Avian Species Richness, Abundance, and Nesting Success in Aspen Habitats of the Truckee River Watershed

Final Report: 2002-2004

T. Will Richardson
Biological Resources Research Center
University of Nevada, Reno

Correspondence: 16810 Glenshire Dr., Truckee, CA 96161, (530) 412-2792, trichard@unr.nevada.edu

TABLE OF CONTENTS

SUMMARY

The third season of fieldwork for the Avian Species Richness, Abundance, and Nesting Success in Aspen Habitats of the Truckee River Watershed Project was completed in 2004. The program emphasized coverage of aspen habitats of the Truckee River watershed that are most susceptible to the effects of conifer encroachment. The study area was restricted to stands above 1800 meters elevation and those typical of the "meadow fringe"," riparian," and "forest opening" aspen types as defined by Burton (2000). Point count transects were located in El Dorado, Placer, and Sierra Counties, California and Carson City, Douglas, and Washoe Counties Nevada, primarily on USFS and Nevada State Parks land. The initial phase of the project, which was initiated in 2002 and focused on bird-habitat relationships using point counts, was completed in 2004. The second phase, which was initiated in 2003 and focused on habitat factors related to nesting success and nest predators, is proposed to continue through at least 2005. In total, we implemented and monitored 175 individual point count stations, 6 nest search plots, and 2 mist-netting stations. We have collaborated with several federal, state, and county agencies, non-profit conservation groups, university personnel, other researchers, and private landowners. We have contributed songbird data to several national databases and California Partners in Flight Bird Conservation Plans. We also presented data at regional habitat and wildlife conferences and a statewide Partners in Flight meeting and workshop. Data from this project have been published in two peer-reviewed scientific journals thus far (Richardson 2003b, Richardson and Heath 2004). Some of the material reported here is directly taken from the latter paper. Here, we present several results on primary and secondary songbird population parameters including species richness, diversity, abundance, and nest success. We present descriptive nest-site and habitat characteristics of several avian breeding species. We further address factors influencing avian abundance, species richness, and nest success by investigating the effects of vegetation and habitat features. We present rates of predation and Brown-headed Cowbird parasitism, and discuss the importance of aspen habitats for migrants and post-breeding dispersers. Lastly, we present management recommendations and habitat considerations derived from the 2002-2004 results.

BACKGROUND AND INTRODUCTION

The importance of quaking aspen (*Populus tremuloides*) to birds and other wildlife in western North America has long been appreciated by biologists (Salt 1957, Flack 1976, DeByle 1985b). Many studies from this region have demonstrated that aspen habitats typically support much greater diversity, richness, and abundance of birds than adjacent habitats (Flack 1976, Winternitz 1980, Mills et al. 2000a, Griffis-Kyle and Beier 2003, Heath and Ballard 2003), and several bird species have shown a strong affinity with aspen, including Northern Goshawk (*Accipiter gentilis*), Red-naped and Red-breasted Sapsuckers (*Sphyrapicus nuchalis/ruber*), Dusky Flycatcher (*Empidonax oberholseri*), Warbling Vireo (*Vireo gilvus*), Swainson's Thrush (*Catharus ustulatus*), and MacGillivray's Warbler (*Oporornis tolmiei*)(Salt 1957, Flack 1976, Finch and Reynolds 1988, Heath and Ballard 2003).

The obvious benefits to birds breeding in aspen stands are many. Ground-nesting birds benefit from an exceedingly thick herbaceous layer and deep leaf litter, which aids in potential for nest concealment (Flack 1976, DeByle 1985b). Both primary and secondary cavity nesters benefit from aspen's susceptibility to heart rot and an associated abundance of cavity-bearing trees (DeByle 1985b, Daily et al. 1993). It is highly likely that one of the main benefits to all birds breeding in aspen stands is the increased abundance and diversity of invertebrate prey (Winternitz 1980).

However, this habitat may become greatly reduced for birds in the foreseeable future. Because western aspen primarily reproduce through vegetative suckering, generally following a disturbance of some kind, whole stands may succumb to conifer succession within a few hundred years if no disturbance occurs (e.g. fire suppression). Much of the aspen in the western United States is threatened in this manner, and much, if not most, of the historic aspen coverage in western states has already been lost (Kay 1997, Bartos and Campbell Jr 1998, Bartos 2001). The current extent and condition of aspen in the Sierra Nevada mountains of California and Nevada has yet to be fully inventoried.

In light of the threatened status of aspen habitat, it is also important to highlight the documented population declines and tenuous status of some aspen-associated bird species in the west. Western Warbling Vireo population declines are well documented (Gardali et al. 2000, Ballard et al. 2003), and Swainson's Thrushes are declining or have been extirpated from much of their historic breeding range in the Sierra Nevada (Verner and Boss 1980, Gaines 1988, Siegel and DeSante 1999). Northern Goshawk is a California Bird Species of Special Concern and a United States Forest Service, Region 5 Sensitive Species (USFS 2001, CDFG and PRBO 2001). Clearly, the losses incurred on both aspen habitats and associated bird species warrants an investigation into the relationship between the two.

As the most widespread native North American tree (and second most widespread tree in the world), the enormous ecological amplitude of aspen must be considered in the interpretation of ecological studies of aspen (Campbell Jr. and Bartos 2001, Romme et al. 2001). Even at the regional or local scale, aspen's ability to occur in a broad environmental context makes generalizations difficult. Within the Sierra Nevada, aspen may occur in a variety of riparian habitats, in association with wet or dry meadows, as isolated or connected patches within a matrix of conifer-dominated forest, as stand-alone groves in snowpockets or along avalanche paths, or in large networks of climax stands. For these reasons Romme et al. (2001) urged the need for more local case studies on aspen ecology.

The principle objectives of this project have been to:

1. Implement a monitoring program utilizing standardized Partners in Flight (PIF) protocol to determine abundance, species richness, and breeding status of songbirds in aspen habitats of the Truckee River watershed, including USFS, Nevada State Parks, and private lands, targeting aspen associated species and riparian focal species.
2. Implement a monitoring program utilizing standardized Partners in Flight (PIF) protocol to estimate survival, productivity, predation, and parasitism rates of songbirds in aspen habitats of the Truckee River watershed.
3. Determine effects of current BLM, USFS and CDFG management practices on riparian breeding songbirds in the region, and make recommendations to enhance bird populations through adaptive management
4. Assess the relationships of aspen songbird abundance, richness, and nesting success to habitat and landscape characteristics.
5. Contribute to national, state, and regional conservation efforts by providing information to, for example: Riparian Bird Conservation Plan, Breeding Biology Research and Monitoring Database (BBIRD), Monitoring Avian Productivity and Survival (MAPS) database, and land management planning processes (refer to Martin et al. 1997regarding standardized protocols, DeSante et al. 2003).

SITE DESCRIPTION AND METHODS

Site Description

Study sites were selected to meet a number of criteria. The focus of this study addresses aspen habitats that are most susceptible to the effects of conifer encroachment. The study area was restricted to stands above 1800 meters elevation and those typical of the "meadow fringe"," riparian," and "forest opening" aspen types as defined by Burton (2000). Thus, the sites were associated with meadow edges, streams, avalanche slide paths, or in large forest stands. Elevation of point count stations ranged from approximately 2030 to 2700 meters. Point count transects were located in El Dorado, Placer, and Sierra Counties, California and Carson City, Douglas, and Washoe Counties Nevada (Table 1, Figures 1,2,). Aspen GIS coverages were either unavailable or too unreliable to utilize in a random-stratified sampling regime. Thus, an attempt was made prior to the field season to locate the largest, most contiguous aspen stands in these habitats. This allowed for a relatively large number of points in each transect and ensured that the points encompassed a broad range of stand conditions.

Nest-searching and mist-netting plots were selected based on size and maturity of stand, apparent productivity, slope, and access considerations. Several plots were purposefully placed within the boundaries of Lake Tahoe Nevada State Park to provide park managers with data and recommendations based on our findings.

TABLE1. Summary of Transects

Transect Number	Transect Name	Abbr.	State	County	Tahoe Basin	No. of points
1	Independence Cr. - Downstream	ICDO	CA	Sierra		8
2	Independence Cr. - Upstream	ICUP	CA	Sierra		9
3	Meathouse Cr.	MEAT	CA	Sierra		15
4	Perrazzo Meadows	PERR	CA	Sierra		15
5	Henness Pass Rd.	HEPA	CA	Sierra		15
6	Sagehen Cr.	SAGE	CA	Sierra		11
7	North Canyon	NOCA	NV	Carson City	√	21
8	Tunnel Cr.	TUNN	NV	Washoe	√	6
9	Marlette Basin	MABA	NV	Washoe	√	10
10	Logan House Cr.	LOHA	NV	Douglas	√	12
11	Fountain Place	FOPL	CA	El Dorado	√	11
12	Paige Meadows	PAIG	CA	Placer	√	12
13	Big Meadow	BIME	CA	El Dorado	√	9
14	Fallen Leaf Lake Rd.	FALL	CA	El Dorado	√	10
15	Glenbrook Cr.	GLEN	NV	Douglas	√	11
					Total	175

A full 98% of point count stations (n = 172) had conifers in the canopy. The canopy at study sites consisted primarily of aspen, Jeffrey and Lodgepole Pine (*Pinus jefferyi* and *P. contorta*), and fir trees (*Abies concolor* and *A. magnifica*). Shrub layers at the sites consisted primarily of willow species (*Salix* spp.), alder (*Alnus incana*), snowberry (*Symphoricarpos rotundifolius*), and immature aspen and coniferous trees. Across the study area, the herbaceous layer was highly variable, ranging from being dominated by low grasses and sedges at meadow edges, to *Wyethia mollis* at drier sites, to a full complement of tall, lush vegetation at moist forest sites. The latter, typically include species such as *Veratrum californicum, Heracleum lanatum, Osmorhiza occidentalis, Hackleia nervosa, Delphinium glaucum*, and *Thalictrum fendleri*. Adjacent vegetation communities were comprised primarily of big sage (*Artemisia tridentata*), conifer species, non-aspen riparian species, or montane and subalpine meadow species.

Field Methods

Description of Methods

In order to meet project objectives, we implemented the following methodologies:
1) Fixed-radius point count censuses (objectives 1, 3, 4, 5)
2) Nest monitoring (objectives 1- 5)
3) Constant-effort mist netting (objectives 1- 5)
4) Habitat and vegetation assessment (objectives 3, 4, 5)

Census techniques are indicated by transect in Table 2.

TABLE 2. Summary of methods employed at Truckee River watershed aspen sites, 2002-2004. Sites are listed in approximate order of point count scheduling, roughly north to south.

Transect Number	Transect Name	Point Counts	Nest Monitoring[1]	Mist-Netting[1]	Vegetation Assessment
1	Independence Cr. - Downstream	√			√
2	Independence Cr. - Upstream	√			√
3	Meathouse Cr.	√			√
4	Perrazzo Meadows	√			√
5	Henness Pass Rd.	√			√
6	Sagehen Cr.	√			√
7	North Canyon	√			√
8	Tunnel Cr.	√	√	√	√
9	Marlette Basin	√	√[2]	√	√
10	Logan House Cr.	√	√	√	√
11	Fountain Place	√			√
12	Paige Meadows	√			√
13	Big Meadow	√			√
14	Fallen Leaf Lake Rd.	√	√	√	√
15	Glenbrook Cr.	√	√	√	√

[1] Methods initiated 2003.

