Glen Canyon Dam, Fluctuating Water Levels, and Riparian Breeding Birds: The Need for Management Compromise on the Colorado River in Grand Canyon[1]

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Abstract.--Large water releases from Glen Canyon Dam in May and June are harmful to riparian breeding birds along the Colorado River in Grand Canyon. Nest inundation can be avoided by releasing surplus water at times other than the breeding season. Habitat loss is the most serious long-term threat to riparian birds.

INTRODUCTION

The completion of Glen Canyon Dam in 1963 signalled a temporary end to floods which swept down the Colorado River through Grand Canyon. Annual pre-dam floods averaging 86,000 cubic feet per second (cfs) would scour the riverbanks of virtually all riparian vegetation except for a narrow band of riparian scrubland above the old high water mark. Floods of up to 120,000 cfs would occur once every ten years before the dam, with the largest known pre-dam flow being 300,000 cfs (Turner and Karpiscak 1980).

Controlled water releases from Glen Canyon Dam greatly reduced the maximum annual flows in the river. Maximum annual flows averaged 31,000 cfs during the period 1963 to 1979 (fig. 1). This allowed a new band of woody riparian habitat to develop in the pre-dam scour zone where only ephemeral and annual plants had previously occurred (Turner and Karpiscak 1980). The old-high-water-zone (OHWZ) vegetation which existed under the pre-dam water regime consisted primarily of mesquite (Prosopis glandulosa), catclaw acacia (Acacia greggii), and netleaf hackberry (Celtis reticulata). Below the OHWZ was the new-high-water-zone (NHWZ), a dense scrubland of rapidly-developing salt cedar (Tamarix chinensis), Baccharis spp., arrowweed (Tessaria sericea), and willow (Salix spp.) (Carothers and Aitchison 1976).

Riparian birds quickly colonized the NHWZ, with some species even expanding their ranges upriver to take advantage of the new habitat (Brown et al. 1983). By the early 1970s, the NHWZ

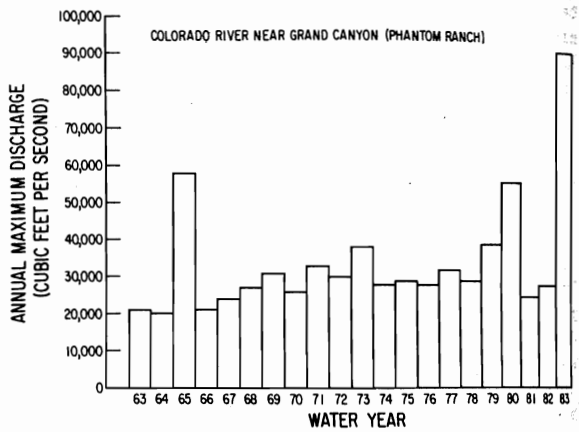

Figure 1. Annual maximum discharge of the Colorado River in Grand Canyon, 1963 to 1983.

habitats probably exceeded OHWZ habitats in avian diversity and equalled or exceeded them in avian density; by the early 1980s this was definitely the case (Brown and Johnson, ms. in prep.). From the short-term perspective of twenty years, the dam has clearly been a benefit to riparian breeding birds. The increase in riparian habitat and associated avian densities has also been, in effect, mitigation for riparian habitat and bird populations lost when Glen Canyon was inundated by Lake Powell. The new riparian habitat in Grand Canyon National Park is the most substantial increase in riparian habitat acreage in the Southwest within the last several decades (Johnson 1978).

Lake Powell reached maximum pool elevation in 1979-80. The filling of the lake coincided with several years of above average snowfall and runoff in the Colorado River drainage, resulting in larger than expected inflow to Lake Powell. These large inflows made necessary the release of large amounts of water through the spillways of Glen Canyon Dam. River flows reached 50,000 cfs during

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first spillway release of June 1980; a spectacular spillway release in June 1983 reached over 93,000 cfs (fig. 1), inundating much of the NHWZ and eroding away a substantial portion of OHWZ vegetation (personal observation). Floods had returned to the Grand Canyon section of the Colorado River.

