Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Bird Banding Summary Report for the 2008 and 2009 Seasons

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

August 2012

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Multi-Species Conservation Program
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Lower Colorado Region
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Introduction

The Lower Colorado River Multi-Species Conservation Program (LCR MSCP) is a multi-stakeholder federal and non-federal partnership responding to the need to balance the use of lower Colorado River (LCR) water resources and the conservation of native species and their habitats in compliance with the Endangered Species Act. This is a long-term (50-year) plan to conserve at least 26 species along the LCR from Lake Mead to the Southerly International Boundary with Mexico.

The Bureau of Reclamation (Reclamation) has operated bird-banding stations at various locations along the Lower Colorado River since 2000. Originally, Reclamation operated Monitoring Avian Productivity and Survivorship (MAPS) summer banding operations; in 2003, winter banding operations were added. Currently, both summer MAPS and winter banding operations are conducted at two sites and banding is conducted for 10 months of the year.

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. 2010). 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, and US Fish and Wildlife Service 1997). Restoration of riparian habitats is an important part of the process to maintain or increase bird populations in the Southwest. Monitoring of restoration sites is also an important part of understanding the effectiveness of restoration techniques and adaptively managing restored sites.

The overall purpose of the mist-netting and bird-banding program is to intensively monitor avian use of restoration sites and analyze details of avian use by LCR MSCP covered species at these sites. Data collected from the bird banding programs are used to determine demographic characteristics of covered species at restoration sites such as survivorship, productivity, and site fidelity.

Previously, the MAPS banding and winter banding were summarized in separate reports. Over the years, it became apparent that some birds are captured in both seasons and that more overlap in site utilization occurs than originally thought. For this reason both summer and winter banding operations will be summarized in one report starting with the

current report. This report for 2009 will summarize the 2008 MAPS season, the 2008-09 winter season, and the 2009 MAPS season.

In September of 2008, a fire occurred at the HAVA banding station that burned the entire habitat south of the dike road, making it necessary to change net and banding locations. The portion of the site that burned included monotypic saltcedar (*Tamarix* spp.), and net lanes 8, 9, and 10 were lost. Before the winter season began, one new 12-meter net was established to bring the total number of nets operated at the site in 2008-09 to 10. This is two fewer nets than were normally operated at the site in previous years. Capture numbers for winter banding 2008-09 at the HAVA site were very low, presumably due to the loss of habitat. Therefore, it was decided to close the station prior to the upcoming summer MAPS session and establish a new station nearby. The Beal restoration site, also on Havasu National Wildlife Refuge, was chosen as the new location for the banding station. Banding for both summer and winter will be conducted at this site. The site is described in the Study Areas section below.

Study Areas

Cibola National Wildlife Refuge is located along the LCR south of Blythe, California, near 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 2009). 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*). Starting in 1999, a total of 1,500 honey mesquite, 1,500 screwbean mesquite, 10,000 Goodding's willow, and 2,600 Fremont cottonwoods were planted (Reclamation 2003). In the years since the site was planted, Johnsongrass (*Sorghum halapense*) and Baccharis (*Baccharis* spp.) have independently established and dominate the ground cover and shrub layers in the areas planted with willow and mesquite.

The Havasu banding site is located on the Havasu National Wildlife Refuge at the southern end of Topock Marsh, approximately 1.2 miles (1.9 km) north of the town of Topock, Arizona. The nets are located on either side of the dirt road, which follows the new south dike road just off Arizona Route 95. A large portion of the area is covered in saltcedar 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 Reclamation personnel in 1987, where most of the trees planted did not survive (Glen Gould, Reclamation, pers. comm.).

The Beal restoration site is also located on the Havasu National Wildlife Refuge, between Beal Lake and Topock Marsh, approximately 5 miles (8 km) northwest of the town of Topock, Arizona. The site comprises 30 separate fields, each planted with different vegetation and each irrigated independently (Reclamation 2010). It was designed as an experimental demonstration of different planting techniques (Reclamation 2010). Feral

pigs have introduced mesquite into almost every cell and the site has developed as a heterogenous mix of mesquite, cottonwood, and willow.

Methods

MAPS

The MAPS stations were conducted once during every 10-day period between May 6 and August 1 in 2008, and between May 5 and August 6 in 2009, for a total of 10 periods each year. 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 Goodding's willow, three 12-m nets were located in Fremont cottonwood, and two 6-m nets were located in mesquite habitat (Figure 1). These locations were chosen in order to sample the three distinct habitat types.

Figure 1. Photo of the Cibola Nature Trail banding site with net lanes. Net lanes in red are only operated during the winter.

At the HAVA site, ten 12-m nets were used. Three nets were located in areas with an overstory of Fremont cottonwood and seven nets were located in areas dominated by saltcedar mixed with arrowweed and Fremont cottonwood (Figure 2). These locations were chosen in order to evenly sample the land cover types found at the site.

Figure 2. A photograph of the HAVA banding site with net lanes. Net lanes in yellow were lost in the fire; net lanes in red are only operated in the winter.

At the BERS site, nine 12-m nets and two 6-m nets were used. The nets were located in the center of the site where watering is most frequently applied. The nine 12-m nets were placed in areas originally planted with cottonwood/willow mix, but these areas are now a mix of cottonwood, Goodding's willow, coyote willow, and honey mesquite. The two 6-m nets were located in an area dominated by honey mesquite (Figure 3). These locations were chosen to sample the core actively managed area at this site.

Figure 3. A photograph of the Beal Restoration Site with net lanes. Net lanes in red are only operated during the winter.

Nets were set up one half hour before sunrise, and closed five 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.

Winter Banding

Banding during the winter utilized the same net lanes as are used during the MAPS summer season, with additional nets being added. At each site the equivalent of two 12-m nets were added to expand area sampled into locations that are not normally shaded well enough to allow banding during the summer. At the CIBO site, one new net was added and two nets that are 6-m in length during the summer were expanded to 12 m in length. At the HAVA site, a new net (13) was added to replace one of the nets lost in the fire. Only 10 nets were operated in 2008-09 due to the habitat lost to fire. After the winter season, banding was discontinued at the HAVA site.

Nets were set up one half hour after sunrise and were open for six hours unless conditions, such as wind or temperature, exceeded protocol limits. Nets were checked every 30-50 minutes. The protocol included 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 2008-09, banding began in October and continued through March.

For all banding, 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. 2010). 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.

Color Banding

During the summer of 2009, a program was initiated to place color band combinations as well as the numbered USFWS silver band on any LCR MSCP covered species captured during banding operations. The purpose of placing unique color band combinations on each individual of a covered species captured is to allow birds to be re-sighted and

identified to individual without needing to be recaptured. For purposes of analysis, data collected from a bird that is re-sighted can be used in the same way as data for a bird that has been recaptured in a net. This provides more information for analysis of survivorship of covered LCR MSCP species. If LCR MSCP covered bird species are surviving between years, then the restoration sites would meet the species' habitat requirements and should meet the conservation measures for each covered species.

Additionally, birds that prove difficult to capture through passive means are target captured using call/playback methods to draw a bird into a net temporarily set up within its territory. This effort is used in both banding seasons because some species are present in the area all year and exhibit territorial behavior even in the winter.

A standard protocol was developed for target capturing and re-sighting of birds. A standardized data sheet was developed for color banding, re-sighting of color-banded birds, targeted captures, and for keeping track of color band combinations used. For each color-banded bird, the color of each band and the leg on which it was placed was recorded. The USFWS bands were recorded as being "silver". The age, USFWS band number, how the bird was captured (passive or targeted), date, and time of capture were also recorded. For re-sighting the location, color-band combination and the confidence of the observer in the accuracy of the re-sight were recorded.

