

DRAFT FINAL REPORT

**1997 AVIAN COMMUNITY MONITORING ALONG THE COLORADO RIVER
FROM LEES FERRY TO LAKE MEAD**

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ABSTRACT

This report documents the principal results of the 1997 program to monitor the breeding riparian avifauna along the Colorado River from Glen Canyon Dam to Lake Mead. Over two field seasons (1996-1997), 143 point count stations have been established in 63 riparian vegetation patches. During the 1997 field season 375 point counts and 154 walking surveys were conducted in 60 of these patches. In all, 72 species were recorded, of which 40 species are primarily riparian-restricted (along the Colorado River) and that are either confirmed or potential riparian breeders. The most common riparian breeders in order of abundance using point counts were Lucy's Warbler, House Finch, Bewick's Wren, Bell's Vireo, Yellow-breasted Chat and Song Sparrow. Lucy's Warbler alone accounted for 31% of all bird detections in 1997. Strong differences in temporal (trip) and spatial distributions along the river were noted for several species. Slightly more species and significantly more individuals were detected in 1997 compared with 1996. Currently, there is adequate statistical power in the program to be able to detect changes in the 15 most common riparian breeders over a five year period with 20% change per year, a power of 0.90, three surveys per year, and 125 point count stations. Habitat characterization was initiated in 1997, and most of the NHWZ habitat has been sampled and characterized by canopy structure (vertical volume) and woody riparian and wetland species composition and cover. However, until the OHWZ vegetation has also been characterized, and all patch areas re-calculated from established ground control points, no attempt is made in this report to relate the avifauna community to habitat data. Recommendations are made pertaining to the 1998-1999 monitoring program.

INTRODUCTION

This report documents the second year (1997) of avifauna monitoring along the Colorado River between Glen Canyon Dam and Lake Mead. The first year (1996) of the program was summarized in Pettersen and Spence (1997) and Spence (1997). Specific objectives of this program were to:

1. Describe the breeding bird community from Glen Canyon Dam to lower Grand Canyon and upper Lake Mead;
2. Quantify and compare point count surveys and total count walking surveys in terms of species richness, community composition, and relative species abundance;
3. Define feasible monitoring objectives based on species' abundance and sample size considerations using Type I and Type II error levels and alternative population monitoring thresholds; and
4. Make recommendations on monitoring techniques suited for long-term avian monitoring along the Colorado River.

In this report we first summarize the principal results and conclusions of the 1996 program, then discuss and analyze the 1997 data, and finally make additional recommendations relevant to the 1998-1999 avifauna program.

PREVIOUS WORK

Previous work on the Colorado River riparian avifauna is summarized in Hualapai Tribe and SWCA (1995), Felley and Sogge (1997), Pettersen and Spence (1997), Spence

(1997a), and Sogge et al. (1998). This work was conducted between 1993-1996, and included several different programs. Sogge and his co-workers contrasted a variety of different monitoring methods, and concluded that point count surveys were overall the best method for long-term monitoring. They also contrasted 5-minute and 10-minute counts, and concluded that if travel time was relatively short between stations that 5 minutes was generally adequate. Their conclusions were supported by Pettersen and Spence (1997). Spence and Pettersen monitored breeding birds along the Colorado River using a combination of point counts and walking surveys in 1996-1997. Spence (1997a) analysed the Glen Canyon program which had been using point count stations since 1992, and concluded that the program lacked adequate power to detect change in most species because of the small number of stations. He suggested that the Glen Canyon program be integrated with the Grand Canyon program. Throughout this period the Hualapai Tribe was conducting walking surveys in patches along their stretch of the river below Diamond Creek.

The Glen Canyon, Grand Canyon, and Hualapai Tribe programs were combined in 1997. Methods chosen included 5-minute, 50 meter, fixed-radius point counts and walking surveys. The results of the first year of this integrated program are presented below.

STUDY AREA

The study area is the same as defined in the earlier reports (Spence 1997a; Pettersen and Spence 1997). Patches of riparian vegetation from Glen Canyon Dam to upper Lake Mead were surveyed. The first patch is at RM -14.5L and the last patch is at RM 264.5L (RM=river mile; by convention minus going upstream from Lee's Ferry, plus below Lee's Ferry, and river Right or Left as looking downstream). In all, 63 patches have been surveyed at least once along this stretch since 1996. Located in these patches are 143 point count stations, with from 1-10 stations per patch (Figure 1). Elevations of patches range from 956 m below Glen Canyon Dam to 365 m at Lake Mead. Vegetation along this 280 mile (460 km) corridor includes both Colorado Plateau vegetation in the upper reaches to Sonoran vegetation through the Grand Canyon. The transition between these two types is gradual as species appear or drop out along the river corridor, but a distinct change in riparian vegetation occurs at RM 39 where Catclaw (*Acacia greggii*) and Mesquite (*Prosopis glandulosa*) first appear.

The river corridor was divided into four reaches as defined by patch distribution in order to analyze differences in species distributions and abundance (Table 1). These four reaches are: Glen Canyon (Rm -14.5 to RM +5.8); Marble Canyon (RM 43.1 to RM 74.4); Lower Gorge (RM 122.8 to RM 214.2), and Upper Lake Mead (Rm 243.2 to RM 264.5). The distribution of patches and point count stations is noted for each reach. Because of the considerable differences in elevation, breeding starts first in the lower stretches, generally in March, at a time when the upper reaches are still dominated by wintering birds. June is the most active month for breeding species in the Glen Canyon stretch. May is generally the most active period in the rest of the study area.

Table 1. The four reaches of the Colorado River from Glen Canyon Dam to Lake Mead defined in this study. River miles, number of patches, and number of point count stations are noted for each reach.

REACH	RIVER MILES	PATCHES	POINT COUNT STATIONS
Glen Canyon	-14.5 to 5.8	20	35
Marble Canyon	43.1 to 74.4	13	31
Lower Gorge	122.8 to 214.2	24	55
Upper Lake Mead	243.2 to 264.5	6	22

FIELD METHODS

AVIFAUNA

Three surveys were conducted along the Colorado River between March 28 and July 9 of 1997. Surveys downstream of Lee's Ferry to Diamond Creek were on March 28-April 11, May 1-14, and June 1-14. Below Diamond Creek surveys were on April 4, April 30-May 2, and June 11-13. Surveys up river of Lee's Ferry were on May 21-23, June 17-19, and July 7-9.

Fifty-meter fixed radius point count stations and walking surveys were used. The principal change made in 1997 was to use this same radius for stations above Lee's Ferry (originally 25 meters). Five-minute count lengths were used. For more information on survey methods see the attached protocols (Appendix A). In 1997 375 point count station surveys and 152 walking surveys were completed on the three trips. Bad weather prevented surveys on the April trip between RM 166.5 and RM 174.2. High Lake Mead levels prevented surveying of some point counts at the large patch at RM 264.5L. Manpower restrictions during the May trip resulted in fewer walking surveys than was anticipated.

HABITAT

On the third river trip of 1996, and on all three trips of 1997, vegetation data was collected from patches and point count station. In both years only NHWZ vegetation was sampled.

Habitat description included sampling of floristic composition and structural (canopy layer) complexity and volume. Floristic composition and prominence (dominance) were recorded in a 0.1 hectare circular plot centered on each bird point count station using a CPVAC relevé form (Rowlands 1994).

The height and vertical structure of the habitat canopy at patches was determined using the Total Vegetation Volume (TVV) method of Mills *et al.* (1991). A 7.0 meter surveyor's rod was held in a vertical position and contacts with vegetation within a 10 cm diameter cylinder around the pole were recorded for each 0.1 meter up to 7.5 meters. However, rather than simply counting contacts up to 10 per meter segment, contacts were

recorded by species in order to extract species-specific structural features. Hence, within a one meter segment more than 10 hits could be recorded depending on the complexity of the vegetation. Maximum scrub height was estimated if canopy height was greater than 7.5 meters. Prior to sampling, each patch was stratified by principal cover types; wetland, riparian scrub, and open beach/clearings. Sampling was proportional to the approximate areal extent of each type in the patch. Within cover types random samples were taken by generating a set of six random numbers, specifying three directions and three distances. After sampling a point this random procedure was repeated.

Spatial heterogeneity in patches was overcome by stratifying patches into the three principal cover types noted above. The proportion of each of these three types in the patch was then determined. Sampling using the TVV method was done randomly within each type in roughly the same proportion as each type's extent. For example, the preliminary stratification of a patch might show; 65% woody scrub, 15% marshland, and 20% open beach. If 100 TVV samples were taken, then the number of samples would be 65 in the scrub, 15 in the marshland, and 20 in the open beach.

DATA ANALYSIS

AVIFAUNA

Only those species that are considered terrestrial riparian breeding species, excluding aerial feeders (e.g., swifts, swallows) and aquatic species, are used in the data analyses. We used the decision rules developed by Sogge *et al.* (1998) to determine riparian breeding status.

Chi-squared analysis was performed on the presence or absence of species in 52 patches that were surveyed in both 1996 and 1997 with the same effort. Because row and column totals are fixed, Fishers Exact Test was used to test for independence of distributions between years.

Numbers of individuals and species detected was summed for each patch and point count station. To contrast data from patches and point counts, a "within-patch" value was calculated by summing detections across all point counts in each patch. It was assumed that, because of the 150 meter or greater spacing between stations, double counting would be minimized. Pearson's correlations were computed between unbounded, bounded and walking survey techniques for both total individuals and species detected. Both total individuals and species of the 15 most common riparian breeding species were used. For selected comparisons, linear regression was performed and the results plotted. Analysis of variance (ANOVA) was performed on differences between trips for each of the 15 most common riparian breeding species. Student's T-tests were performed on numbers of individuals and species detected per patch and counting radius (for all point count stations) between the three survey methods. Where variables were non-normal the Wilcoxon Signed-rank Test was

substituted.

Overlap ratios were computed between the point counts and walking surveys for the 15 most common breeding riparian species. The overlap ratio is calculated as:

$$\frac{\text{Number of surveys on which a particular species was detected by a given survey method}}{\text{Number of surveys on which a species was detected by either method.}}$$

Wilcoxon Signed-rank Tests were used to compare values between survey techniques.

A power analysis was performed on the data. The program MONITOR was used for the analyses (Gibbs 1995). Because the method requires non-zero means, the value of 0.001 was substituted where point count means and standard deviations were 0.

Power is defined as:

$$\text{Power} = 1 - \beta$$

where β is the probability of making a Type II error (accepting a false null hypothesis). Power indicates how likely it is to detect a change when it is in fact occurring. Power levels are generally set at 80% or above. A power of 80% indicates that, on average, 80% of the time a change that is actually occurring will be detected. The inverse is that 20% of the time a change that is actually occurring will not be detected. The Type I error (α or rejection of a true null hypothesis) was set at 0.05 for the simulations. The analysis uses a Monte Carlo simulation to generate simulated sets of count data, which are then compared with the actual inputs. Replications were set at 250. Trend projections were set at 5%, 10%, 15%, 20% and 25% (change in point count detections between years) for a five year time-frame. A two-tailed test was used, testing the null hypothesis that the trend does not differ from zero. For each species, the number of point count stations needed to detect a 10% change using a two-tailed test was also determined.

HABITAT

Mean TVV values were computed by one-meter segments for each patch. An overall mean TVV value was also calculated for each patch. TVV data was compared among patches using TWINSpan and CLUSTER ANALYSIS. The utility of groupings produced by TWINSpan and CLUSTER ANALYSIS was tested by the non-directed classificatory multi-response permutation procedure (MRPP). The program PCORD 2.0 was used (McCune and Mefford 1995).

To determine adequacy of sampling by the TVV method, a mean dissimilarity measure was computed for each patch. Mean dissimilarity was determined by calculating the mean cumulative dissimilarity among TVV samples from 1-N, where N was the number of samples per patch. The number of samples at which mean dissimilarity reached 10% and 5% was determined. The dissimilarity measure used was the Euclidean Distance metric. Computations were performed by the species-area curve algorithm in

PCORD 2.0.

