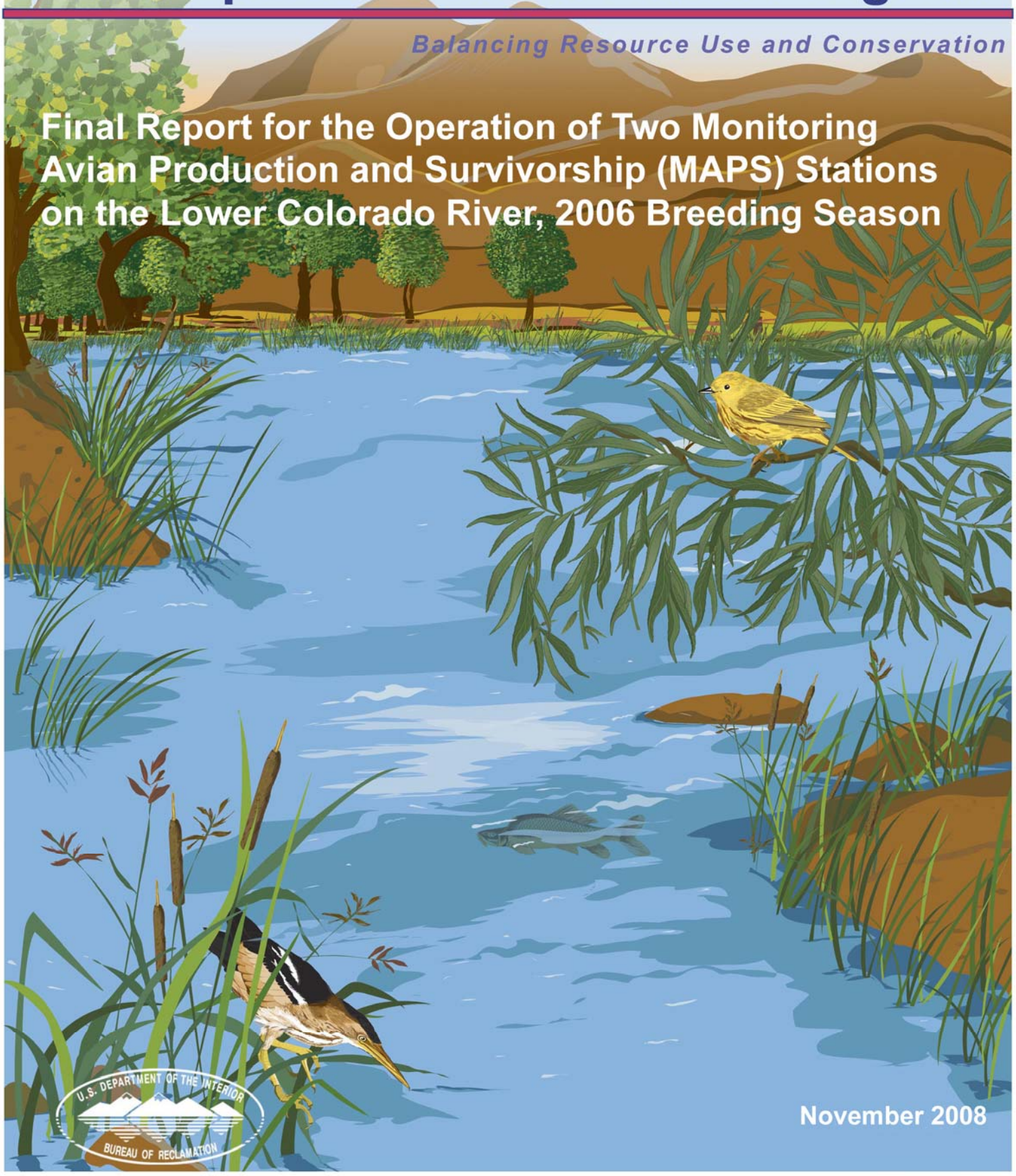
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Final Report for the Operation of Two Monitoring Avian Production and Survivorship (MAPS) Stations on the Lower Colorado River, 2006 Breeding Season



U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

November 2008

Lower Colorado River Multi-Species Conservation Program Steering Committee Members

Federal Participant Group

Bureau of Reclamation
U.S. Fish and Wildlife Service
National Park Service
Bureau of Land Management
Bureau of Indian Affairs
Western Area Power Administration

Arizona Participant Group

Arizona Department of Water Resources
Arizona Electric Power Cooperative, Inc.
Arizona Game and Fish Department
Arizona Power Authority
Central Arizona Water Conservation District
Cibola Valley Irrigation and Drainage District
City of Bullhead City
City of Lake Havasu City
City of Mesa
City of Somerton
City of Yuma
Electrical District No. 3, Pinal County, Arizona
Golden Shores Water Conservation District
Mohave County Water Authority
Mohave Valley Irrigation and Drainage District
Mohave Water Conservation District
North Gila Valley Irrigation and Drainage District
Town of Fredonia
Town of Thatcher
Town of Wickenburg
Salt River Project Agricultural Improvement and Power District
Unit "B" Irrigation and Drainage District
Wellton-Mohawk Irrigation and Drainage District
Yuma County Water Users' Association
Yuma Irrigation District
Yuma Mesa Irrigation and Drainage District

Other Interested Parties Participant Group

QuadState County Government Coalition
Desert Wildlife Unlimited

California Participant Group

California Department of Fish and Game
City of Needles
Coachella Valley Water District
Colorado River Board of California
Bard Water District
Imperial Irrigation District
Los Angeles Department of Water and Power
Palo Verde Irrigation District
San Diego County Water Authority
Southern California Edison Company
Southern California Public Power Authority
The Metropolitan Water District of Southern California

Nevada Participant Group

Colorado River Commission of Nevada
Nevada Department of Wildlife
Southern Nevada Water Authority
Colorado River Commission Power Users
Basic Water Company

Native American Participant Group

Hualapai Tribe
Colorado River Indian Tribes
The Cocopah Indian Tribe

Conservation Participant Group

Ducks Unlimited
Lower Colorado River RC&D Area, Inc.

Lower Colorado River Multi-Species Conservation Program

Final Report for the Operation of Two Monitoring Avian Production and Survivorship (MAPS) Stations on the Lower Colorado River, 2006 Breeding Season

Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

November 2008

Abstract

Summer banding was conducted by the Bureau of Reclamation at two sites along the Lower Colorado River during the summer of 2006, as part of the Monitoring Avian Productivity and Survivorship program. Banding was conducted at Havasu National Wildlife Refuge at a site that represents habitat that is typical of that found on much of the riparian areas of the river, and at Cibola National Wildlife Refuge at a demonstration restoration site planted with mesquite and cottonwood-willow land cover types. Banding was conducted according to a standardized protocol. Area searches were conducted and total vegetation volume was measured in conjunction with the banding data. Banding data were analyzed for annual return of birds originally banded in previous years and for differences in species diversity and richness between sites and with previous year's data, and a Renkonen Index of community similarity was calculated between the two sites to measure the similarity in avian species composition between the sites.

The per-net hour capture was higher at the Cibola site, but only slightly so when only summer resident species were included in the analysis. Species diversity from the banding data was higher at the Havasu site for all species and when migrant species were excluded. A low index of community similarity was found between the two sites using the Renkonen Index. The Renkonen Index was relatively high for the 2006 results when compared to the 2005 data, at both sites. Some annual return captures were recorded in the 2006 data, but the sample size was not large enough to allow any substantial analysis; however, the data may be useful as part of a later multi-year analysis.

Vegetation data tied directly to the banding effort were taken and showed higher amounts of vegetation at the Cibola site in almost all meter layers. There was no exotic tamarisk found at the Cibola site, but a significant portion of the vegetation was tamarisk at the Havasu site. The Cibola site had a much higher proportion of native species, which is to be expected at a restored site planted with native vegetation.

