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

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In Cooperation With:

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Brewer's Sparrow. Dave Herr, U.S. Forest Service.

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EXECUTIVE SUMMARY

The White River National Forest (WRNF) is required to monitor three avian Management Indicator Species (MIS) in their primary habitats: American Pipit (*Anthus rubescens*) in Alpine Tundra habitat, Virginia's Warbler (*Vermivora virginiae*) in Montane Shrubland habitat, and Brewer's Sparrow (*Spizella Breweri*) in Sage Shrubland habitat. The WRNF avian MIS protocols require comparison of trends in the biological population and the state-wide population of each species. Biological populations were delineated based on Ecological Sections within the National Hierarchy of Ecological Units (Bailey 1995).

Rocky Mountain Bird Observatory (RMBO) implemented habitat-stratified bird surveys on transects throughout Colorado in 1998-2007. In 2004-2005, the WRNF established eight additional transects in each of two habitat types within the WRNF boundaries. The RMBO and WRNF transects were surveyed following identical methods and protocols. The comparison of trends can be accomplished through collaboration between the WRNF and RMBO.

I estimated density, observed population trends, and ability to detect population trends for the three avian MIS of the White River NF. Each analysis was conducted separately for two samples: (1), the Colorado state-wide (MCB) data, and (2) the appropriate Ecological Section data.

None of the three MIS showed evidence of population declines from 1999-2007, either from the Ecological Section data or from the MCB data. Populations appeared to be stable (no trend evident) for all three species state-wide and for the American Pipit in the Northern Parks and Ranges Ecological Section. There was evidence for an increasing linear trend in Virginia's Warbler population size between 1999 and 2007 in the Northern Parks and Ranges. In addition, there was evidence for an increasing log-linear trend in Brewer's Sparrow population size between 1999 and 2007 in the North-Central Highlands and Northern Parks and Ranges Ecological Sections.

Simulation results indicated that at the sampling level used in 1999-2007, we would be able to detect a 3% average annual population decline within 20-25 years for all three species, both with MCB data and with the data from the appropriate Ecological Sections.

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 White River NF.

ACKNOWLEDGEMENTS

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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 transects, especially in forested habitats, occurred on lands administered by the U.S. Forest Service (USFS). In addition, in 2004-2005, the White River National Forest (WRNF) established eight additional transects in each of two habitat types within the WRNF boundaries.

The WRNF designated three avian species as Management Indicator Species (MIS) as part of its Forest Plan. Each of the MIS was selected for monitoring by the WRNF to evaluate the quantity and quality of its primary habitat. "The major trigger sparking potential changes in management actions would be based on a comparison between the forest-wide and state-wide population trends" (Potter 2006a). The comparison of trends can be accomplished through collaboration between the WRNF and RMBO.

Recognizing that Forest boundaries rarely define bird populations, the WRNF used the National Hierarchy of Ecological Units (Bailey 1995) to define the boundaries of biological populations of avian MIS (Potter 2004, 2006a, 2006b). Under this classification, the WRNF falls within the North-Central Highlands and Northern Parks and Ranges Sections of the Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province. The WRNF chose to monitor three avian MIS in one habitat type each, within one or more of the Ecological Sections: (1) American Pipit within Alpine Tundra habitat of the Northern Parks and Ranges Section; (2) Virginia's Warbler within Montane Shrubland habitat of the North-Central Highlands Section; (3) Brewer's Sparrow within Sage Shrubland habitat of both sections.

Herein, I present (1) density estimates, (2) observed trends, and (3) estimated ability to detect population trends for the three avian MIS of the White River NF. Each analysis was conducted separately for two samples: (1), the Colorado state-wide (MCB) data, and (2) the appropriate Ecological Section data.

METHODS

Study Area

Selection and locations of MCB point transects are 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.

