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MONITORING BIRD POPULATION DENSITIES ALONG THE COLORADO RIVER IN GRAND CANYON: 1987 BREEDING SEASON

Terrestrial Biology

of the

Glen Canyon Environmental Studies

By

Bryan T. Brown

National Park Service

15 September, 1988

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16. Abstract (Limit: 200 words)

The pupose of this study was to document the density of breeding birds in the Colorado River corridor in 1987 and to compare present avian abundance to available historical information. Two complementary types of breeding bird density were calculated: the site sensus (avian density per unit area for all species at ten paired study sites) and downriver census (indirect count of five indicator species throughout the river corridor). Breeding bird density at established study sites showed a significant trend of decline from 1984 to 1987. In contract, population sizes of three indicator species (Willow Flycatcher, Yellow Warbler, and Yellow-breasted Chat) showed significant trends of increase from 1976 to 1987. Common Yellowthroats exhibited decline in population size in 1987 and have become one of the rarest breeding birds of the river corridor. Bell's Vireo also showed a significant increase from 1986 to 1987. Additional research is neeeded to established the indirect, long-term links between Glen Canyon Dam operations and density and ecology of breeding birds. Monitoring bird populations gives useful short-term, direct response of species to dam operations and serve as a general barometer of ecological health of breeding birds.

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ABSTRACT

The densities of riparian breeding birds along the Colorado River between Glen Canyon Dam and Diamond Creek were documented in the spring of 1987. These densities were compared to similar historical information to 1) reveal long-term population trends and 2) provide further information on the effects of the 1983 surplus water release from the dam. The overall density of the riparian breeding bird community showed a significant trend of decline in all habitats from 1984 to 1987. Three of five indicator species, including Willow Flycatcher, Yellow-breasted Chat, and Common Yellowthroat, declined in numbers from 1986 to 1987. The Common Yellowthroat population has declined to the point where it has become one of the rarest breeding birds of the river corridor, largely as a result of the lingering effects of the flood of 1983. Only Bell's Vireo and Yellow Warbler populations exhibited significant increases from 1986 to 1987. The long-term trend has been for an increase in population size of four of the five indicator species from 1976 to 1987, but the population declines noted between 1986 and 1987 may indicate that populations of indicator species will be stabilizing or even declining in the near future. Long-term population trends in the five indicator species were not useful in predicting absolute density trends for the entire riparian breeding bird community, but indicator species were useful in identifying short-term, direct impacts to birds resulting from certain dam operations.

ACKNOWLEDGMENTS

This study would not have been possible without the cooperation of many people on several levels. J.M. Jackson, S.C. Jones, M. McGee, B. Rushmore and M. Trosset acted as assistants during field work. The logistical support of the staff of Humphrey Summit Associates was invaluable, and I sincerely thank D. Bremner, J. Corn, B. Dierker, R. Garrison, and T. Moody. N. Brian and L. Lucas provided administrative and technical support. M. Trosset performed the statistical analyses presented in this report. The guidance and support of D.L. Wegner, director of the Glen Canyon Environmental Studies, and M. Hahn-O'Neill, project coordinator with the National Park Service, were greatly appreciated. This study was funded by the Bureau of Reclamation and the National Park Service.

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INTRODUCTION

The density of breeding birds along the Colorado River in Grand Canyon was first investigated in the early and mid-1970s (Carothers and Johnson 1975, Carothers and Sharber 1976, Brown et al. 1983). Later studies (Brown and Johnson 1985, Brown and Johnson 1987, Brown 1987) initiated comprehensive, systematic surveys of breeding bird density designed to be as compatible as possible with the investigations of the 1970s. These later studies were also partially designed to illustrate some of the short-term and long-term effects of the operation of Glen Canyon Dam on breeding bird density. The design and scope of the present study was identical to that of Brown (1987) and was a continuation of that work.

The purpose of this study was to document the density of breeding birds in the river corridor in 1987 and to compare present avian abundance to available historical information. This comparison answers two questions. First, how are bird populations adjusting to the long-term effects of the 1983 surplus water release? And second, how can recent changes in the bird community be used to predict long-term change in the birds of the river corridor? The following objectives were designed to address these questions.

1. Document the population sizes of indicator species (selected species of obligate riparian birds) throughout the system.

2. Document the absolute density of all species at 10 established, paired study sites between Glen Canyon Dam and Diamond Creek.

3. Compare this information to historical data in order to identify long-term trends.

The construction and completion of Glen Canyon Dam in 1963 has had a major influence on the density and diversity of breeding birds in the river corridor. Controlled flows from the dam allowed new riparian habitat to develop along the river below the predam scour line (Turner and Karpiscak 1980). This new-high-water-zone (NHWZ) vegetation was quickly colonized by riparian breeding birds which increased greatly in abundance during the next 20 years (Brown et al. 1987). Beginning in 1983, however, a series of large floods (surplus water releases from the dam in excess of powerplant capacity, or greater than 31,500 cubic feet per second) were released by the dam. These floods occurred during the breeding season, inundating many low-lying active bird nests. Vegetative habitat in the NHWZ used for breeding by many species of birds was also lost due to scouring of riverbanks during the floods (Brian 1987, Pucherelli 1987). Nest inundation and loss of breeding habitat reduced the population densities of some species of birds (Bell's Vireo,

Common Yellowthroat) in the years immediately following flooding, while other species (Willow Flycatcher, Yellow Warbler, Yellow-breasted Chat) continued to increase in numbers. By 1986, the Bell's Vireo population had recovered to preflood (1982) levels. However, the Common Yellowthroat population remained low due to the almost complete loss of marshes, their preferred breeding habitat, during the flood years (Brown 1987).

STUDY AREA

Site Census. Ten paired study sites in ten different river reaches were established between Glen Canyon Dam and Diamond Creek in the spring of 1984. In each river reach a permanent set of paired study sites was located in the largest and most well-developed patches of riparian vegetation. One site of each pair was located in the mesquite-dominated old-high-water-zone (OHWZ), while the other site of each pair was located in the tamarisk-dominated NHWZ. These same study sites were censused again during the present study to determine avian density per unit area. The location, elevation, and size of each of the 20 total sites are listed in Table 1. Site selection criteria, the vegetative characteristics of each site, and the ten river reaches chosen were outlined by Brown and Johnson (1987).

Downriver Census. The riparian corridor between Lees Ferry and Diamond Creek, a distance of 225 river-miles, was used as the study area for the downriver census. That portion of the river between Glen Canyon Dam and Lees Ferry, a distance of 15 river-miles, was not included in the downriver census study area for reasons of historical consistency explained by Brown (1987).

