GRAND CANYON AVIAN COMMUNITY MONITORING
1993-94 Annual Progress Report

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General Introduction

The riparian habitat along the Colorado River corridor through the Grand Canyon[1] has undergone dramatic change as a result of the construction and operation of Glen Canyon Dam. Once warm, sediment-laden and free-flowing, the Colorado River was transformed into a cold, clear, flow-regulated river. The extent of daily flow rate fluctuations increased, and as a result river level elevation changed as much as 2-3 meters daily in some areas. Also, reduced sediment load influenced beach formation and erosion, and scouring of the lower riparian zone (Carothers and Brown 1991). Because of these and other changes, riparian habitat characteristics were dramatically altered, with an overall increase in the amount of riparian vegetation. The newly created riparian habitat supports a canyon bird community that is very different from that which occurred as recently as 40 years ago (Brown et al. 1984, Carothers and Brown 1991).

Although some of the most dramatic changes to the riparian avifauna along the river corridor may have already occurred, continued operation of Glen Canyon Dam may have significant on-going and future effects. The fluctuating flows released from the dam could have, in essence, two types of impacts on the avian community - direct and indirect. Direct (short-term) impacts could occur if birds or their nests are drowned, or if the nest substrate is destroyed. Indirect (long-term) impacts could arise primarily from flow-induced changes in riparian habitat (e.g., distribution, amount, patch size, composition, and structure).

In 1991, the Bureau of Reclamation modified the operation of Glen Canyon Dam by adopting an interim flow operations program that included a reduced operation regime (reduced fluctuation levels and flow rates) with specific changes in maximum flows and daily flow fluctuations. Interim flows were initiated in the hopes of reducing negative impacts to the biological, cultural, and physical resources of the Grand Canyon. An interim flow monitoring program was also initiated in 1991, with the intent to determine if the interim flow regime was actually reducing these impacts.

In 1992, the NPS Cooperative Park Studies Unit (now the National Biological Survey Colorado Plateau Research Station) was asked to design and conduct an avian monitoring component for the BoR's interim flow monitoring program. The avian monitoring project was to include examination of direct impacts (e.g., flooding of nests) and indirect impacts (e.g., avian response to habitat changes). Such data would provide resource managers and decision makers with the information needed to make resource and operation decisions.

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[1] Note that the Grand Canyon, as used in this report, includes the Colorado River corridor from Glen Canyon Dam downstream to Diamond Creek. Thus, the Grand Canyon includes portions of Glen Canyon National Recreation Area, the Hualapai Tribe, the Havasupai Tribe, the Navajo Tribe, and Grand Canyon National Park.

We designed this project primarily to meet the following objectives:

1. determine the direct impacts of Glen Canyon Dam interim flow operations on the nests and nesting of riparian birds along the Colorado River Corridor.

2. investigate possible long-term effects of Glen Canyon Dam flows by documenting patterns of avian use of riparian habitats, particularly with regard to bird species composition and habitat patch size/vegetative composition.

We also felt that it was important to develop and test methodologies that would allow park managers to monitor the status of the bird communities along the river, in order to detect and react to changes in species composition or population levels. Furthermore, in order to better interpret and understand changes in the avian community, it would be necessary to understand the resident status, migratory patterns, and habitat use of the birds using the riparian corridor. Therefore, we also included the following objectives:

3. determine the residence status and movements of bird species using the Colorado River riparian corridor (e.g., do individuals stay within the canyon, and do they move between habitat patches).

4. develop and test methodologies suitable for the long-term monitoring of avian population levels and distribution within the river corridor.

5. document patterns of insect abundance in riparian habitats and the diets of common insectivorous birds, in order to better understand how terrestrial birds use the aquatic and terrestrial food resources.

Past research, some of it associated with GCES Phase I, documented the overall composition and general distribution of bird species or communities within the Grand Canyon (Carothers and Sharber 1976, Brown 1988, Brown et al. 1988, Sogge and Tibbitts 1992) or looked at the direct (flooding) impacts of previous flow regimes (Brown and Johnson 1988). However, our avian monitoring project is the first designed specifically to meet all of the objectives listed above.

This is an annual progress report. It is not intended to be, nor should it be interpreted as, a final report. Additional data remains to be collected, synthesized, analyzed and presented in the final project report (due in September 1995). This annual progress report summarizes our monitoring efforts to date, and is organized by "chapters" that address each of the study objectives. Each chapter is organized into sections that introduce the specific topic, outline our methods and progress to date, and present our plans for the 1995 field season. Only the common names of bird species are used throughout the text of this report - scientific names for all species are presented in Appendix 1.

Objective 1. Determining direct impacts of interim flow operations on the nests and nesting of riparian birds.

Introduction

Since the completion of Glen Canyon Dam in 1963, the manipulation of river flows has allowed the development of new riparian habitat for breeding birds along the Colorado River in the Grand Canyon. This new high water zone (NHWZ) vegetation is dominated by salt cedar (*Tamarix chinensis*), seepwillow (*Baccharis salicifolia*), sandbar willow (*Salix exigua*), common reed (*Phragmites communis*), and cattail (*Typha* spp.). The NHWZ is very different from the old high water zone (OHWZ) vegetation dominated by catclaw (*Acacia greggii*), honey mesquite (*Prosopis glandulosa*), and netleaf hackberry (*Celtis reticulata*: Turner and Karpiscak 1980). Brown and Johnson (1987) found that fluctuating flows directly affected birds breeding in this new environment by flooding active nests. Their study was conducted during a period of high daily fluctuations (sometimes over 2 m daily change in river level), and enormous seasonal fluctuations (e.g. high flows of 93,000 cubic feet/second [cfs] in June, 1993). They found that flows as high as 31,000 cfs (maximum powerplant output from Glen Canyon Dam) flooded few nests, while flows over 40,000 cfs began having significant impacts on some riparian breeding species.

Under the current interim flow regime in operation since 1991, peak flows cannot exceed 20,000 cfs and daily fluctuations are limited to between 5,000 and 8,000 cfs (USDI Bureau of Reclamations 1993). Given Brown and Johnson's (1987) findings, flooding of active nests under the interim flows might be expected to be negligible. However, changes in riparian vegetation associated with interim flows have concentrated new vegetative growth in a narrower band near the river's edge (Stevens and Ayers 1994). Also, the relationship between daily and seasonal variations in river stage under interim flows may influence nest inundation more than the maximum daily or seasonal stage alone. These factors may have effects that were not seen in earlier studies on the riparian breeding birds.

In order to determine if interim flows were flooding nests of riparian birds, we conducted searches for bird nests along the river corridor in 1993 and 1994. We concentrated on NHWZ habitats in the hydrologically active zone (HAZ), the area inundated by 20,000 cfs flows. We monitored all nests to see if nest inundation occurred. We also measured river stage at each study site to relate site-specific stage to flows from Glen Canyon Dam. In this way we will be able to determine how many of the nests that we found were below river stage at 20,000 cfs (i.e., how many nests were potentially in danger of inundation).

Methodology

Nest searches were carried out at five direct-impact study sites (Figure 1): Lee's Ferry (RM 0.0R, above and below the boat ramp), Triple Alcoves above Saddle Canyon (RM 46.7R), Stairway Canyon (RM 171.0R 1993 only), above Parashant Wash (RM 198.0R), and Spring Canyon (204.5R, 1994 only). We concentrated nest search efforts in the projected HAZ at each site, and looked for nests in May, June, and July, 1993; and March through July, 1994. Nest searches were conducted following the protocol of Martin and Guepel (1993), where observations of bird behavior, especially during nest construction and brood-rearing, were used to locate active nests. We also monitored all nests found during other field activities, but outside the HAZ. Data collected at the nest site included date found, river mile, species, stage of nest development, number of eggs or young, description and sketch of the nest site, habitat type (NHWZ, OHWZ, upland), nest substrate (i.e. what nest was built on), height above ground, distance to water, distance above water, and water depth below nest (when applicable). Nests were revisited on following trips to determine nest fate and number of eggs or young when nest was revisited.

Because no hydrological model currently exists to accurately define the relationship between flows from Glen Canyon Dam and river stage (elevation) at each of our study sites, we determined the relationships between nest placement, river stage, and water releases by following the methods of Brown and Johnson (1987). We measured peak daily river stage with a staff gage vertically referenced to a permanent point at each direct impact study site. River stage relative to this point will then be related to river flow by back-dating to the corresponding peak flows at the Lee's Ferry gaging station, or the nearest upstream gage if tributaries were flooding.

Progress to Date

We located 17 nests in 1993 (13 at major study sites) and 46 nests in 1994 (24 at major study sites) in the NHWZ and OHWZ habitats along the river corridor (Table 1). Thirty of these belonged to "obligate riparian birds" (Brown and Johnson 1988), those species which nest only in NHWZ vegetation. Though delineation of the HAZ is still incomplete, only three of these 63 nests were located within what was probably the HAZ at any of the major study sites: two Common Yellowthroat nests and one Mallard nest (Tables 2 and 3). Later visits showed that none of these nests failed due to inundation.

While moving by boat between study sites, we also found three active Black Phoebe nests on boulders or rock walls along the river away from our direct impact study sites. Two of these nests were within 1 m of the river stage when found and were later found to have washed away. All three were probably within the HAZ, but without a good flow-to-stage relationship at these locations, it is difficult to say.

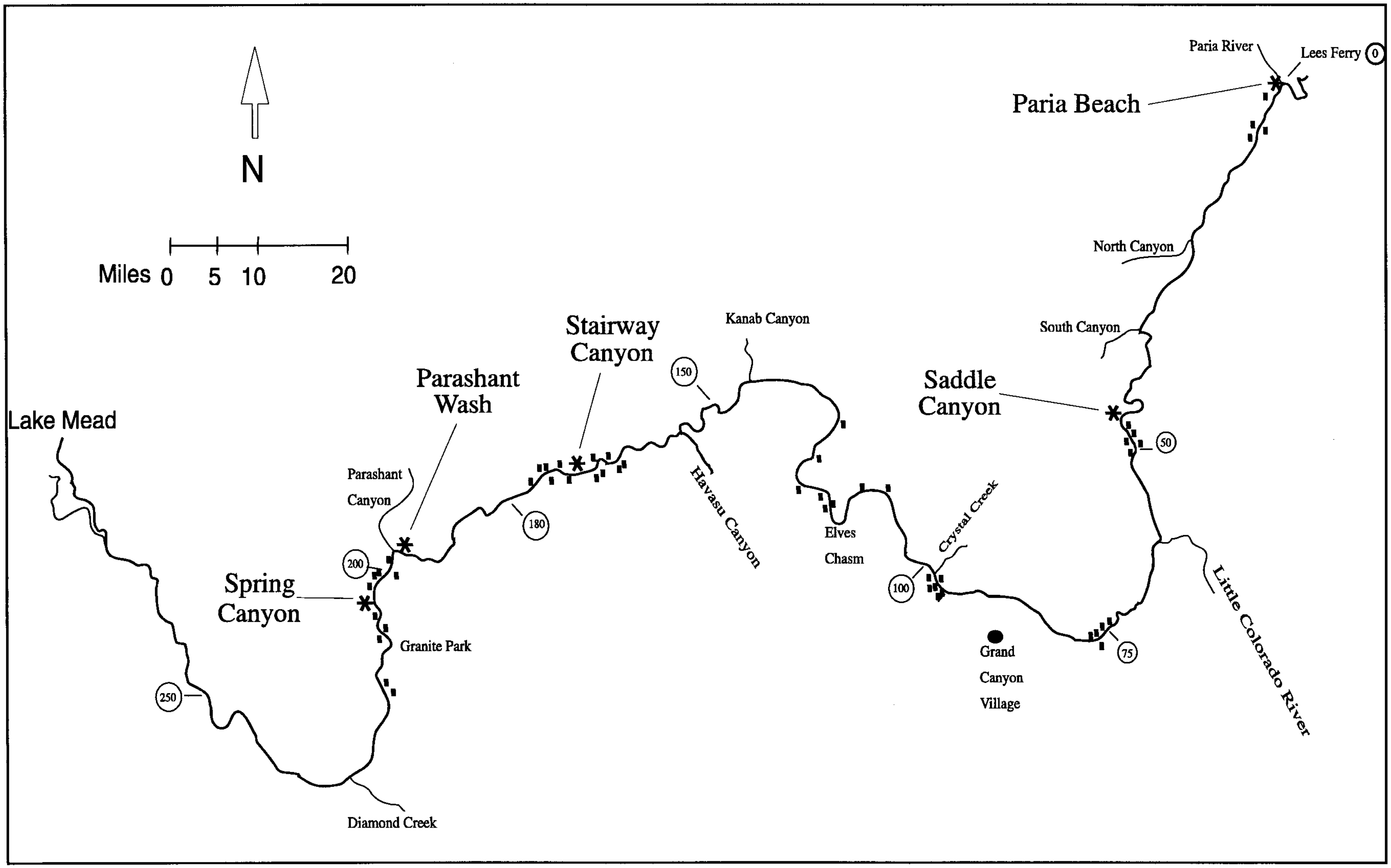

Fig. 1. Location of Grand Canyon avian community monitoring direct impact study sites (✱) and survey sites (▪) in Grand Canyon National Park.

Table 1. Bird species and number of nests found in riparian habitat along the Colorado River in Grand Canyon National Park, 1993-94.

Species nesting	Number	Species nesting	Number
Mallard	1	Lucy's Warbler	3
Mourning Dove	3	Yellow Warbler	3
Black-chinned Hummingbird	8	Common Yellowthroat	5
Black Phoebe	4	Yellow-breasted Chat	2
Say's Phoebe	1	Blue Grosbeak	2
Verdin	1	Great-tailed Grackle	1
Bewick's Wren	1	Northern Oriole	1
Blue-gray Gnatcatcher	9	Lesser Goldfinch	1
Bell's Vireo	15	Unknown	2

Table 2. Results of nest searches in the hydrologically active zone (HAZ) at direct impact study sites in Grand Canyon National Park, 1993.

Site	Search hours in HAZ	# nests found in HAZ	# nests found out of HAZ	# of total nests that were "riparian obligates"
Lee's Ferry	7.0	0	1	1
Saddle	9.5	0	0	0
Stairway	12.5	0	7	5
Parashant	9.5	0	4	4
Total	38.5	0	12	10

Table 3. Results of nest searches in the hydrologically active zone (HAZ) at direct impact study sites in Grand Canyon National Park, 1994.

Site	Search hours in HAZ	# nests found in HAZ	# nests found out of HAZ	# of total nests that were "riparian obligates"
Lee's Ferry	15.0	1	1	1
Saddle	32.5	1	3	4
Stairway	7.5	0	3	2
Parashant	28.0	0	8	4
Spring	18.0	1	6	5
Total	101.0	3	21	15

Plans for 1995

During the 1995 field season, we will continue to search for nests within the inundation zone during monthly river trips from March through June. Work is progressing on identifying the extent of the inundation zone at main study sites using flow data from the Bureau of Reclamation and our staff gage readings. We hope to have the HAZ delineated at the direct impact study sites in early 1995.