AVIFAUNA - HABITAT COMPARISONS

Habitat sampling in 1997 included TVV descriptions of the NHWZ vegetation in 41 patches. Some additional NHWZ vegetation work needs to be completed in 1998. Many patches have significant amounts of OHWZ vegetation, which was not sampled in 1997. Sampling of this vegetation zone will commence in 1998. Because complete patch habitat sampling is not finished, no analyses were conducted to compare bird populations and habitat in this report.

RESULTS

SPECIES RICHNESS

We detected 72 species on 375 point counts and 54 species on 152 walking surveys in 1997. Of these species 40 are considered either riparian breeders, species that are more common as breeders in riparian vegetation along the Colorado River than in adjacent upland habitats, or species that are otherwise restricted to riparian zones. Several of these species were not seen in 1996, including Cassin's and Western Kingbirds, American Crow, Black-headed Grosbeak, and Common Grackle. Many of these species were not analyzed in this report because of relatively few detections (<40 in 1997), or in the case of aerial species because of difficulties in counting. These included Mallard, Spotted Sandpiper, Ladder-backed Woodpecker, Costa's Hummingbird, Black Phoebe, Cassin's Kingbird, Western Kingbird, Brown-crested Flycatcher, Willow Flycatcher, American Crow, Cliff Swallow, Northern Rough-winged Swallow, Violet-green Swallow, Bushtit, Northern Mockingbird, Phainopepla, Lazuli Bunting, Indigo Bunting, Black-headed Grosbeak, Summer Tanager, Hooded Oriole, Common Grackle, Great-tailed Grackle, and Red-winged Blackbird. Bullock's Oriole was examined for some comparisons, although it was considered too rare for the power analyses (49 detections in 1997). All walking survey and point count data is available in MICROSOFT EXCEL files.

RANK BIRD ABUNDANCE

The rank abundance of the 15 most common riparian breeding species is listed in Table 2, along with 1996 data from the Grand Canyon and Glen Canyon programs. Comparison of the Glen Canyon and Grand Canyon programs for 1996 showed that House Finch is the most common species above Lee's Ferry, where Lucy's Warbler is relatively rare. Other differences occur between the two canyon reaches in species ranking. These differences were also seen in the 1997 data. Principal differences are that Bullock's Oriole, Blue Grosbeak, and Mourning Dove are all common in the Glen Canyon stretch and rare below Lee's Ferry. Bell's Vireo is much more common below Lee's Ferry, and especially abundant below National Canyon (RM 166.5).

TOTAL BIRD ABUNDANCE

Table 3 summarizes the abundance of the 15 most common riparian breeding species for unbounded point counts, bounded point counts, and walking surveys. Lucy's Warbler was the most abundant species in 1997, with 1,111 individuals detected on unbounded point counts, accounting for 43% of all detections of the 15 most common riparian species (2,561; 31% of all bird detections). Next in abundance were House Finch, Bewick's Wren, and Bell's Vireo. These four species accounted for 78% of riparian species detections. The relatively low numbers for walking surveys reflects the fact that fewer walking surveys were done in patches in 1997 compared to point counts. On trip two several patches were not surveyed by the walking method.

Table 2. Ranked abundance for the 15 most common riparian breeding species along the Colorado River for the 1996 and 1997 seasons. Comparisons are based on unbounded point count data.

1997 Combined Program	1996 Grand Canyon	1996 Glen Canyon
Lucy's Warbler	Lucy's Warbler	House Finch
House Finch	Bell's Vireo	Bewick's Wren
Bewick's Wren	Bewick's Wren	Ash-throated Flycatcher
Bell's Vireo	Song Sparrow	Yellow-breasted Chat
Yellow-breasted Chat	Yellow-breasted Chat	Blue Grosbeak
Song Sparrow	Blue-gray Gnatcatcher	Mourning Dove
Black-chinned Hummingbird	Common Yellowthroat	Brown-headed Cowbird
Blue-gray Gnatcatcher	House Finch	Black-chinned Hummingbird
Ash-throated Flycatcher	Yellow Warbler	Bullock's Oriole
Common Yellowthroat	Ash-throated Flycatcher	Blue-gray Gnatcatcher
Mourning Dove	Lesser Goldfinch	Bushtit
Yellow Warbler	Black-chinned Hummingbird	Lucy's Warbler
Blue Grosbeak	Brown-headed Cowbird	Yellow Warbler
Lesser Goldfinch	Costa's Hummingbird	Common Yellowthroat
Brown-headed Cowbird	Mourning Dove	Lazuli Bunting

For the 15 most common riparian breeding species, walking surveys detected significantly more individuals ($T=5.82$, $p<0.0001$) and species ($T=5.18$, $p<0.0001$) in 1997 than bounded point counts. Unbounded point counts also detected significantly more individuals ($T=7.44$, $p<0.0001$) and species ($T=9.32$, $p<0.0001$) than bounded point counts. There were no statistically significant differences between walking surveys and unbounded point counts for individuals ($T=0.63$, $p=0.534$) or species ($T=1.66$, $p=0.104$).

Using only trip one and trip three data, Pearson's correlations between unbounded and bounded point count data were relatively strong for both species richness ($R=0.87$) and individuals ($R=0.92$). Comparisons between point counts and walking surveys were generally somewhat weaker (species; unbounded counts-walking surveys $R=0.78$, bounded point counts-walking surveys $R=0.68$; individuals: unbounded point counts-walking surveys $R=0.89$, bounded point counts-walking surveys $R=0.83$). Regression

analysis revealed a strong relationship between unbounded point count and walking surveys for individuals (Figure 2; $r^2=0.78$, $p<0.0001$). Note the tendency in Figure 2 for comparisons involving larger patches (more total detections) to show less correspondence to one another (greater scatter to the right of the figure). A weaker but still significant relationship existed between species richness for unbounded point counts and walking surveys ($r^2=0.61$; $p<0.0001$).

Table 3. Total detections for the 15 most common riparian breeding species along the Colorado River. Individuals detected in 1997 for each species is listed for the three survey methods (n=375 point counts and 152 walking surveys).

SPECIES	UNBOUNDED POINT COUNTS	50 METER POINT COUNTS	WALKING SURVEYS
Lucy's Warbler	1111	827	563
House Finch	310	172	300
Bewick's Wren	300	170	154
Bell's Vireo	286	191	158
Yellow-breasted Chat	208	86	100
Song Sparrow	177	92	112
Black-chinned Hummingbird	171	160	76
Blue-gray Gnatcatcher	162	153	167
Ash-throated Flycatcher	146	60	81
Common Yellowthroat	101	73	46
Mourning Dove	100	42	101
Yellow Warbler	93	73	40
Blue Grosbeak	74	36	42
Lesser Goldfinch	58	53	38
Brown-headed Cowbird	56	49	62

Some species were more common in certain stretches of the river corridor than others in 1997 (Table 4). Lucy's Warbler was relatively rare above Lee's Ferry, while House Finch was abundant. The majority of Blue Grosbeak and Bullock's Oriole detections were also in the Glen Canyon stretch. The majority of the Song Sparrow detections were below Diamond Creek. For several species there was a gradual gradient of increasing detection rates down river from Glen Canyon to upper Lake Mead.

Differences between trips in detection rates occurred for several species (Table 5). For Ash-throated Flycatcher, Yellow Warbler, and Yellow-breasted Chat significantly fewer individuals were detected on trip 1. For Blue Grosbeak, fewer individuals occurred on trip 2, while for Black-chinned Hummingbird fewer individuals were detected on trip 3.

SPECIES DETECTIBILITY

Detectability rates are listed for the 15 most common species detected in 1997 (Table 6). Lucy's Warbler was the most reliably detected species by any method, and Mourning Dove the least reliably detected. Unbounded point counts were least reliable at detecting Mourning Dove and Yellow Warbler. Bounded point counts were least reliable

Table 4. Abundance of the 16 most common riparian breeding species by reach using the unbounded point count data. The number of individuals of each species per reach is divided by the number of point counts conducted in that reach. River miles are listed for each reach.

SPECIES	Reach 1 (-15- 6)	Reach 2 (43-75)	Reach 3 (166-214)	Reach 4 (243-265)
Lucy's Warbler	0.33	3.11	3.50	5.76
Bell's Vireo	0.03	0.10	1.22	2.04
Bewick's Wren	0.57	1.24	0.35	1.67
House Finch	1.60	0.61	0.52	0.35
Ash-throated Flycatcher	0.62	0.34	0.22	0.35
Black-chinned Hummingbird	0.22	0.57	0.60	0.25
Yellow-breasted Chat	0.46	0.29	0.40	1.65
Song Sparrow	-0-	-0-	0.32	2.61
Blue-gray Gnatcatcher	0.15	0.26	0.42	1.24
Common Yellowthroat	0.11	0.16	0.19	0.98
Mourning Dove	0.75	0.10	0.05	0.16
Yellow Warbler	0.05	0.11	0.25	0.84
Blue Grosbeak	0.54	0.15	0.04	-0-
Lesser Goldfinch	-0-	0.01	0.32	0.23
Brown-headed Cowbird	0.33	0.02	0.01	0.37
Bullock's Oriole	0.26	-0-	0.16	-0-

Table 5. Abundance of the 16 most common riparian breeding species by trip using the unbounded point count data. The number of individuals of each species per trip is divided by the number of point counts conducted on each trip. For the highlighted species, an ANOVA comparing trips revealed significant differences between trips at the $\alpha=0.05$ level. The trip that was significantly different is highlighted and indicated by an asterisk (*).

SPECIES	Trip 1	Trip 2	Trip 3
Lucy's Warbler	2.77	2.29	3.69
Bell's Vireo	0.53	0.76	0.94
Bewick's Wren	1.02	0.63	0.75
House Finch	0.84	0.55	1.06
Ash-throated Flycatcher	0.17*	0.44	0.52
Black-chinned Hummingbird	0.56	0.56	0.24*
Yellow-breasted Chat	0.19*	0.61	0.80
Song Sparrow	0.63	0.36	0.42
Blue-gray Gnatcatcher	0.21	0.53	0.52
Common Yellowthroat	0.10	0.27	0.40
Mourning Dove	0.22	0.32	0.24
Yellow Warbler	0.03*	0.36	0.32
Blue Grosbeak	0.26	0.06*	0.27
Lesser Goldfinch	0.20	0.21	0.05
Brown-headed Cowbird	0.05	0.14	0.24
Bullock's Oriole	0.14	0.17	0.08

Table 6. Comparisons of the detectability of 15 most common riparian breeding species by point counts and walking surveys. Overlap ratios are the number of surveys on which a species is detected by a given method divided by the number of surveys on which a species was detected by any method.

SPECIES	WALKING SURVEYS	50 M POINT COUNTS	UNBOUNDED POINT COUNTS
Lucy's Warbler	1.00	0.98	0.98
Bell's Vireo	0.89	1.00	0.96
Bewick's Wren	0.90	0.87	1.00
House Finch	0.82	0.63	0.91
Ash-throated Flycatcher	0.74	0.54	0.89
Black-chinned Hummingbird	0.65	1.00	0.94
Yellow-breasted Chat	0.80	0.70	0.90
Song Sparrow	0.78	0.52	0.70
Blue-gray Gnatcatcher	0.85	0.83	0.83
Common Yellowthroat	0.58	0.61	0.81
Mourning Dove	0.67	0.33	0.73
Yellow Warbler	0.64	0.79	0.79
Blue Grosbeak	0.76	0.72	0.88
Lesser Goldfinch	0.70	0.80	0.80
Brown-headed Cowbird	0.67	0.76	0.90
MEAN RATIO (N=15)	0.77	0.74	0.86

Table 7. Fishers Exact Test of the relationship between the 1996 and 1997 distributions of the 16 most common riparian breeding species among 52 patches along the Colorado River.