Introduction

During the summer breeding season of 2006, Bureau of Reclamation (Reclamation) operated two Monitoring Avian Production and Survivorship (MAPS) stations along the Lower Colorado River (LCR). The Havasu (HAVA) station was operated near Needles, California, on Havasu National Wildlife Refuge for the second year, and the Cibola Nature Trail (CIBO) station was operated for the fourth year at Cibola National Wildlife Refuge, Arizona.

The MAPS program is a cooperative network of bird banding stations operated throughout the United States, Canada, and Mexico. All stations are operated during the summer breeding season, with the principal purpose of documenting use of breeding habitat by birds throughout North America. The data are collected and analyzed by the Institute for Bird Populations (IBP), which also establishes a set of guidelines and protocol for all MAPS stations (DeSante *et al.* 2002). Data from all the stations are compared to one another and long-term trends for many bird species are monitored on a continent-wide basis.

Riparian areas of the Southwest support a disproportionately high bird diversity and abundance, yet form less than 0.5% of all the land area (Powell and Stiedl 2000). Much of this habitat has been altered and decreased due to climate change, habitat destruction, agricultural land conversion, urban development, mining, overgrazing, and river regulation (Powell and Stiedl 2000, Bureau of Reclamation 1996). Species richness, relative abundance, and individual bird condition are being recorded and analyzed in restored and non-restored habitats.

Study Areas

Cibola National Wildlife Refuge is located along the LCR south of Blythe, California, in Cibola, Arizona. Established in 1964 to offset wildlife and habitat losses due to channelization of the Colorado River, the refuge attracts more than 200 bird species (U.S. Fish and Wildlife Service 2007). The Cibola Nature Trail restoration site contains three distinct areas separated into a 13.6-acre (5.5-hectare) mixture of honey mesquite (*Prosopis glandulosa*) and screwbean mesquite (*P. pubescens*), 6.4 acres (2.6 hectares) of Goodding's willow (*Salix gooddingii*), and 2.5 acres (1 hectares) of Fremont cottonwood (*Populus fremontii*). A total of 1,500 honey mesquite, 1,500 screwbean mesquite, 10,000 Goodding's willow, and 2,600 Fremont cottonwoods were planted (USBR 2003).

The Havasu banding site is located on the Havasu National Wildlife Refuge at the southern end of Topock Marsh, approximately 1.2 miles (1.5 km) north of the town of Topock, Arizona. The nets are located on either side of the dirt road that follows the new south dike just off Arizona Route 95. A large portion of the area is covered in saltcedar (*Tamarix* spp.) and arrowweed (*Pulchea sercea*), with some large, mature cottonwoods forming an overstory over roughly half the site. The cottonwoods at the site are the remaining trees from an earlier planting conducted by Bureau of Reclamation personnel in 1987, where most of the trees planted did not survive (Glenn Gould, per. comm.)

Permits

Banding was conducted under the USFWS Banding Permit #22994, with Joe Kahl as the Master Bander and Greg Clune, Matthew Voisine, Beth Sabin, Allen Calvert and Chris Dodge as sub-permittees. At least one of the sub-permit holders was present during banding efforts.

Methods

The MAPS stations were run once during every 10-day period between May 1 and August 4, 2006, for a total of 10 periods. Established protocol for MAPS station operations was used at all times (De Sante *et al.* 2002).

At the Cibola site, nine 12-m nets and two 6-m nets were used. Six 12-m nets were located in the Goodding's willows, three 12-m nets in the Fremont cottonwoods, and two 6-m nets in the mesquites. These locations were chosen in order to sample the three distinct habitat types.

At the HAVA site, ten 12-m nets were used. Three nets were located in areas with an overstory of Freemont cottonwood and seven nets were located in areas dominated by saltcedar mixed with arroweed and Freemont cottonwood. These locations were chosen in order to evenly sample the land cover types found at the site.

Nets were set up 1/2 hour before sunrise, and closed 5 hours later, or when the temperature exceeded 100°F (37.8°C). The nets were checked every 30 to 50 minutes, depending on the temperature. All data were recorded on a standardized data sheet (Desante *et al.* 2002). A metal, numbered USFWS band was placed on all captured birds, with the exception of game species and hummingbirds. Each bird was identified to species, aged, sexed, measured for wing chord, body fat, and pectoral muscle mass, weighed, and released. Time, date, and net location from which a bird was captured were recorded, as well as total hours of net operations. Birds were identified to species using Pyle (1997) and National Geographic (1999). Birds were aged and sexed using Pyle (1997).

Bird Safety

All operations of the banding station were conducted with bird safety as the first priority. If weather conditions, number of captures, or other circumstances were deemed to be unsafe, nets were closed immediately and banding ceased for the day or until conditions improved. Injured birds were cared for and released as soon as possible. All birds were processed in a quick and timely manner in order to reduce stress caused by handling. Standard protocols for bird extraction and handling, as established by Ralph *et al.* (1993), and De Sante *et al.* (2002), were followed at all times.

Annual Return Rate

Data from recaptured birds were used to measure annual return rate. Annual return rate is a measure of birds recaptured in subsequent field seasons after the field season of their initial capture and is recorded as a percentage (Latta and Faaborg 2001, 2002).

Species Diversity

Several statistical tests were run on the data to compare the results for species diversity and to create a similarity index comparing quantitative similarity in the data. Species diversity was calculated at each site using the Shannon-Weaver index (Krebs 1989 in Nur et al. 1999) which uses the formula:

$$H' = \sum_{i=1}^{i=s} (p_i)(\ln p),\ I = 1,2\ldots S \quad ,$$

where S = the number of species in sample, H' = the species diversity index, and p_i = the proportion of all birds detected belonging to the *i*th species. These values were then transformed into a value, N_1, using the formula $N_1 = e^H$. N_1 gives a value that expresses diversity in terms of species, giving a value that represents what the species richness (number of species detected) is when the data are statistically transformed to represent even detection numbers for all species (Macarthur 1965 in Nur et al. 1999).

Renkonen Index

A community similarity index was created using the Renkonen index (Nur et al. 1999). The Renkonen index (P) is calculated using the formula:

$$P = \sum_{i=1}^{i=s} \text{minimum}(p^A{}_i, p^B{}_i) \quad ,$$

where $p^A{}_i$ is the proportion of species *i* to all species for sample A, $p^B{}_i$ is the proportion of species *i* to all species for sample B, and S is the number of species in the sample.

Vegetation Monitoring

A vegetation monitoring protocol was established to collect data on total vegetation volume (TVV) in order to gain further knowledge of how bird captures from constant effort mist-net operations may be associated to vegetation characteristics of the banding sites. This information was collected once during the summer season. At each site, measurements were taken from a starting point located at the center of each net lane. Two randomly chosen transects were established from each net lane. One 66-ft (20-m) transect was run on either side of the lane. Along each transect, 20 TVV sample points were recorded, one point every 6.5 ft (2 m). At each point, a 7.5-m pole was used to measure vegetation hits at every dm section of the pole. At every 10-cm section, a hit was recorded if any vegetation fell within a 10-cm radius of the pole. For each hit, the plant

species was recorded. Hits were estimated for all vegetation over 25 ft (7.5 m) up to approximately 40 ft (12 m) in height. These data were used to estimate percent of area with vegetation for each meter of height and for the entire site. Species composition was estimated for each site and by height class. This protocol was based on Mills et al. (1991).

