Monitoring Birds in the Atlantic Rim Natural Gas Development Project Area; 2010 Report

February 2011

ROCKY MOUNTAIN BIRD OBSERVATORY
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TECH. REPORT # SC-ARIM-01

ROCKY MOUNTAIN BIRD OBSERVATORY

***Mission**: To conserve birds and their habitats*

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

***Core Values**:*
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.*

Suggested Citation:

Van Lanen, N.J., D.C. Pavlacky Jr., D.J. Hanni. 2011. Monitoring Birds In The Atlantic Rim Natural Gas Development Project Area; 2010 Report. Tech. Report # SC-ARIM-01. Rocky Mountain Bird Observatory, Brighton, Colorado, USA.

***Cover Photos**:*

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EXECUTIVE SUMMARY

Rocky Mountain Bird Observatory, in conjunction with the USDI Bureau of Land Management (BLM), conducted landbird monitoring on BLM and private lands south of Rawlins, WY, in the Atlantic Rim Natural Gas Development Project Area. 2010 marked the first year of an ongoing study to obtain data on avian species richness in areas currently undergoing high and low levels of energy development.

The study area was contained within lower elevations of Bird Conservation Region 10 (Northern Rockies) which is characterized by high-elevation mountain ranges with mixed conifer and intermountain regions dominated by sagebrush steppe and grasslands (US North American Bird Conservation Initiative Committee 2000). This project used a spatially balanced sampling design and a survey protocol similar to that implemented in a program titled "Integrated Monitoring in Bird Conservation Regions (IMBCR)" (White et al. 2011). The IMBCR design allows inferences about avian species distributions and population sizes from small scales to entire BCRs, facilitating conservation at local and regional levels.

In 2010, we conducted 20 point count transect surveys, resulting in 209 individual point counts, in areas undergoing for either "high-development" (*n* = 15 transects, 153 points) or "low-development" (*n* = 5 transects, 56 points) to compare levels of avian biodiversity. By collecting data during and after energy development, RMBO and its partners can ascertain the impact of different levels of energy development on avian species richness. Surveys were conducted between May 15th and July 6th when the birds are known to be territorial and vocal. We observed 1,913 birds of 64 species during our surveys.

We used a multi-species extension to the multi-scale occupancy model to assess overall species richness among 14 avian species (total richness), species richness of 3 avian species designated as priority species by the Wyoming BLM (priority species richness), and the occupancy rates of each of the 14 individual species (species specific occupancy rates) at the transect and point levels. Results indicated that there is currently no difference in total richness or priority species richness across the areas undergoing high and low levels of resource development. Species richness was found to be higher within the Atlantic Rim BLM lands than within other BLM lands within BCR 10. Species specific occupancy rates differed across the two treatment groups in the Atlantic Rim, with some species preferring areas undergoing low levels of energy development while other species preferred areas undergoing high levels of energy development. The mixed response of avian species between the two treatment groups likely resulted in similar species richness between the two treatment groups.

ACKNOWLEDGEMENTS

Stratification and allocation of survey effort were determined in collaboration with the USDI Bureau of Land Management (BLM). Many individuals helped make the 2010 field season a success. We thank Frank Blomquist of the BLM-Wyoming for obtaining funds to conduct this research. We thank Chandman Sambuu who managed and updated the RMBO database and produced a new online mapping tool allowing for easier planning of field crew schedules and navigation to survey sites. Rob Sparks of RMBO produced a sample allocation map for this report. RMBO's landowner liaison, Jenny Berven, contacted county assessors to determine land ownership of survey locations. We thank Gary White, professor emeritus of Colorado State University, who implemented the multi-scale occupancy model in program MARK, which was used for estimating species richness. We also thank technicians Erik Nelson and Christine Rothenbach for collecting point count data and contacting private landowners to obtain access to survey locations and establish working relationships for the future. Without their efforts and the cooperation of private landowners RMBO would have been unable to conduct avian monitoring on private lands within the study area. Finally, this report benefited greatly from review by RMBO staff.

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INTRODUCTION

Monitoring is an essential component of wildlife management and conservation science (Witmer 2005, Marsh and Trenham 2008). Common goals of population monitoring are to estimate the population status of target species and to detect changes in populations over time (Thompson et al. 1998, Sauer and Knutson 2008). Effective monitoring programs can identify species that are at-risk due to small or declining populations (Dreitz et al. 2006), provide an understanding of how management actions affect populations (Alexander et al. 2008, Lyons et al. 2008), evaluate population responses to landscape alteration and climate change (Baron et al. 2008, Lindenmayer and Likens 2009) as well as provide basic information on species distributions.

