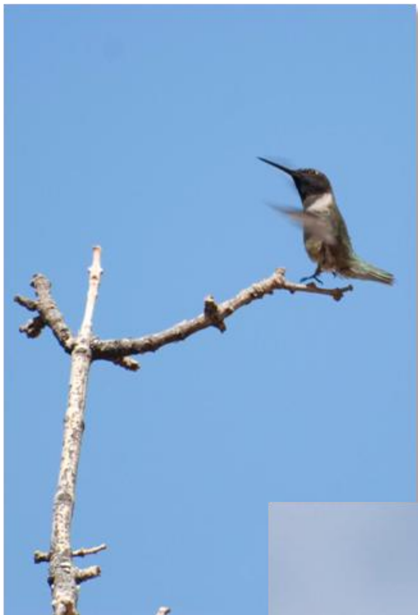
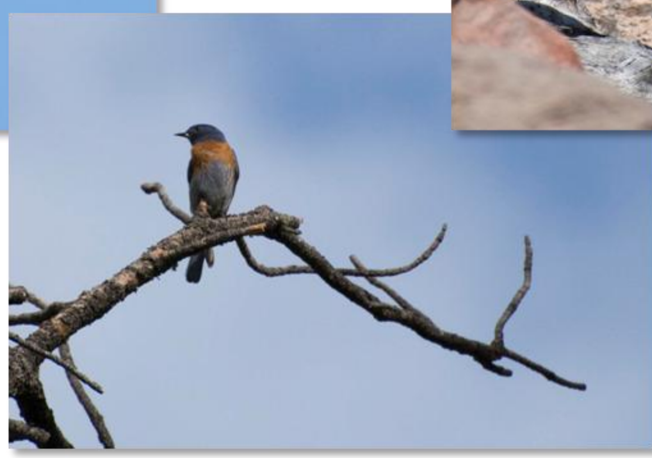
MONITORING THE BIRDS OF COCONINO AND PRESCOTT NATIONAL FORESTS: 2009 FIELD SEASON REPORT





March 2010

ROCKY MOUNTAIN BIRD OBSERVATORY

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Mission*: To conserve birds and their habitats*

Vision*: Native bird populations are sustained in healthy ecosystems*

Core Values*: (Our goals for achieving our mission)*

1. ***Science*** *provides the foundation for effective bird conservation.*
2. ***Education*** *is critical to the success of bird conservation.*
3. ***Stewardship*** *of birds and their habitats is a shared responsibility.*

RMBO accomplishes its mission by:

- ***Monitoring*** *long-term bird population trends to provide a scientific foundation for conservation action.*
- ***Researching*** *bird ecology and population response to anthropogenic and natural processes to evaluate and adjust management and conservation strategies using the best available science.*
- ***Educating*** *people of all ages through active, experiential programs that create an awareness and appreciation for birds.*
- ***Fostering*** *good stewardship on private and public lands through voluntary, cooperative partnerships that create win-win situations for wildlife and people.*
- ***Partnering*** *with state and federal natural resource agencies, private citizens, schools, universities, and other non-governmental organizations to build synergy and consensus for bird conservation.*
- ***Sharing*** *the latest information on bird populations, land management and conservation practices to create informed publics.*
- ***Delivering*** *bird conservation at biologically relevant scales by working across political and jurisdictional boundaries in western North America.*

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EXECUTIVE SUMMARY

Rocky Mountain Bird Observatory, in conjunction with the USDA Forest Service, conducted its first field season of landbird monitoring throughout Coconino and Prescott National Forests in 2009. The Coconino and Prescott National Forests landbird monitoring programs use a randomly-selected, spatially-balanced sampling design with Bird Conservation Regions as the sampling frame and land management boundaries or ecoregional attributes as strata. The Integrated Monitoring in Bird Conservation Regions design allows inferences about avian species populations and distributions from small scales to entire Bird Conservation Regions, facilitating conservation from local to national and international levels.

In 2009, Rocky Mountain Bird Observatory and its partners surveyed 111 of 120 (93 percent) assigned transects throughout Coconino and Prescott National Forests; 57 in Coconino, and 54 in Prescott. Field technicians conducted 1,292 point counts detecting 11,346 birds of 130 species throughout the Forests between 9 May and 10 July 2009.

We estimated forest-level densities and population estimates for 38 landbird species, including two Management Indicator Species in Coconino National Forest and five Species of Concern of Management Indicator Species in Prescott National Forest. The data yielded robust density estimates (with coefficients of variation less than 50 percent) for 37 species in Coconino National Forest and for 33 species in Prescott National Forest. Given similar sampling effort in future years, we would be able to detect an average annual change of three percent in populations of these species within 30 years. The presence of low density species was estimated with the use of occupancy modeling. This procedure allows RMBO and its partners to monitor the presence of avian species that are rare or difficult to detect and therefore result in detection rates too low for density estimation. We estimated the proportion of transects occupied for 20 low-density species throughout the Forests. These are in addition to the 38 species for which we estimated density in both Forests. Altogether, we calculated density or occupancy estimates for 58 species of which 23 are considered priority species.

The spatially-balanced random sampling design implemented in Coconino and Prescott National Forests serves as a model for other long-term monitoring efforts. It’s use allows managers to make inferences regarding avian population and occupancy at the local and regional scales and can therefore assist a wide range of stakeholders, landowners and government. Because this design provides information at multiple scales it represents a method for achieving effective collaboration in North American bird monitoring.

ACKNOWLEDGEMENTS

Stratification and allocation of survey effort in Coconino and Prescott National Forests were determined in collaboration with the US Forest Service. We thank Kim Hartwig and Cecelia Overby of the US Forest Service for their support and interest. Thanks to Bill Noble and Chris Dennison of the Kaibab National Forest for providing radios and a training facility in Williams. The 2009 Rocky Mountain Bird Observatory (RMBO) field crew including Jesse Agee, Dave Kramer, Shannon Pecoraro, and Tim Weber faced many challenges throughout the season. Their perseverance and dedication made this field season a success. Chandman Sambuu managed and updated the RMBO database and produced a new online mapping tool allowing for easier planning and navigation to survey sites. We thank all of the private land owners for allowing access to their land to conduct surveys. Rob Sparks of RMBO produced sample allocation maps for this report. We thank Gary White, professor emeritus of Colorado State University, who wrote the initial SAS code for running the multi-scale occupancy models and Paul Lukacs of the Colorado Division of Wildlife who wrote code in program R for generating density estimates from detection probabilities. Finally, this report benefited greatly from review by RMBO staff.

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INTRODUCTION

Birds can be excellent indicators of biological integrity and ecosystem health (Morrison 1986, Hutto 1998, O'Connell et al. 2000, Rich 2002, U.S. EPA 2002, Birdlife International 2003). Birds comprise a diverse group of niche specialists, occupy a broad range of habitats, are relatively easy to monitor, and are sensitive to both physical and chemical impacts on the environment. They often reflect the abundance and diversity of other organisms with which they coexist. They are useful barometers for environmental change and can indicate the sustainability of human activities on ecosystems.

Bird Conservation Regions (BCRs) are "ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues". The Sierra Madre Occidental Bird Conservation Region (BCR 34) runs south from the Mogollon Rim and isolated mountain ranges in southeastern Arizona and southwestern New Mexico through Sonora to central Mexico. BCR 34 is characterized by high elevations and a complex topography with the presence of oak-pine, pine, and fir forests along the Sierra Madre Occidental mountain range and of semiarid scrub habitats on eastern slopes (ABC 2007). Successful monitoring in BCR 34 provides natural resource managers with data to implement conservation efforts, which, ideally, increase bird populations in the region.

