Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Winter Bird Monitoring Using Constant Effort Mist Netting at Two Sites along the Lower Colorado River 2006-2007

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

August 2009

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Multi-Species Conservation Program
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Lower Colorado Region
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Abstract

As part of a year-round avian monitoring program along the lower Colorado River (LCR), the Bureau of Reclamation (Reclamation) initiated a winter season constant-effort mist netting project in the winter of 2002-03 at a demonstration restoration site. The site, known as the Cibola Nature Trail (CIBO), is located on the Cibola National Wildlife Refuge in Arizona. This project allows Reclamation to gather data about bird use at restoration sites and to better understand habitat needs of avian species covered under the LCR Multi-Species Conservation Program (MSCP). In 2005, another site, which is more typical of habitat along the LCR, was added to the monitoring program at the Havasu National Wildlife Refuge (HAVA) in Arizona. Both sites were monitored for two consecutive days, once a month from October to March. Bird banding data allowed analysis of site persistence both monthly and annually. The ruby-crowned kinglet (*Regulus calendula*) showed high winter site persistence at both sites. Annual returns were found at both the CIBO and HAVA sites. The CIBO site had higher capture rates, species richness, and diversity. The location of each site may affect avian use. Ruby-crowned kinglet and Audubon's warbler (*Dendroica coronata audoboni*) were the most commonly captured species at both sites, although capture rates differed between species at each site. This is probably due to differences in the habitat. As more data is collected at both sites, trends may become more apparent, and they will be able to be better compared to each other. As future habitat creation sites are constructed along the LCR, this data will help in designing these areas so that avian use can be maximized.

Introduction

The lower Colorado River (LCR) travels from Lees Ferry, south of Glen Canyon Dam, to the Southern International Boundary (SIB) with Mexico. Flowing through the Mojave and Sonoran deserts, the LCR provides a large expanse of riparian vegetation in an arid environment. Riparian areas in the Southwest support a disproportionately high bird diversity and abundance, yet form less than 0.5% of the land area (Powell and Stiedl 2000). The decline of size and quality of this habitat has negatively affected the avian species that utilize it (Szaro 1980, Rosenberg *et al*. 1991, Powell and Stiedl 2000). Much of this habitat has been altered due to habitat destruction, agricultural land conversion, urban development, mining, overgrazing, and river regulation (Bureau of Reclamation 1996, Powell and Stiedl 2000). A search of the literature finds very little data concerning year-round bird use in riparian areas of the Southwest, especially in habitat restoration sites.

The Bureau of Reclamation (Reclamation) has established several demonstration sites for native riparian restoration along the LCR. These sites were created to evaluate potential restoration techniques to meet objectives set forth in the LCR Multi-Species Conservation Program (LCR MSCP). The LCR MSCP is a cooperative Federal-State-Tribal-County-Private endeavor to restore over 8,000 acres of habitat along the LCR within 50 years (LCR MSCP 2004). Implementation of the MSCP began in October 2005. Reclamation's goal is to create habitat for LCR MSCP covered species. To accomplish this, Reclamation needs to increase its understanding of restoration science through an adaptive management approach; therefore, monitoring of current restoration sites is crucial.

In the winter of 2002-03, Reclamation initiated a winter season constant-effort mist netting/bird banding operation at a riparian vegetation restoration site along the LCR. In 2005, a new site was added that is considered to be more typical of the habitat currently found along the LCR. Winter season data for the restoration projects will be used, in conjunction with data collected from other times of the year, as a guide to habitat requirements for specific species, particularly those covered under the LCR MSCP. Winter use has been observed for the Gila woodpecker (*Melanerpes uropygialis*), Bell's vireo (*Vireo bellii*), and vermilion flycatcher (*Pyrocephalus rubinus*). Avian species diversity and richness numbers collected from this project will be used as an indicator of what bird use may be expected in future habitat creation projects conducted along the LCR.

Study Areas

Cibola National Wildlife Refuge is located along the LCR south of Interstate 10 in Cibola, Arizona. The refuge was established in 1964 to provide habitat for wildlife. More than 200 species of birds can be seen at the refuge (U.S. Fish and Wildlife Service 2007). The Cibola Nature Trail restoration site (CIBO), planted in 1999, contains three distinct areas: 1) a 13.6-acre (5.5-ha) mixture of honey mesquite (*Prosopis glandulusa*) and screwbean mesquite (*Prosopis pubescens*), 2) 6.4 acres (2.6 ha) of Goodding's willow (*Salix gooddingii*), and 3) 2.5 acres (1 ha) of Fremont cottonwood (*Populus fremontii*). Most of the willow area, and part of the mesquite

area also have cottonwoods along their edges. The mesquite species range in height from 20 to 26 feet (6 to 8 m), the willow range from 23 to 30 feet (7 to 9 m), and most cottonwoods at the site are greater than 40 feet (12 m) in height. *Baccharis* spp. grows throughout the entire site, exceeding 10 feet (3 m) in height in some areas. Exotic Johnsongrass (*Sorghum halepense*) invaded as an understory in each of the three areas, and serves as a ground cover reaching up to 6 feet (2 m) in height.

In 2005, the Havasu banding site (HAVA) was monitored during the winter season for the first time. This 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 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 *Tamarix* spp. and arrowweed (*Pulchea sercea*), with some large, mature cottonwoods (greater than 45 ft (14 m) in height) forming an overstory over roughly 15% of the site. The cottonwoods are the surviving trees from a planting in 1988. The south side of the dike consists of a monotypic stand of *Tamarix* spp., ranging in height from 20 to 26 ft (6 to 8 m), while the north side is comprised of *Tamarix* spp., with an overstory of cottonwoods in some areas. The northern edge of the site is bordered by marsh vegetation. This site is typical of the vegetation now found along the LCR.

Methods

Mist-netting/Bird Banding

Mist-netting/bird-banding occurred at the Cibola Nature Trail site for the fifth consecutive season during the winter of 2006-07. The protocol was adapted from the system used by other organizations, including Point Reyes Bird Observatory, which recently instituted winter banding efforts in North America. The protocol includes six banding sessions of two consecutive days, once a month, from October to March. Inclement weather (wind, temperature, etc.) often caused one or more sessions to be shortened or cancelled. In 2006-07, banding began in October and continued through March. All nets were 40 ft (12 m) long and 8.5 ft (2.6 m) tall, and had a mesh size of 1.2 in (30 mm). At the CIBO site, nine nets were placed in cottonwood-willow habitat and three nets were placed in the mesquite habitat. At the HAVA site, seven nets were placed in the areas where cottonwoods formed an overstory above the *Tamarix* spp., and five nets were placed in areas where *Tamarix* spp. dominated.

Nets were set up ½ hour after sunrise and were open for 6 hours unless conditions, such as wind or temperature, exceeded protocol limits. Nets were checked every 30-50 minutes. A metal, numbered U.S. Fish and Wildlife Service (USFWS) band was placed on the right leg of most captured birds, excluding game species and hummingbirds. Identification of species, age, sex, wing cord length, amount of body fat present, and weight were documented prior to releasing each bird. Time, date, and net location from each bird captured were recorded, as well as total hours of net operations. All data were recorded on a standardized data sheet (Desante ***et al.*** 2002). Birds were identified using Pyle (1997), National Geographic (1999), and Sibley (2000).

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 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.

Winter Site Persistence

Winter site persistence is calculated as a percent of birds captured within one banding period and subsequently re-captured during a later banding period within the same season (Latta and Faaborg 2001, 2002). Winter site persistence is used as an index measure of habitat suitability for birds in the winter. Some species are considered resident birds and stay in the area year-round. If these birds were banded in a previous season, but not a previous year, they were included as birds exhibiting winter site persistence rather than being separated into a different category. If an individual had been recaptured from a previous year and then recaptured again during that same season, then it would be counted as both an annual return as well as a within season (inter-period) return.

Annual Return

Data from birds recaptured between years 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 (Latta and Faaborg 2001, 2002). Annual return rate was measured as a percentage of all individually captured birds recaptured from previous years.

Area Searches

Area searches are conducted at each site during each of the six banding periods to account for species that may not be captured during standard mist-net operations. For 2006-2007, area searches were not conducted in October. A standard area search protocol was followed (Ralph *et al*. 1993). Both sites were split into five sections, which were 2.5 to 7.5 acres (1-3 hectares) in size. An area larger than 7.5 acres could not be thoroughly surveyed in 20 minutes in such dense habitat (Ralph *et al.* 1993). One 20 minute area search was conducted in each section. Temperature, cloud cover, and wind speed were recorded before each area search. The start and ending time were also recorded. During the 20 minutes, the observers attempted to survey all areas within each section equally. Each individual bird heard or seen was recorded on the data form along with method of detection (visually or aurally). Birds seen flying over the area but not utilizing the habitat, were recorded in a separate category as “flyovers”.

Statistical Analysis

Several tests were performed to compare the results for species richness and diversity and to compare 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:

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

where S = the number of species in a sample, H' = the species diversity index, and p_i = the proportion of all birds detected belonging to the *i*th species. The index was then transformed 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 is statistically transformed to represent even detection numbers for all species (Macarthur 1965 in Nur et al.1999). This gives a more useful value to use for site comparison in the analysis. Statistical t-tests were also performed to compare species diversity values between periods for each site and between years.

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

$$P = \sum_{i=1}^{i=s} \text{minimum}(p^A_i, p^B_i)$$

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. Because the index is on a scale from 0-1, each index was converted into a percentage of similarity. A Renkonen index was calculated for the data to compare sites between years, and with each other.

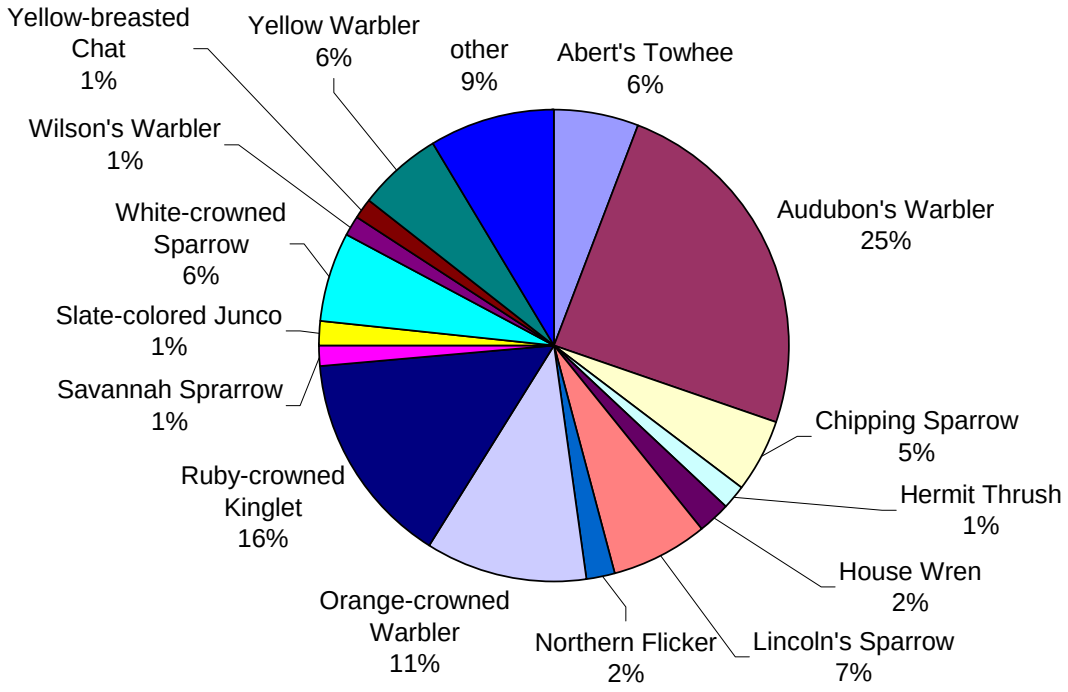
Results

Cibola Nature Trail Site

This was the fifth year of winter banding at CIBO. Banding operations were conducted for a total of 712.3 net hours during the winter of 2006-07. There were 209 individual birds captured (0.29 per net hour), and 35 recaptures (0.05 per net hour), for a total of 244 birds captured. Twenty-eight species were captured, with 4 species accounting for 59% of all captures: Audubon's warbler (*Dendroica coronata audoboni*) 25%, ruby-crowned kinglet (*Regulus calendula*) 16%, orange-crowned warbler (*Vermivora celata*) 11%, and Lincoln's sparrow (*Melospiza lincolnii*) 7% (Figure 1). When all five years were combined for CIBO, a total of 1,088 birds were captured. Forty-seven species were captured with the same four species making up 60% of all species (Figure 2.) In Figure 2, Audubon's warbler is listed as yellow-rumped warbler (Audubon's is the subspecies) because in the 5-year totals, a few of the yellow-rumped warblers were the myrtle subspecies (*Dendroica coronata coronata*), although the vast majority were the Audubon's subspecies. It should be noted that the total species number includes two subspecies of dark-eyed junco (*Junco hyemalis*) as separate taxonomic units. The two subspecies are the Oregon junco (*J. h. thurberi*), and slate-colored junco (*J. h. hyemalis*). While there was no significant difference between captures rates, individual captures were lower than in all previous years except for 2004-05, which showed a slightly lower capture rate per net hour (Table 1). Species composition varied from the results of previous years (Figure 3). The four most captured