Data Analysis

The data collected from banding efforts are used to create several indices to measure avian use of the sites. Some of these indices are then used in statistical analyses to compare changes over time at each site, or to compare sites to each other. These analyses are used to provide detailed demographic measures of avian use of restoration sites in terms of general bird use and specific use by LCR MSCP covered species. Demographic measures of the restoration sites such as survivorship and productivity can be used to analyze how covered species are currently using the sites and may be used to adaptively manage other sites in the future. If covered species are reproducing and surviving well at these sites, it may be useful to mimic these site conditions at other sites that may not be providing sufficient habitat. These analyses are presented in the results section.

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 are recorded as a percentage of returned birds to all birds captured (Latta and Faaborg 2001, 2002). Annual return is a rough measure of survivorship and demonstrates site fidelity.

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 (Nur et. al. 1999), which uses the formula:

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

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 even detection numbers for all species (Nur et al.1999).

N_1 diversity values were compared across all years of banding at each site and between sites for the 2008 MAPS, 2009 MAPS, and 2008-09 winter banding seasons. Species diversity was calculated in two separate manners that yield different results. Species diversity was calculated for each banding season from all captures from the entire banding season. Species diversity was also calculated for each banding period and then averaged for the entire season. The averages from the values calculated from each period allow for standard error to be calculated and for statistical tests to be run, and the value calculated from the entire season provides an overall calculation when the season is taken as a whole. The average value from the banding periods will not be the same as that calculated from the entire season.

The per-period N_1 values were used to compare diversity values between years for each individual site. All the species diversity data were analyzed using a quantile-comparison plot to determine whether the data were normally distributed. At each site, the data were determined to be normally distributed and parametric methods were used for all the analysis of species diversity data. Each site was analyzed separately and a one-way ANOVA was used to compare data between years. If a significant difference was found, a Tukey's HSD Analysis was used to determine the years for which the significant difference occurred.

The per-period N_1 diversity values were also used to compare the two sites where banding took place in each season of banding. CIBO and HAVA were compared in the MAPS 2008 and in the Winter 2008-09 seasons. CIBO and BERS were compared in the MAPS 2009 season. A two-way t-test was used for the analysis for all three seasons.

Site Persistence

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.

Capture Rate

Bird per net hour capture rate was compared across all years of banding for each individual site and between sites for each of the 2008 MAPS, 2009 MAPS, and 2008-09 winter banding seasons. A quantile-comparison plot was used to determine whether the capture data to be analyzed was normally distributed. In most cases, the data were found to be non-parametric, so in order to maintain a consistent approach all data were analyzed using nonparametric methods. For the analysis of capture rate data between years, data were compared for the overall capture rate between the same banding periods from each year at the same site. A Kruskal-Wallace rank sum test was used for this analysis.

For each individual season, each site was compared to the other site where banding was conducted using the capture rates for each species of resident bird that was captured at either of the two sites. Only two sites were operated during each season, and data were compared between these two sites. For the MAPS 2008 and Winter 2008-09 data, this comparison was analyzed between the CIBO and HAVA sites. For the 2009 MAPS data, this comparison was run between the BERS and CIBO sites. A Wilcoxon Signed Rank Test was used to compare the capture rates between sites.

After 2008, MAPS banding was discontinued at the HAVA site; thus, the data between the HAVA and CIBO site for the four years banding occurred at both sites were analyzed for correlation between the capture rates of each species captured at either site. A Spearman Rank Correlation test was used for this analysis.

Permits

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

Results

Following are the results from the 2008 and 2009 MAPS seasons and the 2008-09 winter banding season. All data were recorded in the field, entered, and proofed in MAPSPROG, compiled in EXCEL, and all statistical analysis was processed in program R 2.9.2.

General Capture Results

For capture results, a resident bird is defined as one that is known to breed on the Lower Colorado River. This determination is made by data summarized in Birds of the Lower Colorado River Valley (Rosenberg et. al., 1991) and based on birds that have been captured during banding operations that have demonstrated indications of breeding (full brood patches or cloacal protuberances). Birds not described as resident are considered migrants. All capture totals are summarized below as well as the number of individual birds captured. Individual bird totals are those for all unique individuals captured during banding operations. If a bird was recaptured several times, it would only count once toward the individual bird capture total.

MAPS Season

In 2008, 221 individual birds were captured at the CIBO site, of which 136 were resident birds. The captures comprised 213 new captures and 16 local recaptures. The bird per net hour capture rate at CIBO was 0.51 for all birds and 0.31 for resident birds. There were 30 species captured, of which 17 were resident species.

At the HAVA site, 169 individual birds were captured, of which 133 were resident birds. The captures were comprised 165 new captures and 14 local recaptures. At the HAVA site, the capture rate was 0.42 for all birds and 0.32 for resident birds. There were 23 species captured, of which 15 were resident species.

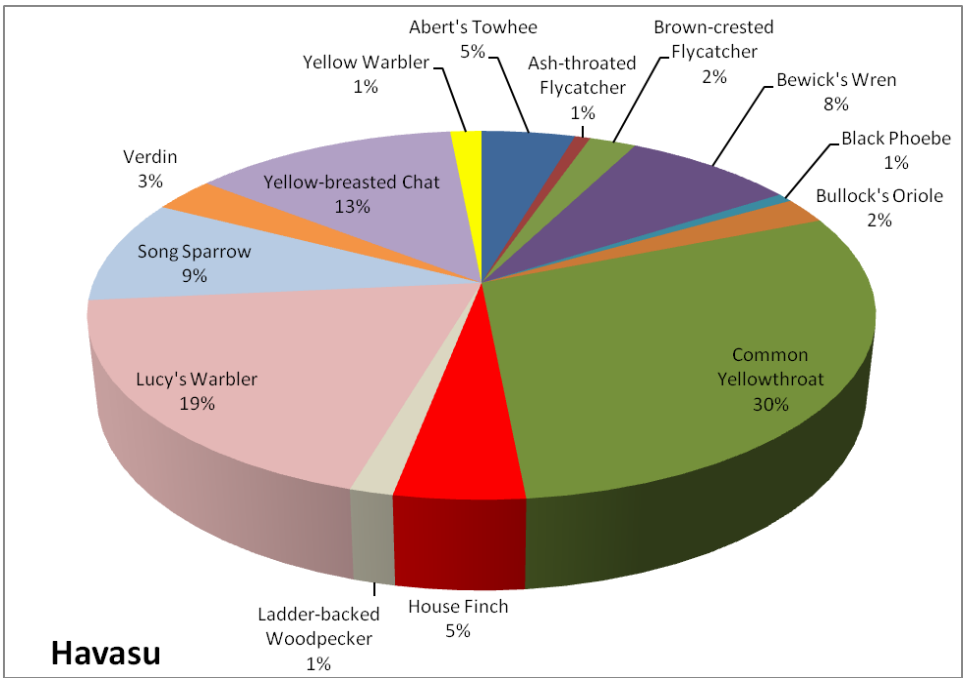

Figure 4. Resident bird species captured and relative abundance at the 2008 HAVA MAPS site.