SPECIES	FISHERS EXACT TEST PROBABILITY	TREND	FISHERS 1-TAILED TEST PROBABILITY
Lucy's Warbler	0.112	96>97	0.056
Bell's Vireo	1.000	96=97	-
Bewick's Wren	0.835	96=97	-
House Finch	0.213	97>96	0.106
Ash-throated Flycatcher	0.168	97>96	0.084
Black-chinned Hummingbird	0.000	97>>96	<0.0001
Yellow-breasted Chat	1.000	96=97	-
Song Sparrow	0.432	96>97	0.216
Blue-gray Gnatcatcher	0.804	96=97	-
Common Yellowthroat	0.556	96=97	-
Mourning Dove	0.164	97>96	0.082
Yellow Warbler	0.695	96=97	-
Blue Grosbeak	0.313	97>96	0.157
Lesser Goldfinch	1.000	96=97	-
Brown-headed Cowbird	1.000	96=97	-
Bullock's Oriole	0.029	97>>96	0.015

at detecting Mourning Dove, Song Sparrow, Ash-throated Flycatcher, and Common Yellowthroat. Walking surveys were least reliable at detecting Common Yellowthroat, Yellow Warbler, and Black-chinned Hummingbird. Overlap ratios were significantly higher for unbounded point counts compared with walking surveys (two-tailed Wilcoxon Signed-rank Test, $p=0.0087$). Walking surveys had significantly higher overlap ratios than bounded point count ratios ($p=0.0034$), while there was no difference between point count methods ($p=0.629$).

POPULATION TRENDS

Goodness of Fit Tests

We tested the distributions of the 16 most common riparian species among 52 patches that were surveyed in both 1996 and 1997 using χ^2 analysis. Overall, most species' distributions were either the same between years, or were somewhat larger in 1997 (Table 7). Only two species, Lucy's Warbler and Song Sparrow, were found at more patches in 1996 than in 1997. Two species, Bullock's Oriole and Black-chinned Hummingbird, showed significant increases in distribution in 1997 over 1996 (Fisher's Exact two-tailed: $p<0.001$ for Black-chinned Hummingbird; $p=0.029$ for Bullock's Oriole).

Comparisons of species richness and total detections between years

Because of different levels of effort between years and different protocols in the Glen Canyon stretch, comparisons between years were limited to 20 patches below Lee's Ferry for unbounded point count data. Mean species richness was not significantly different between years although there was a tendency for greater species richness at point counts in 1997 (Wilcoxon Signed-Rank test, $p=0.073$ for a two-tailed test). Number of individuals detected for unbounded point counts increased significantly from 1996 to 1997 (Wilcoxon signed-rank test, $p=0.0026$ for a two-tailed test).

Power Analysis

Table 8 summarizes the results of power analyses done on the 15 most common riparian species. The simulations were set for 5-25% changes in detection rates over a 5 year run. Because of relatively few detections and high variance, several species failed the tests for 113 point count stations surveyed on all three trips. In particular, declines less than 20% would not be detectable for Yellow Warbler, Blue Grosbeak, Lesser Goldfinch, and Brown-headed Cowbird. We then ran a second set of simulations to determine how many point count stations would be needed to detect a 10% change at a power of 0.90. The results (Table 9) show that up to 165-170 stations would need to be monitored to detect changes in all 15 of the most common riparian breeding species. On the other hand, common species such as Lucy's Warbler and Bell's Vireo could be effectively monitored with relatively few stations. All species could be effectively monitored at changes in detection rates of 20% per year with 125 point count stations.

Table 8. Results of a power analysis for the 15 most common riparian species. The power is shown for runs of 5 years, 3 surveys per year, 113 point count stations, and 250 replications for the Monte Carlo simulation. The percentage is the change in detection rates per year over the 5-year run. Significance was set at $\alpha=0.05$ for a two-tailed test. Species with an asterisk were analyzed using unbounded data, the rest with bounded data.

	+5%	+10%	+15%	+20%	+25%	-5%	-10%	-15%	-20%	-25%
LUWA	0.94	1.00	1.00	1.00	1.00	0.84	1.00	1.00	1.00	1.00
BEVI	0.76	1.00	1.00	1.00	1.00	0.59	0.98	1.00	1.00	1.00
BEWR	0.63	0.99	1.00	1.00	1.00	0.47	0.92	1.00	1.00	1.00
HOFI*	0.71	1.00	1.00	1.00	1.00	0.48	0.95	1.00	1.00	1.00
ATFL*	0.38	0.95	1.00	1.00	1.00	0.30	0.70	0.92	0.97	0.98
BCHU	0.57	1.00	1.00	1.00	1.00	0.45	0.91	0.99	1.00	1.00
YBCH*	0.44	1.00	1.00	1.00	1.00	0.34	0.86	0.97	1.00	1.00
SOSP*	0.77	1.00	1.00	1.00	1.00	0.56	0.93	1.00	1.00	1.00
BGGN	0.61	0.99	1.00	1.00	1.00	0.39	0.82	0.97	1.00	1.00
COYE*	0.38	0.94	1.00	1.00	1.00	0.30	0.63	0.88	0.94	0.99
MODO*	0.32	0.92	1.00	1.00	1.00	0.25	0.58	0.80	0.96	0.98
YEWA	0.12	0.50	0.89	1.00	1.00	0.09	0.20	0.34	0.55	0.65
BLGR*	0.23	0.75	0.99	1.00	1.00	0.18	0.40	0.69	0.83	0.87
LEGO	0.15	0.54	0.93	1.00	1.00	0.13	0.35	0.40	0.67	0.72
BHCO*	0.20	0.70	0.98	1.00	1.00	0.15	0.39	0.62	0.77	0.86

Table 9. Power analysis results for the 15 most common riparian species determining the number of point count stations needed (N) to detect a 10% change at a power of 0.90 for 5 years, 3 surveys per year, and $\alpha=0.05$ for a two-tailed test.

Species	LUWA	BEVI	BEWR	HOFI	ATFL
N=	20	48	100	100	140
Species	BCHU	YBCH	SOSP	BGGN	COYE
N=	110	125	110	125	140
Species	MODO	YEWA	BLGR	LEGO	BHCO
N=	145	150	150	170	165

HABITAT ANALYSIS

1. Relevé Classification

The results of a TWINSpan analysis of 106 relevés sampled in 1996 and 1997 is summarized in Table 10. The TWINSpan produced eight groups of relevés. The classification in Table 10 is derived from the SRFR classification (Spence *et al.* 1995) as modified by Spence (1997b). The series dominants are listed to the left, and floristic associations, defined by unique combinations of associated species, are listed to the right. We do not make any attempts here to number the associations or classify them using the vegetation classification SRFR 2.0. The principal distinction is between sites dominated by Tamarisk (*Tamarix chinensis*) and those dominated by Mesquite (*Prosopis glandulosa*). Some relevés had varying mixtures of both species, and could

not be easily classified into either group. In a few cases Arrowweed (*Tessaria sericea*) or Cattail (*Typha domingensis*) was the dominant. One outlier, R194.0L-3, was not included in the TWINSPAN, as it had a unique assemblage of marsh species dominated by Bulrush (*Scirpus acutus*).

Although we noted some floristic and dominance distinctions along the river corridor, generally the NHWZ vegetation was the same within a series throughout. Hence Tamarisk-dominated vegetation from Lee's Ferry to Diamond Creek was essentially uniform, with varying amounts of subdominants in different geomorphic settings and distances from the river. Mesquite sites showed some variation, with Waterweed appearing, and Mesquite becoming much denser, below ca. RM 190.

2. TVV Sampling

Summary TVV data is listed in Appendix D. In general TVV values were highest near the ground, and decreased sharply upwards. Mean TVV was $1.34 (\pm 0.35)$, and varied from a low of 0.47 to a high of 2.30. The distribution of TVV values among the 41 patches was normally distributed (Figure 3; Wilk-Shapiro Statistic = 0.9803). Most sites could be characterized as low scrub to ca. 3 m with a variable herbaceous understory, and occasional clumps of taller vegetation, mostly Tamarisk or Gooddings Willow (*Salix gooddingii*). Outlier analysis indicated that only one patch, Granite Park (209.0L), was distinctly different in structure compared with the other patches. This patch consisted primarily of open low vegetation with an abundance of bare sand and rock. Only a few small patches of woody scrub existed, and very little wet river-margin vegetation or marsh.

Classification of the structural data using CLUSTER ANALYSIS revealed two groups. The first group was characterized by a relatively tall and dense canopy with a relatively open understory (T01-T12). The second group was the opposite, with a relatively short and open canopy, with dense herbaceous lower layers (T01-T12). Typical structural profiles for four patches are shown in Figure 4.

The presence of each principal species at each sampling point (recorded as a percent of total points per patch) is listed in Appendix D and summarized in Table 11. Tamarisk was the most commonly encountered woody species overall (40% of all samples), followed in order by Arrowweed (19%), Coyote Willow (*Salix exigua*, 13%), Waterweed (7%), Mesquite (7%), Emory Seepwillow (*Baccharis emoryi*, 6%), Willow-leaved Seepwillow (*Baccharis salicifolia*, 3%), and Gooddings Willow (1%). Wetland species or groups were few, and none were as common as most of the woody species.

Classification of the patches by the 11 principal species using TWINSPAN and CLUSTER ANALYSIS revealed similar structure, but the TWINSPAN results were better defined. Using TWINSPAN, the patches fell into five groups, characterized by different combinations of species (Table 12). Important defining species included Reedgrass (*Phragmites australis*), Arrowweed, marsh species, and Waterweed (*Baccharis*

Table 10. Eight principal series defined by the dominant species in NHWZ riparian vegetation associated with 106 point count stations.

SERIES	FLORISTIC ASSOCIATIONS
1. <i>Acacia greggii</i>	1a. <i>Prosopis glandulosa</i> - <i>Baccharis sarathroides</i>
2. <i>Prosopis glandulosa</i>	2a. <i>Bromus rubens</i>
	2b. <i>Tamarix chinensis</i> - <i>Tessaria sericea</i>
3. <i>Tessaria sericea</i>	3a. <i>Tamarix chinensis</i> - <i>Bromus rubens</i>
4. <i>Tamarix chinensis</i> - <i>Salix exigua</i>	4a. <i>Equisetum</i> X <i>ferrissii</i>
	4b. <i>Tessaria sericea</i>
5. <i>Tamarix chinensis</i>	5a. <i>Baccharis emoryi</i>
	5b. <i>Bromus rubens</i> - <i>B. tectorum</i>
	5c. <i>Prosopis glandulosa</i>
	5d. <i>Salix exigua</i>
	5e. <i>Tessaria sericea</i>
6. <i>Typha domingensis</i>	None
7. <i>Scirpus acutus</i>	None
8. <i>Phragmites australis</i>	None

Table 11. Summary of TVV values recorded as number of samples recording each of 11 species or groups among 41 patches of NHWZ vegetation along the Colorado River.

SPECIES	NUMBER OF NHWZ PATCHES FOUND AT	PERCENT OF TOTAL TVV SAMPLES
<i>Baccharis emoryi</i>	26	5.7
<i>B. salicifolia</i>	18	2.6
<i>B. sarathroides</i>	21	7.3
Marsh species	13	1.8
<i>Phragmites australis</i>	17	3.7
<i>Prosopis glandulosa</i>	21	6.9
<i>Salix exigua</i>	30	13.1
<i>S. goodingii</i>	3	0.6
<i>Tamarix chinensis</i>	40	40.3
<i>Tessaria sericea</i>	34	19.3

sarathroides). An MRPP analysis indicated that the patches were readily distinguished by this *a priori* grouping ($T=-11.2$, $\delta_{\text{obs}}=34.97$, $\delta_{\text{exp}}=43.47$, $p<<0.00001$). Group A defined patches in the lower river corridor with extensive adjacent OHWZ vegetation. Group B consisted of patches with extensive NHWZ riparian scrub, often in wetter or lower sites, lacking stands of Arrowweed. Group C comprised patches with extensive wet river margin and return channels dominated by marsh species. Group D included patches dominated by drier mid-elevation stands of Tamarisk and Arrowweed. Group E comprised patches with extensive river margin stands of Reedgrass and Tamarisk.