Objective 2. Determining possible long-term effects of Glen Canyon Dam flows on riparian birds.

Introduction

Possibly the most important long-term effects of dam management on riparian birds in the Canyon will be due to changes in the OHWZ and NHWZ riparian habitats. In conjunction with detailed vegetation studies, bird surveys can shed light on avian habitat relationships. Habitat use is most appropriately studied during the breeding season when most resident passerines live on and defend relatively small territories at specific sites or locales. By documenting the breeding bird community at specific habitat patches, and the physical and vegetative characteristics of these patches, we can develop wildlife-habitat relationship models for individual species and for the avian community as a whole. Using these models, managers will be able to predict changes in the riparian avian community based on predictions of future riparian habitat changes.

Methodology

Study sites

We selected 56 patches of riparian vegetation on the Colorado River in Grand Canyon between Lee's Ferry (RM 0) and Diamond Creek (RM 226; Fig.1, Appendix 2). These 56 study sites were selected to represent a wide range of sizes, vegetative structure, and locations within the Canyon. Study sites vary in size from 0.01 ha to over 2 ha, with most less than 0.2 ha. The number and location of study sites in the Canyon was constrained by the logistics of travel time between sites, and the need to initiate all bird surveys before 1000 hrs.

Bird surveys

We conducted simultaneous walking and floating surveys at each site during four river trips in 1993 (May, June, July, and September) and seven in 1994 (January, March through July, and September). One observer walked through the site, slightly behind a raft carrying one or two floating observers. Floating surveys used a 22-foot or 37-foot motorized raft with the motor off. All observers, floating or walking, attempted to make a complete count of all birds occupying the patch. All surveys were conducted between one-half hour before sunrise and 1000 hrs, a time of high bird activity. Data recorded by each observer included date, site location, start and stop time, length of survey, estimated wind speed, cloud cover, and quality of float. Data collected on the birds included species, number observed, type of detection (aural or visual), sex and age when possible, behavior, and habitat use. Additionally, spot-maps (I.B.C.C. 1970) of some species were made at RM 46.7 R and RM 198.0 R.

Bird Community

The breeding bird community at each study site was identified by integrating data from floating and walking surveys, notes of birds observed in the patch before or after surveys, and banding data at the five direct-impact study sites. Most sites were visited once per river trip, with 3-5 trips during the breeding season. We integrated data from simultaneous walking and floating surveys to produce a list of bird species and abundance for each site and visit. To avoid double-counting birds when estimating abundance, we used only the highest count of a species by any observer during each survey. Because a singing bird usually represents an occupied territory, one singing bird was counted as one breeding pair.

We then compared and integrated lists from all visits in one year to each site, in order to produce one complete list of breeding bird species and abundance for each site in that year. A species was considered a breeder when it was present at a site on two consecutive visits (during the breeding season), when an active nest was found, when an identifiable used nest was found, when recently fledged young were found, when a brood patch was observed on a mist-netted bird, or when adults were seen carrying nesting material, food, or fecal sacs. When estimating a species abundance in a patch, we separated migrants and young-of-year birds from breeders on a species-by-species basis, using information on breeding behavior and the phenology of breeding and migration. Generally, the highest count during a species' breeding period was used to estimate numbers of breeding pairs. The breeding period of each species was determined from Brown et al. (1984), field observations of nests and young, and the presence of brood patches and cloacal protuberances from banding data. High counts occurring after the breeding season were attributed to young-of-year birds or post-breeding dispersal and were not used to estimate abundance. For species which migrate through the Canyon as well as breed there (especially the Yellow-breasted Chat, Common Yellowthroat, and Yellow Warbler), estimating breeding abundance was more complicated. Phenology of migration for these species was estimated from banding data, and high counts from surveys during the peak of migration were not used to estimate abundance. When breeding and migration overlapped, the second highest count from all visits was used.

Bird Habitat

Each survey site was delineated on a 1:4,800 color aerial photo. We stratified vegetation by coarse vegetative composition and structure and delineated strata on enlarged aerial photos while visiting each site. Vegetation strata were named after the dominant plant species in most cases, though combinations (e.g. willow-arrowweed) and dominant physiographic features (e.g. debris fan) were also used. We based our data collection of vegetation structure and floristics on randomly located quadrats (Bonham 1989). Tables 4 and 5 summarize the types of structural and vegetational data collected each year.

Table 4. Vegetation measurement techniques used Grand Canyon avian community monitoring projects in Colorado River riparian habitats in Grand Canyon National Park, 1993.

Sampling unit	Unit location	Type of data collected	Variables measured
2X10-m quadrat	Random within each strata	Physical characteristics	Slope Aspect Exposure to sun Canopy cover
2X10-m quadrat	Random within each strata	Vegetation data for individual plant in: Midstory (woody, 1-2 m ht-class) Overstory-1 (woody, 2-3 m ht-class) Overstory-2 (woody, > 3 m ht-class)	Stem height Height of first foliage Canopy width Foliage shape (sphere, cone, pyramid) Diameter at breast height
10-m line intercept	Length of 2X10-m quadrat	Substrate composition	Number of meters of rock, sand, soil, litter, down wood intercepted along transect line
0.2X0.5-m sub-quadrat	Systematic (2.5 m, 5.0 m, 7.5 m) along 10-m transect	Vegetation data by species present in: Herbaceous (nonwoody) Shrub (woody, < 1.0 m ht-class)	Percent ground cover Mean height

Table 5. Vegetation measurement techniques used in Colorado River riparian habitats in Grand Canyon National Park, 1994.

Sampling unit	Unit location	Type of data collected	Variables measured
2X2-m quadrat	Random within each site	Physical characteristics	Slope Aspect Substrate type: rock, sand, soil, clay
2X2-m quadrat	Random within each site	Herbaceous layer by class: Forbs Grass Equisetum/juncus/typha/phragmites. Rock Sand Soil Litter Down wood	Percent ground cover Mean height Species
2X2-m quadrat	Random within each site	Vegetation data by individual stem in: Shrub (woody, < 2 m ht-class) Tree (woody, > 2 m ht-class)	Number of live stems Minimum height of live stems Maximum height of live stems Mean height of live stems Number of dead stems Minimum height of dead stems Maximum height of dead stems Mean height of dead stems Canopy cover (Tree layer only)
2X2-m quadrat	Random within each site	Tamarisk and mesquite/acacia dominated strata	Same variables as tree layer with addition of: Minimum foliage height Maximum foliage height Mean foliage height Vegetation contacts on 2 perpendicular 1-m transects Percent of 2 perpendicular 1-m^2 vertical quadrats intercepted by stems

Progress to Date

Bird surveys

We conducted 443 surveys at 35 study sites in 1993, and 719 surveys at 51 study sites in 1994 (including some of the sites surveyed in 1993). Preliminary results reported here focus on the breeding season: May-July, 1993 and March-July, 1994. We detected 43 species in 1993, and 78 species in 1994. Sixty-eight species were observed using riparian habitats in 1994: 12 exclusively during winter, 19 during migration, 27 species during the breeding season, and the remainder were visitors that breed in the uplands (Appendix 1).

Bird Communities

The breeding bird communities have been assigned to 34 sites from 1993 and 48 sites from 1994, using data from surveys only. Additional information from pre- and post-survey observations, field notes, and banding data remain to be included. Species richness at these sites ranges from 0 to 19 species per patch, with a median of 7.

Bird Habitat

We have completed habitat measurements, ground-truthed aerial photos, and delineated major vegetation strata at all survey sites in 1993 and 1994. We are currently entering vegetation data into standard database files. We have collected 115 GPS locations at 54 study sites to allow spatial analyses from aerial photos using GIS. Data reduction and error checking is under way.

Plans for 1995

Data analysis of bird community habitat relationships should be completed in early 1995. This will allow us to focus 1995 habitat data collection on fewer vegetation variables. During 1995, we will conduct bird surveys monthly from February through June at most of the 1994 study sites (with some addition and substitution of sites to increase sample diversity and size).

Objective 3. Determining residency status and movements of bird species using the riparian corridor.

Introduction

Riparian habitats along the Colorado River in Grand Canyon National Park provide breeding habitat, migratory stopover sites, and wintering areas for birds throughout the year (Brown et al. 1987). The resources a bird requires to produce young or survive the winter may be very different from those needed for a migratory stopover. To understand habitat use in this context, we must be able to distinguish between local breeders, winter residents, and spring and fall migrants. By capturing and individually marking birds, we may determine breeding status, migration phenology, and residency patterns of the different species found along the river corridor.

Site fidelity (the degree to which migratory birds return to specific locations year-to-year) and philopatry (the tendency for birds to return to the place where they hatched) both relate to management of Glen Canyon Dam and its effects on the riparian habitat of the river corridor. Weins and Rotenberry (1985) found that breeding site fidelity and philopatry remained high for several years after vegetation removal. If the same is true for species breeding in the Canyon, then changes in breeding bird densities may lag behind detrimental changes in riparian habitat by several years. Also, a higher degree of site fidelity means that breeding bird populations may be less flexible at responding to rapid changes in the riparian habitat of the river corridor. By marking birds with color bands unique to their site of capture, we can document important patterns of site fidelity, philopatry, and local movement between patches.

We mist-netted and color-banded birds at five riparian sites in the Canyon during all seasons in 1993 and 1994 to determine residency status, site fidelity, philopatry, and movement patterns along the Colorado River within Grand Canyon National Park. By noting the color of bands and the identification of recaptured birds on successive trips, it was possible to determine approximately how long individuals stayed in one area and if they moved among vegetation patches. We were also able to determine if birds stayed throughout the winter or if they returned to the same area each year.

Methodology

We used mist nests to capture birds at each of the five direct impact study sites (Fig. 1). Each bird was fitted with a numbered Fish and Wildlife Service aluminum leg band and a site-specific color band. We recorded the number and location of each net, as well as the number of hours each net was open. This provided a standard index of capture rate per unit effort.

We mist-netted for three days at each of four study sites per trip. Nets were set up the previous evening and opened after the morning avian monitoring survey was completed. Nets remained open for a minimum of four hours per morning and longer if we were still catching birds. In 1994, if a particular net location proved unproductive, the net was moved to a new location the following day in order to increase capture rates. Each bird was banded and its wing chord length, tail length, tarsus length, culmen length, and weight were measured. Each bird was aged, sexed, and checked for external parasites. If a bird was recaptured, its band number, marker band color, date, time, and breeding condition were recorded. Birds recaptured more than once per visit at the same site were only counted once in the totals for returned and recaptured birds.

All five banding sites were in large vegetation patches. Whenever possible, nets were placed in all available habitats: tamarisk, willow, arrowweed, mesquite and acacia. Of the five banding sites, only Paria is without any OHWZ vegetation. All eight to ten nets at this site were located in tamarisk or a mixture of tamarisk and willow. Seven to nine nets at Saddle were placed in the NHWZ and two nets were in a mixture of mesquite and tamarisk. At Stairway three to four nets were located in a mix of OHWZ and NHWZ, and five to six were in tamarisk. Due to a low number of birds at Stairway and the need to increase capture rates, we switched the banding station from Stairway to Spring Canyon in May 1994. We placed seven nets at Parashant in a mix of OHWZ and NHWZ, one in OHWZ vegetation and three in the NHWZ. At Spring Canyon, three nets were set up in a mix of OHWZ and NHWZ vegetation, two in OHWZ, and two in riparian vegetation crossing a tributary stream. Except during migration, the majority of the birds caught here were in the stream nets.

Progress to Date

During 4,155 net-hours, we caught 959 birds, including 178 hummingbirds (which were immediately released without banding or measurements), recaptured birds, and escapees (Table 6).

Table 6. Net hours and capture information for mist-netting birds along the Colorado River in Grand Canyon National Park from May 1993 through July 1994.

Site	Mist net hours	# of species caught	# of birds banded	# of recaptures, hummingbirds, and escapees from nets	Birds per 100 net hours
Paria	930	28	135	27	17
Saddle	1122	25	208	41	22
Stairway *	615	12	50	9	10
Parashant	1278	35	265	63	26
Spring	210	22	123	38	77
Total	4,155	59	781	178	23

* Replaced with Spring Canyon in May, 1994.

We have banded 57 species for a total of 798 individuals (Appendix 3). The most abundant breeding species were Lucy's Warbler and Bell's Vireo (Figure 2). The high count of 77 birds per 100 net hours at Spring Canyon occurred in May when many migrants were present and relatively few nets were used.

We recaptured 64 different birds, representing 13 species. These included 26 return breeding birds and eight natal returns (Table 7 and Fig. 3), indicating strong breeding site fidelity and philopatry. We recaptured nine Bell's Vireos at Parashant and four Bewick's Wrens at both Saddle and Paria Beach. Parashant had the greatest number of returns with 18 birds belonging to five species. A Bewick's Wren, recaptured at Saddle in January 1994, was the first confirmed permanent resident of that species in the canyon. A Southwestern Willow Flycatcher (*Empidonax traillii extimus*), banded at Saddle in 1993, nested at river mile 50 in 1994. On our July trip, we saw a Bell's Vireo at Spring Canyon which had been banded at Parashant.

Table 7. Breeding and natal birds banded in 1993 which returned to the same study site in 1994.

Species	Paria	Saddle	Stairway	Parashant	Total
Yellow-breasted Chat	1			2	3
Rufous-crowned Sparrow		1			1
Lucy's Warbler		2		5	7
Brown-headed Cowbird				1	1
Bewick's Wren	4	4		2	10
Bell's Vireo			1	9	10
Ash-throated Flycatcher		3			3
Total	5	10	1	19	35

Tamarisk dominated habitats of the Colorado River are used by many migratory species. Peak numbers pass through the river corridor in May (Figure 4). Warblers are by far the most frequently captured migratory birds, with high numbers in May and again in July. Sparrows and most other migrants are highest in April and May. Based on our banding data, the majority of breeding neotropical migrants return to the canyon by May and leave in July (Fig. 2 and Fig. 4).

There were several differences in methods between 1993 and 1994. The most significant was a change in study sites. In 1993, we utilized Stairway Canyon as one of our major sites. However, due to very low capture and banding rates, and repeated poor capture conditions, we replaced the Stairway site with Spring Canyon in May, 1994.