METHODS

Two complementary types of breeding bird density were calculated. One type, the site census, sampled avian density per unit area for all species at 10 paired study sites. The second type of density calculation, that of the downriver census, was an indirect count of the population size of five indicator species of obligate riparian birds throughout the river corridor. Censuses of both types were conducted during two river research trips, from 20 April to 8 May, 1987, and 27 May to 14 June, 1987.

Site Census. Breeding bird censuses at established study sites were made using the absolute count method. With this method, the observer walked slowly through the small site, stopped occasionally, and recorded each vocal or visual contact with a bird. The very small size and linear nature of the study sites, their habitat heterogeneity, and the

Table 1. Location and description of old-high-water-zone (-A) and new-high-water-zone (-B) study sites along the Colorado River in Glen and Grand canyons. River Miles are from Stevens (1983).

Site #	Location	River Mile*	Elevation (ft)	Area (ha)
01-A	Glen Canyon	7.4L**	3150	1.7
01-B	Lees Ferry	0.3R**-0.0R	3100	2.9
02-A	Saddle Canyon	46.9R-47.1R	2800	1.6
02-B	Saddle Canyon	46.4R-46.7R	2800	2.8
03-A	Cardenas Creek	70.8L-70.9L	2625	1.5
03-B	Cardenas Marsh	71.0L-71.1L	2625	1.7
04-A	Lower Bass Camp	108.6R	2200	0.1
04-B	Lower Bass Camp	108.6R	2200	0.1
05-A	Forster Canyon	122.8L	2075	0.6
05-B	Forster Canyon	122.7L-122.8L	2075	0.4
06-A	National Canyon	166.5L-167.0L	1750	2.2
06-B	National Canyon	166.1L-166.5L	1750	0.4
07-A	Stairway Canyon	170.7R-171.0R	1725	1.7
07-B	Stairway Canyon	171.0R-171.1R	1725	0.4***
08-A	Parashant Canyon	198.0R-198.1R	1525	1.4
08-B	Parashant Canyon	198.0R-198.1R	1525	0.2***
09-A	Granite Park	208.4L-208.8L	1450	5.6
09-B	Granite Park	208.7L-208.8L	1450	1.0
10-A	220-Mile Canyon	219.8R-220.1R	1375	0.9
10-B	Granite Springs Canyon	220.3L	1375	0.1

* R and L refer to river right and river left, respectively, as one faces downstream.

** These River Miles are upstream of River Mile 0 at Lees Ferry; all remaining River Miles are downstream of River Mile 0 at Lees Ferry.

*** The NHWZ study sites at Stairway and Parashant Canyons were drastically reduced by streambank erosion between 1985 and 1987. The area of site 07-B in 1985 was 0.7 ha, being reduced to 0.4 ha by 1987; the area of site 08-B in 1985 was 0.5 ha, likewise being reduced to 0.2 ha by 1987. The streambank erosion and subsequent loss of breeding bird habitat did not occur gradually, but occurred almost entirely during the high water release of May 1986.

limits of time and field work scheduling dictated the use of this method. Each study site was sampled from two to five times in the spring of 1987. The absolute count method in this instance was preferable to more sophisticated and time-consuming techniques such as the fixed or variable-strip census and the spot-map method (Ralph and Scott 1981).

The assumptions, details, and possible sources of error associated with the absolute count method were discussed by Brown and Johnson (1987). That report should be consulted for the complete methodology.

A three-way analysis of variance (ANOVA) test (fixed effects model) was used to compare annual avian density values obtained during this study and during the period 1984 to 1986. Standard square root transformations were performed on the data before analysis to comply with the normality assumption. Differences between sites, years, and zones were compared across the period from 1984 to 1987: the two-way interaction between site x year, site x zone, and year x zone were also compared. An important assumption of this test was that no significant three-way interaction occurred between site, zone, and year.

The NHWZ site 01 at Lees Ferry was disturbed by catastrophic wildfire in late March of 1987, and density data from that site for 1987 was regarded as missing. Therefore, this study site (both zones, all years) was not included in the three-way ANOVA.

Downriver Census. The population sizes of five selected species of obligate riparian birds were determined using an indirect count census (Schemnitz 1980). The indirect count, or call count (Bull 1981), was a true census of the number of all singing males heard on an 18-day, oar-powered rivertrip between Lees Ferry and Diamond Creek at the height of the breeding season. This indirect count of bird songs resulted in an index to the population sizes of the five species being censused. An index is a census of some variable (in this case, bird songs) related to the true number of animals under study. Indirect counts can be inaccurate, however, because of bias and sample error. The assumptions, constraints, and details of the indirect count method as used in the downriver census, as well as the rationale behind the choice of the five indicator species, are discussed by Brown (1987).

The estimates of numbers of pairs of the five indicator species were based on the detection of singing males. A singing male was assumed to represent a mated pair of birds of that species, even though some males may have been unmated. The term "numbers of pairs" as used throughout this report concerning the populations of the five indicator

species is synonymous with the term "numbers of detections of singing males."

The downriver census resulted in five indices to population size for the five species of obligate riparian birds chosen as indicator species. The indices, however, did not represent the total population for each species in the river corridor, but instead represented the proportion of the total population whose songs were detected during the study period. The true number of birds of a species present in any given year could be calculated by multiplying the count data by a correction factor. The use of a correction factor accounted for nonsinging males as well as those that were overlooked due to unavoidable bias and sampling error.

Preliminary correction factors were calculated for Bell's Vireo, Yellow Warbler, and Yellow-breasted Chat because they were the three most abundant indicator species. Willow Flycatcher and Common Yellowthroat did not occur in sufficient numbers or with sufficient regularity to allow a determination of the probability of detecting singing males of those species. The known number of vireos, warblers, and chats in several relatively isolated, distinct patches of habitat was compared to the number of those species counted during a downriver census of the same patches to obtain a mean probability that any given singing male would be detected.

Accuracy tests of Bell's Vireo censuses were performed three times in the first week of May 1987: one accuracy test revealed three of four known singing male vireos (75%); a second revealed four of seven known vireos (57%); a third revealed none of four known vireos (0%). All tests were performed between 0815 and 1200 hours in optimal vireo habitat between River Miles 166 and 225.

The correction factor was calculated as the ratio of the total number of vireos known present to the number identified for the same area in the downriver census (Marion 1974, Brown 1987). The mean percent of vireos identified in the three tests was 44%, and the probability of detecting any given singing male was 0.4 (probability rounded off to the nearest tenth). Therefore, a correction factor of 2.5 was used to convert each annual Bell's Vireo index to the true population size.