We calculated dissimilarity measures to determine adequacy of sampling using the TVV method in NHWZ patches. Three patches were selected for analysis, a small patch

(200.5R, N=25), medium-sized patch (1.0R, N=41), and large patch (196.0R, N=100). In addition, a highly variable patch, 194.0L (N=31) was also used. Results are shown in Table 13. For patch 200.5R, 13 samples were adequate to reach mean dissimilarity of <10%, and 20 samples for $\leq 5\%$. For the medium-sized patch 1.0R, 19 samples were needed to reach mean dissimilarity of $\leq 10\%$, and 32 samples for $\leq 5\%$ (Figure 5). For the much larger 196.0R patch, 26 samples were adequate to reach a level of $\leq 10\%$, and 62 samples for $\leq 5\%$. The variable patch (194.0L) showed similar results. As can be seen from Table 13, we sampled all patches at higher intensities than strictly needed. The results suggest that sampling intensity was adequate for all patches along the river, as the four patches were over-sampled by 20-38% at mean dissimilarity of $\leq 5\%$.

Table 12. TWINSpan grouping of NHWZ patches along the Colorado River using percent of TVV samples that recorded each of 11 species or groups. A + sign indicates the group is defined by the presence of the indicator species, and a – sign the group is defined by an absence of the indicator species.

CLUSTER	DEFINING SPECIES	DOMINANT SPECIES
A	+Baccharis sarathroides	B. sarathroides Tamarix chinensis Prosopis glandulosa
B	-Tessaria sericea	Salix exigua Tamarix chinensis
C	+Phragmites australis +Marsh species	Tamarix chinensis Tessaria sericea Salix exigua
D	-Phragmites australis -Marsh species	Tamarix chinensis Tessaria sericea
E	+Phragmites australis	Tamarix chinensis Phragmites australis

Table 13. Sample size needed to reduce Euclidean Dissimilarity among TVV samples to less than 10% and 5% for four riparian patches of NHWZ vegetation.

Patch	Actual Sample Size	Sample Size = (at Mean $D_E = 10\%$)	Sample Size = (at Mean $D_E = 5\%$)
1.0R	41	19	32
194.0L	31	11	22
196.0R	100	26	62
200.5R	25	13	20

DISCUSSION

Pettersen and Spence (1997) made several recommendations based on the results of the 1996 field season. First, ten-minute point counts detected significantly more species and individuals than five-minute counts. However, there are trade-offs between length of time and number of stations that can be monitored, and the power results suggested that more stations were needed. Because of this, and logistics constraints,

we decided to continue to use five-minute point counts, and to increase the number of stations along the river corridor. Felley and Sogge (1997) also reached this conclusion unless logistics and time were not limiting. A second recommendation was that both total number of detections and male detections could be used as indices of abundance, although in general there was not enough power to monitor males-only for many species. Both point counts and walking surveys were shown to be effective in monitoring different types of data, and the combination of the two methods was better than any single method. Another recommendation was that habitat sampling be initiated in order to link changes in the riparian avifauna and habitat resulting from dam operations. Finally, they recommended that the Glen Canyon and Grand Canyon programs be combined, and use the same methodology.

This report summarizes the basic results of the 1997 program. This is the first time that the same methods of monitoring have been used throughout the river corridor from Glen Canyon Dam to Lake Mead. We continued to use both five-minute point counts and walking surveys. Habitat sampling was initiated on the third trip of 1996, and has been ongoing since.

There were some problems in the 1997 field season. First, bad weather on the first trip in April prevented us from surveying five patches between RM 166 and RM 174. Manpower limitations prevented completion of most of the walking surveys during the second (May) trip. However, almost all point count stations along the river corridor were visited on trips two and three (May and June). High Lake Mead levels in 1997 meant that several point count stations at the large patch at RM 264.5L could not be monitored. Despite these problems, we completed 87% of the total possible point count stations and 84% of the total possible walking surveys during 1997. Below we discuss some of the major results of the 1997 field season, and then make recommendations for future monitoring.

AVIFAUNA ABUNDANCE AND SPECIES RICHNESS

As in 1996 Lucy's Warbler was the most common species detected along the Colorado River in 1997. This species accounted for 31% of all bird detections. In 1996 the next three most commonly detected species below Lee's Ferry were Bell's Vireo, Bewick's Wren, and Song Sparrow. However, with the integration of the Grand and Glen Canyon programs in 1997, Song Sparrow dropped to sixth place, and House Finch became the second-ranked species along the river, followed by Bewick's Wren and Bell's Vireo. Overall more riparian species were found in 1997 (40 species) than in 1996 (35). This was reflected in the slightly higher species richness at point counts in 1997 compared with 1996. The 15 most common riparian breeding species accounted for 93% of all detections of riparian species.

Total bird abundance was significantly higher in 1997 compared with 1996. There are two possible explanations for this. First, the severe drought conditions which prevailed during the 1995/96 winter may have depressed breeding bird activity. The second

possible explanation is that different observers were used in the two years. Two species showed especially significant increases in numbers from 1996 to 1997, Black-chinned Hummingbird and Bullock's Oriole. As these two include both a quiet hard-to-detect species and a loud easily detected species, it is likely that factors other than observer variation are involved in the differences in abundance between years. However, in order to determine which is more likely, an ANOVA with observer and year as factors needs to be done. This analysis will be done after the third year of data collection (1998).

Survey methods showed similar results to the 1996 program. Unbounded point counts and walking surveys detected significantly more species and individuals than bounded point counts, while there were no significant difference between walking surveys and unbounded point counts. Correlations between walking surveys and unbounded point counts were fairly high for both total detections (0.89) and species (0.78). However, these relationships are weaker than those in 1996 for the Grand Canyon program (Pettersen and Spence 1997). We feel that this reflects primarily the turnover in walking surveyors among trips.

SPECIES DISTRIBUTIONS ALONG THE RIVER CORRIDOR

Of the 16 most common riparian breeding species, only two showed significant changes in distribution (presence/absence) among patches between 1996 and 1997. Both Black-chinned Hummingbird and Bullock's Oriole showed significant increases in distribution in 1997. Two species, Lucy's Warbler and Song Sparrow, showed minor non-significant declines in distribution in 1997. Most of the remaining species' distributions either did not change between years or showed non-significant increases in 1997. This method of tracking species distribution appears to be useful at a large scale (entire river corridor), and in combination with patch-specific abundance data may provide a useful tool for modeling breeding success and prioritizing patches for species-specific monitoring purposes.

Significant differences in detection rates using unbounded point count data occurred between trips and among reaches along the Colorado River. For example, House Finch is the most abundant species above Lee's Ferry, while it was ranked eighth between Lee's Ferry and Lake Mead in 1996. Song Sparrow is abundant on Lake Mead, but relatively uncommon elsewhere on the river, and is absent above Phantom Ranch (RM 88) as a breeder. Blue Grosbeak is most common above Lee's Ferry. Two species, Brown-headed Cowbird and Bullock's Oriole, display unusual distribution patterns. Five species showed significant differences between trips, as would be expected with individual species breeding phenology patterns. Black-chinned Hummingbird detections dropped dramatically by June-July, since May is peak breeding (Brown 1992).

The Brown-headed Cowbird is found almost entirely between Lee's Ferry and Glen Canyon Dam, or below Diamond Creek on Lake Mead. It is very rare between Lee's Ferry and Diamond Creek. Its abundance in Glen Canyon is most likely the result of the

proximity of Page with its golf courses, livestock grazing, and stock pens. Reasons for its abundance on upper Lake Mead are not known.

Even more unusual is the distribution of Bullock's Oriole. This species is common in the Glen Canyon reach, disappears below Lee's Ferry in the Marble Canyon reach, and only re-appears again below RM 166. It is essentially absent in the upper Lake Mead reach, despite an abundance of tall riparian trees. When the habitat program has been completed, we may be able to determine if the birds' distribution is related to variables associated with particular patches common in those reaches where it is found.

POWER OF THE MONITORING PROGRAM

The statistical power of the Colorado River avifauna monitoring program increased considerably in 1997, with the addition of more point count stations as well as the overall increase in abundance of many species. In 1996, 73 stations were monitored on all three trips, compared with 113 in 1997. With relatively stringent parameters, including 10% change per year for five years, power of 0.90, and two-tailed tests, the 1997 program (N=113) can detect change in six species; Lucy's Warbler, House Finch, Bell's Vireo, Bewick's Wren, Black-chinned Hummingbird, and Song Sparrow. If the power is relaxed to 0.80, 10% changes can be detected in an additional two species, Yellow-breasted Chat and Blue-gray Gnatcatcher. Most problems in the monitoring program are associated with declines rather than increases (see discussion of this in Gibbs 1995). Currently, even large declines (e.g., 25% per year) in Lesser Goldfinch and Yellow Warbler cannot be effectively monitored at reasonable power (0.80). However, both these species can be monitored if either a one-tailed test is substituted for the two-tailed test, or the number of point count stations is increased to 125.

The power program was also used to determine the number of point count stations that would be needed order to detect 10% change in all 15 common riparian breeders. The results showed that the number of stations varied from 20-170 using the 1997 data, depending on species. Rarer species with relatively high variances among counts are more difficult to adequately monitor, compared to abundant species like Lucy's Warbler or Bell's Vireo. Currently, there are 143 point count stations between Glen Canyon Dam and Lake Mead. However, most of the stations below Diamond Creek have been under water since late 1997, and currently cannot be monitored. Above Diamond Creek there are 121 stations, which is only adequate (based on 1997 data) for eight of the 15 most common species (refer to Table 9). However, as noted above (p. 12), all species can be monitored with adequate power at 20% change per year and 125 stations using the current program design.

HABITAT

The vegetation directly around and within 17 meters of most point count stations (85%) consisted primarily of a mixture of Tamarisk and Coyote Willow. Very few stations were near areas of marsh or other wetland species. A majority of the stations were also in

the middle of the NHWZ at most patches, or in some cases along the ecotone between the NHWZ and OHWZ. A few of these ecotonal stations were dominated by the OHWZ Catclaw and Mesquite. Based on the releve data, the only significant trends downriver were the appearance of Waterweed and the increase in abundance of Mesquite and Catclaw in the NHWZ below RM166. Most stations are above the 45,000 cfs stage, and were not directly affected by the 1996 controlled flood.

The Total Vegetation Volume (TVV) method showed that there was a continuum from very dense stands of tall riparian scrub to very open stands, often with dense low shrub and herbaceous layers (<2 meters). Clustering by TWINSpan and CLUSTER ANALYSIS showed a weak distinction between these two extremes. Mean TVV volumes varied from very low open sparse vegetation (e.g., 0.47 at RM 209L) to relatively tall dense riparian scrub (e.g., 2.30 at RM 214.0L). Mean cumulative dissimilarity values using Euclidean Distance showed that mean TVV tended to stabilize at <5% difference overall after a certain number of TVV samples were taken. The number of samples varied from as few as 10 in some small patches to 60 or more in large patches. All patches examined were adequately sampled, and most were over-sampled by at least 20% or more.

Overall, Tamarisk was the most commonly encountered species using the TVV method. Other common species included Coyote Willow and Arrowweed. The patches NHWZ vegetation was classified into five groups using the 11 most frequently encountered woody and wetland species. These groups correspond to elevations and geomorphic settings of the patches. Those patches with extensive channel margin or return-channel marsh vegetation were grouped together. Another grouping corresponded to patches consisting primarily of higher middle riparian stands of Arrowweed and Tamarisk. Overall, it is not known yet if these groupings of patches can be related to bird species composition or abundance. After the OHWZ characterization has been completed, these groupings and others formed by combinations of OHWZ and NHWZ will be compared with the bird data.

RECOMMENDATIONS

We suggest that the emphasis of the monitoring program be changed in one aspect. Since we are attempting to determine impacts of the operations of Glen Canyon Dam on the riparian avifauna, we feel that it is unwarranted to monitor birds on upper Lake Mead. The extensive habitat that has developed on the lake delta is directly affected by operations at Hoover Dam through changes in Lake Mead levels. Although there were some minor effects on riparian vegetation in this area during the controlled flood of 1996, under normal operations Glen Canyon Dam has little if any impacts below ca. RM 238-240. Currently, most of the 22 point count stations in this stretch have been underwater since 1997, and as recently as May 1998 most still were. We recommend that an additional 20-25 stations be established upstream of Diamond Creek. This will provide enough power to be able to effectively monitor the riparian avifauna that may be affected by Glen Canyon Dam operations.