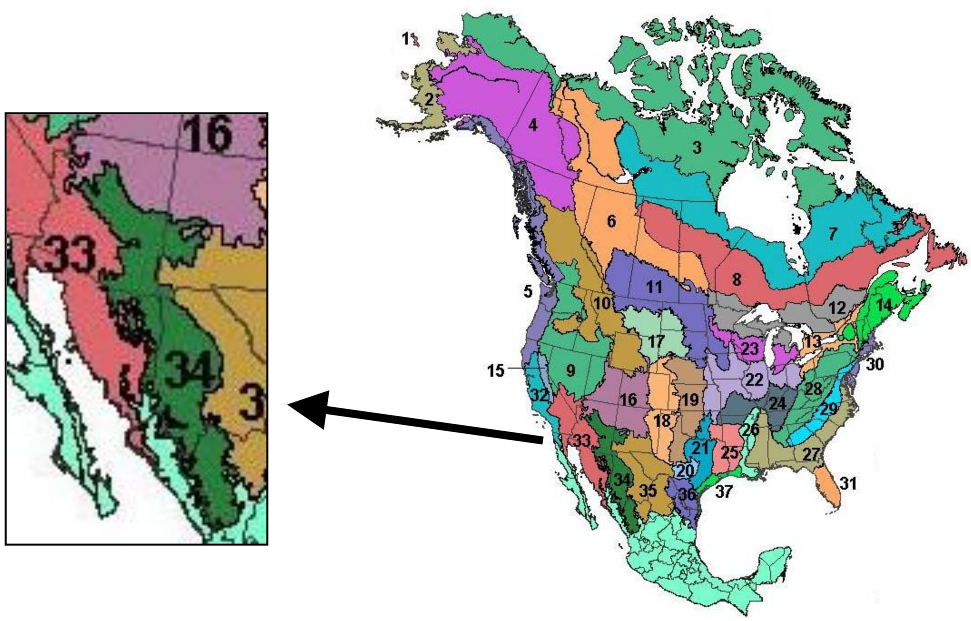

Figure 1: Bird Conservation Regions throughout North America. Inset shows geographic boundaries of BCR 34 (Source: http://www.nabci-us.org/map.html).

Population monitoring forms the backbone of avian conservation. Without current monitoring data, conservation efforts may be misguided and inefficient. Population monitoring helps to achieve the intent of legislation such as the Migratory Bird Treaty Act (1918), National Environmental Policy Act (1969), Endangered Species Act (1973), the National Forest Management Act (1976) and various state laws (Manley et al. 1993, Sauer 1993).

The North American Bird Conservation Initiative's "Opportunities for Improving Avian Monitoring" (NABCI 2007) provided goals and recommendations for avian monitoring programs. The goals are:

> Goal 1: Fully integrate monitoring into bird management and conservation practices and ensure that monitoring is aligned with management and conservation priorities.
>
> Goal 2: Coordinate monitoring programs among organizations and integrate them across spatial scales to solve conservation or management problems effectively.
>
> Goal 3: Increase the value of monitoring information by improving statistical design.
>
> Goal 4: Maintain bird population monitoring data in modern data management systems. Recognizing legal, institutional, proprietary, and other constraints, provide greater availability of raw data, associated metadata, and summary data for bird monitoring programs.

With the NABCI (2007) guidelines in mind, RMBO, USFS and Colorado Division of Wildlife (CDOW) designed a broad-scale monitoring program for Colorado in 2008 (Blakesley and Hanni 2009). This program was adapted and applied to Coconino and Prescott National Forests in 2009. The objectives of this Integrated Monitoring in Bird Conservation Regions (IMBCR) program are to:

1. Provide a design framework to spatially integrate bird monitoring efforts in the region to provide better information on distribution and abundance of breeding birds, especially for high priority species;

2. Provide basic habitat association data for most bird species to address habitat management issues;

3. Provide robust density, population, and occupancy estimates that are comparable at different geographic extents;

4. Provide long-term status and trend data for all regularly occurring breeding species throughout Coconino and Prescott National Forests, with a target of detecting an average annual rate of population change of ≥3.0% per year within 30 years, with power = 0.8 and alpha = 0.1;

5. Maintain a high-quality database that is accessible to all of our collaborators as well as to the public over the internet, in the form of raw and summarized data and;

6. Generate decision support tools that help guide conservation efforts and provide a better measure of conservation success.

Important properties of the study design are:

1. Sampling is conducted within all vegetative types present within the Forest.

2. Strata are based on fixed attributes; allowing RMBO and its partners to relate changes in bird populations to changes on the landscape through time.

3. Each state's portion of a BCR can be stratified differently, depending upon local needs and areas to which one wants to make inferences.

4. Aggregation of strata-wide estimates to BCR- or state-wide estimates is built into the design.
5.
6. Local population trends can be directly compared to regional trends.

7. Coordination among partners can reduce the costs of monitoring per partner.

Program History

Beginning in 2006, Coconino National Forest (CNF) monitored birds on 19 transects in ponderosa pine and pinyon-juniper habitats following a habitat-stratified point transect protocol developed by RMBO (Leukering 2000, Hanni et. al. 2009a). In 2008, RMBO began the first year of *Monitoring Birds of Coconino National Forest*, a partnership effort with CNF. The 2008 program retained the original 19 transects and added 39 new transects, including transects in aspen habitat. In 2009, CNF and Prescott National Forest (PNF), along with RMBO, decided to begin monitoring using our new IMBCR program. This is the first year that the IMBCR design has been implemented in Arizona.

METHODS

Study Area

CNF covers an area of 7,371 km^2 in north-central Arizona (Figure 2). CNF's elevation ranges from 800m in the Verde River Valley to 3,851 m at Humphrey's Peak. Major habitat types include desert scrub, pinyon-juniper woodland, ponderosa pine forest, mixed conifer forest, and alpine tundra (CNF 2010).