[2] Transect overlaps two adjacent nest-monitoring plots

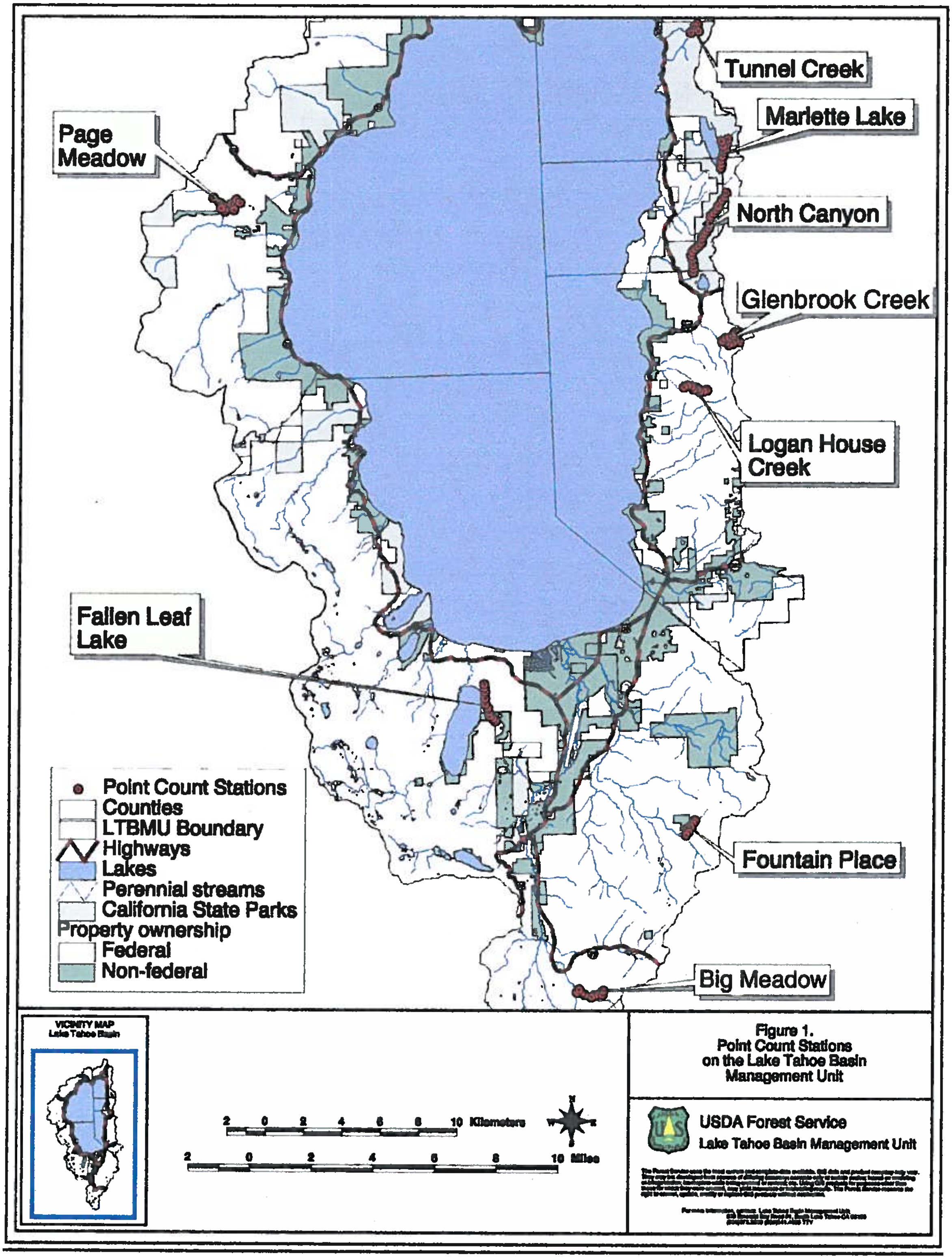

Figure 1. Study Area, Tahoe Basin

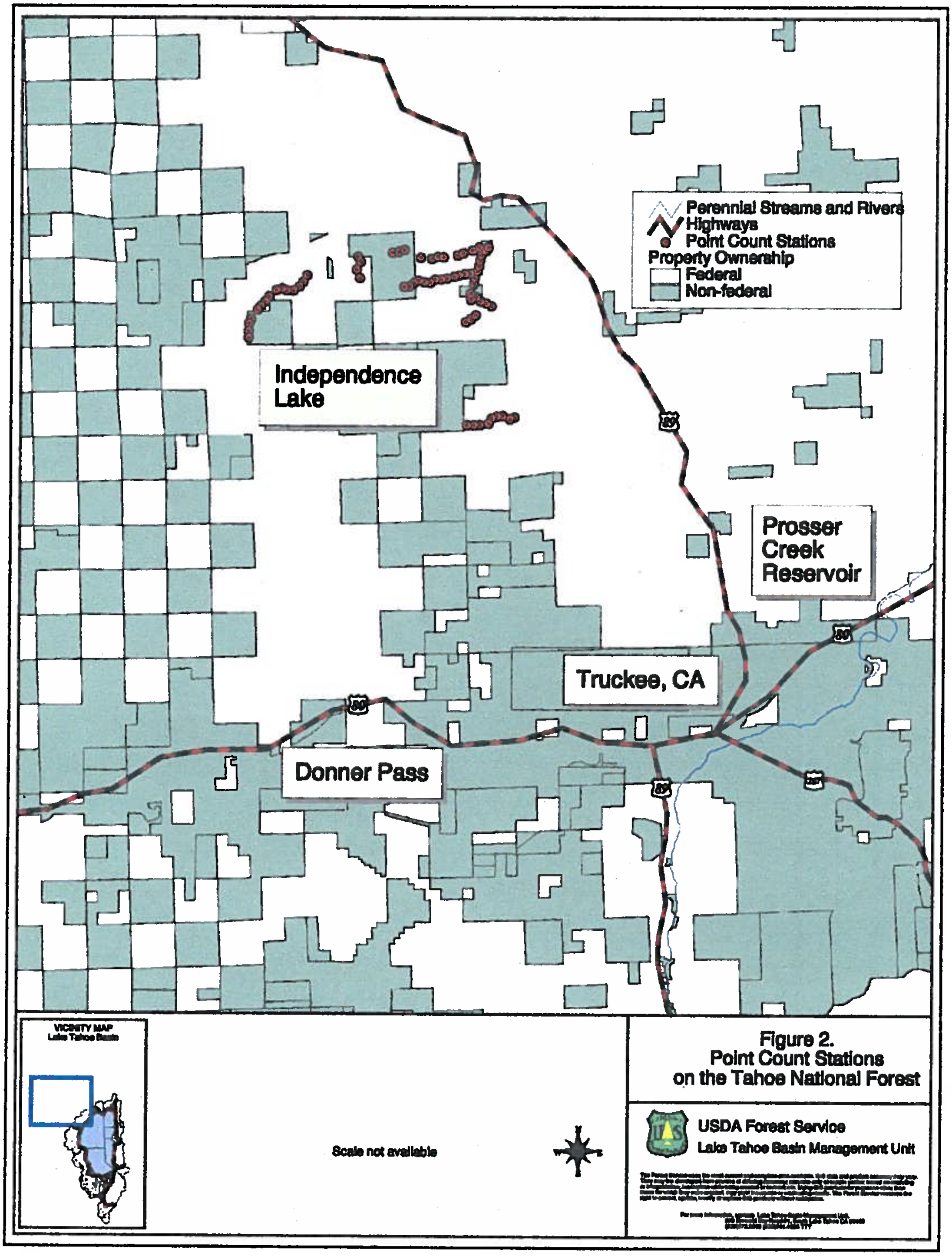

Figure 2. Study area, north of Tahoe Basin

Breeding Status

Active nests and breeding behavior were searched for at and between point count stations. Breeding status for each species detected was evaluated based on a combination of all available data, including nests found and behavioral observations. Breeding status designations are conservatively limited to the area sampled by point count transects and BBIRD and MAPS plots. For example, an active Osprey nest was found along Sagehen Creek a few hundred meters downstream from the transect, but its status is designated as "Possible" for the transect itself. Each species' status was ranked by transect following modified breeding bird atlas criteria based on direct observations. Note that professional opinion, species' range, adjacent breeding, etc. is not factored in to these designations, and they should be considered extremely conservative. These designations are for distributional information only. They are based on uneven effort over transects and plots of variable size, and are not meant for analyses.

Confirmed Breeding	1	Direct observation of active nests; nest building (except woodpeckers and wrens); nesting material, large quantities of food, or fecal sack being carried by adult; distraction display, captured female with eggs in oviduct; dependent juveniles with adults.
Probable Breeding	2	Singing males (especially in high densities) observed in repeated visits in the same location (at least one week apart); territorial behavior noted more than once at the same location; pair observed in courtship behavior; female with full brood patch (males with cloacal protuberances not used as evidence of breeding locally).
Possible Breeding	3	Species encountered singing or acting territorial only once during the breeding season (in suitable habitat).
Breeding Unlikely	0	Species a known early migrant or post-breeding disperser to the region; unsuitable habitat; no evidence of breeding.

See Appendix I. for a complete list of common and taxonomic names for species encountered during point counts, mist-netting, nest-searching, and vegetation assessments.

Point Counts

Fifteen transects comprised of 160 points were established in 2002 (Table 1, Figures 1,2, Appendix II.). Stations were located approximately 200 meters apart to avoid double counting of territorial birds and to assure independence of stations (Ralph et al. 1993, Ralph et al. 1995). All points from 2002 were re-censused in 2003. In 2003,

Statistical Analyses

Point Counts

We calculated mean annual bird species richness (BSR) and mean annual total bird abundance (TBA) for each station, based on annual totals summed over two visits in each of the three years, using the program PointCnt 2.75 (Ballard 2002). We restricted our data set to detections within 50m and further limited the indices to include species most reliably censused with the point count method. We therefore removed nocturnal species (e.g. *Strigidae*), known post-breeding dispersers, vagrants, and migrants (e.g. *Selasphorus rufus*), and species with territories typically too large to ensure independence of individual point count stations (e.g. *Anseriformes, Falconiformes*). A complete list of common and Latin names for all species used in analysis is presented in Appendix I.

Of the hundreds of potential vegetation and environmental variables available, we selected fifteen that we felt would best contribute to models predicting BSR, TBA, and Dusky Flycatcher and Warbling Vireo occurrence or abundance on a regional scale (Table 3). We looked for highly correlated variables when building full models in an attempt to reduce dimensionality, but in no cases found correlations high enough to warrant exclusion of parameters from the full model. Variance inflation factors were examined for each parameter in the reduced models to ensure that no highly correlated variables were causing problems associated with multicollinearity. BSR and TBA model selection was performed using the maximum R^2 improvement (MAXR) technique, as implemented in the SAS macro REGDIAG (Fernandez 2003). Optimal models were selected based on a combination of lowest Akaike's Information Criterion (AIC) score and Mallows' statistic (C_p)(Akaike 1973).

Table 3. Environmental and habitat variables used in model selection to predict bird species richness, bird abundance, abundance of Dusky Flycatcher and Warbling Vireo and occurrence of Douglas's Squirrel and Steller's Jay from point count data, 2002-2004.

Habitat Variable	Units	Habitat Variable	Units
Absolute tree-class cover	%	Ab. shrub-class conifer cover	%
Ab. tree-class aspen cover	%	Ab. shrub-class willow (*Salix*) cover	%
Ab. tree-class conifer cover	%	Ab. herbaceous cover	%
Ab. tree-class Jeffrey pine cover	%	Maximum aspen height	m
Ab. tree-class Lodgepole Pine cov.	%	Maximum aspen dbh	cm
Ab. tree-class fir (*Abies*) cover	%	Canopy cover	%
Ab. shrub-class cover	%	Tree species richness	#
Ab. shrub-class aspen cover	%	Shrub species richness	#

We constructed habitat models predicting BSR and TBA using four regional groupings of the data: (1) the entire study area, (2) Truckee River sites, (3) Walker River sites, and (4) Mono Lake / Owens River sites. At Truckee River sites, we also calculated mean annual Dusky Flycatcher and Warbling Vireo abundance for each station, based on means of annual total detections, summed over two visits in each of three years. To investigate habitat relationships among potential nest predators, we chose the relatively conspicuous Steller's Jay (*Cyanocitta stelleri*) and Douglas's Squirrel (*Tamiasciurus douglasii*). Neither abundance nor occurrence of these species was normally distributed across sites. We therefore constructed models predicting Douglas's Squirrel and Steller's Jay occurrence (on at least one visits over two-three years). Douglas's Squirrels were censused in 2003-2004 only. These models predicted occurrence against the fifteen variables using a forward selection technique on a randomly assigned training data set (approximately 67% of point count stations) and were validated with an independent validation data set (remaining 33% of stations), as implemented in the SAS macro LOGISTIC (Fernandez 2003). Predicted event classification probability was fixed at $P = 0.5$.

Potentially influential extreme outliers (standardized values falling outside ± 3.5) were excluded from analyses. All statistical tests were performed using SAS (SAS 1999). Model significance was designated at $P < 0.05$.

Nest Monitoring

Nest success calculations were limited to nests with known outcome, which were observed with at least one egg or young. Thus, all apparently abandoned nests cannot be used for these analyses. Nest success was calculated using Program MARK (White and Burnham 1999), which allows for more complex and realistic models of nest survival rate that include covariates that vary by individual, nest stage, time, etc.(Dinsmore et al. 2002, Rotella et al. 2004). Important parameters were assessed via AIC model selection (Akaike 1973, Burnham and Andersen 1998). There is currently no method for estimating extra-binomial variation (overdispersion) in the nest survival model in program MARK, but we are exploring techniques to detect spatial autocorrelation among nest-survival residuals to determine if potential lack of independence among nests is a problem. Of the hundreds of potential parameters and covariates from the vegetation assessments, we selected those that were believed to have a potential impact on nesting success based on *a priori* hypotheses. Parameters investigated differed from species to species and are addressed in the Results section for each species.

Personnel

All aspects of fieldwork, project design and set-up, and data analysis were conducted by BRRC Research Associate and project director Will Richardson, with guidance from Program Director, Dennis Murphy. Nest monitoring was conducted by Will Richardson and BRRC field biologists Wendy Beard, Kevin Crouch, Jennifer Knight, Dacey Mercer, Eric Nolte, Alicia Rodrian, and Neal Walker. Point counts were primarily conducted by Will Richardson, with assistance from Eric Nolte and Kristie Nelson. All mist-netting was conducted by Will Richardson (Master Permit # 23272), with assistance in 2003 from Alicia Rodrian. Assistance with statistical analyses was provided by UNR professors George Fernandez and Jim Sedinger, and BRRC Post-Doctorate Lisa Crampton.