The apparent large-scale declines of avian populations and the loss, fragmentation and degradation of native habitats highlight the need for extensive and rigorous landbird monitoring programs (Rich et al. 2004, US North American Bird Conservation Initiative Committee 2009). As natural areas are developed due to a continuously increasing demand for energy resources, it is imperative for land managers to better understand the impacts subsequent landscape changes have on wildlife communities. Higher road densities to facilitate resource transportation may lead to an increase in non-native vegetation along the roads and fragmented habitats. Tall structures resulting from development provide prominent perches which may aid predators in locating prey and/or may dissuade prey species from residing in the area. Furthermore, noise associated with increased traffic volume and the operation of oil and natural gas rigs may interfere with aspects of avian communication that are vital to territory advertisement and attracting mates (Ingelfinger and Anderson 2004, Holloran 2005).

Before monitoring can be used by land managers to guide conservation efforts, sound program designs and analytic methods are necessary to produce unbiased population estimates (Sauer and Knutson 2008). At the most fundamental level, reliable knowledge about the status of avian populations requires accounting for spatial variation and incomplete detection of the target species (Pollock et al. 2002, Rosenstock et al. 2002, Thompson 2002). Addressing spatial variation entails the use of probabilistic sampling designs that allow population estimates to be extended over the entire area of interest (Thompson et al. 1998). Adjusting for incomplete detection involves the use of appropriate sampling and analytic methods to address the fact that few, if any, species are so conspicuous that they are detected with certainty during surveys even when present (Pollock et al. 2002, Thompson 2002). Accounting for these two sources of variation ensures observed trends reflect true population changes rather than artifacts of sampling and observation processes (Pollock et al. 2002, Thompson 2002).

In order to provide local land managers with unbiased and reliable information regarding the effects of development on avian communities in Southern Wyoming, RMBO utilized a probabilistic sampling design based on the “Integrated Monitoring in Bird Conservation Regions (IMBCR)”(Hanni et al. 2009) design for this study. Important properties of the IMBCR design that relate to this study are:

- All vegetation types are available for sampling.
- Strata are based on fixed attributes; this will allow us to relate changes in bird populations to changes on the landscape through time.
- Local population trends can be directly compared to regional trends.
- Coordination among partners can reduce the costs of monitoring per partner.

Using the IMBCR design, RMBO’S monitoring objectives are to:

1. Provide a design framework to spatially integrate existing bird monitoring efforts in the region to provide better information on distribution and abundance of breeding landbirds, especially for high priority species;
2. Provide basic habitat association data for most bird species to address habitat management issues;
3. Provide robust occupancy estimates that account for incomplete detection and are comparable at different geographic extents;
4. 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;

The collection of occupancy and species richness data during and after the installation of roads and pads to facilitate resource extraction will allow RMBO and its partners to determine the relative effect of resource development on the avian community.

METHODS

Study Area

The study area was defined by the Atlantic Rim Natural Gas Development Project (hereafter, "Atlantic Rim") and was composed predominantly of sagebrush and semi-desert shrublands. The 1,085 km^2 study area was located South of Rawlins, WY between Highways 789 and 71 and bordered to the South by Highway 70 (Figure 1). In addition, Atlantic Rim data were compared to data collected under the IMBCR design on BLM lands within BCR 10.

Sampling Design

RMBO and its partners divided the study area into two separate sampling frames (strata) based on different levels of proposed energy development (low and high-intensity; Figure 1) following the IMBCR design. These strata represent the area selected to make inferences about avian occupancy and species richness. Additional data were obtained on BLM lands within BCR 10 through the IMBCR monitoring program (Hanni et al. 2009) to compare Atlantic Rim species richness and occupancy to areas of similar habitat and management techniques.

Within each stratum, the IMBCR design used generalized random-tessellation stratification (GRTS), a spatially balanced sampling algorithm, to select sample units (Stevens and Olsen 2004). Spatial data and grid cells were compiled and selected using ARCGIS 9.2 (ESRI 1999).

- The GRTS design has several appealing properties with respect to long-term monitoring of birds at large spatial scales: Spatially-balanced sampling is generally more efficient than simple random sampling of natural resources (Stevens and Olsen 2004). Incorporating information about spatial autocorrelation in the data can increase precision of density estimates;

- All grid cells 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, we can adjust the sampling effort among years within each stratum while still preserving a random, spatially-balanced sampling design.