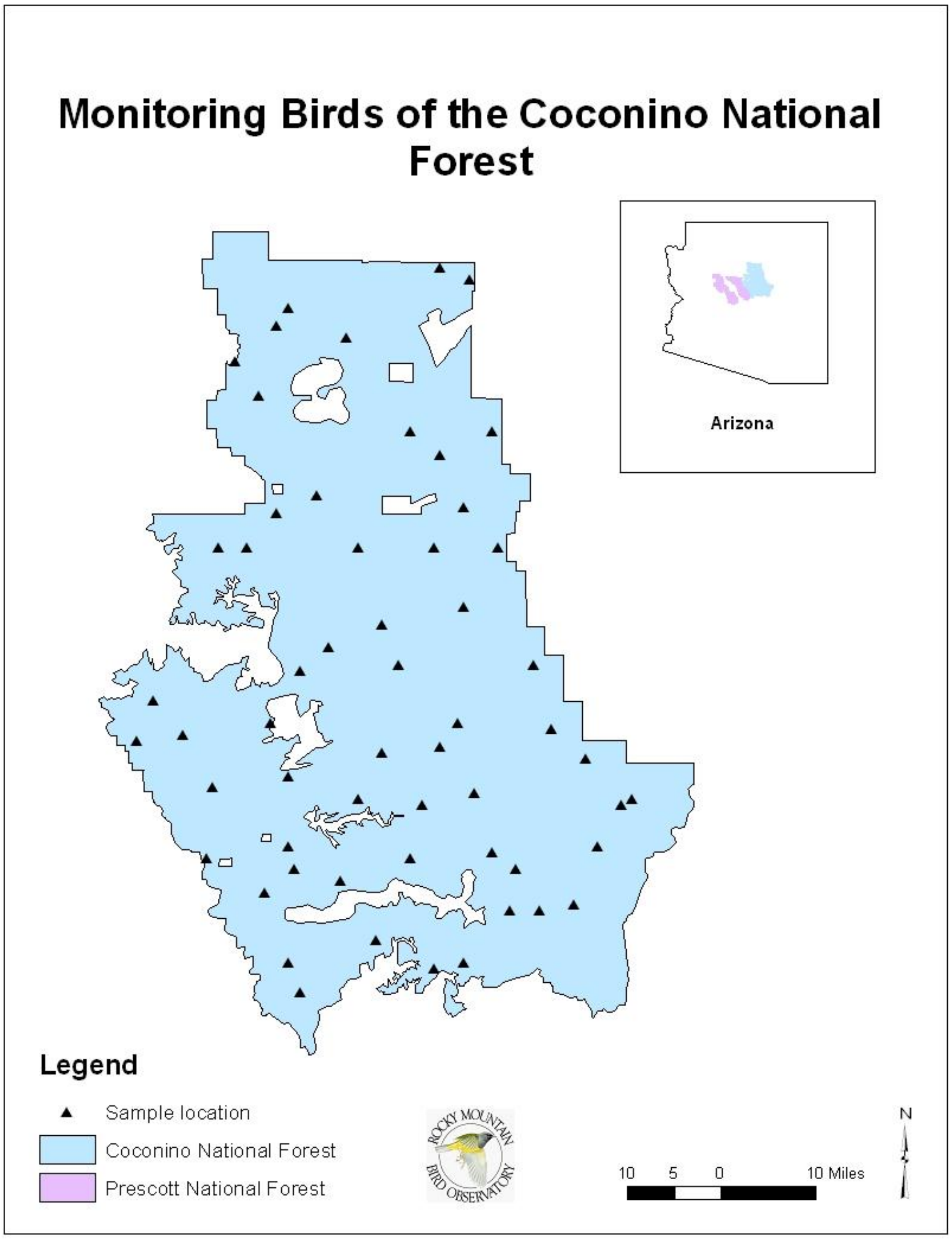

Figure 2: Map of Coconino National Forest with sample locations, 2009.

PNF covers an area of 5,058 km^2 in north-central Arizona to the west of CNF (Figure 3). PNF's elevation ranges from 900 m to 2,400 m. PNF is split into two sections with Prescott and Chino Valley in between. Major habitats include desert scrub, chaparral, pinyon-juniper woodland, and ponderosa pine forest (PNF 2007).

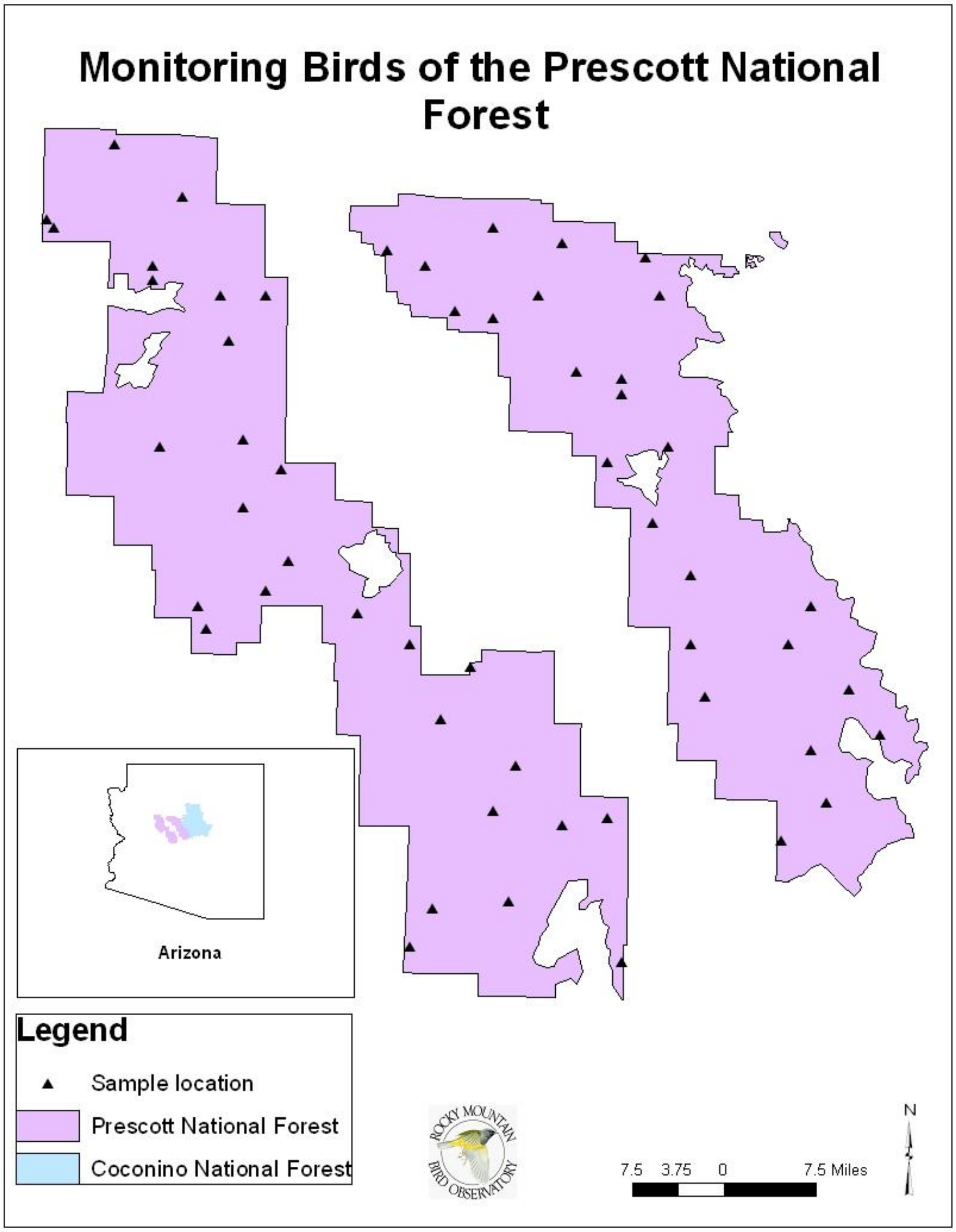

Figure 3: Map of Prescott National Forest with sample locations, 2009.

Sampling Design

Within each Forest, the IMBCR design uses generalized random-tessellation stratification (GRTS), a spatially balanced sampling algorithm in the SPSURVEY package (Kincaid 2008) in Program R (R Development Core Team 2008) to select sample units. The GRTS design has several appealing properties with respect to long-term monitoring of birds at large spatial scales:

1. Spatially-balanced sampling is generally more efficient than simple random sampling of natural resources. Incorporating information about spatial autocorrelation in the data can increase precision in density estimates.

2. Sample units can be weighted according to any factor expected to influence species' distributions, to adjust the probability that sample units will be selected. The sample weight can be accounted for in data analyses.

3. All sample units in the sampling frame are ordered, such that any set of consecutively numbered units is a spatially well-balanced sample (Stevens and Olsen 2004). In the case of fluctuating budgets, RMBO and its partners can adjust the sampling effort among years within each stratum while still preserving a random, spatially-balanced sampling design.

4. The IMBCR design defines sampling units as 1-km^2 cells that are used to create a uniform grid over the entire BCR, with a random starting point. All spatial data were compiled using ARCGIS 9.2 (ESRI).

Stratification and Sample Allocation

The GRTS design allows great flexibility in stratification. RMBO and its partners create strata and allocate samples among strata to reflect partners' management and conservation priorities. In the CNF and PNF, we allocated samples evenly across sampling frames and strata, resulting in 60 sampling units in each stratum for the 2009 survey year.

Survey Methods

Within each sample cell GIS technicians established 16 points spaced 250 meters apart in a four by four grid. Field Technicians surveyed birds from each of the 16 points established within the cell selected for sampling. Survey methods were consistent with those required to incorporate distance sampling theory (Hanni et. al. 2009b). Distance sampling theory was developed to account for the decreasing probability of detecting an object of interest (e.g., a bird) with increasing distance from the observer to the object (Buckland et al. 2001). The detection probability was then used to adjust the number of detections for each species to account for birds that were present but undetected.

