Population Densities and Trend Detection of Avian Management Indicator Species on the Routt National Forest

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EXECUTIVE SUMMARY

The Routt National Forest (NF) implemented habitat-stratified bird surveys to monitor three avian Management Indicator Species (MIS) in their primary habitats: Wilson's Warbler (*Wilsonia pusilla*) in High-Elevation Riparian habitat, Vesper Sparrow (*Pooecetes gramineus*) in Sage/Mountain Meadow habitat, and Golden-crowned Kinglet (*Regulus satrapa*) in Spruce-Fir habitat. In addition to assessing population status of these species at the Forest level, the Routt NF was interested in comparing avian population densities and trends on the Routt NF with densities and trends of the same species in Colorado. This was done at the primary habitat scale as well as at the planning area-state scale. The state-wide data were collected in 1998-2007 as part of the program Monitoring Colorado's Birds (MCB), conducted by the Rocky Mountain Bird Observatory.

I estimated density and ability to detect population trends for the three avian MIS of the Routt NF. Each analysis was conducted separately for two samples: (1), the Colorado state-wide (MCB) data, and (2) the Routt NF data. In addition, I modeled observed trends in the MCB data.

Densities of Wilson's Warblers in High-Elevation Riparian habitat were similar on the Routt NF and state-wide. There was evidence of a gradual state-wide increase in Wilson's Warbler densities in 1999-2007. Given the current sampling levels, a 3% average annual population decline would be observed with 80% power within 25 years in the MCB program and 35 years on the Routt NF. Densities of Vesper Sparrows in Sage/Mountain Meadow habitat were somewhat lower on the Routt NF than state-wide. There was evidence of a gradual state-wide increase in Vesper Sparrow densities in 1999-2007. Given the current sampling levels, a 3% population decline should be observed with 80% power within 20 years in the MCB program and 35 years on the Routt NF. Densities of Golden-crowned Kinglets in Spruce-Fir habitat were essentially identical among the two monitoring programs. There was no evidence of change Golden-crowned Kinglet densities in 1998-2007. Given the current sampling levels, a 3% population decline should be observed with 80% power within 25 years in both the MCB and Routt NF monitoring programs.

Broad-scale avian monitoring programs such as MCB will continue to be necessary for interpreting estimates of population status and trend for avian Management Indicator Species on the Routt NF.

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INTRODUCTION

In 1998, Rocky Mountain Bird Observatory (RMBO) established a program to monitor bird populations throughout Colorado (Monitoring Colorado's Birds; MCB). Sampling design was based on habitat strata, with 30 transects randomly located in 11 habitats. Bird populations were sampled each year, 1998-2007, although not all habitats were sampled each year. Many of the randomly-located transects, especially in forested habitats, occurred on lands administered by the U.S. Forest Service (USFS).

In 2005, additional habitat-stratified bird monitoring transects were added on the Routt National Forest planning area (Routt NF; including the Williams Fork area of the Arapaho-Roosevelt National Forest). The Routt NF transects were sampled each year, 2005-2007, following the same protocol used to sample MCB transects. The objective of the additional transects was to monitor the population trend of avian Management Indicator Species (MIS) at the Forest planning unit level. In addition, the Routt NF was interested in comparing avian population densities and trends on the Routt NF with densities and trends of the same species throughout Colorado. Potential differences observed between state-wide and Forest-wide trends could trigger additional investigations into the causes of differences in observed trends, which could result in changes in Forest management direction. The three MIS and their primary habitats were: Wilson's Warbler (*Wilsonia pusilla*) – High-Elevation Riparian; Vesper Sparrow (*Pooecetes gramineus*) – Sage/Mountain Meadow; and, Golden-crowned Kinglet (*Regulus satrapa*) – Spruce-Fir.

Herein, I present (1) density estimates of three MIS on the Routt NF within the primary habitat strata of each species; (2) density estimates of the same species in the same habitats throughout Colorado; (3) analysis of observed trends for the three species throughout Colorado; (4) estimated ability to detect population trends of the MIS on the Routt NF planning unit; and, (5) estimated ability to detect population trends state-wide.

METHODS

Study Area

Selection and locations of MCB point transects is described in the MCB annual reports (e.g., Beason et al. 2008). Habitat strata in the MCB program are: Alpine Tundra, Aspen, Grassland, High-elevation Riparian, Mixed Conifer, Montane Shrubland, Pinyon-Juniper, Ponderosa Pine, Sage Shrubland, Semi-desert Shrubland, and Spruce Fir. Five MCB Aspen strata transects occurred on the Routt NF; no additional Aspen transects were established by the Routt NF. Aspen comprises 20% of the Routt NF planning area (Table 1). Aspen transects were not sampled in 2007.