Ten MCB Alpine Tundra transects occurred within the Northern Parks and Ranges Section (Table 1). No additional Alpine Tundra transects were established by the WRNF. Fourteen MCB Montane Shrubland transects occurred within the North-Central Highlands Section. The WRNF established 8 "supplemental" Montane Shrubland transects on the WRNF in 2004. Six MCB Sage Shrubland transects occurred within the Northern Parks and Ranges and North-Central Highlands Sections. The WRNF established 8 "supplemental" Montane Shrubland transects on the WRNF in 2005.

The supplemental transects on the White River National Forest were sampled each year through 2007, following the same protocol used to sample MCB transects.

Table 1. Point Transects used to estimate densities of White River National Forest (WRNF) Management Indicator Species. Transect names beginning with "CO" are from the MCB program; names beginning with "FS" are supplemental transects added by the WRNF in 2004 and 2005.

Alpine Tundra	Montane Shrubland	Sage Shrubland
CO-AT01	CO-MS03	CO-SA01
CO-AT02	CO-MS05	CO-SA03
CO-AT03	CO-MS06	CO-SA11
CO-AT04	CO-MS07	CO-SA15
CO-AT05	CO-MS08	CO-SA29
CO-AT06	CO-MS10	CO-SA30
CO-AT07	CO-MS12	FS-SA01-04-WR
CO-AT08	CO-MS14	FS-SA02-04-WR
CO-AT09	CO-MS15	FS-SA03-04-WR
CO-AT11	CO-MS17	FS-SA04-04-WR
	CO-MS18	FS-SA05-04-WR
	CO-MS20	FS-SA06-04-WR
	CO-MS21	FS-SA07-04-WR
	CO-MS22	FS-SA08-04-WR
	FS-MS01-04-WR	
	FS-MS02-04-WR	
	FS-MS03-04-WR	
	FS-MS04-04-WR	
	FS-MS05-04-WR	
	FS-MS06-04-WR	
	FS-MS07-04-WR	
	FS-MS08-04-WR	

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 2007 MCB annual report (Beason et al. 2008). 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 et al. (1998) and modified by RMBO in 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 transects on the White River 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.

I modeled observed trends in populations of the three MIS in their targeted habitats, using both state-wide (MCB) and Ecological Section (including supplemental transect) date. I used 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 variance used as a variable weight (giving more weight to more precise estimates).

I simulated the time to detect population trends for each MIS in its target habitat, separately for state-wide (MCB) transects and the appropriate Ecological Section transects (including WRNF supplemental transects). Time to detect trends was evaluated at the MCB target levels of 3% average 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 White River NF in its target habitat. For Virginia's Warbler in the North-Central Highlands Ecological Section, and Brewer's Sparrow in both Ecological Sections, this was accomplished by fitting a common detection function across years and estimating density for individual years. In all other cases, the best model of detection probability (based on AICc) was achieved by modeling the detection function separately for each year.

None of the three MIS showed evidence of population declines from 1999-2007, either from the Ecological Section data or from the MCB data. Simulation results indicated that at the sampling level used in 1999-2007, we would be able to detect a 3% average annual population decline within 20-25 years for all three species, both with MCB data and with the data from the targeted Ecological Sections.

American Pipit

Estimated density of American Pipits in Alpine Tundra habitat was similar within Colorado (MCB) and within the Northern Parks and Ranges Ecological Section (Table 2). Density estimates varied six-fold among years (51 – 313 individuals per km^2).

Table 2. Estimated densities of American Pipits in Alpine Tundra habitat throughout Colorado and within the Northern Parks and Ranges Ecological Section, 1999-2007[a].

	Colorado					Northern Parks and Ranges				
Year	D	LCL	UCL	%CV	n	D	LCL	UCL	%CV	n
1999	57	37	87	26	227	51	30	87	33	139
2000	180	135	241	18	408	178	134	237	17	281
2001	118	87	161	19	403	127	86	188	23	225
2002	195	132	287	24	346	313	211	463	24	203
2003	77	57	105	18	440	76	49	117	27	295
2004	124	92	167	18	468	137	101	187	19	348
2005	77	56	106	19	352	93	66	131	21	238
2006[b]										
2007[b]										

[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*. [b] MCB Transects in Alpine Tundra habitat were not surveyed in 2006 nor 2007.