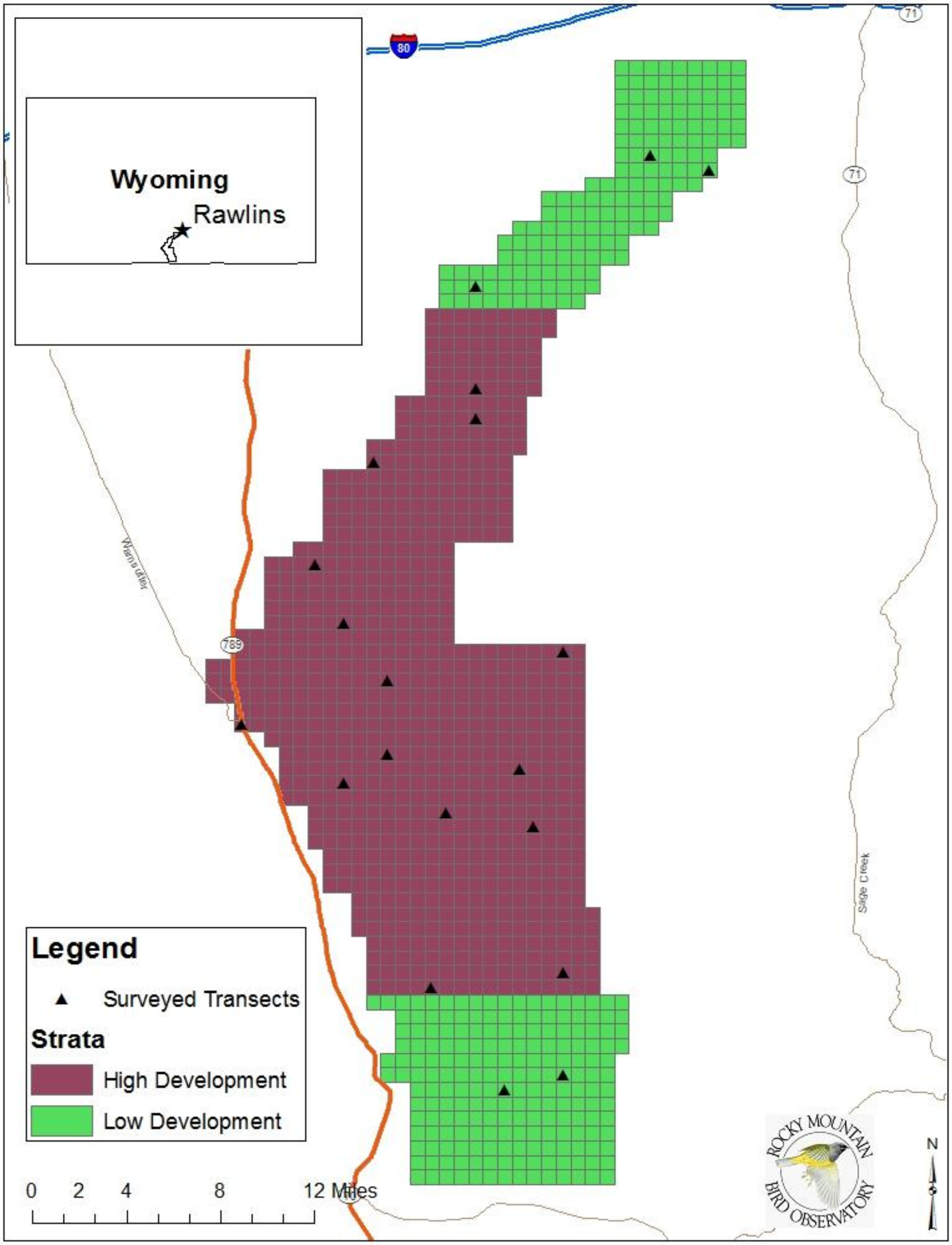


Figure 1. Study area and survey locations on the Atlantic Rim study area in southern Wyoming.

Sampling Methods
Within each grid cell we established a 4 x 4 grid of 16 points spaced 250 meters apart. We surveyed birds from points using methods that allow for estimating detection probability through the principles of Removal and Occupancy modeling. Removal modeling is based on mark-recapture theory; detection probability is estimated based on the number of birds detected during consecutive sampling intervals (Farnsworth et al. 2002). In this design, the complete sampling period at a point consisted of three sampling intervals each consisting of two-minute segments.

Occupancy estimation is most commonly used to quantify the proportion of sample units (e.g., grid cells) occupied by an organism (MacKenzie et al. 2002). The application of occupancy models requires multiple surveys of the sample unit in space or time to estimate a detection probability (MacKenzie et al. 2006). 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). 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).

RMBO staff and biological technicians with excellent aural and visual bird-identification skills conducted field work between May 15th and July 20th in 2010. Prior to conducting surveys, technicians completed an intensive five-day training program to ensure technicians had a complete understanding of field protocols and sufficient knowledge of bird identification.