The purpose of this study is to document the effects of high water releases on obligate riparian breeding birds along the Colorado River in Grand Canyon. The June 1983 high water release will be used as a primary example of these effects. The specific objectives are: 1) quantify nest loss through inundation by various release levels; 2) document avian density changes resulting from the high water release; and 3) predict the future of riparian birds under the new flow regime. Obligate riparian breeding birds were the target organisms chosen for study since they are limited to riparian areas, making them more sensitive to riparian habitat manipulations and more in need of attention from management (Johnson et al. 1977). Information on the long-term effects of high water releases on riparian birds will be useful in making decisions about the long-term management goals for both the dam and the river.

METHODS

Study Area

The study area consists of the Colorado River corridor in Grand Canyon National Park between Lees Ferry and Diamond Creek, a distance of 225 miles. Areas of primary study included Cardenas Creek, Fern Glen Canyon, Lava Falls, Whitmore Wash, Parashant Wash, and Granite Park. A number of secondary sites, ranging in size from less than 1 ha to approximately 5 ha, were also examined.

Procedures

Data on nest location and nest height were gathered in April, May, and June of 1982. Nests were located by coordinated, systematic searches of the vegetation, after which nests were mapped and marked nearby for relocation. Call counts of conspicuous species of obligate riparian birds were made after the methods of Bull (1981), in which singing males were counted during an 18-day, oar-powered float through the study area. Call count data was gathered at all times of day, resulting in an index to population density. The presence of eggs or young was recorded for nesting chronology analysis.

All of the study sites were visited from June 7 to 24, 1983, to determine if or to what extent the known nests of riparian birds were inundated by the high water. Nests were relocated and the water depth at or below the nest recorded to the nearest 0.1 m. Amounts of water released and river level values are from the U.S. Geological Survey gauging station at Phantom Ranch, 104 miles downstream from the dam, or from the U.S. Bureau of Reclamation at Page, Arizona. Water releases from the dam and river level values were generally equivalent during June 1983, as the river quickly stabilized following the few fluctuations.

It was possible to extrapolate back to the approximate cfs level at which a specific nest was inundated by using known values of nest height, depth of water at the nest, and river flow figures. Subtracting the depth to which a nest was inundated from the gauge height reading for the previous day would yield this information. For example, a certain nest at Parashant Wash was 1.24 m below the surface of the river on June 21, at river flows of 62,000 cfs (Phantom Ranch gauge height of 6.94 m)(USGS unpublished data). The nest appears to have been initially inundated at flows corresponding to gauge heights of 5.70 m (6.94 minus 1.24), or 41,170 cfs (USGS unpublished data). The gauge height at Phantom Ranch, however, is not equivalent to river height at Parashant Wash, causing the initial inundation estimate to be slightly inaccurate. The inundation figures which have been extrapolated with this method are only accurate to within a range of plus or minus 2,500 cfs. A rise to the 93,000 cfs range was assumed to have caused a 0.5 m rise over those water levels measured at 62,000 cfs (the level at which most data was gathered). The actual rise at the Phantom Ranch gauge for the increase was 0.9 m, resulting in inundation figures at 93,000 cfs which are somewhat conservative.

Obligate riparian birds which are considered here are Willow Flycatcher (Empidonax traillii), Bell's Vireo (Vireo bellii), Yellow Warbler (Dendroica petechia), Common Yellowthroat (Geothlypis trichas), Yellow-breasted Chat (Icteria virens), Blue Grosbeak (Guiraca caerulea), Hooded Oriole (Icterus cucullatus), Northern Oriole (I. galbula), and Indigo Bunting (Passerina cyanea). Marsh Wren (Cistothorus palustris) and Summer Tanager (Piranga rubra) may also nest rarely and locally in the river corridor, but no nests of these species were located.

Site Selection

Data collection was designed so that the sample of nests found was a representative sample of the nest site preferences of each species. To ensure this representative sample, each habitat type was sampled in direct proportion to its relative occurrence. Since NHWZ habitats comprised approximately 75% of the total vegetation present along the river, 75% of the sample time was spent searching for nests in the NHWZ. Accordingly, 25% of the total sampling time was spent searching OHWZ habitats.

RESULTS AND DISCUSSION

Nest Inundation

Interim results indicate that normal flows of up to 31,000 cfs do not endanger the nests of

obligate riparian birds, as it is only the higher flows which cause nest inundation. Bell's Vireo, Common Yellowthroat, and Yellow-breasted Chat are the three species of obligate riparian birds which were known to experience nest loss through inundation during the June 1983 high water release (table 1). This is primarily due to their nest placement preferences: these species nest both low to the ground and close to the water (Brown and Johnson, ms. in prep.).