RESULTS AND DISCUSSION

Species Composition, Distribution, and Breeding Status

We detected 105 species among aspen habitats of the Truckee River watershed sites, 2002-2004 (Appendix IV). We determined breeding status for all species encountered along fifteen transects over the entire study area and ranked them using the breeding-status scale described in the Methods. Breeding status of the 16 riparian and 13 coniferous focal species from a few representative study sites was incorporated into the California Partners in Flight (CalPIF) statewide database to assist in documenting the most current California breeding distribution for these species. The current breeding distribution for the Warbling Vireo, for example, includes data provided by this project (see http://www.prbo.org/calpif/ for the most current California distribution maps for all CalPIF riparian and coniferous forest).

Avian Richness and Abundance and Bird-Habitat Relationships

A model built for avian abundance had relatively high predictive power ($F_{5,167} = 43.52$, Adj. $R^2 = 0.55$, $P < 0.001$). Mean annual TBA ranged from 1.5 to 27.33 individuals, with a mean of 12.59 (± 5.30) individuals (Table 4A). Variables retained in this model included tree-class conifer and aspen cover, shrub-class aspen cover, herbaceous cover, and maximum aspen height. A model built for BSR also had relatively high predictive power ($F_{5,168} = 41.29$, Adj. $R^2 = 0.54$, $P < 0.001$). Mean annual BSR ranged from 1.5 to 15 species, with a mean of 7.87 (± 2.70) species (Table 4B). Variables retained in this model included tree-class Lodgepole Pine cover, shrub-class aspen cover, shrub-class willow cover, herbaceous cover, and maximum aspen height.

Abundance of Aspen Associated Species

A model built for abundance of Dusky Flycatcher was significant despite very poor predictive power ($F_{5,168} = 7.00$, Adj. $R^2 = 0.15$, $P < 0.001$). Mean annual abundance of Dusky Flycatcher ranged from 0 to 4.67 individuals, with a mean of 1.59 (± 0.99) flycatchers. Variables retained in this model included absolute shrub cover, shrub-class aspen cover, shrub-class willow cover, maximum aspen height, and canopy cover (Table 4C). A model built for Warbling Vireo abundance was also significant but demonstrated much stronger predictive power ($F_{7,165} = 21.83$, Adj. $R^2 = 0.46$, $P < 0.001$). Mean annual vireo abundance ranged from 0 to 5.67 individuals, with a mean of 2.34 (± 1.39) vireos. Variables retained in this model included tree-class conifer cover, tree-class fir cover, shrub-class aspen cover, shrub-class willow cover, herbaceous cover, maximum aspen height, and maximum aspen dbh (Table 4D).

TABLE 4. Habitat parameters retained in optimal regression models predicting (A) BSR, (B) TBA, (C) Dusky Flycatcher abundance, and (D) Warbling Vireo abundance in aspen habitats, 2002-2004. Variables are listed in descending order of influence, based on standardized regression coefficients (STB). P-values are from test that parameter = 0.

Variable	STB	*P*
A. Total Bird Abundance		
Herbaceous cov.	0.342	<0.001
Max. aspen height	0.297	<0.001
Tree-class conifer cov.	-0.139	0.015
Tree-class aspen cov.	0.136	0.061
Shrub-class aspen cov.	0.110	0.085
B. Breeding Bird Species Richness		
Max. aspen height	0.140	<0.001
Shrub-class willow cov.	0.039	0.068
Herbaceous cov.	0.035	<0.001
Shrub-class aspen cov.	-0.032	0.800
Tree-class Lodgepole Pine cov.	-0.030	0.034
C. Dusky Flycatcher Abundance		
Shrub cov.	-0.002	0.658
Shrub-class aspen cov.	0.093	0.137
Shrub-class willow cov.	0.015	0.185
Max. aspen height	0.039	<0.001
Canopy cover	-0.011	<0.001
D. Warbling Vireo Abundance		
Tree-class conifer cov.	-2.551	<0.001
Tree-class fir cov.	0.022	0.072
Shrub-class aspen cov.	2.767	<0.001
Shrub-class willow cov.	0.017	0.157
Herbaceous cov.	0.009	0.009
Max. aspen height	0.029	0.077
Ma. Aspen dbh	0.013	0.065

Discussion

While each of these models retained a slightly different set of parameters that best predicted their response variable, several common threads may be found. For example, indices of stand maturity, which is correlated with maximum aspen size, were retained in every single model. All of these bird-habitat relationship models suggest positive relationships between these birds and mature, pure aspen stands.

While absolute percent of tree-class aspen cover was retained as a positive effect in the model for TBA, several models demonstrated negative relationships between coniferous trees in the canopy and the response variable. It is reasonable to think that the addition of conifers into a pure aspen stand would benefit the avian community by adding structural complexity as well as adding bird species associated with conifers otherwise not found in a pure aspen environment (DeByle 1985b). However, our results suggest that whatever benefits these additions may bring to the avian community are outweighed by the negative impacts of conifer encroachment. These findings mirror those of studies in Colorado (Finch and Reynolds 1988) and South Dakota (Rumble et al. 2001).

Conifer encroachment is the greatest threat to aspen stand survival and condition throughout much of the Sierra Nevada (D. Burton, Aspen Delineation Project, pers. comm.), but the encroachment of conifers may have a direct negative effect on aspen-breeding birds themselves. One possible explanation for the negative relationships between bird numbers and conifer cover is the increased availability of insect prey found in pure aspen habitats. Schimpf and MacMahon (1985) found that insect abundance and species richness were greater in both the aspen understory and canopy than in adjacent coniferous habitats. We speculate that this may be due in part to aspen's ability to remain moist throughout the summer months. DeByle (1985a) provides an overview of the mechanics behind this phenomenon, all of which are compromised by intrusion of conifers into the stand.

Absolute herbaceous cover is an important habitat variable in almost every model. It is unclear whether herbaceous cover provides direct benefits to aspen-breeding birds or if it is merely associated with hidden factors that we failed to measure or parameterize (e.g. moisture, abundance of invertebrates). In these analyses it was often highly positively correlated with a high percentage of aspen in the canopy and negatively correlated with a coniferous overstory. At many sites, release from conifer encroachment through thinning or natural disturbance may stimulate herbaceous growth by increasing both available moisture and sunlight needed by these plants. The herbaceous community experiences significant decreases in species richness and diversity with succession to conifer in the canopy (Harper 1973, Korb and Ranker 2001), and Harper (1973) found that understory production decreased by 50% where the canopy was composed of a high percentage of conifers (>50%).

Shrub-class aspen cover has been an important predictor of either Dusky Flycatcher presence or abundance in every dataset that I've examined for this region (Richardson and Heath 2004). Dusky Flycatchers will use a variety of nesting substrates, including conifer branches, but at these sites they seem to prefer to nest in upright forks of tall shrubs, especially small aspen trees: at sites in the Mono Basin, Owens River, and Truckee River watersheds, Dusky Flycatcher nests averaged 1.44 m above the ground (n=66), and 70% were located in aspen (Richardson and Heath 2004). Increased shrub-class aspen cover thus equates to an increase in preferred nesting substrate for this species, and lack of preferred nesting substrate may be limiting at stations with a low percent of shrub-class aspen.

Absolute tree-class aspen cover has often been retained as an important predictor of Warbling Vireo models in the Sierra Nevada (Heath and Ballard 2003, Richardson and Heath 2004). Our models for these data suggest that shrub-class aspen cover may be equally important. Warbling Vireo has demonstrated an association with *Populus* species throughout its range (Gardali and Ballard 2000) and is considered an aspen-associated species throughout the western United States (Finch and Reynolds 1988, Mills et al. 2000a, Heath and Ballard 2003). Flack (1976) described Warbling Vireo as the "most abundant and frequently encountered bird in aspen forests throughout western mountains," and, despite their widespread presence in other western habitats (e.g. post timber-harvest shrub fields, cottonwoods) Warbling Vireo are more likely to be found in aspen (Hutto and Young 1999). While anecdotal and without comparison of available nesting sites at these locations, it is no less notable that at Mono/Owens and Truckee River study sites, 88 of 91 Warbling Vireo nests were in aspen trees (Richardson and

Heath 2004). That abundance of Warbling Vireo had significantly negative relationships with tree-class conifer cover is also worth note, as this species are known to breed in purely coniferous stands (Smith et al. 2004).

Occurrence of Potential Nest Predators

For the two years they were censused, Douglas's Squirrel was present at 46.3% of stations (28.9% annually). The occurrence of this species was most accurately predicted by a combination of tree-class fir cover, absolute shrub cover, and shrub-class conifer cover (Table 5A). This model accurately predicted the occurrence of Douglas's Squirrel at 67.0% of stations (Brier scores: training = 0.19, validation = 0.21). Over the three year period, Steller's Jays were were present at 42.9% of stations (17.7% annually). The occurrence of this species was most accurately predicted by a combination of tree-class Lodgepole Pine cover and shrub-class conifer cover (Table 5B). This model accurately predicted the occurrence of Steller's Jay at 63.5% of stations (Brier scores: training = 0.20, validation 0.28).

TABLE 5. Maximum likelihood estimates, Wald Chi-Square statistics, and significance for parameters selected from multiple logistic regression models predicting occurrence of (A) Douglas's Squirrel and (B) Steller's Jay in aspen habitats, 2002-2004. Models built using forward selection on randomly assigned training dataset (67% of stations) and tested against independent validation dataset. Results of overall model are expressed as percent of stations correctly classified.

Variable	Estimate	Wald Chi-sq.	*P*
A. Douglas's Squirrel			
P < 0.001			
Correctly classified: 67.2%			
Shrub-class conifer cov.	0.1642	11.4932	<0.001
Shrub cov.	-0.0359	6.364	0.116
Tree-class fir cov.	0.0442	2.0529	0.152
B. Steller's Jay			
P <0.001			
Correctly classified: 63.5%			
Tree-class Lodgepole Pine Cov.	-0.1374	11.3010	<0.001
Shrub-class conifer cov.	0.0765	5.0183	0.025

Nest Success in the Tahoe Basin

In 2003, 254 avian nests of 27 species were found and monitored. In 2004, we found and monitored 291 nests of 29 species. Determination of nest status proved difficult for many species, as mean nest height over the two year years was 800 ± 944 cm for Western Wood-Pewee and 805 ± 735 cm for Warbling Vireo. We had many nests over 15 m high. Note that apparent abandonment of nests accounted for approximately 27% of nest failure. Many of these "failures" were false-starts on behalf of Warbling Vireos. It is impossible to say for certain that a small portion of these were not caused by predation of the first egg, but many of the vireos will apparently change their minds about nest-site selection just prior to nest completion. Predation by mammalian, avian, or reptilian nest predators accounted for 67.7% of all nest failure in 2004 (Figure 3). These results are slightly lower than last year (73.1%), but generally corroborate the findings of (Martin 1992), who found that predation accounted for, on average, 77% of nest failure among several species of neotropical migrants on a national scale. It is hoped in 2005, by using video surveillance techniques, we will be able to positively identify the dominant nest predators of aspen-breeding birds. See the Brown-headed Cowbird section below for more details of nest-parasitism.

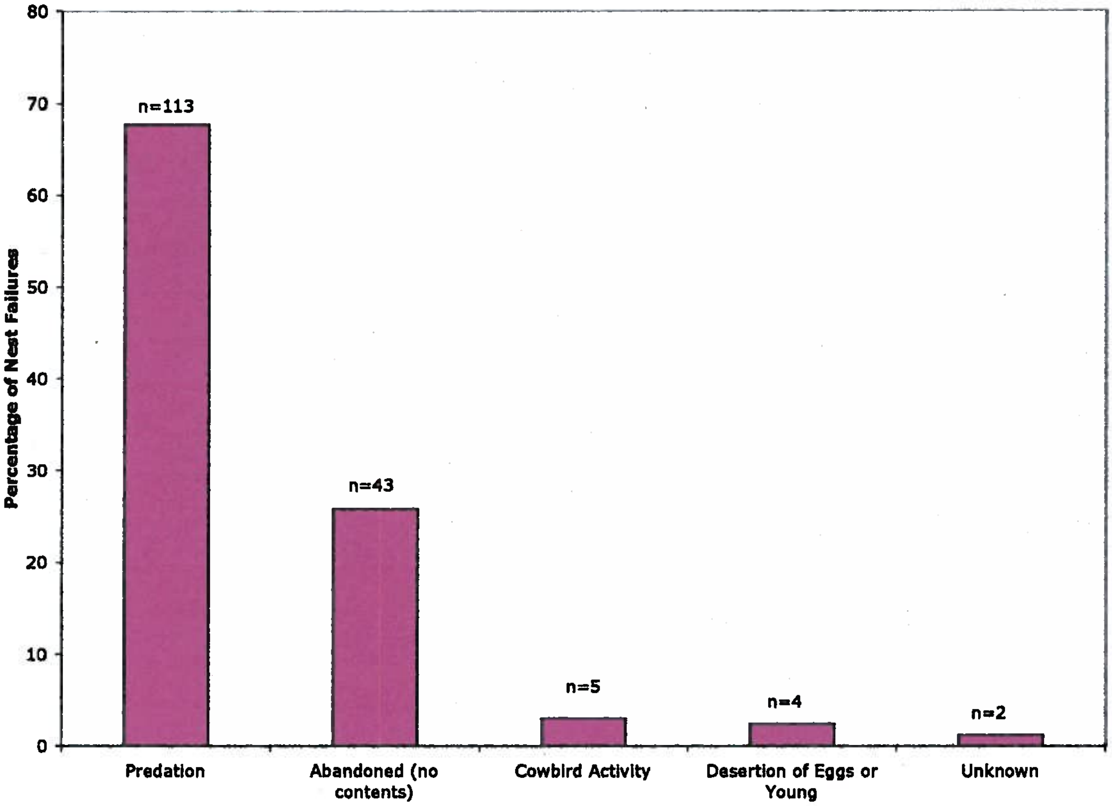

Figure 3. Factors causing nest failure for 167 open cup nests in aspen habitats in the Tahoe Basin, 2004.