Occupancy estimation is most commonly used to quantify the proportion of sample units occupied by an organism (MacKenzie et al. 2002). Occupancy estimation uses a detection probability to adjust the proportion of sites occupied to account for species that were present but undetected (MacKenzie et al. 2002). RMBO used data collected in 2009 to estimate the site occupancy of species of special concern for which there were too few detections to estimate population density. Occupancy estimation requires multiple surveys to the sample unit in time or space (MacKenzie and Royle 2005). The assumptions of occupancy estimation are 1) the probabilities of detection and occupancy are constant across the sample units; 2) each point is closed to changes in occupancy over the sampling season; 3) the detection of species at each point are independent; and 4) the target species are never falsely identified (MacKenzie et al. 2006).

Field technicians conducted point counts (Buckland et al. 2001) following protocol established by RMBO (Hanni et al. 2009b). Technicians conducted surveys in the morning, from ½-hour before sunrise to 11 AM. Technicians conducted up to 16 five-minute point counts within each transect, one at each survey point. At each point, technicians conducted a five-minute survey. For every bird detected during the five minute period, field technicians recorded species, sex, radial distance from the technician, the minute the technician detected each bird, and type of detection (e.g., call, song or visual). Technicians measured distances using laser rangefinders. When it was not possible to measure distance to a bird, technicians estimated distance by measuring to some nearby object. Technicians also recorded birds flying over but not using the immediate surrounding landscape. For distribution mapping purposes, technicians recorded the presence of all low density species heard and seen when traveling the 250 meters between point count locations. Low density species are those rare or difficult to detect species (e.g., woodpeckers, owls, raptors) which field technicians generally record in low numbers.

Field technicians considered all non-independent detections of birds, i.e., flocks or pairs of conspecific birds together in close proximity, as part of a ‘cluster’ rather than as separate independent observations. Technicians recorded clusters by recording the number of birds detected within the cluster along with a letter code to keep track of each distinct cluster.

At the start and end of each transect, technicians recorded the time, temperature, percent cloud cover, precipitation type, and wind speed using the Beaufort scale. At each point, technicians recorded vegetation data (within a 50 meter radius) and distance from a road (if within 100 meters). For vegetation data, technicians recorded the dominant habitat type and structural stage; the relative abundance, percent coverage, and mean height of trees and shrubs; and the percent groundcover. If there was a distinct subcanopy present, technicians recorded the species of sub-canopy trees. Technicians recorded these data prior to beginning each point count.

Data Analysis

<u>Distance Analysis</u>

Analysis of distance data is accomplished by fitting a detection function to the distribution of recorded distances. The distribution of distances can be a function of characteristics of the object (e.g., for birds, its size and color, movement, volume of song or call, and frequency of call), the surrounding environment (e.g., density of vegetation), and observer ability. Because detectability varies among species, we analyzed the data separately for each species.

RMBO used the analysis software Distance 6.0 (Thomas et al. 2010) to estimate detection probabilities using the point count data. We estimated densities of species for which field technicians obtained at least 60 independent detections (*n*) in CNF and PNF. We excluded birds flying over but not using the immediate surrounding landscape and birds detected between-point from analyses. We fit the following functions to the distribution of distances for each species: Half normal key function with cosine series expansion, Uniform function with cosine series expansion, Hazard rate key function with cosine series expansion, and Hazard rate key function with simple polynomial series expansion (Buckland et al. 2001). We used Akaike’s Information Criterion (AIC) corrected for small sample size (AICc) and model selection theory to select the most parsimonious detection function for each species (Burnham and Anderson 2002).

RMBO used the SPSURVEY package (Kincaid 2008) in Program R (R Development Core Team 2008) to estimate density and its variance for each bird species.

Occupancy Analysis

We used a multi-scale occupancy model (Nichols et al. 2008) to estimate 1) the proportion of 1-km^2 sampling units occupied by a species (Psi), 2) the proportion of points occupied by a species given presence within the 1-km^2 sampling units (Theta) and 3) the probability of detecting a species given presence (p). We constrained Theta and p by holding these parameters constant. Our application of the multi-scale model is analogous to a within-season robust design (Pollock 1982) where the points are the primary samples for estimating Theta and the sampling intervals at each point are the secondary samples for estimating p. We considered both Theta and p to be nuisance variables that were important for generating unbiased estimates of Psi. Theta can be considered an availability parameter or the probability that a species was present and available for sampling at the points (Nichols et al. 2008). We estimated the detection probabilities (p) using a removal model with 3 intervals. Using the five 1-minute intervals recorded during sampling, we binned minutes 1 and 2, and minutes 3 and 4 to meet the assumption of a monotonic decline in the detection rates. After the target species was detected at a point, we set all subsequent sample intervals at that point to missing data. We truncated the data, using only detections within 125 m of the sample points. We used program SAS (PROC NLMIXED, SAS Institute 2008) to estimate the model parameters and account for unequal interval length. We combined stratum-level estimates of Psi using a weighted mean indexed by stratum area. We estimated the sampling variance and standard error for the weighted mean of Psi using the delta method (Powell 2007) in program SAS (PROC IML, SAS Institute 2008).

RESULTS

RMBO completed 1,292 point counts on 111 planned transect surveys throughout CNF and PNF in 2009. We detected 11,346 birds of 130 species, 25 Abert's Squirrels, and 20 Red Squirrels throughout the Forests between 9 May and 10 July 2009. We were able to estimate densities for 38 species in both Forests including 13 priority species (Tables 2-3). We estimated occupancy for additional 20 low-density species across CNF and PNF including 10 priority species (Table 4).

One of our technicians was unable to finish the season and we did not complete all the surveys in CNF and PNF (Table 1).

Table 1. Reasons planned surveys were not completed in CNF and PNF, 2009.

Reason transect was not surveyed	**CNF**	**PNF**	**Total**
Inaccessible due to terrain	1	1	2
Miscommunication	--	--	--
Ran out of time	2	5	7
Unable to contact landowner	--	--	--

Coconino National Forest

RMBO completed 57 of 60 (95%) planned transect surveys throughout CNF in 2009. The most common reason for surveys not being conducted was an inability to survey the transect within the sampling time frame. The uncompleted transects were at lower elevations where birds breed early in the season.

RMBO conducted 689 point counts among the 57 transects between 9 May and 10 July 2009. We detected 6,242 birds of 114 species, 22 Abert's Squirrels, and 18 Red Squirrels in CNF (Appendix B). We detected an average of 9.1 individuals of 5.7 species per point sampled in CNF. We detected an average of 110.2 individual of 22.4 species per transect sampled in CNF. The most common species we detected in CNF were Pygmy Nuthatch (290 birds), Northern Mockingbird (254 birds), Mountain Chickadee (240 birds).

We estimated densities and population sizes of 38 landbird species including two Management Indicator Species (MIS) in CNF (Table 2). We obtained robust density estimates with low coefficients of variation (CV<50%) for 37 species in CNF.

RMBO recorded 46 bird species on CNF that hold conservation and management designations in Arizona (Appendix A). We recorded two of these species in sufficient numbers to calculate density estimates; Juniper Titmouse and Pygmy Nuthatch. We estimated species occupancy rates using data from CNF and PNF. We present estimates of the proportion of sample units occupied (Psi) for one priority species, Hairy Woodpecker, for which we were not able to generate density estimates (Table 4).

Table 2: Estimated densities (D), population sizes (N), lower and upper confidence limits on N (LCL and UCL), percent coefficient of variation of estimates (%CV), and sample sizes (n) of breeding bird species in Coconino National Forest, 2009.