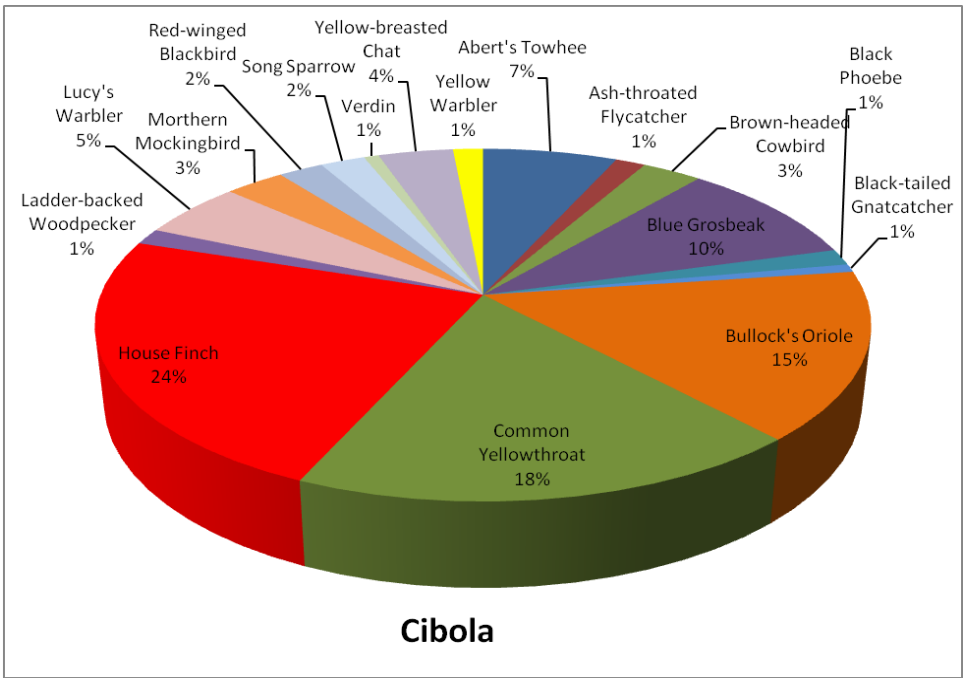

Figure 5. Resident bird species captured and relative abundance at the 2008 CIBO MAPS site.

In 2009, 172 individual birds were captured at the CIBO site, of which 100 were resident birds. The captures comprised 161 new captures, 16 local recaptures, and 2 foreign recaptures (birds that were originally captured at another banding site). The bird per net hour capture rate was 0.41 for all birds and 0.24 for resident birds. There were 32 species captured, of which 18 were resident species.

At the BERS site, 255 individual birds were captured, of which 189 were resident birds. The captures comprised 254 new captures and 20 recaptures. The bird per capture hour rate was 0.59 for all birds and 0.44 for resident birds. There were 31 species captured, of which 21 were resident species.

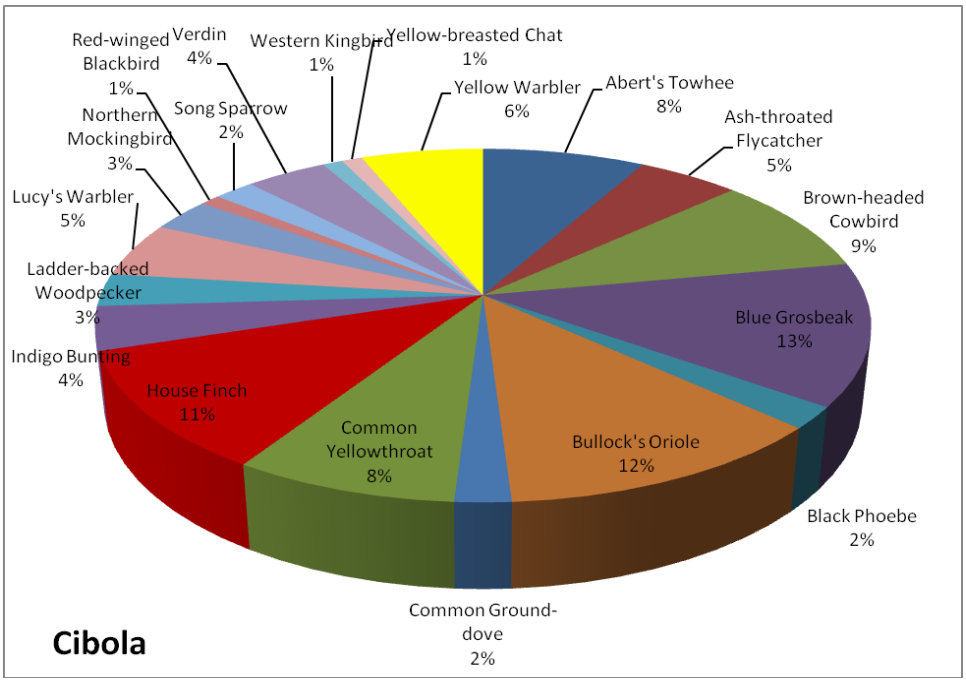

Figure 6. Resident bird species captured and relative abundance at the 2009 CIBO MAPS site.

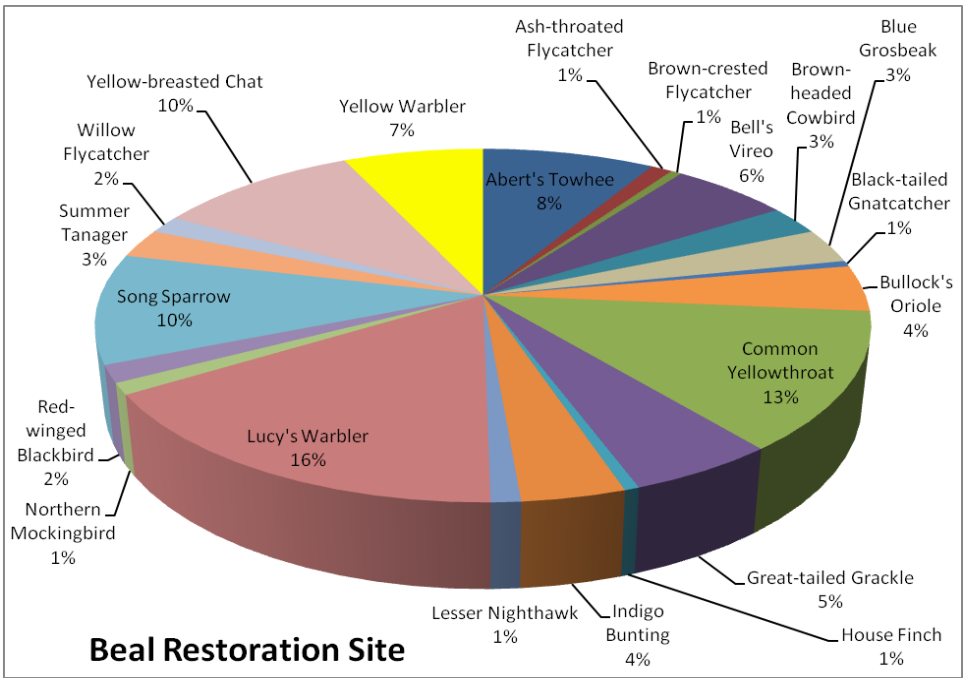

Figure 7. Resident bird species captured and relative abundance at the 2009 BERS MAPS site.

Data were compiled from all years for which MAPS banding has taken place at the three MAPS sites used in 2008 and 2009. Banding began at the CIBO site in 2003, in 2005 at the HAVA site, and in 2009 at the BERS site. Figure 8 diagrams the yearly birds per net hour rate for all sites across all years.

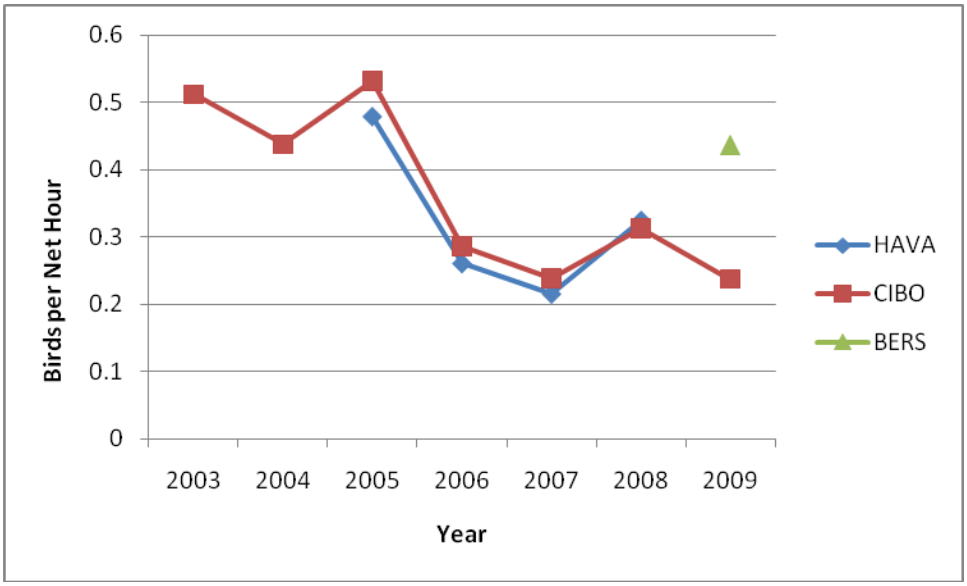

Figure 8. Capture rate of resident individual birds for each year at each site.