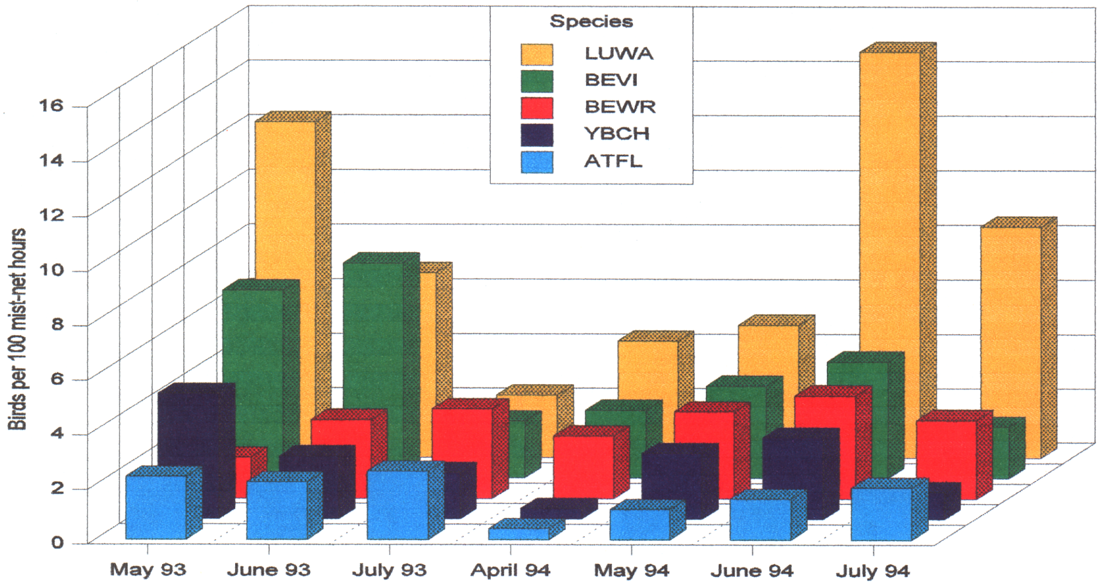

Fig.2. Breeders and young-of-year of the five most abundant bird species banded along the Colorado River in Grand Canyon National Park, from May 1993 through July 1994. LUWA=Lucy's Warbler, BEVI=Bell's Vireo, BEWR=Bewick's Wren, YBCH=Yellow-breasted Chat, ATFL=Ash-throated flycatcher.

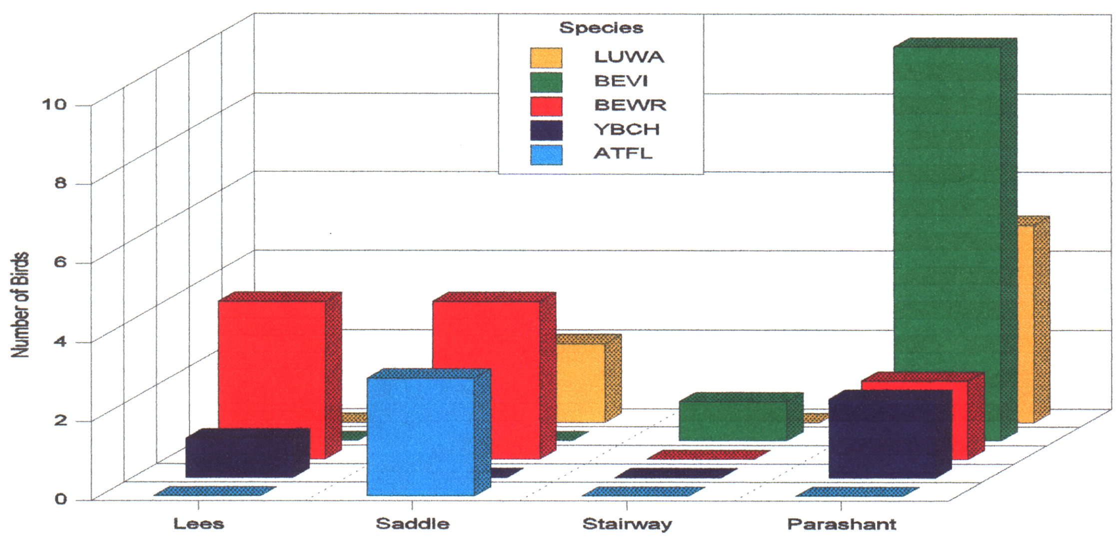

Fig.3. Breeding birds banded along the Colorado River in Grand Canyon National Park in 1993 which returned to the same area in 1994. LUWA=Lucy's Warbler, BEVI=Bell's Vireo, BEWR=Bewick's Wren, YBCH= Yellow-breasted Chat, ATFL=Ash-throated Flycatcher.

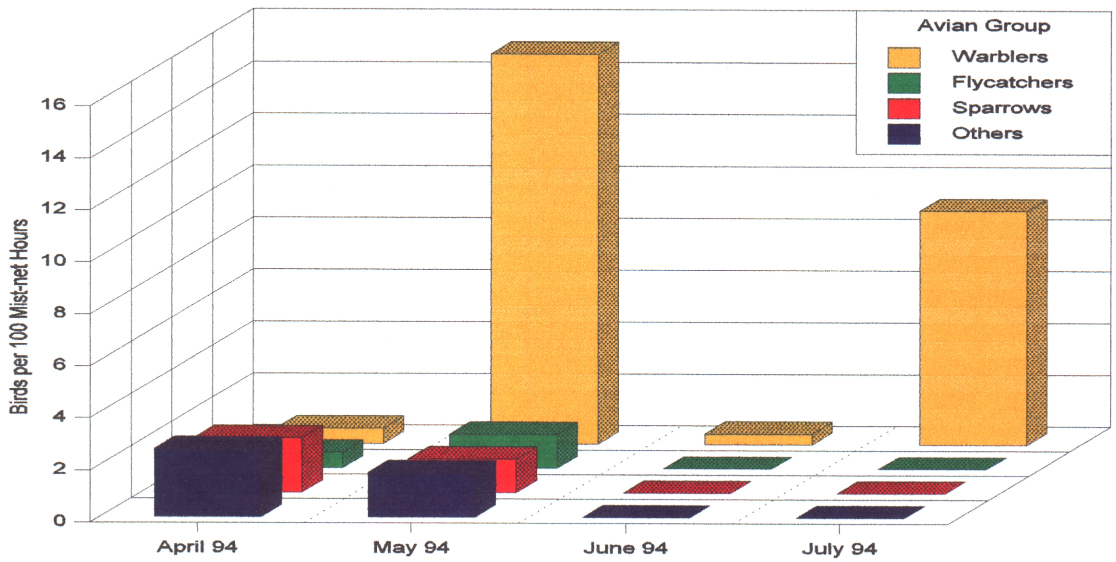

Fig.4. Migrating birds (by taxonomic family) banded along the Colorado River in Grand Canyon National Park, 1994.

Although we frequently saw birds fly between habitat patches located across the river, we found little evidence of movement upstream or downstream between relatively distant sites. Exceptions were the Southwestern Willow Flycatcher banded at Saddle in 1993 and found nesting at RM 50 in 1994, and the Bell's Vireo banded at Parashant that was observed five miles downriver at Spring Canyon in July, 1994.

We presented a summary of this information at the 1994 Ornithological Conference in Missoula, Montana:

Hodgetts, P.A. and M.K. Sogge. Site fidelity and movement of neotropical migrants between isolated habitat patches along the Colorado River in the Grand Canyon. Poster presented at the 1994 North American Ornithological Conference. June 1994.

Plans for 1995

We will continue banding birds and looking at movement patterns through June 1995. In addition to our scheduled river trips, we will monitor bird movement at Paria Beach throughout the year by mist-netting and surveying for three consecutive days each month.

Objective 4. Testing techniques suitable for long-term avian monitoring.

Introduction

Riparian vegetation along the Colorado River in Grand Canyon National Park is affected by management of Glen Canyon Dam (Anderson and Ruffner 1988, Stevens and Ayers 1994, Turner and Karpiscak 1980). Some species of birds are highly dependent on this habitat (riparian obligate species) and may likewise be affected by dam management. Because this avian community is a valuable resource in the Grand Canyon, it is desirable to monitor population levels of these birds to provide feedback for effective management.

In the past, much of the bird monitoring along the Colorado River involved floating surveys, in which observers recorded all observations of birds made while floating by riparian habitat. Data collected during float counts has been used to estimate relative and absolute abundance of breeding birds (Carothers and Sharber 1976), and to develop an index of population trends using selected indicator species (Brown and Johnson 1987). However, Verner (1985) has shown that different survey techniques have different inherent biases that can cause significant variability in survey accuracy and sensitivity, and which must be considered when interpreting survey results. Due to the very nature of floating surveys, possible biases (previously unquantified) include differences in detectibility of different bird species, interference from environmental noise (large habitat patches tend to be associated with noisy rapids in some reaches of the Canyon), and differences in detectibility based on the size and shape of the riparian habitat patches. These factors make the results of floating surveys difficult to interpret, at least without analysis of these factors and comparisons with other survey techniques.

The accuracy of the population estimates produced by the floating surveys and the sensitivity of the technique to detect population changes are currently unknown. The purpose of this project is to compare the floating survey to other, well studied avian survey techniques to quantify the accuracy and sensitivity of the floating survey technique. We are using simultaneous floating and walking surveys, and spot-mapping (I.B.C.C. 1970) to test the accuracy of the floating survey method.

Methodology

Our avian survey methods and study sites are described under Objective 2 (page 8 and Appendix 2). We compared the number of species detected on simultaneous walking and floating surveys by comparing data from one walking observer to pooled data from one to two floating observers on rafts. We compared the number of individuals detected (for each of the most abundant species) by performing a linear regression of data from all surveys with simultaneous walking and floating observers. We also compared population estimates derived from spot-maps with those from our walking surveys. Observer variability will be quantified by comparing counts for different observers using the same technique at the same patch. When the physical parameters of each site have been measured, we will look at how patch size and shape, proximity to rapids (and therefore background noise), and other variables effect the results of floating and walking counts.

Progress to Date

We have restricted these preliminary analyses to our 1993 riparian breeding bird data. Results from 1993 walking and floating surveys showed several important things. The overall species lists (pooled for all study sites) produced by the two techniques were very similar: 19 species on walking surveys and 18 on floating surveys, with only 3 species (Willow Flycatcher, Hooded Oriole, and Lazuli Bunting) not common to both lists. Rank abundance from these two lists was similar with two exceptions (Table 8).

Table 8. Rank abundance of the ten most common species of riparian breeding birds from simultaneous walking and floating surveys on the Colorado River through Grand Canyon National Park, 1993. n = number of birds observed. **Bold** = species ranked differently by the two techniques.

Species Abundance: Walking	n	Species Abundance: Floating	n
Lucy's Warbler	389	Lucy's Warbler	141
Bell's Vireo	120	Bell's Vireo	70
House Finch	95	House Finch	45
Blue-gray Gnatcatcher	82	Yellow Warbler	40
Yellow Warbler	71	Ash-throated Flycatcher	32
Ash-throated Flycatcher	69	Yellow-breasted Chat	31
Yellow-breasted Chat	42	**Blue-gray Gnatcatcher**	24
Bewick's Wren	41	Bewick's Wren	21
Black-chinned Hummingbird	30	Common Yellowthroat	16
Common Yellowthroat	12	**Black-chinned Hummingbird**	7

On the other hand, walking surveys generated much higher population estimates (total counts) for all species than floating surveys in both 1993 and 1994. The slope of a linear regression of counts from walking versus floating surveys is 0.49 ($R^2 = 0.96$, Fig. 5). If population estimates of the two techniques were identical, the slope of the regression would be 1.0, so the difference between the estimated slope and 1.0 is a measure of floating survey accuracy. Floating survey population estimates for especially loud species and those more closely associated with NHWZ habitats (Bell's Vireo, House Finch, Yellow Warbler, Yellow-breasted Chat, Common Yellowthroat, and

Blue Grosbeak) tended to be closer to estimates from walking surveys (falling above the regression line). Populations of quiet or more upland-associated species (Lucy's Warbler, Blue-gray Gnatcatcher, Black-chinned and Costa's Hummingbird) were more seriously underestimated by floating surveys (falling below the regression line). Relatively rare species (e.g. Brown-headed Cowbird and Willow Flycatcher) were poorly monitored by both floating and walking surveys. This helps illustrate the point that rare or widely dispersed species are best monitored with more intensive, specificly-targeted protocols (for example, see Johnson and Sogge 1993, Tibbitts et al. 1994).

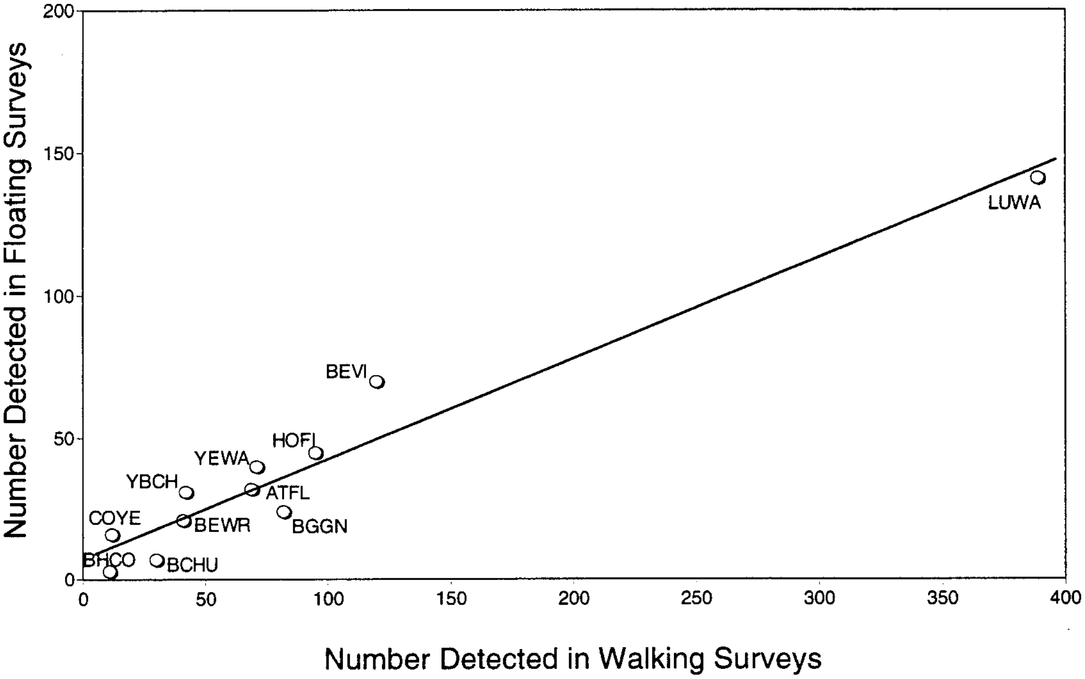

Figure 5. Regression of the numbers of birds detected on simultaneous walking and floating surveys in Grand Canyon National Park, 1994. ATFL=Ash-throated Flycatcher, BCHU=Black-chinned Hummingbird, BEVI=Bell's Vireo, BEWR=Bewick's Wren, BGGN=Blue-gray Gnatcatcher, BHCO=Brown-headed Cowbird, COYE=Common Yellowthroat, HOFI=House Finch, LUWA=Lucy's Warbler, YBCH=Yellow-breasted Chat, YEWA=Yellow Warbler.