American Pipits showed no evidence of population change over the sampling period from either data set; the best approximating model in both cases was the intercept-only (constant) model (Figure 1).

We would be able to detect a future population decline of 3% annually within 20 years for the American Pipit both state-wide and within the targeted Ecological Section, given the current estimates of density, variation in detection probability and encounter rate, and the sampling design used in 1999-2007.

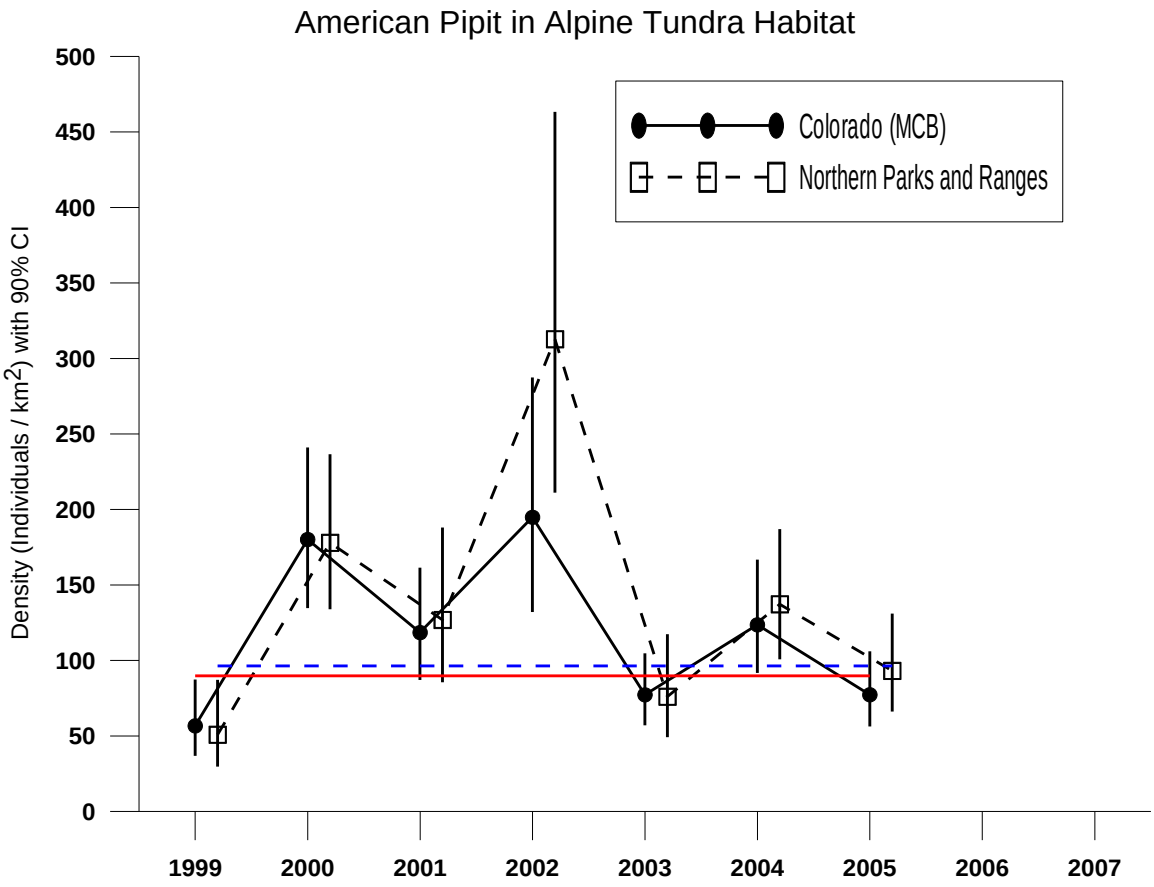

Figure 1. Estimated densities and population trend of American Pipits in Alpine Tundra habitat throughout Colorado and within the Northern Parks and Ranges Ecological Section, 1999-2007. Error bars represent 90% confidence intervals. The red (solid) line represents the best estimate of observed population trend for the MCB data. The blue (dashed) line indicates the best estimate of observed population trend for the Northern Parks and Ranges Ecological Section.