For both the HAVA and CIBO sites, the birds per net hour capture rate was compared across years for each species of resident bird captured. A value was calculated for each species, but these values were used to compare sites as a whole. A Kruskal-Wallace rank sum test was used to test for yearly differences in capture rate. At the CIBO site, no significant difference was found in the capture rate between years through 2009 (K-W $\chi 2 = 7.97$, $p = 0.24$). At the HAVA site, no significant difference was found in the capture rate between years through 2008 (K-W $\chi 2 = 1.17$, $p = 0.76$).

In 2008, the capture rates of resident birds between HAVA and CIBO were compared. A Wilcoxon Signed Rank test was used. There was no significant difference detected between capture rates at the two sites in 2008 ($p = 0.83$), and no significant difference was found between the sites in previous years. A Spearman Rank Correlation Test was run on the data between the sites for all four years and the capture rate data between the sites were moderately correlated ($Rho = 0.53$, $p < 0.0001$).

In 2009, a Wilcoxon Rank Sum test was used to compare the capture rate of resident birds between BERS and CIBO. No significant difference was detected between the two sites ($p = 0.35$).

Winter Banding

At the CIBO site, 267 individual birds were captured over six periods of banding. The captures comprised 261 new captures and 29 local recaptures. The capture rate at the site was 0.33 birds per net hour and 29 different species were captured.

At the HAVA site, 58 individuals were captured over six periods of banding. The captures comprised 50 new captures and 17 local recaptures. The capture rate at the site was 0.10 birds per net hour and 17 different species were captured.

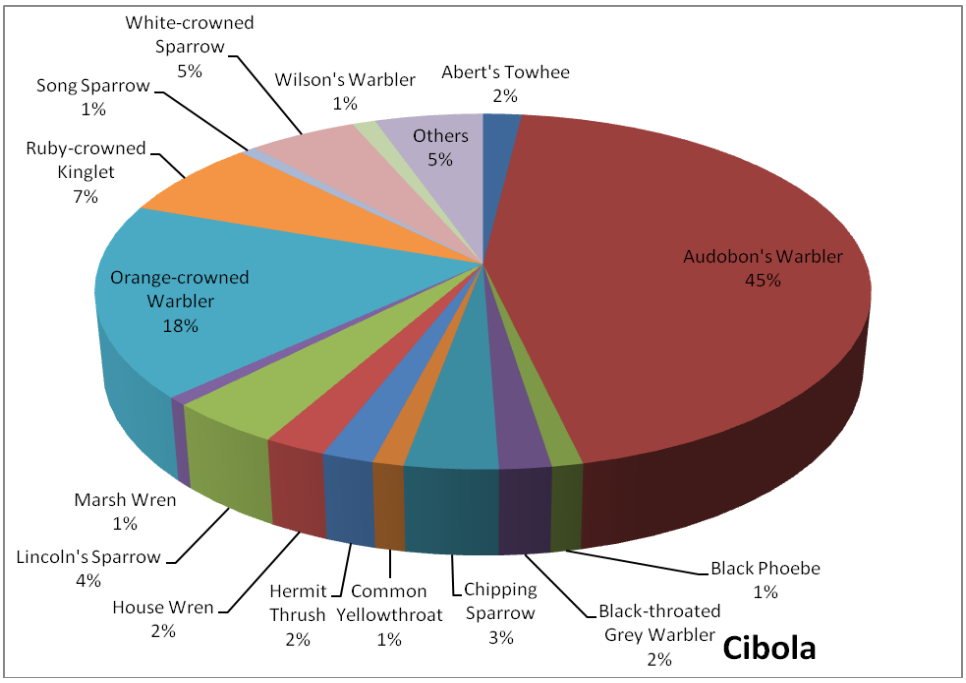

Figure 9. Bird species captured and relative abundance for winter banding at the CIBO site 2008-09.

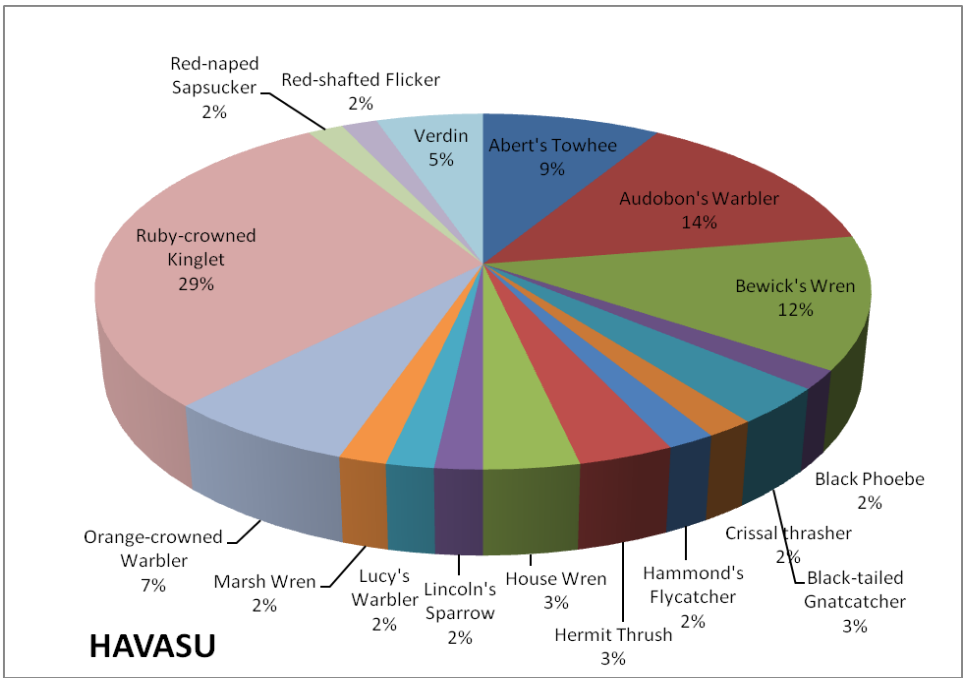

Figure 10. Bird species captured and relative abundance for winter banding at the HAVA site 2008-09.

Data on total capture rate were compiled from all years of winter banding at both sites. Winter banding began at the CIBO site in the 2002-03 season and at the HAVA site in the 2005-06 season. Figure 11 diagrams the total bird per net hour capture rate for each year at both sites.