Area Searches

Area searches were conducted at both sites throughout the summer breeding season. Ten area searches were scheduled to be conducted at each site. Each site was divided into roughly equal sections and each section was searched for a total of 20 minutes. In each section, the numbers of each species and the type of detection for each individual was recorded. Birds were detected either visually, by call, or by song. Any signs of breeding, nesting or flocking behavior were also recorded on the data form. Species diversity and community similarity between sites was calculated from the area search data.

Results

All 10 periods of banding scheduled for the 2006 MAPS season were completed at both sites. A total of 430 net hours were conducted at the HAVA site and 433 net hours were conducted at the CIBO site. Any capture that occurred, including recaptures and unbanded birds, were listed as "all captures". "Individual captures" is a count of each unique banded individual where recaptures of the same individual are not counted in the total. The birds per net hour rate at the HAVA site was 0.35 for individual captures, 0.40 for all captures, and 0.26 for individual captures of resident birds. The birds per net hour rate at the CIBO site was 0.52 for individual captures, 0.58 for all captures, and 0.28 for individual captures of resident birds. A species was determined to be a resident if it is known to breed on the LCR. Rosenberg et al. (1991) was used, along with previous collected data, to determine whether a species was known to breed on the LCR. A total of 36 species, including 25 resident species, were captured at the HAVA site. A total of 35 species, including 19 resident species, were captured at the CIBO site.

At the HAVA site, the N_1 species diversity value was 20.84 for all species, and 17.24 for resident species. At the CIBO site, the N_1 species diversity value was calculated to be 17.95 for all species, and 10.65 for resident species. The Renkonen Index of Community Similarity between the sites was 0.45 for all species and 0.41 for resident species. When resident capture rates are compared to the 2005 rates, the Renkonen Index of Community Similarity values were 0.61 for the CIBO site and 0.74 for the HAVA site.

At the CIBO site, N1 values were calculated per period as well, and these values were compared between years. There were no significant differences between species diversity values for different years of banding data, except for 2003 and 2004 ($p = 0.03$). There was no significant difference in species diversity values between the CIBO site and the HAVA site from the 2006 banding data ($p = 0.47$).

Figure 1. Relative capture percentage for commonly captured, resident species at the CIBO site.

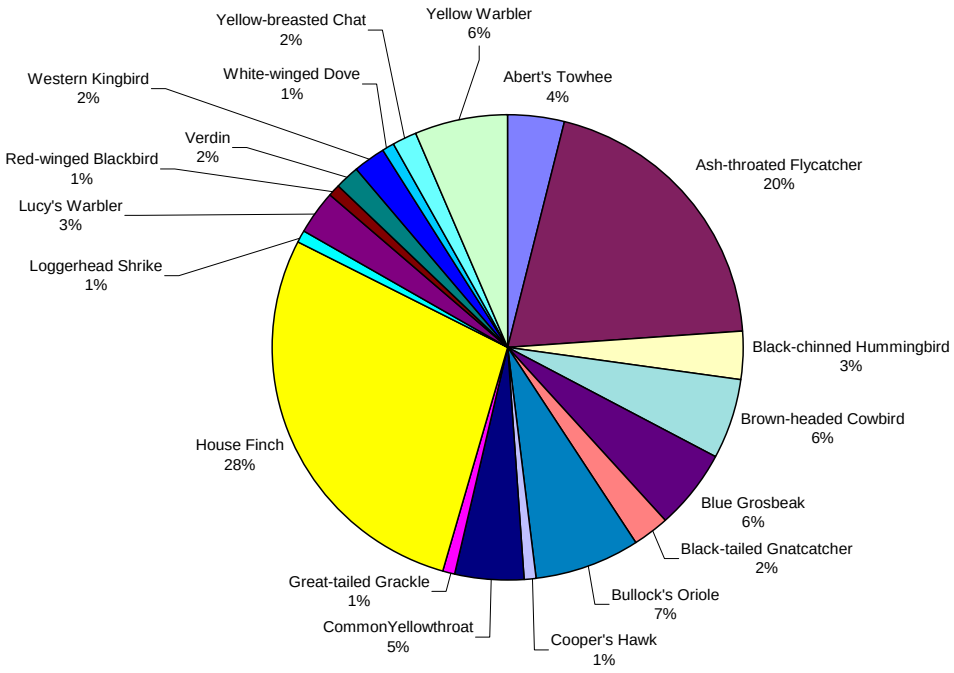


Figure 2. Yearly comparison of birds per net hour, for commonly captured (>0.005), resident species at the CIBO site.

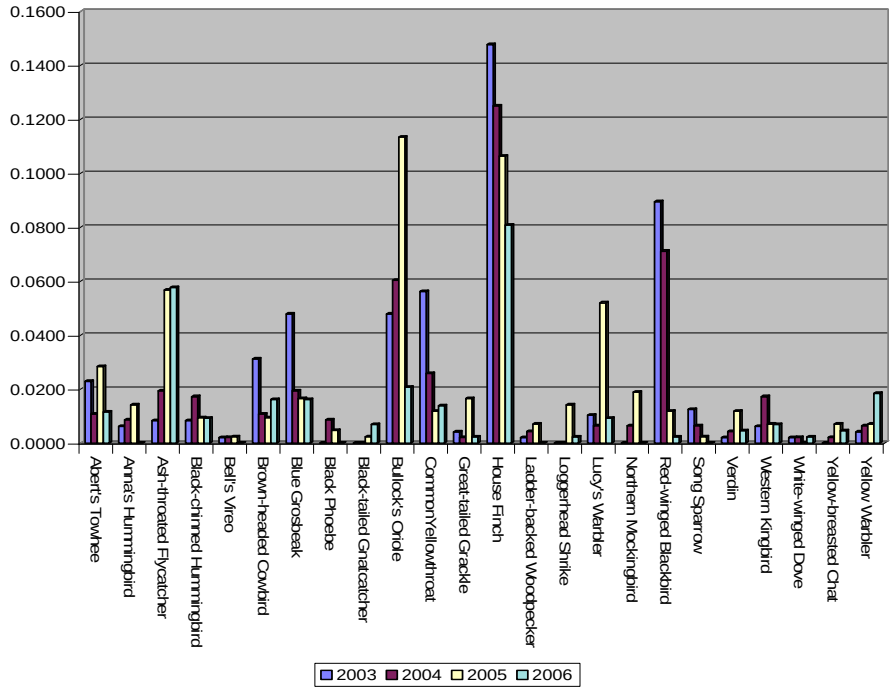


Figure 3. Relative capture percentage for commonly captured (>0.005), resident species at the HAVA site.

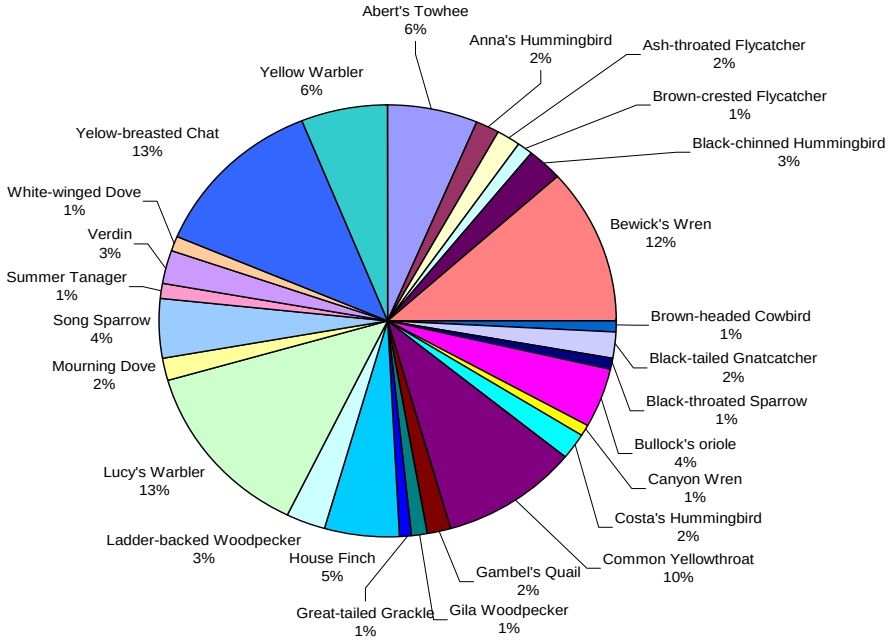


Figure 4. Yearly comparison of birds per net hour for resident species at the HAVA site.