Three MCB High-Elevation Riparian (HR) transects occurred on the Routt NF; nine additional HR transects were established by the Routt NF (Table 2). High-elevation Riparian habitat comprises1% of the Routt NF planning area (Table 1).

One MCB Sage/Mountain Meadow (SA) transect occurred on the Routt NF; 11 additional SA transects were established by the Routt NF (Table 2). Sage/Mountain Meadow habitat comprises 13% of the Routt NF planning area.

One MCB Spruce-Fir (SF) transect occurred on the Routt NF; 11 additional SF transects were established by the Routt NF (Table 2). Spruce-Fir habitat comprises 32% of the Routt NF planning area.

Two additional MCB transects occurred on the Routt NF that are considered part of the Forests 'random' strata; both were in Montane Shrubland Habitat. The Routt NF established 9 additional transects outside of Aspen, HR, SA, and SF habitats. I refer to these transects as belonging to the stratum "Other", which comprises 33% of the Routt NF (Table 1).

Table 1. Area of five habitat strata on the Routt National Forest.

Habitat	Acres	Km^2	% of Area
Aspen	284,117	1,150	20
High-Elevation Riparian	18,474	75	1
Sage/Mountain Meadow	184,960	749	13
Spruce-Fir	462,038	1,870	32
Other	473,090	1,915	33
Total	1,422,680	5,757	100

Table 2. Point Transects used to estimate densities of avian species on the Routt National Forest.

High Elevation Riparian Transects	
RMBO Transect Name	USFS Transect Name
FS-HR01-05-AR	ARWFHR01
FS-HR01-05-RT	RTYAHR01
FS-HR02-05-RT	RTHBHR02
FS-HR03-05-RT	RTYAHR03
FS-HR05-05-RT	RTHBHR05
FS-HR06-05-RT	RTPKHR06
FS-HR07-05-RT	RTPKHR07
FS-HR08-05-RT	RTHBHR08
FS-HR10-05-RT	RTHBHR10
CO-HR06	
CO-HR07	
CO-HR11	

Sage/Mountain Meadow Transects	
RMBO Transect Name	USFS Transect Name
FS-SA01-05-AR	ARWFSA01
FS-SA02-05-RT	RTYASA02
FS-SA03-06-RT	RTHBSA03
FS-SA04-05-RT	RTHBSA04
FS-SA06-05-RT	RTYASA06
FS-SA07-05-RT	RTHBSA07
FS-SA08-05-RT	RTHBSA08
FS-SA10-04-RT	RTPKSA10
FS-SA11-05-RT	RTPKSA11
FS-SA12-05-RT	RTYASA12
FS-SA14-05-RT	RTYASA14
CO-SA01	

Spruce-Fir Transects	
RMBO Transect Name	USFS Transect Name
FS-SF01-05-AR	ARWFSF01
FS-SF03-05-RT	RTPKSF03
FS-SF04-05-RT	RTHBSF04
FS-SF05-05-RT	RTYASF05
FS-SF06-05-RT	RTHBSF06
FS-SF07-05-RT	RTHBSF07
FS-SF08-05-RT	RTYASF08
FS-SF09-06-RT	RTHBSF09
FS-SF11-06-RT	RTHBSF11
FS-SF12-05-RT	RTPKSF12
FS-SF13-06-RT	RTYASF13
CO-SF22	

Aspen Transects	
RMBO Transect Name	USFS Transect Name
CO-AS10	
CO-AS11	
CO-AS12	
CO-AS14	
CO-AS29	

Other Habitat Transects	
RMBO Transect Name	USFS Transect Name
CO-MS05	
CO-MS10	
FS-NO01-05-RT	RTPKRD01
FS-NO02-05-RT	RTPKRD02
FS-NO03-05-RT	RTPKRD03
FS-NO04-06-RT	RTPKRD04
FS-NO05-05-RT	RTPKRD05
FS-NO07-05-RT	RTPKRD07

Other Habitat Transects	
FS-NO08-06-RT	RTPKRD08
FS-NO09-07-RT	RTPKRD09

Field Methods

Point transect sampling is based on distance sampling theory, which estimates detection probability as a function of the distances between the observer and the birds detected (Buckland et al. 1993). The detection probability is used to adjust the count of birds to account for birds that were present but undetected. Details of field sampling methods appear in the 2006 MCB annual report (Hutton et al. 2007). Following is a brief summary of the sampling protocol.