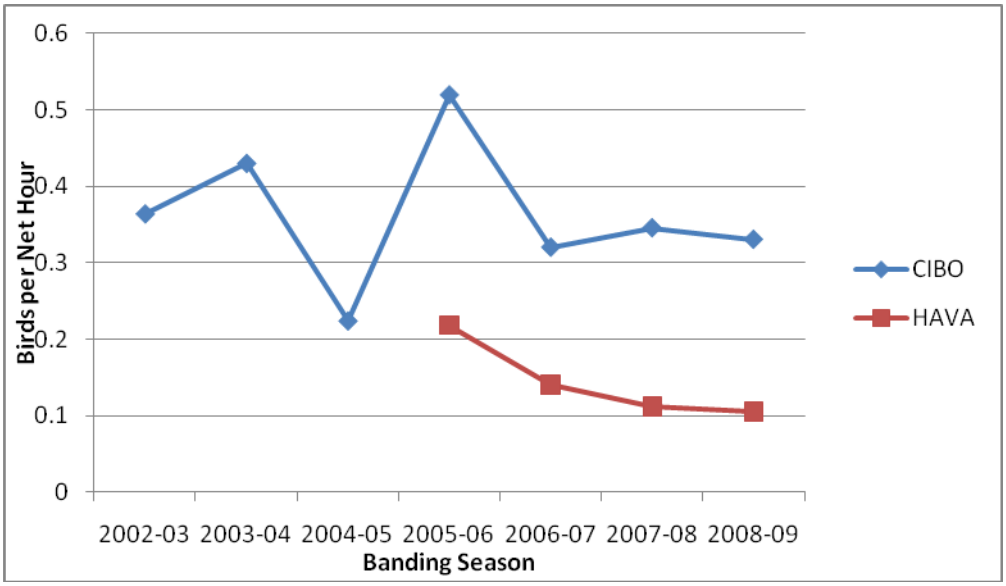

Figure 11. Capture rate of individual birds from the winter, per year, at both sites.

For both the HAVA and CIBO sites, birds per net hour capture rate was compared across years for each species of resident birds captured. A Kruskal-Wallace rank sum test was used to test for yearly differences in capture rate. At the CIBO site no significant difference was found between capture rate between years (K-W $\chi 2 = 2.74$, $p = 0.84$). At the HAVA site no significant difference was found in the capture rate between years (K-W $\chi 2 = 1.78$, $p = 0.62$).

For the 2008-09 season the capture rate between CIBO and HAVA was compared. A Wilcoxon rank sum test was used to compare the two sites. The difference in capture rates was found to be not significant ($p = 0.060$). If an a priori confidence interval was used that was slightly lower (such as a CI of 90%), this difference would be significant.

Annual Return Rate

The annual return rate for any species that experiences at least one annual return recapture was calculated. No data are presented for the BERS site, as 2009 was the first year of banding at the site. Tables 1 and 2 summarize the number of total individuals captured at each site, per season, the number of annual return recaptures, and the annual return rate for each species.

Table 1. Annual return rates for all species with at least 10 individuals captured for the 2008 and 2009 MAPS seasons.

Site and year	Species	Individuals	AR	%
CIBO 2009	Blue Grosbeak	13	1	7.7%
CIBO 2009	Bullock's Oriole	12	3	25.0%
CIBO 2008	Blue Grosbeak	13	1	7.7%
CIBO 2008	Bullock's Oriole	21	2	9.5%
CIBO 2008	Common Yellowthroat	25	1	4.0%
CIBO 2008	House Finch	32	1	3.1%
HAVA 2008	Yellow-breasted Chat	17	1	5.9%

Table 2. Annual return rates for all species with at least 10 individual captures for the 2008-09 winter banding season.

Site	Species	Individuals	AR	%
CIBO	Orange-crowned Warbler	47	3	6.4%
CIBO	Ruby-crowned Kinglet	19	1	5.3%
HAVA	Ruby-crowned Kinglet	17	2	11.8%

Species Diversity

MAPS Season

Transformed species diversity (N_1) was calculated for each site both for the entire season and for each period banding was conducted. For the MAPS season, a calculation of N_1 was made for all species and for resident breeding species at each site. Table 3 summarizes the N_1 values calculated for each MAPS site where banding took place in 2008 and 2009.

Table 3. Transformed species diversity (N_1) yearly total values for MAPS station in 2008 and 2009.

Site and Year	All Species N_1	Resident Species N_1
CIBO 2008	18.1	10.1
HAVA 2008	13.0	9.2
CIBO 2009	21.5	14.8
BERS 2009	17.6	14.2

At each site, N_1 values were calculated for each banding period; the values were then averaged for each year and a standard error was calculated. These values are different

than the values in Table 3 because they are averages for each period value and not a total value for all birds captured in the entire season. An N_1 value calculated for the entire year as a whole will tend to be larger than an average of per period values due to lower number of bird species that are captured in each period rather than over the entire year. The yearly average N_1 values with standard error bars are shown for all three sites in Figure 12.

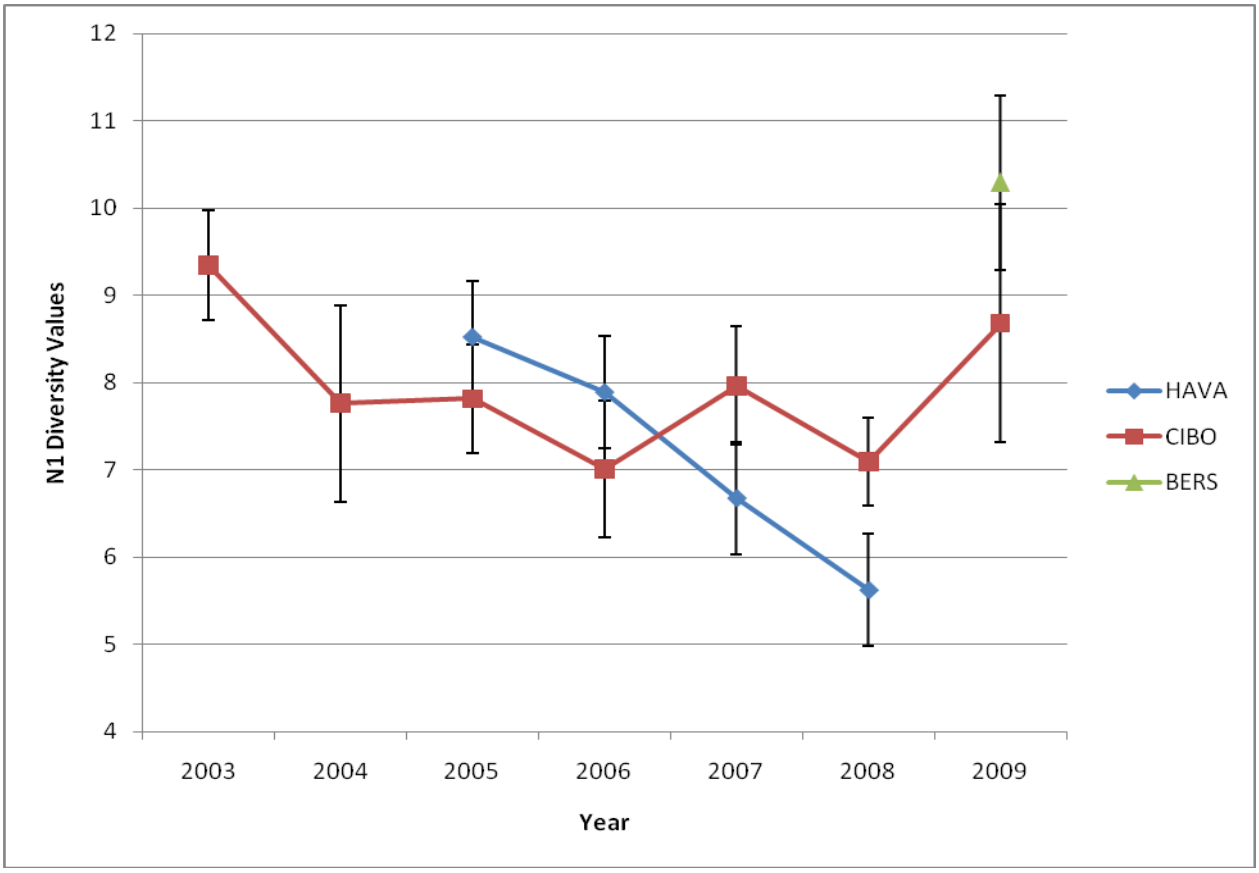

Figure 12. Comparison of average yearly N_1 values between sites with SE bars for MAPS banding.

For both the HAVA and CIBO sites, N_1 values were compared across years for each species of resident birds captured. A one-way ANOVA was used to compare the data between years. At the CIBO site no significant difference was found in N_1 values between years ($p = 0.48$). At the HAVA site a significant difference was found ($p = 0.028$). A Tukey's HSD Analysis was used to determine the years for which N_1 values were significantly different. The analysis showed that the significant difference was between the N_1 values calculated in 2005 and 2008.