Accuracy tests of the Yellow Warbler census were performed twice in mid-June 1987: the first accuracy test identified three of three known warblers (100%), while the second identified four of six known warblers (67%). Both accuracy tests took place between 0840 and 1030 hours in optimum warbler habitat at Stairway Canyon and Parashant Wash. The mean percent of Yellow Warblers detected in the tests was 83%, and the probability of detecting any given singing male was 0.8. Therefore, a correction factor of 1.25 was used to

convert each annual Yellow Warbler index to the true population size.

Accuracy tests of the Yellow-breasted Chat census were performed twice in mid-June 1987: the first test identified one of two known chats (50%), while the second identified four of five known chats (80%). Both tests were conducted between 0840 and 1030 hours in optimum chat habitat at Stairway Canyon and Parashant Wash. The mean percent of Yellow-breasted Chats detected during the accuracy tests was 65%, and the probability of detecting any given singing male chat was 0.7. Therefore, a correction factor of 1.4 was used to convert each annual Yellow-breasted Chat census to the true population size.

Data obtained in the downriver censuses were analyzed in two ways. First, it was desirable to examine the data for significant trends in time. The annual population sizes of four of the indicator species with an adequate sample size for number of years (Common Yellowthroat was excluded since data from 1982 and 1983 were missing) were analyzed using Mann's test for trend (Mann 1945). Only very pronounced trends would be detected using this test when, in this case, the sample size (number of years each indicator species was sampled) was as small as six (6 years, 1982 to 1987). An additional analysis was performed using both the data from 1982 to 1987 (Brown 1987) and the data from 1976 (Carothers and Sharber 1976). Caution must be exercised when combining the 1976 data into a test for trend from 1976 to 1987 because of the 5-year data gap between the two sample periods. However, the data were combined in the additional analysis since the larger sample size resulted in a substantial gain in power.

The second way in which the downriver censuses were analyzed was by using a statistical model to determine if there was significant change between the yearly population indices of an indicator species. This model was a simple test of the null hypothesis that the true populations of a species in two given years (typically, the preceeding and the current year) were identical. Use of this model required the calculation of the proportion of the total population detected during a census of each species as determined through accuracy tests. The model was created specifically for use in this study, and will be referred to throughout the remainder of this report as the annual significant change model.

Let N_i ($i=1,2$) denote the true (but unknown) population of a species in year i, and let P represent the probability (as determined through accuracy tests) that the song of any given male of that species was detected during the census. Let X_i represent the random variable denoting the census in year i. Then, assuming that $(N_i)(P)>5$ and that $(N_i)(1-P)>5$, the distribution of X_i is approximately normal with a

mean of (Ni)(P) and a variance of (Ni)(P)(1-P). Also assume that X1=x1 and that X2=x2, for an absolute difference of x1-x2 . Under the null hypothesis of H:N1=N2,the random variable X1-X2 is normally distributed with a mean of zero and a variance of (N1+N2)(P)(1-P). This variance is unknown, but can be estimated from the data to be (x1 + x2)(1-P). Then, the null hypothesis would be rejected at a significance level of alpha=.05 if and only if

x1-x2 > 1.96 times the square root of [(x1+x2)(1-P)]

where 1.96 is the number of standard deviations away from zero that would allow alpha to equal .05 (obtained from a normal table).

For example, a comparison can be made between the Bell's Vireo population sizes as represented by their indices in 1986 and 1987. Then,

x1-x2 = 121-169 = 48

and

1.96 times the square root of [(x1+x2)(1-P)] =
1.96 times the square root of [(121+169)(1-0.4)] =
1.96 times 13.19 = 25.9

Since 48 > 25.9, the null hypothesis that the true populations in 1986 and 1987 are identical is rejected. Therefore, a significant (P<.05) increase in Bell's Vireo population size occurred from 1986 to 1987.

Several important assumptions of this model must be taken into account:

1. The number of birds detected in any year is a binomial random variable with Ni trials and a known probability P of success (i.e. Ni birds and a probability P of hearing any particular one).

2. Hearing any given singing male is independent of hearing any other singing male.

3. The probability of hearing any singing male is the same as hearing any other singing male.

4. The probability of hearing a singing male of any species under consideration is the same each year.

5. The binomial distribution of the downriver census data can be approximated with a normal distribution.

RESULTS

Site Census. The 1987 densities of breeding birds in the river corridor are presented in Table 2. Historic densities generated in 1984, 1985, and 1986 are also presented in Table 2 for comparative purposes. The data summaries from which the 1987 densities were calculated are found in Appendices 1 and 2.

A significantly greater density of breeding birds occurred in the NHWZ as compared to the OHWZ (three-way ANOVA, P=.0002). A trend of decreasing bird density in both the OHWZ and the NHWZ was evident in the annual mean density values (Table 2). This was a highly significant (three-way ANOVA, P=.0002) trend, indicating that overall avian density along the river has been decreasing since 1984.

Additional analysis (three-way ANOVA) of bird density between sites, years, and zones (OHWZ or NHWZ) indicated no meaningful interaction between those variables. Variation in bird densities between years was independent of sites (no significant difference, P=.189) and zones (no significant difference, P=.165). Variation between zones, however, was not independent of sites (significant difference, P=.021).

Downriver Census. The yearly indices to population size of the five indicator species included in the downriver census are indicated in Table 3. The raw data summaries by year and river reach for each species are presented in Appendices 3 through 8. Figure 1 displays selected yearly indices from Table 3 in graphic form.

Bell's Vireo and Yellow Warbler populations increased from 1986 to 1987, and in both cases these increases were significant (annual significant change model, P<.05). Willow Flycatcher, Common Yellowthroat, and Yellow-breasted Chat populations decreased from 1986 to 1987. The chat decrease was significant (annual significant change model, P<.05), but the flycatcher and yellowthroat decreases could not be examined for significance.

Comparison of annual count indices from 1982 to 1987 revealed a significant trend of increase in the population size of Yellow Warblers (Mann's test for trend, P=.016). A marginally significant trend of increase in the population size of Willow Flycatchers (.056<P<.136) and Yellow-breasted Chats (P=.056) occurred over the same time period. However, when a comparison for trend was made from 1976 to 1987, a significant to highly significant trend of increase occurred in the population sizes of Willow Flycatchers (.010<P<.030), Yellow Warblers (P=.002), and Yellow-breasted Chats (P=.010). Bell's Vireo was the only indicator species which showed no evidence of a significant trend, both for the period 1982 to 1987 (P=.720) and the period 1976 to 1987 (P=.238).