Each transect consisted of 15 points located at 250 m intervals along the transect. Each transect was surveyed by one observer collecting data for five minutes per point following protocol established by Leukering (2000) and modified by Panjabi (2006). Technicians conducted all transect surveys in the morning, between ½-hour before sunrise and 11 AM; most surveys were completed before 10 AM.

Data Analysis

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). Application of distance theory requires that three critical assumptions be met: 1) all birds at and near the sampling location (distance = 0) are detected; 2) distances of birds are measured accurately; and 3) birds do not move in response to the observer's presence. These assumptions are reasonably well met following the MCB protocol. 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, I analyzed the data separately for each species.

I used Program Distance 5.0 (Thomas et al. 2006) to estimate the density of each bird species. I 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). I used Akaike's Information Criterion (AIC) corrected for small sample size (AIC_c) and model selection theory to select the most parsimonious detection function for each species (Burnham and Anderson 2002).

I excluded all (supplemental and RMBO-MCB) transects on the Routt NF from analyses to estimate state-wide population densities from the MCB data.

Therefore, estimates in the MCB 2007 annual report (Beason et al. 2008) may differ slightly from those reported herein.

The required sample size for estimating a detection function is at least 60-80 independent detections. Fewer than 60 detections per habitat type per year were acquired on the Routt NF transects. Fortunately, it is possible using program DISTANCE to construct a common detection function across years, and obtain separate density estimates for each year. It is not valid, however to construct a common detection across dissimilar habitats. Detection probability would be expected to differ, for example, between shrubland and forested habitats for the same species.

I modeled observed state-wide (MCB) trends in populations of Wilson's Warbler in High-Elevation Riparian habitat and Routt Forest Planning Area, Vesper Sparrow in Sage/Mountain Meadow habitat and Routt Forest Planning Area, and Golden-crowned Kinglet in Spruce-Fir habitat and Routt Forest Planning Area using weighted regression and Information-Theoretic model selection (Burnham and Anderson 2002). For each species I modeled 4 different functions using Proc REG in program SAS (SAS Institute 2007): no trend (intercept only model), linear trend, quadratic trend, and log-linear (pseudo-threshold) trend. Input data were density estimates and their variances, with the inverse of the Coefficient of Variation used as a variable weight (giving more weight to more precise estimates). I did not conduct an analysis of observed population trends from the Routt NF data due to the small time span (3 years).

I simulated the time to detect population trends for each MIS in each habitat and for each species across the planning area for which we were able to estimate density. Time to detect trends was evaluated at the MCB target levels of 3% annual population change with power = 0.80 and alpha = 0.10 (Leukering et al. 2000). I used a power simulation created in Program R by Paul Lukacs of the Colorado Division of Wildlife. The simulation includes state and observation processes and uses empirical data from the MCB program as model input. The state model defines the initial population density and trend through time using estimated density and the variance of estimated density. The state model also includes the mean and variance of the trend we are hoping to detect; here I modeled an average annual change of 3%, allowing the change to vary stochastically between 1% and 5%. The observation model defines the detection process and sample size through time, using the coefficient of variation (CV) of estimated detection probability and the CV of estimated encounter rate. These are the two sources of variation that influence the variation in estimated density. I ran simulations for 5, 10, 15, …, 40 years with 1000 replications. Although a 3% annual population change (e.g., decline) may seem small, the result of a constant 3% decline over 24 years would be a loss of one-half of a population. Note that these simulations do not evaluate whether or not a change in the population has occurred; rather, they evaluate our power to detect a trend if the trend had occurred. Also note that we would be able to detect a greater rate of

population change (e.g., 5% or 10% change annually) in a much shorter amount of time.

RESULTS

Buckland et al. (2001) recommend 60-80 observations to fit a detection curve to Distance data. Sample sizes were sufficient to estimate density of each MIS on the Routt NF in its primary habitat, whereas sample size was too small for any species outside of its primary habitat (Table 3). If population size remains similar to 2005-2007, the Routt NF should have sufficient number of observations of Wilson's Warbler in Sage/Mountain Meadow habitat to model a detection function after two more years of surveys at the previous level of survey effort.

Table 3. Detections of avian Management Indicator Species by habitat and year on the Routt National Forest,2005-2007.