The power analysis works on mean detection rates and their variances for species. Variances could probably be reduced if sample sizes (i.e., number of surveys) increase at each point count station. First, however, any differences due to year or observer effects needs to be determined. If these factors are not significant, then the survey data could be combined to provide "averaged" mean values based on several years of data. These averaged values could then be used to determine the adequacy of the monitoring program, and also compared with a "best-year" data set.

We collected data on "males" (singing birds) from point count stations. This data was not analyzed for this report primarily because we have not developed "decision rules" regarding what constitutes a male on territory versus a bird that is singing. In many families, particularly among flycatchers and buntings, females also sing. A set of rules akin to those developed by Sogge *et al.* (1998) for breeding status needs to be developed before an index to "males" is used. We feel that a good compromise may be to record "singing" birds regardless of sex, and use this as an index of territorial birds. However, until we can determine the breeding significance of singing females, and also when migration is over for some species (as some migrants sing), we have not attempted to analyze this data set.

Sogge *et al.* (1998) showed that riparian bird species abundance and richness along the Colorado River corridor was strongly related to several habitat variables. The most important single variable was patch size, and in combination with variables describing woody riparian species, accounted for a large percentage of the variation in species richness and abundance. Both OHWZ and NHWZ vegetation was used in their analyses. We have made no attempt to analyze the 1997 bird data because our habitat sampling program has not been completed. Most NHWZ vegetation has been sampled, but only about 25% of OHWZ vegetation has been sampled.

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Figure 1. The study area from Lee's Ferry to upper Lake Mead. Clusters of point count stations are located along the river corridor in the black areas. Larger areas represent more stations.

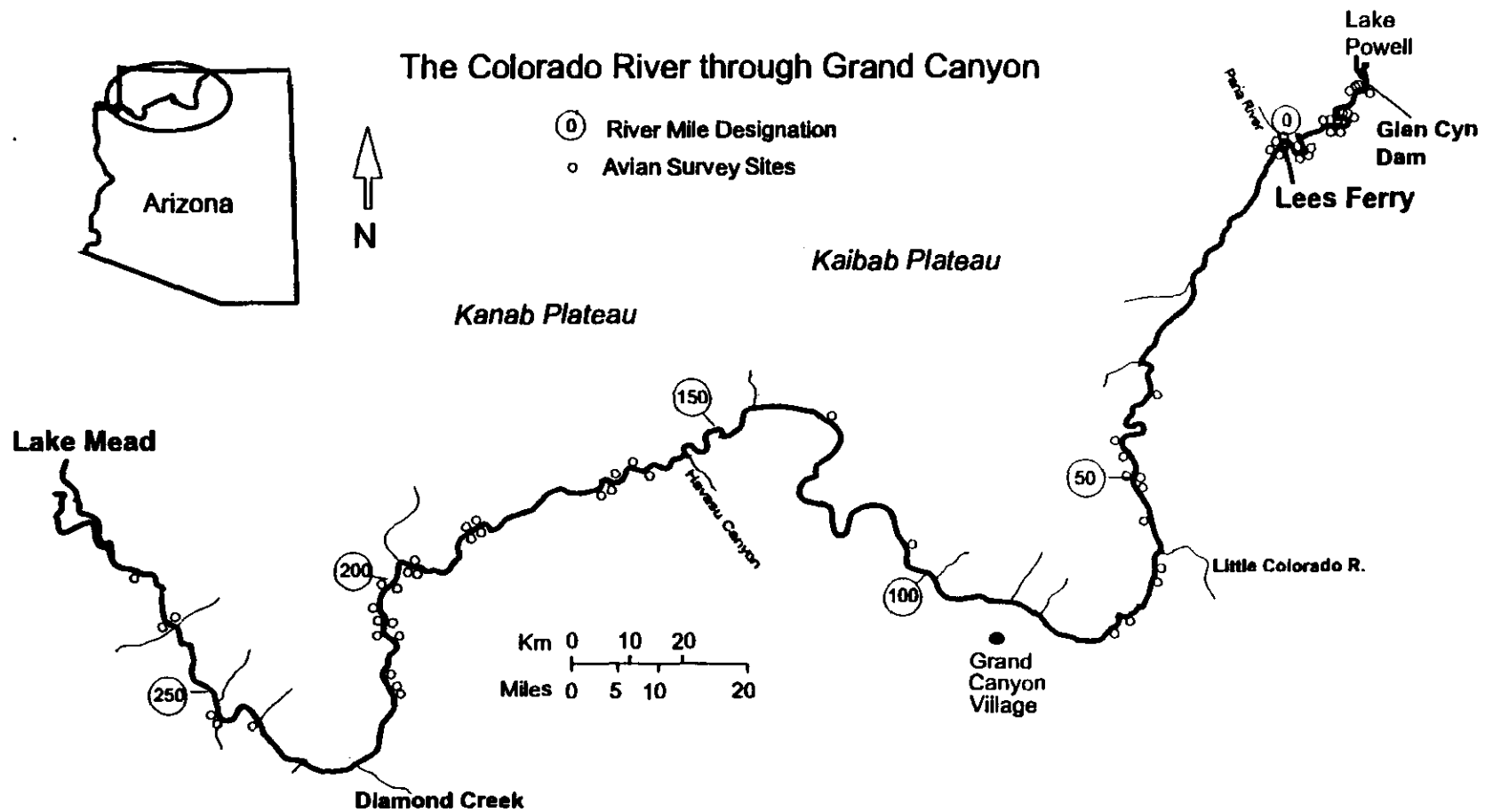


Figure 2. Regression plot of total individuals detected of the 15 most common species compared between unbounded point counts and walking surveys for trips one and three data only. The walking survey is the independent variable. The regression accounted for 78% of the variation in unbounded point count data. The equation is: Individuals detected on point counts = $1.89 + 1.02(\text{individuals detected on walking surveys})$. The 95% confidence intervals (inner lines) and predicted values (outer lines) are also plotted.

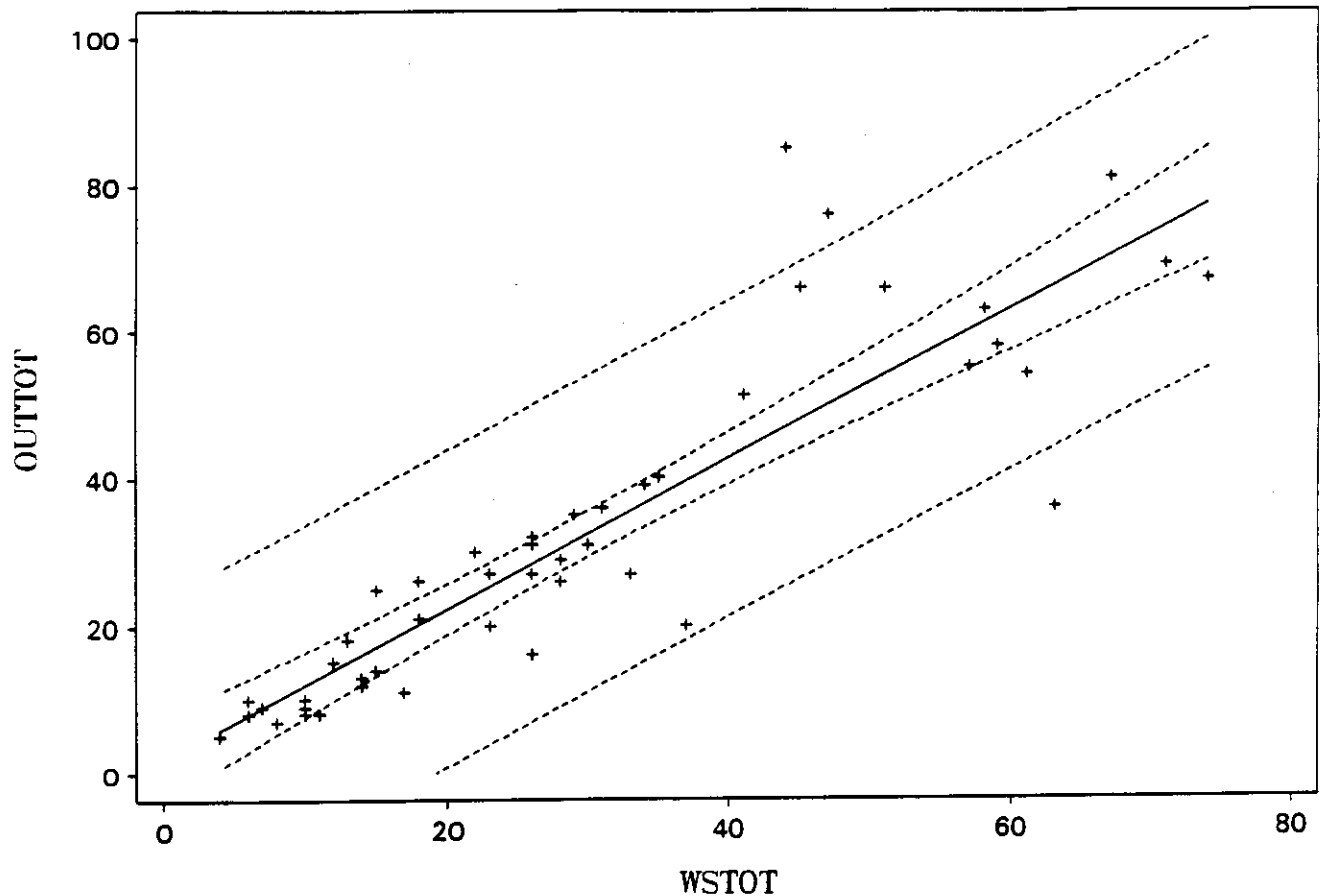


Figure 3. Four selected total vegetation volume (TVV) profiles for patches 204.1R, 51.5L, 5.8R, and 67.1L. Each meter interval up to 7 meters is plotted on the Y-axis, and the TVV score is shown on the X-axis.