Table 2. Breeding bird density (pairs/40 ha) in OHWZ and NHWZ sites along the Colorado River in Glen and Grand canyons, 1984-1987. Site numbers correspond to those used in Table 1.

Site Number	Location	1984		1985		1986		1987	
		OHWZ	NHWZ	OHWZ	NHWZ	OHWZ	NHWZ	OHWZ	NHWZ
01	Glen Canyon/ Lees Ferry	318	441	200	552	282	338	188	21*
02	Saddle Canyon	538	486	300	571	388	371	300	386
03	Cardenas Canyon	747	941	613	824	1000	717	400	612
04	Lower Bass Camp	200	500	300	100	200	200	200	200
05	Forster Canyon	200	400	200	400	200	250	150	275
06	National Canyon	182	600	73	300	109	300	118	225
07	Stairway Canyon	565	857	529	1085	565	771	388	650
08	Parashant Wash	986	1200	943	1200	514	480	614	1500
09	Granite Park	357	480	229	220	182	320	139	160
10	220-Mile Canyon/Granite Springs Canyon	400	200	400	400	556	200	356	400
Mean Density		449	611	379	565	400	395	285	490**

* NHWZ site 01-B at Lees Ferry between the raft ramp and just above the mouth of the Paria River experienced a catastrophic wildfire in late March of 1987, leaving only a few tamarisk at the water's edge and the small cattail and Phragmites marshes intact. Density for this site reflects only those birds known to make use of these habitat remnants.

** The 1987 mean density for the NHWZ was calculated without including the 21 pairs/40 ha in the burned site 01-B.

Table 3. Yearly index to the population sizes of five indicator species of obligate riparian birds between Lees Ferry and Diamond Creek along the Colorado River in Grand Canyon, 1976 to 1987.

	Number of Singing Males Heard						
Species	1976	1982	1983	1984	1985	1986	1987
Willow Flycatcher*	1+	2	4	4	8	11	7
Bell's Vireo**	67++	135	78+++	92	75	121	169
Yellow Warbler***	17+	32	39	33	61	80	108
Common Yellowthroat***	8+	-	-	21	21	29	12
Yellow-breasted Chat*	18+	46	53	65	62	101	71

* Census data from June of each year.

** Census data from mid-April to early May of each year.

*** Census data from late May to June of each year.

\+ From Carothers and Sharber (1976). Average absolute density for April, May, and June, 1974 to 1976.

++ From the April 1976 field journal of S.W. Carothers (Brown et al. 1983).

+++ Census inaccurate due to poor weather and high winds.

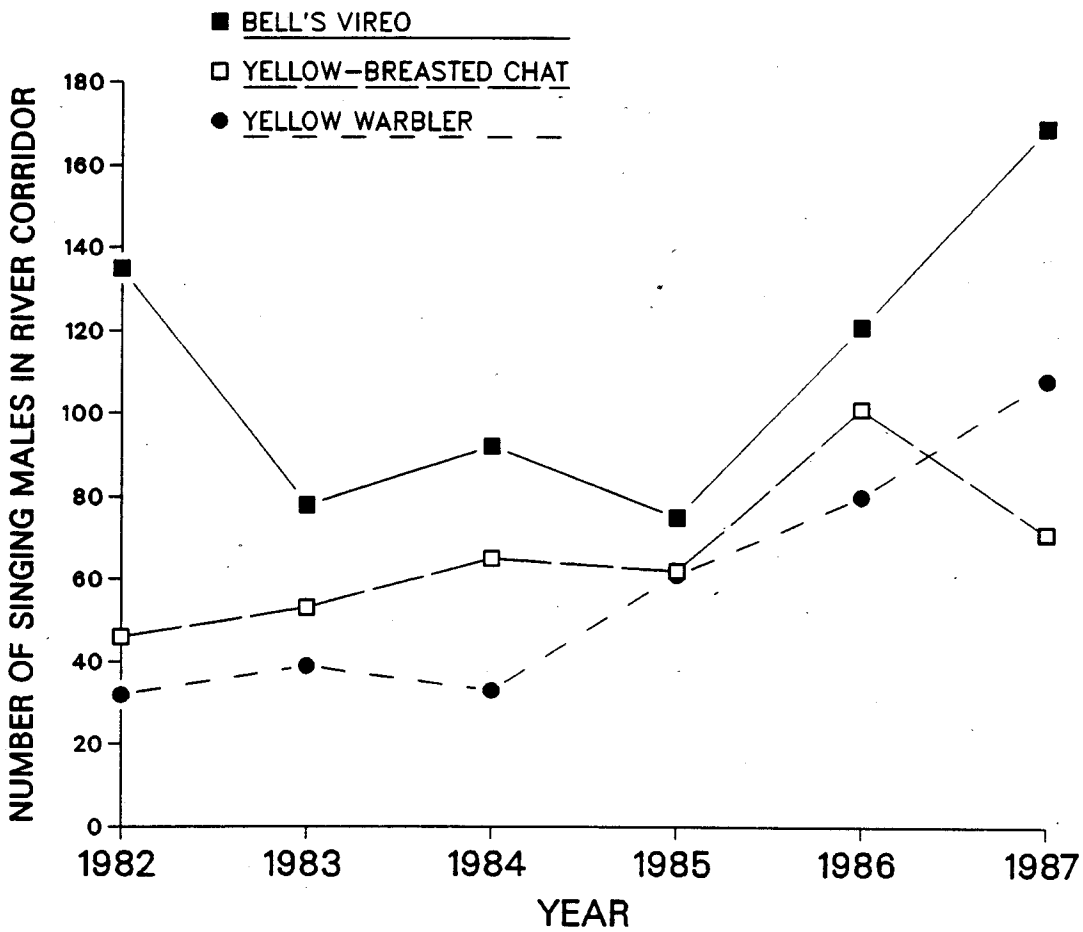

Figure 1. Indices to population sizes of Bell's Vireo, Yellow Warbler, and Yellow-breasted Chat along the Colorado River from Lees Ferry to Diamond Creek, 1982 to 1987.

DISCUSSION

Site Census. Breeding bird density per unit area has changed significantly from 1984 to 1987, and this change reflects a significant trend of decrease. The trend of decreasing density over time was independent of site and zone differences. This indicated that the changes over time were occurring evenly throughout the entire river corridor in both the NHWZ and the OHWZ. These findings over a 4-year period substanatiated the earlier findings of Brown (1987) that the uniform decline in density throughout the river corridor suggested one or more large scale, regional influences over bird density.

