



Effects of drought on birds and riparian vegetation in the Colorado River Delta, Mexico

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ABSTRACT

The riparian corridor in the delta of the Colorado River in Mexico supports internationally important bird habitat. The vegetation is maintained by surface flows from the U.S. and Mexico and by a high, non-saline aquifer into which the dominant phreatophytic shrubs and trees are rooted. We studied the effects of a regional drought on riparian vegetation and avian abundance and diversity from 2002 to 2007, during which time surface flows were markedly reduced compared to the period from 1995 to 2002. Reduced surface flows led to a reduction in native tree cover but an increase in shrub cover, mostly due to an increase in *Tamarix* spp., an introduced halophytic shrub, and a reduction in *Populus fremontii* and *Salix gooddingii* trees. However, overall vegetation cover was unchanged at about 70%. Overall bird density and diversity were also unchanged, but riparian-obligate species tended to decrease in abundance, and generalist species increased. Although reduction in surface flows reduced habitat value and negatively impacted riparian-obligate bird species, portions of the riparian zone exhibited resilience. Surface flows are required to reduce soil salt levels and germinate new cohorts of native trees, but the main source of water supporting this ecosystem is the aquifer, derived from underflows from irrigated fields in the U.S. and Mexico. The long-term prospects for delta riparian habitats are uncertain due to expected reduced flows of river water from climate change, and land use practices that will reduce underflows to the riparian aquifer and increase salinity levels. Active restoration programs would be needed if these habitats are to be preserved for the future.

Resumen: El corredor ripario en el delta del río Colorado en México contiene hábitat para aves de importancia internacional. La vegetación se mantiene con flujos superficiales de E.U. y México y por un acuífero somero de baja salinidad al cual llegan las raíces de los arbustos y árboles freatófitos. Estudiamos los efectos de una sequía regional sobre la vegetación riparia y la abundancia y diversidad de aves entre el 2002 y 2007, periodo en el que los flujos superficiales se redujeron drásticamente, en comparación con el periodo entre 1995–2002. La reducción de flujos superficiales causó la reducción en cobertura de árboles nativos y un incremento en la cobertura de arbustos, principalmente por el aumento de *Tamarix* spp., un arbusto halófito introducido, y por la pérdida de *Populus fremontii* y *Salix gooddingii*. Sin embargo, la cobertura vegetal se mantuvo sin cambio, en cerca de 70%. La densidad y diversidad de aves también se mantuvo, pero la abundancia de especies riparias descendió, mientras que las especies generalistas aumentaron. Aunque la reducción en flujos superficiales redujo el valor de hábitat y afectó negativamente a las aves riparias, algunas porciones de la zona exhibieron resiliencia. Los flujos superficiales se requieren para reducir la salinidad en el suelo y para la germinación de nuevos cohortes de árboles nativos, pero la principal fuente de agua para este ecosistema es el acuífero, derivado de los flujos subterráneos que provienen de la irrigación agrícola en E.U. y México. La expectativa para los hábitats riparios en el delta es incierta debido a que se espera una reducción en los flujos superficiales a causa del cambio climático, y por las prácticas que reducirán los flujos subterráneos y aumentarán la salinidad. Para poder preservar estos hábitats hacia el futuro se requiere la implementación de programas de restauración activa.

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1. Introduction

The Colorado River supports valuable bird habitat in its delta reach in Mexico (Hinojosa-Huerta et al., 2007). However, flows in the Colorado River are expected to diminish over the next 50 years due to a regional drying trend induced by climate change and more complete utilization of river water for human use (Christensen et al., 2004; McCable and Wolock, 2007; Seager et al., 2007; Barnett and Pierce, 2008; Hidalgo et al., 2009; Rajagopalan et al., 2009). This is expected to result in a deterioration of riparian habitat for numerous resident and migratory birds along the river in the U.S. and Mexico (United States Bureau of Reclamation, 1996; Sogge et al., 2008; van Riper et al., 2008). Natural resource managers are attempting to maintain viable populations of sensitive bird species through a variety of mitigation strategies, currently under development (e.g., Lower Colorado River Multi-Species Conservation Program, 2004). A necessary step in designing avian restoration projects is to understand the likely effects of climate change and land use practices on vegetation and birds (e.g., Miller and Hobbs, 2007; MacNally et al., 2009).

In other biomes short-term droughts have been used as proxies to project the effects of long-term drying trends induced by climate change (Nobre and Borma, 2009; Lewis et al., 2010). We used this approach to study the effects of drought on vegetation and birds in the riparian corridor of the Colorado River in Mexico. Flows in this river reach largely originate from “waste spills” from the U.S. to Mexico, and these flows fluctuate depending on precipitation patterns in the watershed and the amount of water stored in the reservoirs at any given time (Medellin-Azuara et al., 2007; Nagler et al., 2008). Precipitation patterns are driven by ENSO cycles and the Pacific Decadal Oscillation and have high year-to-year variability (Balling and Goodrich, 2007; Thomas, 2007).