Figure 3

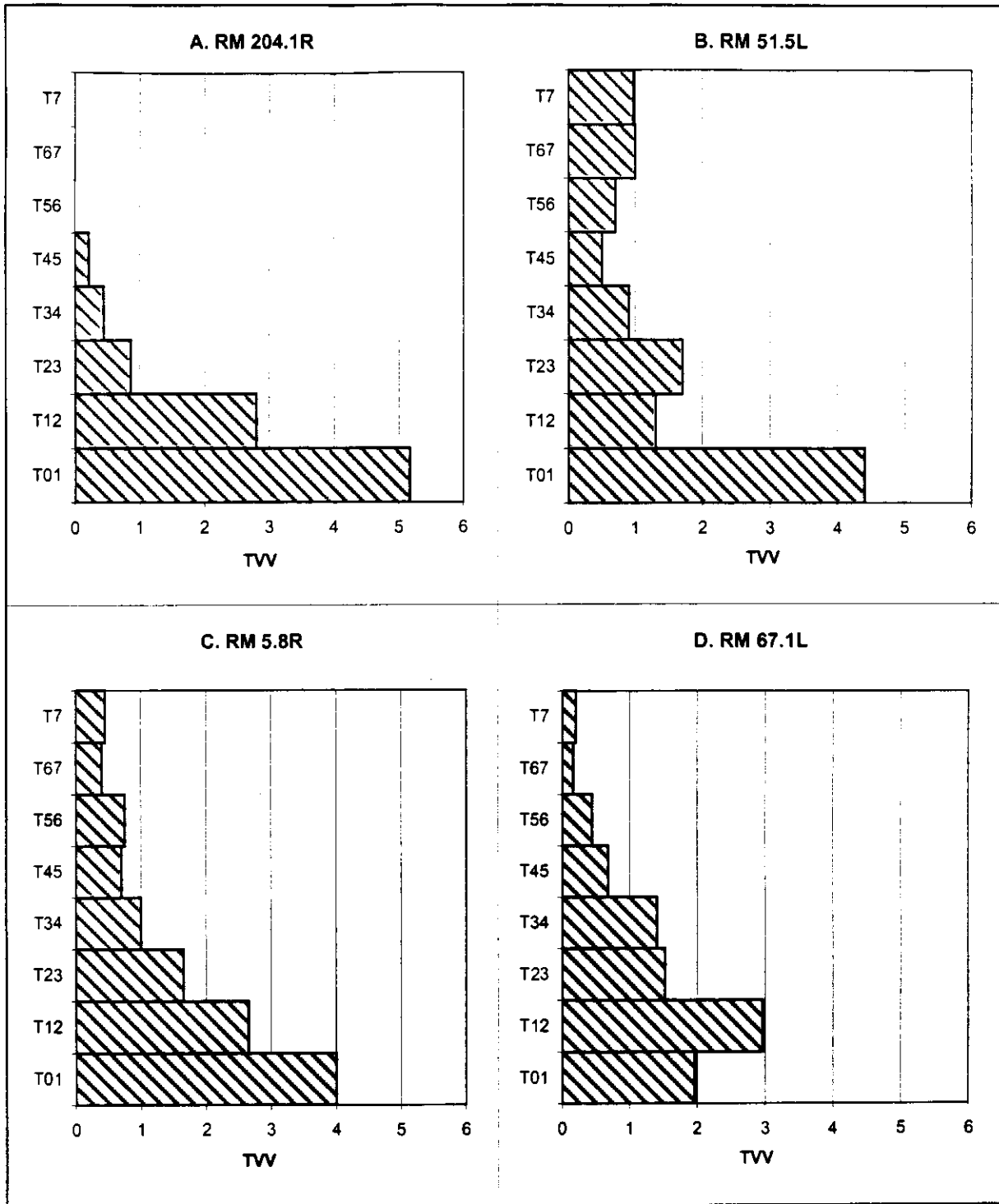


Figure 4. A plot of the mean TVV value for each of 43 patches of NHWZ vegetation, along with the observed frequency distribution and test for normality (Wilk-Shapiro Statistic).

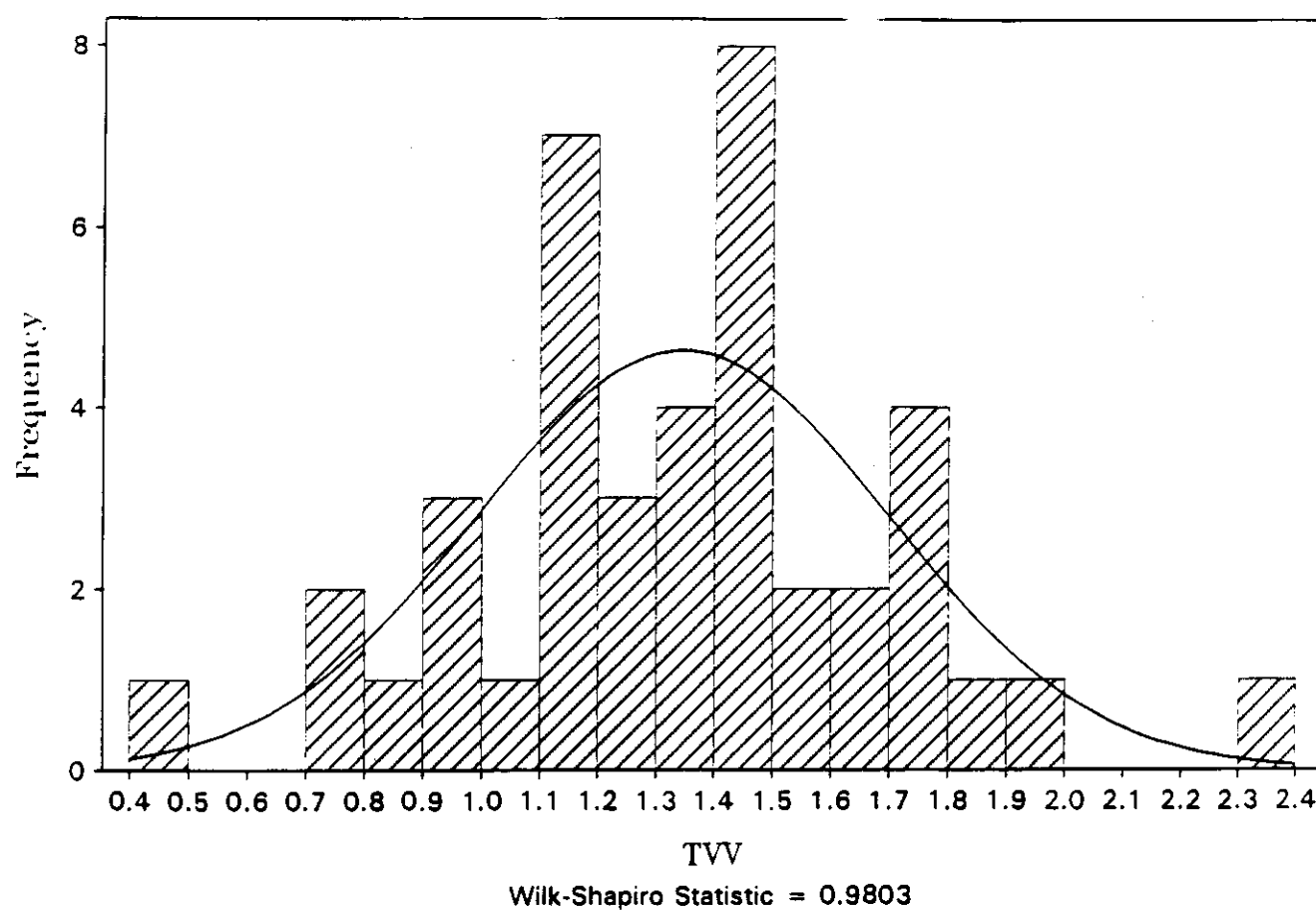
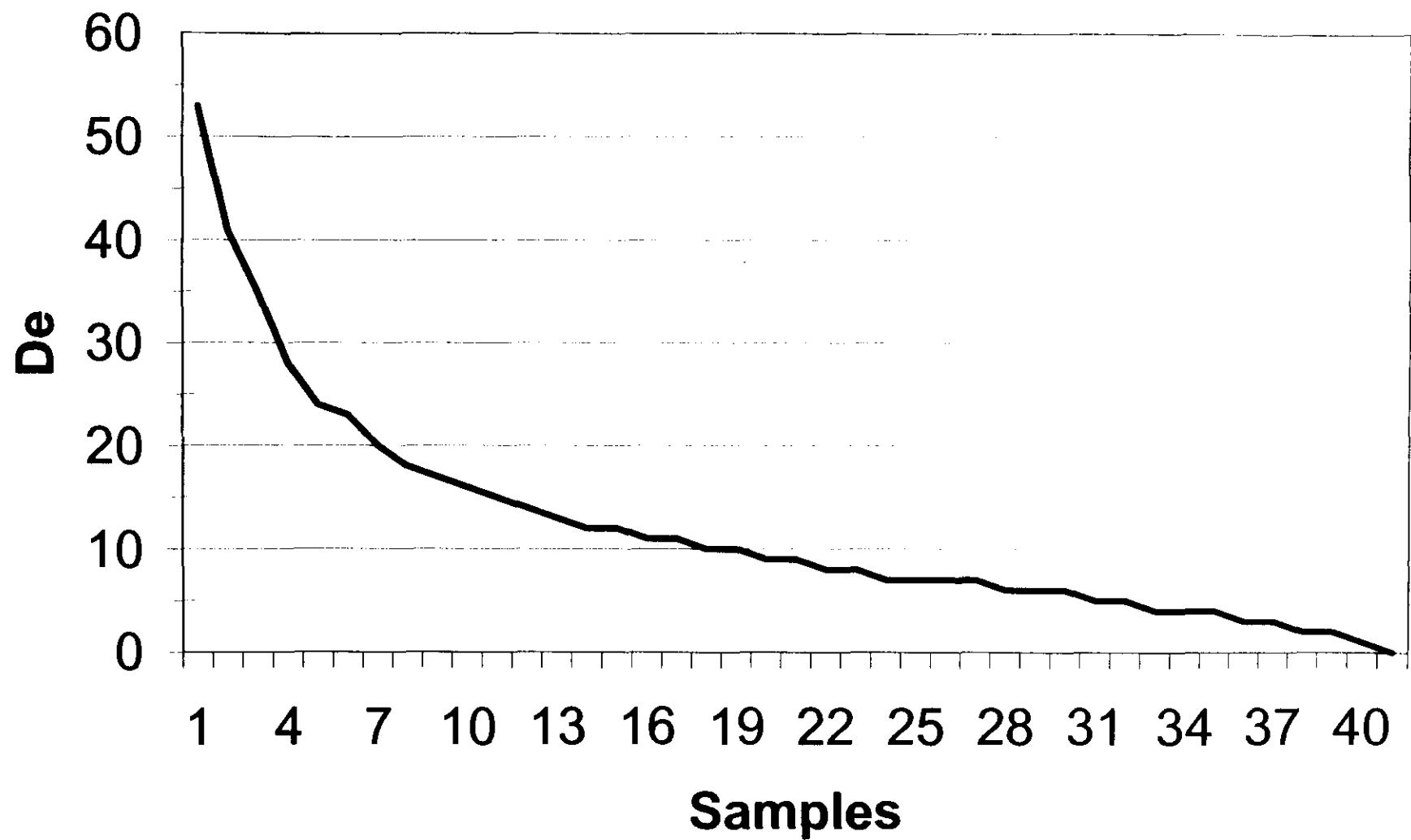


Figure 5. Plot of the change in cumulative mean dissimilarity on the Y-axis among TVV samples in patch 1.0R, from the first sample to the last sample (N=41; X-axis).

RM 1.0R



APPENDICES

Appendix A: Protocols

TERRESTRIAL BIRDS - GENERAL COMMENTS AND APPROACH

1. Two methods will be used to monitor birds in riparian vegetation during the breeding season, fixed-radius point counts and walking surveys. The point counts will be used to determine changes over time in numbers, while the walk through surveys will provide a back up of estimated number of birds per patch as well as species presence/absence in each patch. On winter trips only walking surveys will be done.
2. At each patch, use the following approach. The point count surveyor starts first, moving to the first station. The walk through surveyor waits at the edge of the patch. After the point count surveyor has finished the first count and moved to second station, the walk through surveyor waits 10 minutes (5 minutes in small patches with only 1 station), then begins the survey. This is done to allow birds to settle down after the point counts, and to prevent the two surveyors from meeting in the patch.
3. The boat can be left at the upstream edge, but it is preferable if the boat floats past the patch to a pick up point below it. This is necessary on large patches, but less so for small patches. Both surveyors end up at the downstream point.
4. The surveys (point count and walking) should begin around sunrise or first light and be completed before 11am. Surveys should not be conducted if the weather conditions make it difficult to detect the birds. These conditions include: 1) too hot--usually above 32 degrees Celsius especially with intense direct sunlight; 2) too windy-- above 15-20 mph; and 3) moderate to intense rain--in most cases surveys could be conducted in a light rain.
5. Every two or three days have an evening data party duplicating all filled-in data forms. At this time you can discuss sightings, find out what that weird scribbled acronym really means, and generally clean up the data.

WALKING SURVEYS

Walking surveys are modified strip transects and are ultimately used to create a species list for the patch. A surveyor attempts to walk through the survey area (patch) recording all avian species seen or heard; at a minimum, covering approximately 100-150 meters around a point (especially important, if there is only one point in the patch). The walking surveys are usually started after the point counts have been initiated or completed in order reduce interference (*i.e.* cause noise disturbance or flushing birds into or out of the area). The wait time before beginning the walk through surveys varies, depends on the number of points within the patch and proximity of the points. Usually, for patches with 2 to 3 points, a 10 to 15 minute wait is usually adequate; whereas patches with only

one point, it is best to wait until the point count is completed. The time spent covering the patch also varies, depending on the terrain and methods of traversing the patch; usually an range of 7 to 10 minutes is spent per point in each patch. For example, in a patch containing 3 point count stations, the walk through survey should take approximately 20 to 30 minutes with time spent evenly distributed throughout the patch.

