding site at SKSW was used, which was in Prospect, OR (Coop ID# 356907) for the same years for which MAPS data was collected, from 1994-2007. Climate data were analyzed for trends over time and in the non-metric multi-dimensional scaling ordination analysis. Trends between species abundance and climate were also analyzed using regression analysis.

Non-Metric Multidimensional Scaling (NMS) Ordination

Ordination is a technique that arranges items along an axis, or multiple axes, which can graphically summarize complex relationships by extracting the most dominant patterns out of many possible patterns. The purpose of ordination is to summarize a multivariate pattern into a few dimensions while retaining as much information as possible. The underlying principle of ordination is the network of correlations between variables. Community ecologists often rely on the use of ordination to describe patterns in species composition. For instance, species composition may change with environmental gradients such as temperature, elevation, or time.

The data will ordinate into the appropriate dimensions that visually show this pattern of change.

Non-metric multidimensional scaling (NMS) (Mather 1976 and Kruskal 1964) is an ordination technique which uses an iterative approach to reducing dimensionality based on calculations of a distance, or dissimilarity matrix. Dissimilarity is a distance measure between sample units or species (by rows or columns in the data matrix), and is a measure of the difference between two points. Sorensen's index (also known as Bray-Curtis) is an index which emphasizes shared abundances in species composition, calculated by taking shared abundance divided by total abundance.

The NMS procedure begins with calculating a dissimilarity matrix and assigning sample units to a starting configuration, which are usually assigned with a random number generator. A distance matrix is then calculated between sample units in ordination space. The dissimilarity matrix scores from the original data are then ranked in ascending order, and the dissimilarity scores from the sample units in ordination space are ranked in the same order. Ranking the distances tends to linearize the relationship between the distances in species and environmental space, and any distance measure or relativization is acceptable (McCune and Grace 2002). Finally, the distances between the two dissimilarity matrices are calculated and plotted in ordination space.

NMS searches for the best position of the data points in the fewest dimensions which reduce stress in the new configuration. In this case, "stress" is the deviation from monotonicity in the relationship between dissimilarity in the original space and that in the ordination space.

NMS will perform an ordination with a step-down in dimensionality, which uses more axes than necessary in order to find the optimal number of axes which reduces the data while retaining the most amount of information. When stress is plotted against the number of dimensions (axes), the point at which the reduction in stress becomes monotonic suggests the optimal number of axes to retain for analysis. NMS is unique in that the solution changes for a particular axis as the number of dimensions are changed. NMS is particularly useful in the case of non-normal or arbitrarily scaled data. Advantageous to community ecologists, assumptions about linearity, gradient responses, or inherent dimensionality are not required by NMS.

NMS was performed on species frequencies over time from 1994-2007 (McCune and Grace 2002) using Sorensen's (Bray-Curtis) distance measure and random starting coordinates. Only adult birds with unique band numbers in each year were analyzed and rare birds that were caught five times or less were removed from the ordination analysis. Nets 1, 2, 9, and 10 were also removed from the analysis since these nets were phased out over time and did not represent a large proportion of the catch over the fourteen year period. A step-down procedure using six dimensions was used to determine the optimal number of axes to retain. Ten runs with real data were used with a stability criterion set to 0.0005. The appropriate dimensionality was assessed based on the amount of stress that was reduced by each dimension.

Results

Exploratory Analysis

The most number of species were caught at SKSW in 2005 (n=38), while the least number of species were caught in 1995 (n=19), however comparable numbers of species were caught over the fourteen year sampling period (Figure 3). The most number of adult individuals were caught in 2003 (n=188), while the least number of adult individuals were caught in 1995 (n=56). The most number of young individuals were caught in 2005 (n=103), and the least number of young individuals were also caught in 1995 (n=18) (Figure 4). MacGillivray's Warbler was by far the most abundant species caught at the SKSW banding station in all years (23% of catch), followed by Rufous Hummingbird (9%), Song Sparrow (7%), and Wilson's Warbler (7%) (Figure 5). Net performance varies from 0.3% (net 1) to 15% (net 5) of the catch over fourteen years (Figure 6). Nets 1, 2, 9, and 10 do not exhibit high captures because these nets were phased out early in the monitoring program. Nets 9 and 10 were replaced after the 1996 season with nets 11 and 12; net 2 was replaced by net 13 after the 1997 season, and net 1 was replaced after the 1999 season by net 14.

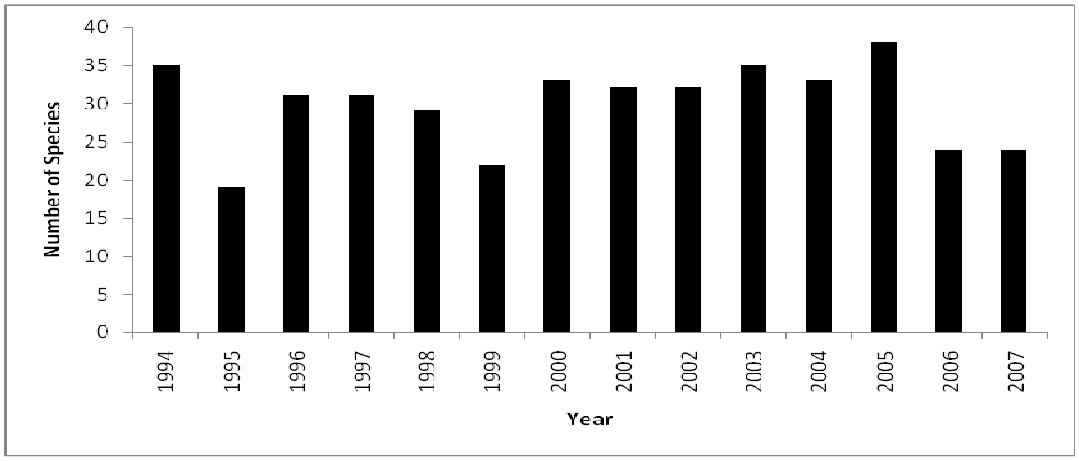

Figure 3: Number of Species Caught Over Fourteen Years at SKSW

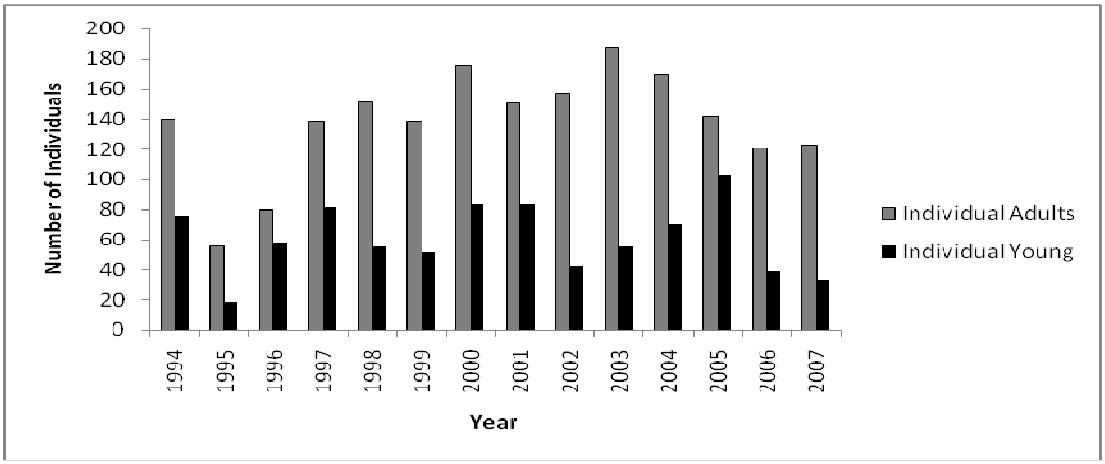

Figure 4: Number of Individual Adults (After Hatch Year) and Young (Hatch Year) Caught Over Fourteen Years at SKSW

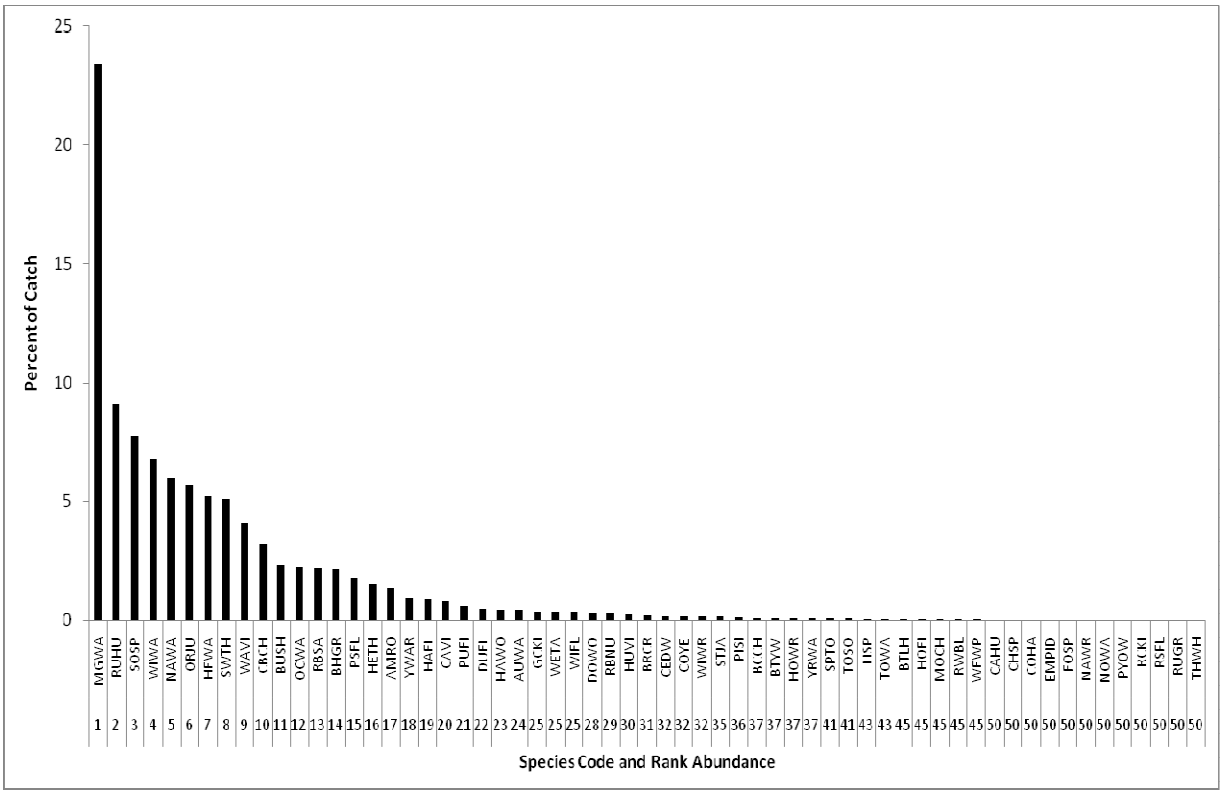

Figure 5: Rank Abundances of Species Catch Over Fourteen Years at SKSW

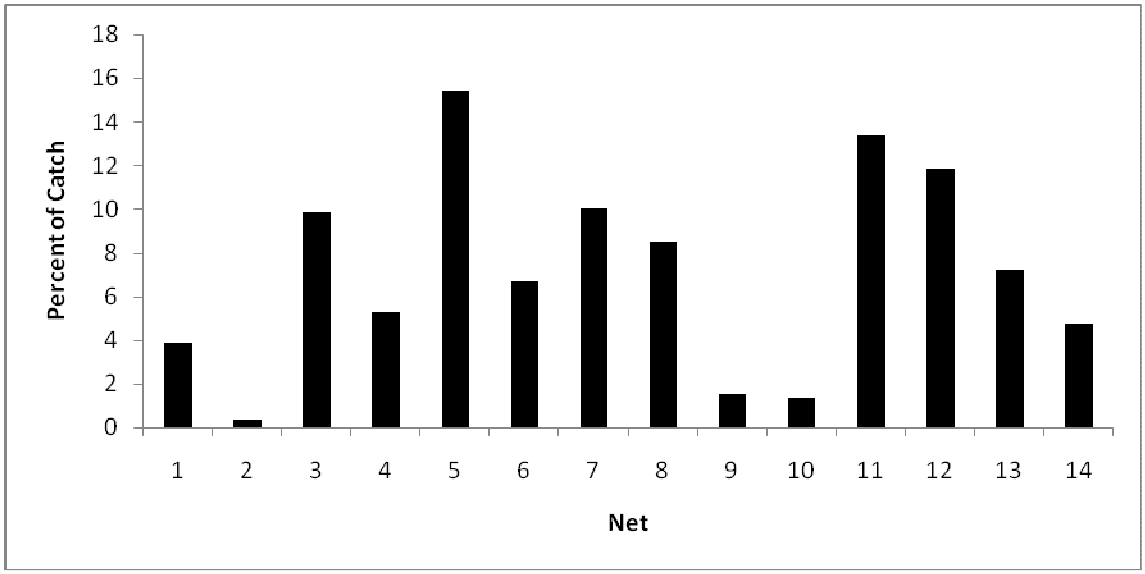

Figure 6: Net Performance Indicated by Percent of Catch at Each Net Across All Years

A variety of life history strategies are represented in the species that were caught at SKSW (Table 2). Migration strategy is roughly split in half between migratory and short-distance migrants, or residents. There is a general increase in neotropical migrants from 1994 to 1999 and from 2004 to 2007 (Figure 7). Species at SKSW are predominantly insectivores that build open nests. The presence of insectivores gently increases over the fourteen year sampling period, while a decrease in omnivores occurs simultaneously (Figure 8). Twenty eight percent of species captured at SKSW are regular breeders, while twenty-five percent were usual breeders, twenty-three percent were occasional breeders, twenty-one percent were transients, and two percent were each altitudinal dispersers and migrants. Seral stage associations are represented equally among species caught at SKSW, between the preferred habitat of open canopy, closed canopy, and generalist. Although none of the species in this study prefer old growth, certain species that prefer closed canopy occur there, such as the Pacific Slope Flycatcher (Marshall et al 2003). Microhabitat association is dominated by generalists, although there is a large proportion of species with no data for this group (which is why this group does not add up to 100%). Finally, reproductive index was calculated for migratory species and short distance migrants/residents separately (Figure 9). Reproductive index for migratory species is high in 1994 and 2005, while short distance migrants and residents exhibit a high reproductive index in 2001.