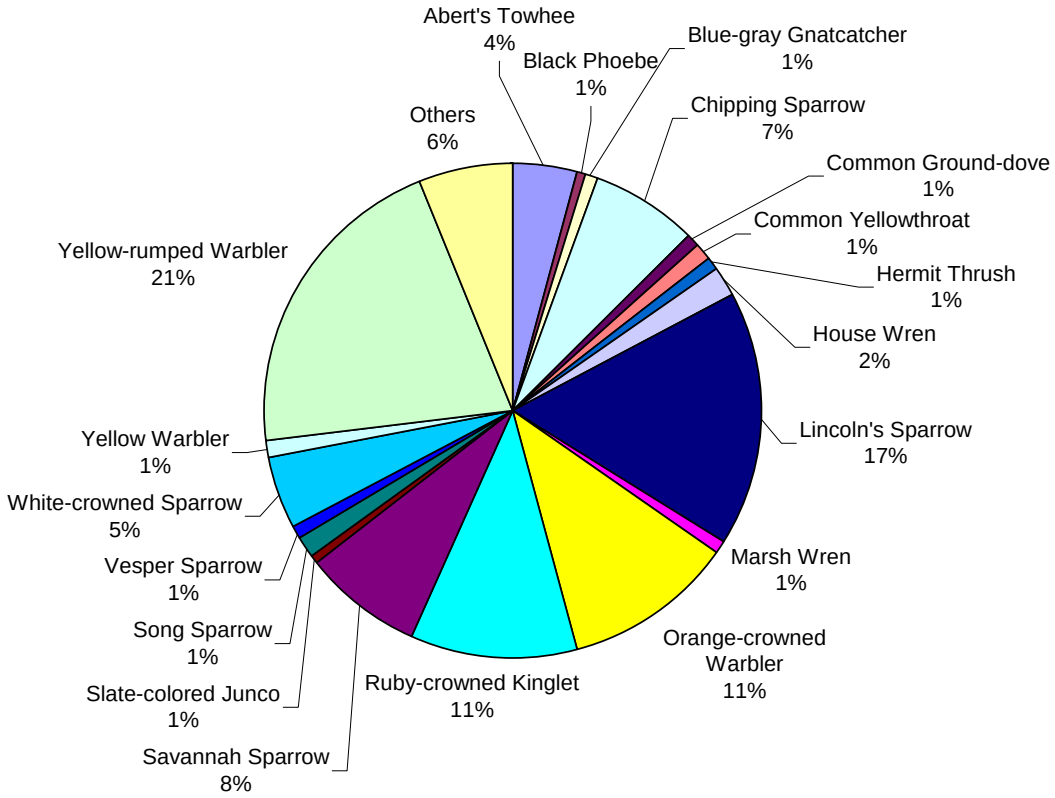
species all had lower captures rates from the previous year. White-crowned sparrow (*Zonotrichia leucophrys*) showed a noticeable increase in capture rate from last year, which is comparable to capture rates from the first three years. Capture rate varied from year to year for most species. Average capture rate and standard error were calculated for all species that had at least 10 captures during any given year (Table 2).

Figure 1. Species composition of birds captured during the 2006-07 season at the CIBO site.



*****other category includes 13 species with 2 captures or less including: American Redstart, Blue-gray Gnatcatcher, Black Phoebe, Brewer's Sparrow, Black-throated Gray Warbler, Dusky Flycatcher, Oregon Junco, Swainson's Thrush, Common Yellowthroat, Loggerhead Shrike, Marsh Wren, Song Sparrow, and Verdin.

Figure 2. Species composition of birds captured over all five years at CIBO.



*other category includes 28 species that accounted for less than 1% of all captures including: American Kestrel, American Redstart, Ash-throated Flycatcher, Bell's Vireo, Bewick's Wren, Brewer's Sparrow, Black-throated Gray Warbler, Dusky Flycatcher, Eastern Phoebe, Fox Sparrow, Green-tailed Towhee, Gray Flycatcher, Great-tailed Grackle, House Finch, Loggerhead Shrike, Northern Flicker, Northern Harrier, Oregon Junco, Red-winged Blackbird, Sharp-shined Hawk, Spotted Towhee, Swainson's Thrush, Verdin, Warbling Vireo, Western Flycatcher, Wilson's Warbler, White-throated Sparrow, Yellow-breasted Chat.

Table 1. Individual capture rates per net hour for all five years.

Years	CIBO
2002-03	0.43
2003-04	0.43
2004-05	0.28
2005-06	0.43
2006-07	0.29

Figure 3. Five-year comparison of individual bird captures per net hour at the CIBO site.

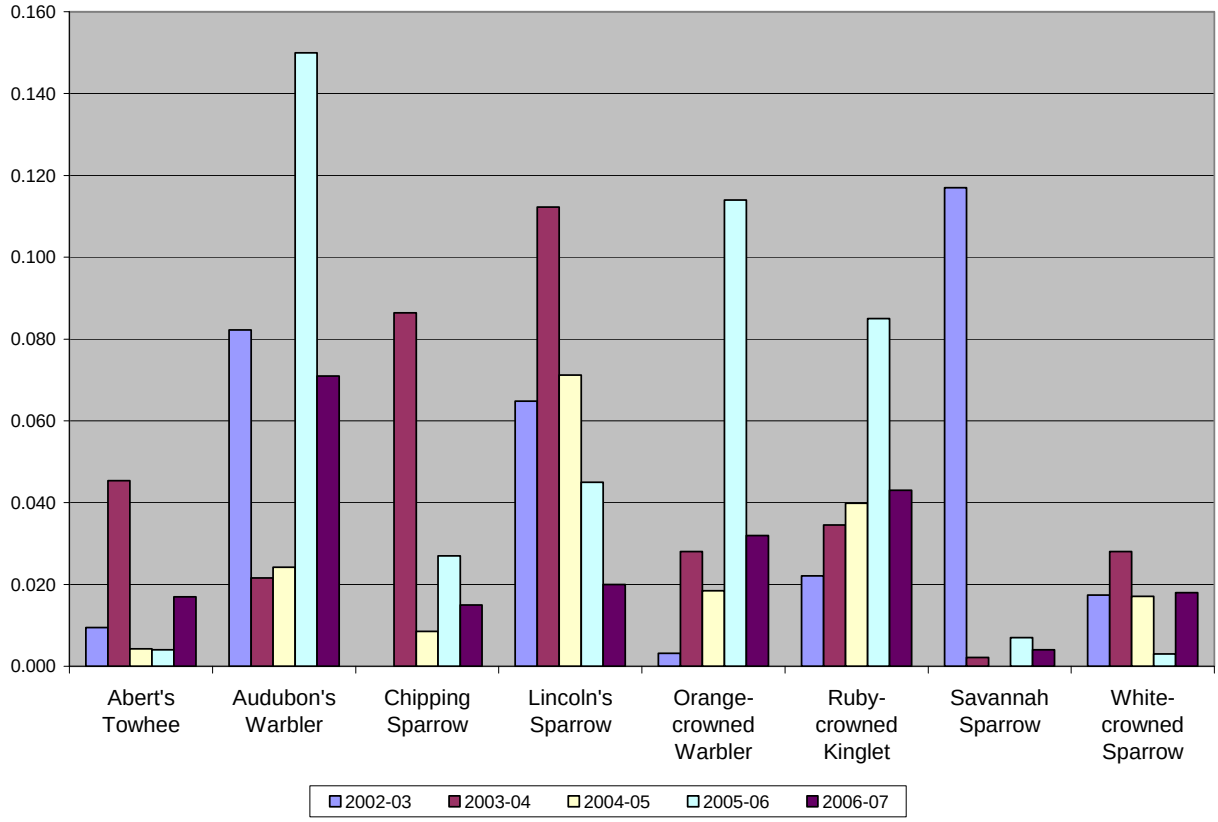


Table 2. A five-year average of birds captured per net hour with standard error at CIBO.

Species	Average (std. error)
Abert's Towhee	0.016 (0.008)
Audubon's Warbler	0.070 (0.023)
Chipping Sparrow	0.027 (0.015)
Lincoln's Sparrow	0.063 (0.015)
Orange-crowned Warbler	0.039 (0.019)
Ruby-crowned Kinglet	0.045 (0.011)
Savannah Sparrow	0.026 (0.023)
White-crowned Sparrow	0.017 (0.004)

Annual Return

Annual return rates were calculated for all species that had at least one individual return at the CIBO site. Fifteen individuals of eight species had annual returns at the CIBO site (Table 3). A list of original capture dates for all annual returns can be found in Table 4. Of note is a ruby-crowned kinglet that was captured three seasons previous, and both a ruby-crowned kinglet and an orange-crowned warbler that were captured two previous seasons ago. The Abert's towhee

and verdin are year-round residents, while all others are winter residents only. The four most captured species all showed an increase in proportion of annual returns from previous years (Figure 4).

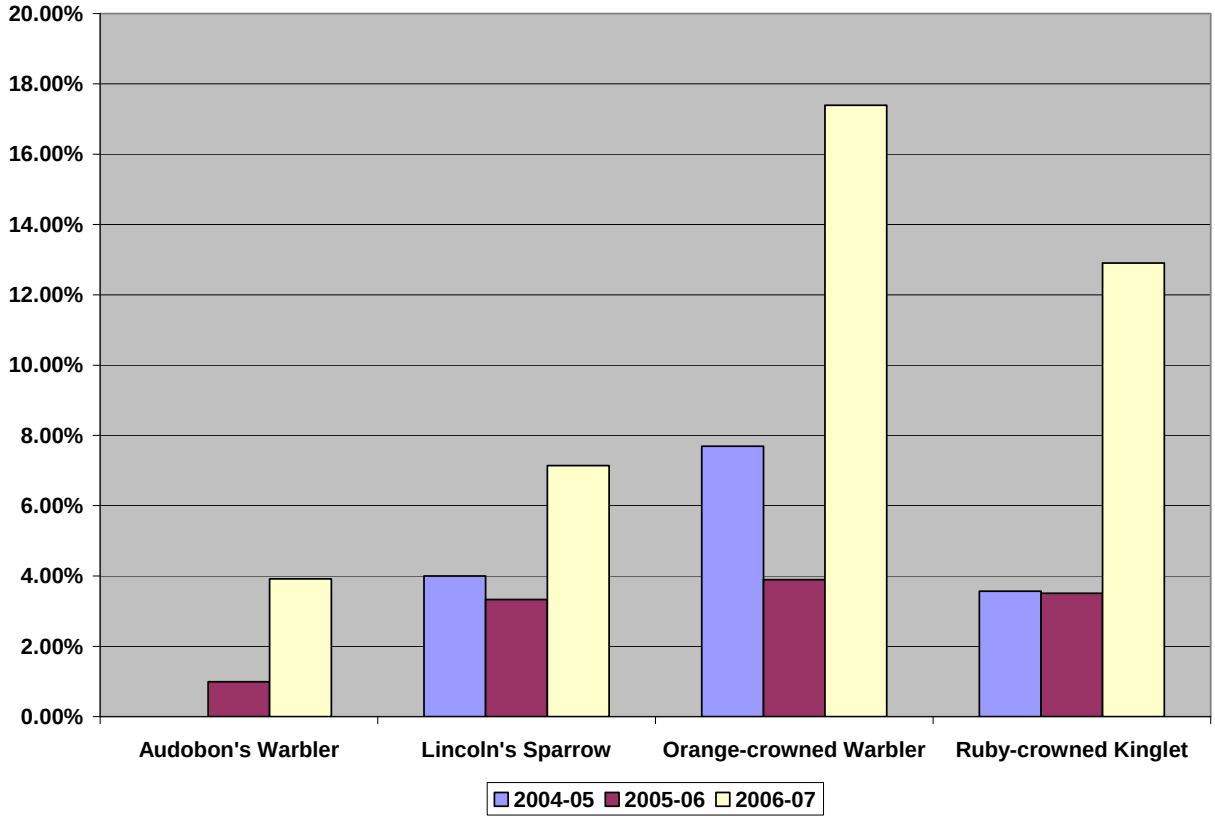
Table 3. Annual return rates at the CIBO site winter 2006-07.