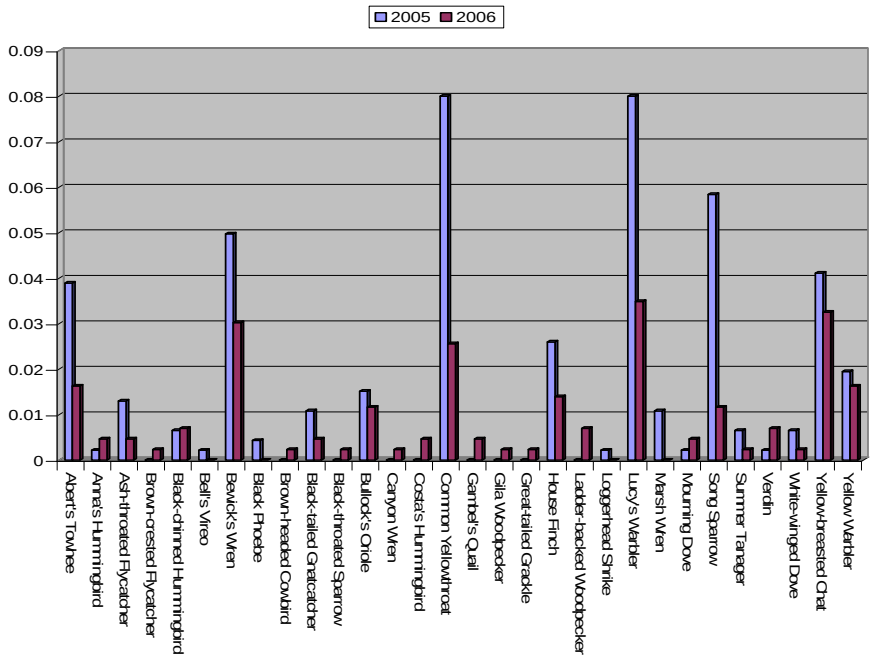
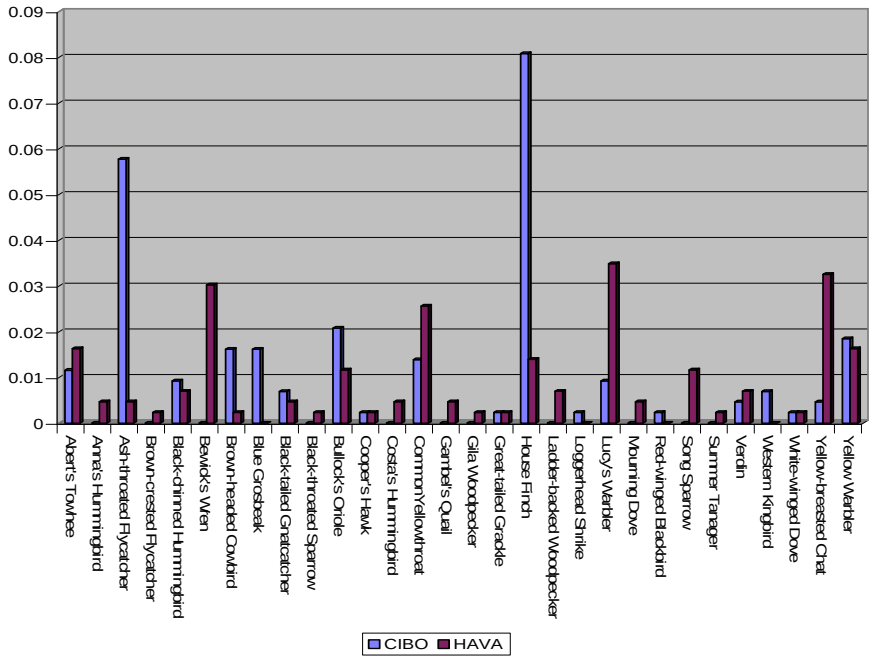


Figure 5. Resident birds per net hour comparison between the CIBO and HAVA sites for 2006.



Bird capture rate for all individuals was higher at the CIBO site (0.522) than at the HAVA site (0.356). When only the resident birds are considered, the difference in capture rates is slight (0.289 at the CIBO site and 0.260 at the HAVA site). At both sites, the capture rate of individual resident birds was nearly half that of the previous year, when the capture rate was 0.550 at the CIBO site and 0.480 at the HAVA site (Reclamation 2006).

Species diversity values were also similar for all species between the sites, but a noticeable difference exists between the two sites for resident birds. When all species are considered, the value for the CIBO site (17.952) is lower than that at the HAVA (20.838) site. However, when only resident species are considered the difference between the CIBO site (10.653) and the HAVA site (17.240) is almost two times greater. N1 species diversity was also calculated per period at both sites for the two years banding has been conducted at both sites, and no statistically significant difference was found between the two sites. The Renkonen Index of Community Similarity was below 50% (0.408) for resident species between the two sites in 2006. When 2005-06 data were combined, the Renkonen Index of Community Similarity was slightly lower for the two sites (0.400).

When the two sites were compared to the 2005 MAPS results, the Renkonen values were fairly high (0.61 for CIBO and 0.74 for HAVA). The difference between years is partially due to the lower capture numbers in 2006. In 2006 at the CIBO site, the species diversity index was slightly lower (10.65 in 2006 and 13.80 in 2005), and at the HAVA it was higher (17.24 in 2006 and 12.34 in 2005). At the CIBO site, the relative proportion of captures per species was similar, but the actual capture rate was lower for most species in 2006, as compared to 2005 (Figure 2). While fewer birds were captured at the HAVA site, more species were commonly captured in 2006 (Figure 4).

Annual Return Rate

Individuals from five different species, which had been originally captured in previous years, were recaptured in 2006. In total, 11 individual birds were recaptured as annual returns at the CIBO site, and 17 individual birds were recaptured as annual returns at the HAVA site. Tables 1 and 2 summarize the annual returns for each species at each site.

Table 1. Annual return rates for all species with at least 1 annual return at the CIBO site.