Virginia's Warbler

Estimated density of Virginia's Warblers in Montane Shrubland habitat was similar within Colorado (MCB) and within the Northern Parks and Ranges Ecological Section in most years (Table 3). Density estimates were higher in the Northern Parks and Ranges than throughout the state in one year, based on non-overlapping 90% confidence intervals. Montane Shrubland habitat was not surveyed under the MCB program in 2006 nor 2007.

Virginia's Warblers showed no evidence of population change state wide from 1999-2005; the best approximating model was the intercept-only (constant) model (Figure 2). In contrast, there was evidence for an increasing linear trend in population size between 1999 and 2007 in the Northern Parks and Ranges.

Table 3. Estimated densities of Virginia's Warblers in Montane Shrubland habitat throughout Colorado and within the North-Central Highlands Ecological Section, 1999-2007[a].

	Colorado					Northern Parks and Ranges				
Year	D	LCL	UCL	%CV	n	D	LCL	UCL	%CV	n
1999	19	11	33	32	75	30	17	53	32	28
2000	30	18	48	29	80	41	25	68	29	46
2001	21	15	30	20	98	24	16	38	25	25
2002	47	16	144	75	136	99	67	145	22	74
2003	63	40	99	27	163	62	39	97	26	72
2004	72	50	104	23	182	58	35	93	29	97
2005	19	12	27	24	142	57	39	84	23	113
2006[b]						44	25	78	32	41
2007[b]						89	66	120	17	66

[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*. [b] MCB Transects in Montane Shrubland habitat were not surveyed in 2006 nor 2007.