Brown (1987) discussed several large scale influences that could be affecting avian density. These influences include 1) operation of the dam, 2) regional climatic changes or cycles, 3) changing conditions on the wintering grounds or during migration, or 4) some combination of the above. Avian densities may have been declining due to habitat deterioration, habitat loss, or nest inundation resulting from dam operations during the period 1983 to 1987. The present monitoring study was designed only to identify potential patterns or trends, not to determine why the patterns or trends occurred.

That a significantly greater density of breeding birds was found in the NHWZ compared to the OHWZ was also a finding of previous studies (Brown 1987, Brown and Johnson 1987). This density contrast maintained itself over the 4-year period from 1984 to 1987.

The raw data for numbers of pairs per study site (Appendix 1 and 2) were converted to the standard unit of pairs/40 ha. This was done for the ease of comparison between areas, but has the drawback of possibly misrepresenting the area effects on converted density. All study sites were small, their combined total being less than 30 ha. To extrapolate the raw data to the standard pairs/40 ha, then, may have been misleading because no 40 ha tracts of riparian habitat existed in the study area. Furthermore, the same densities of birds would not have occurred in a contiguous, 40 ha tract because the edge effect (which greatly increases avian density in small areas) was not operating as strongly. This problem of comparison and scale was discussed by Brown and Johnson (1987).

Downriver Census. The abundance of all five indicator species increased from 1976 to 1986 (Brown 1987), but this pattern of increase appeared to stabilize or even reverse itself in 1987 for three of the five species. Yellow Warbler was the only indicator species which showed a strong and consistent trend of increase from 1976 to 1987. Although the 1987 Bell's Vireo population exceeded both its 1986 and pre-flood densities, the trend for increase was not

significant because of the cycle-like decline and recovery in numbers exhibited after the 1983 flood. Willow Flycatcher and Yellow-breasted Chat exhibited significant trends of increase from 1976 to 1987. However, the increasing trends were punctuated by sharp declines in 1987. Although data from the years 1976 to 1983 are missing, Common Yellowthroat apparently increased in numbers from 1976 to 1982 (Brown and Johnson 1987), declined sharply during and after the flood of 1983, and enjoyed a modest recovery in numbers by 1986 (Brown 1987). Nevertheless, the Common Yellowthroat population again declined sharply in 1987. Only 12 singing male Common Yellowthroats were detected in 1987, making this species one of the rarest breeding birds of the river corridor.

The reasons why Willow Flycatcher, Bell's Vireo, Yellow Warbler, and Yellow-breasted Chat population sizes changed so dramatically from 1986 to 1987 were not clear. Willow Flycatcher apparently prefers to nest in situations with shallow standing water beneath the nest (John Hubbard, personal communication). Flood conditions from 1983 to 1986 may have benefitted flycatchers with respect to this preference, while the lower water levels present in the river in the spring and early summer of 1987 may not have provided this benefit. Bell's Vireo and Yellow Warbler populations increased in 1987, apparently in response to changing conditions which were advantageous to them. The Yellow-breasted Chat decline in 1987 was a surprise, considering the strong and consistent chat increase from 1982 to 1986. Many of the long-term effects of flooding are indirect, and a lag time may exist between the flooding event and its eventual effect on bird populations. The Yellow-breasted Chat decline may have been related to an aspect of dam operation such as flooding, but the deline may not have occurred until 1987 due to this lag time. This is only speculation, but cyclic changes in nature involving lag times are not uncommon (Peek 1986).

The primary reasons for the continued Common Yellowthroat decline, however, were directly related to dam operations. The lowered water levels in 1987 were responsible for a number of factors which had a negative impact on yellowthroats or on their preferred habitat of marshes. First, the floods from 1983 to 1986 scoured away most low-lying marshy habitat (Brown and Johnson 1987). By 1986, marshes were being re-established at or above the 1984 to 1986 high-water-line of approximately 40,000 cubic feet per second (cfs). Flows in 1987 did not exceed approximately 30,000 cfs, and the lowered water levels caused the developing marshes to dessicate or to develop poorly. Furthermore, the few developing marshes were largely on unstable sand deposits formed during the 1983 flood. Marshes located on unstable sand deposits under observation during this study were quickly eroded away under low flow conditions, reducing the extent of developing marshes. And

finaly, Common Yellowthroats prefer to nest in close proximity to or over water (Brown and Johnson 1987). The majority of vegetation suitable for yellowthroat nesting below the 40,000 cfs waterline had been eroded away by the floods of 1983 to 1986, leaving little or no vegetation near the 1987 waterline. This combination of factors apparently was partially responsible for the Common Yellowthroat decline observed in 1987. Other factors could have been involved, such as poor reproductive success in 1986.

The correction factors calculated for Bell's Vireo, Yellow Warbler, and Yellow-breasted Chat allowed for a determination of their true population size. The 169 singing male Bell's Vireos identified during the 1987 downriver census, multiplied by the vireo correction factor of 2.5, indicate a total of 422.5 pairs present in the river corridor. The vireo correction factor of 2.5 generated during this study was the same as the correction factor previously generated (Brown 1987). This similarity over time placed a higher degree of confidence in both the vireo correction factor of 2.5 and in the probability of 0.4 that any given singing male vireo would be detected.

The number of singing male Yellow Warblers detected in the 1987 census (108) multiplied by the warbler correction factor (1.25) indicated approximately 135 pairs of Yellow Warblers were present. Likewise, the number of Yellow-breasted Chats present in 1987 (71) multiplied by their correction factor (1.4) indicated approximately 99 pairs of chats were present. These correction factors can be used to calculate the true population sizes of warblers and chats in previous years for which census data is available. The ability to perform additional accuracy tests of warbler and chat censuses in the future would greatly increase the reliability of the correction factors calculated in 1987 for these species.

The accuracy tests that were performed, however, were limited in number due to the constraints of logistics and scheduling required by the study. The result was that the accuracy tests were undersampled and the variation involved with these samples was too high. The mean detection rates for these three species suggested a substantial error rate in the estimates of true population size. For this reason, the estimates of true population size should be interpreted with caution.

The probability of detecting any given Yellow Warbler or Yellow-breasted Chat was much greater than the probability of detecting a Bell's Vireo, based on the accuracy tests of the downriver census. This difference was due to several reasons. Yellow Warblers occurred almost entirely at the river's edge, making it easier to detect them from a boat on the river. Yellow Warblers and Yellow-breasted Chats also appeared to be consistently more vocal than vireos, although

data on rates of vocalizations were not gathered in this study. And finally, the loud, piercing vocalizations of Yellow-breasted Chats allowed them to be detected from greater distances.