Table 2: Representation of Life History Strategies of Species Caught at SKSW

Life History Trait	Percent of Species
Migration Strategy	
Migratory	52
Short Distance Migrant	10
Resident	38
Food Type	
Insectivorous	60
Omnivorous	32
Herbivorous	4
Carnivorous	4
Nest Type	
Open	79
Hole	21
Brood Parasite	0
Breeding Status	
Regular Breeder	28
Usual Breeder	25
Occasional Breeder	23
Transient	21
Altitudinal Disperser	2
Migrant	2
Seral Stage Association	
Open Canopy	32
Closed Canopy	30
Generalist	38
Old Growth	0
Microhabitat Association	
Generalist	28
No Data	16
Snag	9
Fallen Tree	3
Large Tree	0

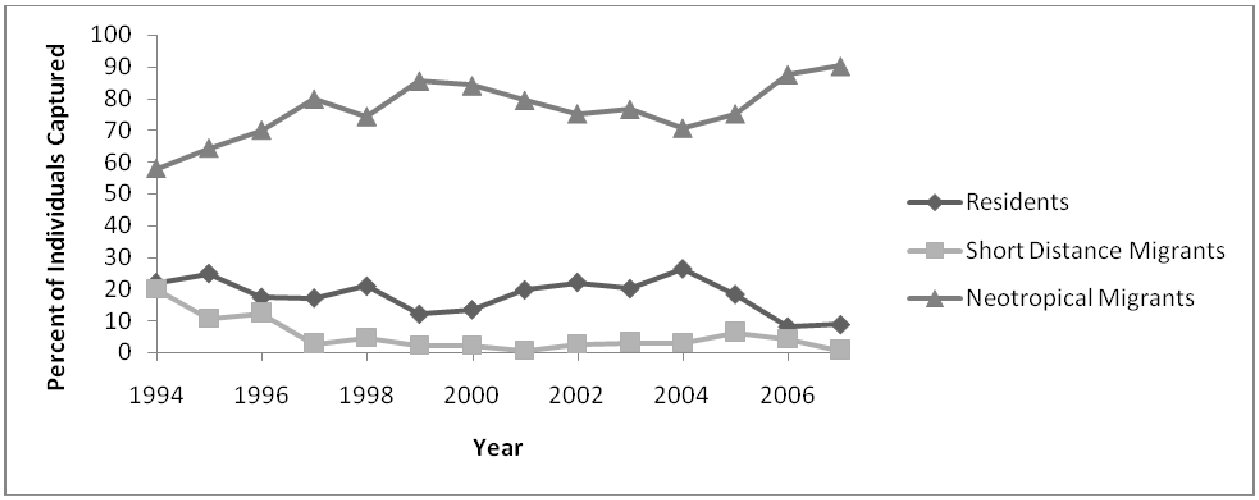

Figure 7: Percent of Neotropical Migrants, Short Distance Migrants, and Residents Captured at SKSW Over Time

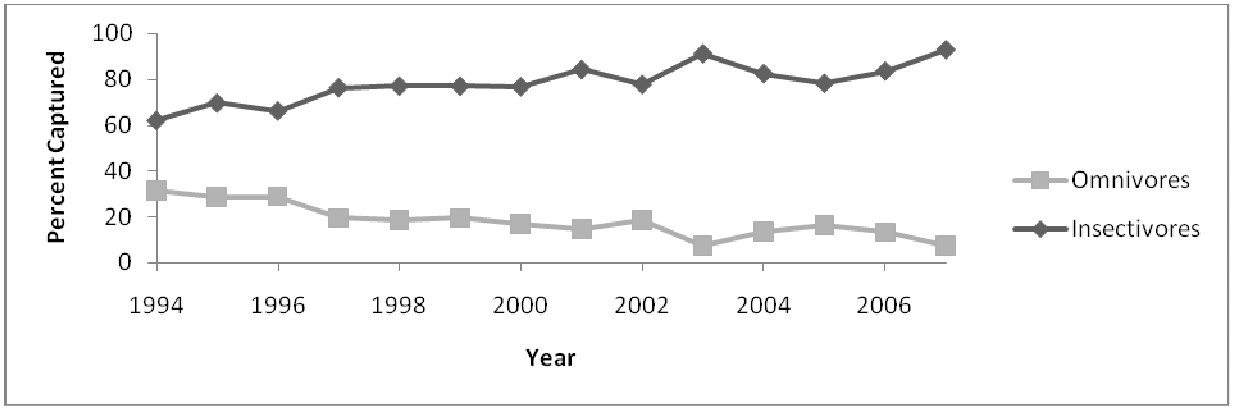

Figure 8: Percent of Insectivores and Omnivores Captured at SKSW Over Time

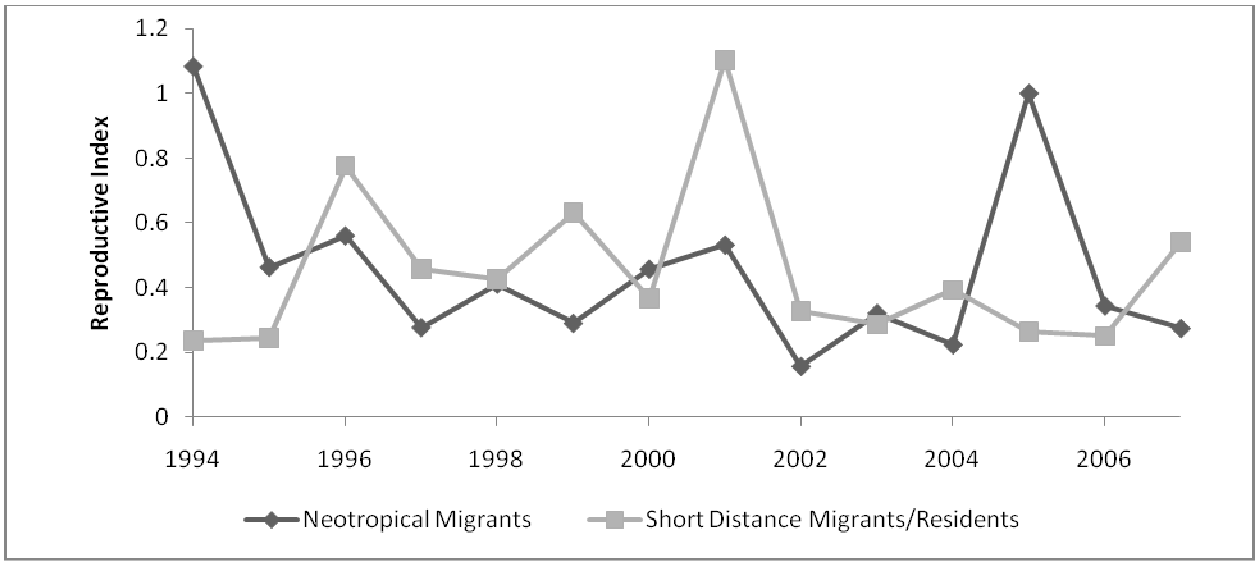

Figure 9: Reproductive Index Over Fourteen Years for Neotropical Migrants and Short Distance Migrants

Mean annual precipitation increases from 1994 to 1996, peaking at 55 inches, and then remaining relatively constant throughout the fourteen year period (Figure 10). Mean winter precipitation (December – February) exhibits the same pattern, but spring precipitation is more variable, with the wettest springs occurring in 1995 (52 in), 2003 (50 in), and 2005 (48 in) (Figure 10). Mean annual temperature remains relatively constant, but peaks in 2003 at 55°F (Figure 11). Mean winter temperature varies, with the warmest winters occurring in 1995 (44°F) and 2003 (43°F) and mean spring temperatures vary between 46°F and 52°F (Figure 11).

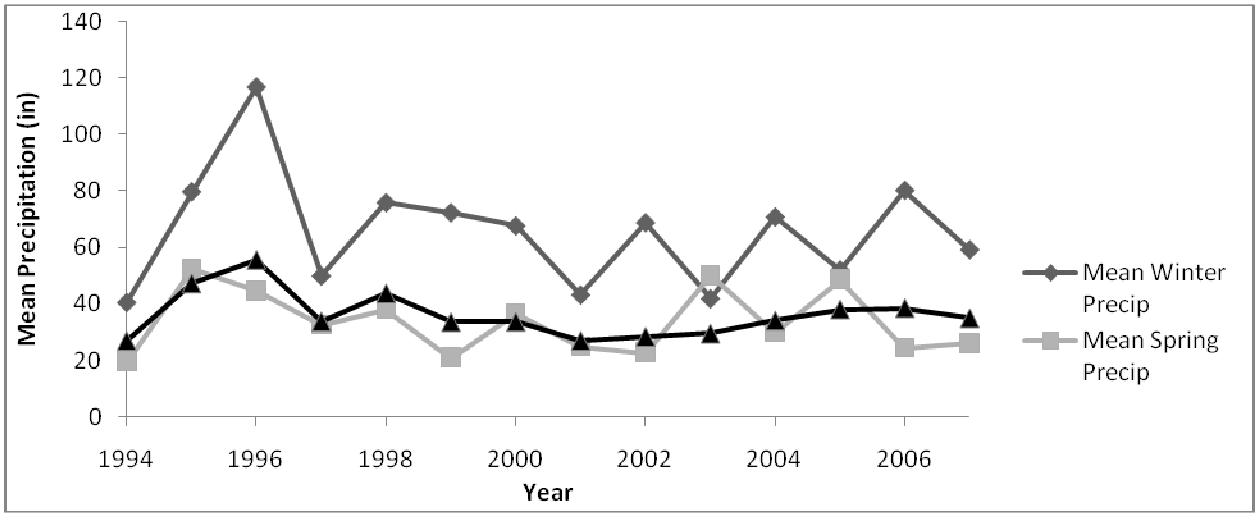

Figure 10: Mean Annual, Winter (Dec-Feb), and Spring (March-May) Precipitation (in) From 1994-2007 at the Prospect Cooperative Weather Station

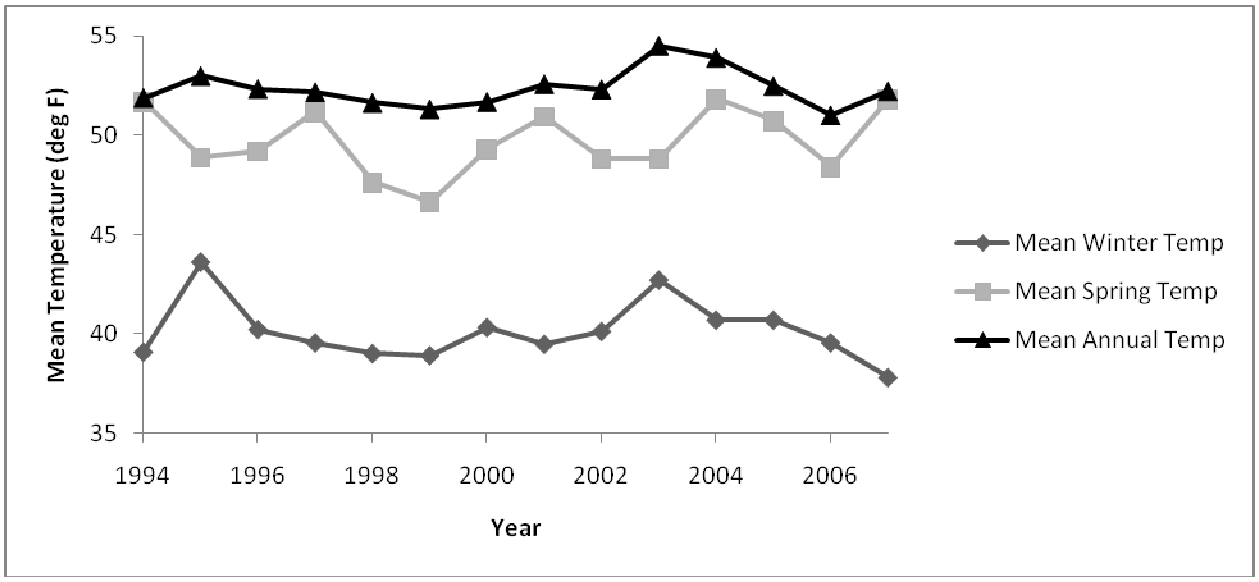

Figure 11: Mean Annual, Winter (Dec-Feb) and Spring (March-May) Temperature (deg F) From 1994-2007 at the Prospect Cooperative Weather Station

Species-Specific Analyses: Regressions

Of thirty nine species analyzed for after hatch year population trends, only six species demonstrated significant trends (Table 3). Four species exhibited significantly increasing trends, including the Chestnut-Backed Chickadee (R^2=0.491, $p<0.05$), Nashville Warbler (R^2=0.341, $p<0.05$), Swainson's Thrush (R^2=0.327, $p<0.05$), and Yellow Warbler (R^2=0.684 $p<0.05$) (Figures B.1-B.4 of Appendix). Two species exhibited significantly decreasing trends ($p<0.05$) in the adult population, including the Purple Finch (R^2=0.635 $p<0.05$), and Song Sparrow (R^2=0.526 $p<0.05$) (Figures B.5-B.6 in the Appendix). Percent changes and reproductive index for adult species that exhibited significant trends were compared to MAPS data regional trends (Table 5), and survival rate estimates are presented from the regional MAPS database (Table 6) using a modified Cormack-Jolly-Seber mark-recapture analysis. Of thirty five species for which there was adequate data for analyzing hatch year populations, no species demonstrated significant trends in either direction (Table 4).