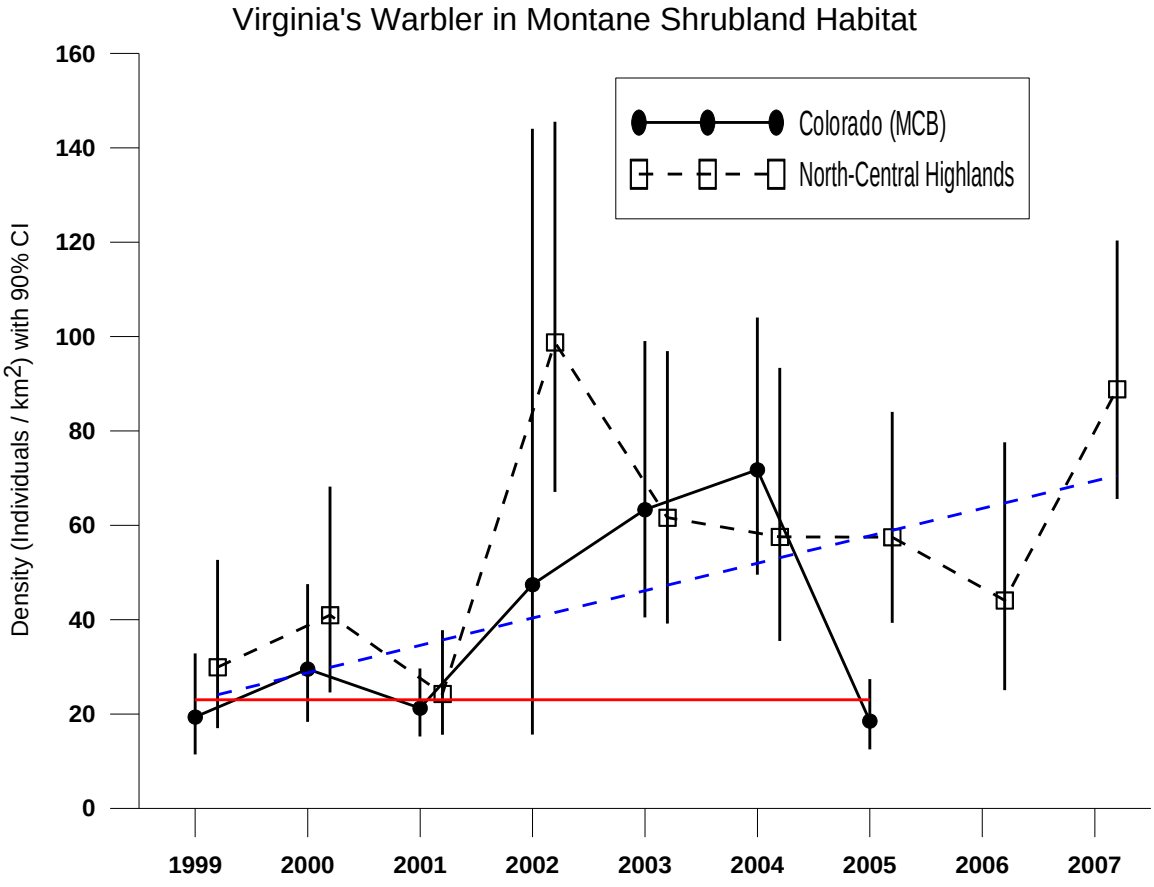

Figure 2. Figure 1. Estimated densities and population trend of Virginia's Warblers in Montane Shrubland habitat throughout Colorado and within the North-Central Highlands Ecological Section, 1999-2007. Error bars represent 90% confidence intervals. The red (solid) line represents the best estimate of observed population trend for the MCB data. The blue (dashed) line indicates the best estimate of observed population trend for the North-Central Highlands Ecological Section.

We would be able to detect a future population decline of 3% annually within 25 years for the Virginia's Warbler state-wide and within 20 years in the targeted Ecological Section, given the current estimates of density, variation in detection probability and encounter rate, and the sampling design used in 1999-2007.

Brewer's Sparrow

Estimated density of Brewer's Sparrows in Sage Shrubland habitat was similar within Colorado (MCB) and within the North-Central Highlands and Northern Parks and Ranges Ecological Sections in most years (Table 4). Density estimates were higher in the targeted Ecological Sections than throughout the state in 2007.

Table 4. Estimated densities of Brewer's Sparrows in Montane Shrubland habitat throughout Colorado and within the North-Central Highlands and Northern Parks and Ranges Ecological Sections, 1999-2007[a].

	Colorado					North Central Highlands & Northern Parks and Ranges				
Year	D	LCL	UCL	%CV	n	D	LCL	UCL	%CV	n
1999	57	38	86	25	324	29	9	91	58	29
2000	85	61	119	20	350	69	25	188	45	55
2001	112	74	169	25	352	154	77	308	34	147
2002	38	27	53	20	264	55	30	102	32	66
2003	73	55	97	17	472	83	45	153	30	83
2004	109	80	147	18	397	88	36	213	40	70
2005	94	70	127	18	515	96	71	132	18	209
2006[b]						77	60	100	14	123
2007	99	68	143	23	667	181	129	254	19	432

[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*. [b] Observers that conducted MCB Transects in Sage Shrubland habitat in 2006 did not correctly identify Brewer's Sparrows.

Brewer's Sparrows showed no evidence of population change state wide from 1999-2007; the best approximating model was the intercept-only (constant) model (Figure 3). In contrast, there was evidence for an increasing log-linear trend in population size between 1999 and 2007 in the targeted Ecological Sections.