Habitat correlates

For four cup-nesting species with relatively large sample sizes we attempted to build nesting success models in Program MARK (White and Burnham 1999). These are Western Wood-Pewee, Dusky Flycatcher, Warbling Vireo, and American Robin. Complex nest fates involving higher rates of cowbird parasitism and partial predation events precluded attempts to model nesting success for Oregon Junco at this time.

Several parameters were included in model selection for all species. These included time ("t", day of nesting cycle), year (2003 vs. 2004), nest phase ("phase", incubation vs. nestling), and date of initiation ("jda"). Other individual covariates included were be (index of immediate concealment below the nest), ab (index of concealment above the nest), x4 (index of immediate concealment in the four cardinal directions from the nest), edge (distance to edge of cover), htfrgd (nest height, from ground), and various measures of conifer densities around the nest. See Appendix V for a complete list of parameters and definitions. Note that standard errors of β estimates are relatively large, and that AIC scores for many of the top models are within two or three points. This is almost certainly due to the small sample sizes. While estimates of nest survival may be considered to be valid for these data, model selection and parameter estimates should by no means be considered definitive based on these results. Larger samples sizes will be required to estimate with confidence the relationships between habitat correlates and nesting success.

Western Wood-Pewee

Of 50 nests utilized for nesting success analyses, 49 were located in aspen trees, typically a meter or two out on a lower, lateral branch, which was often dead. The remaining nest was placed in a Juniper tree (*Juniperus occidentalis*). Nests were generally placed in a fully exposed location, with little or no concealment in any direction. Eighteen models were developed for Western Wood-Pewee nesting success (Appendix VI). During model selection, phase immediately demonstrated its importance on nesting success. An additive model of phase and 5al20 was the most competitive, and density of mature conifers within 50m consistently fell out as an important variable. This model estimates daily egg survival at 0.9896099 (± 0.004 SE) and daily nestling survival at 0.9720508 (± 0.007 SE), which taken out to the full 29-day nesting cycle for this species equals an average survival rate of 0.526 for each nest. This falls almost halfway between rates published for New Mexico (0.43, Bemis and Rising 1999) and Colorado (0.66, Chace et al. 1997). Parameter estimates from the optimal model are as follows:

Intercept	3.5492	± 0.25 (SE)
Phase	1.0074	± 0.43 (SE)
5al20	0.4419	± 0.23 (SE)

Nestlings of this species are considerably more at risk than eggs. However, because of their aggression and vigilance (flycatchers can forage and watch their nests at the same time), adult pewees appear to be very effective defenders of their nests. Because of their highly conspicuous nests, I suspect they may be victims of systematic predation by larger avian predators (e.g. Accipiters, owls, Clark's Nutcracker). In 2004, the Glenbrook Creek site lost seven Western Wood-Pewee nests within a three- or four-day period, which lends support to this theory.

Dusky Flycatcher

Of 34 nests used for nesting success analyses, 27 were located in an upright crotch of an aspen tree, typically a very small aspen. Remaining nests were located in *Ribes* (3), *Salix* (1), *Symphoricarpos* (1), *Artemisia* (1), and in the peeling bark of a fallen aspen log (1). Twenty-four models were constructed (Appendix VII), yet data were presumably too sparse to find any parameters affecting nesting success. Despite the inability to find influential habitat correlates or other meaningful parameters, estimates were obtained for daily nesting success with an unparameterized model: 0.9674991 (±

0.007 SE). Taken out to a full 36-day nesting cycle results in a comparatively low 0.304 average survival rate per nest. However, total nest survival above 0.30 is generally defined as "high" for most passerines, and this is within the range of estimates reported for the species from elsewhere in California (0.36, 0.29, 0.19 Liebezeit and George 2002).

Warbling Vireo

All nests found in 2003-2004, including abandoned attempts, were located in aspen (n = 106). Thirty-two models were constructed (Appendix VIII), the most competitive of which all incorporated below-nest concealment (be), x4, edge, and number of 20m conifers within 50 meters of the nest (5al20). The optimal model was an additive model of individual covariates be, x4, edge, and 5al20. This model estimated daily nest survival at 0.9846002 (±0.004 SE), which when extrapolated to the full 31-day nesting cycle equals an average survival rate of 0.618 for each nest. This nesting success far exceeds estimates from elsewhere in California:

Region	Total Nest Success	Source
Central Coastal California	0.21	(Gardali et al. 2000)
Northern Sierra Nevada	0.19	(Gardali and Ballard 2000)
Inyo and Mono counties	0.10	(PRBO data)

Estimates of parameters are as follows:

Intercept	4.1579	± 0.304 (SE)
x4	0.8495	± 0.297 (SE)
5al20	0.6485	± 0.234 (SE)
edge	1.7297	± 1.189 (SE)
be	-1.2967	± 0.341 (SE)

Note that concealment around the nest and distance to edge of foliage are positively correlated with nest survivorship. That concealment below consistently falls towards the top of the model selection may have implications on the lack of pressure from predators approaching from below or may be correlated with vigilance benefits. A positive correlation with density of mature conifers is inconsistent with the hypothesis that conifer encroachment may bring with it increases in an associated suite of predators (e.g. Douglas's Squirrel, Steller's Jay).

American Robin

Of 68 nests, three were located in fir trees (*Abies*), two were in an alder (*Alnus*), and the remaining 63 were located in aspen trees, typically in a high vertical fork. Mean nest height was 730 cm (± 563). In the model selection for American Robin nesting success, phase of nest was clearly an important parameter, and indices of medium-sized aspen trees in close proximity to the nest and indices of concealment immediately around the nest were all important covariates. Of thirty-two models investigated, the optimal model was an additive combination of phase, x4, and as23 (Appendix IX). This model estimates daily egg survival at 0.9842367 (± 0.004 SE) and daily nestling survival at

0.9609827 (± 0.009 SE), which taken out to the full 29-day nesting cycle for this species equals an average survival rate of 0.501 for each nest. Parameter estimates from the optimal model are as follows:

Intercept	3.2040	± 0.241 (SE)
Phase	0.9302	± 0.348 (SE)
x4	0.3779	± 0.171 (SE)
as23	-0.2668	± 0.166 (SE)

Clearly eggs are less vulnerable than nestlings in this species; indeed most predation events in this species happen within 2-3 days of hatching. Again, concealment immediately around the nest is correlated with increased nest survivorship. The negative relationship with medium-sized aspen in close proximity to the nest is more difficult to explain.

Brood Parasitism

Brown-headed Cowbirds were found to occur at all transects, although little direct evidence of their impact was observed outside of BBIRD plots. Parasitism has been confirmed for eight transects (Appendix IV). In two years of monitoring nests on our BBIRD plots, Brown-headed Cowbird eggs were found in only 21 nests: Warbling Vireo (8 nests), MacGillivray's Warbler (2 nests), Wilson's Warbler (3 nests), Green-tailed Towhee (1 nest), and Oregon Junco (7 nests), and only eleven nests are believed to have failed directly due to cowbird parasitism: Warbling Vireo (6 nests), MacGillivray's Warbler (1 nest), and Oregon Junco (4 nests). High nest height and predation have likely obscured true parasitism rates. However, parasitism rates as a percentage of failed ground and shrub nesters are only slightly higher (approx. 5%) than the sample as a whole. Thus, based on results from the 2003-4 breeding seasons, it does not appear that Brown-headed Cowbird parasitism is a major limiting factor to nesting success among aspen-nesting birds in the Tahoe Basin. In 2003 they accounted for 3.6% of all nest failures, and in 2004 cowbirds were responsible for a similar 2.9%. Most of the species under consideration are putative cowbird egg "accepters," and very few cowbird fledglings are seen on the plots. Cowbird presence and abundance were not quantified, but Brown-headed Cowbird density appeared to be higher at the lower elevation Fallen Leaf Lake Road site than the higher, more heavily forested Carson Range sites.

Results from Mist-netting

Comparison of sites

Mist-netting capture rates provided us with a set of indices for species richness and abundance for 2004 (Table 6), and augmented results derived from point counts (see Appendix X for a comparison of results from the two techniques).

TABLE 6. Summary of constant effort mist-netting during the breeding season, 30 May - 5 August, 2004

Station	Total birds	Caps/100 nethours	New birds banded	n/100 nthrs.	Number of Recaptures	n/100 nthrs.	Number Unbanded	n/100 nthrs.
Logan House Creek	281	70.25	204	51.00	67	16.75	10	2.50
Marlette Basin	171	48.86	98	28.00	40	11.43	33	9.43
Grand Total	452	69.54	302	46.46	107	16.46	42	6.46

Capture rates in 2004 were very consistent with those of 2003 (LOHO - 73.8, MABA – 53.2) and well above the MAPS program national average (37.2 in 1996)

Use of aspen by post-breeding dispersers/migrants

Migrants and upslope dispersers make up a large proportion of the captures, especially during the latter half of the season (Figure 4). In 2004, southbound Rufous Hummingbirds and dispersing Orange-crowned Warblers made up a combined 68% of all Hatch-Year birds captured at the two sites.

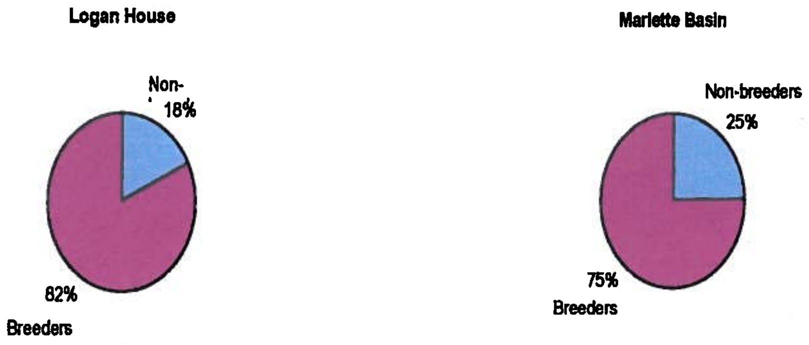

Figure 4. Breeding species vs. non-breeding species as a proportion of total captures, Logan House Creek and Marlette Basin, 2004.

Table 7 shows a detailed summary of constant effort mist-netting by species for both MAPS stations. Logan House Creek demonstrated higher species richness and capture rates, probably due to the position of one net in close proximity to a shallow spring that attracted large numbers of birds to drink and bathe. Several species have been captured exclusively in this net that either do not breed at the site or breed in adjacent habitat but are attracted to the site (e.g. Pacific-Slope Flycatcher, Purple Finch, Pine Grosbeak). Net arrays are chosen to maximize bird captures, but this one landscape feature likely contributed disproportionately to the discrepancy in species richness and capture rates.

Estimates of Productivity

Juvenile (HY) to adult (AHY) ratios (Table 8) were much more similar between sites this year. However, estimates of productivity, on average, are slightly lower than those from last year. This is likely an artifact of small sample sizes and variable capture rates, rather than evidence of, say, decreased nesting success in Oregon Juncos in 2004. Productivity estimates from these data should be treated with caution because of high numbers of post-breeding dispersers utilizing these sites in mid- to late-summer (Figure 4) and the utilization of these sites by birds from adjacent habitats. As mentioned above, suspected migrants or post-breeding dispersers comprised 68% of all Hatch-Year captures. A comparison of productivity of neotropical migrant versus resident or short-distant migrant species is of questionable value due to small sample sizes. We calculated average HY/AHY ratios of known breeders across sites and found virtually identical productivity rates for residents and short-distance migrants (0.125) versus neotropical migrants (0.12). However, if we expand our analysis to include the importance of the sites to migrant Rufous Hummingbirds and Orange-crowned Warblers, we get a very high rate for neotropical migrants (0.775).

Estimates of Survivorship

Unfortunately, techniques of estimating annual survivorship from capture-recapture data require capture histories from at least three years to establish estimates of capture rates (Cormack 1964, Jolly 1965, Seber 1965). That is why the MAPS program requires a three-year commitment from all of its stations. Exceptions are Robust Design models (Kendall et al. 1995, Kendall et al. 1997), but such models would require very large sample sizes with high recapture rates to get meaningful estimates from two-year's worth of data. Provided we can find additional funding, we will continue to mist-net at these two stations to fulfill our commitment. Recapture rates of a few species are probably high enough (Table 6) that we may get reasonable estimates of annual survivorship after a third year. However, estimates of annual survivorship for these sites are not possible at this time.

TABLE 7. Summary of constant effort mist-netting captures by species, 29 May - 5 August, 2004.