An apparent contradiction existed between the results of the site census and the results of the downriver census. How can overall bird density be decreasing, while the population sizes of two of the indicator species were increasing? This apparent contradiction was also present in previous findings by Brown (1987), and was discussed in that study. In summary, the site census and the downriver census were only partially overlapping. The site census measured absolute density per unit area, without any measure of population size for the entire river corridor. The downriver census measured only the population size of five selected indicator species for the entire river corridor. The apparent contradiction of decreasing absolute density for the entire community and increasing population size of only a few species was not a contradiction at all. This was especially evident when considering that a few species could easily be increasing while the density of the entire breeding bird commuity decreased. This apparent contradiction does reinforce the previous finding (Brown 1987) that population trends of the indicator species may not accurately reflect population trends of the avian commuity as a whole. Nevertheless, indicator species did serve to provide information on the overall ecological health of the avian community and to identify some of the short-term, direct impacts to birds caused by the dam.

Long-term Prospects for the Breeding Bird Community. All indications suggested that the breeding bird community has been in a state of constant change, or flux, during the last 5 years. This state of constant change actually began with construction of Glen Canyon Dam in 1963 and has continued to the present. The change in operating criteria at the dam once the reservoir reached maximum pool elevation in 1980, as well as the floods from 1983 to 1986, acted to further increase the rate of change. The breeding bird community will not stabilize until dam operations stabilize around consistent, long-term operating criteria. The population increases observed in the indicator species from 1976 to 1986 may soon level off or even reverse themselves, as indicated by the substantial population declines of 1987.

The long-term patterns and trends identified in this study stronly suggest management guidelines for operating the dam for the benefit of avian resources. For example, the elimination of floods during the breeding season would prevent the drastic population declines that were observed after the 1983 flood due to nest inundation (Brown and Johnson 1987). However, only these most dramatic patterns of avian density change have been directly linked with dam operations.

Most research to date has been centered around what the patterns and trends are. Future research should be focused on why the patterns and trends occur in order to firmly establish the indirect, more subtle links between dam operations and breeding birds. These subtle links mainly involve food resources and habitat availability and quality, subjects which would require long-term, multidisciplinary research to provide conclusive results.

The future of breeding birds along the Colorado River in Grand Canyon is closely linked to the operation of Glen Canyon Dam. Effective long-term management of breeding birds will be a function of well-designed dam operations based on a clear knowledge of how operations affect avian density and ecology.

CONCLUSIONS

The following conclusions can be drawn from the findings of this study:

1. Breeding bird density at established study sites showed a significant trend of decline during the period from 1984 to 1987.

2. In contrast, population sizes of three of the five indicator species (Willow Flycatcher, Yellow Warbler, and Yellow-breasted Chat) show significant trends of increase from 1976 to 1987. However, Willow Flycatcher and Yellow-breasted Chat populations declined significantly from 1986 to 1987, possibly indicating that they have reached a peak and may now stabilize or decline.

3. Common Yellowthroats exhibited a further decline in population size in 1987, and have become one of the rarest breeding birds of the river corridor. This was partly due to the inability of their preferred marshy habitat to recover in extent and quality from the effects of flooding during the period 1983 to 1986.

4. The Bell's Vireo population showed a significant increase from 1986 to 1987. The vireo population has fully recovered from the negative impacts of the 1983 flood, to the extent that by 1987 the population had exceeded its preflood (1982) size.

5. The findings of this study were not designed to indicate why these patterns and trends occurred in the riparian breeding bird community, with the exception of those direct and dramatic impacts of flooding. Additional research would be necessary to firmly establish the indirect, long-term links between dam operations and the density and ecology of breeding birds.

6. Trends in population sizes of the five indicator species were not found to be useful as a guide to understanding long-term trends in the density of the entire riparian breeding bird community. Monitoring the populations of the five indicator species was useful, however, both in identifying the short-term, direct response of some species to dam operations, and in serving as a barometer of the general ecological health of riparian breeding birds.

LITERATURE CITED

Brian, N.J. 1987. Aerial photographic comparison of 1983 high flow impacts to vegetation at eight Colorado River beaches. Final technical report, Glen Canyon Environmental Studies, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Brown, B.T. 1987. Monitoring bird population densities along the Colorado River in Grand Canyon. Final technical report, Glen Canyon Environmental Studies, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Brown, B.T., S.W. Carothers, and R.R. Johnson. 1983. Breeding range expansion of Bell's Vireo in Grand Canyon, Arizona. Condor 85:499-500.

Brown, B.T., S.W. Carothers, and R.R. Johnson. 1987. Grand Canyon birds: historical notes, natural history, and ecology. University of Arizona Press, Tucson.

Brown, B.T., and R.R. Johnson. 1985. Glen Canyon Dam, fluctuating water levels, and riparian breeding birds: the need for a management compromise on the Colorado River in Grand Canyon. USDA For. Serv. Gen. Tech. Rep. RM-120:76-80.

Brown, B.T., and R.R. Johnson. 1987. Fluctuating flows from Glen Canyon Dam and their effect on breeding birds of the Colorado River. Final technical report, Glen Canyon Environmental Studies, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Bull, E.L. 1981. Indirect estimates of abundance of birds. Studies in Avian Biology 6:76-80.

Carothers, S.W., and R.R. Johnson. 1975. Recent observations on the status and distribution of some birds of the Grand Canyon region. Plateau 47(4):140-153.

Carothers, S.W., and N.J. Sharber. 1976. Birds of the Colorado River. In: S.W. Carothers and S.W. Aitchison (eds.), An ecological survey of the riparian zone of the Colorado River between Lees Ferry and the Grand Wash Cliffs,

Arizona. Colorado River Tech. Rpt. No. 10, Grand Canyon National Park, Arizona. pp. 109-122.

Mann, H.B. 1945. Nonparametric tests against trend. Econometrica 13:245-259.

Marion, W.R. 1974. Status of the Plain Chachalaca in south Texas. Wilson Bull. 86:200-205.

Peek, J.M. A review of wildlife management. Prentice-Hall Books, Englewood Cliffs, New Jersey.

Pucherelli, M.J. 1987. Evaluation of riparian vegetation trends in the Grand Canyon using multitemporal remote sensing techniques. Final technical report, Glen Canyon Environmental Studies, Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah.

Ralph, C.J., and J.M. Scott (Eds.). 1981. Estimating numbers of terrestrial birds. Studies in Avian Biology No. 6, Cooper Ornithological Society. 630 pp.