When comparing walking and floating surveys, we assumed that population estimates from walking surveys would be closest to the true avian abundances. To test whether walking surveys produced reliable population estimates, we compared our estimates from walking surveys with estimates obtained from spot-mapping - a highly accurate method for avian population estimation (Franzreb 1981). Comparisons between walking surveys and spot-mapping at two of the direct impact study sites showed good correlation between the two techniques for the species we were able to spot-map (Table 9). Spot-mapping is known to be most effective for species which sing to advertise territorial boundaries. These are also the same species that are most accurately surveyed by the walking or floating surveys. However, the accuracy of walking and floating counts with respect to species which do not sing distinct territorial songs (e.g. Ash-throated Flycatcher, Black-chinned Hummingbird) is still uncertain.

Table 9. Comparisons of population estimates of riparian breeding birds from absolute-count walking surveys and spot-mapping at two sites along the Colorado River through Grand Canyon National Park, 1994.

	Saddle Canyon (RM 46.7R)		Parashant (RM 198.0R)	
Species	# territories walking	# territories spot-map	# territories walking	# territories spot-map
Lucy's Warbler	5	6-7	4	4-8
Bewick's Wren	3	2-3	2	2
Yellow Warbler	2	2	1	1
Common Yellowthroat	2	2	1	1
Yellow-breasted Chat	1	2	2	2
Blue-gray Gnatcatcher	2	1	5	2-3
Bell's Vireo			6	7

We presented a summary of this information at the 1994 Ornithological Conference in Missoula, Montana:

Felley, D.R. and M.K. Sogge. Comparison of floating and walking surveys for measuring avian abundance and species diversity in a Southwestern riparian habitat. Poster presented at the 1994 North American Ornithological Conference. June 1994.

Plans for 1995

In 1995, we will continue to survey sites used on in 1994. We will try to compare other proven survey techniques, possibly including line-transect or point-count surveys (Verner 1985) to test their applicability to the Grand Canyon's riparian environment. We will continue spot-mapping, expanding our efforts to more species and possibly one or two new locations.

Objective 5. Diet analysis of selected riparian breeding bird species.

Introduction

This study was designed to investigate the diets of common insectivorous birds breeding in the riparian area along the Colorado River. Given that as much as 95% of riparian habitat in most western states has been lost (Krueper 1992), the remaining riparian zones in the southwest are extremely important for breeding and migratory birds. Over 60% of the species identified by *Partners In Flight* as neotropical migrant birds use riparian areas in the West for stopover areas during migration or for breeding (Bent 1919 - 1968, Ehrlich et al. 1988). Stevens et al. (1977) reported that western riparian areas contained up to 10 times the number of migrants per hectare than adjacent non-riparian habitats. The riparian area along the Colorado River in Grand Canyon is one of the largest protected riparian areas in the West and is provides valuable habitat resident and migratory birds.

There has been a considerable amount of study on breeding birds of the Colorado River in the Grand Canyon (see for example, Carothers and Sharber 1976, Brown et al 1987, Sogge et al 1993), but very little is known about the diet of these birds. Knowledge of what the birds are feeding upon within the riparian habitat will allow us to link the ecology of terrestrial bird species to the river's aquatic resources that are strongly influenced by flow releases from Glen Canyon Dam. Study of avian diet composition may allow us to draw conclusions about how flow-related changes in the insect food base could affect birds that forage within the riparian vegetation.

The objectives of this avian diet research are:

(A) to determine the similarities and/or differences in diet between six common insectivores in the riparian area along the Colorado River.

(B) to document differences in the diet of common insectivores in the upper Grand Canyon (above the Little Colorado River) versus the lower Grand Canyon related to differences in the insects (Shannon and Blinn 1994)

(C) to determine avian foraging location (NHWZ, OHWZ) by identification of stomach contents and relative prey abundance in each of these habitats.

(D) to quantify proportions of the birds diet that are insects of a terrestrial versus aquatic origin (i.e., insects emerging from the Colorado River; Shannon 1993).

Methodology

We obtained diet samples from birds that were captured as part of the general mist netting and banding efforts at the five direct impact study sites along the river . The common insectivores chosen for diet sampling were Lucy's Warbler, Yellow Warbler, Yellow-breasted Chat, Bewick's Wren, Bell's Vireo, and Ash-throated Flycatcher. Diet samples were obtained from March through July 1994, using the non-lethal lavage method (Moody 1970). A small flexible plastic tube is inserted gently through the bird's mouth into the crop, and warm water is slowly injected in order to flush the stomach contests into a vial containing 95% ethanol.

In conjunction with obtaining diet samples, we also trapped insects in the OHWZ and NHWZ at each site during each month. We collected insects within the vegetation by beating branches and sweep-netting, and collected flying insects with a Malaise trap. These insect collections will be used as a reference collection for identification of insect prey remains found in the diet samples and to estimate prey diversity and relative abundance within the NHWZ and the OHWZ.

Progress to date

We lavaged 226 birds to obtain diet samples during the 1994 season (Table 10). The mortality rate (one bird) was less than 0.5%, much lower than the 3% typical of most studies using the lavage method (Laursen, 1978). Insect remains in the diet samples will be identified to order and, when possible, to family.

Plans for 1995

We will continue identifying insect prey remains from the diet samples and identifying insects collected at each site. Based on the literature (Sherry 1984, Rosenberg and Cooper 1990) and consultations with avian diet experts (Dr. Robert Cooper, Dr. Frank Moore and Dr. Kenneth Rosenberg, *personal communications*) the 226 samples we collected should yield sufficient data to meet our objectives. However, if a large number of samples contain insects that are impossible to identify (due to degree of digestion or dehydration), it may be necessary to collect additional samples in 1995.

Table 10. Number of diet samples collected by month, species, and study site from birds mist-netted along the Colorado River in Grand Canyon National Park, 1994. Samples were obtained using the Lavage method (Moody 1970). PR= Paria Beach, SA=Saddle Canyon, ST= Stairway Canyon, PT=Parashant Wash, SP=Spring Canyon. Species - LUWA = Lucy's Warbler, BEWR = Bewick's Wren, YEWA = Yellow Warbler, BEVI = Bell's Vireo, YBCH = Yellow-breasted Chat, ATFL = Ash-throated Flycatcher.

Month	Site	LUWA	BEWR	YEWA	BEVI	YBCH	ATFL	Total
March	PR							
	SA	1						1
	ST	1						1
	PT	4	1		1			6
	Total	**6**	**1**		**1**			**8**
April	PR	3	5					8
	SA	2	4					6
	ST	1			1			2
	PT	11			8	2		21
	Total	**17**	**9**		**9**	**2**		**37**
May	PR	1	2			2	1	6
	SA	3	1	1		1	4	10
	PT	4	1	1	9	2		17
	SP	9		12	5	2		28
	Total	**17**	**4**	**14**	**14**	**7**	**5**	**61**
June	PR		3				1	4
	SA	10	4	1		2	1	18
	PT	7	2		3	5	2	19
	SP	16	1	1	8	2	1	29
	Total	**33**	**10**	**2**	**11**	**9**	**5**	**70**
July	PR		2			1	2	5
	SA	18	8	4		1	5	36
	PT		1		3			4
	SP		1		3	1		5
	Total		**12**	**4**	**6**	**3**	**7**	**50**
Season	**Total**	**91**	**38**	**20**	**41**	**21**	**17**	**226**

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Appendix 1. List of bird species observed in riparian habitats during avian monitoring surveys in the Grand Canyon, 1993-94, and their status (B = breeding, M = migrant, W = wintering, R = year-round resident, V = visitor, may breed in uplands). Status from Brown et al. (1987).

Species	Status
Green-backed Heron (*Butorides striatus*)	V
Great Blue Heron (*Ardea herodias*)	V
Canada Goose (*Branta canadensis*)	W,M
Mallard (*Anas platyrynchos*)	B,M,W
Bufflehead (*Bucephala albeola*)	M,W
Sora (*Porzana carolina*)	M
Killdeer (*Charadrius vociferus*)	M
Spotted Sandpiper (*Actitus macularia*)	B,M
Ring-billed Gull (*Larus delawarensis*)	M
Turkey Vulture (*Cathartes aura*)	M,V
Sharp-shinned Hawk (*Accipiter striatus*)	M,W
Red-tailed Hawk (*Buteo jamaicensis*)	M,V
Peregrine Falcon (*Falco peregrinus*)	M,V
Gambel's Quail (*Callipepla gambelii*)	V
Wild Turkey (*Meleagris gallopavo*)	B,R
Mourning Dove (*Zenaida macroura*)	B,M
White-throated Swift (*Aeronautes saxatalis*)	V
Costa's Hummingbird (*Calypte costae*)	B
Black-chinned Hummingbird (*Archilochus alexandri*)	B,V
Northern Flicker (*Colaptes auratus*)	M,W
Red-naped Sapsucker (*Sphyrapicus nuchalis*)	M,W
Ladder-backed Woodpecker (*Picoides scalaris*)	R,V
Western Kingbird (*Tyrannus verticalis*)	M,B?
Cassin's Kingbird (*Tyrannus vociferans*)	M
Brown-crested Flycatcher (*Myiarchus tyrannulus*)	B
Ash-throated Flycatcher (*Myiarchus cinerascens*)	B,V
Olive-sided Flycatcher (*Contopus borealis*)	M
Western Wood-pewee (*Contopus sordidulus*)	M
Black Phoebe (*Sayornis nigricans*)	B,M
Say's Phoebe (*Sayornis saya*)	B,R
Gray Flycatcher (*Empidonax wrightii*)	M
Willow Flycatcher (*Empidonax traillii*)	B,M
Western Flycatcher (*Empidonax difficilis*)	M
Violet-green Swallow (*Tachycineta thalassina*)	B,V
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)	M
Scrub Jay (*Aphelocoma coerulescens*)	M,W,V
Common Raven (*Corvus corax*)	B,V
Mountain Chickadee (*Parus gambeli*)	W
Bushtit (*Psaltriparus minimus*)	W
Bewick's Wren (*Thryomanes bewickii*)	B,R
Marsh Wren (*Cistothorus palustris*)	M
Canyon Wren (*Catherpes mexicanus*)	R,V
Rock Wren (*Salpinctes obsoletus*)	R,V
Ruby-crowned Kinglet (*Regulus calendula*)	W
Blue-gray Gnatcatcher (*Polioptila caerulea*)	B,M,V
Western Bluebird (*Sialia mexicana*)	W
Townsend's Solitaire (*Myadestes townsendi*)	M
Hermit Thrush (*Catharus guttatus*)	W
American Robin (*Turdus migratorius*)	M
Loggerhead Shrike (*Lanius ludovicianus*)	M,V
Northern Mockingbird (*Mimus polyglottus*)	B
Crissal Thrasher (*Toxostoma crissale*)	B?
Phainopepla (*Phainopepla nitens*)	B,M
Bell's Vireo (*Vireo bellii*)	B
Orange-crowned Warbler (*Vermivora celata*)	M
Lucy's Warbler (*Vermivora luciae*)	B
Yellow-rumped Warbler (*Dendroica coronata*)	M,W
Yellow Warbler (*Dendroica petechia*)	B,M
MacGillivray's Warbler (*Oporornis tolmiei*)	M
Wilson's Warbler (*Wilsonia pusilla*)	M
Common Yellowthroat (*Geothlypis trichas*)	B,M
Yellow-breasted Chat (*Icteria virens*)	B,M
Black-headed Grosbeak (*Pheucticus melanocephalus*)	M
Blue Grosbeak (*Guiraca caerulea*)	B
Indigo Bunting (*Passerina cyanea*)	B,M
Lazuli Bunting (*Passerina amoena*)	B,M
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	M
Song Sparrow (*Melospiza melodia*)	W,M,B?
Lark Sparrow (*Chondestes grammacus*)	M
Black-throated Sparrow (*Amphispiza bilineata*)	V
Rufous-crowned Sparrow (*Aimophila ruficeps*)	B,V
Chipping Sparrow (*Spizella passerina*)	W,M
Dark-eyed Junco (*Junco hyemalis*)	W,M
White-crowned Sparrow (*Zonotrichia leucophrys*)	W
Lincoln's Sparrow (*Melospiza lincolnii*)	M
Brown-headed Cowbird (*Molothrus ater*)	B
Great-tailed Grackle (*Quiscalus mexicanus*)	B,M
Scott's Oriole (*Icterus parisorum*)	V
Northern Oriole (*Icterus galbula*)	B,M
Hooded Oriole (*Icterus cucullatus*)	B,M
Western Tanager (*Piranga ludoviciana*)	M
Summer Tanager (*Piranga rubra*)	B
American Goldfinch (*Carduelis tristas*)	M
Lesser Goldfinch (*Carduelis psaltria*)	B,V
House Finch (*Carpodacus mexicanus*)	B,V
House Sparrow (*Passer domesticus*)	M?

Appendix 2. Location of avian community monitoring study sites in Grand Canyon National Park, 1993 and 1994. Direct impact study sites are named in brackets.

Site #	Location (river miles below Lee's Ferry)	GCES 1993 aerial photo #	Site #	Location (river miles below Lee's Ferry)	GCES 1993 aerial photo #
10	0.0 R [Lee's Ferry]	11-3	232	122.8 L	73-13
20	1.0 R [Paria]	11-7	234	125.5 R	75-7
30	1.6 R	12-2	236	131.3 R	78-3
40	5.1 L	12-16	240	167.0 R	96-2
50	5.2 R	12-16	250	167.2 L	96-2
60	5.6 R	12-17	260	167.6 R	96-4
70	46.7 R [Saddle]	37-2	270	168.5 L	97-5
80	47.5 L	37-5	280	168.8 R	97-5
90	48.5 L	37-5	290	171.0 R [Stairway]	98-9
100	49.1 R	37-9	291	171.1 R	98-9
110	49.2 L	37-9	300	172.2 L	98-13
120	50.0 R	37-14	310	173.1 R	99-5
130	73.9 R	50-6	318	174.2 L	99-9
140	74.1 R	51-2	320	174.4 R	99-9
150	74.3 R	51-2	330	174.5 R	100-3
160	74.4 R	51-3	340	174.7 R	100-3
170	75.9 R	51-9	350	198.0 R [Parashant]	114-2
180	76.0 L	51-9	360	199.5 R	114-6
182	95.7 L	52-4	370	200.0 L	114-8
183	95.9 L	52-4	380	200.4 R	114-11
185	97.4 R	61-11	382	200.5 R	114-11
186	97.4 L	61-11	390	202.5 R	115-8
187	97.5 L	61-11	400	204.5 R [Spring]	116-11
188	97.6 L	61-11	410	205.8 R	117-5
190	110.0 R	66-6	420	206.5 L	117-8
200	112.0 R	68-3	430	208.7 R	118-6
210	117.5 R	71-6	440	213.7 L	123-3
220	119.5 R	72-4	450	214.0 L	123-4
230	119.6 L	72-4			

Appendix 3. Species and number of individuals banded at the five direct impact study sites along the Colorado River in Grand Canyon National Park, from May 1993 through July 1994.