Species	Individuals	Returns	AR %
Abert's Towhee	5	4	80.00%
Brown-headed Cowbird	7	4	57.14%
Blue Grosbeak	7	1	14.29%
Bullock's Oriole	9	1	11.11%
Verdin	2	1	50.00%

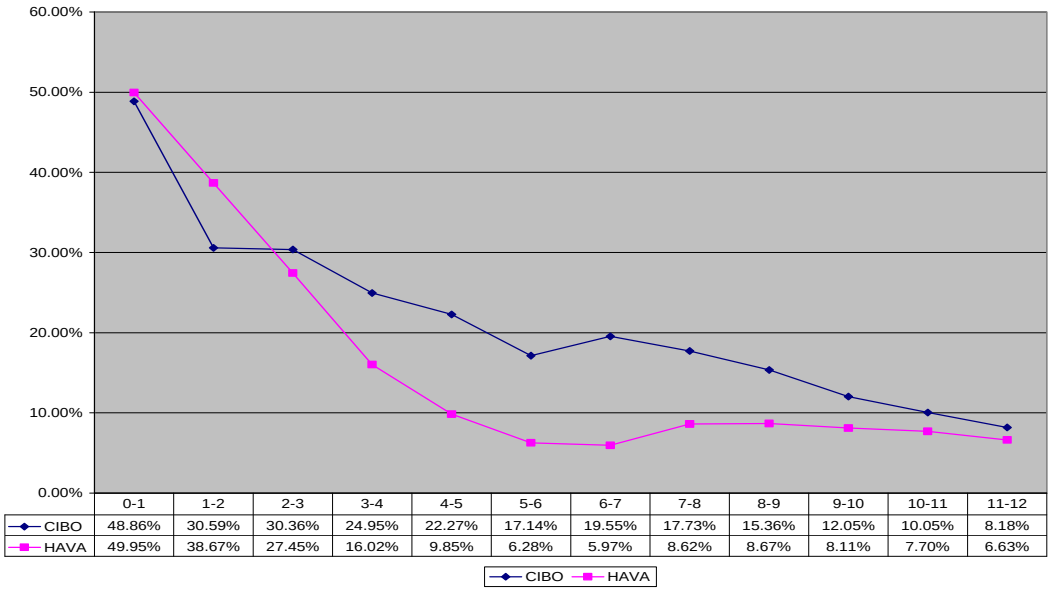
Table 2. Annual return rates for all species with at least 1 annual return at the HAVA site.

Species	Individuals	Returns	AR %
Abert's Towhee	7	2	28.57%
Bewick's Wren	13	5	38.46%
Bullock's Oriole	5	1	20.00%
Song Sparrow	5	1	20.00%
Summer Tanager	1	1	100.00%
Verdin	3	1	33.33%
Yellow Breasted Chat	14	4	28.57%
Yellow Warbler	7	2	28.57%

Vegetation Monitoring

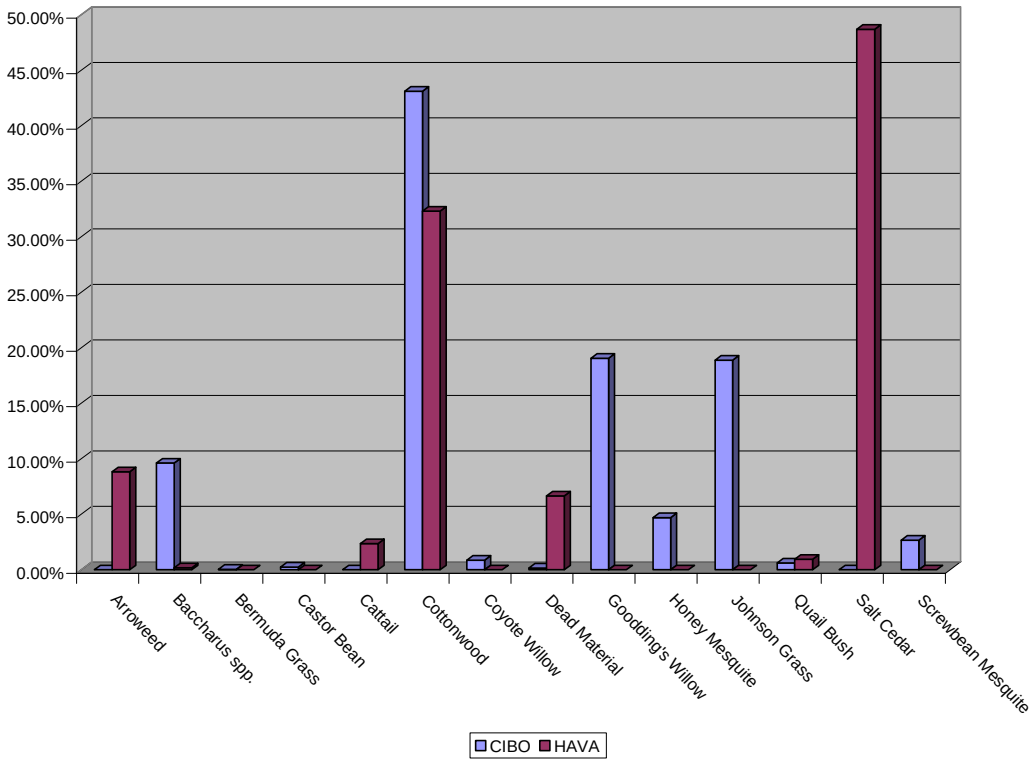
At the HAVA site, a total of 196 points were surveyed from 10 net lanes; 4 points were inaccessible and therefore excluded. At the CIBO site, 220 points were surveyed from 11 net lanes. At the HAVA site, the N_1 species diversity value was calculated to be 3.51 and at CIBO it was calculated to be 4.76. The Renkonen Index of Community Similarity was calculated to be 0.33. Only three species were encountered at both sites: Fremont cottonwood, *Baccharis* spp., and quailbush. Of those three species, Fremont cottonwood was the only species that made up more than 1% of all vegetation surveyed at either site.

Figure 6. Percent vegetation per meter layer comparison between the CIBO and HAVA sites.



	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12
CIBO	48.86%	30.59%	30.36%	24.95%	22.27%	17.14%	19.55%	17.73%	15.36%	12.05%	10.05%	8.18%
HAVA	49.95%	38.67%	27.45%	16.02%	9.85%	6.28%	5.97%	8.62%	8.67%	8.11%	7.70%	6.63%

Figure 7. Comparison of relative percentages of each plant species surveyed between the CIBO and HAVA sites.



See Appendix B for scientific names of the plant species surveyed at both sites.

Area Searches

At both sites, 10 area searches were conducted. At the CIBO site, 34 resident and 41 total species were detected. The N_1 species diversity value was 12.665 for resident species and 14.097 for all species. At the HAVA site, 46 resident species and 50 total species were detected. The N_1 species diversity value was 18.709 for resident species and 19.160 for all species. At the CIBO site, the Renkonen Index of Community Similarity between 2006 and 2005 was 0.798 and at the HAVA site it was 0.773. The Renkonen Index value between the two sites was 0.346.

Figure 8. Relative detection percentages for commonly detected resident species and LCR MSCP covered species at the CIBO site.

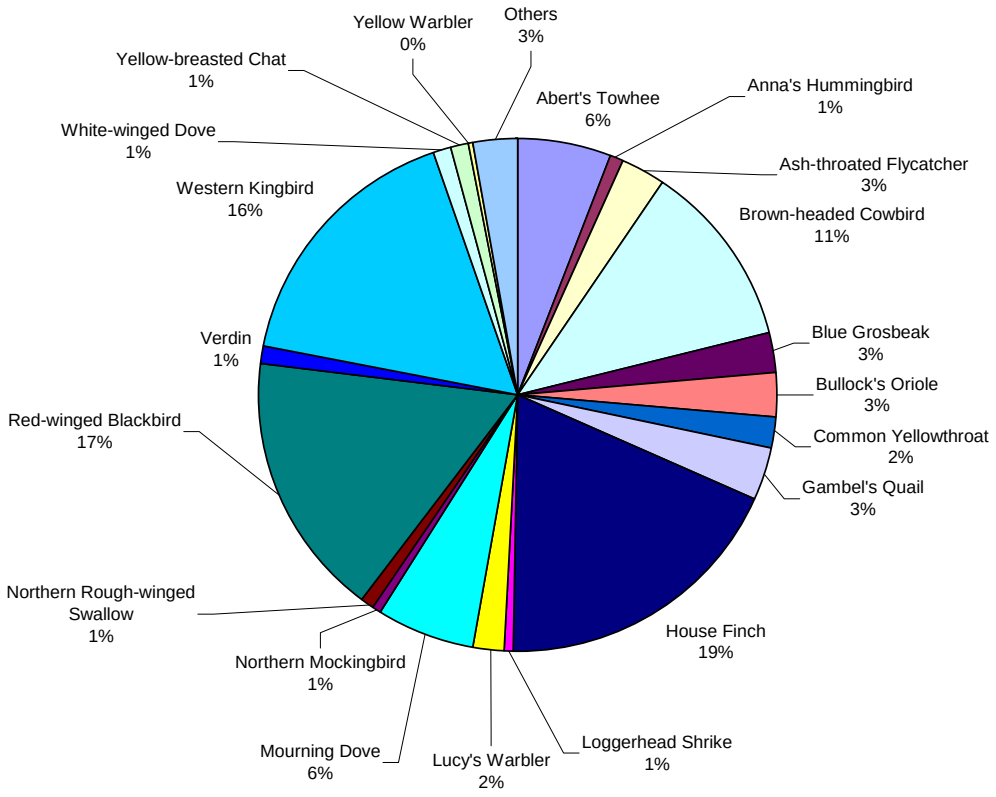


Figure 9. Relative detection percentages for commonly detected resident species and LCR MSCP covered species at the HAVA site.