Table 3: Summary Table of Regression Statistics and Reproductive Index of Adult Populations

* significantly increasing **significantly decreasing

Species Code	Slope	R-Squared	P-Value	Average Reproductive Index
AMRO	-0.220	0.208	0.117	0.022
AUWA	-0.182	0.393	0.096	0.031
BHGR	0.332	0.230	0.083	0.060
BRCR	0.286	0.571	0.454	0.667
BTWY	0.000	1.000	-	1.500
BUSH	0.004	0.000	0.993	0.280
CAVI	0.151	0.192	0.205	0.770
CBCH*	0.675	0.491	**0.011**	0.492
CEWA	0.034	0.119	0.776	0.000
COYE	0.108	0.915	0.189	0.500
DOWO	0.056	0.160	0.286	0.111
DUFL	0.061	0.030	0.654	0.200
GCKI	-0.212	0.435	0.154	0.625
HAFL	-0.023	0.003	0.881	0.382
HAWO	-0.084	0.093	0.505	0.714
HETH	-0.457	0.327	0.084	0.451
HEWA	0.648	0.273	0.055	0.285
HUVI	0.186	0.372	0.582	0.000
MGWA	0.914	0.127	0.212	0.488
NAWA*	0.686	0.341	**0.028**	0.640
OCWA	0.098	0.084	0.362	1.935
ORJU	-0.103	0.013	0.695	0.553
PISI	-0.030	0.120	0.568	0.000
PSFL	-0.022	0.002	0.881	0.513
PUFI**	-0.389	0.635	**0.018**	0.083
RBNU	0.075	0.068	0.619	0.056
RBSA	0.198	0.103	0.285	0.753
RUHU	-0.684	0.044	0.535	0.524
SOSP**	-0.640	0.526	**0.003**	0.983
STJA	0.000	1.000	-	0.333
SWTH*	0.422	0.327	**0.032**	0.254
TOWA	0.000	1.000	-	0.000
WAVI	0.279	0.196	0.113	0.323
WETA	-0.091	0.137	0.415	0.190
WIFL	0.009	0.015	0.750	0.222
WIWA	0.167	0.009	0.741	0.385
WIWR	-1.000	1.000	-	0.000
YEWA*	0.413	0.684	**0.006**	0.380
YWAR	0.000	1.000	-	1.000

Table 4: Summary Table of Regression Statistics of Young Population Trends

Species Code	Slope	R-Squared	P-Value
BHGR	-0.086	0.994	0.058
BTWY	-0.200	1.000	-
BRCR	0.000	1.000	-
BUSH	-0.377	0.285	0.173
CAVI	-0.296	0.312	0.328
CBCH	0.159	0.023	0.698
DOWO	0.000	1.000	-
GCKI	-0.027	0.063	0.749
HAWO	0.643	0.964	0.121
HAFL	-0.153	0.595	0.127
HETH	-0.180	0.227	0.195
HEWA	-0.197	0.096	0.354
HOWR	-4.000	1.000	-
HUVI	0.182	1.000	-
LISP	0.000	1.000	-
MGWA	0.314	0.033	0.532
NAWA	-0.313	0.100	0.318
OCWA	1.365	0.181	0.253
ORJU	-0.019	0.000	0.951
PSFL	-0.050	0.028	0.623
PUFI	-0.333	1.000	-
RBNU	-1.000	1.000	-
RBSA	-0.011	0.001	0.928
RUHU	0.217	0.122	0.323
SOSP	0.053	0.002	0.873
SPTO	0.000	1.000	-
STJA	0.000	1.000	-
SWTH	-0.031	0.027	0.612
WAVI	0.057	0.014	0.749
WETA	0.000	1.000	-
WIFL	0.000	1.000	-
WIWA	-0.218	0.288	0.059
WIWR	0.000	1.000	-
YEWA	0.000	1.000	-
YWAR	0.000	1.000	-

Table 5: Comparison Between Species Trends at SKSW and Regional MAPS Trends From 1994-2003

	Mean Annual Percent Change		Reproductive Index	
	Pacific Northwest Region	SKSW	Pacific Northwest Region	SKSW
CBCH	12.88	1.91	0.901	0.587
NAWA	1.47	57.10	1.138	0.635
PUFI	-7.60	-63.33	0.355*	0.111
SOSP	-1.13	-4.85	1.058	0.863
SWTH	0.22	52.60	0.176	0.282
YEWA	4.99	0.00	0.417**	0.650

*9 years of data available: only through 2002, **5 years data available: 1997-1999, 2000, 2003

Table 6: MAPS Regional Survival Rate Estimates from 1992-2003

Species	Region	Number of Stations Included in Analysis	Number of Adult Individuals Captured	Number of Adult Individuals that Returned	Survival Probability[1]			
					Φ	SE(Φ)	CV(Φ)	$w(\Phi_i)^{12}$
CBCH	NW	45	1026	82	**0.333**	0.048	14.5	0.002
NAWA	NW	21	829	50	**0.332**	0.056	16.7	0.004
PUFI	NW	36	2795	287	**0.437**	0.025	5.6	0.011
SOSP	NW	109	7478	2036	**0.477**	0.009	1.8	0.928
SWTH	NW	81	8808	3561	**0.593**	0.007	1.1	0.003
YEWA	NW	64	6225	1388	**0.561**	0.011	2	0.402

[1] Defined as the probability of an adult bird surviving to and returning in a particular year (breeding season) to the area where it was present during the previous year (breeding season). The estimated survival probability (Φ), standard error of the estimate (SE(Φ)), and coefficient of variation (CV(Φ)=100*SE(Φ)/Φ) are presented.

Exploratory analysis revealed that particularly low numbers of birds were captured in the same years that received high levels of rainfall. To explore this relationship and others with climate factors for significance, regression analyses were performed. Two significant relationships were found: A negative, but significant relationship was found between the numbers of adult birds that were captured and total annual precipitation (Figure 12), and a positive, significant relationship was found between the number of adult, resident birds that were captured and mean annual temperature (Figure 13).

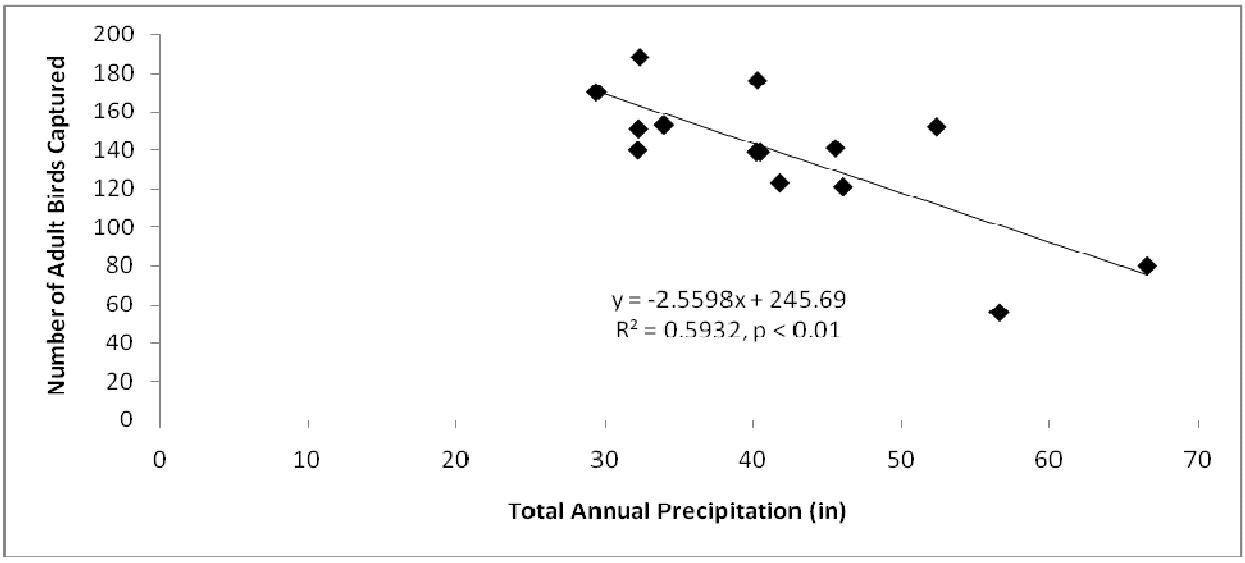

Figure 12: Birds Captured versus Total Annual Precipitation

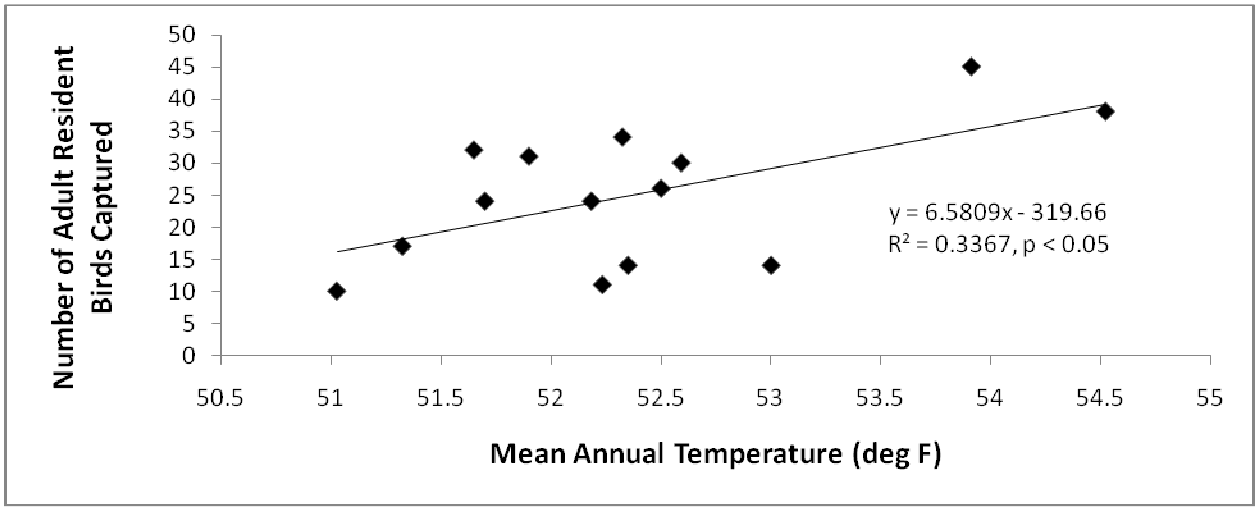

Figure 13: Adult, Resident Birds Captured versus Mean Annual Temperature

Non Metric Multi-Dimensional Scaling Ordination

The step – down procedure using six dimensions retained three dimensions as the best solution for these data, as indicated in the scree plot (Figure 14). The final solution of three dimensions captured most of the variance in species frequencies ($R^2 = 0.66$). Based on the R-squared value between distance in the ordination space and distance in the original space, the proportions of variance represented by each axis were 0.181, 0.138, and 0.346, for axis 1, 2, and 3 respectively, leading to a cumulative R-squared value of 0.66. The mean stress for the three dimensional solution was 21.8, with a final instability of 0.00049 for 99 iterations. Sample scores (Figure 15) and species scores (Figure 16) demonstrate a gradient with respect to axis 3, as shown in simple scatter plots. Correlations of species scores with axes are summarized in Table 7. R-squared values that demonstrate weak species correlations with ordination axes range from 0.0 to 0.4, and only few species are significantly correlated with ordination axes (Table 9). There is a slight compositional change in species along axis 3, however there are no distinct groups. The Cedar Waxwing score in the bottom left hand corner of the scatter plot

showing species scores (Figure 16), although did not meet the criteria for the designation of rare, there were only few captures of this species which is why it received a score so different from the others.