Table 1. Nest inundation at 62,000 cfs during the high water of June 1983. Sample size (N) follows names.

Species	Nests Inundated	
	No.	%
Willow Flycatcher(2)	0	0
Bell's Vireo(75)	45	60
Yellow Warbler(2)	0	0
Common Yellowthroat(1)	1	100
Yellow-breasted Chat(19)	2	11
Blue Grosbeak(0)*	-	-
Hooded Oriole(2)	0	0
Northern Oriole(1)	0	0
Indigo Bunting(1)	0	0

*No nests of this species were under observation at this time.

The high percentage of yellowthroat nests known to have been inundated is not just a result of the small sample size for this species (N=1, or less than 5% of the known population). Yellowthroat nest inundation began to occur at lower release levels than for vireo or chat nests, largely due to yellowthroat nest placement just above the surface of the ground or water in low-lying areas. The only known yellowthroat nest was extrapolated to have been inundated by releases of 36,000 cfs. Based on later work and a larger sample size, the height of this nest above water was found to be near the mean for this species, strongly indicating that the majority (ca. 90%) of yellowthroat nests were inundated by the initial rise to the 40,000 cfs level. This would identify Common Yellowthroat as the species most susceptible to significant nest loss through inundation.

The percentage of vireo nests inundated by various release levels is indicated in figure 2. Vireo nests began to be inundated at river flows of 41,000 cfs, but the largest number of nests inundated per 1,000 cfs rise was in the 49,000 to 62,000 cfs range. The percentage of chat nests lost to various release levels is illustrated in figure 3. Some chat nests were inundated by releases as low as 36,000 cfs, although only a small percentage of chat nests were lost to flows of 62,000 cfs or less.

The initial rise to 62,000 cfs in mid-June coincided exactly with the peak of nesting for yellowthroats and chats. Bell's Vireo nesting had

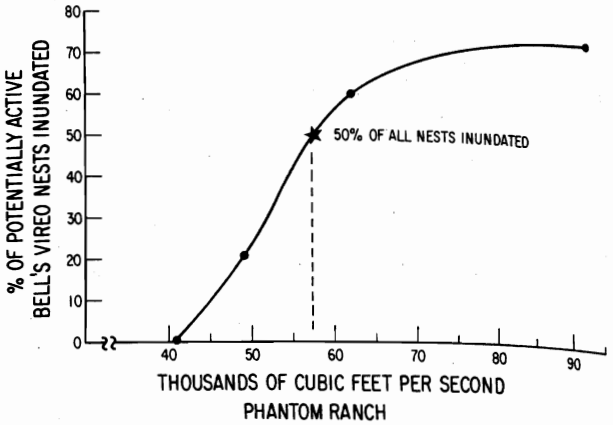

Figure 2. Percent of Bell's Vireo nests inundated at various release levels, June 1983.

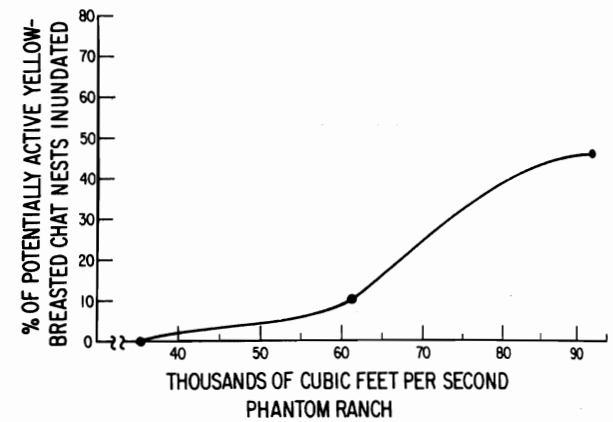

Figure 3. Percent of Yellow-breasted Chat nests inundated by various release levels, June 1983.

just passed its peak at that time (Brown and Johnson, ms. in prep.). At levels of 62,000 cfs, 100% of yellowthroat nests and 11% of chat nests were inundated (table 1); 100% of these were active (eggs or young present) at the time. The timing of the high water release was at the worst possible time for these two species. Sixty percent of the vireo nests were inundated by the same flows, but only 46% of these nests were active. By multiplying percent inundated by percent active (.60 x .46), it is apparent that only 28% of the active vireo nests were lost. If the initial rise to 62,000 cfs had occurred a short time earlier, a much higher percentage of active vireo nests would have been lost.