	Golden-crowned Kinglet			Vesper Sparrow			Wilson's Warbler		
Habitat	2005	2006	2007	2005	2006	2007	2005	2006	2007
Aspen	0	0		0	0		0	0	
High-Elev. Riparian	9	2	4	1	3	9	**149**	**74**	**100**
Sage/Mountain Mdw	0	2	4	**29**	**43**	**75**	15	13	13
Spruce-Fir	**15**	**28**	**31**	0	9	0	2	5	17
Other	4	3	16	4	1	0	1	3	2
Total	28	35	55	34	56	84	167	95	132

None of the three MIS showed evidence of state-wide population declines from 1998-2007. The best model of population trend for Wilson's Warblers in High-Elevation Riparian habitat was an increasing log-linear function (Fig. 1). The best model of population trend for Vesper Sparrows in Sage/Mountain Meadow habitat was an increasing linear trend (Fig. 2). Golden-crowned Kinglets showed no evidence of population change over the sampling period; the best approximating model was the intercept-only (constant) model.

Simulation results indicated that at the sampling level used in 2005-2007, the Routt NF should be able to a future population decline of 3% annually within 25 years for the Golden-crowned Kinglet, and within 35 years for both the Vesper Sparrow and Wilson's Warbler. In comparison, the MCB data should be able to a future population decline of 3% annually within 25 years for the Golden-crowned Kinglet, within 20 years for the Vesper Sparrow, and within 25 years for the Wilson's Warbler.

Wilson's Warbler

Density of Wilson's Warblers in High-Elevation Riparian Habitat of the Routt NF appeared to be higher than state-wide estimates in 2005, but were similar to state-wide estimates in 2006-2007, based on overlapping 90% confidence intervals (Table 4, Fig. 1).

Table 4. Estimated densities of Wilson's Warblers in High Elevation Riparian Habitat throughout Colorado, 1999-2007, and within the Routt National Forest, 2005-2007.

	Colorado					Routt National Forest Planning Area				
Year	D	LCL	UCL	%CV	n	D	LCL	UCL	%CV	n
1999	48	20	112	53	20					
2000	110	62	196	36	59					
2001	172	101	293	33	96					
2002	222	122	402	37	105					
2004	295	173	503	33	174					
2005	183	115	291	29	108	492	336	721	23	138
2006	138	85	226	30	78	265	184	383	22	64
2007	218	130	365	32	126	273	159	468	32	75

[a] *D* = estimated density (birds/km^2); *LCL* and *UCL* = lower and upper 90% confidence limits on *D*; *%CV* = percent coefficient of variation of *D*; *n* = number of observations used to estimate *D*.

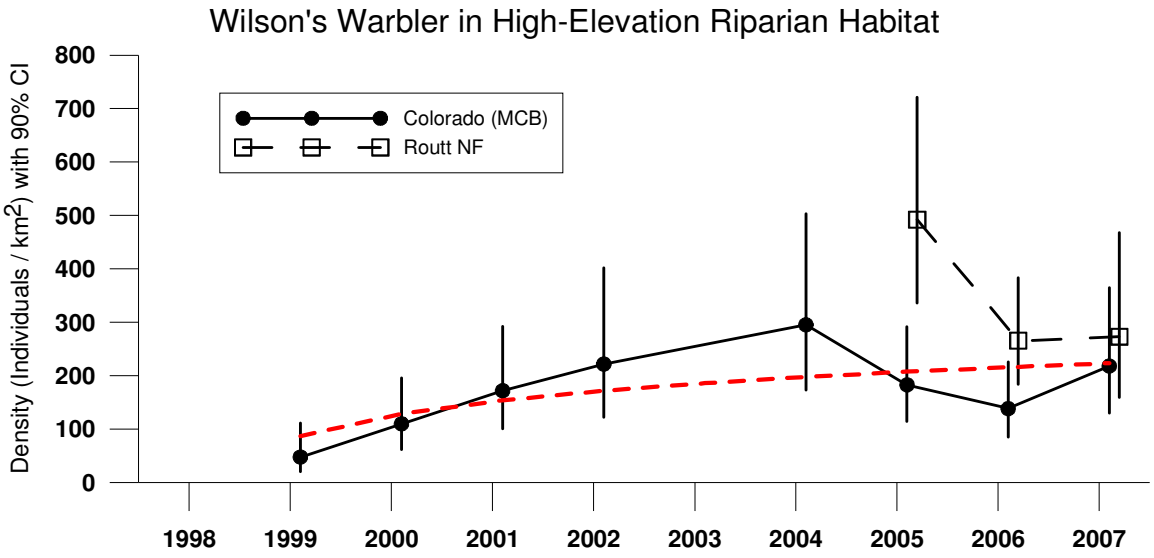

Figure 1. Estimated densities of Wilson's Warblers in High Elevation Riparian habitat throughout Colorado (MCB), 1999-2007, and within the Routt National Forest, 2005-2007. Error bars represent 90% confidence intervals. The red (dashed) line represents the best estimate of observed population trend for the MCB data.