POINT COUNTS

(This type of survey method is also referred to as Standard fixed-radius point counts.) Point count stations are marked with flagging and are located at the edge of the vegetation or within the vegetation. Aerial photos are provided to help locate the points and/or trails between the points. Most stations within the same patch are spaced at least 100 meters apart.

The surveyor arrives at the station, waits 1 minute before beginning the count, during which time, the timer can be set, the thermometer set/hung in a nearby place outside of the direct sunlight, and the wind and cloud conditions can be recorded. The count consists of a 5 minute listening period broken into two time frames: 0 to 3 minutes and 3 to 5 minutes. During the count, the surveyor records all the birds heard within (inside) a 50 meter radius of the station (I) and also those outside of the 50 meter radius (O), but within the patch (i.e. *not* across the river). Airspace above the point is also included in the 50 meter radius (e.g. if a bird flew over the point during the survey time, indicate whether it was inside or outside an estimated 50 meter boundary above the point).

The bird species are recorded according to the standard AOU coding: 4-letter acronyms based on the common name. For example, using common name, use the first four letters of a single-worded name (Mallard=MALL) or in a two-worded name, the first two letters of the first word and the first two letters of the second (Lucy's Warbler=LUWA). For hyphenated words, use the first letter of each word; for example, Brown-headed Cowbird=BHCO. See the attached "How to do..." sheets.

DATA SHEET DESCRIPTIONS

Patch: The Glen Canyon NRA (GLCA) patches are not numbered individually, just record the point count station number(s) that are included in the patch. In the case of the point count data sheets, indicate that it's GLCA.

The Grand Canyon NP (GRCA) patches are numbered according to the river mileage and often include a R or L to indicate which side of the river the patch is located (R: river right; L: river left -- as determined when facing downstream).

Date: day month year (e.g. 23 May 1997) or if you use numbers, specify the order of the day and month (e.g. is 6/7/97 the 7th of June or the 6th of July).

Observer: Initials of first and middle name and write out full last name or just all initials.

Time Start/Stop: In military time, record the time the survey started and stopped

Temperature: Record temperature in degrees Celsius (as determined by a thermometer)

Wind Speed: Record estimated wind speed in meters per second at the start and stop of survey period, using the Beaufort Scale or modification thereof (see below) or with the use of the wind meter.

Beaufort Scale (for Wind Speeds)

- 0 = calm, smoke rises vertically
- 1 = 1-3 mph, smoke drift shows wind direction
- 2 = 4-7 mph, leaves rustle, wind felt on face
- 3 = 8-12 mph, leaves, small twigs in constant motion, a light flag flutters
- 4 = 13-18 mph, raises dust and leaves, small branches move

Cloud Cover: Record the estimated percentage of cloud cover. This can be given in ranges in 5 or 10 percent increments. (e.g. 5-10%, 50-60%, etc.)

Point Number: pre-set number given to the point

Min. (minutes): time period in which detections were made

- 0-3 = within the first three minutes
- 3-5 = within the last two minutes

Species: according to AOU codes four letters (see protocol and code sheet)

/ Number Detected: number of individuals seen

Location (Point Count): (WITHIN THE PATCH)

- I = individual(s) are inside/within a 50 meter radius of the station
- O = individual(s) are outside the 50 meter radius of the station
- A = IGNORE THIS CODE (stood for across the river)

How Detected: Indicate how the individual was first detected

- A= aural/auditory
- V= visual

When: IGNORE this category; detections for point counts are only recorded during the 5 minute survey period. However, if you flushed a bird upon approach or when leaving, you could record it (though it can't be used in analyses), but write B for before survey or A for after survey.

Sex: Leave blank unless you are certain as to the sex of the individual (visual detection); (not all singing birds are males!!). Unless you specify otherwise, no entry =

unknown. Please note the bird's activity, especially if it was/is singing.

Habitat (Point Count)/ Location (Total Count):

Record the location of the individual(s) when it was detected.

O = OHWZ: Old high water zone, this habitat usually consists of low shrubs (sagebrush, brittlebrush), or in certain areas, mesquite, hackberry, *Acacia*.

W = Water: on the water surface (river)

N = NHWZ: New high water zone, this consists of the existing riparian habitat (tamarisk, willow, Russian olive); usually where the point count station is located

A = Air: especially the case with swallows or swifts, but also includes flyovers

U = Uplands: Areas (canyon walls, rock faces, etc.) above the OHWZ

K = Unknown

Activity: Indicate what the individual was doing when it was detected.

S = singing

C = calling

F = feeding

P = perching/ resting

R = reacting (flushing, with hummers-dive bombing surveyor, checking out the colorful flagging or shirts, etc.)

N = nesting

O = flying

Comments: More than one point count station can be recorded on one sheet; if this is the case, then record the survey time period (in military time) and the temperature in the first two spaces of this column at the beginning of the survey (see attached example survey sheet). Other notes of observations, behaviors, and breeding status, can also be recorded in this column.

APPENDIX B: Patches, reach designation, number of point count stations, and number of surveys completed in 1997

APPENDIX B

PATCH	REACH	NO. PC STATIONS IN PATCH	TRIPS IN 1997	PC DONE IN 1997	WS DONE IN 1997
(-)14.5L	1	1	3	3	3
(-)14.2L	1	3	3	9	3
(-)13.6R	1	1	3	3	3
(-)10.0L	1	2	3	6	3
(-)9.4L	1	1	3	3	3
(-)8.9L	1	1	3	3	3
(-)8.4R	1	3	3	9	3
(-)7.5L	1	1	3	3	3
(-)7.0L	1	2	3	6	3
(-)6.5R	1	1	3	3	3
(-)6.1R	1	1	3	3	3
(-)3.8L	1	1	3	3	3
(-)3.2R	1	4	3	12	3
(-)2.5L	1	3	3	9	3
(-)0.4R	1	1	3	3	3
1.0R	1	2	3	6	3
1.6R	1	3	3	9	2
3.7L	1	1	3	3	2
5.2R	1	2	2	4	2
5.8R	1	1	2	2	2
43.1L	2	2	3	6	3
45.5L	2	3	3	9	2
46.7L	2	4	3	12	2
49.1R	2	2	3	6	2
50.0R	2	2	3	6	2
50.4L	2	3	3	9	2
51.5L	2	2	3	6	2
56.R	2	2	3	5	2
58.7L	2	1	1	1	2
65.3L	2	2	3	6	2
67.1L	2	2	3	6	2
71.0L	2	2	3	6	2
74.4L	2	4	3	12	3
122.8L	3	2	2	4	2
125.8L	3	1	2	2	2
166.5L	3	4	2	8	2
168.8R	3	2	2	4	2
171.0R	3	2	2	4	2
172.2L	3	2	2	4	2
174.2L	3	2	2	4	2
193.8R	3	2	3	6	3
194.0L	3	3	3	9	3
196.0R	3	4	3	12	3
197.6L	3	2	3	6	3
198.0R	3	3	3	9	3
198.2L	3	3	3	9	3
200.4R	3	1	3	3	3
200.5R	3	1	3	3	3
202.5R	3	1	3	3	3
204.1R	3	4	3	12	3

APPENDIX B

204.5R	3	5	3	15	3
205.0L	3	3	3	9	3
208.7R	3	2	3	6	3
209.0L	3	3	3	9	3
213.6L	3	1	3	3	3
214.0L	3	1	3	3	3
214.2L	3	1	3	3	3
243.2L	4	2	2	4	1
246.0L	4	3	2	6	1
249.0L	4	1	0	0	0
260.2L	4	4	3	9	1
260.2R	4	2	3	6	1
264.5L	4	10	3	24	1
PC=Point Count					
WS=Walking Survey					

APPENDIX C: Summary bird species data by survey method

Total Birds

PATCH	PC Totals <50m	PC Totals >50m	WS Totals	PC Species <50 m	PC Species >50m	WS Species
(-)14.5L	4	8	24	4	6	10
(-)14.2L	89	96	125	12	15	12
(-)13.6R	17	23	23	7	9	11
(-)10.0L	32	48	68	10	12	14
(-)9.4L	23	28	41	8	8	10
(-)8.9L	3	8	19	2	4	9
(-)8.4R	43	84	108	11	11	16
(-)7.5L	8	11	11	5	5	6
(-)7.0L	7	15	21	5	10	9
(-)6.5R	11	22	22	6	9	7
(-)6.1R	11	19	30	8	11	7
(-)3.8L	11	19	44	5	7	7
(-)3.2R	54	86	128	13	13	13
(-)2.5L	48	69	110	12	13	15
(-)0.4R	8	19	10	5	8	6
1.0R	22	32	37	7	9	10
1.6R	39	49	25	11	11	9
3.7L	7	16	17	4	7	7
5.2R	16	31	25	4	8	7
5.8R	6	40	17	3	6	5
43.1L	30	54	56	7	10	10
45.5L	31	40	43	6	9	8
46.7L	71	132	109	9	15	12
49.1R	35	49	33	8	11	8
50.0R	29	49	41	6	11	11
50.4L	32	82	68	12	16	15
51.5L	33	57	31	10	14	13
56.R	18	37	31	8	11	11
65.3L	20	33	19	8	11	7
67.1L	33	57	35	6	7	9
71.0L	49	62	34	11	12	9
74.4L	40	55	22	8	10	6
122.8L	17	20	25	5	7	3
125.8L	15	17	14	4	5	7
166.5L	12	12	21	3	3	3
168.8R	35	46	36	7	8	9
171.0R	32	34	41	8	9	10
172.2L	34	39	22	12	15	7
174.2L	26	35	18	10	13	9
193.8R	28	40	31	10	13	13
194.0L	85	106	89	14	16	18
196.0R	72	122	112	14	18	16
197.6L	47	66	67	10	14	15
198.0R	57	116	54	14	19	14
198.2L	46	71	43	11	13	13
200.4R	17	20	19	5	6	9
200.5R	28	34	24	10	11	9
202.5R	28	33	40	10	10	12
204.1R	73	106	57	12	14	15
204.5R	87	135	51	14	18	15

Total Birds

205.0L	63	102	64	10	18	12
208.7R	31	41	19	10	10	6
209.0L	30	47	32	6	11	9
213.6L	23	29	20	6	9	8
214.0L	35	44	37	8	11	7
214.2L	10	12	8	4	6	2
PC=Point Count						
WS=Walking Survey						
Totals=Total bird abundance						
Species=Species richness						

15 Riparian Species

PATCH	PC Totals <50m	PC Totals >50m	PC Species <50 m	PC Species >50m	WS Totals	WS Species
(-)14.5L	7	9	5	6	13	7
(-)14.2L	52	67	7	9	58	10
(-)13.6R	20	24	9	9	17	8
(-)10.0L	27	41	7	8	43	8
(-)9.4L	18	24	6	7	31	6
(-)8.9L	3	11	2	5	15	7
(-)8.4R	39	72	10	10	78	9
(-)7.5L	5	8	2	3	4	4
(-)7.0L	6	15	4	7	8	6
(-)6.5R	10	20	5	6	17	5
(-)6.1R	7	14	5	7	13	4
(-)3.8L	6	12	3	4	20	5
(-)3.2R	65	110	10	10	103	9
(-)2.5L	49	75	11	11	75	11
(-)0.4R	6	13	4	5	6	3
1.0R	17	22	5	6	23	6
1.6R	10	14	5	5	10	6
3.7L	3	7	2	3	7	3
5.2R	15	19	3	3	16	3
5.8R	4	5	2	3	5	2
43.1L	27	46	6	8	42	8
45.5L	29	34	5	6	28	5
46.7L	66	113	7	9	43	7
49.1R	35	47	8	9	30	6
50.0R	22	40	4	7	33	8
50.4L	29	69	10	10	59	9
51.5L	28	50	7	9	24	8
56.R	17	33	7	8	24	7
65.3L	19	32	7	10	15	6
67.1L	25	49	5	6	33	7
71.0L	32	45	8	9	26	7
74.4L	29	44	5	7	22	6
122.8L	16	18	4	5	24	2
125.8L	15	17	5	5	12	5
166.5L	12	12	3	3	21	3
168.8R	35	45	7	7	35	8
171.0R	32	34	8	9	24	6
172.2L	30	32	9	9	20	5
174.2L	24	29	9	11	16	7
193.8R	23	35	6	9	23	8
194.0L	77	95	10	11	74	10
196.0R	64	109	11	13	71	8
197.6L	45	62	8	11	62	11
198.0R	52	103	11	12	45	10
198.2L	43	65	9	11	34	7
200.4R	17	20	5	5	15	6
200.5R	27	32	9	9	23	8
202.5R	25	29	8	8	37	9
204.1R	71	103	10	11	51	11
204.5R	84	123	11	13	47	12