Species[1]	D[2]	N	CV%	LCL	UCL	n[3]
Gambel's Quail	1.93	14306	22	9942	20585	109
Mourning Dove	8.68	64490	15	50361	82582	170
Broad-tailed Hummingbird	30.60	227200	21	161686	319260	69
Northern Flicker	5.04	37426	18	27969	50081	132
Western Wood-Pewee	3.08	22866	22	16033	32611	61
Gray Flycatcher	16.12	119679	24	81352	176062	77
Ash-throated Flycatcher	12.69	94273	16	72286	122948	128
Western Kingbird	1.16	8598	38	4687	15772	9
Plumbeous Vireo	9.11	67619	17	51350	89043	148
Steller's Jay	8.66	64272	27	41551	99418	120
Common Raven	2.07	15376	22	10704	22087	132
Horned Lark	1.12	8295	62	3258	21119	8
Violet-green Swallow	28.70	213111	36	119509	380025	98
Mountain Chickadee	31.28	232282	21	165442	326126	230
Juniper Titmouse	**13.07**	**97045**	**24**	**65609**	**143543**	**104**
Bushtit	18.04	133968	22	93797	191344	39
White-breasted Nuthatch	13.09	97193	20	69922	135100	148
Pygmy Nuthatch	**37.65**	**279602**	**21**	**199407**	**392049**	**207**
Rock Wren	4.28	31811	35	18230	55509	46
Bewick's Wren	8.80	65322	18	48598	87802	94

Species[1]	D[2]	N	CV%	LCL	UCL	n[3]
Western Bluebird	19.65	145952	17	110637	192539	144
American Robin	12.10	89859	18	66465	121487	133
Northern Mockingbird	9.18	68172	17	51778	89757	246
Yellow-rumped Warbler	26.84	199285	22	139515	284661	187
Black-throated Gray Warbler	5.63	41800	37	23360	74797	47
Grace's Warbler	22.62	168009	16	128425	219793	171
Western Tanager	4.41	32767	22	23036	46608	72
Spotted Towhee	11.09	82364	22	57250	118494	125
Rufous-crowned Sparrow	1.77	13181	38	7177	24208	19
Chipping Sparrow	14.36	106609	18	78899	144051	152
Black-chinned Sparrow	2.03	15076	35	8593	26450	26
Lark Sparrow	9.12	67710	30	41488	110505	93
Black-throated Sparrow	10.03	74460	23	51657	107329	101
Dark-eyed Junco	16.90	125512	20	90395	174271	150
Black-headed Grosbeak	2.57	19120	27	12435	29399	46
Brown-headed Cowbird	8.59	63755	25	42797	94975	70
Scott's Oriole	2.50	18578	37	10364	33301	29
Lesser Goldfinch	6.19	45991	43	23458	90167	39

[1] MIS are in bold
[2] D = (birds/km^2)
[3] n = number of independent detections used to estimate D and N

Prescott National Forest

RMBO completed 54 of 60 (90%) planned transect surveys throughout PNF in 2009. The most common reason for surveys not being conducted was an inability to survey the transect within the sampling time frame. The uncompleted transects were at lower elevations where birds breed early in the season.

RMBO conducted 603 point counts among the 54 transects between 10 May and 24 June 2009. We detected 5,104 birds of 132 species, 3 Abert's Squirrels, and 2 Red Squirrels in PNF (Appendix B). We detected an average of 8.5 individuals of 5.4 species per point sampled in PNF. We detected an average of 94.6 individuals of 19.5 species per transect sampled in PNF. The most common bird species we detected in PNF were Northern Mockingbird (407 birds), Black-throated Sparrow (318 birds), and Spotted Towhee (301 birds).

We estimated densities and population sizes of 38 landbird species including five Species of Concern (SOC) or MIS for PNF (Table 3). We obtained robust density estimates with low coefficients of variation (CV<50%) for 33 species in PNF.

RMBO recorded 43 bird species on PNF that hold conservation and management designations in Arizona (Appendix A). We recorded five of these species in sufficient numbers to calculate density estimates; Juniper Titmouse, Pygmy Nuthatch, Grace's Warbler, Spotted Towhee, and Brown-headed Cowbird. We estimated species occupancy rates using data from CNF and PNF. We present estimates of the proportion of sample units occupied (Psi) for four priority species, for which we were not able to generate density estimates (Table 4).

Table 3: Estimated densities (D), population sizes (N), lower and upper confidence limits on N (LCL and UCL), percent coefficient of variation of estimates (%CV), and sample sizes (n) of breeding bird species in Prescott National Forest, 2009.

Species[1]	D[2]	N	CV%	LCL	UCL	n[3]
Gambel's Quail	4.84	25391	18	18980	33968	256
Mourning Dove	12.02	63038	14	49772	79839	238
Broad-tailed Hummingbird	2.50	13092	67	4805	35675	4
Northern Flicker	1.13	5926	35	3369	10423	23
Western Wood-Pewee	2.13	11153	30	6860	18132	45
Gray Flycatcher	16.11	84480	31	51712	138011	61
Ash-throated Flycatcher	16.38	85866	14	68019	108395	124
Western Kingbird	7.08	37142	35	21084	65429	70
Plumbeous Vireo	1.63	8572	31	5174	14201	24
Steller's Jay	1.66	8727	40	4603	16548	17
Common Raven	2.09	10957	24	7428	16163	91
Horned Lark	16.75	87829	43	44578	173042	121
Violet-green Swallow	1.19	6214	72	2143	18018	3
Mountain Chickadee	4.53	23766	31	14494	38971	26
Juniper Titmouse	**8.18**	**42873**	**20**	**30900**	**59485**	**64**
Bushtit	31.80	166746	20	120952	229878	66
White-breasted Nuthatch	2.42	12666	37	7067	22702	21
Pygmy Nuthatch	**5.93**	**31066**	**51**	**14075**	**68567**	**23**
Rock Wren	8.45	44327	46	21421	91725	70
Bewick's Wren	20.49	107447	13	86709	133144	175
Western Bluebird	0.16	853	92	235	3091	1
American Robin	6.36	33346	31	20312	54743	52
Northern Mockingbird	16.43	86152	14	68980	107600	400
Yellow-rumped Warbler	1.16	6067	84	1821	20214	7
Black-throated Gray Warbler	1.78	9327	48	4439	19597	13
Grace's Warbler	**5.40**	**28308**	**37**	**15794**	**50736**	**34**
Western Tanager	3.45	18063	27	11687	27918	42
Spotted Towhee	**28.43**	**149052**	**14**	**117685**	**188779**	**277**
Rufous-crowned Sparrow	5.67	29720	24	19982	44204	65
Chipping Sparrow	3.95	20716	33	12165	35277	38
Black-chinned Sparrow	13.81	72394	24	48971	107020	146
Lark Sparrow	4.31	22603	30	13876	36819	43
Black-throated Sparrow	32.40	169851	18	126995	227170	267
Dark-eyed Junco	8.32	43630	27	28013	67954	54
Black-headed Grosbeak	6.78	35563	20	25666	49276	101
Brown-headed Cowbird	**12.97**	**68024**	**25**	**45166**	**102451**	**94**
Scott's Oriole	2.97	15564	31	9473	25572	46
Lesser Goldfinch	6.19	32464	40	17317	60859	35

[1] SOC and MIS are in bold
[2] D = (birds/km^2)
[3] n = number of independent detections used to estimate D and N

Occupancy Modeling in CNF and PNF

We estimated the proportion of sample units occupied for 20 low-density species that had a minimum of 10 detections across the Forests. We presented combined occupancy rates for both CNF and PNF. To avoid observer bias, we estimated occupancy rates for four species using a subset of the sample units (Table 4).