Temperature and precipitation variables correlate weakly with ordination axes (Table 8). Pearson's r correlation coefficients represent linear correlations, while Kendall's tau correlation coefficients represent the rank relationship between the ordination scores and individual variables. Mean spring precipitation was significantly correlated, although negatively, with axis one ($r = -0.187$, $p = 0.04$), mean annual temperature was significantly correlated with axis two ($r = 0.19$, $p = 0.04$), and mean spring temperature was associated with axis three ($r = 0.116$, $p = 0.20$). The gradient response in species scores along axis 3 suggest that species may be sensitive in their response to spring temperatures, as the gradient only represents a three degree change in temperature, from 51° to 54.5°F. Sample scores plotted against time demonstrate there is no pattern in the variation of species over time (Figure 17).

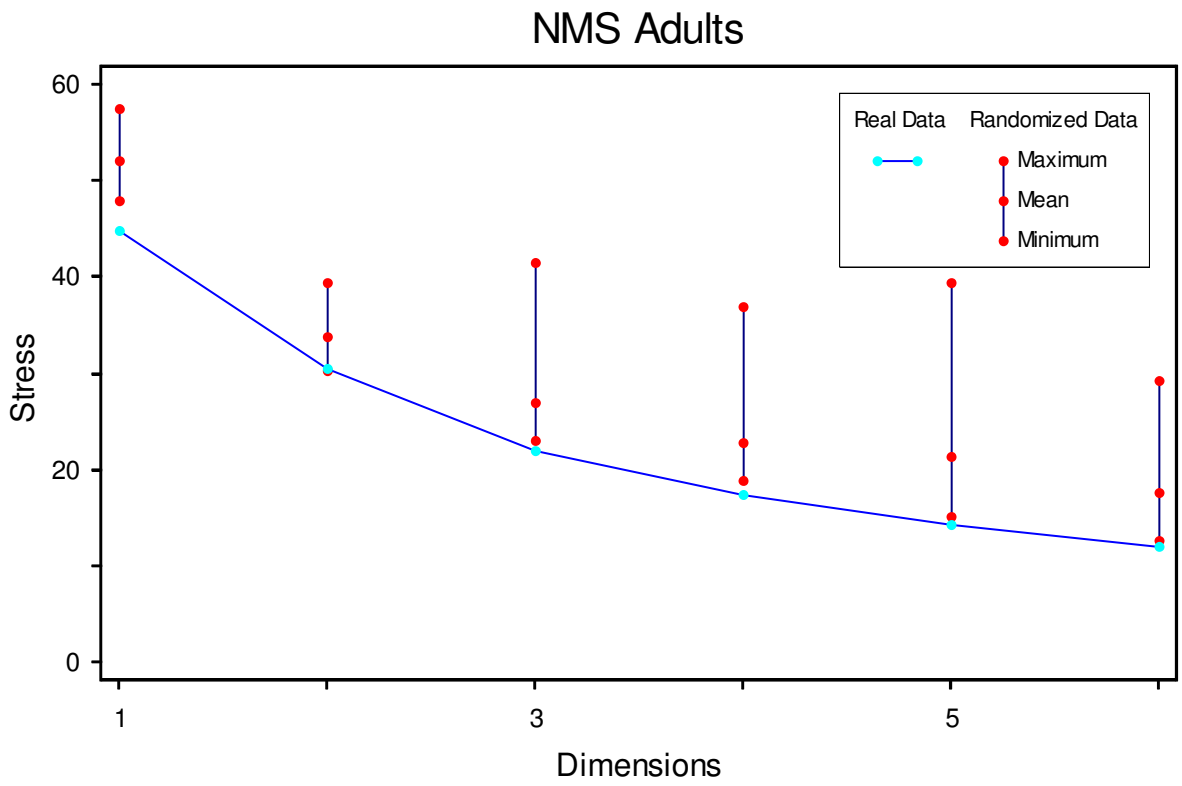

Figure 14: A scree plot showing stress as a function of dimensionality. "Stress" is an inverse measure of fit to the data. Stress stabilizes after three dimensions, at the "elbow" in the line which indicates three axes is the optimal solution.

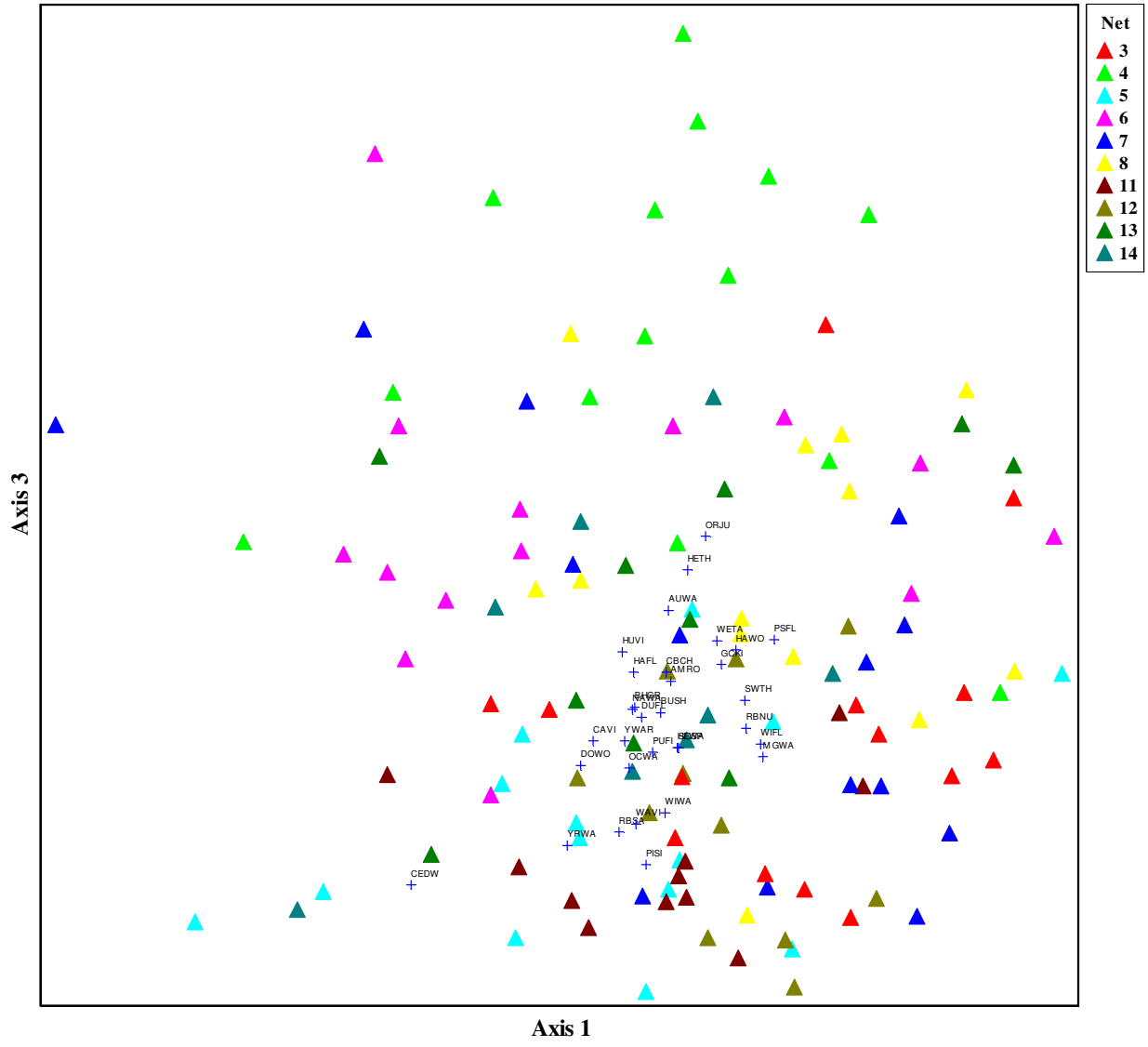

Figure 15: Simple Scatterplot For Axes 1 and 3 Categorized by Net. Mean spring precipitation was significantly associated, although negatively, with axis one (r = -0.187, p = 0.04*) and mean spring temperature was associated with axis three (r = 0.116, p = 0.20).

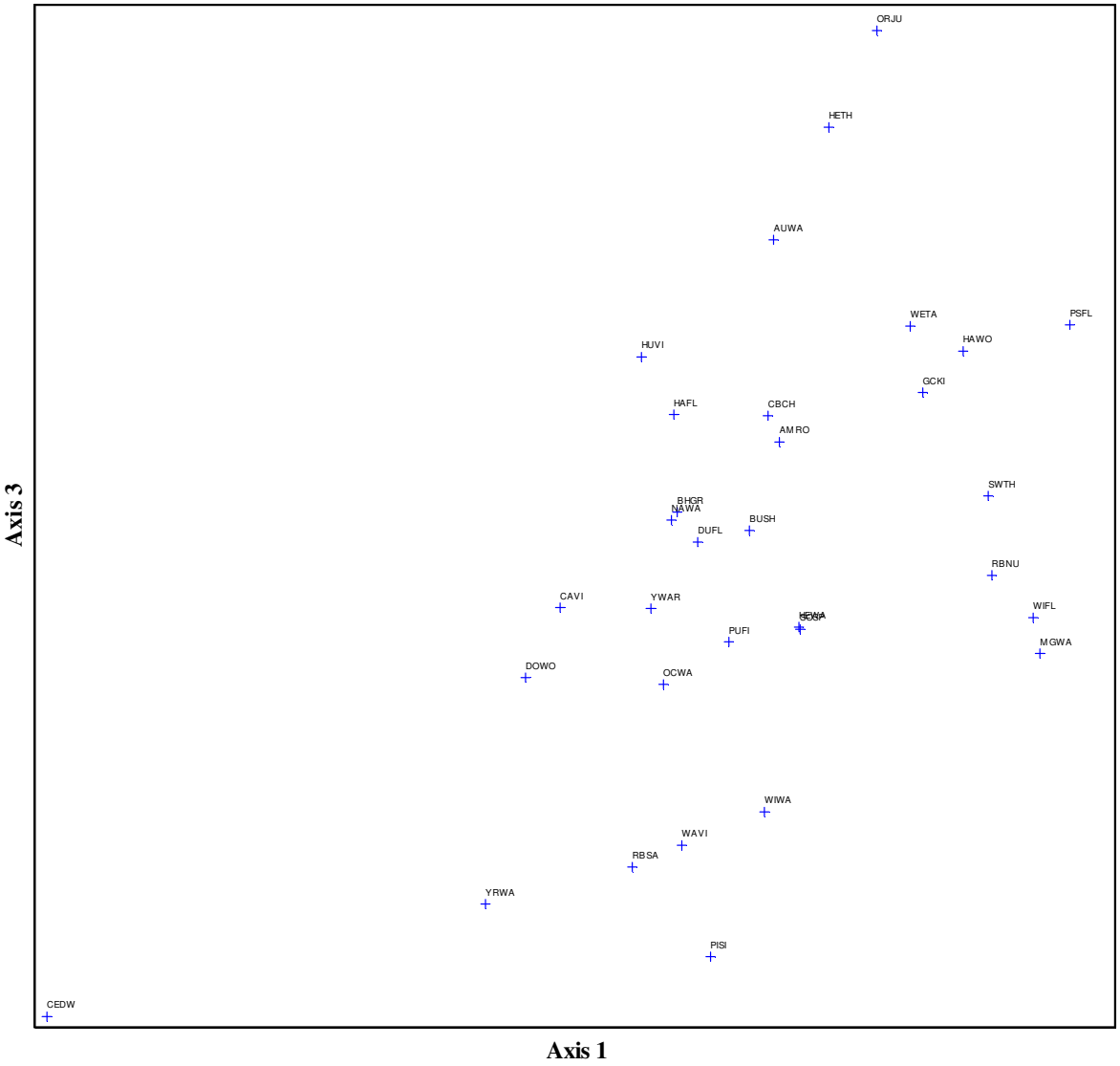

Figure 16: Species Scores for Ordination Axes 1 and 3. A gradient in species scores is observed along axis 3, which correlates to Mean Spring Temperature.

Table 7: Summary of Statistically Significant Correlations Between Species and Ordination Axes. Negative relationships are marked, and all others are positive.