Field technicians conducted point counts (Buckland et al. 2001) following protocol established by RMBO (Hanni et al. 2009). Observers surveyed in the morning, beginning ½-hour before sunrise and concluding their survey no later than 11 AM. The complete sampling interval at each point was six minutes. For every bird detected during each of the six minute counts, we recorded species, sex, horizontal distance from the observer, minute we detected the bird, and type of detection (e.g., call, song, visual). Observers measured distances using laser rangefinders. When it was not possible to measure the distance to a bird, observers estimated distance by measuring to some nearby object. Observers recorded birds flying over but not using the immediate surrounding landscape. The “flyover” detections were not included in the estimates of occupancy as it was unclear whether these birds were actively occupying the site. We 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 independent observations. Observers recorded 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, ambient temperature, cloud cover, precipitation, and wind speed. Technicians navigated to each point using hand-held Global Positioning System (GPS) units. Before beginning each count, surveyors recorded vegetation data (within a 50 meter radius) and distance from a road (if within 100 meters). We recorded vegetation data according to the dominant habitat type and structural stage, and the relative abundance, percent cover, and mean height of trees and shrubs by species, as well as grass height and groundcover. We recorded vegetation data quietly to allow birds, potentially disturbed by our approach, time to return to their normal habits prior to the beginning of each count.

For more detailed information about survey methods, refer to RMBO’s Field Protocol for Spatially Balanced Sampling of Landbird Populations on our Avian Data Center website:

http://www.rmbo.org/PUBLIC/MONITORING/protocols/Field_protocol_for_spacially_balanced_sampling_final_2010.pdf.

Data Analysis

We used detections of 14 species [Black-billed Magpie (*Pica husonia*), Brown-headed Cowbird (*Molothrus ater*), Brewer's Sparrow (*Spizella breweri*), Dusky Flycatcher (*Empidonax oberholseri*), Green-tailed Towhee (*Pipilo chlorurus*), Horned Lark (*Eremophila alpestris*), Lark Sparrow (*Chondestes grammacus*), Mourning Dove (*Zenaida macroura*), Sage Sparrow (*Amphispiza belli*), Say's Phoebe (*Sayornis saya*), Sage Thrasher (*Oreoscoptes montanus*), Savannah Sparrow (*Passerculus sandwishensis*), Vesper Sparrow (*Pooecetes gramineus*) and Western Meadowlark (*Sturnella neglecta*)] from all BLM lands within BCR10 collected under the IMBCR design for analyses in this report, including the Atlantic Rim. By utilizing data collected outside of the Atlantic Rim we were able to produce more precise estimates of detection probabilities for individual species. The estimates of occupancy and species richness in BLM lands within BCR10 also provided a regional context for the Atlantic Rim estimates. Of the species analyzed, three are considered priority species by BLM in Wyoming (Brewer's Sparrow, Sage Sparrow, and Sage Thrasher). We truncated the data, using only detections within 125 meters of the sample points to use bird detections over a consistent plot size and to ensure that data were independent (points were spread 250 meters apart).

Under the sampling framework, we used a removal design (MacKenzie et al. 2006) to estimate a separate detection probability for 13 of the species listed above. Due to an insufficient number of detections of Savannah Sparrows, we set the detection probability for Savannah Sparrow equal to that of the Vesper Sparrow. By binning minutes 1 and 2, minutes 3 and 4, and minutes 5 and 6 into 3 sequential sampling intervals we met the assumption of a monotonic decline in detection rates through time. After each target species was detected at a point, we set all subsequent sampling intervals at that point to missing data (MacKenzie et al. 2006).

The 16 points within a transect served as spatial replicates for estimating the proportion of points occupied within each sampled grid cell. We used a multi-species extension to the multi-scale occupancy model (Nichols et al. 2008) to estimate 1) the probability of detecting a species given presence (p); 2) the proportion of points occupied by a species given presence within sampled grid cells (Theta); and 3) the proportion of grid cells occupied by a species (Psi). All models were fit using program MARK (White and Burnham 1999).

Our application of the multi-species multi-scale model was analogous to a within-season robust design (Pollock 1982) in which the minute intervals at each point were the secondary samples for estimating p and the points were the primary samples for estimating Theta (Nichols et al. 2008). Under the multi-species multi-scale occupancy models for species richness Psi represents the proportion of the species on the species list that are expected to occupy each transect and Theta represents the proportion of species occupying the transect that are expected to be present at an individual point.