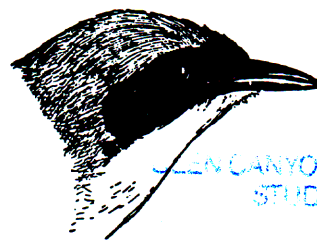
Species	Paria	Saddle	Stairway	Parashant	Spring	Total
Red-naped Sapsucker				1		1
Brown-crested				7		7
Ash-thoated Flycatcher	5	12	2	21	2	42
Western Wood Pewee				1	1	2
Gray Flycatcher				2		2
Dusky Flycatcher		1		1	1	3
Hammond's Flycatcher				1		1
Willow Flycatcher	1	2		1		4
Western Flycatcher					2	2
Mountain Chickadee	2	1				3
Verdin					1	1
Bushtit	11	16				27
House Wren			1	2		3
Bewick's Wren	15	25	2	19	2	63
Marsh Wren	6					6
Canyon Wren	1	1				2
Rock Wren		1				1
Ruby-crowned Kinglet	12	7	4	7		30
Blue-gray Gnatcatcher	3	4	9	7	2	25
Hermit Thrush				1		1
American Robin				1		1
Northern Mockingbird	3			4		7
Bell's Vireo			8	52	19	79
Solitary Vireo	1			1		2
Warbling Vireo					2	2
Orange-crowned	1	4				5
Virginia's Warbler	3	2				5
Lucy's Warbler	4	84	17	65	31	201
Yellow-rumped Warbler	3	1		1		5
Yellow Warbler	14	16		7	20	57
MacGillivrays' Warbler	3	2		1	7	13
Wilson's Warbler	6	5		1	12	24
Northern Waterthrush				1		1
Common Yellowthroat	4	4		10	11	29
Yellow-breasted Chat	5	6	3	24	9	47
Black-headed Grosbeak	1				1	2
Blue Grosbeak	2	1				3
Lazuli Bunting			1			1
Green-tailed Towhee	1					1

Species	Paria	Saddle	Stairway	Parashant	Spring	Total
Rufous-sided Towhee				1		1
Song Sparrow				5	1	6
Lark Sparrow		1				1
Black-throated Sparrow		2		2	1	5
Rufous-crowned		2	1			3
Chipping Sparrow	1					1
Brewer's Sparrow	1					1
Dark-eyed Junco	4					4
White-crowned Sparrow	14					14
Lincoln's Sparrow	3	2	1	2		8
Brown-headed Cowbird	2			1		3
Great-tailed Grackle					1	1
Northern Oriole				4		4
Western Tanager	1		2		3	6
Summer Tanager				5		5
Loggerhead Shrike				2		2
Lesser Goldfinch				1		1
House Finch	2	11		3		16
Total	135	213	51^	265	129*	793
Species Total	28	25	12^	35	20*	57

^mist-netted 5/93-4/94
*mist-netted 5/94-7/94
Records are 12 higher than mist-net hours reported due to nestlings banded and one bird caught in box trap.

AVIAN COMMUNITY MONITORING IN THE GRAND CANYON

1995 Progress Report



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Project Name: GRAND CANYON AVIAN COMMUNITY MONITORING

Principle Investigators: Terry May, Graduate Studies and Research, Northern Arizona University, Flagstaff, AZ 86011 and

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General Introduction

Avian communities along the Colorado River in Grand Canyon[1] have changed significantly since completion of Glen Canyon Dam. Once warm, sediment-laden and free-flowing, the Colorado River was transformed into a cold, clear, flow-regulated river. The extent of daily flow rate fluctuations increased, and as a result river level elevation changed as much as 2-3 meters daily in some areas. Also, reduced sediment load influenced beach formation and erosion, and scouring of the lower riparian zone. Because of these and other changes, riparian habitat characteristics were dramatically altered, with an overall increase in the amount of riparian vegetation. These habitat changes have caused changes in the canyon bird community as well (Brown et al. 1987, Carothers and Brown 1991).

Although some of the most dramatic changes to the riparian avifauna along the river corridor may have already occurred, future operation of Glen Canyon Dam may continue to have significant effects far into the future. The fluctuating flows released from the dam could have both direct and indirect impacts on the bird community. Direct (short-term) impacts could occur if birds or their nests are drowned, or if the nest substrate is destroyed. Indirect (long-term) impacts could arise primarily from flow-induced changes in riparian habitat (eg., distribution, amount, patch size, composition, and structure) or avian food resources.

In 1991, the Bureau of Reclamation modified the operation of Glen Canyon Dam by adopting an interim flow operations program that included a reduced operation regime (reduced fluctuation levels and flow rates) with specific changes in maximum flows and daily flow fluctuations. Interim flows were initiated in the hopes of reducing negative impacts to the biological, cultural, and physical resources of the Grand Canyon. An interim flow monitoring program was also initiated in 1991, with the intent to determine if the interim flow regime was actually reducing these impacts.

In 1992, the National Biological Service Colorado Plateau Research Station (at that time a unit of the National Park Service) was asked to carry out an avian monitoring project for the Bureau of Reclamation's interim flow monitoring program, in order to examine the potential of both direct and indirect impacts. Such data would provide resource managers and decision makers with the information needed to make resource and operation decisions.

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[1]Note that the Grand Canyon, as used in this report, includes the Colorado River corridor from Glen Canyon Dam downstream to Diamond Creek. Thus, the area we call the Grand Canyon includes portions of Glen Canyon National Recreation Area, Hualapai Tribe lands, Navajo Nation lands, and Grand Canyon National Park.

This project was designed to emphasize the following objectives:

1. determine the direct impacts of Glen Canyon Dam interim flow operations on the nests and nesting of riparian birds along the Colorado River Corridor.

2. investigate possible long-term effects of Glen Canyon Dam flows by documenting patterns of avian use of riparian habitats, particularly with regard to bird species composition and habitat patch size/vegetative composition.

We also felt that it was important to develop and test methodologies that would allow resource managers to monitor the status of the bird communities along the river, in order to detect and react to changes in species composition or population levels. Furthermore, in order to better interpret and understand changes in the avian community, it would be necessary to understand the resident status, migratory patterns, and habitat use of the birds using the riparian corridor. Therefore, our project also included efforts directed at the following objectives:

3. determine the residence status and movements of bird species using the Colorado River riparian corridor (e.g., do individuals stay within the canyon, and do they move between habitat patches).

4. develop and test methodologies suitable for the long-term monitoring of avian population levels and distribution within the river corridor.

5. document patterns of insect abundance in riparian habitats and in the diets of common insectivorous birds, in order to better understand how terrestrial birds use the aquatic and terrestrial food resources.

Past research, some of it associated with GCES Phase I, documented the overall composition and general distribution of bird species or communities within the Grand Canyon (Carothers and Sharber 1976, Brown 1988, Brown et al. 1987, Sogge and Tibbitts 1992) or looked at the direct (flooding) impacts of previous flow regimes (Brown and Johnson 1987). However, our avian monitoring project is the first designed specifically to meet all of the objectives listed above.

This is the last progress report associated with this avian community monitoring project. The first progress report (Sogge et al. 1994) reported the nature and status of project efforts in 1993 and 1994. This current 1995 report is not intended to be, nor should it be interpreted as, a final report. Additional data remains to be synthesized, analyzed and presented in the final project report (due in 1996). This progress report summarizes our monitoring efforts in 1995, and is organized by chapters that address each of the study objectives. Each chapter is organized into sections that introduce the specific topic, outline our methods, and report our progress. Only common names of bird species are used throughout the text of this report - scientific names for all species are presented in Appendix 1.

Chapter 1. Determining direct impacts of interim flow operations on the nests and nesting of riparian birds.

Introduction

Since the completion of Glen Canyon Dam in 1963, the manipulation of river flows has allowed the development of new riparian habitat for breeding birds along the Colorado River in the Grand Canyon. This new high water zone (NHWZ) vegetation is dominated by salt cedar (*Tamarix chinensis*), seepwillow (*Baccharis salicifolia*), sandbar willow (*Salix exigua*), common reed (*Phragmites communis*), and cattail (*Typha* spp.). The NHWZ is very different from the old high water zone (OHWZ) vegetation dominated by catclaw (*Acacia greggii*), honey mesquite (*Prosopis glandulosa*), and netleaf hackberry (*Celtis reticulata*: Turner and Karpiscak 1980). Brown and Johnson (1987) found that fluctuating flows directly affected birds breeding in this new environment by flooding active nests. Their study was conducted during a period of high daily fluctuations (sometimes over 2 m daily change in river level), and enormous seasonal fluctuations (e.g. high flows of 93,000 cubic feet/second [cfs] in June, 1993). They found that flows as high as 31,000 cfs (maximum power plant output from Glen Canyon Dam) flooded few nests, while flows over 40,000 cfs began having significant impacts on some riparian breeding species.

Under the Bureau of Reclamation's interim flow regime in operation from 1991 through 1995, peak flows could not exceed approximately 20,000 cfs and daily fluctuations were limited to between 5,000 and 8,000 cfs (USDI Bureau of Reclamation 1993). Given Brown and Johnson's (1987) findings that few nests were flooded until flows reached 40,000 cfs, flooding of active nests under the interim flows might be expected to be negligible. However, changes in riparian vegetation associated with interim flows have concentrated new vegetative growth in a narrower band near the river's edge (Stevens and Ayers 1994). Also, the relationship between daily and seasonal variations in river stage under interim flows may influence nest inundation more than the maximum daily or seasonal stage alone. These factors may have effects that were not seen in earlier studies on the riparian breeding birds.

In order to determine if interim flows were flooding nests of riparian birds, we conducted searches for bird nests along the river corridor from 1993 through 1995. We concentrated on NHWZ habitats in the hydrologically active zone (HAZ), the area potentially inundated by flows between the low water mark and the high 20,000 cfs flows. We monitored all nests to see if nest inundation occurred. In this way we were be able to determine how many of the nests that we found were below river stage at 20,000 cfs (i.e., how many nests were potentially in danger of inundation).

Methodology

We conducted nest searches at five direct-impact study sites (Figure 1-1): Lees Ferry (RM 0.0 R, above and below the boat ramp), Triple Alcoves above Saddle Canyon (RM 46.7 R), Stairway Canyon (RM 171.0 R; 1993 only), above Parashant Wash (RM 198.0 R), and Spring Canyon (204.5 R; 1994 and 1995). We concentrated our nest search efforts in the projected HAZ at each site, and looked for nests from May through July, 1993; March through July, 1994; and March through June 1995. Nest searches were conducted following the protocol of Martin and Guepel (1993), where observations of bird behavior, especially during nest construction and brood-rearing, were used to locate active nests. We also monitored all nests found during other field activities, but outside the HAZ. Data collected at the nest site included date found, river mile, species, stage of nest development, number of eggs or young, description and sketch of the nest site, habitat type (NHWZ, OHWZ, upland), nest substrate (i.e. what nest was built on), height above ground, distance to water, distance above water, and water depth below nest (when applicable). Nests were revisited on following trips to determine nest fate and number of eggs or young when nest was revisited.

Because no hydrological model currently existed to accurately define the relationship between flows from Glen Canyon Dam and river stage (elevation) at each of our study sites, we intended to determine the relationships between nest placement, river stage, and water releases by following the methods of Brown and Johnson (1987). We measured peak daily river stage with a staff gage vertically referenced to a permanent point at each direct impact study site. River stage relative to this point could then be related to river flow by back-dating to the corresponding peak flows at the Lees Ferry gaging station, or the nearest upstream gage if tributaries were flooding. However, one of our river trips in 1995 corresponded with a relatively constant release of approximately 20,000 cfs. This allowed us to directly determine the location of the upper limit of the HAZ at each site.

Progress to Date

We located a total of 100 nests, representing 20 different species, in the NHWZ and OHWZ habitats along the river corridor from 1993 to 1995 (Table 1-1). Thirty of these belonged to "obligate riparian birds" (Brown and Johnson 1987), those species which nest only in NHWZ vegetation (Bell's Vireo, Bewick's Wren, Blue Grosbeak, Common Yellowthroat, Great-tailed Grackle, Lesser Goldfinch, Mallard, Yellow-breasted Chat, and Yellow Warbler). Overall, only one[2] of these 100 nests (a Common Yellowthroat in 1994) was located within the HAZ at any of the major study sites, and this nest did not fail due to inundation (Sogge et al. 1994). None of the 37 nests found in 1995 were within the HAZ (Table 1-2).

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[2] Sogge et al. (1994) reported a preliminary estimate of three nests within the HAZ. However, more accurate delineation in 1995 of the upper level of the HAZ showed that two of these three nests were actually above the 20,000 cfs level.

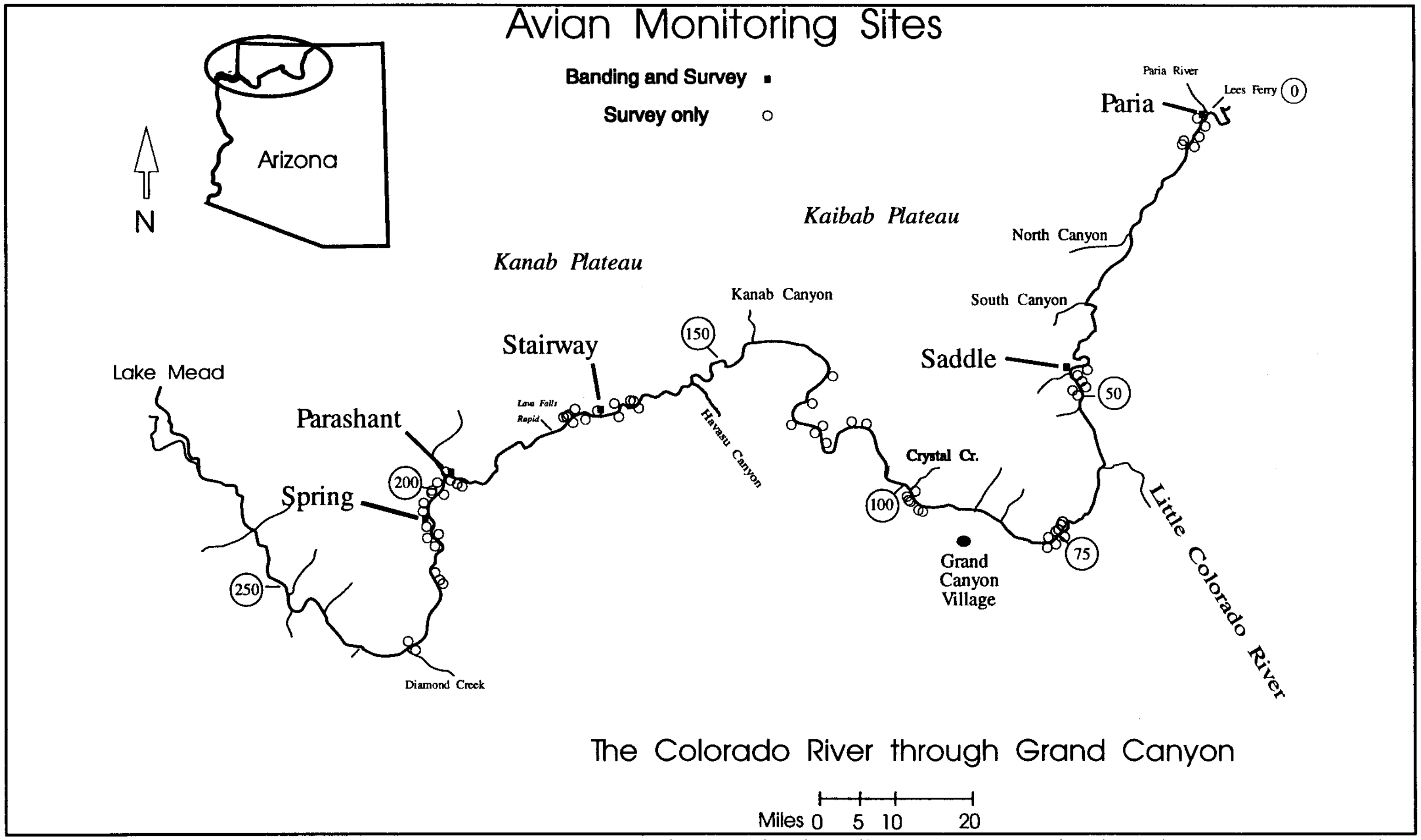

Figure 1-1. Location of Grand Canyon avian community monitoring direct impact study sites (black squares) and survey sites (open circles) in the Grand Canyon.