Axis 1 Mean Spring Precipitation	Axis 2 Mean Annual Temperature	Axis 3 Mean Spring Temperature
33% short-distance migrants/residents and 67% migratory	50% short-distance migrants/residents and 50% migratory	20% short-distance migrants/residents and 80% migratory
MacGillivray's Warbler	Bushtit	MacGillivray's Warbler (-)
Nashville Warbler (-)	Cassin's Vireo	Nashville Warbler (-)
Pacific Slope Flycatcher	Chestnut-Backed Chickadee	Orange-Crowned Warbler (-)
Swainson's Thrush	Downy Woodpecker	Oregon Junco
	MacGillivray's Warbler	Red-Breasted Sapsucker (-)
	Nashville Warbler	Swainson's Thrush (-)
	Orange-Crowned Warbler	Warbling Vireo (-)
	Oregon Junco	
	Purple Finch	
	Swainson's Thrush	
	Wilson's Flycatcher	

Table 8: Pearson and Kendall Correlations of Variables with Ordination Axes

	Axis 1				Axis 2				Axis 3			
	r	r-sq	P value	tau	r	r-sq	P value	tau	r	r-sq	P value	tau
MAP	-0.131	0.017	0.148	-0.046	-0.017	0	0.855	-0.082	0.022	0	0.811	-0.01
MAT	-0.121	0.015	0.181	-0.112	0.19	0.036	**0.034**	0.132	-0.019	0	0.828	0.039
MWT	-0.151	0.023	0.094	-0.107	0.028	0.001	0.732	0.067	0.018	0	0.843	0.019
MST	-0.039	0.002	0.66	-0.015	0.103	0.011	0.254	0.107	0.116	0.013	0.204	0.081
MWP	-0.09	0.008	0.321	-0.001	0.055	0.003	0.554	-0.052	0.052	0.003	0.574	0.016
MSP	-0.187	0.035	**0.038**	-0.108	-0.014	0	0.907	0.006	-0.064	0.004	0.486	-0.08

MAP:Mean Annual Precipitation, MAT: Mean Annual Temperature, MWT: Mean Winter Temperature, MST:Mean Spring temperature, MWP: Mean Winter Precipitation, MSP: Mean Spring Precipitation

p-values in bold type are statistically significant

Table 9: Pearson and Kendall Correlations of Species with Ordination Axes

	Axis 1				Axis 2				Axis 3			
	r	r-sq	P value	tau	r	r-sq	P value	tau	r	r-sq	P value	tau
AMRO	-0.044	0.002	0.632	-0.064	0.148	0.022	0.105	0.098	-0.08	0.006	0.380	-0.054
AUWA	-0.027	0.001	0.769	-0.005	0.126	0.016	0.160	0.094	0.06	0.004	0.508	0.015
BHGR	-0.166	0.028	0.064	-0.215	0.024	0.001	0.791	0.003	-0.163	0.027	0.071	-0.113
BUSH	-0.035	0.001	0.708	-0.092	0.256	0.066	**0.004**	0.1	-0.074	0.005	0.412	-0.081
CAVI	-0.153	0.024	0.963	-0.131	0.177	0.031	**0.054**	0.165	-0.131	0.017	0.150	-0.115
CBCH	-0.048	0.002	0.600	-0.127	0.313	0.098	**0.000**	0.248	-0.046	0.002	0.608	0.016
CEDW	-0.172	0.029	-	-0.146	-0.024	0.001	-	-0.02	-0.132	0.017	-	-0.133
DOWO	-0.146	0.021	0.110	-0.124	0.259	0.067	**0.004**	0.23	-0.141	0.02	0.118	-0.13
DUFL	-0.084	0.007	0.361	-0.086	0.058	0.003	0.522	0.082	-0.112	0.013	0.214	-0.08
GCKI	0.04	0.002	0.660	0.029	0.1	0.01	0.256	0.077	-0.013	0	0.892	0.013
HAFL	-0.12	0.014	0.193	-0.134	0.121	0.015	0.193	0.04	-0.041	0.002	0.655	-0.027
HAWO	0.069	0.005	0.443	0.044	0.127	0.016	0.162	0.112	0.003	0	0.971	0.009
HETH	0.005	0	-	-0.013	0.007	0	-	0.002	0.138	0.019	-	0.117
HEWA	-0.037	0.001	-	-0.083	0.093	0.009	-	0.072	-0.401	0.161	-	-0.278
HUVI	-0.055	0.003	0.537	-0.002	-0.125	0.016	0.177	-0.044	-0.001	0	0.996	-0.001
MGWA	0.505	0.255	**2.16 e-09**	0.432	0.286	0.082	**0.001**	0.184	-0.619	0.383	**2.83 e-14**	-0.491
NAWA	-0.248	0.061	**0.006**	-0.28	0.434	0.189	**4.06 e-07**	0.338	-0.241	0.058	**0.007**	-0.145
OCWA	-0.119	0.014	0.187	-0.126	0.176	0.031	**0.053**	0.119	-0.224	0.05	**0.013**	-0.187
ORJU	0.089	0.008	0.324	0.029	0.362	0.131	**3.47 e-05**	0.273	0.473	0.224	**3.31 e-08**	0.443
PISI	-0.039	0.002	-	-0.072	-0.037	0.001	-	-0.023	-0.193	0.037	-	-0.17
PSFL	0.266	0.071	**0.003**	0.219	0.025	0.001	0.767	0.013	0.031	0.001	0.722	0.084
PUFI	-0.052	0.003	0.576	-0.094	0.206	0.042	**0.024**	0.167	-0.14	0.02	0.119	-0.1
RBNU	0.092	0.008	0.309	0.063	0.125	0.016	0.165	0.112	-0.106	0.011	0.243	-0.076
RBSA	-0.148	0.022	0.102	-0.136	0.118	0.014	0.200	0.111	-0.362	0.131	**3.78 e-05**	-0.326
SOSP	-0.03	0.001	-	-0.047	0.517	0.268	-	0.431	-0.347	0.121	-	-0.293
SWTH	0.262	0.069	**0.003**	0.202	0.324	0.105	**0.000**	0.257	-0.194	0.038	**0.030**	-0.162
WAVI	-0.168	0.028	0.064	-0.198	0.169	0.028	0.064	0.103	-0.531	0.282	**2.72 e-10**	-0.486
WETA	0.046	0.002	0.617	0.04	0.084	0.007	0.387	0.083	0.016	0	0.870	0.018
WIFL	0.109	0.012	0.231	0.1	0.236	0.056	**0.009**	0.18	-0.12	0.014	0.185	-0.097
WIWA	-0.079	0.006	-	-0.114	-0.096	0.009	-	-0.095	-0.568	0.323	-	-0.508
YRWA	-0.081	0.007	0.389	-0.094	-0.11	0.012	0.206	-0.116	-0.116	0.014	0.203	-0.105
YWAR	-0.14	0.02	-	-0.167	0.206	0.043	-	0.222	-0.186	0.034	-	-0.207

p-values in bold type are statistically significant

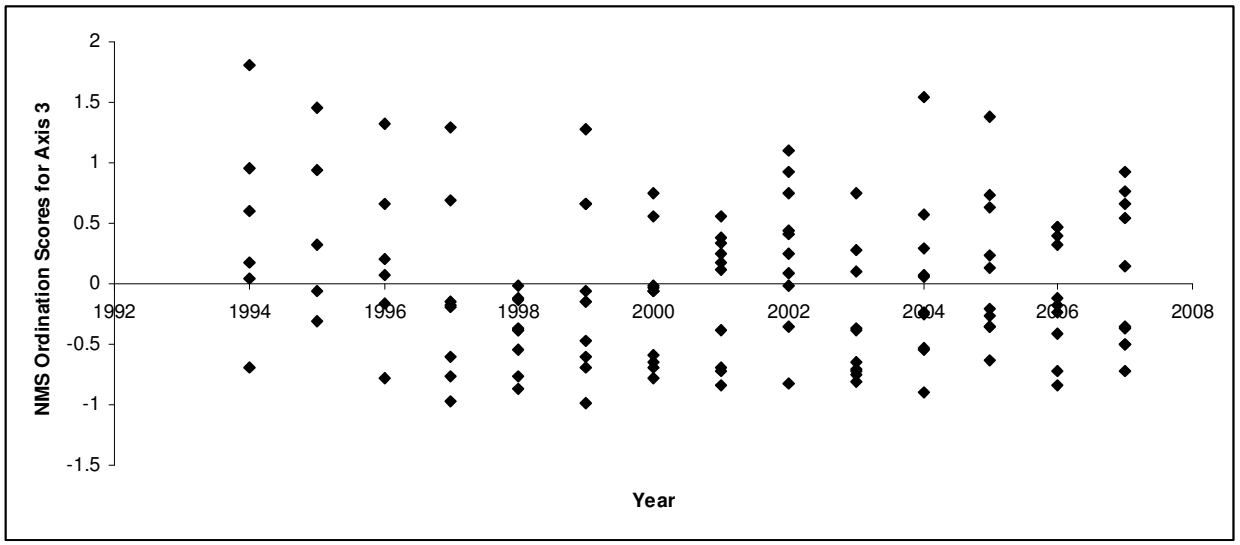

Figure 17: NMS Sample Scores for Axis 3 (the axis which captured the most variation in the data, 40%) Over the Fourteen Year Sampling Period

Discussion

Few species demonstrate significant trends at the SKSW banding station in southern Oregon. The species that do not exhibit significant trends are interpreted to have stable populations. In some cases, however, it is possible that although a regression was performed, the data was too noisy to show strong trends. The species that do exhibit significant trends at SKSW also share the same trends when compared to regional MAPS analysis. Although the magnitude of the difference between the two is substantial, the direction of the trends is consistent. The difference in magnitude between the site – specific and regional trends are most likely due to the difference in data robustness. The regional MAPS trends are calculated using several MAPS stations; hence, the dataset is large. As mentioned in the objectives of this study, constant-effort mist netting can suffer from problems when analyzing trends at one local site; the data are noisy and may not accurately reflect population dynamics. A network of stations in a region can offer useful insights into local and regional population trends. However,

the trends that can be detected at local sites will certainly help managers understand how their efforts fit into the big picture.

Commonalities across life history traits, productivity, as measured by reproductive success, and regional survival rate estimates were assessed in this study to help interpret the significant population trends that were observed. However, site-specific survivorship estimates should be assessed for SKSW to conjecture reasons for observed trends at this site. Additionally, changes in predator and prey populations are likely influential factors on population trends that were not assessed in this study.

Species with Significantly Increasing Trends

The four species that exhibited increasing trends (CBCH, NAWA, SWTH, and YEWA) do not exhibit commonalities across life history traits, except that these species are all insectivores. Particularly wet ENSO years can affect primary productivity (Wiles *et al* 2001) and consequently insect abundance (Kemp *et al* 1985), which may favor these particular insectivorous species, although ENSO events were not looked at in this study. Annual reproductive indices have been observed to significantly increase with the springtime ENSO Precipitation Index (ESPI), especially for neo-tropical wintering species. It would be interesting to research whether or not the peaks in reproductive indices (Figure 9) in this study correlate with the ESPI index as well. All nest types, migration strategies, seral stage associations, and microhabitat associations are represented by these species, and thus, do not help to interpret the increasing population trends. Furthermore, all species are regular, usual, or occasional breeders at SKSW.

Oregon populations of Chestnut-Backed Chickadee appear to be stable, although the population at SKSW is increasing. As one would expect, this species exhibits a relatively high reproductive index at SKSW (0.6) and at the regional level (0.9), but dissimilarly exhibits a relatively low survival probability (0.33) for the Pacific Northwest region. The Chestnut-backed Chickadee selects very large-diameter snags for nesting. Abundance has been found to increase with increasing density of large Douglas-fir trees (Manuwal 1990) and large old-growth forest patches (McGarigal and McComb 1995). It remains unclear what implications exist if there is a lack of large – diameter snags on the ability of chickadees to persist in intensively managed landscapes. Since the Chestnut-backed Chickadee is listed as a Species of Continental Importance, and 90% of its breeding population occurs solely in the Pacific Northwest region, productivity and survivorship should be periodically checked for changes.

The Nashville Warbler is experiencing population increases throughout Oregon and at SKSW. As expected, relatively high reproductive success is observed at SKSW (0.6) and at the regional level (1.1), however, a relatively low survival probability is observed at the regional level (0.33). This species prefers early successional habitats with moderately dense understory, and low elevation forests where fire has not recently cleared out the understory. As such, changing forest practices including restrictions on clearcuts and an increased use of prescribed fire to reduce fire hazard, may pose threats to this species in the future (Marshall *et al* 2003). Also, this species is host to brood parasitism by the Brown-headed Cowbird (Verner and Boss 1980), and increasing rural development and forest fragmentation may bring these two species into closer contact.