We compared species richness among three treatment levels; all other BLM lands in BCR 10 outside the Atlantic Rim study area, the area undergoing high-development in the Atlantic Rim study area, and the area undergoing low-development in the Atlantic Rim study area using detection data for the 14 species listed above. In total, we evaluated the strength of evidence for four models using Akaike's Information Criterion (AIC) corrected for small sample size (AICc), and model selection theory, to select the most parsimonious model (Burnham and Anderson 2002). We report estimates derived from a single model which estimated Psi and Theta separately for each of the three treatment levels in order to produce treatment-specific estimates. Next, we compared species richness across the same treatment levels using data for only the three Wyoming BLM priority species listed above. We assessed four models using AICc to evaluate differences in richness for these three species. We evaluated the effects sizes of Psi and Theta for treatments by assessing 95% confidence intervals (CI) of the beta parameters with respect to zero. Finally, we produced individual Psi and Theta estimates of the14 species for each of the 3 treatment levels to assess species-specific responses across the two treatment groups within the Atlantic Rim.

RESULTS

Total Species Richness

The top model investigating potential differences in species richness between the high and low-development sections of the Atlantic Rim estimated a common Psi and Theta parameter for the two Atlantic Rim treatment groups and a separate Psi and Theta for the rest of BLM lands within BCR 10 (Table 1). This indicated that there was little difference in species richness across the two treatments within the Atlantic Rim study area. The second-ranking model was within two AICc of the top model; however, the addition of the parameter for the treatment effect for the proposed high and low-development portions of the Atlantic Rim did not appreciably increase model fit (deviance values of 8307.9 and 8306.7 for the first and second ranking models, respectively). No difference in species richness between the proposed high and low-development portions of the Atlantic Rim was also evidenced by beta parameter estimates for the effects of the low-development region when compared to the high-development region (β_{Psi} = -0.34; 95% CI = -1.13, 0.45; β_{Theta} = 0.17; 95% CI = -0.13, 0.47). Although results indicated that species richness within the Atlantic Rim was similar, species richness was higher in the Atlantic Rim than in other BLM lands within BCR 10 at the transect and point levels (β_{Psi} = 1.01; 95% CI = 0.61, 1.42; β_{Theta} = 0.22; 95% CI = 0.06, 0.37). We presented the estimated species richness expected at the transect and point levels for the three treatment regions in Tables 2 and 3, respectively.

Table 1. Ranking of four models investigating differences in species richness via Psi (the proportion of the 14 species occupying a transect) and Theta (proportion of expected species on the transect that, on average, occupied individual points) for breeding birds in all BLM lands within BCR 10 (BCR10), the high-development region of the Atlantic Rim (Hi), and the low-development region of the Atlantic Rim in 2010 (Lo).

Model	Delta AICc§	AICc Weights*	K†
p(Spp) Theta(BCR10, Hi+Lo) Psi(BCR10, Hi+Lo)	0.00	0.40	18
p(Spp) Theta(BCR10, Hi, Lo) Psi(BCR10, Hi+Lo)	0.90	0.25	19
p(Spp) Theta(BCR10, Hi+Lo) Psi(BCR10, Hi, Lo)	1.53	0.19	19
p(Spp) Theta(BCR10, Hi, Lo) Psi(BCR10, Hi, Lo)	2.28	0.13	20

§difference in AICc units between a given model and the top-ranking model
*probability that a given model is the best-approximating model of the models in the set.
†number of parameters included in the model

Table 2. Estimated number of species expected to be present on a transect (Trans Species), and lower (Species LCL) and upper (Species UCL) 95% confidence limits. Results are displayed for BLM lands within BCR 10 (BCR 10 BLM), the proposed high-development (ARIM-Hi) and low-development (ARIM-Lo) regions of the Atlantic Rim.

Treatment	Trans Species	Species LCL	Species UCL
Richness of 14 species analyzed			
BCR 10 BLM	6.1	5.4	6.8
ARIM-Hi	9.8	8.4	10.9
ARIM-Lo	8.7	6.3	10.7
Richness of 3 BLM priority species analyzed			
BCR 10 BLM	0.8	0.7	1.0
ARIM-Hi	1.5	1.2	1.8
ARIM-Lo	1.2	0.8	1.7

Table 3. Estimated number of species expected to be present on a point (Point Species), and lower (Species LCL) and upper (Species UCL) 95% confidence limits. Results are displayed for BLM lands within BCR 10 (BCR 10 BLM), the proposed high-development (ARIM-Hi) and low-development (ARIM-Lo) regions of the Atlantic Rim.