Species	Annual return	Captures	Annual return %
Abert's Towhee	1	12	8.3%
Audubon's Warbler	2	51	3.9%
Hermit Thrush	1	3	33.3%
House Wren	1	5	20.0%
Lincoln's Sparrow	1	14	7.1%
Orange-crowned Warbler	4	23	17.4%
Ruby-crowned Kinglet	4	31	12.9%
Verdin	1	2	50.0%

Table 4. Original capture dates for all annual returns at CIBO.

Species	Original Capture Date
Abert's Towhee	July 2005
Audubon's Warbler	November 2005
Audubon's Warbler	February 2006
Hermit Thrush	February 2006
House Wren	November 2005
Lincoln's Sparrow	November 2005
Orange-crowned Warbler	January 2005
Orange-crowned Warbler	October 2005
Orange-crowned Warbler	October 2005
Orange-crowned Warbler	December 2005
Ruby-crowned Kinglet	January 2004
Ruby-crowned Kinglet	March 2005
Ruby-crowned Kinglet	October 2005
Ruby-crowned Kinglet	November 2005
Verdin	December 2005

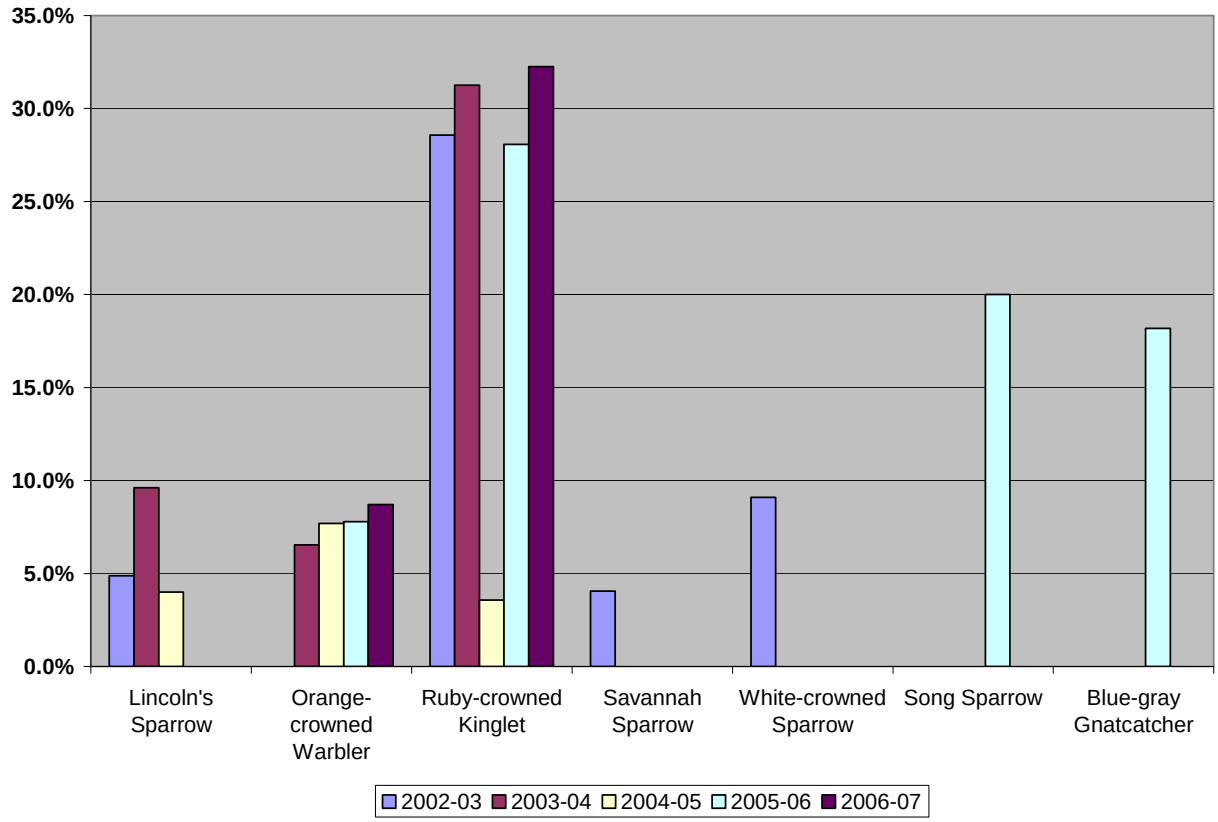
Figure 4. Year to year comparison of annual returns of the four most captured species at CIBO.



Winter Site Persistence

Over-winter site persistence was calculated as a percentage of total birds recaptured in at least one other period than that of a species original capture in the same season. A total of three species showed site persistence for 2006-2007, with the ruby-crowned kinglet (n = 10) having the most within season recaptures. The orange-crowned warbler (n = 2) and dusky flycatcher *(Empidonax oberholseri*) (n = 1) also showed site persistence for 2006-2007. Except for the winter of 2004-05, the ruby-crowned kinglet has had the highest percentage of winter site persistence (Figure 5). The orange-crowned warbler has had similar site persistence since the winter of 2003-04. The Lincoln's sparrow has not shown any site persistence for the past two winter seasons.

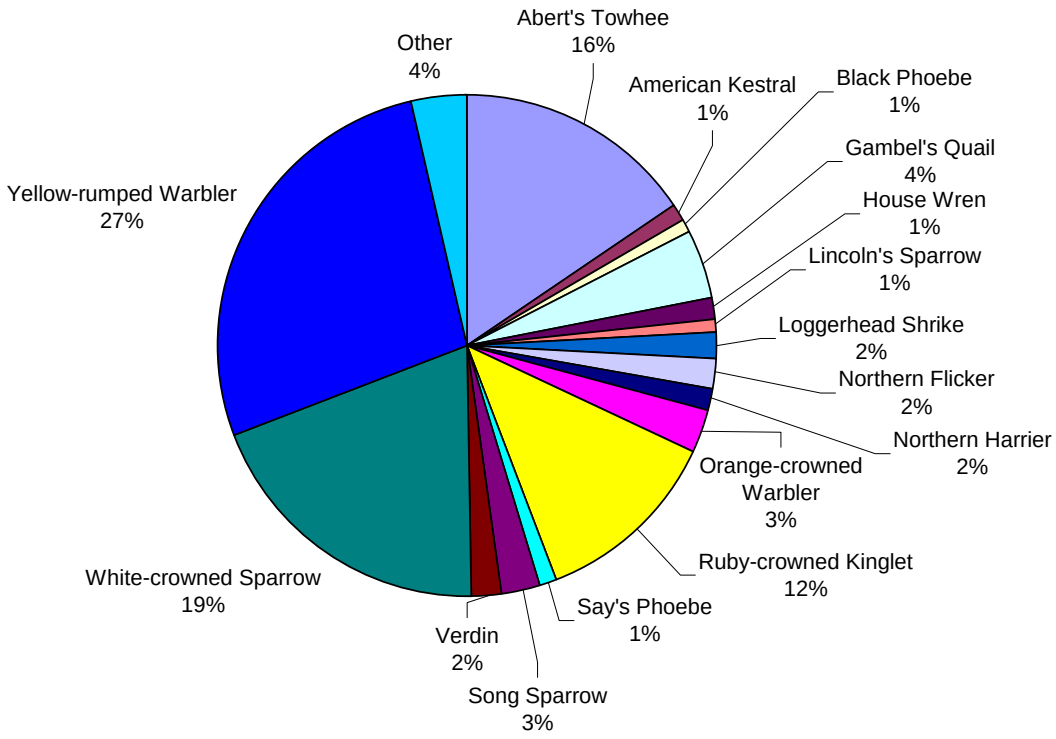
Figure 5. A comparison of winter site persistence over the five years of banding at the CIBO site.



Area Search Analysis

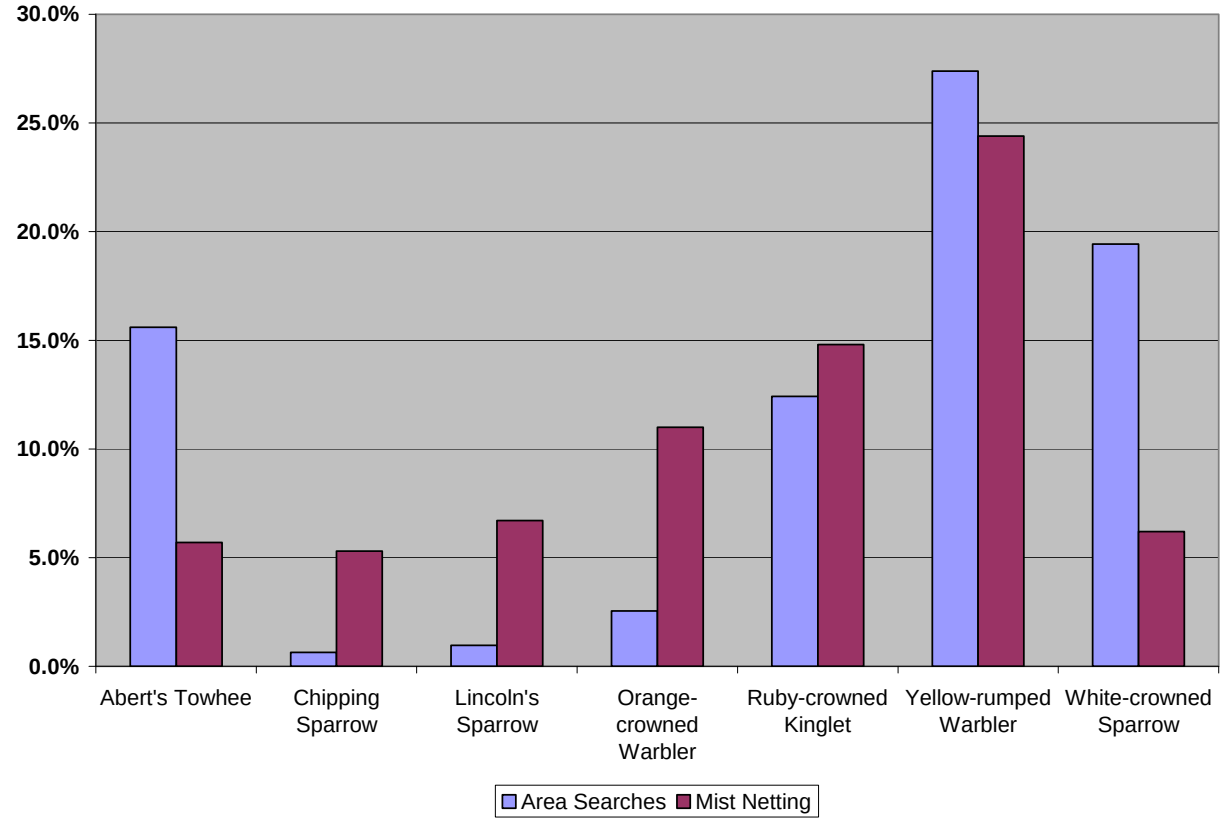
Area searches were performed for five of six periods (November-March), with a total 314 birds of 25 species detected, and an average of 62.8 birds detected per period. Periods 2, 3, and 5 (November, December, and February) accounted for 83% of all birds detected. The vermilion flycatcher was the only LCR MSCP covered species observed during area searches. The yellow-rumped warbler was the most commonly observed species (Figure 6). A comparison of capture/detection rates between area searches and mist-netting of all species that made up at least 5% of species composition from either method can be found in Figure 7. This comparison is only displayed to compare how species composition can differ between two different survey methods. All yellow-rumped warbler (*Dendroica coronata*) captures were of the Audubon's subspecies. The area search method cannot reliably identify yellow-rumped warblers to subspecies, so comparisons were made at the species level. Yellow-rumped warbler and ruby-crowned kinglet were the only species that showed similar detection rates between the two survey methods. The savanna sparrow (*Passerculus sandwichensis*) was only found using mist-netting.