Table 1-1. Bird species and number of nests found in riparian habitat along the Colorado River in Grand Canyon National Park, 1993-95.

Species nesting	Number	Species nesting	Number
Mallard	1	Lucy's Warbler	7
Mourning Dove	4	Yellow Warbler	5
Black-chinned Hummingbird	14	Common Yellowthroat	5
Black Phoebe	8	Yellow-breasted Chat	3
Say's Phoebe	2	Blue Grosbeak	3
Ash-throated Flycatcher	1	Great-tailed Grackle	1
Verdin	2	Northern Oriole	1
Bushtit	1	Hooded Oriole	1
Bewick's Wren	3	Lesser Goldfinch	1
Blue-gray Gnatcatcher	13	Unknown	2
Bell's Vireo	22	Total	100

Table 1-2. Results of nest searches in the hydrologically active zone (HAZ) at direct impact study sites in Grand Canyon National Park, 1995. Results for 1993-1994 are presented in Sogge et al. (1994).

Site	Search hours in HAZ	# nests found in HAZ	# nests found out of HAZ	# of total nests that were "riparian obligates"
Lee's Ferry	30.0	0	3	0
Saddle	37.5	0	11	4
Parashant	34.0	0	4	3
Spring	36.5	0	4	2
Total	138.0	0	22	9

Chapter 2. Determining possible long-term effects of Glen Canyon Dam flows on riparian birds.

Introduction

Possibly the most important long-term effects of dam management on riparian birds in the Canyon will be due to changes in the OHWZ and NHWZ riparian habitats. In conjunction with detailed vegetation studies, bird surveys can shed light on avian habitat relationships. Habitat use is most appropriately studied during the breeding season when most resident passerines live on and defend relatively small territories at specific sites or locales. By documenting the breeding bird community at specific habitat patches, and the physical and vegetative characteristics of these patches, we can develop wildlife-habitat relationship models for individual species and for the avian community as a whole. Using these models, managers will be able to predict changes in the riparian avian community based on predictions of future riparian habitat changes.

Methodology

Study sites

We selected a total of 71 patches (1993-1995 combined) of riparian vegetation on the Colorado River in Grand Canyon between Lee's Ferry (RM 0) and Diamond Creek (RM 226; refer to Fig.1-1 and Appendix 2). These study sites were selected to represent a wide range of sizes, vegetative structure, and locations within the Canyon. Study sites varied in size from 0.01 ha to over 2 ha, with most less than 0.2 ha. The number and location of study sites in the Canyon was constrained by the logistics of travel time between sites, and the need to initiate all bird surveys before 1000 hrs.

Bird surveys

We conducted simultaneous walking and floating surveys at each site during four river trips in 1995 (March, April, May, and June). One observer walked through the site, slightly behind a raft carrying one or two floating observers. Floating surveys used a 22-foot or 37-foot motorized raft with the motor off. All observers, floating or walking, attempted to make a complete count of all birds occupying the patch. All surveys were conducted between one-half hour before sunrise and 1000 hrs, a time of high bird activity. Data recorded by each observer included date, site location, start and stop time, length of survey, estimated wind speed, cloud cover, and quality of float. Data collected on the birds included species, number observed, type of detection (aural or visual), sex and age when possible, behavior, and habitat use. Additionally, spot-maps (I.B.C.C. 1970) of some species were made at RM 46.7 R and RM 198.0 R.

Bird Community

The breeding bird community at each study site was identified by integrating data from floating and walking surveys, notes of birds observed in the patch before or after surveys, and banding data at the five direct-impact study sites. Most sites were visited once per river trip, with four trips during the 1995 field season. We integrated data from simultaneous walking and floating surveys to produce a list of bird species and abundance for each site and visit. To avoid double-counting birds when estimating abundance, we used only the highest count of a species by any observer during each survey. Because a singing bird usually represents an occupied territory, one singing bird was counted as one breeding pair.

We then compared and integrated lists from all visits in one year to each site, in order to produce one complete list of breeding bird species and abundance for each site in that year. A species was considered a breeder when it was present at a site on two consecutive visits (during the breeding season), when an active nest was found, when an identifiable used nest was found, when recently fledged young were found, when a brood patch was observed on a mist-netted bird, and/or when adults were seen carrying nesting material, food, or fecal sacs. When estimating a species abundance in a patch, we separated migrants and young-of-year birds from breeders on a species-by-species basis, using information on breeding behavior and the phenology of breeding and migration. Generally, the highest count during a species' breeding period was used to estimate numbers of breeding pairs. The breeding period of each species was determined from Brown et al. (1984), field observations of nests and young, and the presence of brood patches and cloacal protuberances from banding data. High counts occurring after the breeding season were attributed to young-of-year birds or post-breeding dispersal and were not used to estimate abundance. For species which migrate through the Canyon as well as breed there (especially the Yellow-breasted Chat, Common Yellowthroat, and Yellow Warbler), estimating breeding abundance was more complicated. Phenology of migration for these species was estimated from banding data, and high counts from surveys during the peak of migration were not used to estimate abundance. When breeding and migration overlapped, the second highest count from all visits was used.

Bird Habitat

Each survey site was delineated on a 1:4,800 color aerial photograph. We stratified vegetation by coarse vegetative composition and structure, then delineated strata on enlarged aerial photographs while visiting each site. Vegetation strata were named after the dominant plant species in most cases, though combinations (e.g. willow-arrowweed) and dominant physiographic features (e.g. debris fan) were also used. We based our data collection of vegetation structure and floristics on the delineated vegetation strata. Table 2-1 summarizes the types of structural and vegetational data collected for each strata in 1995. This approach differed from the measurements made in 1993 and 1994 (Sogge et al. 1994), which relied more heavily on quadrat-based measurements within each vegetation strata.

Table 2-1. Vegetation and habitat variables measured in association with the Grand Canyon avian community monitoring projects in Colorado River riparian habitats in Grand Canyon National Park, 1995.

Sampling unit	Unit location	Type of data collected	Variables measured
Habitat Patch		Physical characteristics	Georeferenced location (UTM) Slope and aspect Size (aerial extent) and Shape Factor
Habitat Patch		Delineation of discernable vegetation strata, defined by dominant species.	Georeferenced coordinates Size (aerial extent) and Shape Factor Susbstrate heterogeneity Substrate (eg., sand, rock, etc.)
Delineated Strata	Within each habitat patch	For each vegetation layer: Tree Shrub Herbaceous Ground cover	 Braun-Blanquet cover estimate mean height layer top mean height layer bottom max height layer top
		For each species:	Braun-Blanquet cover estimate mean maximum height of species dispersion (high, medium, or low)

Progress to Date

Bird surveys

We conducted 291 surveys at 59 sites in 1995 (including some of the sites surveyed in 1993-94). Preliminary results reported here focus on March through June, 1995 (although some analyses include 1993 and 1994 data). We detected 88 species in 1995; more than were found in 1993 (43 species) or 1994 (78 species; Sogge et al. 1994). We observed a total of 104 species using riparian habitats along the river corridor from 1993 through 1995 (Appendix 1).

Bird Communities

The breeding bird communities have been assigned to all 59 of the 1995 sites, using data from surveys and banding efforts (see Chapter 3). Additional information from pre- and post-survey observations, and field notes remain to be included.

Bird Habitat

We have completed habitat measurements, ground-truthed aerial photos, and delineated major vegetation strata at all survey sites from 1993 through 1995. Data entry is complete for 1993 and 1994 data. We are currently entering 1994 vegetation data into standard database files. We have collected GPS locations at all study sites and have georeferenced (including differential correction) all patches and vegetation strata, with the data stored in ArcInfo.

Chapter 3. Determining residency status and movements of bird species using the riparian corridor.

Introduction

Riparian habitats along the Colorado River in Grand Canyon National Park provide breeding habitat, migratory stopover sites, and wintering areas for birds throughout the year (Brown et al. 1987). The resources a bird requires to produce young or survive the winter may be very different from those needed for a migratory stopover. To understand habitat use in this context, we must be able to distinguish between local breeders, winter residents, and spring and fall migrants. By capturing and individually marking birds, we may determine breeding status, migration phenology, and residency patterns of the different species found along the river corridor.

Site fidelity (the degree to which migratory birds return to specific locations year-to-year) and philopatry (the tendency for birds to return to the place where they hatched) both relate to management of Glen Canyon Dam and its effects on the riparian habitat of the river corridor. Weins and Rotenberry (1985) found that breeding site fidelity and philopatry remained high for several years after vegetation removal. If the same is true for species breeding in the Canyon, then changes in breeding bird densities may lag behind changes in riparian habitat. Also, a higher degree of site fidelity means that breeding bird populations may be less flexible at responding to rapid changes in the riparian habitat of the river corridor. By marking birds with color bands unique to their site of capture, we can document important patterns of site fidelity, philopatry, and local movement between patches.

We mist-netted and color-banded birds at four riparian sites in the Canyon during 1995 to determine residency status, site fidelity, philopatry, and movement patterns along the Colorado River within the Grand Canyon. By noting the color of bands and the identification of recaptured birds on successive trips, it was possible to infer if individuals stayed in a patch in successive months, and if they moved among vegetation patches. Results of 1993 and 1994 capture and banding efforts were reported in Sogge et al. (1994).

Methodology

We used mist nests to capture birds at each of the four direct impact study sites (refer to Fig. 1-1). Each bird was fitted with a numbered U. S. Fish and Wildlife Service aluminum leg band and a site-specific color band. We recorded the number and location of each net, as well as the number of hours each net was open. This provided a standard index of capture rate per unit effort.

We mist-netted for three days at each of the four study sites on each trip. Nets were set up the previous evening and opened after the morning avian monitoring survey was completed. Nets remained open for a minimum of four hours per morning and longer if we were still catching birds. In 1995, 11 nets were placed in fixed locations at each site. Each bird was banded and its wing chord length, tail length, tarsus length, culmen length, and weight were measured. Each bird was aged, sexed, and checked for external parasites. If a bird was recaptured, its band number, marker band color, date, time, and breeding condition were recorded. Birds recaptured more than once per visit at the same site were only counted once in the totals for returned and recaptured birds.

All four banding sites were in large vegetation patches. Whenever possible, nets were placed in all available habitats: tamarisk, willow, arrowweed, mesquite and acacia (Table 3-1). Of the four banding sites, only Paria is without any Old High Water Zone (OHWZ) vegetation.

Table 3-1. Vegetative zone of mist-net placement at each site

Zone	Paria	Saddle	Parashant	Spring	Total
Old High Water Zone			2	5	7
New High Water Zone	11	8	1	2	22
Mixture of OHWZ and NHWZ		3	8	4	15
TOTAL	11	11	11	11	

Progress to Date

During 2,667 net-hours in 1995, we caught 680 birds, including 220 recaptured birds, hummingbirds (which were immediately released without banding or measurements), and escapees (Table 3-2). We banded 46 species for a total of 463 individuals (Appendix 3). The most abundant breeding species were Lucy's Warbler and Bell's Vireo (Figure 3-1).

Table 3-2. Net hours and capture information for mist-netting birds along the Colorado River in the Grand Canyon from March through June 1995.

Site	Mist net hours	# of species caught	# of birds banded	# of recaptures, hummingbirds, and escapees from nets	Birds per 100 net hours
Paria *	940	31	142	68	22
Saddle	475	16	31	38	16
Parashant	662	27	121	57	27
Spring	591	29	166	57	38
Total	2,667	49	460	220	25

* includes data from banding efforts in January and February at the Paria site.

We recaptured 57 different birds, representing 13 species. These included 41 return breeding birds and three natal returns (Table 3-3). Based on our banding data, the majority of breeding neotropical migrants returned to the canyon in May. By June, many young-of-the-year birds are moving about in riparian vegetation, contributing to high capture rates in that month (Figure 3-1).

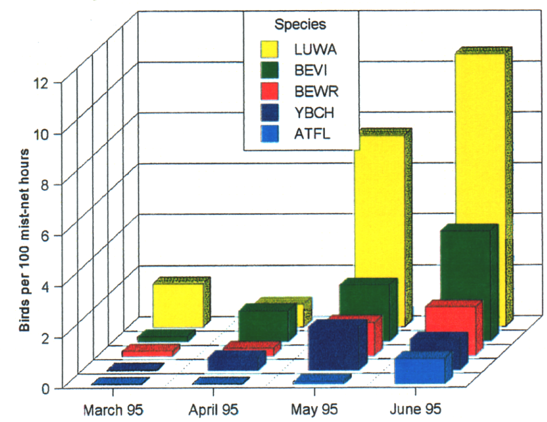

Figure 3-1. The number of breeding and young-of-the-year birds captured (of the five most common riparian breeding species) along the Colorado River in the Grand Canyon, 1995. LUWA = Lucy's Warbler; BEVI = Bell's Vireo; BEWR = Bewick's Wren; YBCH = Yellow-breaseted Chat; ATFL = Ash-throated Flycatcher.

Table 3-3. Breeding and natal birds banded in 1993 or 1994 which returned to the same study site in 1995.

Species	Paria	Saddle	Parashant	Spring	Total
Ash-throated Flycatcher		3	2		5
Bewick's Wren	3	3	2		8
Bell's Vireo			6	4	10
Lucy's Warbler		7	4	3	14
Yellow Warbler		1	1		2
Yellow-breasted Chat		1	3	1	5
Total	3	15	18	8	44

Riparian habitats of the Colorado River are used by many migratory species. Peak numbers pass through the river corridor in May (Figure 3-2). Warblers are by far the most frequently captured migratory birds, with high numbers in May. Sparrows and most other migrants are highest in April and May.