Treatment	Point Species	Species LCL	Species UCL
Richness of 14 species analyzed			
BCR 10 BLM	3.1	2.9	3.2
ARIM-Hi	5.3	5.0	5.7
ARIM-Lo	5.1	4.6	5.6
Richness of 3 BLM priority species analyzed			
BCR 10 BLM	0.4	0.4	0.4
ARIM-Hi	0.8	0.7	0.8
ARIM-Lo	0.6	0.6	0.7

Priority Species Richness

Results of the analyses for priority species richness were similar to the results of the total species richness. Again, the top model estimated a common Psi and Theta parameter for the two Atlantic Rim treatment groups and a separate Psi and Theta for the rest of BLM lands within BCR 10 (Table 4). The second ranked model, which estimated Psi separately for all three treatment groups, explained little additional variation despite the added parameter (deviance values for the top two ranked models = 8298.4 and 8297.0, respectively). This indicated that there was no difference in priority species richness between treatment groups within the Atlantic Rim study area. The 95% confidence intervals for the beta estimates comparing the proposed high and low-development regions covered zero (β_{Psi} = -0.12; 95% CI = -1.46, 1.22; β_{Theta} = 0.28 95% CI = -0.19, 0.75), indicating no difference in richness of priority species between the Atlantic Rim treatment groups. As in the analyses of total species richness, priority species richness estimates produced by the top model indicate that priority species richness in the Atlantic Rim is higher than in other BLM lands within BCR 10 at both the transect and point levels (β_{Psi} = 0.83; 95% CI = 0.15, 1.51; β_{Theta} = 0.39; 95% CI = 0.15, 0.62). We presented the estimated species richness for the three treatment regions in Table 2.

Table 4. Ranking of four models investigating differences in species richness via Psi (the proportion of transects occupied) and Theta (proportion of points occupied given that the

species was detected on the transect) for Brewer's Sparrow, Sage Sparrow, and Sage Thrasher in all BLM lands within BCR 10 (BCR10), the high-development region of the Atlantic Rim (Hi), and the low-development region of the Atlantic Rim in 2010 (Lo).

Model	Delta AICc§	AICc Weights*	K†
p(SppC) Theta(BCR10, Hi+Lo) Psi(BCR10, Hi+Lo)	0.00	0.43	21
p(SppC) Theta(BCR10, Hi, Lo) Psi(BCR10, Hi+Lo)	0.66	0.31	22
p(SppC) Theta(BCR10, Hi+Lo) Psi(BCR10, Hi, Lo)	2.06	0.15	22
p(SppC) Theta(BCR10, Hi, Low) Psi(BCR10, Hi, Lo)	2.73	0.11	23

§difference in AICc units between a given model and the top-ranking model
*probability that a given model is the best-approximating model of the models in the set.
†number of parameters included in the model

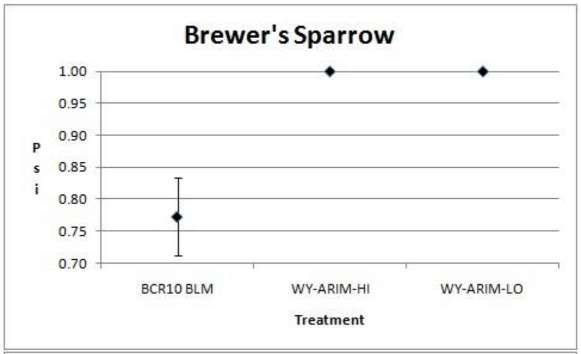
Single Species
Occupancy analyses are most effective when some surveyed areas are occupied by a particular target species while others are not. Unfortunately, due to small sample sizes, nine species were either detected on all transects (ex: Brewer's Sparrow) or not detected on any transects (e.g., Black-billed Magpie) within a particular treatment group (Table 5). Additionally, we were unable to estimate Psi when the number of transects occupied (*n* Tran) was equal to the total number of transects (S), and we were unable to estimate Theta when the species occurred on a single point on a transect. The dashes in Table 5 indicated the data were insufficient for estimating occupancy.

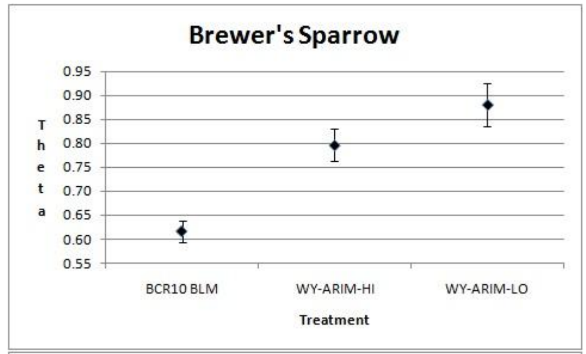
Results of the single species occupancy analyses indicate that most species occupy a similar proportion of transects (Psi) across the two treatment groups within the Atlantic Rim (Figure 2). The Sage Sparrow was the only species for which Psi estimates differed substantially, with a higher proportion of transects being occupied within the low-development area. The proportion of points occupied given that the species was detected on the transect (Theta) differed substantially between the two Atlantic Rim treatment groups for four species. Brewer's Sparrow, Green-tailed Towhee and Horned Lark occupied a significantly higher proportion of points in the low-development area than in the high-development area (Figure 2). Conversely, Sage Thrasher occupied a significantly higher proportion of points in the high-development area than in the low-development area (Figure 2).