Figure 6. Species composition of area searches for all five surveys at CIBO.



*other category includes species with two detections or less including: Anna's hummingbird, Blue-gray gnatcatcher, Black-tailed gnatcatcher, Great horned owl, Ladder-backed woodpecker, Mourning dove, Vermilion flycatcher, Western flycatcher, and Chipping sparrow.

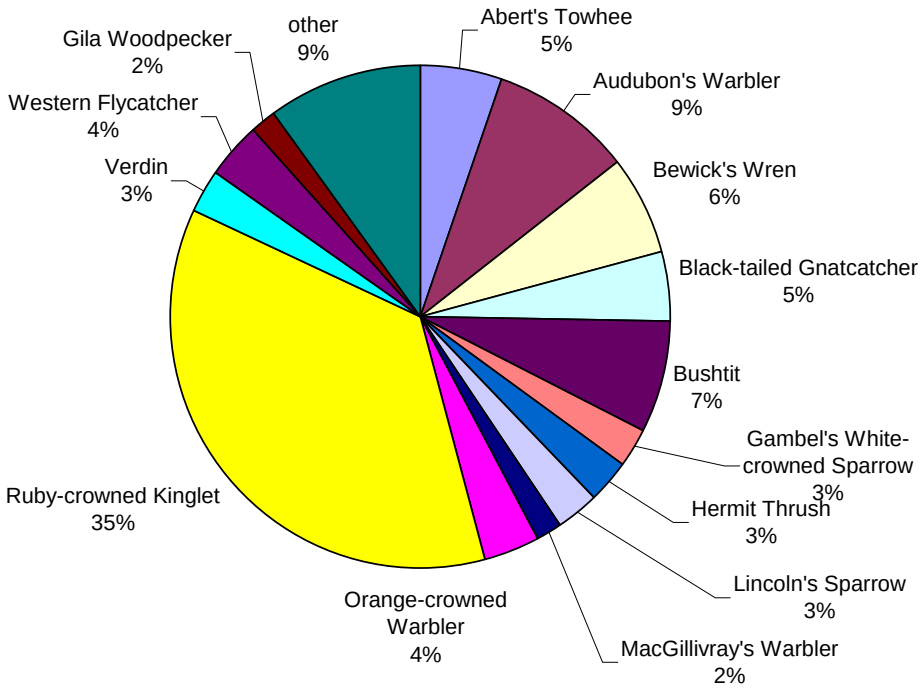
Figure 7. A comparison of capture/detection rates between area searches and mist-netting at CIBO.



Havasu Banding Site

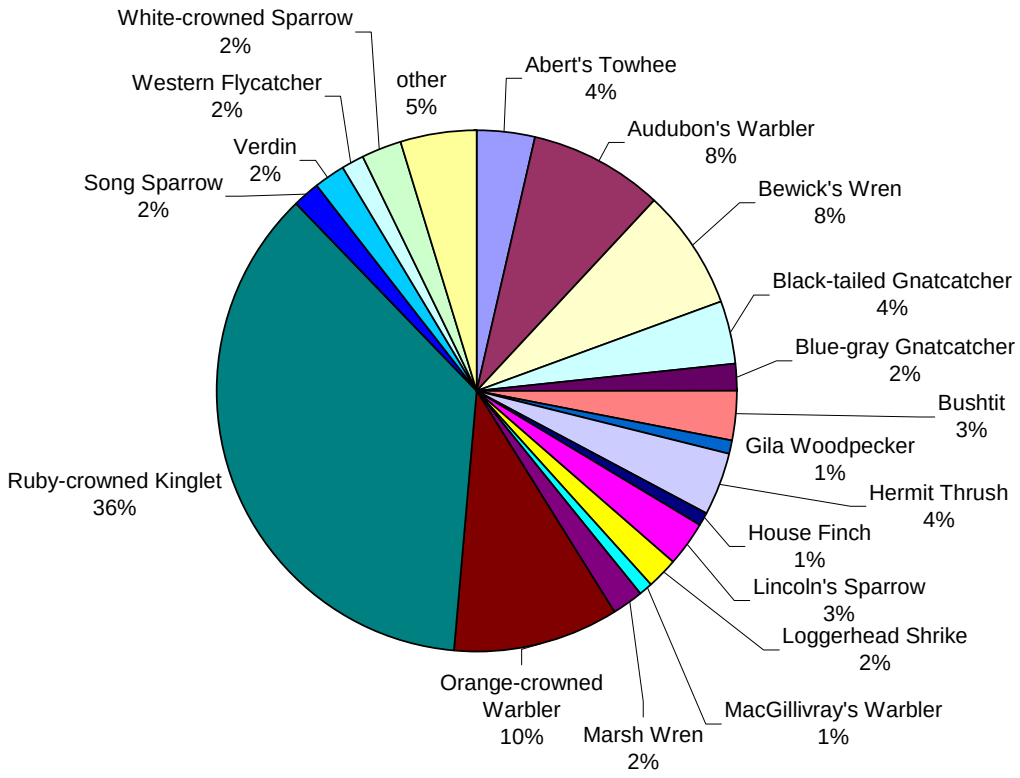
This was the second year of banding at HAVA. Banding operations were conducted for a total of 788.33 net hours during the winter of 2006-07. There were 111 individual birds captured (0.14 per net hour) and 27 recaptures (0.03 per net hour) for a total of 138 birds captured. Individual capture rates were lower than in the previous year (0.21 per net hour). Twenty-five species were captured, with two species accounting for 45% of all captures: ruby-crowned kinglet 35% and Audubon's warbler 9% (Figure 8). When this season and last season of banding are combined, 31 species were captured, with two species accounting for 46% of all captures: ruby-crowned kinglet 36% and orange-crowned warbler 10% (Figure 9). When both seasons are combined, individual birds captured per net hour decreased from the previous year's results (0.22). Capture rates of individuals per net hour were calculated for all species with at least nine captures total between the two years (Figure 10). Capture rates were lower in 2006-2007 for all but one (Abert's towhee) of those species. Average and standard error of captures per net hour were calculated for all species that had at least nine captures total for both years (Table 5).

Figure 8. Species composition of birds captured at the HAVA site in the 2006-07 season.



*other category includes 11 species with only a single capture including: Black-and-white Warbler, Cassin's Vireo, Common Yellowthroat, Gray-headed Junco, Hammond's Flycatcher, Loggerhead Shrike, Red-naped Sapsucker, Song Sparrow, Willow Flycatcher, Wilson's Warbler, and White-throated Sparrow.

Figure 9. Species composition of birds captured over both years at HAVA.

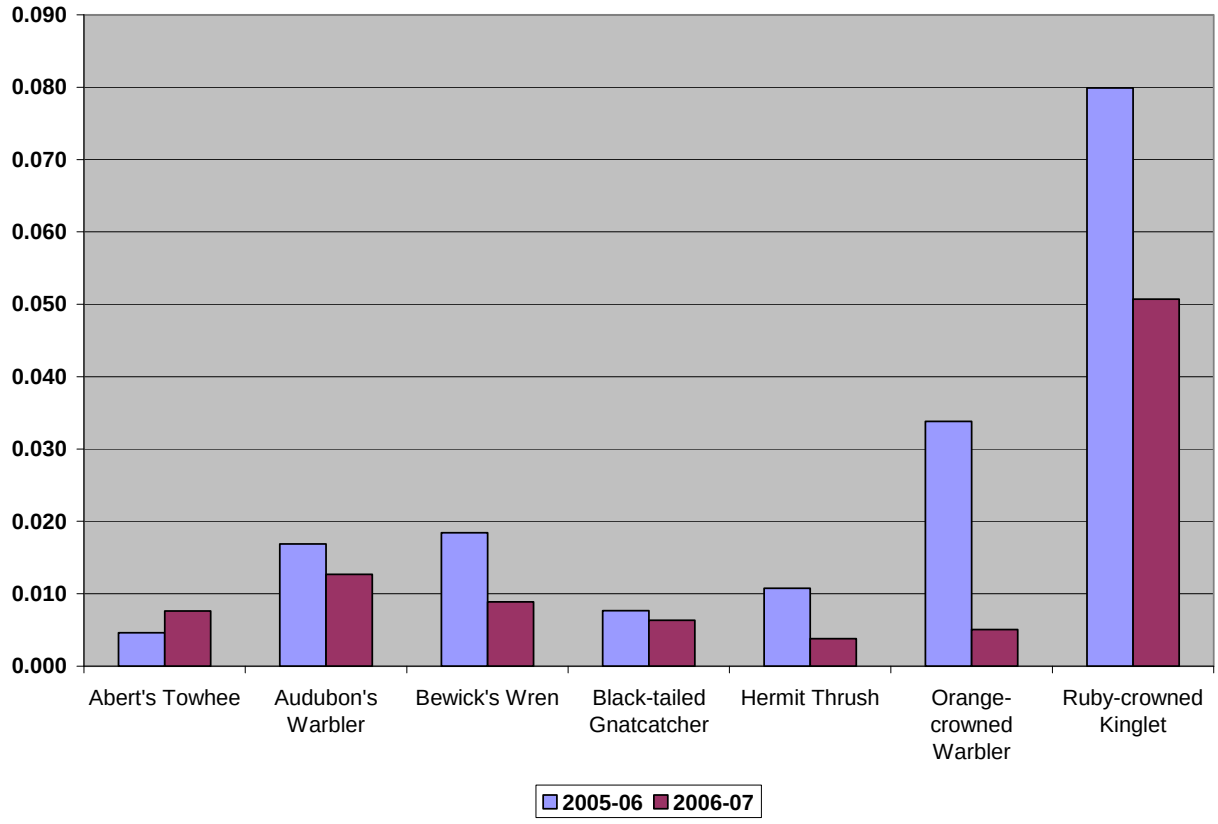


*other category includes 12 species that accounted for less than 1% of all captures including: Black-and-white Warbler, Cassin's Vireo, Common Yellowthroat, Dusky Flycatcher, Golden-crowned Kinglet, Gray-headed Junco, Hammond's Flycatcher, Red-naped Sapsucker, Spotted Towhee, Willow Flycatcher, Wilson's Warbler, and White-throated Sparrow.

Table 5. A two-year average of birds captured per net hour with standard error at HAVA.

Species	Average (std. error)
Abert's Towhee	0.006 (0.001)
Audubon's Warbler	0.015 (0.002)
Bewick's Wren	0.014 (0.005)
Black-tailed Gnatcatcher	0.007 (0.001)
Hermit Thrush	0.007 (0.003)
Orange-crowned Warbler	0.019 (0.014)
Ruby-crowned Kinglet	0.065 (0.015)

Figure 10. Two-year comparison of individual bird captures per net hour at the HAVA site.



Annual Return

Annual return rates were calculated for all species that had at least one individual return at the HAVA site. Nine individuals of four species had annual returns at the HAVA site (Table 6). A list of all annual returns and their original capture dates can be found in Table 7. Two of the original captures occurred during the summer banding season. The Abert's towhee and Bewick's wren are year-round residents, while the ruby-crowned kinglet is a winter resident only.

Table 6. Annual return rates at the HAVA site; winter 2006-07.

Species	Annual return	All captures	Annual return %
Abert's Towhee	2	6	33.3%
Bewick's Wren	2	10	20.0%
Black-tailed Gnatcatcher	2	6	33.3%
Ruby-crowned Kinglet	3	51	5.9%

Table 7. Original capture dates for all annual returns at HAVA.