The riparian corridor in Mexico experienced significant restoration of marsh and riparian vegetation in response to water releases from the U.S. to Mexico during a 20 year period following the filling of Lake Powell, behind Glen Canyon Dam in the U.S. in 1981 (Nagler et al., 2005, 2008). Relatively large volumes of water were released to the riparian corridor in Mexico in 1979–1986, 1993, and 1997–2000 (Fig. 1). Since 2000, however, the watershed has experienced a severe drought (Barnett and Pierce, 2008), reservoirs are only partially filled, and flows into the Colorado River floodplain in Mexico have diminished, from $2.93 \times 10^8 \text{ m}^3$ in 1998 to $0.60 \times 10^8 \text{ m}^3$ in 2002 and 0 m^3 in 2006 and 2007 (Fig. 2).

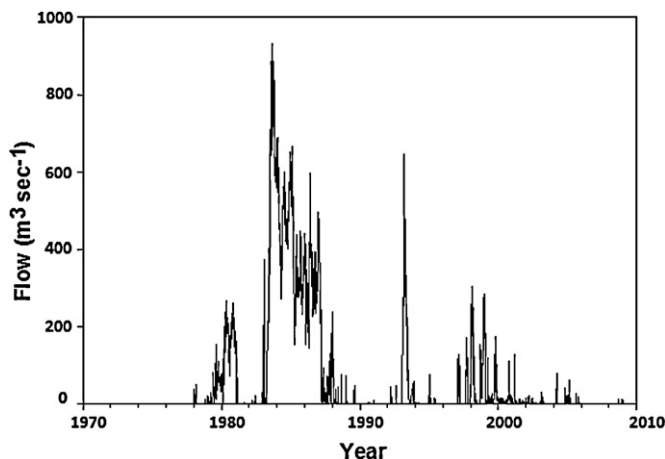


Fig. 1. Flows from the U.S. to Mexico at the Northernly International Boundary. Lake Powell behind Glen Canyon Dam filled for the first time in 1980, resulting in flood releases during El Niño in subsequent years.

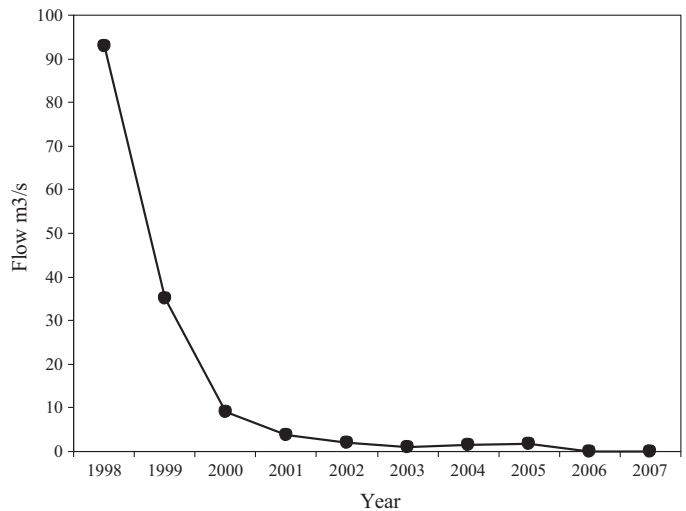


Fig. 2. Average flows ($\text{m}^3 \text{ s}^{-1}$) per year reaching the Colorado River floodplain in Mexico from 1998 to 2007. Flows were measured at the Southerly International Boundary by the International Boundary and Water Commission.

From 2000 to 2002, the vegetation and avian populations in the riparian corridor were monitored four times per year along fixed transects in the delta (Hinojosa-Huerta, 2006; Hinojosa-Huerta et al., 2008). These surveys were continued through 2007 in the present study and provided the opportunity to determine the effects of flow reduction on the riparian ecosystem, as presented in this paper.

2. Methods

2.1. Study area

The study area was located within the floodplain of the Colorado River in Baja California and Sonora, Mexico (Fig. 3). The floodplain traverses the Mexicali Valley as the river flows toward the Gulf of California, and is confined by flood control levees on both banks. Within this region, we worked in the area from San Luis Río Colorado downstream to the confluence of the Colorado with the Hardy River, covering 12,630 ha and extending for 65 river kilometers. This study area included the main stem of the Colorado, secondary streams, backwater lagoons, and portions of the major agricultural canals within the floodplain. The floodplain maintains a continuous corridor of vegetation along this stretch, dominated by saltcedar and arrowweed with significant patches of cottonwood and willow (Glenn et al., 2001). Water flows in the area have been intermittent since the completion of Hoover Dam in 1937, depending upon excess deliveries from the U.S. to Mexico and operational releases from the Mexicali Irrigation District, and agricultural drainage water. These variations in flow have determined the extent and quality of riparian habitat in the floodplain, ranging from degradation due to desiccation to regeneration in response to the return of flows (Glenn et al., 1996; Nagler et al., 2005, 2008, 2009). Extended dry periods have occurred (1952–1979), in which no flows reached the area, as well as extreme flooding events of over $800 \text{ m}^3 \text{ s}^{-1}$ (1981–1983; International Boundary and Water Commission, 2012).

2.2. Bird surveys

We monitored birds at 136 sites (grouped in 17 transects, with 8 points each, Fig. 3) following a variable distance point count methodology (Ralph et al., 1996). The surveys reported here were

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