Table 4: Estimated site occupancy (Psi; proportion of sample units occupied), percent coefficient of variation of Psi (%CV) and number of transects with detections (n Tran) of species of concern in CNF and PNF, 2009. S indicates the number of transects surveyed

Species[1]	Psi	%CV	n Tran	S
White-winged Dove	0.107	39	10	111
Acorn Woodpecker	0.099	32	9	111
Hairy Woodpecker	**0.209**	**34**	**12**	**111**
Cordilleran Flycatcher	**0.158**	**30**	**10**	**81**
Say's Phoebe	0.233	32	15	111
Cassin's Kingbird	0.301	20	24	111
Gray Vireo	**0.361**	**21**	**21**	**81**
Brown Creeper	0.177	35	11	111
Cactus Wren	0.155	26	14	111
Canyon Wren	0.229	44	11	111
House Wren	0.276	20	23	111
Blue-gray Gnatcatcher	0.203	58	10	111
Hermit Thrush	0.132	27	12	111
Virginia's Warbler	**0.096**	**37**	**8**	**111**
Hepatic Tanager	0.238	25	16	81
Canyon Towhee	0.298	23	18	81
Blue Grosbeak	0.092	41	7	111
Eastern Meadowlark	0.045	44	6	111
Bullock's Oriole	0.139	65	7	111
Red Squirrel	0.081	44	6	111

[1]Priority species are in bold.

DISCUSSION AND RECOMMENDATIONS

2009 was the first year the IMBCR design was implemented in Arizona. The average number of individuals and species per transect in CNF averaged slightly greater than in PNF. This is most likely due to the large range of elevation and variety of habitats that can occur on transects in the CNF. The 2009 CNF results represent this well; the three most common species detected on the CNF are Pygmy Nuthatch, Northern Mockingbird, and Mountain Chickadee. Pygmy Nuthatches and Mountain Chickadees are present in forested habitats while Northern Mockingbird inhabits desert scrub and chaparral habitats. The 2009 PNF results imply lower variability in habitat; the three most common species detected on the PNF are Northern Mockingbird, Black-throated Sparrow, and Spotted Towhee. These species all prefer chaparral and desert scrub habitats. In future years, when our survey efforts are more similar between CNF and PNF, we may see a slight increase in the average number of species detected per transect in our PNF results.

One of our technicians left early in the season. Despite this, we were able to complete 93% of proposed sampling. In future years, we should be able to complete all planned transects. Another technician did not detect a few fairly common species. We removed this technician's data when analyzing affected species: Gray Vireo, Hepatic Tanager, Canyon Towhee, and Rufous-crowned Sparrow. This will be improved next year by checking technician's data for errors early in the season and by providing the 2010 technician's species lists from the 2009 data. Without this issue, we will be able to estimate density or occupancy for more species in future years.

We were able to use data from both forests to estimate detection probabilities for species. This allowed us to estimate densities for 38 species in both forests. We would have only been able to calculate 28 species in CNF and 18 species in PNF had we not combined the Forests into one stratum. We provide precise (CV < 50%) forest-level density and population estimates for 37 species in CNF and 33 species in PNF using Distance sampling theory. Simulations using 10 years of data from a similar avian monitoring program (J. Blakesley, unpublished) indicated that it would be possible to detect an average annual 3% decline in the population of a species within 25 years with 80% power and CV ≤ 40%. A similar trend could be detected within 30 years with CV ≤ 50%. It is important to note that the ability to detect population trends for any species is a function of not only the sampling effort but also the abundance and annual variation in abundance of that particular species. Some bird species shift their breeding ranges from year to year based on environmental conditions. These species may require more precise density estimates to monitor population trends within 25-30 years.

For the first time, we used occupancy modeling to provide estimates for 20 species that had insufficient data to estimate density. This new method for monitoring uncommon species required substantial time for data preparation and analysis. In addition to distance sampling, we believe using analytical methods such as occupancy modeling can increase the number of bird species that are able to be effectively monitored, thus providing a clearer picture of the health of bird populations throughout CNF and PNF.

Rare species present formidable challenges for sampling and monitoring wildlife populations. Unfortunately, these are species for which strong inference on population parameters are most needed and are species for which such information is most difficult to obtain (MacKenzie et al. 2005). Inferences about populations of rare species can be improved by estimating site occupancy instead of abundance, and borrowing information about detectability from other places or times (MacKenzie et al. 2005). We followed these two principles and successfully estimated the proportion of sample units occupied for 20 species across the CNF and PNF. Within the monitoring framework, occupancy estimation is a useful state variable for making inferences about species distributions and population change over time. By estimating a common detection parameter across the two Forests, we were able to estimate site occupancy for species that would otherwise have had insufficient numbers of samples and detections (MacKenzie et al. 2005). Our application of the multi-scale occupancy model (Nichols et al. 2008) is notable in that we appropriately accounted for the hierarchical nature of the sample design. By separating the detection process into availability and detection parameters, we avoided the estimation bias associated with the spatial replication of point count data (Kendall and White 2009). Estimating an availability parameter likely improved inference for rare species by accounting for infrequent point count detections and situations where the territories of species only partially overlap the sample unit.

Two occupancy estimates exhibited low precision with Coefficients of Variation exceeding 50%. Optimal sample designs for estimating the site occupancy of rare species involves increasing the number of sample units rather than increasing the number of repeat surveys at each sample unit (MacKenzie and Royle 2005). Therefore, we anticipate that increasing the number of sample units can improve the precision of the occupancy estimates.

The multi-scale occupancy model can easily be extended to investigate habitat relationships for priority species. The probability of occupancy for the 1 km^2 sample units can be modeled as a function of habitat covariates such as vegetation cover and land use. The habitat relationships can be used to identify habitats that support populations of priority species and these habitats can then be highlighted for protection by management. Habitat models may reveal spatial trends in occupancy related to habitat loss or land use that are symptomatic of population declines, and suggest land management strategies for species recovery.

This sampling design did not use habitat type as a basis for stratification. However, because field technicians collect vegetation data in the field at each survey point, we can post-stratify the data by vegetation cover type and habitat, and estimate avian densities by habitat (for habitats with large enough sample size). Alternatively, we can use remotely-sensed data such as the Gap Analysis data layers to post-stratify the data by vegetation and habitat type. Analyses of avian-habitat relationships using these data will help guide future conservation and management, especially for species of concern.

Population estimates are becoming an important conservation tool to evaluate success of land management. Population estimates are currently provided by Partners in Flight (PIF) at a variety of scales varying from the BCR, state and BCR/state boundaries. These estimates, found in the PIF Population Estimates Database (http://rmbo.org/pif_db/laped/), are the first population estimates provided for landbirds. This first effort to calculate population estimates used BBS data and several correction factors to try to compensate for detectability (Blancher et.al. 2007).

The IMBCR design has taken steps to improve upon the estimates within the PIF population estimates Database. For the first time, RMBO has generated population estimates for an entire BCR and BCR/state boundaries. We have also calculated population estimates for smaller land areas such as Forest Service lands. The population estimates can be directly compared to evaluate bird populations at a variety of scales. In the Badlands and Prairies Bird Conservation Region (BCR 17) we have also calculated species-specific detection distances that can be used to update the PIF Landbird Population Estimate Database. This new design can work with the database to refine the population estimates and reflect a more precise estimate that will improve abilities to more successfully evaluate management actions (White et. al. 2010).

The spatially-balanced sampling design in BCR 17 serves as a model for other long-term monitoring efforts because of its ability to address the conservation and management needs of a wide range of stakeholders, landowners and governmental entities at both local and regional scales. Our monitoring design represents one method for achieving effective collaboration and coordinated bird monitoring in North America (NABCI 2007) and could be applied to other BCRs and regions across the continent.

Our sampling design is not limited to estimating population density and occupancy rates of birds. This design could be used to estimate nesting success or other demographic parameters. Furthermore, this sampling design could be used to monitor the distribution and population dynamics of additional taxa, including reptiles, small mammals and plants. A spatially balanced design using similar stratification and cell weighting for ponds and wetlands could be used to monitor shorebirds and amphibians, whereas a design with larger sample cells would be appropriate for monitoring large mammals. Identifying and monitoring the distributions of plants and animals at multiple spatial scales over time will help scientists and land managers face challenges associated with climate change and other natural and anthropogenic changes to the environment.

LITERATURE CITED

American Bird Conservancy (ABC). 2007. BCR 34: Sierra Madre Occidental. http://www.abcbirds.org/abcprograms/domestic/landscape/BCR/sierramadre.html.