The data for per period N_1 values was compared between the HAVA and CIBO site in 2008 using a two-way t-test. There was no significant difference between the two sites in

2008 (p = 0.11). The data for N_1 values was compared between CIBO and BERS in 2009 using a two-way t-test. There was no significant difference between the sites (p = 0.43).

Winter Banding

Transformed species diversity (N_1) was calculated for each site both for the entire season and for each period banding was conducted. At the HAVA site a N_1 value of 10.4 was calculated and at the CIBO site a value of 7.7 was calculated.

At each site, N_1 values were calculated for each banding period. The values were then averaged for each year and a standard error was calculated. The yearly average N_1 values with standard error bars are shown for both sites in Figure 13.

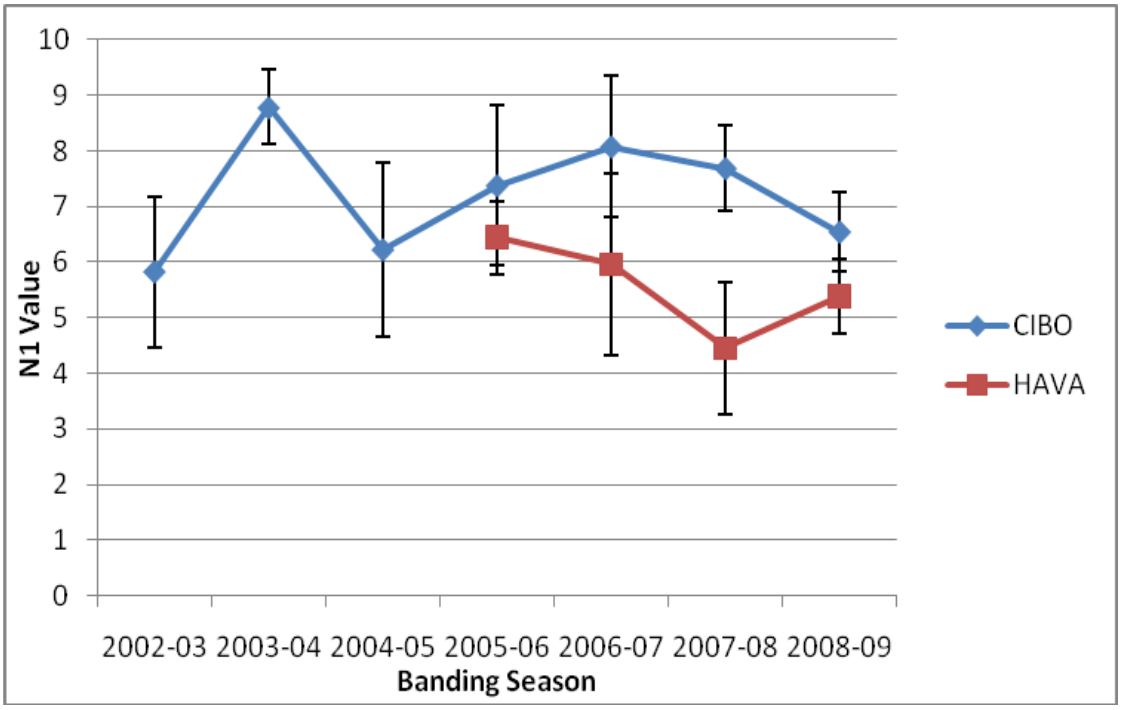

Figure 13. Comparison of average yearly N_1 values between sites with SE bars for winter banding 2008-09.

For both the HAVA and CIBO sites, N_1 values were compared across years for each species of resident birds captured at the respective site. A quantile-comparison plot showed that the data at the CIBO site were parametric, but at the HAVA site the data were non-parametric. At the CIBO site a one-way ANOVA was used to compare data across years and no significant difference was found (p = 0.70). At the HAVA site a Kruskal-Wallace Ranks Sum test was used to compare the data across years and no significant difference was found (K-W $\chi 2 = 3.83$, p = 0.28). N_1 values were compared between the CIBO and HAVA sites for the 2008-09 season and no significant difference was found (p = 0.26).

Site Persistence

The site persistence rate was calculated for any species that had at least one recapture or re-sighting in a different banding period than that of its original capture, but within the same banding season. The tables below summarize the site persistence rates for each location and season.

Summer Banding Season

Table 4. Site persistence for all species with at least 10 individuals captured at the MAPS sites for 2008.

Site	Species	Individuals	Inter-period recapture	%
CIBO	Blue Grosbeak	13	2	15.4%
CIBO	Bullock's Oriole	21	2	9.5%
HAVA	Common Yellowthroat	39	4	10.3%
HAVA	Yellow-breasted Chat	17	1	5.9%

Table 5. Site persistence for all species with at least 10 individuals captured for the 2009 MAPS season.

Site	Species	individuals	inter-period recapture	%
BERS	Abert's Towhee	16	1	6.3%
BERS	Bell's Vireo	12	3	25.0%
BERS	Common Yellowthroat	24	2	8.3%
BERS	Yellow-breasted Chat	19	5	26.3%
BERS	Yellow Warbler	13	4	30.8%
CIBO	Blue Grosbeak	13	2	15.4%
CIBO	Bullock's Oriole	12	1	8.3%

Winter Banding Season

Table 6. Site persistence for all species with at least 10 individuals captured for the 2008-09 season.

Site	Species	Individuals	Inter-period recaptures	%
CIBO	Audubon's Warbler	119	1	0.8%
CIBO	Lincoln's Sparrow	11	2	18.2%
CIBO	Orange-crowned Warbler	47	5	10.6%
CIBO	Ruby-crowned Kinglet	19	5	26.3%
HAVA	Ruby-crowned Kinglet	17	4	23.5%

Color Banding

LCR MSCP covered species were color banded during the MAPS banding season for the first time in 2009 on a trial basis. All individuals of covered species were given a unique color band combination and starting in July re-sighting of color bands was attempted. At the BERS site re-sighting and target netting was attempted on six different mornings and the same was attempted at the CIBO site on one morning. Re-sighting and target netting started 30 minutes before dawn and continued until temperatures were too hot (around 10 am). Between 2 and 5 individuals were present each day attempting to re-sight or target capture birds. No analysis of annual survivorship is possible with one year of data. The sample size for LCR MSCP covered species caught from all years combined at the CIBO site is not currently adequate to analyze survivorship, but it may be possible with color re-sights added in from future years. The numbers of birds color banded and re-sighted is summarized in the Table 7.

Table 7. Number of birds color banded and re-sighted in 2009.

Site	Species	Color Banded	Re-sighted
Cibola	Yellow Warbler	5	0
Beal	Yellow Warbler	13	2
Beal	Bell's Vireo	11	3
Beal	Summer Tanager	5	1

Discussion

The overall purpose of the mist-netting and bird-banding program is to intensively monitor avian use of restoration sites and analyze details of avian use by LCR MSCP covered species at these sites. With this in mind, the MAPS and winter banding programs have changed with the addition of color banding and new analysis methods in the last two years. As a result, the HAVA station has been discontinued, in part because of a fire at the site, but also to shift monitoring to the Beal restoration site. The Beal site has many more covered avian species than any other restoration site (Great Basin Bird Observatory 2009), which may result in a much larger sample size for two species in particular, Bell's vireo and yellow warbler. Larger sample sizes for resident species will allow survivorship and productivity analysis to be conducted.