Vesper Sparrow

Density estimates of Vesper Sparrows in Sage/Mountain Meadow habitat were slightly lower on the Routt NF than state wide for 2005-2007, although 90% confidence intervals of the two samples overlapped in two of the 3 years (Table 5, Fig. 2).

Table 5. Estimated densities of Vesper Sparrows in Sage/Mountain Meadow Habitat throughout Colorado, 1999-2007, and within the Routt National Forest, 2005-2007.

	Colorado					Routt National Forest Planning Area				
Year	D	LCL	UCL	%CV	n	D	LCL	UCL	%CV	n
1999	16	10	26	30	145					
2000	37	21	64	34	210					
2001	19	13	30	26	172					
2002	21	14	33	26	175					
2003	29	20	43	24	153					
2004	22	16	31	20	179					
2005	40	28	57	21	231	12	4	32	59	26
2006						13	6	29	46	40
2007	47	30	74	28	346	24	12	46	39	59

[a] *D* = estimated density (birds/km^2); *LCL* and *UCL* = lower and upper 90% confidence limits on *D*; *%CV* = percent coefficient of variation of *D*; *n* = number of observations used to estimate *D*.

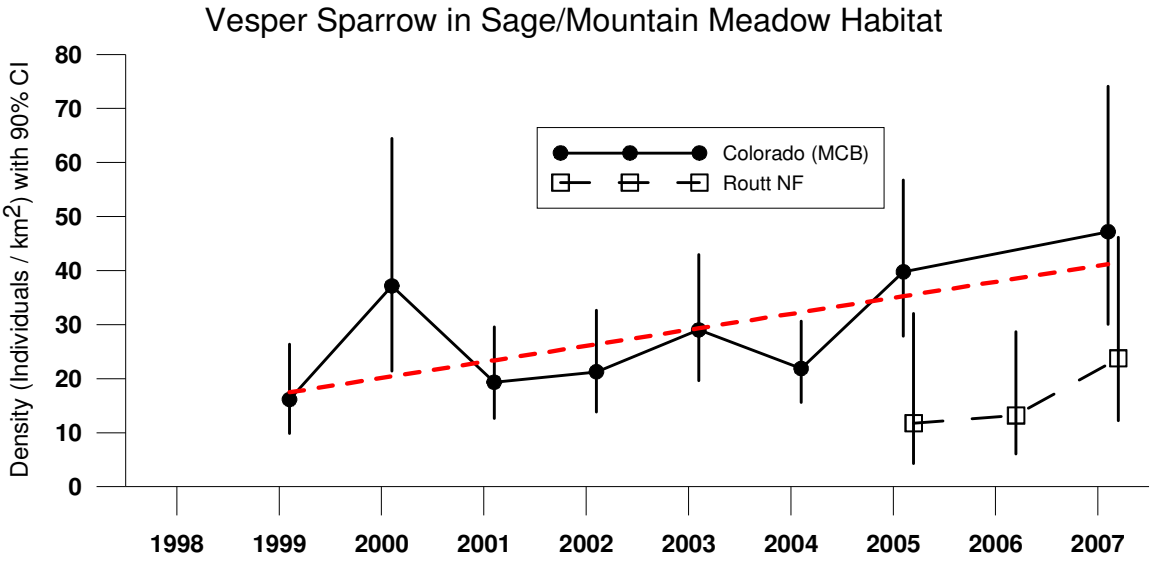

Figure 2. Estimated densities of Vesper Sparrows in Sage/Mountain Meadow habitat throughout Colorado (MCB), 1999-2007, and within the Routt National Forest, 2005-2007. Error bars represent 90% confidence intervals. The red (dashed) line represents the best estimate of observed population trend for the MCB data.

Golden-crowned Kinglet

Density estimates of Golden-crowned Kinglets in Spruce-Fir habitat on the Routt NF were essentially identical to state-wide estimates for each year, 2005-2007 (Table 6, Fig. 3).

Table 6. Estimated densities of Golden-crowned Kinglets in Spruce-Fir Habitat throughout Colorado, 1998-2007, and within the Routt National Forest, 2005-2007.