Species	Logan House	Marlette Basin	Both Sites
Sharp-shinned Hawk	1		1
Calliope Hummingbird	1	7	8
Rufous Hummingbird	8	26	34
Red-breasted Sapsucker	3	2	5
Downy Woodpecker	1		1
Hairy Woodpecker		2	2
White-headed Woodpecker		4	4
Black-backed Woodpecker		1	1
Red-shafted Flicker		2	2
Western Wood-Pewee	12	1	13
Pacific-Slope Flycatcher	1		1
Dusky Flycatcher	8	14	22
Warbling Vireo	23	7	30
Steller's Jay	1		1
Mountain Chickadee	8		8
White-breasted Nuthatch		2	2
Red-breasted Nuthatch	3	1	4
Brown Creeper	2	3	5
Townsend's Solitaire	2		2
Hermit Thrush	2	2	4
American Robin	14	9	23
Orange-crowned Warbler	33	11	44
Audubon's Warbler	11	2	13
MacGillivray's Warbler	16	6	22
Wilson's Warbler	17	3	20
Western Tanager	6	1	7
Green-tailed Towhee	3		3
Fox Sparrow	6	7	13
Lincoln's Sparrow	1	1	2
Song Sparrow	1		1
Mountain White-crowned Sparrow		19	19
Oregon Junco	82	37	119
Lazuli Bunting	5		5
Black-headed Grosbeak	2		2
Brown-headed Cowbird	2		2
Pine Grosbeak	1		1
Cassin's Finch	5	1	6
Total Captures	281	171	452
Caps/100Nethr	70.25	48.86	60.27
Species Richness	31	25	37
(as % of total)	83.78	67.57	100

MANAGEMENT RECOMMENDATIONS

Summary

The results presented above support our hypotheses that mature, pure aspen stands support high bird species richness as well as higher abundances of aspen-associated species (ie. Dusky Flycatcher, Warbling Vireo). Results from nest-searching suggest that productivity of certain species (e.g. Warbling Vireo) is relatively high. These results support the assertion that aspen habitats act as sources for insectivorous birds in a conifer-dominated landscape (Griffis-Kyle and Beier 2003). Productivity results from mist-netting were inconclusive. Mist-netting data suggest that aspen habitats are likely utilized commonly by birds breeding in other habitats locally (e.g. Pine Grosbeak) or regionally (e.g. Rufous Hummingbird). Management actions should seek to release aspen habitats from conifer encroachment, particularly in the overstory. Further restoration should retain standing aspen snags, and where possible, attempt to increase overall aspen cover on the landscape through vegetative reproduction. Monitoring protocols should continue for at least one more year to capture potential annual variation, allow for calculation of annual survivorship estimates for select species, and increase sample size of nests, which in turn would allow for improved model selection and parameter estimates of nest-survivorship. Additional effort should also be made to determine the predominate nest-predators of aspen-breeding birds.

Habitat Considerations

Encroachment into aspen stands by conifers has negative impacts on herbaceous cover (Harper 1973, Korb and Ranker 2001), stand moisture (DeByle 1985a), insect abundance (Schimpf and MacMahon 1985), and bird species richness and abundance. Removal of conifers not only helps to ensure long-term persistence of the stand itself, it can be a critical factor in the preservation of the stand's ecological function. We believe that conifer removal in at-risk stands, performed outside of the avian breeding season, may increase bird species richness and abundance overall, and increase the likelihood of occurrence and abundance of aspen-associated species such as Dusky Flycatcher and Warbling Vireo in the Sierra Nevada. Any successful management plan designed to maintain or improve the purity, area, and function of mature aspen stands will almost certainly have positive effects on aspen-breeding bird population levels.

Efforts should be made to manage aspen stands for a healthy herbaceous community. Aspen stands are often very wet or in a true riparian context, and Potter (1998) considered the Quaking Aspen/Corn Lily (*Veratrum californicum*) plant association to be one of the more fragile habitats in the Sierra Nevada. Thus, any conifer-thinning treatment must consider its impact on the soil and its seedbank as well as local hydrological considerations. Also, excessive livestock grazing in aspen stands can degrade the quality of herbaceous cover, alter the hydrological conditions that allow for a vigorous herbaceous understory, and limit aspen regeneration (Bartos and Campbell Jr 1998).

Efforts should also be made to increase the area, age complexity, and regeneration of aspen habitats at the landscape scale to ensure long-term persistence of aspen in the riparian or otherwise, in the Sierra Nevada may help to offset or possibly reverse this negative trend at a regional scale.

An added difficulty in conservation planning for aspen explicitly is the wide variety of ecological roles aspen can play, depending on the environmental context. For example, what are the differences between seral and climax aspen communities in terms of importance to breeding birds? Wherever aspen occurs, it is likely to be a keystone species, especially in terms of its effect on local soil, hydrology, and vascular plants, but also birds and other wildlife. Certain generalizations would likely apply to any management guidelines for bird conservation (e.g. herbaceous cover is good for birds in Sierra Nevada aspen stands). However, because of aspen's ecological amplitude, management actions should always be locally prescriptive and not based solely on regional or broader-scale generalizations.

ACKNOWLEDGEMENTS

This project was supported by the Lake Tahoe Basin Management Unit, Nevada Division of State Lands, United States Fish and Wildlife Service Nevada Biodiversity Initiative, the United States Forest Service Region 5 Partners in Flight. We thank W. Beard, K. Crouch, J. Knight, D. Mercer, K. Nelson, E. Nolte, A. Rodrian, and N. Walker for their long hours in the field and behind the computer. We thank G. Fernandez, J. Sedinger, and L. Crampton for assistance with the statistical analyses.

LITERATURE CITED

Akaike, H. 1973. Information theory and an extension of the maximum likelihood principle. Pages 267-281 *in* B. N. Petran and F. Csaki, editors. International symposium on information theory. Second edition. Akademiai Kiado, Budapest, Hungary.

Ballard, G. 2002. Pointcnt 2.75. Point Reyes Bird Observatory. Stinson Beach, CA. <http://www.prbo.org/tools>. Accessed.

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

Bartos, D. L. 2001. Landscape Dynamics of Aspen and Conifer Forests. Pages 5-14 in Sustaining Aspen in Western Landscapes, Symposium Proceedings. United States Forest Service RMRS-P-18.

Bartos, D. L., and R. B. Campbell Jr. 1998. Decline of Quaking Aspen in the interior West - examples from Utah. Rangelands **20**:17-24.

Bemis, C., and J. D. Rising. 1999. Western Wood-Pewee (*Contopus sordidulus*). *in* A. Poole and F. Gill, editors. The Birds of North America, No. 451. The Birds of North America, Inc., Philadelphia, PA.

Burnham, K. P., and D. E. Andersen. 1998. Model selection and inference: a practical information-theoretic approach. Springer-Verlag, New York, New York.

Burton, D. 2000. Aspen Delineation Project Summary to the Pacific and Placerville Ranger Districts, Eldorado National Forest. USFS.

Campbell Jr., R. B., and D. L. Bartos. 2001. Aspen Ecosystems: Objectives for Sustaining Biodiversity. Pages 299-307 in Sustaining Aspen in Western Landscapes, Symposium Proceedings. United States Forest Service RMRS-P-18.

Chace, J. F., A. Cruz, and A. Cruz Jr. 1997. Nesting success of the Western Wood-Pewee in Colorado. Western Birds **28**.

Cormack, R. M. 1964. Estimates of survival from the sighting of marked animals. Biometrika **51**:429-438.

Daily, G. C., P. R. Ehrlich, and N. M. Haddad. 1993. Double keystone bird in a keystone species complex. Proceedings of the National Academy of Science, USA **90**:592-592.

DeByle, N. V. 1985a. Water and Watershed. Pages 153-160 in N.V. DeByle and R.P. Winkour, editors. Aspen: Ecology and Management in the Western United States. United States Forest Service GTR-RM-119.

DeByle, N. V. 1985b. Wildlife. Pages 135-152 *in* N.V. DeByle and R.P. Winkour, editors. Aspen: Ecology and Management in the Western United States. United States Forest Service GTR-RM-119.

DeSante, D. F., K. M. Burton, P. Velez, and D. Froelich. 2003. MAPS Manual, 2003 Protocol. Institute for Bird Populations, Point Reyes Station, CA.

Dinsmore, S. J., G. C. White, and F. L. Knopf. 2002. Advanced techniques for modeling avian nest survival. Ecology **83**:3476-3488.

Fernandez, G. 2003. Data Mining Using SAS Applications. Chapman and Hall/CRC Press, New York, NY.

Finch, D. M., and R. T. Reynolds. 1988. Bird response to understory variation and conifer succession in aspen forests. Pages 87-95 *in* J. Emerick, F. S.Q, L. Hayden-Wing, J. Hodgson, J. W. Monarch, A. Smith, O. Thorne, and J. Todd, editors. Proceedings III: Issues and Technology in the Management of Impacted Wildlife. Thorne Ecological Institute, Boulder, CO.

Flack, J. A. D. 1976. Bird populations of aspen forest in western North America. Ornithological Monographs **19**:1-97.

Gaines, D. 1988. Birds of Yosemite and the East Slope. Artemisia Press, Lee Vining, California.

Gardali, T., and G. Ballard. 2000. Warbling Vireo (*Vireo gilvus*) *in* A. Poole and F. Gill, editors. Birds of North America, No. 551. Academy of Natural Science of Philadelphia, American Ornithologists Union, Washington, D.C.

Gardali, T., G. Ballard, N. Nur, and G. R. Geupel. 2000. Demography of a declining population of Warbling Vireos in coastal California. Condor **102**:601-609.

Gardali, T., and A. Jaramillo. 2001. Further evidence for a population decline in the western Warbling Vireo. Western Birds **32**:173-176.

Griffis-Kyle, K. L., and P. Beier. 2003. Small isolated aspen stands enrich bird communities in southwestern ponderosa pine forests. Biological Conservation **110**:375-385.

Harper, K. T. 1973. The influence of tree overstory on understory production and composition in aspen forests of central Utah. Society for Range Management. Abstract of papers **26**:22.

Heath, S. K., and G. Ballard. 2003. Patterns of breeding songbird diversity and occurrence in riparian habitats of the Eastern Sierra Nevada. Pages 21-34 *in* P. M. Faber, editor. California Riparian Systems: Processes and Floodplain Management, Ecology, and Restoration. Riparian Habitat and Floodplains Conference Proceedings, Riparian Habitat Joint Venture, Sacramento, CA.

Hogg, E. H. 2001. Modeling aspen responses to climatic warming and insect defoliation in western Canada. Pages 325-338 in Sustaining Aspen in Western Landscapes, Symposium Proceedings. United States Forest Service RMRS-P-18.

Hutto, R. L., and J. S. Young. 1999. Habitat relationships of landbirds in the Northern Region. United States Forest Service RMRS-GTR-32.

Jolly, G. M. 1965. Explicit estimates from capture-recapture data with both death and immigration stochastic model. Biometrika **52**:225-247.

Kay, C. E. 1997. Is aspen doomed? Journal of Forestry **95**:4-11.

Kendall, W. L., J. D. Nichols, and J. E. Hines. 1997. Estimating temporary emigration using capture-recapture data with Pollock's robust design. Ecology **78**:563-578.

Kendall, W. L., K. H. Pollock, and C. Brownie. 1995. A likelihood-based approach to capture-recapture estimation of demographic parameters under the robust design. Biometrics **51**:293-308.

Korb, J. E., and T. A. Ranker. 2001. Changes in stand composition and structure between 1981 and 1996 in four Front Range plant communities in Colorado. Plant Ecology **157**:1-11.

Liebezeit, J. R., and T. L. George. 2002. Nest predators, nest-site selection, and nesting success of the Dusky Flycatcher in a managed Ponderosa Pine forest. Condor **104**:507-517.

Martin, T. E. 1992. Breeding productivity considerations: What are the appropriate habitat features for management? Pages 455-473 *in* J. M. Hagan and D. W. Johnston, editors. Ecology and Conservation of Neotropical Migrants. Smithsonian Institute Press, Washington, D.C.

Martin, T. E., C. Paine, C. J. Conway, W. M. Hochachka, P. Allen, and W. Jenkins. 1997. The Breeding Biology Research and Monitoring Database (BBIRD) Field Protocol. University of Montana Cooperative Wildlife Research Unit, Unpublished Manual.

Mills, T. R., M. A. Rumble, and L. D. Flake. 2000a. Habitat of birds in ponderosa pine and aspen/birch forest in the Black Hills. United States Forest Service RMRS-RP-21.

Mills, T. R., M. A. Rumble, and L. D. Flake. 2000b. Optimum timeframes for detecting songbird vocalizations in the Black Hills. United States Forest Service RMRS-RP-21.

Palmeirim, J. M., and J. E. Rabaca. 1994. A method to analyze and compensate for time-of-day effects on bird counts. Journal of Field Ornithology **65**:17-26.

Potter, D. A. 1998. Forested Communities of the Upper Montane in the Central and Southern Sierra Nevada. United States Forest Service GTR-169.

Pyle, P. 1997. Identification Guide to North American Birds, Part I: Columbidae to Ploceidae. Slate Creek Press, Bolinas, CA.

Ralph, C. J., S. Droege, and J. R. Sauer. 1995. Managing and Monitoring Birds using Point Counts: Standards and Applications *in* Monitoring Bird Populations by Point Counts. United States Forest Service PSW-GTR-149.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Field Methods for Monitoring Landbirds. United States Forest Service PSW-GTR-144.

RHJV. 2004. Version 2.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. <http://www.prbo.org/calpif/pdfs/riparian.v-2.pdf>. Accessed.