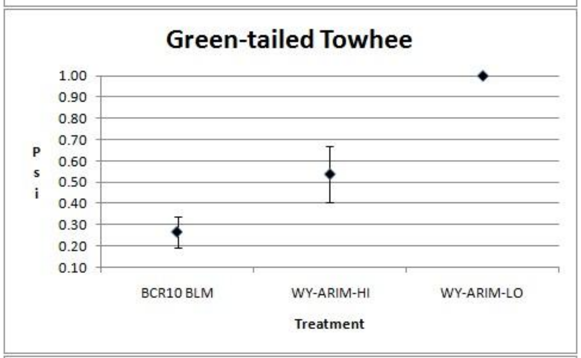
Table 5. Estimated proportion of sample units occupied (Psi), the standard error associated with the Psi estimate (Psi SE), number of transects with one or more detections (n Tran), the proportion of points occupied given that the species was detected on the transect (Theta), the standard error associated with the Theta estimate (Theta SE), and the number of points with one or more detections (n Pt) of breeding bird species for all BLM lands within BCR 10 (BCR 10 BLM), the high-development region of the Atlantic Rim (WY-ARIM-Hi), and the low-development region of the Atlantic Rim (WY-ARIM-Lo) in 2010. Dashes indicated the data were insufficient for estimating occupancy. S indicates the number of transects surveyed. Priority species, designated by the BLM in Wyoming, are bolded.

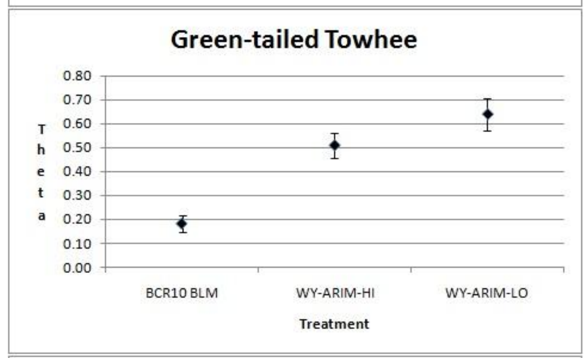
Species	Treatment	S	Psi	Psi SE	*n* Tran	Theta	Theta SE	*n* Points
Black-billed Magpie	BCR 10 BLM	48	0.12	0.10	3	0.06	0.06	4
	WY-ARIM-Hi	15	0	-	0	0	-	0
	WY-ARIM-Lo	5	0.33	0.35	1	0.09	0.08	2
Brown-headed Cowbird	BCR 10 BLM	48	-	-	4	-	-	4
	WY-ARIM-Hi	15	0.58	0.17	7	0.21	0.06	17

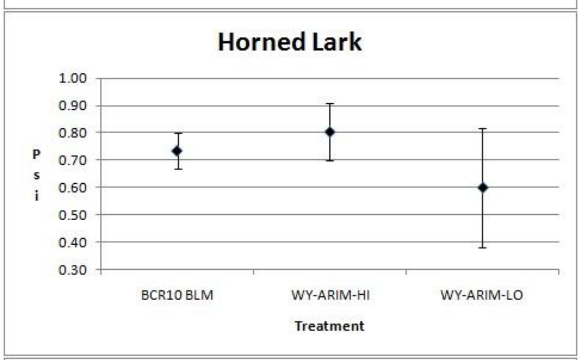
Species	Treatment	S	Psi	Psi SE	*n* Tran	Theta	Theta SE	*n* Points
	WY-ARIM-Lo	5	0.42	0.23	2	0.35	0.11	10
Brewer's Sparrow	BCR 10 BLM	48	0.77	0.06	37	0.62	0.02	290
	WY-ARIM-Hi	15	1	-	15	0.80	0.03	121
	WY-ARIM-Lo	5	1	-	5	0.88	0.04	49
Dusky Flycatcher	BCR 10 BLM	48	0.14	0.06	6	0.19	0.06	13
	WY-ARIM-Hi	15	0.32	0.18	3	0.12	0.06	7
	WY-ARIM-Lo	5	0	-	0	0	-	0
Green-tailed Towhee	BCR 10 BLM	48	0.27	0.07	11	0.18	0.04	28
	WY-ARIM-Hi	15	0.54	0.13	8	0.51	0.05	48
	WY-ARIM-Lo	5	1	-	5	0.64	0.07	35
Horned Lark	BCR 10 BLM	48	0.73	0.06	35	0.59	0.02	278
	WY-ARIM-Hi	15	0.80	0.10	12	0.65	0.04	79
	WY-ARIM-Lo	5	0.60	0.22	3	0.80	0.08	19
Lark Sparrow	BCR 10 BLM	48	0.09	0.04	4	0.39	0.10	16
	WY-ARIM-Hi	15	-	-	1	-	-	1
	WY-ARIM-Lo	5	0	-	0	0	-	0
Mourning Dove	BCR 10 BLM	48	-	-	3	-	-	3
	WY-ARIM-Hi	15	0.24	0.13	3	0.45	0.87	6
	WY-ARIM-Lo	5	0	-	0	0	-	0
Sage Sparrow	BCR 10 BLM	48	0.42	0.07	20	0.51	0.03	148
	WY-ARIM-Hi	15	0.52	0.15	7	0.23	0.05	19
	WY-ARIM-Lo	5	0.60	0.22	3	0.42	0.10	10
Say's Phoebe	BCR 10 BLM	48	0.17	0.07	6	0.12	0.05	11
	WY-ARIM-Hi	15	0.34	0.33	2	0.06	0.05	3
	WY-ARIM-Lo	5	0	-	0	0	-	0
Sage Thrasher	BCR 10 BLM	48	0.52	0.07	24	0.33	0.03	107
	WY-ARIM-Hi	15	0.80	0.10	12	0.52	0.05	57
	WY-ARIM-Lo	5	0.60	0.22	3	0.34	0.10	8
Savannah Sparrow	BCR 10 BLM	48	0.06	0.04	3	0.32	0.10	8
	WY-ARIM-Hi	15	-	-	1	-	-	1
	WY-ARIM-Lo	5	0	-	0	0	-	0
Vesper Sparrow	BCR 10 BLM	48	0.65	0.07	31	0.49	0.03	184
	WY-ARIM-Hi	15	1	-	14	0.45	0.04	68
	WY-ARIM-Lo	5	1	-	5	0.38	0.07	21
Western Meadowlark	BCR 10 BLM	48	0.21	0.06	10	0.48	0.05	50
	WY-ARIM-Hi	15	0.62	0.13	9	0.37	0.06	31
	WY-ARIM-Lo	5	0.22	0.20	1	0.25	0.12	4