	Colorado					Routt National Forest Planning Area				
Year	D	LCL	UCL	%CV	n	D	LCL	UCL	%CV	n
1998	63	48	83	16	80					
1999	38	23	63	30	43					
2000	94	68	131	19	81					
2001	28	18	45	28	32					
2002	18	8	39	47	21					
2004	23	14	38	31	23					
2005	32	21	50	25	38	33	17	67	39	15
2006	37	23	60	29	39	43	22	83	39	26
2007	57	32	100	34	56	58	35	94	28	29

[a] *D* = estimated density (birds/km^2); *LCL* and *UCL* = lower and upper 90% confidence limits on *D*; *%CV* = percent coefficient of variation of *D*; *n* = number of observations used to estimate *D*.

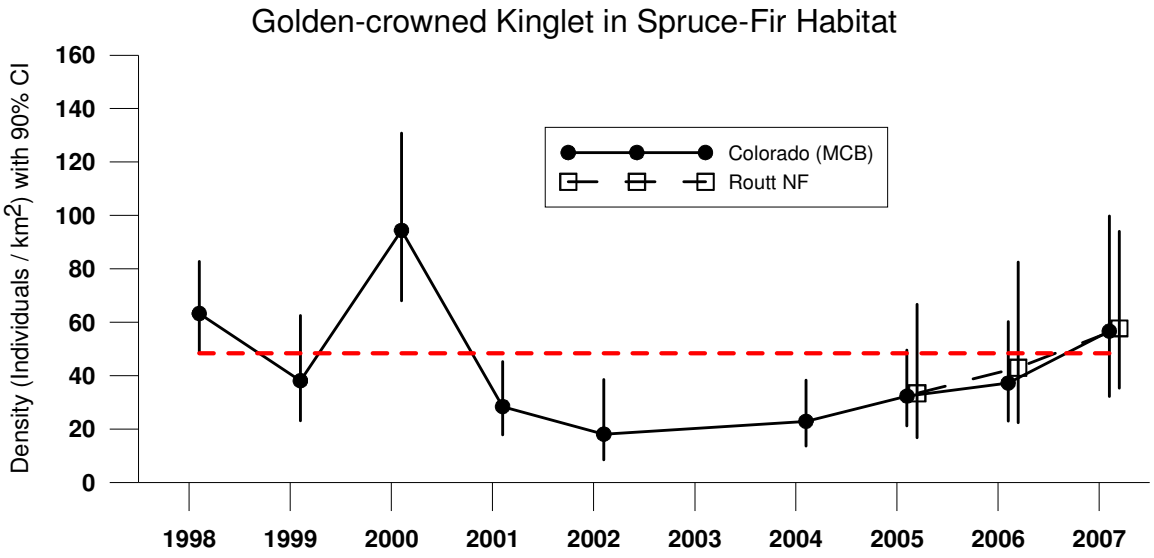

Figure 3. Estimated densities of Golden-crowned Kinglets in spruce-fir habitat throughout Colorado (MCB), 1998-2007, and within the Routt National Forest, 2005-2007. Error bars represent 90% confidence intervals. The red (dashed) line represents the best estimate of observed population trend for the MCB data.

DISCUSSION AND RECOMMENDATIONS

The Routt NF will need to increase the number of transects surveyed in Sage/Mountain Meadow and High-Elevation Riparian habitats in order to be able to detect a 3% population decline within 30 years for the Vesper Sparrow and Wilson's Warbler, respectively. An increase in sage and riparian transects on the Routt NF (and resulting increase in the precision of density estimates) will probably also be necessary for meaningful statistical comparisons of observed future trends between the Routt NF and MCB population estimates.

Density of Vesper Sparrows appeared to be lower on the Routt NF than state-wide; this may be due to inclusion of mountain meadows in the Routt NF stratum – the MCB Sage Shrubland stratum does not explicitly include Mountain Meadow habitat.

The strategy used by the Routt NF and other Forests in the Region to monitor avian Management Indicator Species relies upon rigorous long-term sampling of birds at two spatial scales. The habitat-stratified MCB program has provided a broad-scale reference of avian densities and population trends to which density and trend estimates from the individual Forests may be compared. In the future, broad-scale monitoring may occur state-wide and/or at the scale of the Bird Conservation Region, and may not be based on habitat strata. National Forests can continue to contribute valuable information to understand broad-scale population status and trends of many avian species. At the same time, broad-scale programs will remain necessary to provide a context in which to interpret avian MIS monitoring programs.

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