Richardson, T. W. 2003a. Avian Species Diversity in Aspen Habitats of the Truckee River Watershed: Results from the 2003 Field Season. Annual report.

Richardson, T. W. 2003b. First records of Black-backed Woodpecker (*Picoides arcticus*) nesting in Nevada. Great Basin Birds **6**:52-55.

Richardson, T. W., and S. K. Heath. 2004. Effects of conifers on aspen-breeding bird communities in the Sierra Nevada. Accepted to Transactions of the Western Section of the Wildlife Society **39**.

Romme, W. H., L. Floyd-Hanna, D. D. Hanna, and E. Bartlett. 2001. Aspen's Ecological Role in the West. Pages 243-259 in Sustaining Aspen in Western Landscapes, Symposium Proceedings. United States Forest Service RMRS-P-18.

Rotella, J. J., S. J. Dinsmore, and T. L. Shaffer. 2004. Modeling nest-survival data: a comparison of recently developed methods that can be implemented in MARK and SAS. Animal Biodiversity and Conservation **27**:*In Press.*

Rumble, M. A., L. D. Flake, T. R. Mills, and B. L. Dystra. 2001. Do pine trees in aspen stands increase bird diversity? Pages 185-191 *in* Sustaining aspen in western landscapes, symposium proceedings. United States Forest Service RMRS-P-18.

Salt, G. W. 1957. Analysis of avifaunas in the Teton Mountains and Jackson Hole, Wyoming. Condor **82**:373-393.

SAS. 1999. SAS Online Doc, Version Eight. SAS Institute, Cary, NC.

Schimpf, D. J., and J. A. MacMahon. 1985. Insect communities and faunas of a Rocky Mountain subalpine sere. Great Basin Naturalist **45**:37-60.

Scott, V. E., and G. L. Crouch. 1998. Breeding bird in uncut aspen and 6- to 10-year old clearcuts in Southwestern Colorado. United States Forest Service RN-RM-485.

Seber, G. A. F. 1965. A note on the multiple recapture census. Biometrika **52**:249-259.

Siegel, R. B., and D. F. DeSante. 1999. CalPIF Sierra Nevada Bird Conservation Plan. Institute for Bird Populations. <http://www.prbo.org/calpif/htmldocs/sierra.html>. Accessed 16 November, 2002.

Smith, J. I., M. D. Reynolds, and G. LeBuhn. 2004. Warbling Vireo nesting ecology in the northern Sierra Nevada. Western Birds **35**:32-41.

Verner, J., and A. B. Boss. 1980. California wildlife and their habitats: western Sierra Nevada. United States Forest Service PSW-37.

White, G. C., and K. P. Burnham. 1999. Program MARK:Survival estimation from populations of marked animals. Bird Study **46**:120-139.

Winternitz, B. L. 1980. Birds in aspen. Pages 247-257 *in* R.M. Degraff, editor. Workshop proceedings on management of western forests and grasslands for nongame birds. United States Forest Service GTR-INT-86.

APPENDIX I. Avian species encountered at the study sites, Summers 2002-2004.

Common Name	**Scientific Name**
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhynchos*
Common Merganser	*Mergus merganser*
Turkey Vulture.	*Cathartes aura*
Osprey	*Pandion haliaetus*
Bald Eagle	*Haliaeetus leucocephalus*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*
Cooper's Hawk	*A. cooperii*
Northern Goshawk	*A. gentilis*
Red-shouldered Hawk	*Buteo lineatus*
Red-tailed Hawk	*B. jamaicensis*
Blue Grouse	*Dendropagus obscurus*
Virginia Rail	*Rallus limicola*
Sora	*Poranza carolina*
Mountain Quail	*Oreortyx pictus*
California Quail	*Callipepla californica*
Kildeer	*Charadrius vociferus*
Spotted Sandpiper	*Actitus macularius*
Wilson's Snipe	*Gallinago delicata*
Band-tailed Pigeon	*Columba fasciata*
Mourning Dove	*Zenaida macroura*
Yellow-billed Cuckoo	*Coccyzus americanus*
Northern Pygmy-Owl	*Glaucidium gnoma*
Long-eared Owl	*Asio otus*
Vaux's Swift	*Chaetura vauxi*
Calliope Hummingbird	*Stellula calliope*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Rufous Hummingbird	*S. rufus*
Belted Kingfisher	*Ceryle alcyon*
Red-breasted Sapsucker	*Sphyrapicus ruber*
Williamson's Sapsucker	*S. thyroideus*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*P. villosus*
White-headed Woodpecker	*P. albolarvatus*
Black-backed Woodpecker	*P. arcticus*
Red-shafted Flicker	*Colaptes auratus collaris*
Pileated Woodpecker	*Drycopus pileatus*
Olive-sided Flycatcher	*Contopus cooperi*
Western Wood-Pewee	*C. sordidulus*
Willow Flycatcher	*Empidonax traillii*
Hammond's Flycatcher	*E. hammondii*
Dusky Flycatcher	*E. oberholseri*
Pacific-Slope Flycatcher	*E. difficilis*
Cordilleran Flycatcher	*E. occidentalis*
Western Kingbird	*Tyrannus verticalis*
Loggerhead Shrike	*Lanius ludovicianus*

APPENDIX 1 (cont'd). Avian species encountered at the study sites, Summers 2002-2004.

Common Name	**Scientific Name**
Cassin's Vireo	*Vireo cassinii*
Warbling Vireo	*V. gilvus*
Steller's Jay	*Cyanocitta stelleri*
Clark's Nutcracker	*Nucifraga columbiana*
Common Raven	*Corvus corax*
Tree Swallow	*Tachycineta thalassina*
Cliff Swallow	*Petrochelidon pyrrhonota*
Mountain Chickadee	*Poecile gambeli*
Red-breasted Nuthatch	*Sitta canadensis*
White-breasted Nuthatch	*S. carolinensis*
Pygmy Nuthatch	*S. pygmaea*
Brown Creeper	*Certhia americana*
House Wren	*Troglodytes aedon*
Winter Wren	*T. troglodytes*
American Dipper	*Cinclus mexicanus*
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*R. calendula*
Mountain Bluebird	*Sialia currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*C. guttatus*
American Robin	*Turdus migratorius*
European Starling	*Sturnus vulgaris*
Orange-crowned Warbler	*Vermivora celata*
Nashville Warbler	*V. ruficapilla*
Virginia's Warbler	*V. virginiae*
Yellow Warbler	*Dendroica petechia*
Audubon's Warbler	*D. coronata auduboni*
Black-throated Gray Warbler	*D. nigrescens*
Townsend's Warbler	*D. townsendi*
Hermit Warbler	*D. occidentalis*
MacGillivray's Warbler	*Oporornis tolmiei*
Wilson's Warbler	*Wilsonia pusilla*
Western Tanager	*Piranga ludoviciana*
Green-tailed Towhee	*Pipilo chlorurus*
Spotted Towhee	*P.maculatus*
Chipping Sparrow	*Spizella passerina*
Brewer's Sparrow	*S. breweri*
Savannah Sparrow	*Passerculus sandwichensis*
Fox Sparrow	*Passerella iliaca*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*M. lincolnii*
Mountain White-crowned Sparrow	*Zonotrichia leucophrys oriantha*
Oregon Junco	*Junco hyemalis thurberi*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Lazuli Bunting	*Passerina amoena*
Red-winged Blackbird	*Agelaius phoeniceus*

APPENDIX I (cont'd). Avian species encountered at the study sites, Summers 2002-2004.

Common Name	Scientific Name
Brewer's Blackbir	*Euphagus cyanocephalus*
Brown-headed Co	*Molothrus ater*
Bullock's Oriole	*Icterus bullockii*
Pine Grosbeak	*Pinicola enucleator*
Purple Finch	*Carpodacus purpureus*
Cassin's Finch	*C. cassinii*
Red Crossbill	*Loxia curvirostra*
Pine Siskin	*Carduelis pinus*
Lesser Goldfinch	*C. psaltria*
American Goldfin	*C. tristis*
Evening Grosbeak	*Coccothraustes vespertinus*

Appendix II. UTM Coordinates for Census Points

Point ID	Zone	X	Y	State	Converted X Zone 10	Converted Y Zone 10
BIME01	11	240692	4295790	CA	761952	4295877
BIME02	11	240509	4295697	CA	761775	4295772
BIME03	11	240169	4295851	CA	761426	4295903
BIME04	11	239989	4295961	CA	761239	4296001
BIME05	11	239757	4296000	CA	761005	4296025
BIME06	11	239905	4296133	CA	761144	4296167
BIME07	11	240893	4295789	CA	762153	4295889
BIME08	11	241101	4295788	CA	762360	4295902
BIME09	11	241160	4295994	CA	762406	4296111
FALL01	10	756684	4310120	CA	756684	4310120
FALL02	10	756537	4310278	CA	756537	4310278
FALL03	10	756369	4310377	CA	756369	4310377
FALL04	10	756330	4310590	CA	756330	4310590
FALL05	10	756255	4310826	CA	756255	4310826
FALL06	10	756133	4311009	CA	756133	4311009
FALL07	10	756109	4311328	CA	756109	4311328
FALL08	10	756112	4311656	CA	756112	4311656
FALL09	10	756105	4311873	CA	756105	4311873
FALL10	10	756072	4312060	CA	756072	4312060
FOPL01	11	246465	4304554	CA	767138	4305001
FOPL02	11	246358	4304390	CA	767042	4304831
FOPL03	11	246207	4304265	CA	766899	4304696
FOPL04	11	246034	4304161	CA	766733	4304581
FOPL05	11	246090	4303977	CA	766801	4304401
FOPL06	11	245949	4303833	CA	766670	4304248
GLEN01	11	250261	4329283	NV	769297	4329929
GLEN02	11	250071	4329374	NV	769102	4330007
GLEN03	11	249912	4329231	NV	768952	4329854
GLEN04	11	249720	4329194	NV	768763	4329805
GLEN05	11	249581	4329326	NV	768616	4329927
GLEN06	11	249384	4329400	NV	768414	4329988
GLEN07	11	249556	4329551	NV	768576	4330150
GLEN08	11	249760	4329547	NV	768780	4330160
GLEN09	11	249959	4329657	NV	768971	4330282
GLEN10	11	250082	4329824	NV	769083	4330457
GLEN11	11	250298	4329816	NV	769299	4330464
HEPA01	10	729384	4373510	CA	729384	4373510
HEPA02	10	729265	4373831	CA	729265	4373831
HEPA03	10	729405	4374098	CA	729405	4374098
HEPA04	10	729314	4374288	CA	729314	4374288
HEPA05	10	730577	4374431	CA	730577	4374431
HEPA06	10	730813	4374473	CA	730813	4374473
HEPA07	10	731011	4374534	CA	731011	4374534
HEPA08	10	731615	4374259	CA	731615	4374259
HEPA09	10	732001	4374214	CA	732001	4374214
HEPA10	10	732234	4374288	CA	732234	4374288
HEPA11	10	732436	4374281	CA	732436	4374281

Appendix II (cont'd). UTM Coordinates for Census Points

Point ID	Zone	X	Y	State	Converted X Zone 10	Converted Y Zone 10
HEPA12	10	732948	4374355	CA	732948	4374355
HEPA13	10	733144	4374423	CA	733144	4374423
HEPA14	10	733480	4374518	CA	733480	4374518
HEPA15	10	733727	4374645	CA	733727	4374645
ICDO01	10	733551	4373301	CA	733551	4373301
ICDO02	10	733579	4373515	CA	733579	4373515
ICDO03	10	733674	4373762	CA	733674	4373762
ICDO04	10	733727	4373961	CA	733727	4373961
ICDO05	10	733769	4374157	CA	733769	4374157
ICDO06	10	733825	4374349	CA	733825	4374349
ICDO07	10	733984	4374503	CA	733984	4374503
ICDO08	10	734063	4374642	CA	734063	4374642
ICUP01	10	734177	4372508	CA	734177	4372508
ICUP02	10	733995	4372611	CA	733995	4372611
ICUP03	10	733796	4372684	CA	733796	4372684
ICUP04	10	733631	4372822	CA	733631	4372822
ICUP05	10	733445	4372740	CA	733445	4372740
ICUP06	10	733426	4372948	CA	733426	4372948
ICUP07	10	733258	4371925	CA	733258	4371925
ICUP08	10	733439	4372026	CA	733439	4372026
ICUP09	10	733610	4372173	CA	733610	4372173
LOHO01	11	248445	4326895	NV	767643	4327426
LOHO02	11	248252	4326846	NV	767453	4327365
LOHO03	11	248053	4326836	NV	767255	4327342
LOHO04	11	247954	4327010	NV	767145	4327509
LOHO05	11	247754	4326996	NV	766946	4327481
LOHO06	11	247636	4327139	NV	766819	4327616
LOHO07	11	247428	4327196	NV	766608	4327660
LOHO08	11	247241	4327139	NV	766425	4327590
MABA01	11	249854	4338398	NV	768289	4338998
MABA02	11	249901	4338597	NV	768323	4339200
MABA03	11	249885	4338793	NV	768294	4339395
MABA04	11	249998	4338989	NV	768394	4339598
MABA05	11	250057	4339188	NV	768439	4339800
MABA06	11	250164	4339372	NV	768534	4339991
MABA07	11	250229	4339599	NV	768584	4340222
MABA08	11	250300	4339843	NV	768638	4340470
MABA09	11	250022	4339542	NV	768381	4340151
MABA10	11	249957	4339760	NV	768302	4340364
MEAT01	10	733414	4373682	CA	733414	4373682
MEAT02	10	733205	4373672	CA	733205	4373672
MEAT03	10	733001	4373605	CA	733001	4373605
MEAT04	10	732810	4373566	CA	732810	4373566
MEAT05	10	732561	4373504	CA	732561	4373504
MEAT06	10	732354	4373468	CA	732354	4373468
MEAT07	10	732134	4373469	CA	732134	4373469
MEAT08	10	731956	4373351	CA	731956	4373351