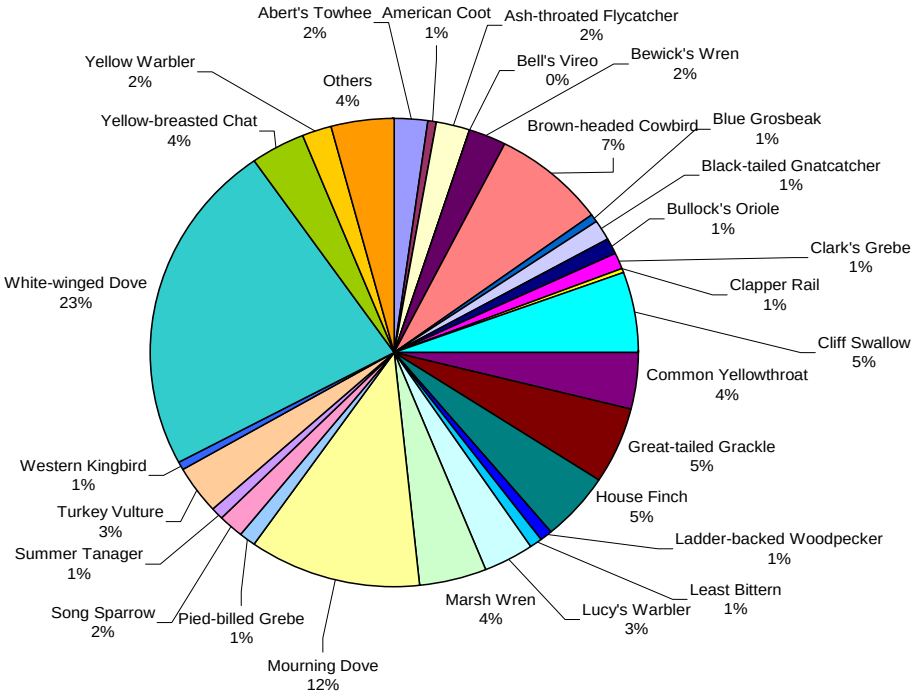
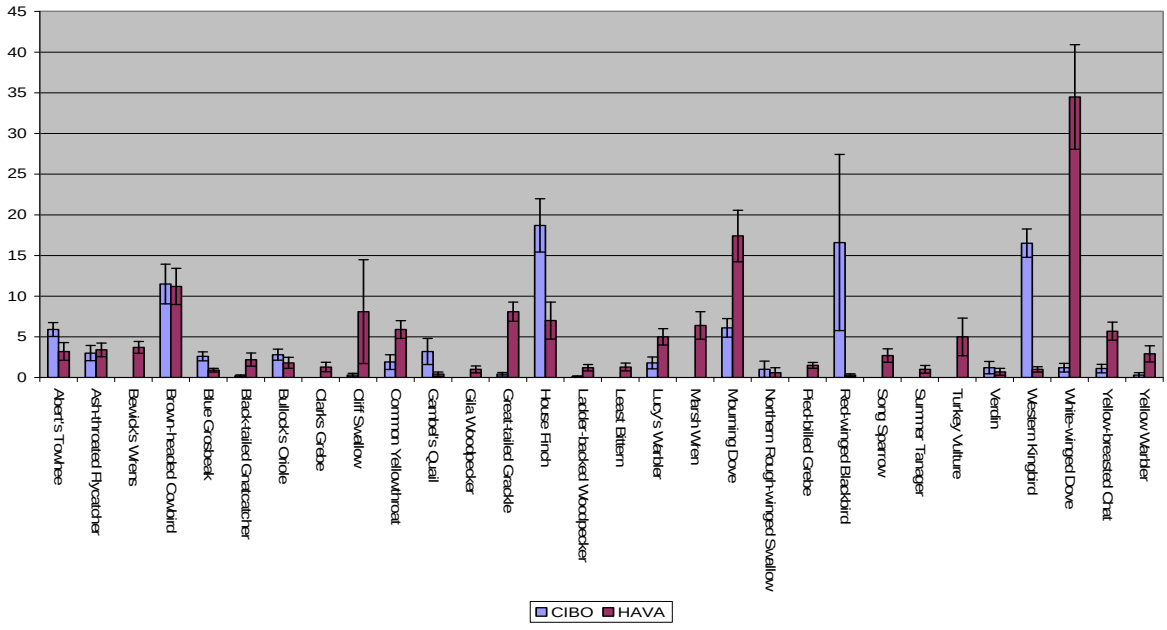


Figure 10. Comparison of average detections per period for commonly detected species (>1 detection per period) at each site, with standard error bars.



Discussion

The main vegetative difference between the two sites is the large amount of saltcedar (nearly 50%) at the HAVA site, while very little saltcedar is found at the CIBO site (Figure 7). No willow species are present at the HAVA site, but at the CIBO site Goodding's willow made up roughly 17% of the vegetation surveyed (Figure 7). Lower amounts of vegetation volume were found at the HAVA site in the mid-level height strata (Figure 6). The HAVA site has considerably less vegetation from the 3-10 meter layers, reflecting the lower number of cottonwood and willows at the site. The cottonwoods present at the HAVA site are older and taller than at the CIBO site and have higher vegetative volume in the higher meter layers. Measuring vegetation at heights above 12 meters, with accuracy, is very difficult and was not attempted. It is possible that the HAVA site has a greater overall vegetative volume present than at the CIBO site. In previous years, vegetation volume was estimated at heights above 12 meters but these estimates were unreliable. In 2007, protocols will be changed to obtain a more reliable estimate for large, overstory trees. Only three tree or shrub species were found in both sites, with only cottonwood comprising greater than 1% of the total tree species at both sites.

At both sites, capture rates declined to nearly half that of the previous year. At both sites, area search detections also decreased, on average, but not as dramatically as in the banding data. This would indicate that bird use declined at both sites in a consistent manner from the previous year. It is hard to accurately determine what may have caused a decline, as many system-wide or population factors may be influencing bird use at individual sites. The fact that both declined at roughly the same rate may point to an overall decline in bird use along the LCR in 2006. Resident bird use at both sites is similar in terms of overall capture rate, but it is higher at the CIBO site when non-resident birds are considered. The increase in habitat diversity at the CIBO site, mainly due to the mesquite habitat, may be attracting more migrant birds as the higher capture rate at CIBO is mainly due to the capture of migrant species. Migrant species are rarely detected in area searches so migrant birds would not have as much of an effect on detection numbers.