Although Swainson's Thrush was found to experience increasing populations at SKSW, others have noted declines throughout Oregon in the last several decades (Marshall *et al* 2003). Low reproductive indices for SKSW (0.3) and the Pacific Northwest region (0.2), and a high survival probability at the regional level (0.6) indicate that observed declines throughout Oregon may be due to low productivity. Since this species is strongly associated with closed canopy forests in which the mid and understory are comprised of dense deciduous hardwood vegetation, abundance typically declines following timber harvests that remove most of the overstory (Chambers 1996), but abundance has been found to increase with stand age (Bettinger 1996). Abundance of Swainson's Thrush can also decline following high intensity burns (Sallabanks 1995). Moderate levels of timber removal may not affect this species, and may even improve the habitat if increased shrub cover results from the disturbance (Marshall *et al* 2003).

While consistent declines in Yellow Warbler populations have been observed throughout Oregon (Marshall *et al* 2003) and the western U.S. (Ortega and Ortega 2000), the population at SKSW is increasing. To the contrary, however, relatively high reproductive success at SKSW (0.7) and relatively high survival probability for the region (0.6) has been recorded by MAPS data. Regional estimates for reproductive success, however, are relatively low (0.4). Due to its close association with riparian habitat, declines across the western U.S. are most likely due to degradation and destruction of riparian habitat, especially by grazing (Sanders and Edge 1998). The relatively undisturbed riparian habitat at SKSW is likely one cause for an increasing population at this site. Brood parasitism by the Brown-headed Cowbird has also had adverse impacts on the Yellow Warbler in some parts of North America (Ortega

and Ortega 2000). This species should be monitored closely for changes in productivity and survivorship across the state.

Species With Significantly Decreasing Trends

Similar to species with increasing trends, both species that exhibit significantly decreasing trends (PUFI and SOSP), do not exhibit commonalities across life history traits, except that they are both omnivores and build open nests.

Although Purple Finches are one of the most widely distributed finches in western Oregon, declines have recently been observed across the state. A low reproductive index (0.1) at SKSW and regionally (0.4) may indicate that this species is declining due to low productivity. However, regional estimates of survival probability are also low (0.4), indicating that the species may also be declining due to low survivorship. Reasons for decline may be due to clearing of forested and woodland habitat for residential, agricultural, and industrial development, as well as displacement from House Finch populations (Marshall *et al* 2003).

Surprisingly, the Song Sparrow, an opportunist that appears to fill any available habitat, is experiencing declines at SKSW and across the region even though populations were thought to be stable throughout Oregon. Relatively high productivity at SKSW (0.9) and regionally (1), in addition to an average survival probability (0.5), are contradictory to interpretation of the population trends observed in this study. Destruction of riparian habitat, although not an issue at SKSW, may be detrimental to this species. In addition, overgrazing and the resulting erosion have reduced Song Sparrow populations in some areas (Taylor 1984).

Population and Climate Trends

A significant relationship was found between bird captures and total annual precipitation. Specifically, fewer birds were captured during years of particularly high levels of precipitation. Although nets were not operated during rainy weather, these days were made up during the monitoring season, and consequently, nets were operated for the same amount of time each year. Furthermore, a significant relationship was also found to exist between captures of resident birds and mean annual temperature. More birds were captured during years with warmer temperatures. Resident species may be more sensitive to slight temperature changes than migratory species, which may be why there is no relationship between temperature and migratory species. It has been observed that unusually wet or cold weather in the early breeding season may cause high rates of nest failure and abandonment for some species, such as the Chestnut-backed Chickadee (Gaddis, undated). These results suggest that nest success and consequent productivity may depend on climatic factors. Future research investigating the relationship between avian demographic indices and climate factors will facilitate our understanding of how avian species will respond to climate change.

General Patterns in NMS

NMS does not reveal clear ecological trends in the data, despite the low stress and instability that the ordination achieved. Species composition does not exhibit a pattern when the data is reduced to three axes, although there is a slight gradient response along axis 3. One interpretation of this result is that each species was captured equally enough over the fourteen year sample period and there is no pattern. The data do show that a similar number of species

were captured in any given year (Figure 3). Another possibility, however, is that the data are too noisy for NMS to detect patterns. Although spring temperatures and precipitation do correlate with the variation in the data, the relationships do not justifiably explain any variation, other than a slight gradient response to temperature. The response suggests that different species may have different levels of tolerance for changing temperatures. Species composition does exhibit variation with net placement. Different species composition at each net is most likely due to territory size, which in many cases can be less than one hectare. Certain species that exhibit site fidelity may also influence this pattern. Upon closer examination of the species scores, it is clear that abundance of the birds that were captured varies from species to species. As one would expect, many common birds were captured, and few rare species (or species that do not regularly occur at SKSW) were captured over the fourteen year period.

Recommendations

Three main recommendations developed as a result of this study. First, long term monitoring of avian populations is invaluable in understanding shifts in population trends and the mechanisms that drive them. As demonstrated by this study, even fourteen years may not be long enough to tease out trends among natural fluctuations in populations. Focused conservation actions of past have demonstrated that birds will respond quickly and positively to management efforts. Monitoring is of course, the first step in determining which species need the most attention. The Rogue River/Siskiyou National Forest has a unique opportunity to continue long term monitoring in relatively undisturbed riparian habitat that will most assuredly provide insight to population changes with respect to altered habitats elsewhere in

the region. MAPS monitoring will facilitate our understanding of shifts in populations and species ranges that will most likely occur in light of increased habitat alterations and climate change. To accompany monitoring efforts, myriad opportunities for further research exist, including the changing relationship between avian demographic indices and land use change or climate change. Bird populations remain an important indicator of our nation's environmental health, particularly throughout the changes that will inevitably ensue.

Second, the Institute for Bird Populations as yet, has no solid tool for communicating results to specific banding stations. Communication between IBP and agencies that manage banding stations should be enhanced. Even though MAPS analysis is best applied across banding stations in a regional context, managers should have access to site-specific data. The IBP web-based query that already offers an interface to search for regional data analyses, can easily incorporate a search function to access data from specific banding stations. With increased communication, agencies will be able to adapt their own forest plans to accommodate their management actions needed to maintain, enhance, or increase land bird populations across the region.

Finally, collaborative initiatives involving international partnerships are essential for successful conservation of bird species and their habitats. Half of all forest bird species migrate from breeding habitats in the U.S. and Canada to winter in the Caribbean, Mexico, and Central and South America. Constant effort mist netting on the wintering grounds will provide a complete picture of migratory species population trends and the mechanisms that drive them. Land use change may be more severe in Central America, and may have impacts on avian species that are little known unless these partnerships are built.

Literature Cited

Bettinger, K. 1996. Bird communities in 5 to 34 yr-old managed Douglas Fir stands on the Willamette National Forest, Oregon Cascades. M.S. thesis, Oregon State University, Corvallis.

Brown, L.R., 1991. *State of the World, 1992*. Worldwatch Institute, Washington, D.C.

Chambers, C.L. 1996. Response of terrestrial vertebrates to three silvicultural treatments in the Central Oregon Coast Range. PhD. Dissertation, Oregon State University, Corvallis.

DeSante, D., Burton, K., Velez., P., Froehlich, D., and Kaschube, D. 2007. MAPS Manual, 2007 Protocol. Instructions for the Establishment and Operation of Constant-Effort Bird Banding Stations as Part of the Monitoring Avian Productivity and Survivorship (MAPS) Program. The Institute for Bird Populations, Point Reyes, CA.

DeSante, D. 1995. Suggestions for future directions for studies of marked migratory land birds from the perspective of a practitioner in population management and conservation. Journal of Applied Statistics 22: 949-965.

Gaddis, P.K. Undated. Reproductive biology of the Chestnut-backed Chickadee. Unpublished report, Northwest Ecological Research Institute, Portland, OR.

Hagar, J.C. 1999. Influence of riparian buffer width on bird assemblages in western Oregon. Journal of Wildlife Management 63:484-496.

Hansen, A.J. and Dean L. Urban. 1992. Avian response to landscape pattern: the role of species' life histories. Landscape Ecology 7(3): 163-180.

Kemp, W.P., Everson, D.O. and W.G. Wellington. 1985. Regional climatic patterns and western spruce budworm outbreaks, technical bulletin 1693. U.S. Department of Agriculture, Forest Service, Canada/United Stated Budworms Program, Washington, D.C.

Kruskal, J.B. 1964. Nonmetric multidimensional scaling: a numerical method. Psychometrika 29:115-129.

Lundquist, R.W., and D. Manuwal. 1990. Seasonal differences in foraging habitat of cavity-nesting birds in the southern Washington Cascades. Studies in Avian Biology 13: 218-225.

Marshall, D.B., M.G.Hunter, and A.L. Contreras, Eds. 2003. Birds of Oregon: A General Reference. Oregon State University Press, Corvallis, OR. 768 Pp.

Mather, P.M. 1976. Computational methods of multivariate analysis in physical geography. J. Wiley & Sons, London. 532 pp.

McCune, B. and J.B. Grace. 2002. Analysis of Ecological Communities. MjM Software Design. Gleneden Beach, OR.

McGarigal, K., and W.C. McComb. 1995. Relationships between landscape structure and breeding birds in the Oregon Coast Range. Journal of Wildlife Management. 56: 10-23.

Michel, N., DeSante, D.F., Kaschube, D.R., and Nott, M.P. 2006. The Monitoring Avian Productivity and Survivorship (MAPS) Program Annual Reports, 1989-2003. NBII/MAPS Avian Demographics Query Interface. http://www.birdpop.org/nbii/NBIIHome.asp (December 2006).

North American Bird Conservation Initiative, U.S. Committee, 2009. The State of the Birds, United States of America, 2009. U.S. Department of Interior: Washington, DC. 36 pages.

Nott, M.P., DeSante, D.F., Pyle, P., and N. Michel. 2005. Managing land bird populations in forests of the Pacific Northwest: Formulating population management guidelines from landscape-scale ecological analyses of MAPS data from avian communities on seven national forests in the Pacific Northwest. A report to the Pacific Northwest Region (Region 6), USDA Forest Service.

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.

Ortega, J.C, and C.P. Ortega. 2000. Effects of Brown-headed Cowbirds and predators on the nesting success of Yellow Warblers in southwestern Colorado. Journal of Field Ornithology 71: 516-524.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. 2004. Partners in Flight North American Land bird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Sallabanks, R. 1995. Effects of wildfire on breeding bird communities in coniferous forests of northeastern Oregon. Annual report to the Blue Mountain Natural Resource Institute.

Sanders, T.A. and W.D. Edge. 1998. Breeding bird community composition in relation to riparian vegetation structure in the western United States. Journal of Wildlife Management 62: 461-473.

Siegel, Rodney. 2008. The Institute for Bird Populations 2008 Annual Report.

Sutherland, W.J. 1983. Aggregation of the 'Ideal Free Distribution.' Journal of Animal Ecology 52: 821-828.

Taylor, D.M. 1984. The effects of cattle grazing and other factors on passerine birds nesting in willow riparian habitat. M.S. thesis, Idaho State University, Pocatello.

Temple, S.A. and J.A. Wiens. 1989. Bird populations and environmental changes: can birds be bio-indicators? American Birds 43: 260-270.

Terborgh, J. 1989. *Where Have all the Birds Gone? Essays on the Biology and Conservation of Birds that Migrate to the American Tropics*. Princeton University Press, Princeton, NJ. 207 p.

United States Department of Agriculture. Forest Service, Pacific Northwest Region. 1990. Land and Resource Management Plan: Rogue River National Forest. Medford, OR.

Van Horne, B. 1983. Density as a misleading indicator of habitat quality. Journal of Wildlife Management 47:893-901.

Verner, J., and A.S. Boss. 1980. California wildlife and their habitats: western Sierra Nevada. U.S. Department of Agriculture, Forest Service General Technical Report, PSW-GTR 37. Berkeley, CA.

Wiles, G.C., D'Arrigo, R.D. and Jacoby, G.C. 2001. Gulf of Alaska atmosphere-ocean variability over recent centuries inferred from coastal tree-ring records. Climatic Change 38:289-306.

Appendix A: Population Status and Life History Traits of Species

Table A.1: Species of Continental Importance in the Pacific Avifaunal Biome occurring at SKSW as designated by the Partners in Flight North American Land bird Conservation Plan (Rich *et al* 2004)

Species	% Breeding Population	% Winter Population	Primary Habitat	Continental Population Objective	Monitoring Need
Immediate Action					
None					
Management					
Hermit Warbler	94%	0%	Coniferous forest	Maintain/Increase	**
Rufous Hummingbird	61%	0%	Western shrublands	Increase 100%	**
Willow Flycatcher	24%	0%	Riparian	Increase 50%	**
Long-term Planning & Responsibility					
Pacific-slope Flycatcher	91%	0%	Mixed forest	Maintain	**
Chestnut-backed Chickadee	90%	90%	Coniferous forest	Maintain	**
Red-breasted Sapsucker	78%	77%	Mixed forest	Maintain	Mo3
Black-throated Gray Warbler	69%	0%	Mixed forest	Maintain	**
Steller's Jay	54%	54%	Coniferous forest	Maintain	**
Fox Sparrow	8%	52%	Western shrublands	Maintain	Mo3
Winter Wren*	26%	50%	Coniferous forest	Maintain	Mo3

1 Species are sorted by Action Category (Immediate Action, Management, Planning & Responsibility), then by decreasing % of global population that occurs in the biome (by greater of breeding or winter population). Species highlighted in orange are Watch List species, with at least 10% of their global population in this biome. Species in green (in species or % population columns) are Stewardship Species, with ≥50% of their population in this biome.
2 Monitoring Need (this assessment addresses only the adequacy of long-term population trend monitoring at the continental scale): Mo1=no trend data, Mo2=imprecise trends, Mo3=inadequate northern coverage.
*For this species, % of Population is for Western Hemisphere. All others are % of Global Population.
**Long-term population trend monitoring is generally considered adequate but some issues, such as bias, may not have been accounted for.