Vireos, yellowthroats, and chats all have the capability to renest if their nest is destroyed prior to the end of the breeding season. However, the persistence of high water into August reduced the possibilities of renesting.

Avian Density Changes

Bell's Vireo is the only obligate riparian bird showing a marked decline in numbers (32% from 1982-84) after the June 1983 high water (table 2). However, it is normal for population densities of riparian birds in the Southwest to fluctuate in response to annual variations in precipitation, weather, and other factors. Avian densities along the Verde River of Arizona have been shown to vary by as much as 50% over a 2-year period, presumably due to environmental variations of this sort (Carothers and Johnson 1973).

Table 2. Densities of selected riparian birds between Lees Ferry and Diamond Creek, 1976 to 1985.

Species	No. singing males heard			
	1976*	1982	1983	1984
Willow Flycatcher	1	2	4	4
Bell's Vireo	67	135	70**	92
Yellow Warbler	17	32	39	33
Common Yellowthroat	8	-	-	21
Yellow-breasted Chat	18	46	53	65

*Average absolute density from Carothers and Aitchison (1976).
**Inaccurate census due to poor weather.

The Bell's Vireo decline was independent of a simultaneous decline in other species (with the possible exception of Common Yellowthroat, for which density data is unavailable). It is hard to overlook the substantial reduction in NHWZ habitats which accompanied the high water, together with a simultaneous loss of 28% of active vireo nests, and the effect this would have on vireo populations the following year. The Grand Canyon vireo population is at the northern limit of its range in Arizona and is somewhat geographically isolated from main population centers, resulting in a population more susceptible to local perturbations due to limited immigration. For these reasons, the vireo population decrease from 1982 to 1984 must be seen largely as a result of the June 1983 high water event.

CONCLUSIONS AND MANAGEMENT IMPLICATIONS

The release of large amounts of water from Glen Canyon Dam can have significant negative effects on downstream riparian breeding birds. Nest inundation begins to occur at flows of ca. 36,000 cfs and nest losses of 50% or more for Bell's Vireo and Common Yellowthroat begin to occur at flows from 40,000 cfs to 62,000 cfs.

Releases above 36,000 cfs should be avoided during May and June, although this is unfortunately the exact time at which the peak runoff into Lake Powell occurs and the need arises to release surplus water. Nest inundation can be avoided by releasing surplus water at times other than the peak of the breeding season whenever the possibility of surplus water in May and June is foreseen. Adequate flood storage could be maintained in Lake Powell by lowering the reservoir level prior to the peak runoff, a compromise that may occasionally be necessary to prevent widespread nest loss to downstream birds.

The nest loss and subsequent vireo population decline resulting from the June 1983 high water release is a relatively short-term effect from which bird populations can be expected to naturally recover. However, a series of repetitive high water releases would result in long-term instability for the obligate riparian bird community, a situation which would reduce avian density and diversity.

The rate of sediment loss from the river is the most important long-term question regarding the future of riparian birds downstream from Glen Canyon Dam. The dam traps sediment behind it, and the clear water released downstream may pick up and transport sediment out of the river corridor. Sediment loss would eventually result in a loss of riparian vegetation through erosion, a process which caused substantial losses of NHWZ vegetation during the June 1983 high water release. It is essential to understand the effect of dam operations on sediment transport, in order to predict the influence this might have on riparian vegetation and the birdlife associated with it. Studies in progress by the U.S. Geological Survey should quantify the rates of erosion and sediment loss associated with specific flow regimes, but it will be 1987 before this data is available.

A worst-case scenario of future sediment loss would be the nearly total loss of NHWZ habitats. Seven of the nine species of obligate riparian birds along the river are limited primarily to the NHWZ (Brown and Johnson, ms. in prep.). The NHWZ also hosts the great majority (from 50-90%, depending on the species) of the populations of obligate riparian birds in the entire Grand Canyon region (Brown and Johnson, ms. in prep.). For this reason, the complete or partial loss of NHWZ habitats would have a disproportionately negative impact on their regional well-being.

The future of obligate riparian birds along the Colorado River will be largely determined by those who manage Glen Canyon Dam. It is the responsibility of these managers to strike an acceptable compromise that will satisfy both hydroelectric power generation and flood storage needs as well as maintain the diversity of the riparian bird community in Grand Canyon.

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