No statistically significant difference was found in the N1 species diversity calculations from the banding data between the two sites, but the Renkonen index was lower than 50%. The CIBO site did have a higher N1 species diversity than the HAVA site and the species composition was substantially different as is demonstrated by the Renkonen index value. When banding was conducted in previous years at the Pratt Agricutural site during the winter, no statistically significant difference was found between the Pratt site and CIBO during any one year. However, a 4-year comparison did demonstrate a significant difference in species diversity between the two sites. This would indicate that capture rates at any one site may not be high enough to allow differences in species diversity to be detected and a 4-year or longer analysis may be needed in order to detect differences in habitat use. In future years of banding, it may prove that a significant difference does exist in several factors, and the low Renkonen Index value between the two sites and the higher capture rate at CIBO would support the idea that significant

difference in the two sites may be found with more years of data available. All these measures taken together show that, while species diversity and richness were not different between the sites, species composition was.

The species distribution was different between the two sites, with no one or two species making up a greater proportion of the captures at the HAVA site while two species had higher capture rates at the CIBO site. Differences in vegetation composition between the two sites may explain species distribution, as the HAVA site has less diversity in plant species, with large areas of monotypic tamarisk, while the CIBO site has a mesquite-grassland habitat component that is heavily utilized by ash-throated flycatchers and house finches, the two species that showed higher capture rates at the CIBO site.

In 2006, lower bird activity was recorded at both sites, roughly in equal proportion as compared with results from 2005. However, the Renkonen index values were fairly high for both sites when banding data from 2006 were compared with 2005 data. Species diversity values were relatively similar and, while lower bird use was experienced at both sites, a substantial change in relative use by species was not recorded. Two years of data may not be adequate to compare bird use between the two sites. At the CIBO site, 5 years of data have been collected and the use of the site by MSCP listed species is still noticeably low. Nonetheless, other riparian obligate bird species are using the site, such as blue grosbeak and common yellowthroat, which are commonly found in riparian areas where some MSCP covered species are commonly present. CIBO was originally established as a demonstration site to test restoration techniques, consequently cottonwood and willow habitats were planted in small, non-contiguous plots. The site has not reached full maturity and many changes in bird use may become evident as the trees continue to grow and form a larger and thicker canopy.

Due to the low capture rate experienced at both sites, the annual return rates are difficult to use as index of avian use (Tables 1 and 2). Individual capture totals for species that had annual return recaptures in 2006 were not high enough to draw any meaningful conclusions from the data.

The area search method detects certain species of birds more readily than does banding, and less so for other species. Generally, species such as corvids and raptors are rarely, if ever, caught in mist nets designed for capturing passerines. Conversely, these species are more readily detected visually, and in some cases aurally, than smaller, more secretive passerine species. Although data collected from the two sampling methods cannot be directly compared, area search data can be used to compliment data collected during banding to better describe bird use at these sites.

Habitat characteristics, including surrounding or peripheral habitats, influence area search data, especially the presence of open water and marsh habitat at the HAVA site. On the north side of the dike road that runs through the center of the HAVA site, there is cattail marsh habitat that is located adjacent to the cottonwood-saltcedar habitat. Several nets are located on the edge of these habitats. There is no such habitat at the CIBO site; therefore, several species, such as Clark's grebe (*Aechmophorus clarkii*), western grebe

(*Aechmophorus occidentalis*), clapper rail (*Rallus longirostris*), and least bittern (*Ixobrychus exilis*), were found only at the HAVA site. As expected, the N_1 species diversity values were higher for both resident and all species at the HAVA site. Species richness was greater at HAVA by 12 resident species and 9 total species. When aquatic species are excluded from the analysis, however, species richness is equal for resident birds. Thus, most of the difference in species richness and species diversity, which is partially dependent on species richness, can be explained by the presence of standing water and marsh at the HAVA site.

In 2006, capture rate declined at both sites as compared to the previous year. Overall, the CIBO site declined more in terms of species diversity, species richness, and capture rate than what the HAVA site experienced. In 2005, the CIBO site had higher values for species diversity, richness, and capture rate when compared to the HAVA site. This may be due to vagaries experienced in bird use due to a wide variety of factors that change from year to year. As more data are collected, it will be useful to see if the gradual increase in the size and maturity of the habitat at the CIBO increases the quality of the habitat as measured by the indices used from banding and area search data.

Literature Cited

Bibby, C. J., N. D. Burgess, and D. A. Hill. 1992. Monitoring Bird Populations. Academic Press Inc., San Diego, CA.

Bureau of Reclamation. 2001. Yearly Report for the 2001 MAPS Field Season. Report for the Bureau of Reclamation, Lower Colorado Region, Boulder City, Nevada. 3 pp.

Bureau of Reclamation. 2003. Habitat Restoration on the Lower Colorado River Demonstration Projects: 1995-2002. U.S. Department of the Interior, Lower Colorado Regional Office, Bureau of Reclamation, Boulder City, NV.

Bureau of Reclamation. 2004. FINAL Report for the Operation of Two Monitoring Avian Production and Survivorship (MAPS) Stations on the Lower Colorado River, 2004 Breeding Season. U.S. Department of the Interior, Lower Colorado Regional Office, Bureau of Reclamation, Boulder City, NV.

Bureau of Reclamation 2006. FINAL Report for the Operation of Two Monitoring Avian Production and Survivorship (MAPS) Stations on the Lower Colorado River, 2005 Breeding Season. U.S. Department of the Interior, Lower Colorado Regional Office, Bureau of Reclamation, Boulder City, NV.

Desante, D. F., K. M. Burton, P. Velez, and D. Froehlich. 2002. Maps Manual 2002 Protocol Instructions for the Establishment and Operation of Constant-effort Bird-banding Stations as Part of the Monitoring Avian Productivity and Survivorship (MAPS) Program. The Institute for Bird Populations. Point Reyes Bird Observatory Bolinas, CA.

Fleishman, E., D. D. Murphy, T. Floyd, N. McDonal, and J. Walters. 2002. Characterization of riparian bird communities in a Mojave Desert watershed. Great Basin Birds 5(1):38-44.

Gosler, A. G. 1991. On the use of greater covert moult and pectoral muscle as measures of condition in passerines with data for the greater tit *Parus major*. Bird Study 38:1-9.

Latta, S. C., and J. Faaborg. 2001. Winter site fidelity of prairie warblers in the Dominican Republic. The Condor 103(3):455-468.

Latta, S. C., and J. Faaborg. 2002. Demographic and population responses of Cape May warblers wintering in multiple habitats. Ecology 83(9):2502-2515.

Mills, S. G., J. B. Dunning Jr., and J. M. Bates. 1991. The relationship between breeding bird density and vegetation volume. Wilson Bulletin 103(3):468-479.

National Geographic Society. 1999. Field Guide to the Birds of North America, Third edition. National Geographic Society, Washington, D.C. 457 pp.

Nur, N., S. L. Jones, and G. R. Geupel. 1999. A Statistical Guide to Data Analysis of Avian Monitoring Programs. U.S. Department of the Interior, Fish and Wildlife Service, BTP-R6001-1999, Washington, D.C.

Powell, B. F., and R. J. Stiedl. 2000. Nesting habitat and reproductive success of southwestern riparian birds. The Condor 102:823-831.

Pyle, P. 1997. Identification Guide to North American Birds. Slate Creek Press, Bolinas, CA.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. Desante. 1993. Handbook of Field Methods for Monitoring Landbirds. U.S. Department of Agriculture, Gen. Tech. Rep Report PSW-GTR-144. Pacific Southwest Research Station, Albany, CA.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Rosenberg, K. V., R. D. Ohmart, W. C. Hunter, and B. W. Anderson. 1991. Birds of the Lower Colorado River Valley. The University of Arizona Press. Tucson, AZ. 416 pp.