Schemnitz, S.D. (Ed.) 1980. Wildlife management techniques manual. Fourth edition, revised. The Wildlife Society, Washington, D.C. 686 pp.

Stevens, L. 1983. The Colorado River in Grand Canyon: a guide. Red Lake Books, Flagstaff, Arizona. 107 pp.

Turner, R.M., and M.M. Karpiscak. 1980. Recent vegetation changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona. U.S. Geol. Survey Prof. Paper 1132, U.S. Govt. Print. Office, Washington, D.C. 125 pp.

Appendix 1. Actual numbers of pairs of breeding or potentially breeding birds in OHWZ study sites along the Colorado River in Glen and Grand Canyons, 1987.

	OHWZ study sites									
Species	1	2	3	4	5	6	7	8	9	10
Mourning Dove	1						1	2.5	1	2
Black-chinned Hummingbird	1	2	1		0.5		2	2	2	
Costa's Hummingbird						1		1		
Ash-throated Flycatcher	1	1	1		0.5	0.5	1	1	1.5	1
Bewick's Wren	1	1	3					1		
Blue-gray Gnatcatcher	1	2	3				2	2	2	2
Phainopepla							1	1	1	
Mockingbird									1	
Bell's Vireo							1	3	4.5	2
Lucy's Warbler	1	2.5	4	0.5	.75	5	6	3	4	1
Yellow Warbler								0.5		
Yellow-breasted Chat	0.5	0.5					0.5	1		
Summer Tanager								0.5		
Blue Grosbeak		1			0.5		0.5	0.5	1	
Black-headed Grosbeak	0.5									
Brown-headed Cowbird		1	1				0.5	1		
Hooded Oriole								0.5		
Lesser Goldfinch			1					1		
House Finch	1	1	1				1	2	0.5	
Total Density	8	12	15	0.5	2.25	6.5	16.5	21.5	18.5	8
No. of Species	9	9	8	1	4	3	11	16	10	5

Appendix 2. Actual numbers of pairs of breeding or potentially breeding birds in NHWZ study sites along the Colorado River in Glen and Grand canyons, 1987.

	NHWZ study sites									
Species	1	2	3	4	5	6	7	8	9	10
Mourning Dove		1	1					0.5		
Black-chinned Hummingbird		5	4		0.5		1	1	1	
Costa's Hummingbird						0.5				
Ladder-backed Woodpecker		0.5								
Willow Flycatcher		1	2							
Ash-throated Flycatcher		1	1		0.5	0.25		0.5	0.5	
Bewick's Wren	1	2.5	2							
Blue-gray Gnatcatcher		3	1			0.5				
Bell's Vireo							2	1	1.5	0.5
Lucy's Warbler		4	4	0.5	0.75	0.5	1			0.5
Yellow Warbler		2	2			0.5	1	1.5		
Common Yellowthroat			1							
Yellow-breasted Chat		4	1				1	0.5		
Summer Tanager		1								
Blue Grosbeak			1		0.5			0.5		
Great-tailed Grackle	0.5				0.5					
Brown-headed Cowbird		2	1					1	1	
Hooded Oriole			1				0.25	0.5		
Lesser Goldfinch			1							
House Finch			3							
Total Density (pairs)	1.5*	27	26	0.5	2.75	2.25	6.5	7.5	4	1
Number of Species	2*	12	15	1	5	5	7	10	4	2

* NHWZ site 01-B experienced a catastrophic wildfire in late March of 1987, destroying virtually all vegetation in the site except for a few tamarisk at the water's edge and the small cattail and *Phragmites* marshes. The reduced number of species and total density exhibited at this site reflects the loss of vegetation due to wildfire.

Appendix 3. Yearly index to the number of detections of singing male Willow Flycatchers from Lees Ferry to Diamond Creek, 1982-1987, by river reach. Censuses made in June.

	Year					
River Reach	1982	1983	1984	1985	1986	1987
River Reach 1						
Lees Ferry to Buckfarm	0	0	0	0	0	0
Buckfarm to Nankoweap Creek	1	4	3	7	8	4
Nankoweap to Little Colorado	0	0	0	0	1	0
(Yearly total for Reach 1)	(1)	(4)	(3)	(7)	(9)	(4)
River Reach 2						
Little Colorado to Cardenas	1	0	1	1	2	3
Cardenas to Phantom Ranch	0	0	0	0	0	0
(Yearly total for Reach 2)	(1)	(0)	(1)	(1)	(2)	(3)
River Reach 3						
Phantom Ranch to Kanab	0	0	0	0	0	0
Kanab to National Canyon	0	0	0	0	0	0
(Yearly total for Reach 3)	(0)	(0)	(0)	(0)	(0)	(0)
River Reach 4						
National to Lava Falls	0	0	0	0	0	0
Lava Falls to Parashant	0	0	0	0	0	0
Parashant to Granite Park	0	0	0	0	0	0
Granite Park to Diamond Cr.	0	0	0	0	0	0
(Yearly total for Reach 4)	(0)	(0)	(0)	(0)	(0)	(0)
Yearly Total	2	4	4	8	11	7

Appendix 4. Yearly index to the number of detections of singing male Bell's Vireos from Lees Ferry to Diamond Creek, 1982-1987, by river reach. Censuses made in April and early May.

	Year					
River Reach	1982	1983	1984	1985	1986	1987
River Reach 1						
Lees Ferry to Buckfarm	0	0	0	0	0	0
Buckfarm to Nankoweap Creek	0	0	0	2	1	2
Nankoweap to Little Colorado	0	0	3	0	0	2
(Yearly total for Reach 1)	(0)	(0)	(3)	(2)	(1)	(4)
River Reach 2						
Little Colorado to Cardenas	3	0	3	1	2	2
Cardenas to Phantom Ranch	0	0	0	0	0	1
(Yearly total for Reach 2)	(3)	(0)	(3)	(1)	(2)	(3)
River Reach 3						
Phantom Ranch to Kanab	0	0	0	1	0	1
Kanab to National Canyon	3	0	0	0	0	1
(Yearly total for Reach 3)	(3)	(0)	(0)	(1)	(0)	(2)
River Reach 4						
National to Lava Falls	36	32	28	32	34	39
Lava Falls to Parashant	46	15	40	18	53	64
Parashant to Granite Park	39	24	15	16	20	47
Granite Park to Diamond Cr.	8	7	3	5	11	10
(Yearly total, Reach 4)	(129)	(78)	(86)	(71)	(118)	(160)
Yearly Total	135	78*	92	75	121	169

* Census inaccurate due to poor weather and high winds.