Species	original capture date
Abert's Towhee	July 2005
Abert's Towhee	October 2005
Bewick's Wren	June 2005
Bewick's Wren	January 2006
Black-tailed Gnatcatcher	January 2006
Black-tailed Gnatcatcher	February 2006
Ruby-crowned Kinglet	November 2005
Ruby-crowned Kinglet	December 2005
Ruby-crowned Kinglet	December 2005

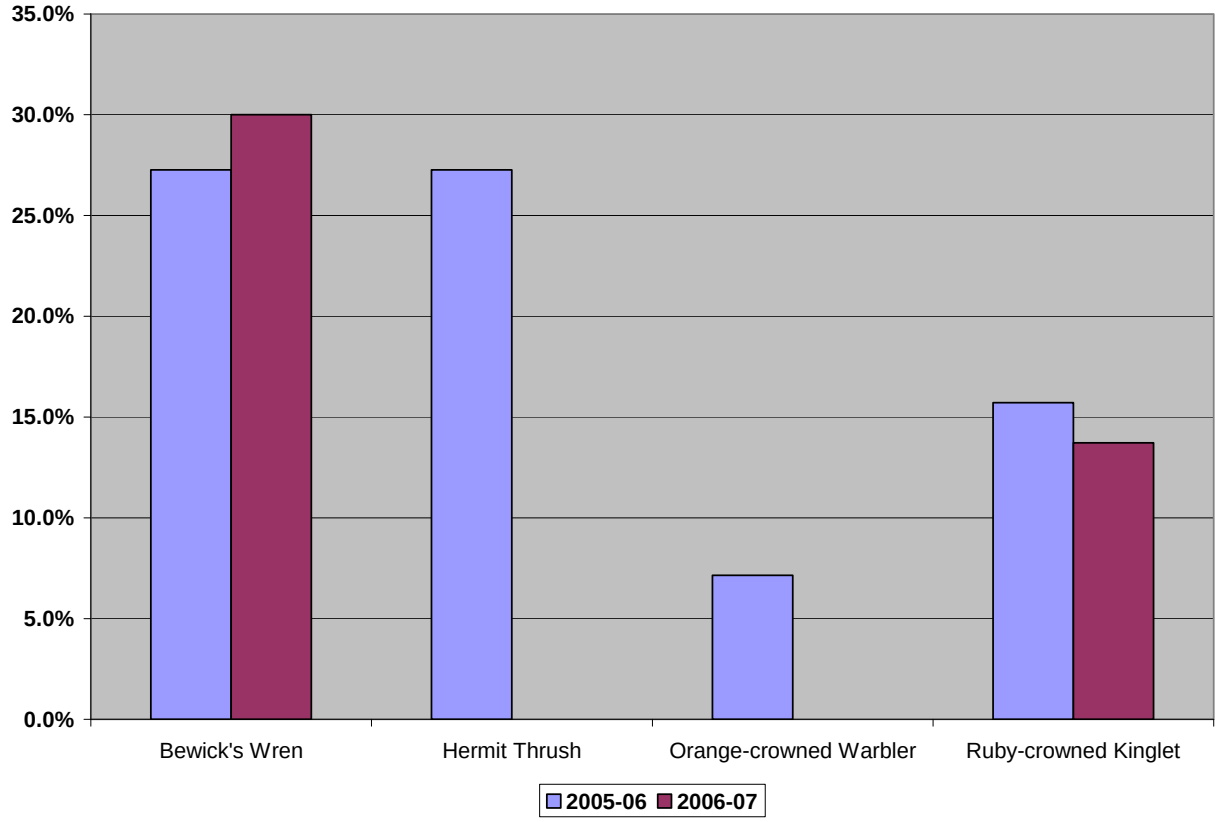
Winter Site Persistence

Over-winter site persistence was calculated as a percentage of total birds captured that were recaptured in at least one other period than that of the original species capture in the same season. A total of five species showed site persistence in 2006-2007, with the ruby-crowned kinglet (n = 7) having the most within season recaptures. Two species showed site persistence in both years (Table 8). Eight other species showed site persistence in only one of the two years. The Bewick's wren and ruby-crowned kinglet showed similar percentages of site persistence for both years. There were no inter-period returns for the hermit thrush and orange-crowned warbler in 2006-2007 (Figure 11).

Table 8. Total number of inter-period returns for two years of banding at the HAVA site.

Species	2005-06	2006-07
Abert's Towhee	0	1
Bewick's Wren	8	3
Black-tailed Gnatcatcher	0	1
Gila Woodpecker	0	1
Hermit Thrush	3	0
Loggerhead Shrike	1	0
Orange-crowned Warbler	2	0
Ruby-crowned Kinglet	11	7
Song Sparrow	1	0
Verdin	1	0

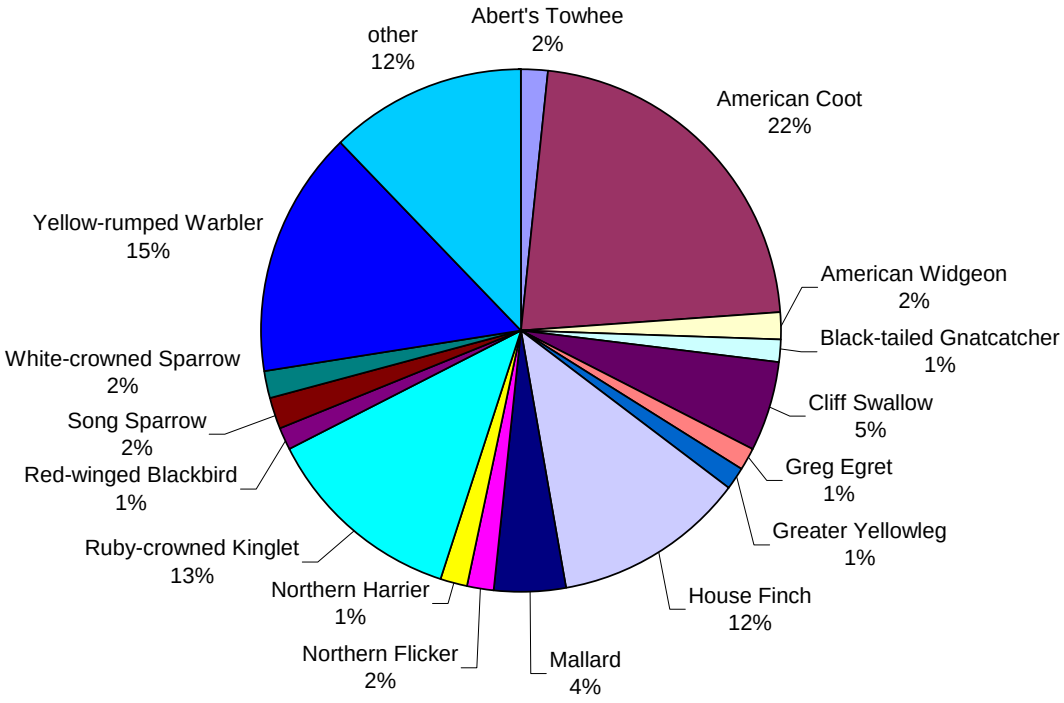
Figure 11. A comparison of winter site persistence over the two years of banding at the HAVA site.



Area Search Analysis

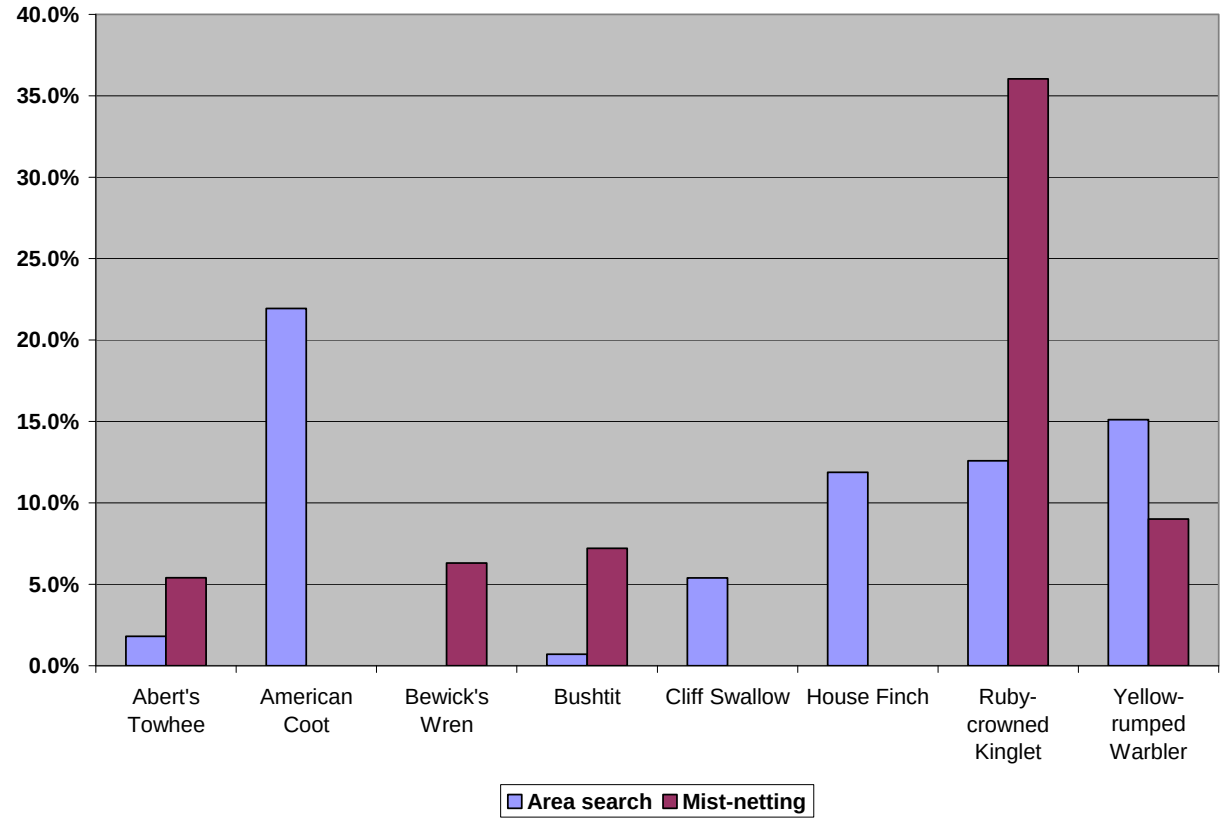
Area searches were performed for five of six periods (November-March) with a total of 277 birds of 36 species detected, and an average of 55.6 birds detected per period. Periods 2 and 3 (November and December) accounted for 65% of all birds detected. American coot (*Fulica Americana*) was the most detected species, yellow-rumped warbler was the most detected passerine species and the Gila woodpecker was the only LCR MSCP covered species detected (Figure 12). A comparison of capture/detection rates between area searches and mist-netting of all species that made up at least 5% of species composition from either method can be found in Figure 13. The American coot (*Fulica americana*), cliff swallow (*Petrochelidon pyrrhonota*), and house finch (*Carpodacus mexicanus*) were only found using area searches. The Bewick's wren was only found using mist-netting.

Figure 12. Species composition of area searches for all five surveys at HAVA.



*other category includes 20 species that had three detections or less including: Anna's Hummingbird, American Robin, Belted Kingfisher, Blue-gray Gnatcatcher, Black Phoebe, Bushtit, Clark's Grebe, Dowitcher spp., Great Blue Heron, Gila Woodpecker, Green-winged Teal, House Wren, Ladder-backed Woodpecker, Marsh Wren, Northern Shoveler, Sora, Verdin, Killdeer, Red-naped Sapsucker, and Sharp-shinned Hawk

Figure 13. A comparison of capture/detection rates between area searches and mist-netting at HAVA.



Site Comparison

The CIBO site had a slight increase in species richness (number of total species) compared to species richness from previous years, and HAVA had a larger increase from the previous year of banding (Table 9). A common species has been designated as one that makes up at least 5% of species composition at a site, and is found during at least three different periods within the same season. When common species are compared at each site, CIBO had seven common species, while HAVA only had three (Figure 14). The chipping sparrow is considered common at CIBO but was not captured at HAVA. When capture rates were compared per period, CIBO consistently had a higher rate, although the capture rate decreased each month in a similar manner at both sites (Figure 15).

Table 9. Species Richness numbers for both sites for all years.

Year	CIBO	HAVA
2002-03	22.0	NA
2003-04	21.0	NA
2004-05	25.0	NA
2005-06	26.0	18.0
2006-07	28.0	25.0
all years	47.0	31.0

Figure 14. A comparison between HAVA and CIBO for all commonly captured species.