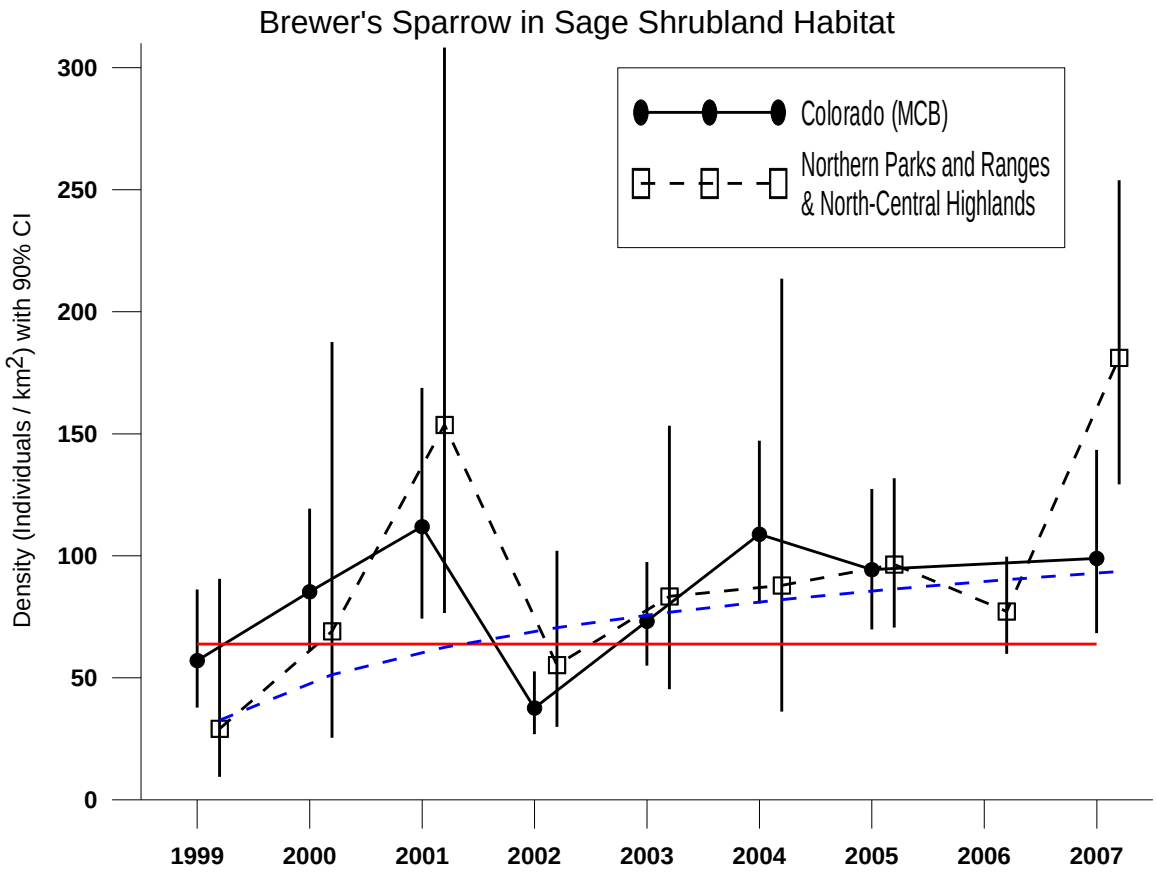

Figure 3. Estimated densities and population trend of Brewer's Sparrows in Sage Shrubland habitat throughout Colorado and within the North-Central Highlands and Northern Parks and Ranges Ecological Sections, 1999-2007[a] Error bars represent 90% confidence intervals. The red (solid) line represents the best estimate of observed population trend for the MCB data. The blue (dashed) line indicates the best estimate of observed population trend for the North-Central Highlands and Northern Parks and Ranges Ecological Sections.

We would be able to detect a future population decline of 3% annually within 20 years for the Brewer's Sparrow state-wide and within 25 years in the targeted Ecological Sections, given the current estimates of density, variation in detection probability and encounter rate, and the sampling design used in 1999-2007.

DISCUSSION AND RECOMMENDATIONS

The White River NF would be able to compare population trends of its avian MIS between state-wide and Ecological Section data under the sampling design used in 1999-2007 and the sampling intensity achieved in 2004-2005. Alpine Tundra and Montane Shrubland habitats were not sampled under the MCB program in 2006-2007 due to budget constraints.

The strategy used by the White River 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. Beginning in 2008, Rocky Mountain Bird Observatory and its partner agencies, including the US Forest Service, will be implementing a new sampling design for monitoring breeding landbirds in Colorado that is not based on habitat strata. However, each National Forest in Colorado will be a stratum. 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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