One of the objectives of this report is to determine the effectiveness of the various analysis methods used with the banding data and to direct and focus future efforts of bird banding. For the Beal site, color banding was fully initiated in 2009 and a complete analysis of survivorship and productivity will not be possible until at least five years of data have been collected. Due to the fact that many more yellow warblers and Bell's vireos were present at the Beal site than originally presumed in this first year, not all individuals of these species were captured or banded. This means that in future years more birds will be color banded as previous years' birds returning to the site will already be banded and fewer individuals will need to be captured and color banded, allowing for more effort to be put into re-sighting birds. In future years re-sighting can commence with the beginning of the summer breeding season instead of in July as in 2009. Using passive capture, target capture, and re-sight data, a mixed model will be utilized; thus, the need for at least five years of data to analyze survivorship.

It should be noted that willow flycatchers were caught at all sites where MAPS banding took place in both 2008 and 2009. There is no reliable way to identify these birds to sub-species, but they were not detected utilizing the sites through the summer. They were captured during the early part of the summer when migration is at its peak, and these birds were therefore considered migratory.

In this report, banding data were analyzed using additional methods, as enough data has been collected to allow greater depth of analysis. Each analysis is discussed in a separate section in this report, according to each method used. While information was recorded on fat levels of birds, this information cannot be used to analyze bird condition. Many birds do not put on fat except during migration, which makes levels of fat a poor indicator of bird condition during resident periods. No analysis of bird condition was possible, and is not presented in this report.

Capture Rate and Species Composition

The most notable result from the capture rates is the similar capture rates between the HAVA and CIBO sites for the four years of MAPS banding. As shown in Figure 8, the MAPS capture rates mirror each other very closely. The Spearman Rank Correlation Test further demonstrates a correlation between the capture rates at each site with a Rho value of 0.53. This is fairly high for environmental data and may indicate that the two sites experienced similar capture rates between species and not just for the overall capture rate. Both of these indicate that for these two sites, the capture rate may be driven by system-wide effects (bird use of the LCR watershed as a whole) as opposed to site-specific factors.

In 2009 with the initiation of the BERS banding site and the end of banding at the HAVA site, a different result was found, although with only a year of data no real trends can be determined. There were several more yellow warblers at Beal than at Cibola, and Bell's vireos and summer tanagers were only captured at the Beal site.

For every year winter banding was conducted at both CIBO and HAVA sites (Figure 11), the winter capture rate was lower at the HAVA site. The consistently lower capture rates at the Havasu site may be due to the lack of ground vegetation that is used by sparrows and other species commonly found in the winter. The capture rate was not found to be significantly different in any of the years, but in 2008-09 if a slightly lower confidence interval was used (such as a 90% CI instead of the standard 95%), then the capture rates would have been significantly different. A lower confidence interval may need to be used, a priori, in future analysis in order to account for the low sample sizes and the stochastic nature of the data collected. The nearly significant difference in N_1 values between sites is likely due to the fire that occurred just before the start of the 2008-09 winter season that destroyed the habitat where nets 8, 9, and 10 were located. This fire reduced the amount of usable habitat at the site and precipitated the decision to abandon the site after the winter season ended.

Species Diversity

Although the capture rates between CIBO and HAVA were very similar, species diversity values at the HAVA site declined over the four years, whereas they remained constant at CIBO. In the first two years the Havasu site showed higher diversity values than at the Cibola site, but then declined to a significantly lower average value by 2008 (Figure 12). This decline occurred before the fire, and therefore shows a possible declining trend in bird diversity at the site.

While similar numbers of birds were being captured at the Havasu site as compared with the CIBO site, the captures were coming from an increasingly less diverse species composition every year. This was not the case at the Cibola site, where diversity values remained constant. The winter results did not show the same patterns as those demonstrated in the MAPS results. The N_1 values were lower every year at the Havasu

site as compared to the Cibola site. At the Havasu site, the values decreased every year for the first three years but then increased slightly in the last year of banding. This increase is likely due to the very low capture numbers at the Havasu site in 2008-09 after the fire. With low capture numbers, one capture of an individual from a rare species will have more effect on the diversity value. This indicates that sites with low capture rates may not be suitable for analysis.

Site Persistence

Site persistence is difficult to use as a measure for most bird species as not enough captures and re-captures occurred. They are useful for several species however, especially with the winter banding results. Site persistence in the winter for the three commonly captured species: Audubon's warbler (*Dendroica coronata*), orange-crowned warbler (*Vermivora celata*), and ruby-crowned kinglet (*Regulus calendula*), does demonstrate differences in relative use of the sites by these species. Ruby-crowned kinglets showed relatively high persistence rates (24% at HAVA, 26% at CIBO) given the fact that many birds will not be recaptured passively (without being targeted). Orange-crowned warblers also showed relatively high persistence at the CIBO site (10.6%), but not at the HAVA site. These numbers are in contrast to the persistence rate of Audubon's warblers (0.8% at CIBO), which is very low. This indicates that use of the sites in the winter differs between species. Ruby-crowned kinglets used the same sites repeatedly during the same winter, while Audubon's warblers had high capture rates, but lower re-capture rates during the same winter. This indicates that different flocks of Audubon's warblers were using the sites at different times of the winter.

The use of re-sights may help obtain a larger number of recaptures for LCR MSCP covered species during MAPS operations. In this first year of color banding, re-sighting was not undertaken until later in the summer, once some birds had been captured and color banded. In future years, color band re-sights conducted throughout the year may help calculate persistence, which would largely depend on survivorship of birds that are breeding.

Annual Return

Overall, annual return rates were lower than in previous years for both the winter of 2008-09 and for the 2009 MAPS season. The low number of individual captures for most species precludes any causal explanation at this point. No annual return data is possible at the Beal site as banding began at the site in 2009. With the large number of LCR MSCP covered species and the color band re-sights adding to the data in future years, and presumably increasing sample size, a much more robust annual return rate analysis may be possible and could complement survivorship analysis.

Color Banding and Target Netting

The first year of color banding provided some insight into how operations can be conducted in the coming years. The first thing learned was that the most effective way to capture covered LCR MSCP species is passive netting. Passive captures do not require call playback methods to attract birds into a net, and therefore minimize possibility of harassment of birds. Only one bird was target netted at the BERS site, while 28 were captured passively. At the BERS site 6 mornings were spent target netting and re-sighting, while 10 mornings were spent operating MAPS stations. The number of people target netting was often higher than was present during MAPS operations, but the large disparity in capture numbers strongly supports the idea that passive MAPS operations were more efficient at capturing covered species.

At the Cibola site, five birds were passively captured, and none were target captured using target netting techniques. At the Beal site, five birds were passively re-captured and six birds were re-sighted. The re-sighting did not begin until July, so results are not complete, but it does demonstrate that passive MAPS banding is the most efficient way to capture and possibly re-capture LCR MSCP species. Target banding provides an alternative method to capture birds outside the passive banding periods. Even though re-sighting occurred during only half the summer season, it nearly doubled the recapture rate. An increase in sample size will allow for an analysis of survivorship. In the future, both methods will be utilized to obtain capture-recapture data on LCR MSCP covered species.

Future Analysis and Methods

In the next year of banding, additional analysis can be conducted and added to the work completed as of 2009. In 2010, with two years of data at the Beal site including color-banding data, it may be possible to begin analyzing both productivity and survivorship. A complete analysis of survivorship will not be possible until at least five years of data have been collected, but it may be possible to determine whether the sample size of captured LCR MSCP covered species will make analysis possible. In 2010, it will be possible to determine how many birds have returned and whether individuals captured continue to match the numbers from 2009.

It may also be possible to measure productivity as a proportion of adult to juvenile birds for yellow warblers and Bell's vireos. In the past, captures of these species were too low to allow for an analysis of productivity at any of the sites. This may be possible at the BERS site and at both sites combined with the increase in captures. After the 2010 banding season an attempt will be made to calculate productivity for covered species, and results will be included in the final report for 2010.

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Appendix 1. All species of birds caught at each site, per season, with scientific names.