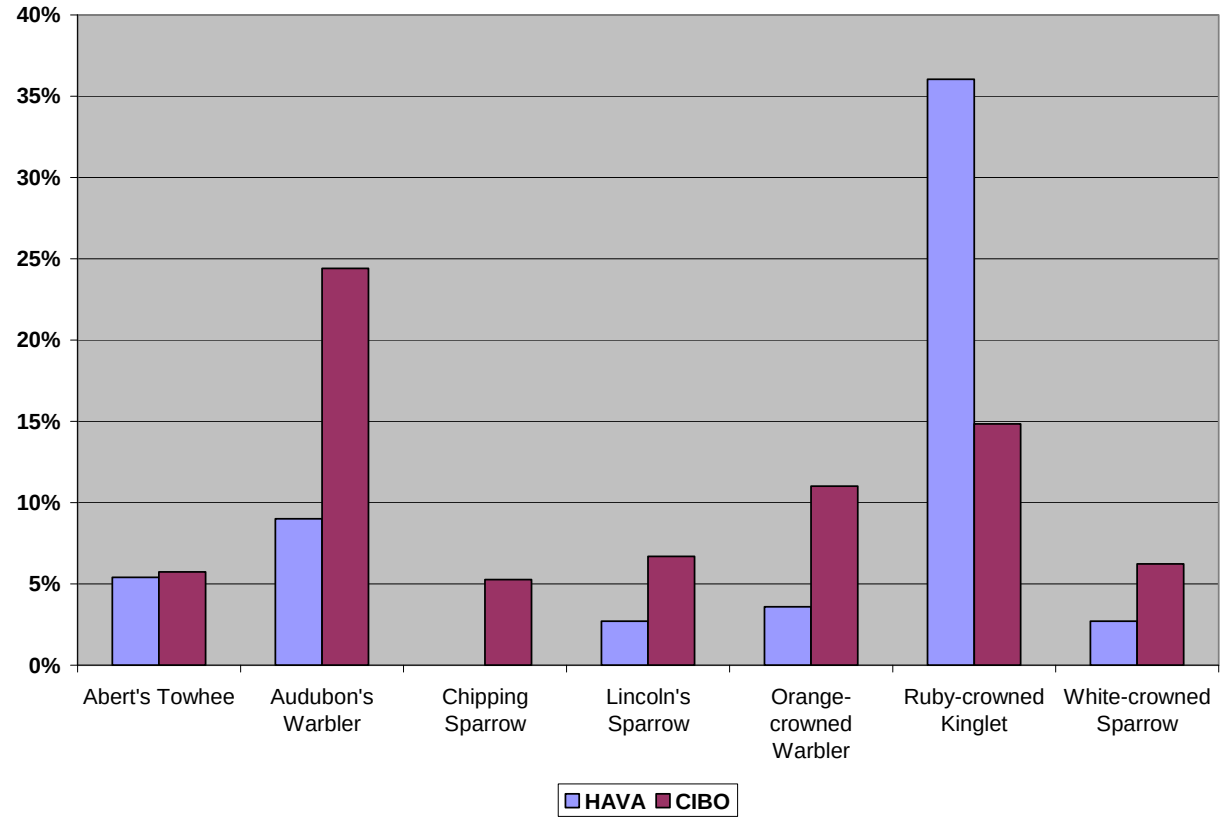


Figure 15. A comparison of capture rates per period at each site.

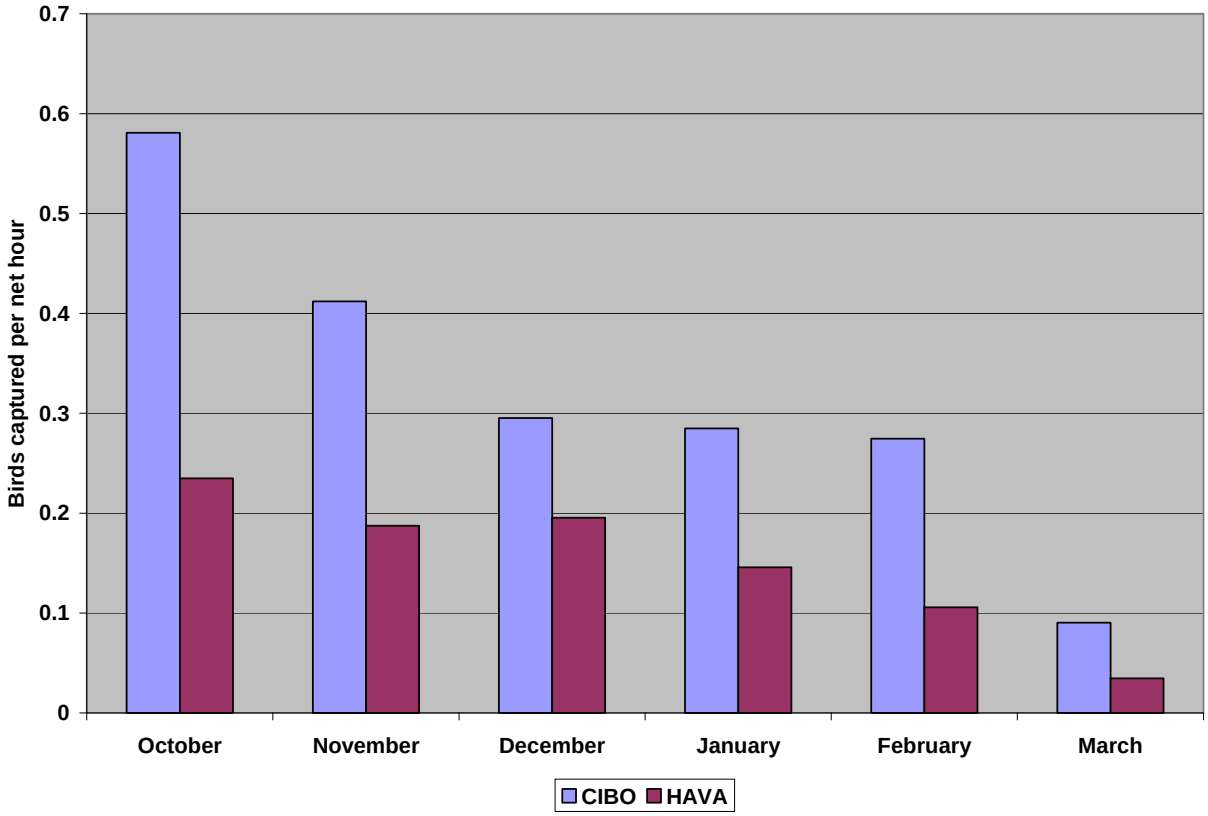
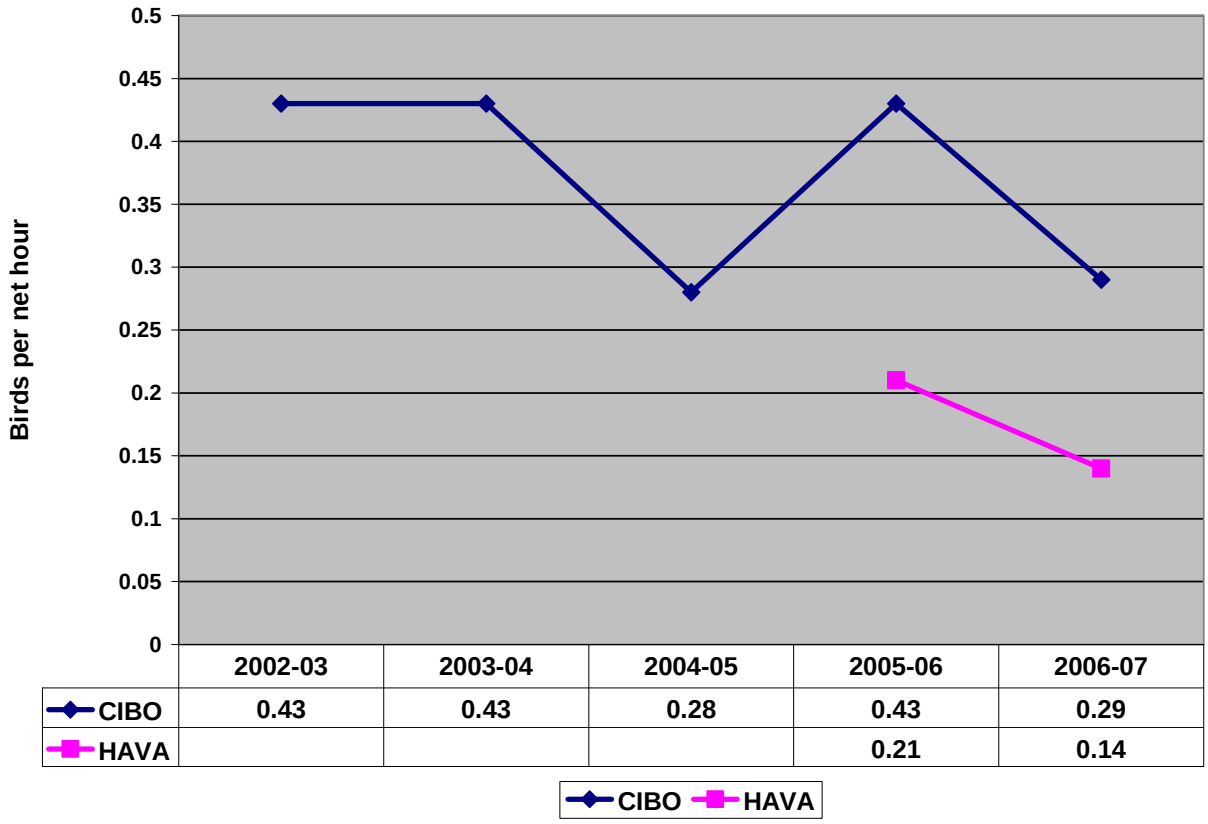


Figure 16. A year to year comparison of bird captures per net hour at CIBO and HAVA.



Statistical Analysis

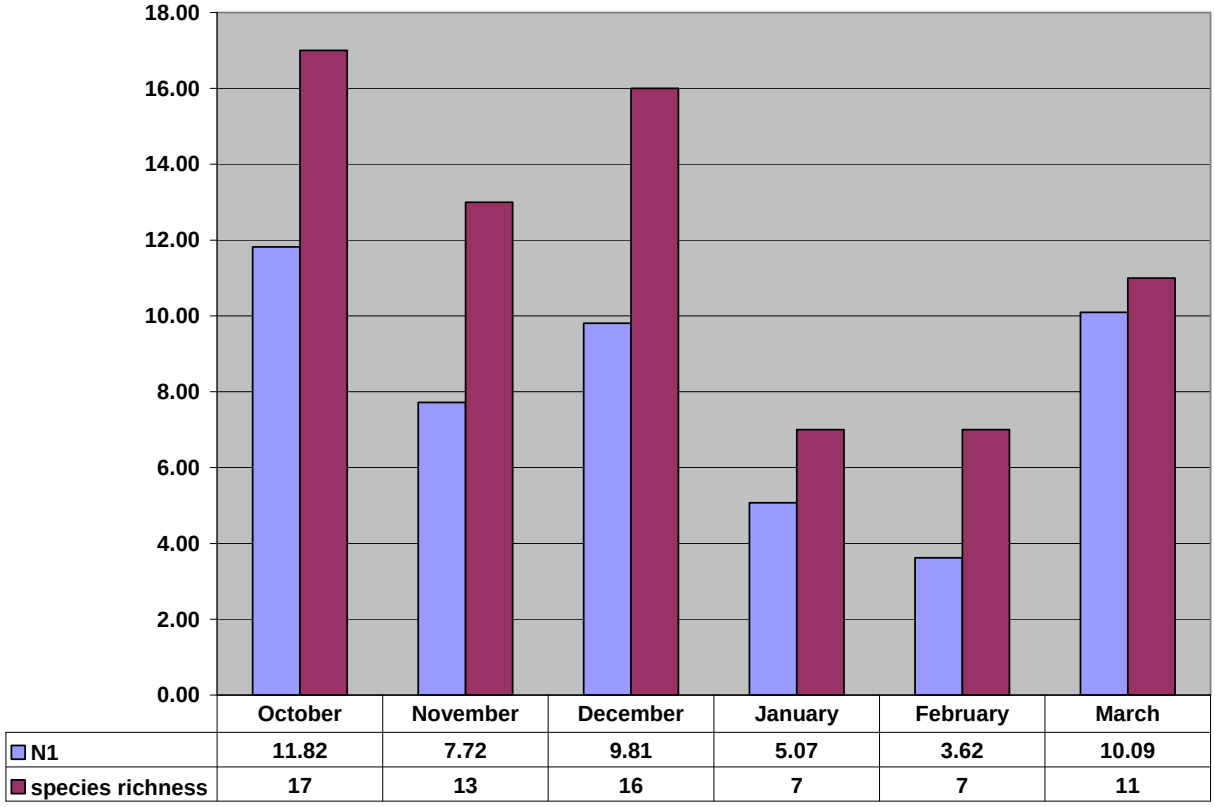
Several tests were used to compare the results for species diversity and to create a similarity index comparing quantitative similarity in the data. The Shannon-Weaver index was calculated for both the banding and area search data to determine species diversity. For the CIBO site, the index was 2.6 for banding and 2.3 for area searches. For the HAVA site, it was 2.5 for banding and 2.7 for area searches. These indices were then transformed into the N1 value. 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 is statistically transformed to represent even detection numbers for all species (Macarthur 1965 in Nur *et al.* 1999). Once transformed, the higher the N1 value, the higher the diversity. The CIBO site yielded the highest diversity value for banding data, and the HAVA site had the highest value for area searches (Table 10).