American Ornithologists Union (AOU). 2007. Check-list of North American Birds, 7th Edition. http://www.aou.org/checklist/north/full.php.

Birdlife International. 2003. Biodiversity Indicator for Europe: Population Trends of Wild Birds. http://www.birdlife.org/action/science/indicators/pdfs/eur_biodiversity_indicators.

Blakesley, J. A. and D. J. Hanni. 2009. Monitoring Colorado's Birds, 2008. Tech. Rep. M-MCB08-01. Rocky Mountain Bird Observatory, Brighton, CO. 39 pp.

Blancher, P. J., K. V. Rosenberg, A. O. Panjabi, B. Altman, J. Bart, C. J. Beardmore, G. S. Butcher, D. Demarest, R. Dettmers, E. H. Dunn, W. Easton, W. C. Hunter, E. E. Iñigo-Elias, D. N. Pashley, C. J. Ralph, T. D. Rich, C. M. Rustay, J. M. Ruth, and T. C. Will. 2007. Guide to the Partners in Flight Population Estimates Database. Version: North American Landbird Conservation Plan 2004. Partners in Flight Technical Series No 5. http://www.partnersinflight.org/

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to Distance Sampling. Oxford University Press, London, UK.

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. 2nd Edition. Springer-Verlag, New York, New York, USA. 488 pp.

Coconino National Forest (CNF). 2010. About Us: Statistics. http://www.fs.fed.us/r3/coconino/about/index.shtml

Hanni, D. J., C. M. White, J. A. Blakesley, G. J. Levandoski, and J. J. Birek. 2009a. Habitat-based Point Transect Protocol. Unpublished report. Rocky Mountain Bird Observatory, Brighton, CO. 37 pp. http://www.rmbo.org/public/monitoring/

Hanni, D. J., C. M. White, R. A. Sparks, J. A. Blakesley, G. J. Levandoski, and J. J. Birek. 2009b. Field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, CO. 28 pp. http://www.rmbo.org/public/monitoring/.

Hutto, R. L. 1998. Using landbirds as an indicator species group. Pp. 75-92 in J. M. Marzluff and R. Sallabanks (eds.), Avian Conservation: Research and Management. Island Press, Washington, DC.

Kendall, W. L., and G. C. White. 2009. A cautionary note on substituting spatial subunits for repeated temporal sampling in studies of site occupancy. Journal of Applied Ecology 46:1182-1188.

Kincaid, T. 2008. User Guide for spsurvey, version 2.0; Probability Survey Design and Analysis Functions.

Leukering, T. 2000. Point Transect Protocol for *Monitoring Colorado's Birds*. Unpubl. document, Rocky Mountain Bird Observatory, Brighton, CO. 16 pp.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J. A. Royle, and C. A. Langtimm. 2002. Estimating site occupancy rates when detection probabilities are less than one. Ecology 83:2248-2255.

MacKenzie, D. I., and J. A. Royle. 2005. Designing occupancy studies: general advice and allocating survey effort. Journal of Applied Ecology 42:1105-1114.

MacKenzie, D. I., J. D. Nichols, N. Sutton, K. Kawanishi, and L. L. Bailey. 2005. Improving inferences in population studies of rare species that are detected imperfectly. Ecology 86:1101-1113.

MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence. Elsevier, Burlington.

Manley, P. N., W. M. Block, F. R. Thompson, G. S. Butcher, C. Paige, L. H. Suring, D. S. Winn, D. Roth, C. J. Ralph, E. Morris, C. H. Flather, and K. Byford. 1993. Guidelines for Monitoring Populations of Neotropical Migratory Birds on National Forest System Lands. USDA Forest Service, Washington. 35 pp.

Morrison, M. L. 1986. Bird populations as indicators of environmental change. Current Ornithology 3:429-451.

U.S. North American Bird Conservation Initiative Monitoring Subcommittee (NABCI). 2007. Opportunities for Improving Avian Monitoring. U.S. North American Bird Conservation Initiative Report. 50 pp. Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Arlington, VA. http://www.nabci-us.org/.

Nichols, J. D., L. L. Bailey, A. F. O'Connell, N. W. Talancy, E. H. C. Grant, A. T. Gilbert, E. M. Annand, T. P. Husband, and J. E. Hines. 2008. Multi-scale occupancy estimation and modeling using multiple detection methods. Journal of Applied Ecology 45:1321-1329.

O'Connell, T. J., L. E. Jackson, and R. P. Brooks. 2000. Bird guilds as indictors of ecological condition in the central Appalachians. Ecological Applications 10:1706-1721.

Pollock, K. H. 1982. A capture-recapture design robust to unequal probability of capture. Journal of Wildlife Management 46:752-757.

Powell, L. A. 2007. Approximating variance of demographic parameters using the delta method: a reference for avian biologists. Condor 109:949-954.

Prescott National Forest (PNF). 2007. About Us. http://www.fs.fed.us/r3/prescott/about/index.shtml

R Development Core Team. 2008. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051- 07-0. http://www.R-project.org.

Rich, T. D. 2002. Using breeding land birds in the assessment of western riparian systems. Wildlife Society Bulletin 30(4):1128-1139.

SAS Institute. 2008. SAS/STAT. Version 9.2. SAS Institute, Incorporated, Cary, North Carolina.

Sauer, J. R. 1993. Monitoring Goals and Programs of the U.S. Fish and Wildlife Service. In Finch, D. M. and P. W. Stangel (eds.) Status and Management of Neotropical Migratory Birds; 1992 Set. 21-25; Estes Park, Co. Gen. Tech. Rep. RM-229. Fort Collins, CO. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 422 pp.

Stevens, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. Journal of the American Statistical Association 99:262-278.

Thomas, L., S. T. Buckland, E. A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R. B. Bishop, T. A. Marques and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47:5-14.

U.S. Environmental Protection Agency (U.S. EPA). 2002. Methods for evaluating wetland condition: biological assessment methods for birds. Office of Water, U.S. Environmental Protection Agency, Washington. D.C. EPA-822-R-02-023.

White, C. M., J. A. Blakesley, J. A. Rehm-Lorber, D. C. Pavlacky, Jr., R. A. Sparks and D. J. Hanni. 2010. Monitoring the Birds of the Badlands and Prairies Bird Conservation Region (BCR 17): 2009 Field Season Report. Tech. Rep. SC-BCR1709-01. Rocky Mountain Bird Observatory, Brighton, CO. 81 pp.

APPENDIX A

Priority Species recorded in CNF and PNF with management designations, 2009

		USFS[3]			USFWS[4]		
Species[1]	**AZGFD[2]**	**CNF**	**PNF**	**Region 3**	**BCR34**	**Region 2**	**PIF[5] BCR34**
Common Merganser	SGCN						
Wild Turkey	SGCN	MIS	MIS,SOC	R3SS			
Gambel's Quail							CS,RS
Double-crested Cormorant	SGCN						
Osprey	SGCN						
Cooper's Hawk							RS
Peregrine Falcon	SGCN		SOC	R3SS	BCC	BCC	
Band-tailed Pigeon							CC
Western Screech-Owl							RS
Common Poorwill							RS
White-throated Swift							CC,RS
Lewis's Woodpecker	SGCN				BCC	BCC	CC,RC
Downy Woodpecker	SGCN						
Hairy Woodpecker		MIS	MIS,SOC				
Olive-sided Flycatcher	SGCN						CC
Cordilleran Flycatcher			SOC				RS
Ash-throated Flycatcher							RS
Cassin's Kingbird							RC,RS
Loggerhead Shrike				R3SS		BCC	RC
Bell's Vireo			SOC	R3SS	BCC	BCC	CC,RC
Gray Vireo			SOC	R3SS	BCC	BCC	CC,RC,RS
Plumbeous Vireo							RS
Pinyon Jay			SOC		BCC	BCC	CC,RC
Clark's Nutcracker	SGCN						
Purple Martin	SGCN		SOC				
Bridled Titmouse							RS
Juniper Titmouse		MIS	MIS,SOC				RC,RS
Pygmy Nuthatch		MIS	MIS,SOC				RS
Cactus Wren							RC
Canyon Wren							RS
Ruby-crowned Kinglet	SGCN						
Western Bluebird							RS
European Starling			SOC				
Crissal Thrasher			SOC				CS,RS