Appendix II (cont'd). UTM Coordinates for Census Points

Point ID	Zone	X	Y	State	Converted X Zone 10	Converted Y Zone 10
MEAT09	10	731737	4373357	CA	731737	4373357
MEAT10	10	731529	4373425	CA	731529	4373425
MEAT11	10	731359	4373335	CA	731359	4373335
MEAT12	10	731189	4373205	CA	731189	4373205
MEAT13	10	730993	4373188	CA	730993	4373188
NOCA01	11	248070	4333068	NV	766861	4333562
NOCA02	11	248105	4333276	NV	766882	4333772
NOCA03	11	248110	4333491	NV	766873	4333986
NOCA04	11	248081	4333727	NV	766828	4334220
NOCA05	11	248037	4333940	NV	766770	4334430
NOCA06	11	248100	4334140	NV	766820	4334633
NOCA07	11	248266	4334276	NV	766977	4334780
NOCA08	11	248435	4334445	NV	767134	4334960
NOCA09	11	248624	4334598	NV	767313	4335125
NOCA10	11	248645	4334839	NV	767318	4335367
NOCA11	11	248780	4335016	NV	767441	4335552
NOCA12	11	248902	4335190	NV	767551	4335734
NOCA13	11	249035	4335345	NV	767673	4335898
NOCA14	11	249098	4335592	NV	767720	4336148
NOCA15	11	249158	4335929	NV	767758	4336489
NOCA16	11	249332	4336093	NV	767920	4336664
NOCA17	11	249486	4336228	NV	768065	4336809
NOCA18	11	249588	4336410	NV	768155	4336997
NOCA19	11	249799	4336714	NV	768345	4337314
NOCA20	11	249979	4336876	NV	768514	4337488
NOCA21	11	250044	4337086	NV	768565	4337702
PAIG01	10	741787	4337381	CA	741787	4337381
PAIG02	10	742092	4337130	CA	742092	4337130
PAIG03	10	742272	4336997	CA	742272	4336997
PAIG04	10	742434	4336885	CA	742434	4336885
PAIG05	10	742700	4337054	CA	742700	4337054
PAIG06	10	742894	4336970	CA	742894	4336970
PAIG07	10	742855	4336738	CA	742855	4336738
PAIG08	10	742976	4337281	CA	742976	4337281
PAIG09	10	743159	4337126	CA	743159	4337126
PAIG10	10	742375	4336665	CA	742375	4336665
PAIG11	10	742179	4336824	CA	742179	4336824
PERR01	10	727460	4373604	CA	727460	4373604
PERR02	10	727319	4373357	CA	727319	4373357
PERR03	10	727183	4373180	CA	727183	4373180
PERR04	10	726965	4373047	CA	726965	4373047
PERR05	10	726727	4373036	CA	726727	4373036
PERR06	10	726539	4373108	CA	726539	4373108
PERR07	10	726340	4373051	CA	726340	4373051
PERR08	10	726073	4372826	CA	726073	4372826
PERR09	10	725935	4372644	CA	725935	4372644
PERR10	10	725777	4372492	CA	725777	4372492

Appendix II (cont'd). UTM Coordinates for Census Points

Point ID	Zone	X	Y	State	Converted X Zone 10	Converted Y Zone 10
PERR11	10	725657	4372338	CA	725657	4372338
PERR12	10	725425	4372014	CA	725425	4372014
PERR13	10	725346	4371848	CA	725346	4371848
PERR14	10	725331	4371575	CA	725331	4371575
PERR15	10	725336	4371325	CA	725336	4371325
SAGE01	10	735058	4368484	CA	735058	4368484
SAGE02	10	734899	4368408	CA	734899	4368408
SAGE03	10	734638	4368534	CA	734638	4368534
SAGE04	10	734417	4368517	CA	734417	4368517
SAGE05	10	734230	4368448	CA	734230	4368448
SAGE06	10	734114	4368261	CA	734114	4368261
SAGE07	10	733796	4368194	CA	733796	4368194
SAGE08	10	733574	4368196	CA	733574	4368196
SAGE09	10	733332	4368198	CA	733332	4368198
TUNN01	11	249086	4345943	NV	767023	4346477
TUNN02	11	248946	4345821	NV	766892	4346346
TUNN03	11	248885	4345632	NV	766843	4346153
TUNN04	11	248710	4345512	NV	766677	4346022
TUNN05	11	249112	4345567	NV	767074	4346103

APPENDIX III. Mist-netting dates and nethours by location, 2004

MAPS Period	Logan House	Nethours	Marlette Basin	Nethours
3	5/30/04	50	~	~
4	6/6/04	50	6/10/04	50
5	6/15/04	50	6/17/04	50
6	6/24/04	50	6/25/04	50
7	7/6/04	50	7/8/04	50
8	7/15/04	50	7/19/04	50
9	7/21/04	50	7/23/04	50
10	8/3/04	50	8/5/04	50
		400		350

APPENDIX IV. Known breeding status of avian species encountered at each transect, Summers 2002-2004.

SPECIES	ICDO	ICUP	MEAT	PERR	HEPA	SAGE	NOCA	TUNN	BIME	MABA	LOHO	FOPL	FALL	PAIG	GLEN
Canada Goose										3					
Mallard				1										1	
Common Merganser					3										
Turkey Vulture											3				
Osprey	3	3				0									
Bald Eagle										0					
Northern Harrier				3											
Sharp-shinned Hawk		3	3							3					
Cooper's Hawk				3	3	3			3			3			3
Northern Goshawk									3	3					
Red-shouldered Hawk				3									3	3	
Red-tailed Hawk	3			3	3	3	3	3	3	3	3				
Blue Grouse				1	3		1			1	1	3		1	1
Mountain Quail				3	3	1			3	3	2			1	1
California Quail	3				3										
Virginia Rail				3											
Sora														3	
Killdeer					3										
Spotted Sandpiper[1]														3	
Wilson's Snipe				3	2									3	
Band-tailed Pigeon				3	2	3	3	2	3	3	3	3	3		3
Mourning Dove				3									3		
Yellow-billed Cuckoo[1]													0		
Long-eared Owl							3		3	3					
Northern Pygmy-Owl					1								1		
Vaux's Swift[2]					3										
Calliope Hummingbird	3	3	1	3	3	3	1	3	3	1	1	2		1	2
Broad-tailed Hummingbird											1				
Rufous Hummingbird	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Belted Kingfisher	3	3		3	3										
Red-breasted Sapsucker	1	1	1	1	1	1	1		1	1	1	1	1	1	1
Williamson's Sapsucker				3	3	3	3	3	1	3			1		
Downy Woodpecker					1								1	3	
Hairy Woodpecker	1	3	1	1	1		1	1	1	1	1	1	1	1	1
White-headed Woodpecker		3	3	1	3	3	3	3			3	1	1	1	3
Black-backed Woodpecker[2]							3			1	1	1			
Red-shafted Flicker	3	3	3	1	3	1	3	1	3	1	3	3	1	3	3
Pileated Woodpecker[2]		3											3		
Olive-sided Flycatcher[2]					3	3	3	3	3	3		3		3	3
Western Wood-Pewee	2	1	2	2	1	2	1	1	2	1	1	2	1	1	1
Willow Flycatcher[1]			3												
Hammond's Flycatcher	3		3	3	3		3	3				3			
Dusky Flycatcher	2	1	1	1	1	1	1	3	1	1	1	2	3	2	1
Pacific-Slope Flycatcher				2				3		3					
Cordilleran Flycatcher										3					
Western Kingbird				3											
Loggerhead Shrike					3										
Cassin's Vireo			3	3	3		2			3		3	3	3	
Warbling Vireo[1]	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Steller's Jay	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Clark's Nutcracker				3	3		3	1	3	3	3	3	3	3	3
Common Raven		3	3	3				3	3				3	2	
Cliff Swallow									3						
Tree Swallow[1]				1	2	3			3				1		
Mountain Chickadee	2	1	1	1	1	2	1	1	1	1	1	1	1	1	1
Red-breasted Nuthatch[2]		3	3	3	3	1	3	1	3	3	3	3	2	3	3
White-breasted Nuthatch		3	3		3	1	3	1	3	3	3	3	3		3
Pygmy Nuthatch	3	3	3		1	3	3				3		1	3	
Brown Creeper[2]	3	3	1	3	3	3	1	3	1	3	1	2	1	3	2
Winter Wren									3						3
House Wren	3	3	3	1	1	3	1	1	3	1	1		1	1	1
American Dipper						2									
Golden-crowned Kinglet[2]	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

APPENDIX IV (cont'd). Known breeding status of avian species encountered at each transect, Summers 2002-2004.

SPECIES	ICDO	ICUP	MEAT	PERR	HEPA	SAGE	NOCA	TUNN	BIME	MABA	LOHO	FOPL	FALL	PAIG	GLEN
Ruby-crowned Kinglet				3					3			3			
Mountain Bluebird				1						1					
Townsend's Solitaire	3	3	3	3	3		3	3	3		3	1		3	3
Swainson's Thrush[1]				2	3				2						
Hermit Thrush		3	3	3	1	3	2	3	1	2	2	3	3	2	2
American Robin	1	1	2	1	1	1	1	1	1	1	1	2	1	1	1
European Starling				1											
Orange-crowned Warbler			3	3		3	3		3	3	3	3		3	3
Nashville Warbler	3	3	3	3	3	3	3		2	3	3	3	3	2	3
Virginia's Warbler								3							
Yellow Warbler[1]	2	3	3	3	3	3	3								
Black-throated Blue Warbler										0					
Audubon's Warbler	1	2	2	2	1	2	2	1	2	1	1	3	3	1	1
Black-throated Gray Warbler[2]											3				
Townsend's Warbler										0					
Hermit Warbler		3	3		3	3				3			3		
MacGillivray's Warbler[2]	3	2	3	2	3	3	2	3	2	1	1	2	1	1	2
Wilson's Warbler[1]	3	3	3	2	2	1	1	2	2	1	1	2		3	3
Western Tanager[2]	3	2	3	3	2	3	2	3	3	3	3	3	3	3	2
Green-tailed Towhee					3	3	3	1	3	3	1	3			2
Spotted Towhee		3													
Chipping Sparrow	3	3	3	3	1	2		3					3	1	3
Brewer's Sparrow				3			3								
Savannah Sparrow				3											
Fox Sparrow[2]			3	3	3	3	2	1	2	1	1	3	3	3	1
Song Sparrow[1]	1	3		3	3	1	2		3	3	3	3	1	2	
Lincoln's Sparrow	3	3		2	3	2	3		3	3	3	3		3	
Mountain White-crowned Sparrow	3	1		1	2	3	1			1		3			
Oregon Junco[2]	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Rose-breasted Grosbeak										0					
Black-headed Grosbeak[1]	3	3		3	3			3	3				2		3
Lazuli Bunting	2		3	2		3			3		1			3	3
Red-winged Blackbird				2	3		3		2	3				2	
Brewer's Blackbird	3			1	3	3	3		3	3				3	
Brown-headed Cowbird	2	1	3	2	2	3	1	1	3	1	1	2	1	1	1
Bullock's Oriole													3		
Pine Grosbeak		3	3				1			3	3			3	
Purple Finch											0				
Cassin's Finch	3	3	3	1	1	3	3	1	3	1	1			3	1
Red Crossbill				3	3					3					3
Pine Siskin		3		3	3		3	3	3	3	3	3	3	3	3
Lesser Goldfinch							3						3	3	
American Goldfinch				0											
Evening Grosbeak		3	3	3	3	3	3		3				3	2	3

Breeding Status: Confirmed=1, Probable=2, Possible=3, Unlikely=0

[1] CalPIF Riparian focal species [2] CalPIF Coniferous Forest focal species

APPENDIX V. Parameter definitions from model selection in Program MARK.