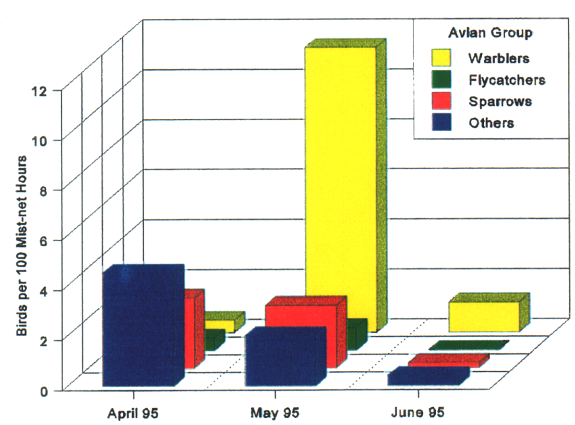

Figure 3-2. Migrating birds (by taxonomic group) banded along the Colorado River in Grand Canyon in 1995.

We caught our first Indigo Bunting of the project at Spring Canyon in May and a second one in June at the same site. Both birds were second year males with a developed cloacal protuberance, singing continuously throughout their respective territories. Other new species banded included Mourning Dove and Gray Vireo at Paria and Red-winged Blackbird at Parashant. We also caught two fledgling Song Sparrows at Spring Canyon in May, the first verification of breeding for that species at that site.

Although we frequently saw birds fly between habitat patches located across the river, we found little evidence of bird movement more than about 100 meters upstream or downstream of a site. Thus, resident birds appear to have high site fidelity with respect to their breeding territory, within a breeding season.

Chapter 4. Testing techniques suitable for long-term avian monitoring.

Introduction

Riparian vegetation along the Colorado River in Grand Canyon National Park is affected by management of Glen Canyon Dam (Anderson and Ruffner 1988, Stevens and Ayers 1994, Turner and Karpiscak 1980). Some species of birds are highly dependent on this habitat (riparian obligate species) and may likewise be affected by dam management. Because this avian community is a valuable resource in the Grand Canyon, it is desirable to monitor population levels of these birds to provide feedback for effective management.

In the past, much of the bird monitoring along the Colorado River involved floating surveys, in which observers recorded all observations of birds made while floating by riparian habitat. Data collected during float counts has been used to estimate relative and absolute abundance of breeding birds (Carothers and Sharber 1976), and to develop an index of population trends using selected indicator species (Brown and Johnson 1987). However, Verner (1985) has shown that different survey techniques have different inherent biases that can cause significant variability in survey accuracy and sensitivity, and which must be considered when interpreting survey results. Due to the very nature of floating surveys, possible biases (previously unquantified) include differences in detectibility of different bird species, interference from environmental noise (large habitat patches tend to be associated with noisy rapids in some reaches of the Canyon), and differences in detectibility based on the size and shape of the riparian habitat patches. These factors make the results of floating surveys difficult to interpret, at least without analysis of these factors and comparisons with other survey techniques.

The accuracy of floating versus walking total-counts was evaluated by Sogge et al. (1994). The overall species lists produced for the two techniques were very similar, but walking surveys generated much higher population estimates. Relatively rare species were poorly monitored by both techniques, illustrating that rare or widely dispersed species are best monitored with intensive, target-specific protocols (eg., Tibbitts et al. 1994). The emphasis of our 1995 efforts was to compare total-count walking surveys and point-count surveys, in order to evaluate the accuracy and sensitivity of the point-count technique with respect to long-term monitoring.

Methodology

Our study sites and total-count walking survey methods are described in Chapter 2. We conducted paired total-count surveys and point-count surveys at 11 sites from March through June, 1995. Point-counts were of 10- (March) or 5-minute (April-June) duration using a 50-meter detection radius to separate observations in and out of the survey area. We located from one to five point-count stations in each study site depending on size and configuration of the site. Point-count stations were systematically located, 150 meters apart along the length of each patch, half way between the river and upland vegetation. When comparing results of the two techniques, all point-count data from a single site were combined. We compared the number of species detected and the number of individuals detected (for each of the most abundant species) by performing a linear regression of data from all surveys with comparative total-count and point-count data.

Progress to Date

Results in this report are restricted to preliminary analyses to our 1995 riparian breeding bird data. For point counts, greater than 80% of all species detections were made in the first 5 minutes of 10-minute point-counts. Therefore, all future point-counts were conducted for only 5 minutes. The probability of detecting a species on 5 minute point-counts (given that the species was known to occur at the site) was 0.73, varying from 0.96 to 0.12 for different species. Probability of detecting a species on a walking total-count survey was 0.88, ranging from 1.0 to 0.7 for different species. Different levels of survey effort could account for differences in detection probability between the two techniques. However, the average length of walking total-counts (45 ± 3.8 min) and point-counts (44 ± 4.1 min) were not significantly different (T-test: T=0.15, 77 df, P=0.88).

The variability in detecting different species is related to the interaction betwen the life history characteristics of the bird species and the details of a particular survey technique. The species most reliably detected were either the most common (Lucy's Warbler, Bell's Vireo, Bewick's Wren), loudest (Yellow-breasted Chat, Bell's Vireo, Bewick's Wren), or the most wide-ranging (Ash-throated Flycatcher, House Finch) species in the canyon. The species most commonly missed on point-counts (Yellow Warbler, Common Yellowthroat) are concentrated primarily near the river's edge, relatively rare (the Common Yellowthroat), not as vocal, and maintain small territories. The interplay of these characteristics increases the probability that these two species will not be detected in a fixed-radius point count.

Overall abundance estimates for each species from point-counts and total-counts were highly correlated (R^2=0.98), with a regression line slope of 0.88. The closer the slope is to 1.0, the closer the two variables are to a one-to-one relationship. Thus, a slope of 0.88 represents a good correspondence between the two techniques.

Of the 22 riparian breeding species observed on walking and point-count surveys, ten were observed on less than 5% of all point-count surveys (Table 4-1). These species are too rare for effective population trend monitoring by general techniques such as walking or point-count surveys.

Table 4-1. Obligate riparian breeding birds in the Grand Canyon observed on <5% of all point-count surveys, 1995.

Brown-crested Flycatcher	Lazuli Bunting
Brown-headed Cowbird	Northern Mockingbird
Blue Grosbeak	Northern Oriole
Costa's Hummingbird	Phainopepla
Indigo Bunting	Summer Tanager

Chapter 5. Quantifying diet patterns of riparian breeding birds

Introduction

Riparian zones in the southwest are extremely important for resident and migratory birds. Over 60% of neotropical migratory birds use riparian habitat in the West for breeding or as stopover areas during migration (Ehrlich et al. 1988). Of 166 species of nesting birds in the southwest, 77% were dependent on water associated habitats and 51% were completely dependent upon riparian habitat (Johnson et al. 1977). The thick, multi-storied vegetation found in riparian areas provides more nest sites and greater food production (i.e. insects) for birds (Gori 1992) than do adjacent sites. Steven's et al. (1977) reported that western riparian areas contained up to 10 times the number of migrants per hectare as did adjacent non-riparian habitats. Knowing how important riparian areas are to birds, it is of growing concern that estimates have placed riparian habitat loss at greater than 95% in the western United States (Krueper 1992). Recent studies suggest that neotropical migrant songbird populations are declining and that these declines have accelerated in recent years. Lower numbers of songbirds may be due to declining habitat availability (Finch 1991).

A new riparian habitat was established along the Colorado River due to controlled releases of river flows after the completion of Glen Canyon Dam in 1963. This new riparian habitat (termed the new high water zone [NHWZ]) immediately parallel to the river is composed predominately of introduced tamarisk, native coyote willow, and several species of seepwillow. Before controlled flows, vegetation adjacent to the river was sparse due to annual flooding (Turner and Karpiscak 1980). The pre-dam vegetation (termed old high water zone [OHWZ]) that still exists is comprised of a band of vegetation characterized predominately by native honey mesquite and catclaw acacia. Breeding bird densities along the Colorado river corridor have increased in the last 20 years due to the increased amount of the new riparian habitat (Carothers and Johnson 1975, Brown and Johnson 1985, Carothers and Brown 1991).

Past studies on breeding bird communities along the Colorado River corridor in the Grand Canyon have concentrated on species present, nesting habits and the effects of fluctuating flows on densities of birds in the riparian areas (Carothers and Sharber 1976, Brown 1988, Brown and Johnson 1987). Very little is known about the diet of birds that use the riparian vegetation along the river. In fact, the diet of most neotropical migrant species is poorly known throughout their ranges (Karr 1976, Loiselle and Blake 1990). Diet studies are seldom undertaken due to difficulties in identifying fragmented arthropods found in diet samples, but such studies can quantify direct habitat use by avian insectivores (Sherry 1984, Rosenberg and Cooper 1990). Examination of avian diet is essential in gaining an understanding of bird species and how they use their habitat. Within the Grand Canyon, it is important to study avian diet in order to: (1) understand what arthropods are important as food resources to the birds within the riparian vegetation along the Colorado River and (2) link the ecology of these terrestrial bird species to aquatic resources (i.e. insects emerging from the river) that may be directly affected by river flow regimes and management.

Stevens (1976, 1985) inventoried arthropods found in the NHWZ and OHWZ riparian vegetation at selected sites along the Colorado River in the Grand Canyon. While information and results from this collection were invaluable in identification of arthropods collected in the present study, our's is the first effort to relate arthropod availability to actual composition of bird diets along the Colorado River.

Our primary goal was to quantify the arthropod composition of the diets of selected breeding birds along the Colorado River in the Grand Canyon, as related to the use of riparian vegetation and aquatic resource food base. In order to accomplish this, we designed the project to accomplish the following objectives:

1) determine the similarities and/or differences in diet between six common insectivores in the riparian area along the Colorado River in Grand Canyon, emphasizing proportions of the birds' diet composed of aquatic-origin (ie. emerging from the Colorado River) versus terrestrial-origin arthropods.

2) compare the diet of these bird species in the upper Grand Canyon (above the Little Colorado River at river mile 60.3) versus the lower Grand Canyon.

(3) determine avian foraging location (NHWZ, OHWZ) by identification of stomach contents and relative prey abundance in each of the habitats.

This 1995 annual report will include results only for objective 1. The results for all objectives will be submitted in the final project report.

Methodology

We selected the following bird species for dietary analysis: Bewick's Wren, Lucy's Warbler, Bell's Vireo, Yellow Warbler, Yellow-breasted Chat, and Ash-throated Flycatcher. Bewick's Wren appears to be a permanent resident, while the last five species are neotropical migrants. All six species are insectivores.

Four study sites were chosen along the Colorado River: Paria Creek (RM 1.0); Saddle Canyon (RM 47.0); Stairway Canyon (RM 171.0); Parashant Canyon (RM 198.0). Partway through 1994, Spring Canyon (RM 204) was substituted for the Stairway Canyon site due to low capture rate of birds at the latter. Stairway Canyon was sampled for birds March and April of 1994, then Spring Canyon was sampled in May, June and July.

Diet Samples

Diet samples were obtained from birds that were captured in mist nets two days per month at each study site from March through June of 1994 and in May of 1995. Diet samples were taken from birds caught between dawn and noon when high feeding rates usually guarantee full stomachs for sampling (Sherry 1984). Nets were placed in the same basic locations within each study sites during each month of the breeding season of 1994 to maintain consistency of sampling. The netting efforts were already underway as part of the overall avian community study (refer to Chapter 3).

Stomach contents from the birds were obtained by flushing the digestive tract with a fixed amount of warm water as described by Moody (1970). Lavage has a low mortality rate compared to using chemical emetics for forced regurgitation (Laursen 1978, Robinson and Holmes 1982, Gavett and Wakeley 1986). In past studies, the efficiency rate of the lavage technique was 52% $\pm$ 29 (Laursen 1978). The stomach content samples were labeled with the date, location of sample, and species of bird, then stored in vials with 70% alcohol and identified in the lab. In the event of rare accidental mortality, the entire stomach was removed and dissected after flushing, to determine what, if any, prey remained in the stomach after lavage.

Individual arthropods, usually fragmented, were pieced together until all identifiable prey fragments were accounted for. One item of prey was tallied for each head capsule, pair of mandibles, four wings (two for Diptera), or two elytra found in each diet sample (Anthony and Kunz 1977). Food items were identified to order and when possible, family. Aquatic or terrestrial origin of the arthropod was also specified. In order to make dietary comparisons between the six species of birds, orders of arthropods found in stomach samples were grouped into eight categories: Hemiptera (true bugs); Araneae (spiders); Coleoptera (beetles); Homoptera (leafhoppers); Hymenoptera (wasps, bees and ants); Diptera (flies); Lepidoptera (moths and butterflies - most often larvae) and Other (Thysanoptera, Neuroptera, Acari and unknown - two unknown larvae).

An analysis of variance (ANOVA; Sokal and Rohlf 1995) was used to test for a significant difference in the proportions of aquatic-origin versus terrestrial-origin arthropods in the diet of all six species of birds at all the sites. To date, data has been analyzed for all samples collected in 1994.

Several procedures in this study minimize the problem of different digestion rates of insect taxa: 1) diets limited to arthropods minimize the range of digestion times (compared with seeds, nectar and fruit); 2) collection of birds for diet sampling during peak feeding activity tends to standardize the stage of digestion among different stomachs (Sherry 1984).

Arthropod Samples

Arthropod sampling was conducted at each site one day per month from March through July during the same period that birds were captured to collect diet samples in mist nets. Three methods of sampling were employed to obtain a more representative collection of what prey items were available. In order to collect vegetation dwelling arthropods, we made 25 sweeps with a standard sweep net (37 cm in diameter) and 25 beats on the vegetation (collected onto a beating canvas). A Malaise trap was used to collect flying insects. All three sampling methods described above were used simultaneously in both the NHWZ and the OHWZ. Arthropods were stored in 70% alcohol for later identification in the lab. They were identified to order and family, then counted and grouped into the same eight categories of orders used for the dietary analysis. The origin (aquatic or terrestrial) of each arthropod was determined, and the proportions of each origin were calculated to give an estimate of the observable availability at all of our sampling sites along the Colorado River.

Progress to Date

Arthropods in bird diets

Diet samples (arthropod fragments) were successfully obtained from 202 (92%) of 220 birds lavaged in 1994 (Table 5-1). We were able to classify 98% of the arthropods identified in diet samples as aquatic or terrestrial in origin. Arthropods of unknown origin comprised 2% of the diet. Terrestrial-origin arthropods comprised 90% of the diet of all six bird species combined, while aquatic-origin arthropods accounted for only 8% (Figure 5-1).

Table 5-1. Number of bird species caught for diet analysis during the breeding season in 1994 at five sites along the Colorado River in Grand Canyon National Park.