Species[1]	AZGFD[2]	USFS[3]			USFWS[4]		PIF[5] BCR34
		CNF	PNF	Region 3	BCR34	Region 2	
Phainopepla					BCC		RC,CS,RS
Olive Warbler					BCC	BCC	RS
Orange-crowned Warbler	SGCN		SOC				
Virginia's Warbler			SOC				CC,RS
Lucy's Warbler		MIS	MIS,SOC		BCC	BCC	CC,RC,CS,RS
Black-throated Gray Warbler					BCC		RC
Grace's Warbler			SOC		BCC	BCC	CC,RS
MacGillivray's Warbler	SGCN		SOC				
Red-faced Warbler			SOC		BCC	BCC	CC,CS,RS
Hepatic Tanager							RS
Green-tailed Towhee	SGCN						
Spotted Towhee			MIS,SOC				RC,RS
Canyon Towhee					BCC		RC,CS,RS
Abert's Towhee			SOC	R3SS			CC
Cassin's Sparrow							RC
Rufous-crowned Sparrow							RS
Black-chinned Sparrow					BCC	BCC	CC,RS
Black-throated Sparrow							RS
Grasshopper Sparrow	SGCN		SOC	R3SS	BCC	BCC	
Eastern Meadowlark							RC
Brown-headed Cowbird			SOC				
Scott's Oriole							CS,RS
Abert's Squirrel		MIS	MIS				

[1]Common Names are from the AOU. Check-list of North American Birds, Seventh Edition (2007).
[2] AZGFD = Arizona Game and Fish Department, SGCN = Species of Greatest Conservation Need (Arizona's Comprehensive Wildlife Conservation Strategy: 2005-2015 [2006]).
[3] USFS = United States Forest Service, KNF= Kaibab National Forest, MIS = Management Indicator Species; Region3 = USFS Region 3, R3SS = USFS Region 3 Sensitive Species.
[4] USFWS = U.S. Fish and Wildlife Service, BCR=Bird Conservation Region, Region 2 = USFWS Region 2, BCC = Bird of Conservation Concern.
[5] PIF = Partners in Flight, BCR = Bird Conservation Region, CC = Continental Concern Species, RC = Regional Concern Species, CS = Continental Stewardship Species, RS = Regional Stewardship Species.

APPENDIX B

Number of birds detected in CNF and PNF by Forest, 2009

Species	CNF	PNF	Total
Common Merganser	2		2
Wild Turkey	9	1	10
Gambel's Quail	130	284	414
Double-crested Cormorant		3	3
Great Blue Heron	7		7
Turkey Vulture	16	14	30
Osprey	3		3
Cooper's Hawk	4	2	6
Zone-tailed Hawk		2	2
Red-tailed Hawk	19	15	34
American Kestrel	7	3	10
Peregrine Falcon	1	1	2
Killdeer	4		4
Band-tailed Pigeon	4		4
Eurasian Collared-Dove		6	6
White-winged Dove	9	17	26
Mourning Dove	219	256	475
Greater Roadrunner	2	1	3
Western Screech-Owl	1		1
Great Horned Owl	1		1
Common Nighthawk	13		13
Common Poorwill		3	3
White-throated Swift	90	3	93
Black-chinned Hummingbird	10	15	25
Anna's Hummingbird	19	17	36
Broad-tailed Hummingbird	75	6	81
Lewis's Woodpecker	1		1
Acorn Woodpecker	42	12	54
Ladder-backed Woodpecker	5	9	14
Downy Woodpecker	6	2	8
Hairy Woodpecker	39	5	44
Northern Flicker	142	25	167
Olive-sided Flycatcher	1		1
Greater Pewee	2		2
Western Wood-Pewee	61	46	107
Hammond's Flycatcher		1	1
Gray Flycatcher	80	63	143
Cordilleran Flycatcher	36		36
Black Phoebe	4		4
Say's Phoebe	15	12	27
Ash-throated Flycatcher	144	162	306
Brown-crested Flycatcher		3	3
Cassin's Kingbird	25	58	83
Western Kingbird	12	83	95
Loggerhead Shrike	4	4	8
Bell's Vireo	1	6	7
Gray Vireo	23	39	62

Species	CNF	PNF	Total
Plumbeous Vireo	162	29	191
Hutton's Vireo		1	1
Warbling Vireo	10		10
Steller's Jay	124	18	142
Western Scrub-Jay	58	82	140
Pinyon Jay	65	69	134
Clark's Nutcracker	1		1
American Crow	2		2
Common Raven	146	102	248
Horned Lark	8	191	199
Purple Martin	5		5
Violet-green Swallow	142	6	148
Northern Rough-winged Swallow	2		2
Cliff Swallow	1	2	3
Barn Swallow	9		9
Mountain Chickadee	240	28	268
Bridled Titmouse	2	1	3
Juniper Titmouse	123	78	201
Verdin	6	2	8
Bushtit	72	132	204
Red-breasted Nuthatch	11	1	12
White-breasted Nuthatch	153	22	175
Pygmy Nuthatch	290	32	322
Brown Creeper	15	2	17
Cactus Wren	7	42	49
Rock Wren	48	74	122
Canyon Wren	15	32	47
Bewick's Wren	94	181	275
House Wren	36	25	61
Ruby-crowned Kinglet	4		4
Blue-gray Gnatcatcher	6	8	14
Black-tailed Gnatcatcher	1	2	3
Western Bluebird	187	1	188
Mountain Bluebird	10		10
Townsend's Solitaire	11		11
Hermit Thrush	52	7	59
American Robin	135	53	188
Northern Mockingbird	254	407	661
Curve-billed Thrasher	3	3	6
Crissal Thrasher		2	2
European Starling	8		8
Phainopepla	101	269	370
Olive Warbler	15		15
Orange-crowned Warbler		1	1
Virginia's Warbler	9	14	23
Lucy's Warbler	5	4	9
Yellow-rumped Warbler	191	8	199
Black-throated Gray Warbler	49	19	68
Grace's Warbler	194	38	232
MacGillivray's Warbler		1	1
Wilson's Warbler		2	2

Species	CNF	PNF	Total
Red-faced Warbler	12	2	14
Hepatic Tanager	30	26	56
Western Tanager	72	42	114
Green-tailed Towhee	2		2
Spotted Towhee	132	301	433
Canyon Towhee	22	44	66
Abert's Towhee		1	1
Cassin's Sparrow		1	1
Rufous-crowned Sparrow	22	74	96
Chipping Sparrow	158	40	198
Black-chinned Sparrow	32	196	228
Lark Sparrow	106	45	151
Black-throated Sparrow	131	318	449
Grasshopper Sparrow		1	1
Song Sparrow	3		3
Dark-eyed Junco	164	55	219
Northern Cardinal		5	5
Black-headed Grosbeak	46	104	150
Blue Grosbeak	7	8	15
Lazuli Bunting	1		1
Red-winged Blackbird		1	1
Eastern Meadowlark	44	37	81
Western Meadowlark	6		6
Great-tailed Grackle	11		11
Brown-headed Cowbird	73	117	190
Bullock's Oriole	5	11	16
Scott's Oriole	37	62	99
House Finch	83	93	176
Red Crossbill	53		53
Pine Siskin	10	4	14
Lesser Goldfinch	51	40	91
House Sparrow	16		16
Abert’s Squirrel	22	3	25
Dark-eyed Junco	164	55	219
Red Squirrel	18	2	20
Yellow-rumped Warbler	191	8	199