Beal Site (BERS) MAPS 2009

Abert's Towhee	Pipilo aberti
Ash-throated Flycatcher	Myiarchus cinerascens
Audobon's Warbler	Dendroica coronata
Black and White Warbler	Mniotilta varia
Brown-crested Flycatcher	Myiarchus tyrannulus
Bell's Vireo	Vireo bellii
Brown-headed Cowbird	Molothrus ater
Black-headed Grosbeak	Pheucticus melanocephalus
Blue Grosbeak	Passerina caerulea
Black-tailed Gnatcatcher	Polioptila melanura
Bullock's Oriole	Icterus bullockii
Common Yellowthroat	Geothlypis trichas
Great-tailed Grackle	Quiscalus mexicanus
House Finch	Carpodacus mexicanus
Hooded Warbler	Wilsonia citrina
Indigo Bunting	Passerina cyanea
Lazuli Bunting	Passerina amoena
Lesser Nighthawk	Chordeiles acutipennis
Lucy's Warbler	Vermivora luciae
Macgillivray's Warbler	Opornis tolmiei
Northern Mockingbird	Mimus polyglottos
Northern Parula	Parula americana
Red-winged Blackbird	Agelaius phoeniceus
Song Sparrow	Melospiza melodia
Summer Tanager	Piranga rubra
Warbling Vireo	Vireo gilvus
Western Flycatcher	Empidonax difficilis/occidentalis
Willow Flycatcher	Empidonax trailii
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Yellow Warbler	Dendroica petechia

Cibola Nature Trail (CIBO) MAPS 2009

Abert's Towhee	Pipilo aberti
Ash-throated Flycatcher	Myiarchus cinerascens
Brown-headed Cowbird	Molothrus ater
Black-headed Grosbeak	Pheucticus melanocephalus
Blue Grosbeak	Passerina caerulea
Black Phoebe	Sayornis nigricans
Bullock's Oriole	Icterus bullockii
Common Ground-dove	Columbina passerina
Common Yellowthroat	Geothlypis trichas
Hammond's Flycatcher	Empidonax hammondii
Hermit Warbler	Dendroica occidentalis
House Finch	Carpodacus mexicanus
Indigo Bunting	Passerina cyanea
Lazuli Bunting	Passerina amoena
Ladder-backed Woodpecker	Picoides scalaris
Lucy's Woodpecker	Vermivora luciae
MacGillivray's Warbler	Opornis tolmiei
Nashville Warbler	Vermivora ruficapilla
Northern Mockingbird	Mimus polyglottos
Orange-crowned Warbler	Vermivora celata
Red-winged Blackbird	Agelaius phoeniceus
Song Sparrow	Melospiza melodia
Swainson's Thrush	Catharus ustulatus
Towsend's Warbler	Dendroica townsendi
Verdin	Auriparus flaviceps
Western Flycatcher	Empidonax difficilis/occidentalis
Western Kingbird	Tyrannus verticalis
Western Tanager	Piranga ludoviciana
Willow Flycatcher	Empidonax trailii
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Yellow Warbler	Dendroica petechia

Havasu (HAVA) MAPS 2008

Abert's Towhee	Pipilo aberti
Ash-throated Flycatcher	Myiarchus cinerascens
Brown-crested Flycatcher	Myiarchus tyrannulus
Bewick's Wren	Thryomanes bewickii
Black Phoebe	Sayornis nigricans
Bullock's Oriole	Icterus bullockii
Common Yellowthroat	Geothlypis trichas
Green-tailed Towhee	Pipilo chlorurus
Hammond's Flycatcher	Empidonax hammondii
House Finch	Carpodacus mexicanus
Ladder-backed Woodpecker	Picoides scalaris
Lincoln's Sparrow	Melospiza lincolnii
Lucy's Warbler	Vermivora luciae
Macgillivray's Warbler	Opornis tolmiei
Song Sparrow	Melospiza melodia
Verdin	Auriparus flaviceps
Warbling Vireo	Vireo gilvus
White-crowned Sparrow	Zonotrichia leucophrys
Western Flycatcher	Empidonax difficilis/occidentalis
Willow Flycatcher	Empidonax trailii
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Yellow Warbler	Dendroica petechia

Cibola Nature Trail (CIBO) MAPS 2008

Abert's Towhee	Pipilo aberti
Ash-throated Flycatcher	Myiarchus cinerascens
Brown-headed Cowbird	Molothrus ater
Black-headed Grosbeak	Pheucticus melanocephalus
Blue Grosbeak	Passerina caerulea
Black Phoebe	Sayornis nigricans
Black-tailed Gnatcatcher	Polioptila melanura
Bullock's Oriole	Icterus bullockii
Common Yellowthroat	Geothlypis trichas
Hammond's Flycatcher	Empidonax hammondii
House Finch	Carpodacus mexicanus
Indigo Bunting	Passerina cyanea
Lazuli Bunting	Passerina amoena
Ladder-backed Woodpecker	Picoides scalaris
Lucy's Warbler	Vermivora luciae
Macgillivray's Warbler	Opornis tolmiei
Morthern Mockingbird	Mimus polyglottos
Pacific-slope Flycatcher	Empidonax difficilis
Red-winged Blackbird	Agelaius phoeniceus
Song Sparrow	Melospiza melodia
Swainson's Thrush	Catharus ustulatus
Towsend's Warbler	Dendroica townsendi
Verdin	Auriparus flaviceps
Western Flycatcher	Empidonax difficilis/occidentalis
Western Tanager	Piranga ludoviciana
Western Wood Pee-wee	Contopus sordidulus
Willow Flycatcher	Empidonax trailii
Wilson's Warbler	Wilsonia pusilla
Yellow-breasted Chat	Icteria virens
Yellow Warbler	Dendroica petechia

Havasu (HAVA) Winter 2008-09

Abert's Towhee	Pipilo aberti
Audubon's Warbler	Dendroica coronata
Bewick's Wren	Thryomanes bewickii
Black Phoebe	Sayornis nigricans
Black-tailed Gnatcatcher	Polioptila melanura
Crissal thrasher	Toxostoma crissale
Hammond's Flycatcher	Empidonax hammondii
Hermit Thrush	Catharus guttatus
House Wren	Troglodytes aedon
Lincoln's Sparrow	Melospiza lincolnii
Lucy's Warbler	Vermivora luciae
Marsh Wren	Cistothorus palustris
Orange-crowned Warbler	Vermivora celata
Ruby-crowned Kinglet	Regulus calendula
Red-naped Sapsucker	Sphyrapicus nuchalis
Red-shafted Flicker	Colaptes auratus
Verdin	Auriparus flaviceps

Cibola Nature Trail (CIBO) Winter 2008-09

Abert's Towhee	Pipilo aberti
American Redstart	Setophaga ruticilla
American Robin	Turdus migratorius
Audubon's Warbler	Dendroica coronata
Black and White Warbler	Mniotilta varia
Bell's Vireo	Vireo bellii
Black Phoebe	Sayornis nigricans
Black-throated Grey Warbler	Dendroica nigrescens
Chipping Sparrow	Spizella passerina
Common Yellowthroat	Geothlypis trichas
Chestnut-sided warbler	Dendroica pensylvanica
Hammond's Flycatcher	Empidonax hammondii
Hermit Thrush	Catharus guttatus
House Finch	Carpodacus mexicanus
House Wren	Troglodytes aedon
Lincoln's Sparrow	Melospiza lincolnii
Marsh Wren	Cistothorus palustris
Orange-crowned Warbler	Vermivora celata
Dark-eyed Junco	Junco hyemalis
Ruby-crowned Kinglet	Regulus calendula
Northern Flicker	Colaptes auratus
Song Sparrow	Melospiza melodia
Spotted Towhee	Pipilo maculatus
Verdin	Auriparus flaviceps
White-crowned Sparrow	Zonotrichia leucophrys
Western Flycatcher	Empidonax difficilis/occidentalis
Worm-eating Warbler	Helmitheros vermivora
Wilson's Warbler	Wilsonia pusilla
White-throated Sparrow	Zonotrichia albicollis