Table 10. A comparison between sites from the transformed (N1) Shannon-Weaver diversity index.

Site	Banding Data	Area Search Data
CIBO	13.5	9.8
HAVA	11.8	15.3

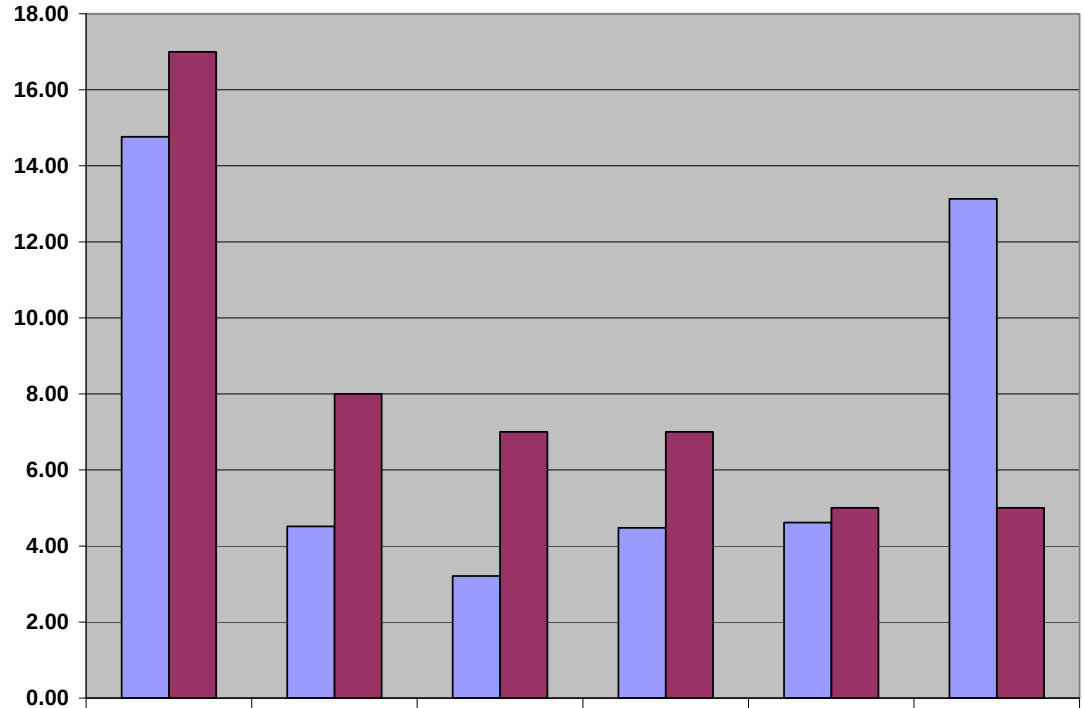
Species diversity was also calculated for each period (month) at each site. Species diversity and richness showed similar changes between periods at CIBO (Figure 17). At HAVA, species diversity and richness also showed similar changes, except for March, where species richness did not increase from the previous period, and the N1 value did increase (Figure 18). Species diversity was also calculated per period and compared to capture rates at each site. The October period at CIBO and HAVA had the highest N1 values and capture rates (Figures 19 and 20). March had the second highest N1 value, but the lowest capture rate at both CIBO and HAVA. When both sites were compared per period, HAVA had a higher N1 value in October and March, while CIBO had a higher N1 value in November and December (Figure 21). A t-test was performed and found that there was no significant difference (P = 0.44) between the two sites when species diversity was compared between periods.

Figure 17. Species diversity and species richness per period at CIBO.



	October	November	December	January	February	March
N1	11.82	7.72	9.81	5.07	3.62	10.09
species richness	17	13	16	7	7	11

Figure 18. Species diversity and species richness per period at HAVA.



	October	November	December	January	February	March
N1	14.77	4.51	3.21	4.48	4.61	13.13
species richness	17	8	7	7	5	5

Figure 19. Species diversity and captures per net hour for each period at CIBO.

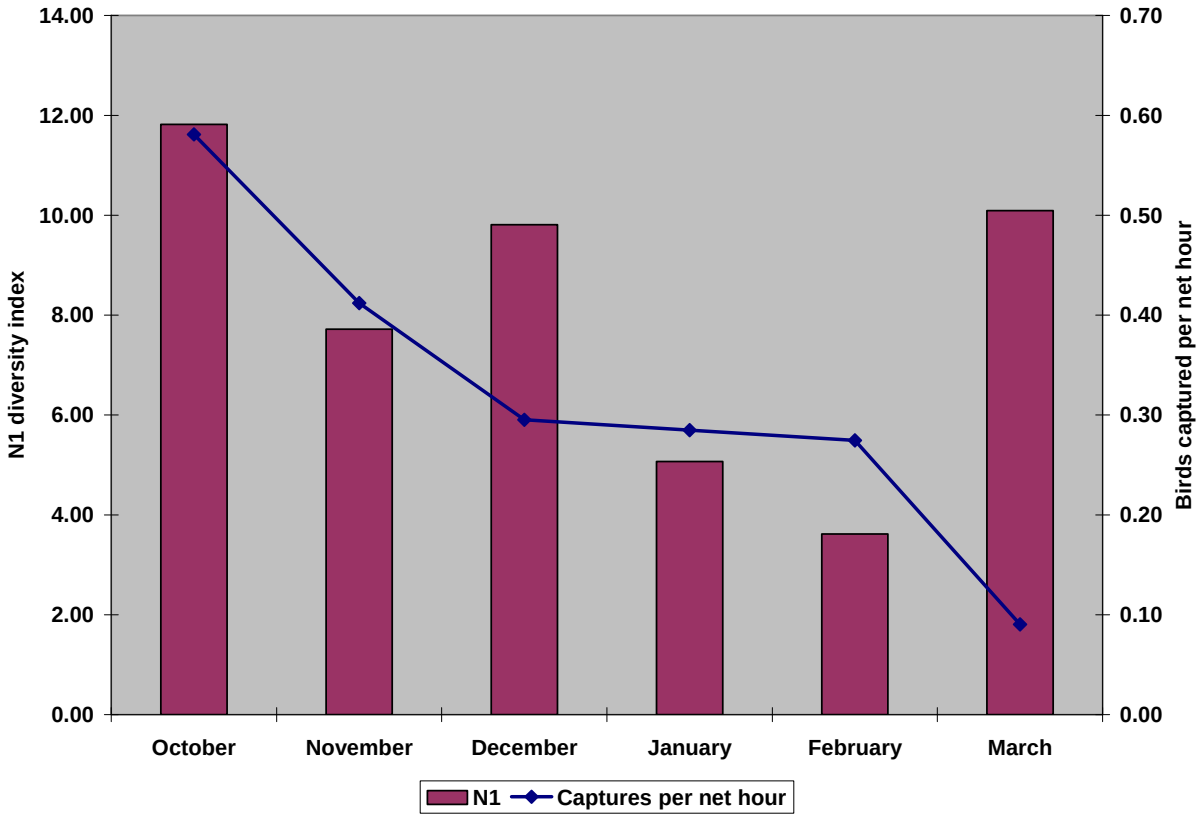


Figure 20. Species diversity and captures per net hour for each period at HAVA.

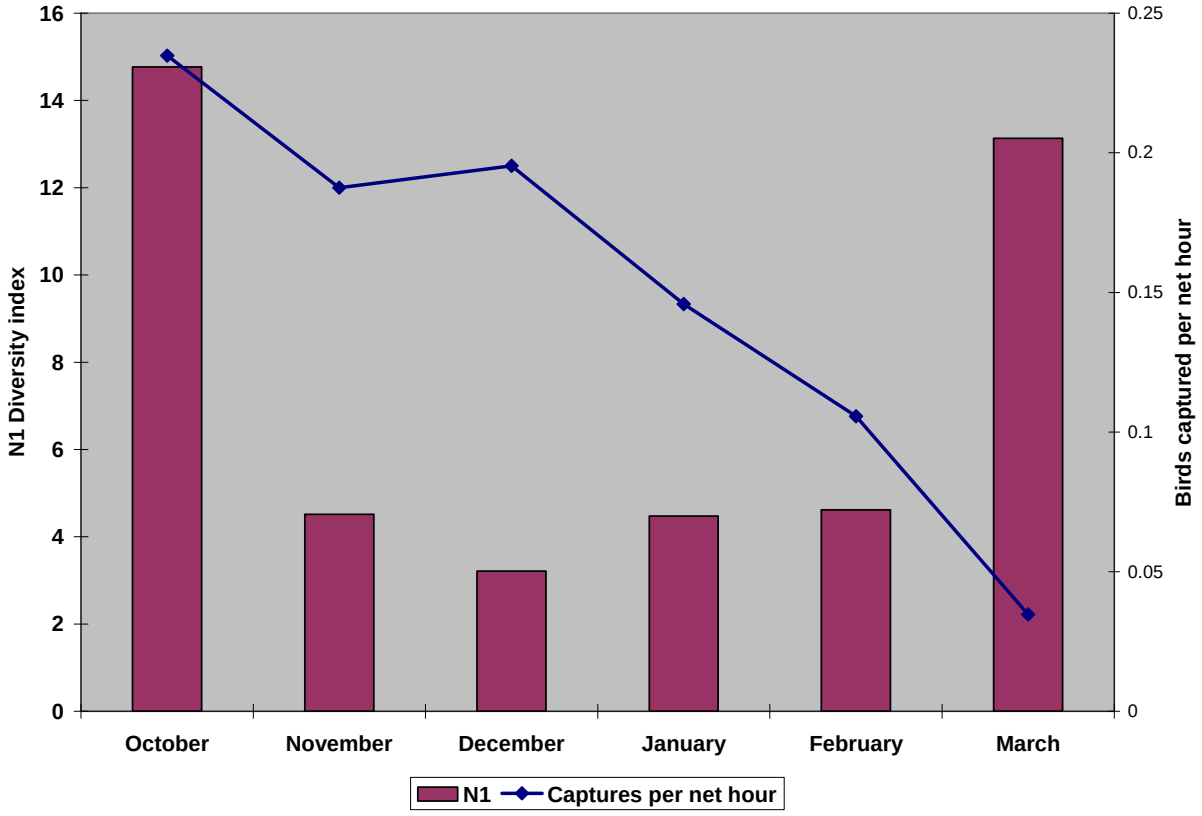
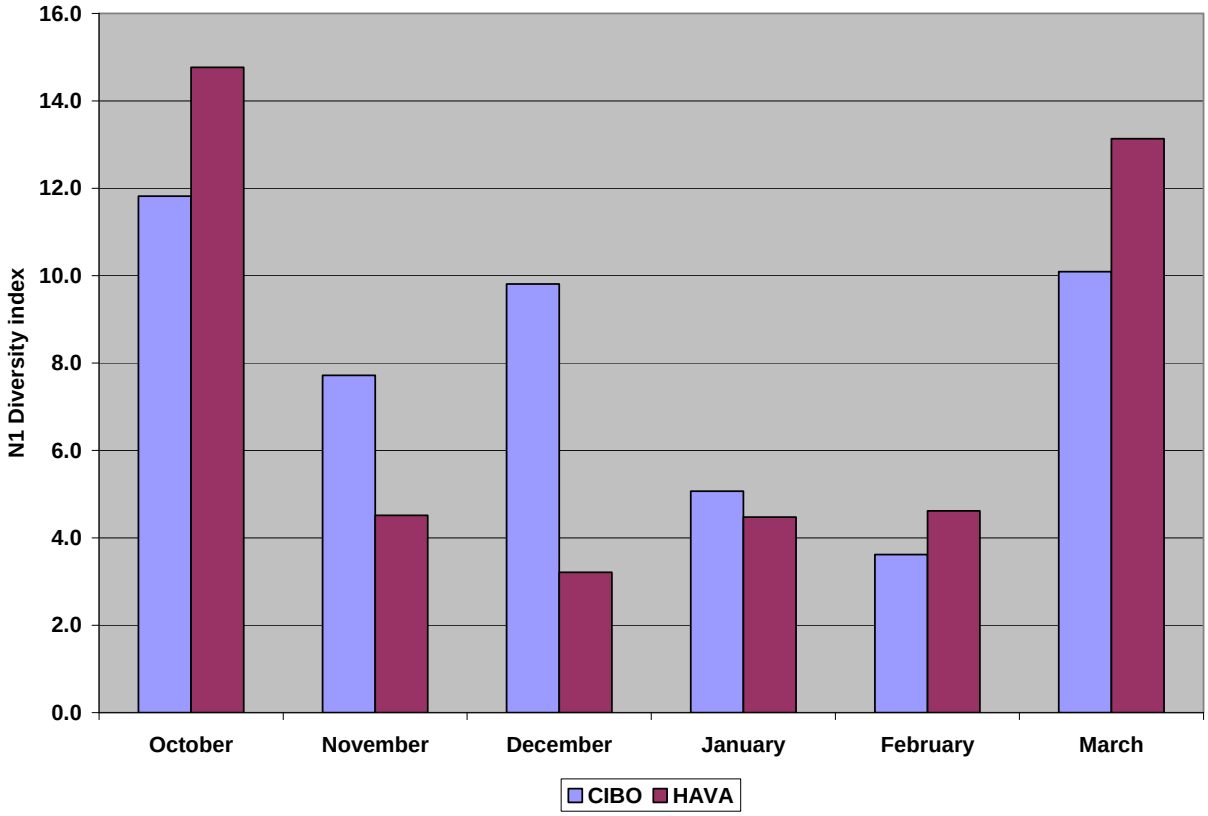