U.S. Fish and Wildlife Service. 1997. Biological and conference opinion on lower Colorado operations and maintenance — Lake Mead to southerly international border. Biological opinion issued to the Bureau of Reclamation.

U.S. Fish and Wildlife Service. 2007. Cibola National Wildlife Refuge. http://www.fws.gov/southwest/refuges/CibolaNWR/index.html. Accessed April 2007.

Appendix A. Standard AOU (American Ornithological Union) Codes for North American Bird Species Found Along the LCR.

Code	Common Name	Scientific Name
NOHA	northern harrier	*Circus cyaneus*
SSHA	sharp-shinned hawk	*Accipiter striatus*
AMKE	American kestrel	*Falco parverius*
GAQU	Gambel's quail	*Callipepela gambelii*
WWDO	white-winged dove	*Zenaida asiatica*
MODO	mourning dove	*Zenaida macroura*
COGD	common ground-dove	*Columbina passerine*
YBCU	yellow-billed cuckoo	*Coccyzus americanus*
GRRO	greater roadrunner	*Geococcyx californianus*
LENI	lesser nighthawk	*Chordeiles acutipennis*
WTSW	white-throated swift	*Aeronautes saxatalis*
BCHU	black-chinned hummingbird	*Archilocus alexandri*
ANHU	Anna's hummingbird	*Calypte anna*
COHU	Costa's hummingbird	*Calypte costae*
RUHU	rufous hummingbird	*Selaphorus rufus*
LBWO	ladder-backed woodpecker	*Picoides scolaris*
RSFL	red-shafted flicker	*Colaptes auratus cafer*
YSFL	yellow-shafted flicker	*Colaptes auratus auratus*
WWPE	western wood-peewee	*Contopus sordidulus*
WIFL	willow flycatcher	*Empidonax trailii*
LEFL	least flycatcher	*Empidonax minimus*
HAFL	Hammond's flycatcher	*Empidonax hammondii*
GRFL	gray flycatcher	*Empidonax wrightii*
DUFL	dusky flycatcher	*Empidonax oberholseri*
WEFL	western flycatcher	*Empidonax difficilis/occidentalis*
PSFL	Pacific-slope flycatcher	*Empidonax difficilis*
COFL	Cordilleran flycatcher	*Empidonax occidentalis*
EAPH	eastern phoebe	*Sayornis phoebe*
BLPH	black phoebe	*Sayornis nigricans*
SAPH	Say's phoebe	*Sayornis saya*
VEFL	vermillion flycatcher	*Pyrocephalus rubinus*
ATFL	ash-throated flycatcher	*Myiarchus cinerascens*
BCFL	brown-crested flycatcher	*Myiarchus tyrannulus*
WEKI	western kingbird	*Tyrannus verticalis*
LOSH	loggerhead shrike	*Lanius ludovicianus*
BEVI	Bell's vireo	*Vireo belli*
PLVI	plumbeous vireo	*Vireo plumbeus*
CAVI	Cassin's vireo	*Vireo cassinii*
WAVI	warbling vireo	*Vireo gilvus*
CORA	common raven	*Corvus corax*
HOLA	horned lark	*Eremophila alpestris*
TRES	tree swallow	*Tachycineta bicolor*
VGSW	violet-green swallow	*Tachycineta thalassina*
NRWS	northern rough-winged swallow	*Stelgidopteryx serripennis*
CLSW	cliff swallow	*Petrochelidon pyrrhonota*

Code	Common Name	Scientific Name
BARS	barn swallow	*Hirundo rustica*
VERD	verdin	*Auriparus flaviceps*
CACW	cactus wren	*Campylorhynchus brunneicapillus*
BEWR	Bewick's wren	*Thryomanes bewickii*
HOWR	house wren	*Troglodytes aedon*
MAWR	marsh wren	*Cistothorus palustris*
RCKI	ruby-crowned kinglet	*Regulus calendula*
BGGN	blue-grey gnatcatcher	*Polioptila caerulea*
BTGN	black-tailed gnatcatcher	*Polioptila melanura*
SWTH	Swainson's thrush	*Catharus ustulatus*
HETH	hermit thrush	*Catharus guttatus*
NOMO	northern mockingbird	*Mimus polyglottos*
CRTH	crissal thrasher	*Toxostoma crissale*
PHAI	phainopepla	Phainopepla nitens
OCWA	orange-crowned warbler	*Vermivora celata*
NAWA	Nashville warbler	*Vermivora ruficapilla*
LUWA	Lucy's warbler	*Vermivora luciae*
YWAR	yellow warbler	*Dendroica petechia*
AUWA	yellow-rumped (Audubon's) warbler	*Dendroica coronata auduboni*
MYWA	yellow-rumped (Myrtle's) warbler	*Dendroica coronata coronata*
BTYW	black-throated gray warbler	*Dendroica nigrescens*
TOWA	Townsend's warbler	*Dendroica townsendi*
HEWA	hermit warbler	*Dendroica occidentalis*
AMRE	American redstart	*Setophaga ruticilla*
NOWA	northern waterthrush	*Seiurus noveboracensis*
KEWA	Kentucky warbler	*Oporornis formosus*
MGWA	Macgillivray's warbler	*Oporornis tolmiei*
COYE	common yellowthroat	*Geothypis trichas*
WIWA	Wilson's warbler	*Wilsonia pusilla*
YBCH	yellow-breasted chat	*Icteria virens*
SUTA	summer tanager	*Piranga rubra*
WETA	western tanager	*Piranga ludoviciana*
GTTO	green-tailed towhee	*Pipilo chlorurus*
SPTO	spotted towhee	*Pipilo maculatus*
ABTO	Abert's towhee	*Pipilo aberti*
BRSP	Brewer's sparrow	*Spizella breweri*
BTSP	black-throated sparrow	*Amphispiza bilenata*
SOSP	song sparrow	*Melospiza melodia*
LISP	Lincoln's sparrow	*Melospiza lincolnii*
WTSP	white-throated sparrow	*Zonotrichia albicollis*
WCSP	white-crowned sparrow	*Zonotrichia leucophrys*
GWCS	Gambel's white-crowned sparrow	*Zonotrichia l. gambelii*
MWCS	mountain white-crowned sparrow	*Zonotrichia l. oriantha*
DEJU	dark-eyed junco	*Junco hyemalis*
SCJU	slate-colored junco	*Junco hyemalis hyemalis*
BHGR	black-headed grosbeak	*Pheucticus melanocephalus*
BLGR	blue grosbeak	*Passerina caerulea*

Code	Common Name	Scientific Name
LAZB	lazuli bunting	*Passerina amoena*
INBU	indigo bunting	*Passerina cyanea*
RWBL	red-winged blackbird	*Agelaius phoeniceus*
WEME	western meadowlark	Sturnella neglecta
YHBL	yellow-headed blackbird	*Xanthocephalus xanthocephalus*
GTGR	great-tailed grackle	*Quiscalus mexicanus*
BHCO	brown-headed cowbird	*Molothrus ater*
HOOR	hooded oriole	*Icterus cucullatus*
BUOR	Bullock's oriole	*Icterus bullockii*
HOFI	house finch	*Carpodacus mexicanus*

Appendix B. Plant Species — Common and Scientific Names.

arroweed	*Pluchea sercea*
baccharis	*Baccharis* spp.
Bermudagrass	*Cynodon dactylon*
castor bean	*Ricinus communis*
cattail	*Typha latifolia*
cottonwood	*Populus freemontii*
coyote willow	*Salix exigua*
Goodding's willow	*Salix gooddingii*
honey mesquite	*Prosopis glandulosa*
Johnsongrass	*Sorghum halapense*
quailbush	*Atriplex lentiformis*
saltcedar	*Tamarix* spp.
screwbean mesquite	*Prosopis pubescens*