SITE	Lucy's Warbler	Bell's Vireo	Bewick's Wren	Yellow Warbler	Yellow-breasted Chat	Ash-throated Flycatcher	TOTAL
Paria Beach RM 1.0	4	0	11	0	3	4	22
Saddle Canyon RM 47.0	27	0	15	6	3	10	61
Stairway Canyon RM 172.0	2	2	0	0	0	0	4
Parashant RM 198.0	23	22	5	1	8	2	61
Spring Canyon RM 202.0	21	15	2	11	4	1	54
TOTAL	77	39	33	18	18	17	202

There was a significant difference in the proportions of aquatic-origin versus terrestrial-origin arthropods in the diets of the six species of birds (ANOVA: $F_{5, 201} = 3.871$, $P = 0.002$). Mean proportions of aquatic-origin arthropods varied (Figure 5-2), with Yellow Warbler consuming the highest (15.8% ± 5.7), and Yellow-breasted Chat the lowest (0.79% ± 0.79). Post hoc multiple analysis (Duncan's multiple range test) revealed that Yellow Warblers had a significantly higher proportion of aquatic-origin arthropods in their diet than did the other five species ($P < 0.05$). No other significant differences in proportion of aquatic-origin arthropods were found between bird species.

Arthropods in the habitat

The collections from the riparian habitat along the Colorado River were composed of 83% terrestrial-origin and 17% aquatic-origin arthropods (Figure 5-1). Arthropods of unknown origin comprised less than 1.0% of the samples.

Effectiveness of lavage technique

Only three birds out of 220 (1.4%) died of apparent stress due to lavage in 1994 and 1995. All three were Lucy's Warblers that were lavaged prior to their death. Arthropod fragments were lavaged from two of the birds, but no prey items were obtained from the third. The stomachs of all three warblers were removed and preserved immediately after mortality. No prey items remained in the preserved stomachs when they were examined in the lab. This is a good indication that lavage was effective in obtaining the actual stomach contents from birds.

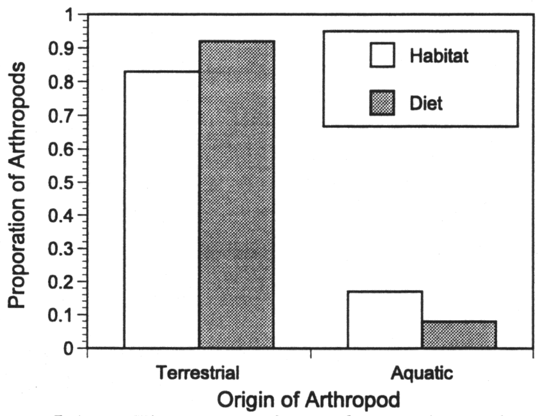

Figure 5-1. The proportion of aquatic-origin and terrestrial-origin arthropods recoreded in the riparian habitat along the Colorado River, and in the diet of selected insectivoruous birds in these same habitats.

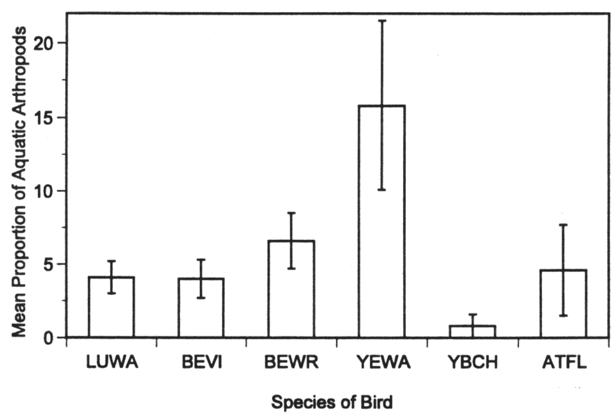

Figure 5-2. The mean proportions of aquatic-origin arthropods found in the diets of six riparian bird species along the Colorado River. Vertical lines represent ± one standard deviation.

Summary

Our data clearly show that terrestrial-origin arthropods are the primary food resource for the six species of birds we studied, comprising approximately 90% of their diet. Terrestrial-origin arthropods were also five times more abundant in the riparian habitat collections than were aquatic-origin arthropods. This low prevalence of aquatic-origin arthropods in both the habitat and the diet samples may occur because the cold temperatures of the Colorado River may limit the number of emerging arthropods (Shannon 1993).

The relatively low importance of aquatic-origin arthropods in the birds' diets suggests that the the river has only a minor role as a direct food source for the riparian breeding birds that we studied. Therefore, any effect of river flow management on these birds' diet is likely to be manifested indirectly, through changes in riparian vegetation that in turn may cause changes in the composition and abundance of terrestrial-origin arthropod prey.

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Appendix 1. List of bird species observed in riparian habitats during avian monitoring surveys in the Grand Canyon, 1993-95, and their status (B = breeding, M = migrant, W = wintering, R = year-round resident, V = visitor, may breed in uplands). Status from Brown et al. (1987).

Species	Status
Green-backed Heron (*Butorides striatus*)	V
Black-crowned Night-heron (*Nycticorax nycticorax*)	B,W
Great Blue Heron (*Ardea herodias*)	V
Snowy Egret (*Egretta thula*)	M
Canada Goose (*Branta canadensis*)	W,M
Mallard (*Anas platyrynchos*)	B,M,W
Northern Pintail (*Anas acuta*)	M,W
American Wigeon (*Anas americana*)	M,W
Common Goldeneye (*Bucephala clangula*)	M,W
Bufflehead (*Bucephala albeola*)	M,W
Common Merganser (*Mergus merganser*)	M,W
Sora (*Porzana carolina*)	M
American Coot (*Fulica americana*)	B,M,W
Killdeer (*Charadrius vociferus*)	M
Spotted Sandpiper (*Actitus macularia*)	B,M
Ring-billed Gull (*Larus delawarensis*)	M
Turkey Vulture (*Cathartes aura*)	M,V
Sharp-shinned Hawk (*Accipiter striatus*)	M,W
Red-tailed Hawk (*Buteo jamaicensis*)	M,V
Bald Eagle (*Haliaeeetus luecocephalus*)	M,W
American Kestrel (*Falco sparverius*)	B,R
Peregrine Falcon (*Falco peregrinus*)	M,V
Gambel's Quail (*Callipepla gambelii*)	V
Wild Turkey (*Meleagris gallopavo*)	B,R
Mourning Dove (*Zenaida macroura*)	B,M
White-throated Swift (*Aeronautes saxatalis*)	V
Costa's Hummingbird (*Calypte costae*)	B
Black-chinned Hummingbird (*Archilochus alexandri*)	B,V
Belted Kingfisher (*Ceryle alcyon*)	M
Northern Flicker (*Colaptes auratus*)	M,W
Red-naped Sapsucker (*Sphyrapicus nuchalis*)	M,W
Ladder-backed Woodpecker (*Picoides scalaris*)	R,V
Western Kingbird (*Tyrannus verticalis*)	M,B?
Cassin's Kingbird (*Tyrannus vociferans*)	M
Brown-crested Flycatcher (*Myiarchus tyrannulus*)	B
Ash-throated Flycatcher (*Myiarchus cinerascens*)	B,V
Olive-sided Flycatcher (*Contopus borealis*)	M
Western Wood-pewee (*Contopus sordidulus*)	M
Black Phoebe (*Sayornis nigricans*)	B,M
Say's Phoebe (*Sayornis saya*)	B,R
Gray Flycatcher (*Empidonax wrightii*)	M
Willow Flycatcher (*Empidonax traillii*)	B,M
Western Flycatcher (*Empidonax difficilis*)	M
Violet-green Swallow (*Tachycineta thalassina*)	B,V
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)	M
Scrub Jay (*Aphelocoma coerulescens*)	M,W,V
American Crow (*Corvus brachyrynchos*)	V
Common Raven (*Corvus corax*)	B,V
Mountain Chickadee (*Parus gambeli*)	W
Bushtit (*Psaltriparus minimus*)	W
Bewick's Wren (*Thryomanes bewickii*)	B,R
Marsh Wren (*Cistothorus palustris*)	M
Canyon Wren (*Catherpes mexicanus*)	R,V
Rock Wren (*Salpinctes obsoletus*)	R,V
House Wren (*Troglodytes aedon*)	M
Ruby-crowned Kinglet (*Regulus calendula*)	W
Blue-gray Gnatcatcher (*Polioptila caerulea*)	B,M,V
Western Bluebird (*Sialia mexicana*)	W
Townsend's Solitaire (*Myadestes townsendi*)	M
Hermit Thrush (*Catharus guttatus*)	W
American Robin (*Turdus migratorius*)	M
Loggerhead Shrike (*Lanius ludovicianus*)	M,V
Northern Mockingbird (*Mimus polyglottus*)	B
Crissal Thrasher (*Toxostoma crissale*)	B?
American Pipit (*Anthus rubescens*)	M
Cedar Waxwing (*Bombycilla cedrorum*)	M,W
Phainopepla (*Phainopepla nitens*)	B,M
Bell's Vireo (*Vireo bellii*)	B
Gray Vireo (*Vireo vicinior*)	M
Orange-crowned Warbler (*Vermivora celata*)	M
Lucy's Warbler (*Vermivora luciae*)	B
Yellow-rumped Warbler (*Dendroica coronata*)	M,W
Yellow Warbler (*Dendroica petechia*)	B,M
MacGillivray's Warbler (*Oporornis tolmiei*)	M
Wilson's Warbler (*Wilsonia pusilla*)	M
Common Yellowthroat (*Geothlypis trichas*)	B,M
Yellow-breasted Chat (*Icteria virens*)	B,M
Black-headed Grosbeak (*Pheucticus melanocephalus*)	M
Blue Grosbeak (*Guiraca caerulea*)	B
Indigo Bunting (*Passerina cyanea*)	B,M
Lazuli Bunting (*Passerina amoena*)	B,M
Green-tailed Towhee (*Piplio chlorurus*)	M
Rufous-sided Towhee (*Pipilo erythrophthalmus*)	M
Brown Towhee (*Piplio fuscus*)	W,B?
Song Sparrow (*Melospiza melodia*)	W,M,B?
Lark Sparrow (*Chondestes grammacus*)	M
Black-throated Sparrow (*Amphispiza bilineata*)	V
Rufous-crowned Sparrow (*Aimophila ruficeps*)	B,V
Chipping Sparrow (*Spizella passerina*)	W,M
Black-chinned Sparrow (*Spizella atrogularis*)	M,V
Dark-eyed Junco (*Junco hyemalis*)	W,M
White-crowned Sparrow (*Zonotrichia leucophrys*)	W
Lincoln's Sparrow (*Melospiza lincolnii*)	M
Brown-headed Cowbird (*Molothrus ater*)	B
Great-tailed Grackle (*Quiscalus mexicanus*)	B,M
Red-winged Blackbird (*Agelaius phoeniceus*)	M,W
Scott's Oriole (*Icterus parisorum*)	V
Northern Oriole (*Icterus galbula*)	B,M
Hooded Oriole (*Icterus cucullatus*)	B,M
Western Tanager (*Piranga ludoviciana*)	M
Summer Tanager (*Piranga rubra*)	B
American Goldfinch (*Carduelis tristas*)	M
Lesser Goldfinch (*Carduelis psaltria*)	B,V
House Finch (*Carpodacus mexicanus*)	B,V
House Sparrow (*Passer domesticus*)	M?

Appendix 2. Location of avian community monitoring study sites in Grand Canyon National Park, 1993-95. Direct impact study sites are named in brackets.

Site #	Location (river miles below Lees Ferry)	Site #	Location (river miles below Lees Ferry)
10	0.0 R [Lee's Ferry]	236	131.3 R
20	1.0 R [Paria]	240	167.0 R
30	1.6 R	250	167.2 L
32	2.0 L	260	167.6 R
34	3.7 L	270	168.5 L
40	5.1 L	280	168.8 R
50	5.2 R	290	171.0 R [Stairway]
60	5.6 R	291	171.1 R
67	46.0 L	300	172.2 L
70	46.7 R [Saddle]	310	173.1 R
80	47.5 L	318	174.2 L
90	48.5 L	320	174.4 R
100	49.1 R	330	174.5 R
110	49.2 L	340	174.7 R
120	50.0 R	342	197.3 L
130	73.9 R	345	197.6 L
140	74.1 R	350	198.0 R [Parashant]
150	74.3 R	352	198.2 L
160	74.4 R	355	198.3 R
165	74.4 L	360	199.5 R
170	75.9 R	370	200.0 L
180	76.0 L	380	200.4 R
185	76.5 L	382	200.5 R
182	95.7 L	390	202.5 R
183	95.9 L	398	204.1 R
185	97.4 R	400	204.5 R [Spring]
186	97.4 L	410	205.8 R
187	97.5 L	420	206.5 L
188	97.6 L	422	206.6 R
190	110.0 R	430	208.7 R
200	112.0 R	440	213.7 L
210	117.5 R	450	214.0 L
220	119.5 R	455	214.2 L
230	119.6 L	460	224.0 L
232	122.8 L	470	224.1 R
234	125.5 R		

Appendix 3. Species and number of individuals banded at the four direct impact study sites along the Colorado River in Grand Canyon National Park during 1995.

Species	Paria	Saddle	Parashant	Spring	Total
Mourning Dove	3				3
Ash-thoated Flycatcher	3	1		2	6
Western Wood Pewee				1	1
Gray Flycatcher		1	1	1	3
Dusky Flycatcher	1	1		1	3
Willow Flycatcher			1	1	2
Bushtit	28				28
House Wren	1				1
Bewick's Wren	3	7	6	2	18
Marsh Wren	7		1	3	11
Ruby-crowned Kinglet	12	1	4	3	20
Blue-gray Gnatcatcher	3	1	6	4	14
Hermit Thrush			1		1
Northern Mockingbird			1	1	2
Bell's Vireo			18	21	39
Gray Vireo	1				1
Solitary Vireo				1	1
Orange-crowned Warbler	2			1	3
Virginia's Warbler	2	1			3
Lucy's Warbler	1	10	45	58	114
Yellow-rumped Warbler			1	1	2
Yellow Warbler	5	2	12	36	55
MacGillivrays' Warbler	2		2	1	5
Wilson's Warbler	3	2	2	3	10
Northern Waterthrush	1				1
Common Yellowthroat	7		3	2	12
Yellow-breasted Chat	2		4	9	15
Black-headed Grosbeak	1				1
Blue Grosbeak	1				1
Indigo Bunting				2	2
Lazuli Bunting	2				2
Green-tailed Towhee	2				2
Song Sparrow	3		2	3	8
Black-throated Sparrow			1		1
Rufous-crowned Sparrow			1		1
Chipping Sparrow	1				1
Dark-eyed Junco	19	2	4		25
White-crowned Sparrow	22				22
Lincoln's Sparrow	6		2	1	9
Red-winged Blackbird			1		1
Northern Oriole	1			1	2
Western Tanager				5	5
Phainopepla				1	1
Lesser Goldfinch			2	1	3
House Finch		2			2
Total	145	31	121	166	463
Species Total	29	12	23	27	45