Table A.2: Species of Continental Importance in the Intermountain West Avifaunal Biome occurring at SKSW as designated by the Partners in Flight North American Land bird Conservation Plan (Rich *et al* 2004)

Species	% Breeding Population	% Winter Population	Primary Habitat	Continental Population Objective	Monitoring Need2
Immediate Action - None					
Management					
Willow Flycatcher	46%	0%	Riparian	Increase 50%	**
Rufous Hummingbird	36%	0%	Western shrublands	Increase 100%	**
Long-term Planning & Responsibility					
Calliope Hummingbird	95%	0%	Western shrublands	Maintain/Increase	Mo2
Dusky Flycatcher	86%	0%	Western shrublands	Maintain	**

[1] Species are sorted by Action Category (Immediate Action, Management, Planning & Responsibility), then by decreasing % of global population that occurs in the biome (by greater of breeding or winter population). Species highlighted in yellow are Watch List species, with at least 10% of their global population in this biome. Species in green (in species or % population columns) are Stewardship Species, with ≥75% of their population in this biome.

[2] Monitoring Need (this assessment addresses only the adequacy of long-term population trend monitoring at the continental scale): Mo1=no trend data, Mo2=imprecise trends, Mo3=inadequate northern coverage.

**Long-term population trend monitoring is generally considered adequate but some issues, such as bias, may not have been accounted for.

Table A.3: Description of Breeding Status Designations

	Breeding Status	Description
B	Regular Breeder	Summer resident during all years the station was operated
U	Usual Breeder	Summer resident for more than half of the years the station was operated
O	Occasional Breeder	Summer resident for half or fewer of the years the station was operated
T	Transient	The station lies within the species breeding range, but no individual of that species was a summer resident at the station during any year
A	Altitudinal Disperser	(A species which breeds only at lower elevations from the station and disperses to higher elevations after breeding
M	Migrant	The station falls outside of the species normal breeding range

Table A.4: Breeding Status for Species Caught at the SKSW Banding Station

Alpha Code	Common Name	Scientific Name	Breeding Status
AMRO	American Robin	*Turdus migratorius*	B
AUWA	Audubon's Warbler	*Dendroica c. auduboni*	O
BCCH	Black-capped Chickadee	*Poecile atricapillus*	U
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*	B
BRCR	Brown Creeper	*Certhia americana*	O
BTYW	Black-throated Gray Warbler	*Dendroica nigrescens*	O
BUSH	Bushtit	*Psaltriparus minimus*	U
CAVI	Cassin's Vireo	*Vireo cassinii*	U
CBCH	Chestnut-backed Chickadee	*Poecile rufescens*	U
CEDW	Cedar Waxwing	*Bombycilla cedrorum*	O
CHSP	Chipping Sparrow	*Spizella passerina*	T
COHA	Cooper's Hawk	*Accipiter cooperii*	T
COYE	Common Yellowthroat	*Geothlypis trichas*	T
DOWO	Downy Woodpecker	*Picoides pubescens*	U
DUFL	Dusky Flycatcher	*Empidonax oberholseri*	O
FOSP	Fox Sparrow	*Passerella iliaca*	T
GCKI	Golden-crowned Kinglet	*Regulus satrapa*	O
HAFL	Hammond's Flycatcher	*Empidonax hammondii*	U
HAWO	Hairy Woodpecker	*Picoides villosus*	B
HETH	Hermit Thrush	*Catharus guttatus*	U
HEWA	Hermit Warbler	*Dendroica occidentalis*	B
HOFI	House Finch	*Carpodacus mexicanus*	T
HOWR	House Wren	*Troglodytes aedon*	O
HUVI	Hutton's Vireo	*Vireo huttoni*	T
LISP	Lincoln's Sparrow	*Melospiza lincolnii*	T
MGWA	MacGillivray's Warbler	*Oporornis tolmiei*	B
NAWA	Nashville Warbler	*Vermivora ruficapilla*	B
NOPO	Northern Pygmy-Owl	*Glaucidium gnoma*	T
OCWA	Orange-crowned Warbler	*Vermivora celata*	A
ORJU	Oregon Junco	*Junco h. oregonus*	B
PISI	Pine Siskin	*Carduelis pinus*	T
PSFL	Pacific-slope Flycatcher	*Empidonax difficilis*	B
PUFI	Purple Finch	*Carpodacus purpureus*	U
RBNU	Red-breasted Nuthatch	*Sitta canadensis*	U
RBSA	Red-breasted Sapsucker	*Sphyrapicus ruber*	B
RWBL	Red-Winged Blackbird	*Agelaius phoeniceus*	O

RCKI	Ruby-crowned Kinglet	*Regulus calendula*	T
Alpha Code	**Common Name**	**Scientific Name**	**Breeding Status**
RUGR	Ruffed Grouse	*Bonasa umbellus*	O
RUHU	Rufous Hummingbird	*Selasphorus rufus*	B
SOSP	Song Sparrow	*Melospiza melodia*	B
SPTO	Spotted Towhee	*Pipilo maculatus*	O
STJA	Steller's Jay	*Cyanocitta stelleri*	U
SWTH	Swainson's Thrush	*Catharus ustulatus*	B
TOSO	Townsend's Solitaire	*Myadestes townsendi*	O
TOWA	Townsend's Warbler	*Dendroica townsendi*	M
WAVI	Warbling Vireo	*Vireo gilvus*	B
WEFL	"Western" Flycatcher	*Empidonax (sp)*	B
WETA	Western Tanager	*Piranga ludoviciana*	U
WEWP	Western Wood-Pewee	*Contopus sordidulus*	O
WIFL	Willow Flycatcher	*Empidonax traillii*	U
WIWA	Wilson's Warbler	*Wilsonia pusilla*	B
WIWR	Winter Wren	*Troglodytes troglodytes*	T
YWAR	Yellow Warbler	*Dendroica petechia*	O
YRWA	Yellow-Rumped Warbler	*Dendroica coronata*	

Table A.5: Life History Traits of Species Caught at SKSW Banding Station

Species	Code	Reproductive Effort	Nest Type	Nest Height (m)	Territory Size (ha)	Territory Density	Seral Stage Association	Microhabitat Association	Feeding Strategy
Residents									
Black-Capped Chickadee	BCCH	7	H	1.8	3.6		G	S	I
Brown Creeper	BRCR	6	H	8		32.1	CC	S	I
Bushtit	BUSH	10	0	4.6	0.6		OC	G	I
Chesnut-Backed Chickadee	CBCH	7	H	2.1	1.3	61.8	CC	S	I
Cooper's Hawk	COHA	4	0	12.2	280		CC	G	C
Downy Woodpecker	DOWO	5	H	8.3	2.8		CC	S	I
Fox Sparrow	FOSP	8	0	0.6		12.4	OC	G	O
Golden Crowned Kinglet	GCKI	16	0	9.8		148.2	CC	G	I
Hairy Woodpecker	HAWO	4	H	9.8	2.8		CC	S	I
House Finch	HOFI	5	O	5.6			OC	G	H
Hutton's Vireo	HUVI	4	0				CC		O
Mountain Chickadee	MOCH	9	H		4.9		G		O
Northern Flicker	NOFL	9	H	3.4	16		G	S	I
Northern Pygmy Owl	PYOW	5	H	4.3	8		CC	S	C
Red Breasted Sapsucker	RBSA	5	H	10.1	2		CC	S	I
Red-Breasted Nuthatch	RBNU	6	H	6.7		64.2	CC	S	I
Ruby-Crowned Kinglet	RCKI	5	0	1		106.2	G	G	I
Ruffed Grouse	RUGR	10.5	0		8		G	L	O
Song Sparrow	SOSP	8	0	0.6	2.8	306.3	OC	G	O
Stellar's Jay	STJA	4	0	5.2		46.9	G	G	O
Winter Wren	WIWR	6	H	0.9	0.8	34.6	CC	L	I
Short Distance Migrants									
American Robin	AMRO	8	0	4.6		64.2	OC	G	O
Cedar Waxwing	CEDW	10	0	7	1.6		G	G	H
Chipping Sparrow	CHSP	8	0	1.8	2.8	76.6	OC	G	O
Hermit Thrush	HETH	5	0	1.2	0.8	24.7	G	G	I
Rufous Hummingbird	RUHU	4	0	2.4	0.1		G	G	O
Townsend's Solitaire	TOSO	4	0	1.5	4	7.4	G	L	I

Species	Code	Reproductive Effort	Nest Type	Nest Height (m)	Territory Size (ha)	Territory Density	Seral Stage Association	Microhabitat Association	Feeding Strategy
Neotropical Migrants									
Audubon's Warbler	AUWA						G		O
Black Headed Grosbeak	BHGR	4	0	2.4		163	OC	G	I
Black-Throated Gray Warbler	BTWY	4	0	7		37.1	G	G	I
Broad-Tailed Hummingbird	BTLH		0	0.9			G		O
Calliope Hummingbird	CAHU	2	O	3.5			OC		O
Cassin's Vireo	CAVI		0				CC		I
Common Yellowthroat	COYE	4	0	0			OC		I
Oregon Junco	ORJU	10	0	3.1	1	133.4	G	G	O
Dusky Flycatcher	DUFL		0	1.5			OC		I
Hammond's Flycatcher	HAFL	4	0	7.6	1.2	29.6	CC	G	I
Hermit Warbler	HEWA	4	0	17.7		353.2	CC	G	I
House Wren	HOWR	8	H	5.4	1.8		G		I
Lincoln's Sparrow	LISP	5			1.2		OC		O
MacGillivray's Warbler	MGWA	4	0		1.7		OC		I
Nashville Warbler	NAWA		0				G		I
Orange-Crowned Warbler	OCWA	5	0	0.6	2	103.7	OC	G	I
Pacific Slope Flycatcher	PSFL		0	4.5			CC		O
Pine Siskin	PISI	8	0	8.6		34.6	G	G	O
Purple Finch	PUFI	5	0	7		54.3	G	G	O
Red-Winged Blackbird		4	0	0.4			OC		O
Spotted Towhee	SPTO		0				OC		O
Swainson's Thrush	SWTH	8	0	3.7		98.8	G	G	I
Townsend's Warbler	TOWA	4	0	3.7		353.2	CC	G	I
Warbling Vireo	WAVI	4	0	18.3		103.7	OC	G	I
Western Tanager	WETA	4	0	11		113.6	G	G	I
Western Wood Pewee	WEWP	3	0	7.6	1.6	12.4	CC	G	I
Willow Flycatcher	WIFL		0	1.2	0.44		OC		I
Wilson's Warbler	WIWA	5	0	0.6	0.8	42	G	G	I
Yellow Warbler	YEWA		0	2			OC		I
Yellow-Rumped Warbler	YRWA	8	0	8.3		98.8	G	G	I

Appendix B: Statistically Significant Population Trends

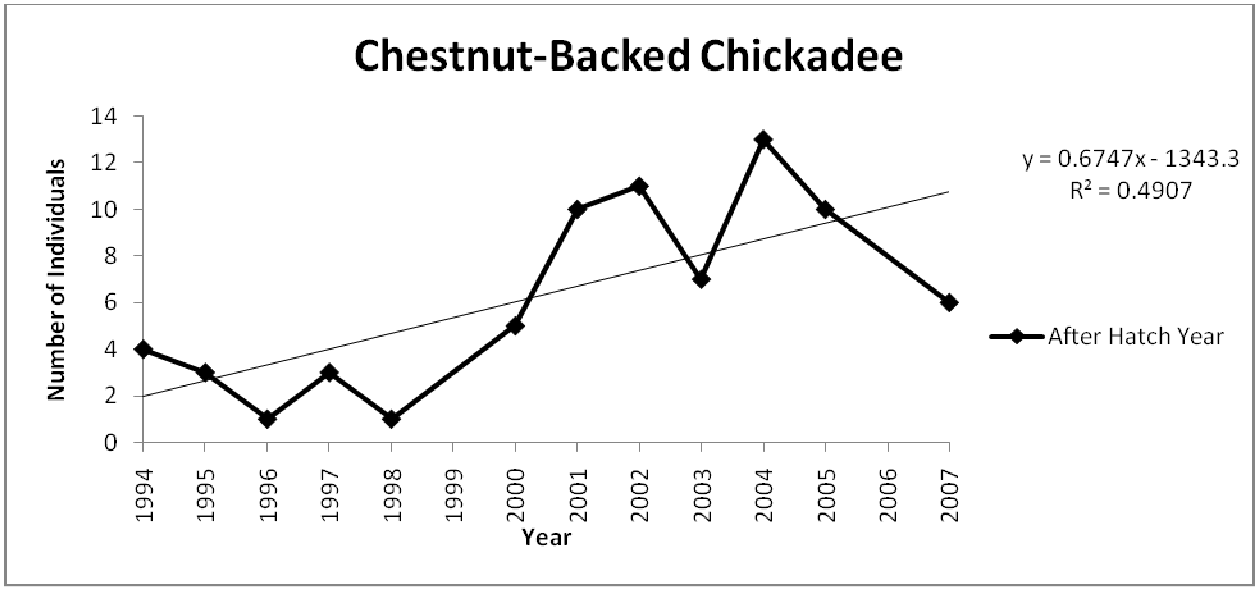

Figure B.1: Chestnut Backed Chickadee Adult Population Trend From 1994-2007 at SKSW