Parameter	Definition
.	Unparameterized model
phase	Nesting phase
t	Day
year	Year
jda	Julian date of first egg
ab	Index of concealment of nest from above
be	Index of concealment of nest from below
X4	Index of lateral concealment of nest
edge	Distance from edge of foliage
htfrgrd	Height from ground
dbh	Diameter breast height of nest tree/shrub
5al20	Density of 20m conifers within 50m of nest
5al10	Density of 10m conifers within 50m of nest
5al5	Density of 5m conifers within 50m of nest
5a20	Density of 20m *Abies* trees within 50m of nest
5a10	Density of 10m *Abies* within 50m of nest
5a5	Density of 5m *Abies* within 50m of nest
5p20	Density of 20m *Pinus* trees within 50m of nest
5p10	Density of 10m *Pinus* within 50m of nest
5p5	Density of 5m *Pinus* within 50m of nest
2al20	Density of 20m conifers within 20m of nest
2al10	Density of 20m conifers within 20m of nest
2al5	Density of 20m conifers within 20m of nest
etc.	etc.
asL8	Density of <8cm dbh aspen within 11.3m of nest
as8	Density of 8-23 cm dbh aspen within 11.3m of nest
as23	Density of 23-38cm dbh aspen within 11.3m of nest
asG38	Density of >38cm dbh aspen within 11.3m of nest
con8	Density of 8-23cm dbh aspen within 11.3m of nest
con23	Density of 23-38cm dbh aspen within 11.3m of nest
trees8	Density of 8 cm trees within 11.3m of nest
etc.	etc.
shrcov	Absolute percentage of 11.3m plot covered by shrubs
forbcov	Absolute percentage of 11.3m plot covered by forbs
cancov	Canopy cover (mean of four densiometer readings)
canht	Average maximum canopy height
shras	Total number of shrub-class aspen stems within 11.3m of n
shrrib	Total number of *Ribes* stems within 11.3m of nest
shrsyro	Total number of *Symphoricarpos* stems within 11.3m of ne
shrtot	Total number of shrub stems within 11.3m of nest

APPENDIX VI. Model selection for Western Wood-Pewee nesting success in aspen habitats of the Tahoe Basin, 2003-2004 (n=51).

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(Phase+5al20)}	184.865	0	0.22949	1	3	178.846
{S(Phase+5p20)}	185.77	0.91	0.14594	0.6359	3	179.752
{S(Phase+5al10)}	186.354	1.49	0.10901	0.475	3	180.335
{S(Phase)}	187.101	2.24	0.07504	0.327	2	183.091
{S(Phase+con8)}	187.534	2.67	0.06042	0.2633	3	181.515
{S(Phase+asG38)}	188.176	3.31	0.04382	0.1909	3	182.158
{S(Phase+trees8)}	188.518	3.65	0.03694	0.161	3	182.5
{S(Phase+5a20)}	188.578	3.71	0.03584	0.1562	3	182.56
{S(Phase+canht)}	188.659	3.79	0.03442	0.15	3	182.64
{S(Phase+htfrgrd)}	188.75	3.89	0.03289	0.1433	3	182.731
{S(5al20)}	188.783	3.92	0.03236	0.141	2	184.773
{S(Phase+2al20)}	188.8	3.94	0.03208	0.1398	3	182.781
{S(Phase+5al5)}	188.897	4.03	0.03057	0.1332	3	182.878
{S(Phase+dbh)}	188.937	4.07	0.02996	0.1305	3	182.918
{S(Phase+jda)}	188.941	4.08	0.02991	0.1303	3	182.922
{S(5p20)}	189.467	4.6	0.02298	0.1001	2	185.458
{S(.) PIM}	190.577	5.71	0.01319	0.0575	1	188.574
{S(Year)}	192.464	7.6	0.00514	0.0224	2	188.455

APPENDIX VII. Model selection for Dusky Flycatcher nesting success in aspen habitats of the Tahoe Basin, 2003-2004 (n=34).

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(.) PIM}	134.984	0	0.08675	1	1	132.977
{S(trees8)}	135.296	0.31	0.0742	0.8553	2	131.276
{S(be)}	135.514	0.53	0.06653	0.7669	2	131.494
{S(Phase)}	135.905	0.92	0.05473	0.6309	2	131.885
{S(2al20)}	136.115	1.13	0.04926	0.5678	2	132.095
{S(Phase+be)}	136.176	1.19	0.04779	0.5509	3	130.136
{S(5al20)}	136.187	1.2	0.04754	0.548	2	132.166
{S(as8)}	136.305	1.32	0.04482	0.5166	2	132.284
{S(5al5)}	136.339	1.36	0.04405	0.5078	2	132.319
{S(2al5)}	136.369	1.38	0.04341	0.5004	2	132.348
{S(5al10)}	136.531	1.55	0.04001	0.4612	2	132.511
{S(asL8)}	136.532	1.55	0.04	0.4611	2	132.512
{S(2al10)}	136.547	1.56	0.0397	0.4576	2	132.527
{S(be+trees8)}	136.729	1.75	0.03624	0.4177	3	130.689
{S(Year)}	136.799	1.82	0.035	0.4034	2	132.779
{S(shrcov)}	136.833	1.85	0.03441	0.3966	2	132.813
{S(ab)}	136.912	1.93	0.03308	0.3813	2	132.891
{S(htfrgrd)}	136.97	1.99	0.03214	0.3705	2	132.949
{S(shrtot)}	136.979	2	0.03199	0.3688	2	132.959
{S(con8)}	136.981	2	0.03195	0.3683	2	132.961
{S(forbcov)}	136.995	2.01	0.03174	0.3659	2	132.975
{S(x4)}	136.997	2.01	0.0317	0.3654	2	132.977
{S(Phase+Year)}	137.642	2.66	0.02296	0.2647	3	131.602
{S(t) PIM}	184.993	50.01	0	0	35	110.469

APPENDIX VIII. Model selection for Warbling Vireo nesting success in aspen habitats of the Tahoe Basin, 2003-2004. (n=7

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(be+x4+edge+5al20}	246.631	0	0.24229	1.0000	5.0000	236.592
{S(phase+be+x4+edge+5al20}	247.293	0.66	0.17407	0.7184	6.0000	235.238
{S(be+x4+edge+5al20+htfrgrd}	247.866	1.23	0.13071	0.5395	6.0000	235.811
{S(be+x4+edge+5a20}	248.391	1.76	0.10052	0.4149	5.0000	238.352
{S(phase+be+x4+edge+5a20}	248.931	2.3	0.07672	0.3166	6.0000	236.877
{S(be+x4+5al20}	249.287	2.66	0.06422	0.2651	4.0000	241.261
{S(be+x4+edge+5al10}	249.37	2.74	0.0616	0.2542	5.0000	239.331
{S(phase+be+x4+5al20}	249.675	3.04	0.05289	0.2183	5.0000	239.636
{S(be+x4+5al20+htfrgrd}	250.445	3.81	0.03598	0.1485	5.0000	240.407
{S(be+x4+edge+2al10)}	252.41	5.78	0.01347	0.0556	5.0000	242.371
{S(be+edge+5al20}	252.979	6.35	0.01014	0.0419	4.0000	244.953
{S(be+edge+5al20+htfrgrd}	253.748	7.12	0.0069	0.0285	5.0000	243.709
{S(be+x4+edge+con)}	253.874	7.24	0.00648	0.0267	5.0000	243.836
{S(be+x4+edge)}	254.407	7.78	0.00496	0.0205	4.0000	246.381
{S(t) PIM}	255.055	8.42	0.00359	0.0148	31.000	234.912
{S(be+x4+edge+5p20}	255.241	8.61	0.00327	0.0135	5.0000	245.202
{S(be+x4+edge+2al20)}	255.39	8.76	0.00304	0.0125	5.0000	245.351
{S(be+x4+edge+2al5)}	255.912	9.28	0.00234	0.0097	5.0000	245.873
{S(be+x4+edge+2a5)}	255.939	9.31	0.00231	0.0095	5.0000	245.9
{S(be+x4+edge+5al5}	256.093	9.46	0.00214	0.0088	5.0000	246.054
{S(be+x4)}	257.082	10.45	0.0013	0.0054	3.0000	251.066
{S(phase+be)}	259.043	12.41	0.00049	0.0020	3.0000	253.028
{S(be)}	259.984	13.35	0.00031	0.0013	2.0000	255.976
{S(x4+edge+5al20}	262.777	16.15	0.00008	0.0003	4.0000	254.751
{S(x4+edge+5al20}	262.777	16.15	0.00008	0.0003	4.0000	254.751
{S(phase)}	263.929	17.3	0.00004	0.0002	2.0000	259.921
{S(.) PIM}	265.446	18.81	0.00002	0.0001	1.0000	263.444
{S(year+phase)}	265.896	19.26	0.00002	0.0001	3.0000	259.88
{S(phase+jda)}	265.914	19.28	0.00002	0.0001	3.0000	259.898
{S(g) PIM}	267.429	20.8	0.00001	0.0000	2.0000	263.421
{S(Year)}	267.429	20.8	0.00001	0.0000	2.0000	263.421
{S(year+day}	302.301	55.67	0	0.0000	32.000	236.91

APPENDIX IX. Model selection for American Robin nesting success in aspen habitats of the Tahoe Basin, 2003-2004 (n=70)

Model	AICc	Delta AICc	AICc Weight	Model Likelihood	#Par	Deviance
{S(phase+x4+as23)}	254.277	0	0.12208	1	4	246.249
{S(phase+x4)}	254.761	0.48	0.09582	0.7849	3	248.744
{S(phase+x4+as38)}	255.49	1.21	0.06654	0.5451	4	247.463
{S(phase+x4+be)}	255.806	1.53	0.05682	0.4654	4	247.779
{S(phase+x4+can)}	255.886	1.61	0.05461	0.4473	4	247.858
{S(phase+x4+as8+as23)}	255.95	1.67	0.05288	0.4332	5	245.909
{S(phase+x4+con23)}	255.979	1.7	0.05213	0.427	4	247.951
{S(phase+x4+as23+as38)}	256.068	1.79	0.04985	0.4083	5	246.026
{S(phase+x4+jda)}	256.335	2.06	0.04361	0.3572	4	248.308
{S(phase+x4+htfrgd)}	256.477	2.2	0.04064	0.3329	4	248.449
{S(phase+x4+as8)}	256.581	2.3	0.03856	0.3159	4	248.554
{S(phasc+x4+plht)}	256.616	2.34	0.03789	0.3104	4	248.589
{S(phase+x4+5al20)}	256.646	2.37	0.03734	0.3059	4	248.618
{S(phase+x4+con38)}	256.759	2.48	0.03528	0.289	4	248.732
{S(phase+x4+ab)}	256.763	2.49	0.03521	0.2884	4	248.736
{S(phase+x4+2al20)}	256.771	2.49	0.03507	0.2873	4	248.744
{S(phase+x4+be+con23)}	256.997	2.72	0.03133	0.2566	5	246.956
{S(phase+as23)}	257.199	2.92	0.02832	0.232	3	251.182
{S(phase)}	258.331	4.05	0.01608	0.1317	2	254.323
{S(phase+as38)}	258.376	4.1	0.01572	0.1288	3	252.359
{S(phase+jda)}	258.814	4.54	0.01263	0.1035	3	252.797
{S(x4)}	259.104	4.83	0.01092	0.0895	2	255.096
{S(phase+be)}	260.032	5.76	0.00687	0.0563	3	254.015
{S(phase+dbh)}	260.296	6.02	0.00602	0.0493	3	254.279
{S(x4+5al20)}	260.945	6.67	0.00435	0.0356	3	254.929
{S(as23)}	261.358	7.08	0.00354	0.029	2	257.35
{S(.) PIM}	261.753	7.48	0.00291	0.0238	1	259.75
{S(jda)}	262.418	8.14	0.00208	0.017	2	258.41
{S(g)}	262.468	8.19	0.00203	0.0166	2	258.459
{S(htfrgd)}	262.726	8.45	0.00179	0.0147	2	258.718
{S(dbh)}	263.722	9.45	0.00109	0.0089	2	259.714
{S(t) PIM}	286.532	32.26	0	0	32	221.05

APPENDIX X. Comparison of constant effort mist-netting and point count data by site, 2004.

	Logan House		Marlette Basin	
Species	Mist-netting	Point Count	Mist-netting	Point Count
Sharp-shinned Hawk	1			
Red-tailed Hawk		1		
Band-tailed Pigeon				3
Calliope Hummingbird	1	1	7	2
Rufous Hummingbird	8	3	26	8
Red-breasted Sapsucker	3	1	2	
Williamson's Sapsucker				1
Downy Woodpecker	1	1		
Hairy Woodpecker			2	3
White-headed Woodpecker			4	
Black-backed Woodpecker		1	1	1
Red-shafted Flicker			2	1
Western Wood-Pewee	12	8	1	10
Pacific-Slope Flycatcher	1			
Dusky Flycatcher	8	7	14	14
Warbling Vireo	23	17	7	31
Steller's Jay	1	1		
Clark-s Nutcracker		1		
Mountain Chickadee	8	5		4
White-breasted Nuthatch		2	2	
Red-breasted Nuthatch	3	2	1	1
Brown Creeper	2		3	2
Golden-crowned Kinglet		2		
House Wren		2		13
Townsend's Solitaire	2			
Hermit Thrush	2	1	2	5
American Robin	14	8	9	10
Orange-crowned Warbler	33		11	1
Audubon's Warbler	11	6	2	8
MacGillivray's Warbler	16	6	6	5
Wilson's Warbler	17	1	3	5
Western Tanager	6		1	1
Green-tailed Towhee	3			
Fox Sparrow	6	3	7	8
Lincoln's Sparrow	1		1	
Song Sparrow	1			1
Mountain White-crowned Sparrow			19	8
Oregon Junco	82	19	37	20
Lazuli Bunting	5			
Black-headed Grosbeak	2			4
Brown-headed Cowbird	2			9
Pine Grosbeak	1			2
Cassin's Finch	5	3	1	1
Species Richness	31	24	25	29