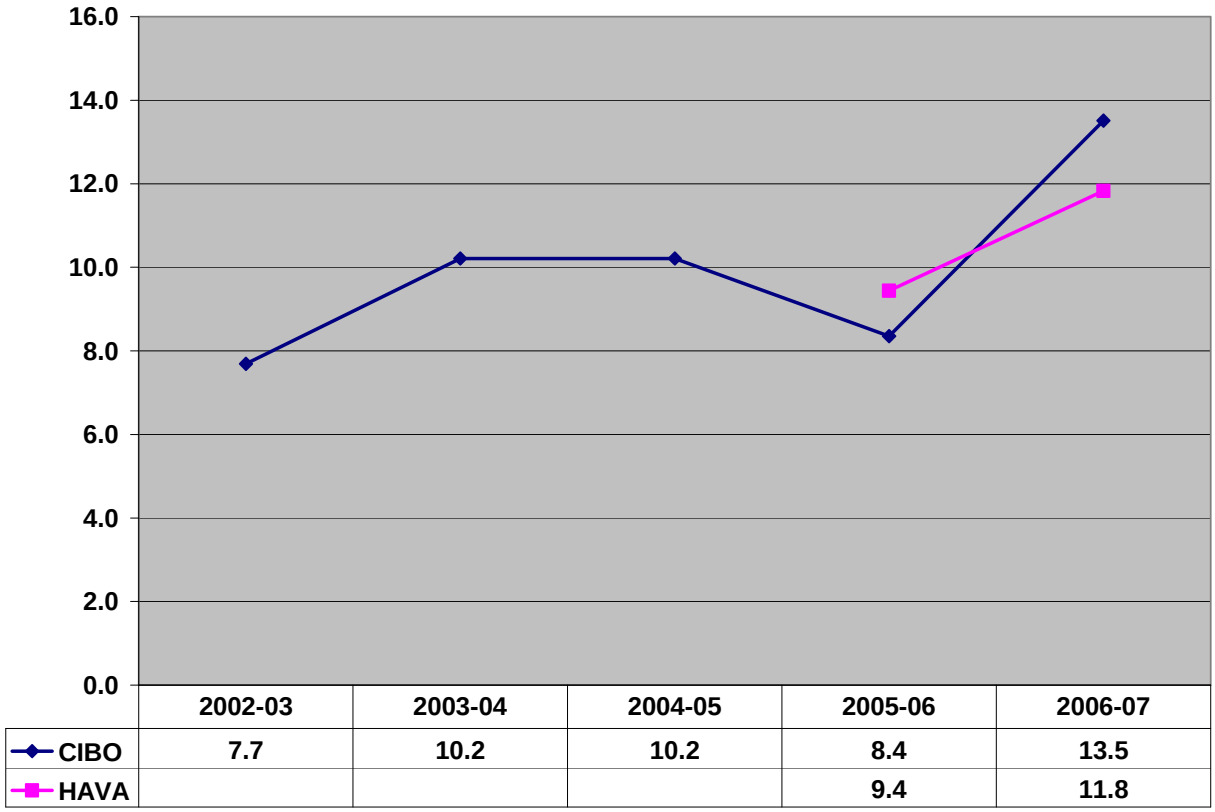
Figure 21. A comparison of species diversity per period between sites.



When species diversity per period was compared between subsequent years at CIBO using a t-test, no statistical significance was found ($P > 0.12$). When species diversity was compared between both years at HAVA using a t-test, there was also no statistical significance ($P = 0.44$).

A year-to-year comparison showed that CIBO had a drop in diversity during the 2005-06 season, but then had the highest diversity of the five years for 2006-2007 (Figure 22). When all years were combined at CIBO, the N1 value was 13.9. The HAVA site also showed an increase from the 2005-06 season, but it was not as large an increase as for CIBO. When all years at HAVA were combined, the N1 value was 11.9. A previous site had been monitored during the first four years that CIBO was being operated that did not show any significant differences from CIBO until all four years of data were combined (Calvert 2008). This indicates that it can take several years to detect significant differences between sites.

Figure 22. A year to year comparison of species diversity between CIBO and HAVA.



	2002-03	2003-04	2004-05	2005-06	2006-07
CIBO	7.7	10.2	10.2	8.4	13.5
HAVA				9.4	11.8

A Renkonen index was calculated for the data in a number of ways. Banding data from both sites was compared. This comparison found that CIBO and HAVA were 44% similar to each other. A Renkonen index was used to compare year-to-year changes at both CIBO and HAVA. The HAVA site had a higher community similarity between the last two seasons (Table 11). The CIBO site showed the highest between-year similarity between the last two seasons and between the 2003-04 and 2004-05 seasons.

Table 11. The similarity between years for CIBO and HAVA using a percentage of the Renkonen index.

Years of Comparison	CIBO	HAVA
2002-03/2003-04	41%	NA
2003-04/2004-05	66%	NA
2004-05/2005-06	49%	NA
2002-03/2005-06	45%	NA
2002-03/2006-07	48%	NA
2003-04/2006-07	51%	NA
2004-05/2006-07	63%	NA
2005-06/2006-07	66%	71%
All years combined	25%	71%

Discussion

This was the second year in which banding occurred at both sites. While comparisons can only be made with two or more years of data, it appears that CIBO has a higher abundance and species diversity of birds. This is true for both the entire season as well as when each period is analyzed separately. One possible explanation is the location of each site. The CIBO site is surrounded by agriculture or waterfowl ponds and open fields. The HAVA site is surrounded by more typical riparian habitat as well as Topock Marsh and extensive stands of monotypic *Tamarix* spp. The CIBO site may be showing the effects of birds concentrating in one area while the HAVA site is not isolated and has similar habitat as the rest of the area (with the exception of a few mature cottonwood trees). The added effect of having the mesquite/Johnsongrass area at CIBO may also explain the differences in abundance and diversity.

Many of the same species utilize both sites, but capture rates varied. Two of the most common species found in the winter along the LCR showed different capture rates at the two sites. Audubon's warbler was captured much more often at CIBO, while the ruby-crowned kinglet had a higher capture rate at HAVA, although capture rates were more similar for the kinglets. This is probably due to differences in foraging behavior between the two species as well as differences in habitat between the two sites. Audubon's warblers tend to forage higher in the canopy (Hutto 1988). At HAVA, the canopy of the cottonwoods is very distinct from the understory where the nets are located. At CIBO, there is not a true separation between the upper and lower canopies, which may have caused the warblers to spend more time foraging closer to where the nets are. Ruby-crowned kinglets are very active birds that forage anywhere in the habitat where small branches are available for perching (Laurenzi et. al 1982).

Area search data has shown the importance of using both methods to adequately census the birds using each site. Most birds recorded during area searches at CIBO are usually captured using mist-netting, but sometimes in lower numbers than what area searches show. Because only three nets are located in the mesquite area at CIBO, this area is under-surveyed. Many of the sparrow species may be captured more often if more nets were placed in the mesquite habitat. This area of the site is also more open, making it difficult to place nets in the shade, which is necessary to protect captured birds from heat stress. Temperatures often exceed 90°F (32°C) in October. At the HAVA site, area search data varied from mist-netting data more than at CIBO. This was mainly due to having the open water and marsh habitat at the edges of the site causing waterfowl, shorebirds, and marsh birds to be recorded during area searches but never captured in nets. Mist-netting proves useful in recording rare or uncommon species at a site.

At the CIBO site, a high number (n = 12) of yellow warblers (*Dendroica petechia*) were captured during the October period. It is unknown whether any of these were the Sonoran subspecies (*D. p. sonorana*), which is an MSCP covered species. These birds were most likely migrating south and our October netting period coincided with a pulse of yellow warblers. While these birds were not wintering at the site, the importance of the site as a migration stopover can be seen with this species this season, as well as other species in previous years. At the HAVA site, a migrating willow flycatcher (*Empidonax trailii*) was captured on the first day of the October period, and was recaptured the following day. This gives evidence that this bird was using the site as a stopover area. It is unknown whether this was the southwestern subspecies (*E. t. extimus*). Also

at the HAVA site, a Gila woodpecker (*Melanerpes uropygialis*) was captured. This MSCP covered species is known from summer banding data and area searches to be a year-round resident of the area. The mature cottonwoods at the site are some of the few trees in the area that are large enough to have adequate nesting cavities for this species. The cottonwoods at the CIBO site are not quite large enough to allow this species to nest in. As monitoring continues, signs of nesting woodpeckers would indicate that the trees have reached the size needed for large cavity nesting birds. A male vermilion flycatcher was observed during one area search survey, as well as when the mist-netting station was in operation.

With five years of data at CIBO, we are just starting to see some possible trends. Continuing to monitor this site longer than five years is important for understanding avian use of this small restoration site, and discovering whether any changes in use occur after the adjacent areas are planted with native riparian vegetation. It is anticipated that once all habitat creation areas have been planted, there will be approximately 900 acres of habitat, with the Nature Trail only making up a small part of the entire area (Garnett and Calvert 2007). After two years of data at HAVA, baseline data has been gathered, and as banding continues, long-term trends may be found which allow us to compare both sites. Understanding avian use at these two sites will aid the design of future habitat creation sites.

Literature Cited

Bureau of Reclamation. 1996. Description and assessment of operations, maintenance, and sensitive species of the Lower Colorado River. Final biological assessment prepared for U.S. Fish and Wildlife Service and Multi-Species Conservation Program. Bureau of Reclamation. Boulder City, NV.

Calvert, A. 2008. Winter bird monitoring using constant effort mist-netting at three sites along the lower Colorado River 2005-06. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program Office, 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.

Garnett, G., and A. Calvert. 2007. Cibola NWR Unit 1 Conservation Area, restoration development and monitoring plan: overview. Bureau of Reclamation, Lower Colorado Region, Lower Colorado River Multi-Species Conservation Program Office, Boulder City, NV. http://www.lcrmscp.gov/worktasks/conservationareas/E24/overview.pdf . Accessed Feb. 2008.

Hutto, R.L. 1988. Foraging behavior patterns suggest a possible cost associated with participation in mixed-species bird flocks. Oikos 51:79-83.

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

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

Laurenzi, A.W., B.W. Anderson, and R.D. Ohmanrt. Wintering biology of ruby-crowned kinglets in the lower Colorado River valley. The Condor 84:385-398.

Lower Colorado River Multi-Species Conservation Program. 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan. Final. December 17. (J&S 00450.00.) Sacramento, CA.

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. 1999. Handbook of field methods for monitoring landbirds. U.S. Department of Agriculture, General Technical Report PSW-GTR-144. Pacific Southwest Research Station, Albany, CA.

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.

Sibley, D.A. 2000. National Audubon Society, The Sibley Guide to Birds. Chanticleer Press, Inc. (New York).

Szaro, R.C. 1980. Factors influencing bird populations in southwestern riparian forests. Management of western forests and grasslands for nongame birds. USDA Forest Service, General Technical Report. Ogden, UT.

U.S. Fish and Wildlife Service. 2007. Cibola National Wildlife Refuge. http://southwest.fws.gov/refuges/arizona/cibola.html. Accessed Nov. 2007.