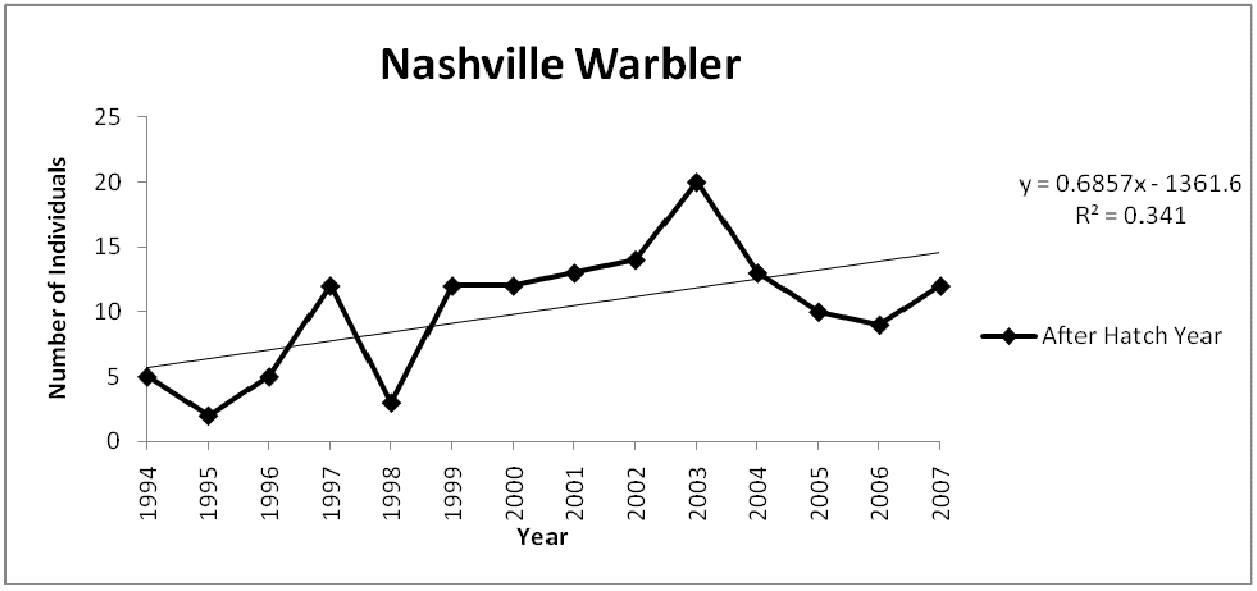

Figure B.2: Nashville Warbler Adult Population Trend From 1994-2007 at SKSW

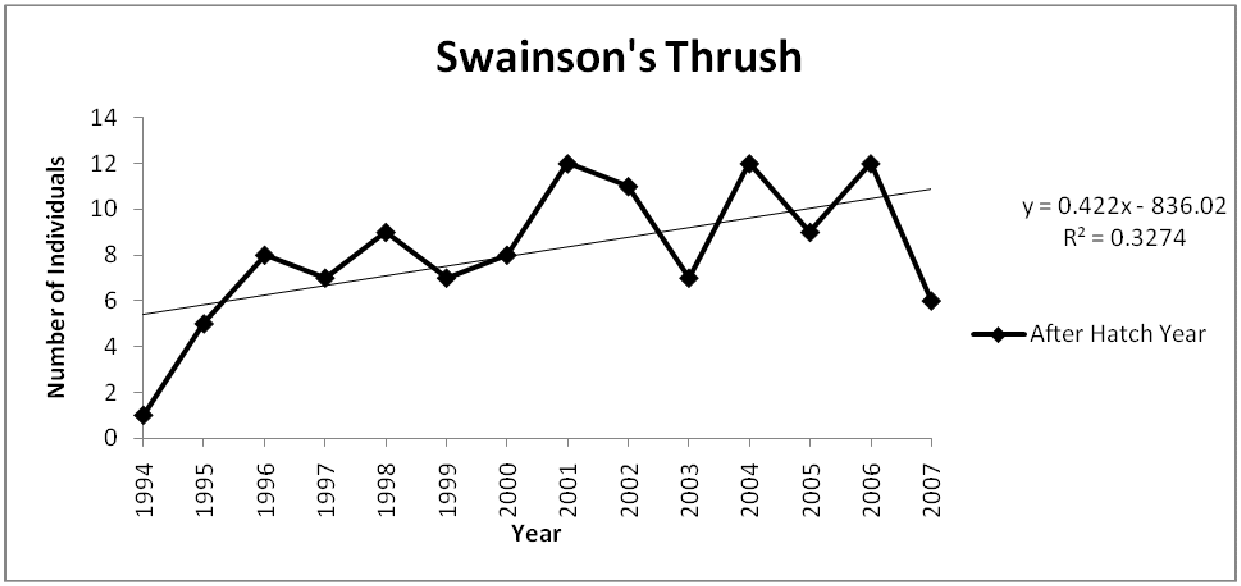

Figure B.3: Swainson's Thrush Adult Population Trend From 1994-2007 at SKSW

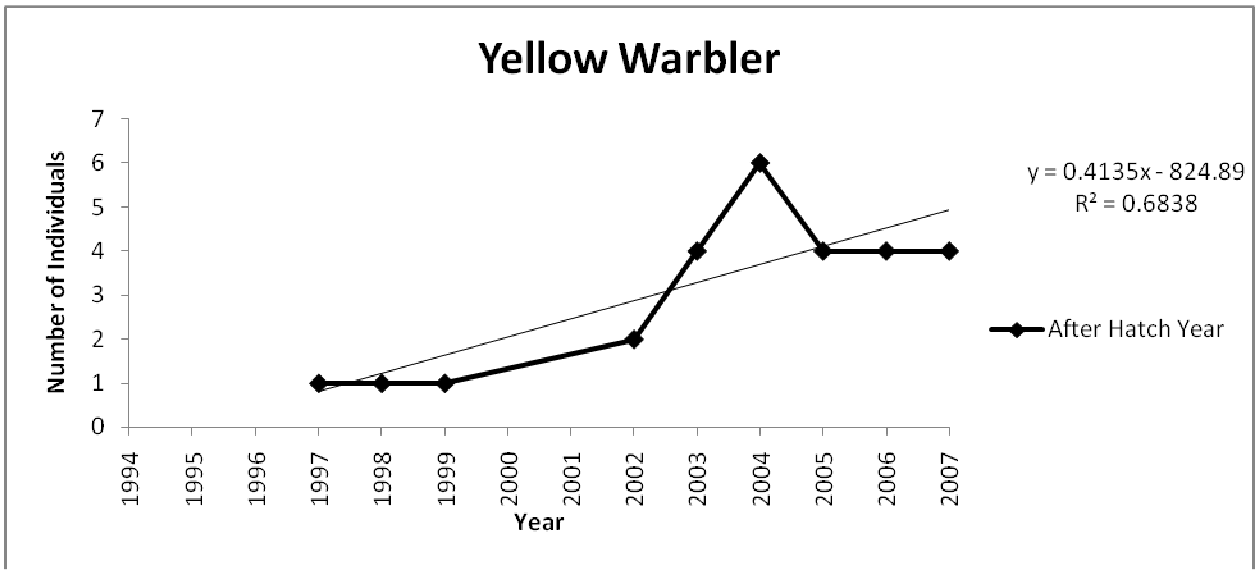

Figure B.4: Yellow Warbler Adult Population Trend From 1994-2007 at SKSW

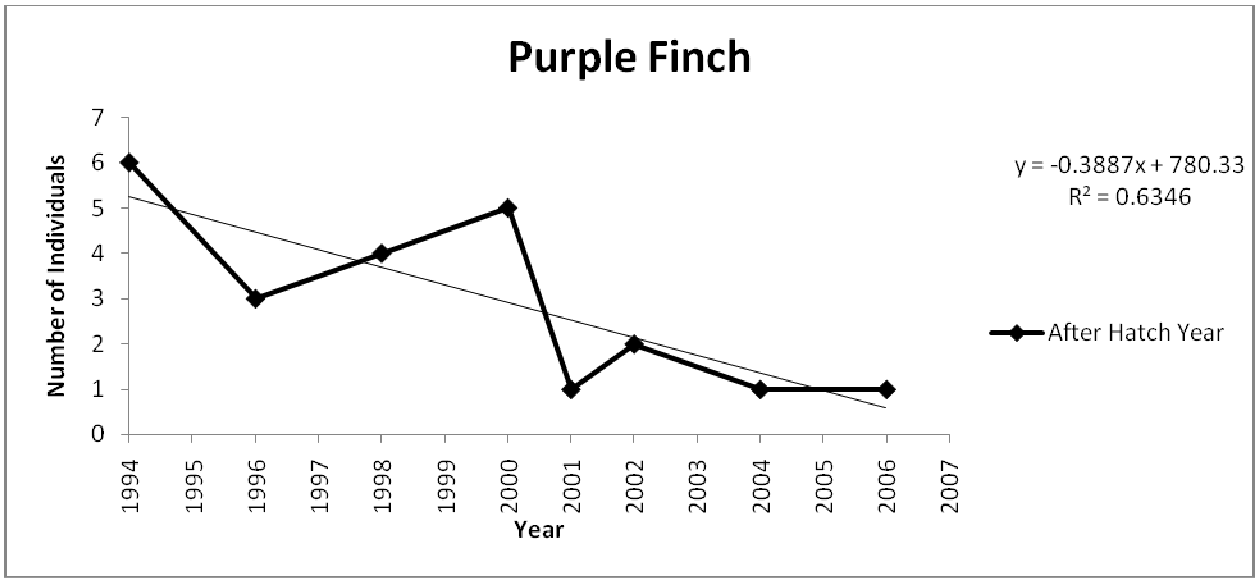

Figure B.5: Purple Finch Adult Population Trend From 1994-2007 at SKSW

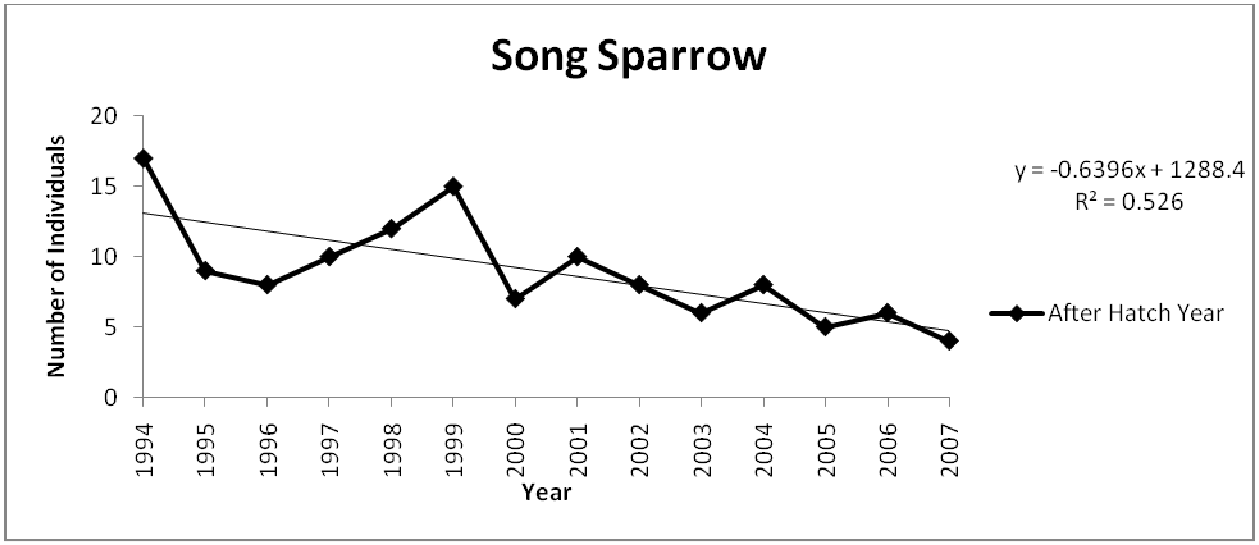

Figure B.6: Song Sparrow Adult Population Trend From 1994-2007 at SKSW