Appendix 5. Yearly index to the number of detections of singing male Bell's Vireos from Lees Ferry to Phantom Ranch, 1982-1987, by river reach. Censuses made in June.

	Year					
River Reach	1982	1983	1984	1985	1986	1987
River Reach 1						
Lees Ferry to Buckfarm	0	1	0	0	0	0
Buckfarm to Nankoweap Creek	1	2	2	1	7	5
Nankoweap to Little Colorado	1	1	0	2	3	5
(Yearly total for Reach 1)	(2)	(4)	(2)	(3)	(10)	(10)
River Reach 2						
Little Colorado to Cardenas	1	2	3	2	2	3
Cardenas to Phantom Ranch	1	1	0	0	0	0
(Yearly total for Reach 2)	(2)	(3)	(3)	(2)	(2)	(3)
Yearly total, Both Reaches	4	7	5	5	12	13

Appendix 6. Yearly index to the number of detections of singing male Yellow Warblers from Lees Ferry to Diamond Creek, 1982-1987, by river reach. Censuses made in late May and June.

	Year					
River Reach	1982	1983	1984	1985	1986	1987
River Reach 1						
Lees Ferry to Buckfarm	1	3	2	1	2	0
Buckfarm to Nankoweap Creek	5	27	8	32	42	35
Nankoweap to Little Colorado	5	0	3	7	5	24
(Yearly total for Reach 1)	(11)	(30)	(13)	(40)	(49)	(59)
River Reach 2						
Little Colorado to Cardenas	3	1	4	2	3	4
Cardenas to Phantom Ranch	0	1	3	4	3	0
(Yearly total for Reach 2)	(3)	(2)	(7)	(6)	(6)	(4)
River Reach 3						
Phantom Ranch to Kanab	1	0	1	1	1	0
Kanab to National Canyon	0	0	0	1	1	1
(Yearly total for Reach 3)	(1)	(0)	(1)	(2)	(2)	(1)
River Reach 4						
National to Lava Falls	12	5	3	7	13	23
Lava Falls to Parashant	5	2	8	6	10	19
Parashant to Granite Park	0	0	1	0	0	2
Granite Park to Diamond Cr.	0	0	0	0	0	0
(Yearly total for Reach 4)	(17)	(7)	(12)	(13)	(23)	(44)
Yearly Total	32	39	33	61	80	108

Appendix 7. Yearly index to the number of detections of singing male Yellow-breasted Chats from Lees Ferry to Diamond Creek, 1982-1987, by river reach. Censuses made in June.

	Year					
River Reach	1982	1983	1984	1985	1986	1987
River Reach 1						
Lees Ferry to Buckfarm	4	3	9	5	6	2
Buckfarm to Nankoweap Creek	6	21	17	20	27	19
Nankoweap to Little Colorado	3	2	3	1	5	11
(Yearly total for Reach 1)	(13)	(26)	(29)	(26)	(38)	(32)
River Reach 2						
Little Colorado to Cardenas	2	2	4	3	6	3
Cardenas to Phantom Ranch	0	2	0	1	3	1
(Yearly total for Reach 2)	(2)	(4)	(4)	(4)	(9)	(4)
River Reach 3						
Phantom Ranch to Kanab	1	1	0	0	1	0
Kanab to National Canyon	1	0	0	0	0	0
(Yearly total for Reach 3)	(2)	(1)	(0)	(0)	(1)	(0)
River Reach 4						
National to Lava Falls	12	4	8	14	17	12
Lava Falls to Parashant	13	8	21	13	24	12
Parashant to Granite Park	4	8	2	5	11	11
Granite Park to Diamond Cr.	0	2	1	0	1	0
(Yearly total for Reach 4)	(29)	(22)	(32)	(32)	(53)	(35)
Yearly Total	46	53	65	62	101	71

Appendix 8. Yearly index to the number of detections of singing male Common Yellowthroats from Lees Ferry to Diamond Creek, 1982-1987, by river reach. Censuses made in June.

	Year					
River Reach	1982	1983	1984	1985	1986	1987
River Reach 1						
Lees Ferry to Buckfarm	-	-	2	2	3	0
Buckfarm to Nankoweap Creek	-	-	2	3	8	2
Nankoweap to Little Colorado	-	-	1	0	4	1
(Yearly total for Reach 1)	(-)	(-)	(5)	(5)	(15)	(3)
River Reach 2						
Little Colorado to Cardenas	-	-	1	1	3	2
Cardenas to Phantom Ranch	-	-	0	1	0	0
(Yearly total for Reach 2)	(-)	(-)	(1)	(2)	(3)	(2)
River Reach 3						
Phantom Ranch to Kanab	-	-	1	2	3	3
Kanab to National Canyon	-	-	0	0	0	0
(Yearly total for Reach 3)	(-)	(-)	(1)	(2)	(3)	(3)
River Reach 4						
National to Lava Falls	-	-	4	5	4	2
Lava Falls to Parashant	-	-	7	6	4	0
Parashant to Granite Park	-	-	0	1	0	0
Granite Park to Diamond Cr.	-	-	3	0	0	2
(Yearly total for Reach 4)	(-)	(-)	(14)	(12)	(8)	(4)
Yearly Total	-	-	21	21	29	12

Appendix 8. Yearly index to Common Yellowthroat densities from Lees Ferry to Diamond Creek, 1982-1986, by river reach. Censuses made in June.

River Reach	Year 1982	1983	1984	1985	1986
River Reach 1					
Lees Ferry to Buckfarm Canyon	-	-	2	2	5
Buckfarm to Nankoweap Creek	-	-	2	3	8
Nankoweap to Little Colorado	-	-	1	0	4
(Yearly total for Reach 1)	(-)	(-)	(5)	(5)	(15)
River Reach 2					
Little Colorado to Cardenas	-	-	1	1	3
Cardenas to Phantom Ranch	-	-	0	1	0
(Yearly total for Reach 2)	(-)	(-)	(1)	(2)	(3)
River Reach 3					
Phantom Ranch to Kanab Creek	-	-	1	2	3
Kanab to National Canyon	-	-	0	0	0
(Yearly total for Reach 3)	(-)	(-)	(1)	(2)	(3)
River Reach 4					
National to Lava Falls	-	-	4	5	4
Lava Falls to Parashant Wash	-	-	7	6	4
Parashant to Granite Park	-	-	0	1	0
Granite Park to Diamond Creek	-	-	3	0	0
(Yearly total for Reach 4)	(-)	(-)	(14)	(12)	(8)
Yearly Total	-	-	21	21	29