15 Riparian Species

205.0L	62	96	9	13	58	9
208.7R	30	40	9	9	18	5
209.0L	30	42	6	8	28	7
213.6L	23	26	6	6	18	6
214.0L	34	40	7	7	31	5
214.2L	9	11	3	5	7	1
243.2L	42	53	10	10	x	x
246.0L	92	129	11	11	x	x
260.2L	104	144	12	12	x	x
260.2R	66	93	9	9	x	x
264.5L	347	504	12	12	x	x
PC=Point Count						
WS=Walking Survey						
Totals=Total bird abundance						
Species=Species richness						

Appendix D: Summary TVV data and number of encounters (percent of total TVV samples) for 11 principal riparian species

TVV DATA

PATCH	T01	T12	T23	T34	T45	T56	T67	T7	MEAN TVV	SAMPLE SIZE
1.0R	2.63	2.61	2.63	1.37	1.07	0.37	0.12	0.02	1.35	41
1.6R	4.82	2.7	1.14	0.98	0.41	0.07	0	0	1.27	40
3.7L	5.82	2.59	1.23	0.64	0.45	0.41	0.5	0	1.46	22
5.2R	3.36	1.68	1.2	1.92	1.04	0.68	0.08	0	1.25	25
5.8R	4	2.65	1.65	1	0.7	0.75	0.4	0.45	1.45	20
43.1L	4.58	4.45	2.28	0.88	0.6	0.6	0.1	0	1.69	40
45.5L	4.83	3.33	2.93	1.3	1.4	0.47	0.27	0.17	1.84	30
46.7L	3.7	1.7	1.4	1.1	0.8	0.5	0.2	0	1.18	45
49.1R	3.2	1.1	0.9	0.7	0.67	0.53	0.4	0.1	0.95	30
50.0R	3	0.93	0.73	0.3	0.43	0.7	0.2	0.07	0.8	30
50.4L	4.13	1.33	1.29	1.71	1.37	0.84	0.3	0.03	1.38	70
51.5L	4.4	1.3	1.7	0.9	0.5	0.7	1	0.97	1.43	30
56.R	4.69	2.54	1.83	1.29	1.06	0.54	0.11	0.11	1.52	35
65.3L	2.46	2.22	1.96	1.2	0.56	0.31	0.11	0	1.1	54
67.1L	1.96	2.96	1.52	1.4	0.68	0.44	0.16	0.2	1.17	24
71.0L	3.46	3	1.86	1.26	0.94	0.26	0.6	0.4	1.47	35
74.4L	4.4	5.09	1.86	0.43	0.11	0	0	0	1.49	35
122.8L	5.08	4.16	3.16	1.08	0.48	0.12	0	0	1.76	25
125.8L	5.72	2.72	0.72	0.16	0	0	0	0	1.17	25
166.5L	2.25	2.08	1	0.46	0.25	0.02	0.02	0	0.76	63
168.8R	4.75	1.32	1.71	1.68	1.14	0.68	0.18	0.04	1.44	28
171.0R	3.82	3.09	1.03	1.24	0.64	0.52	0.03	0	1.3	33
172.2L	4.43	3.6	1.73	0.77	0.33	0	0.07	0	1.37	33
174.2L	4.63	3.17	1.2	0.83	0.67	0.57	0.33	0.03	1.43	30
193.8R	3.88	2.48	2.28	0.28	0.24	0.2	0	0	1.17	25
194.0L	4.52	4.26	2.06	1.42	0.52	0.19	0.06	0.03	1.63	31
196.0R	4.21	2.61	1.3	0.59	0.41	0.24	0.08	0	1.18	100
197.6L	6.43	3.38	2.45	1.55	1.08	0.58	0.23	0.05	1.97	40
198.0R	2.06	2.27	1.52	1.19	0.51	0.23	0.01	0	0.97	73
198.2L	4.63	3.34	2.2	1.28	1.08	0.8	0.34	0.06	1.72	35
200.4R	6.35	2.9	1.45	0.6	0	0	0	0	1.41	20
200.5R	4.48	4.16	2.4	1.48	0.84	0.28	0.08	0	1.72	25
202.5R	4.6	3.05	2.2	1.5	0.6	0.35	0.05	0	1.54	20
204.1R	5.17	2.8	0.86	0.44	0.21	0	0	0	1.19	70
204.5R	2.88	1.88	0.95	0.51	0.08	0.02	0	0	0.79	103
205.0L	3.14	2.11	1.97	1.37	0.83	0.54	0.26	0.09	1.29	35
208.7R	6.83	3.57	2.2	1.03	0.13	0	0	0	1.72	30
209.0L	1.96	1.25	0.38	0.13	0.03	0.01	0	0	0.47	120
213.6L	3.05	2.2	1.6	1.2	0.25	0.1	0.05	0	1.06	20
214.0L	4.6	2.9	2.1	2.6	2.5	1.9	1.3	0.5	2.3	20
214.2L	4.5	2.3	0.9	0	0	0	0	0	0.96	10

TVV SPECIES

PATCH	BAEM	BASA	BASL	SAEX	SAGO	TACH	TESE	PRGL	PHAU	TYPHA	MARSH
1.0R	4.9	0	0	26.8	0	58.5	7.3	0	0	0	0
1.6R	27.3	0	0	36.4	0	40.9	0	0	2.3	0	6.8
3.7L	0	0	0	13.6	0	36.4	9.1	0	0	0	4.5
5.2R	0	0	0	12	0	44	8	0	4	0	16
5.8R	20	0	0	15	0	60	0	0	10	0	0
43.1L	5	0	0	20	0	42.5	42.5	0	2.5	0	2.5
45.5L	20	0	0	43.3	0	53.3	0	0	0	0	3.3
46.7L	20	0	2.2	0	0	42.2	4.4	0	6	0	0
49.1R	16.7	0	0	6.7	0	33.3	3.3	0	10	0	0
50.0R	0	0	16.7	13.3	0	36.7	3.3	0	0	0	0
50.4L	5.7	0	2.9	24.3	0	47.1	18.6	2.9	0	0	0
51.5L	0	0	10	23.3	0	53.3	0	0	3.3	3.3	10
56.R	17.1	0	0	25.7	0	40	5.7	0	14.3	0	2.9
65.3L	1.9	0	0	35.2	0	31.5	20.4	13	3.7	0	1.9
67.1L	4.2	0	0	16.7	0	41.7	45.8	8.3	0	0	0
71.0L	2.9	0	0	11.4	22.9	42.9	5.7	0	34.3	0	0
74.4L	5.7	0	2.9	31.4	0	22.9	48.6	2.9	0	0	0
122.8L	0	0	4	44	0	44	12	0	4	0	0
125.8L	20	0	4	24	0	20	20	0	0	0	0
166.5L	0	34.9	1.6	1.6	0	23.8	0	0	0	0	0
168.8R	7.1	7.1	7.1	0	0	60.7	17.9	3.6	3.6	0	0
171.0R	6.1	9.1	3	0	0	42.4	36.4	12.1	0	0	0
172.2L	16.7	13.3	3.3	36.7	0	50	13.3	0	0	0	0
174.2L	0	6.7	3.3	0	0	50	43.3	0	0	0	0
193.8R	0	20	0	0	0	28	12	36	0	4	0
194.0L	3.2	3.2	0	22.6	0	38.7	9.7	12.9	6.5	32.3	6.5
196.0R	4	3	0	3	0	22	19	9	8	5	4
197.6L	0	20	0	0	0	47.5	17.5	5	0	0	0
198.0R	1.4	20.5	2.7	6.8	0	46.6	47.9	19.2	9.6	0	0
198.2L	0	17.1	0	2.8	0	42.9	31.4	0	22.9	0	0
200.4R	0	30	5	0	0	30	30	0	0	0	5
200.5R	4	0	0	0	0	44	56	8	0	0	0
202.5R	5	20	0	5	0	35	30	25	0	0	0
204.1R	2.9	12.9	11.4	4.3	0	25.7	21.4	10	0	0	0
204.5R	0	5.8	14.6	8.7	0	27.2	36.9	13.6	6.8	7.8	6.8
205.0L	5.7	2.9	0	0	0	45.7	17.1	20	0	0	0
208.7R	3.3	13.3	0	10	0	50	36.7	6.7	0	0	0
209.0L	1.7	13.3	0.8	0.8	0	16.7	30	13.3	0	0	3.3
213.6L	0	10	10	0	0	50	0	5	0	0	0
214.0L	0	5	0	10	0	85	30	5	0	0	0
214.2L	0	30	0	0	0	0	0	50	0	0	0

BAEM=Baccharis emoryi

PHAU=Phragmites australis

BASA=B. sarathroides

MARSH=Marsh species

BASL=B. salicifolia

TACH=Tamarix chinensis

SAEX=Salix exigua

TESE=Tessaria sericea

SAGO=S. gooddingii

TYPHA=Typha species

PRGL=Prosopis glandulosa

Appendix E: List of bird species encountered on walking surveys and point counts, April to July 1997

Species	4-letter Acronym
Mallard	MALL
Turkey Vulture	TUVU
Red-tailed Hawk	RTHA
Spotted Sandpiper	SPSA
Mourning Dove	MODO
Ladder-backed Woodpecker	LBWO
Northern (Red-shafted) Flicker	NOFL
Belted Kingfisher	BEKI
White-throated Swift	WTSW
Black-chinned Hummingbird	BCHU
Costa's Hummingbird	COHU
Western Kingbird	WEKI
Cassin's Kingbird	CAKI
Ash-throated Flycatcher	ATFL
Brown-crested Flycatcher	BCFL
Black Phoebe	BLPH
Say's Phoebe	SAPH
Gray Flycatcher	GRFL
Willow Flycatcher	WIFL
Cliff Swallow	CLSW
Northern Rough-winged Swallow	NRWS
Viole-green Swallow	VGSW
Tree Swallow	TRSW
Pinyon Jay	PIJA
American Crow	AMCR
Common Raven	CORA
Bushtit	BUSH
Bewick's Wren	BEWR
Rock Wren	ROWR
Canyon Wren	CAWR
House Wren	HOWR
Marsh Wren	MAWR
Blue-gray Gnatcatcher	BGGN
Ruby-crowned Kinglet	RCKI
Northern Mockingbird	NOMO
American Robin	AMRO
Western Bluebird	WEBL
Phainopepla	PHAI
Cedar Waxwing	CEWA

Gray Vireo	GRVI
Bell's Vireo	BEVI
Warbling Vireo	WAVI
Yellow Warbler	YEWA
Wilson's Warbler	WIWA
Audubon's Warbler	AUWA
Lucy's Warbler	LUWA
Common Yellowthroat	COYE
Yellow-breasted Chat	YBCH
Summer Tanager	SUTA
Western Tanager	WETA
Black-headed Grosbeak	BHGR
Blue Grosbeak	BLGR
Lazuli Bunting	LABU
Indigo Bunting	INBU
Spotted Towhee	SPTO
Green-tailed Towhee	GTTO
Song Sparrow	SOSP
Chipping Sparrow	CHSP
Black-throated Sparrow	BTSP
Rufous-crowned Sparrow	RCSP
Brewer's Sparrow	BRSP
White-crowned Sparrow	WCSP
Dark-eyed Junco	DEJU
Red-winged Blackbird	RWBL
Common Grackle	COGR
Great-tailed Grackle	GTGR
Brown-headed Cowbird	BHCO
Hooded Oriole	HOOR
Bullock's Oriole	BUOR
House Finch	HOFI
Cassin's Finch	CAFI
Lesser Goldfinch	LEGA