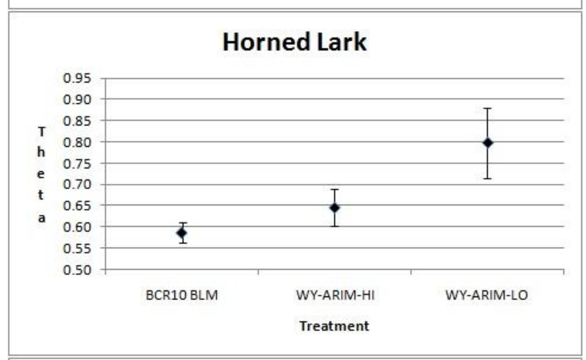

Brewer's Sparrow
1.00
0.95
0.90
0.85
0.80
0.75
0.70
Psi
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment

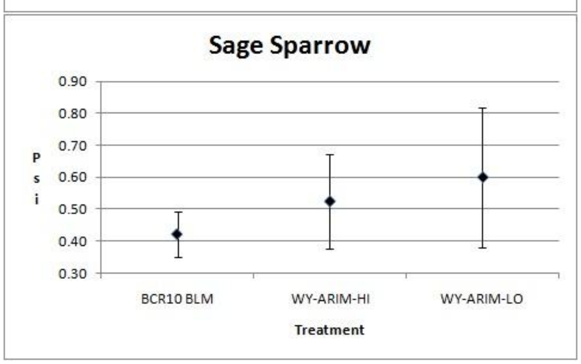

Brewer's Sparrow
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
Theta
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment

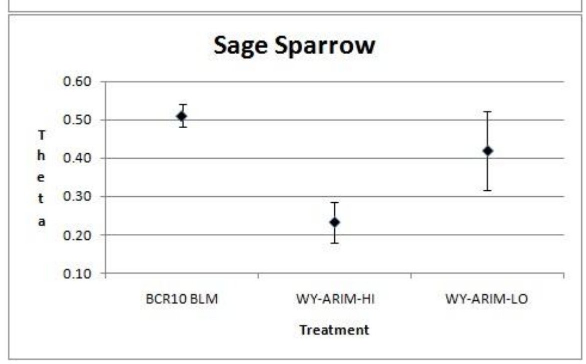

Green-tailed Towhee
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
Psi
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment


Green-tailed Towhee
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Theta
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment


Horned Lark
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
Psi
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment


Horned Lark
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
Theta
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment


Sage Sparrow
0.90
0.80
0.70
0.60
0.50
0.40
0.30
Psi
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment


Sage Sparrow
0.60
0.50
0.40
0.30
0.20
0.10
Theta
BCR10 BLM
WY-ARIM-HI
WY-ARIM-LO
Treatment

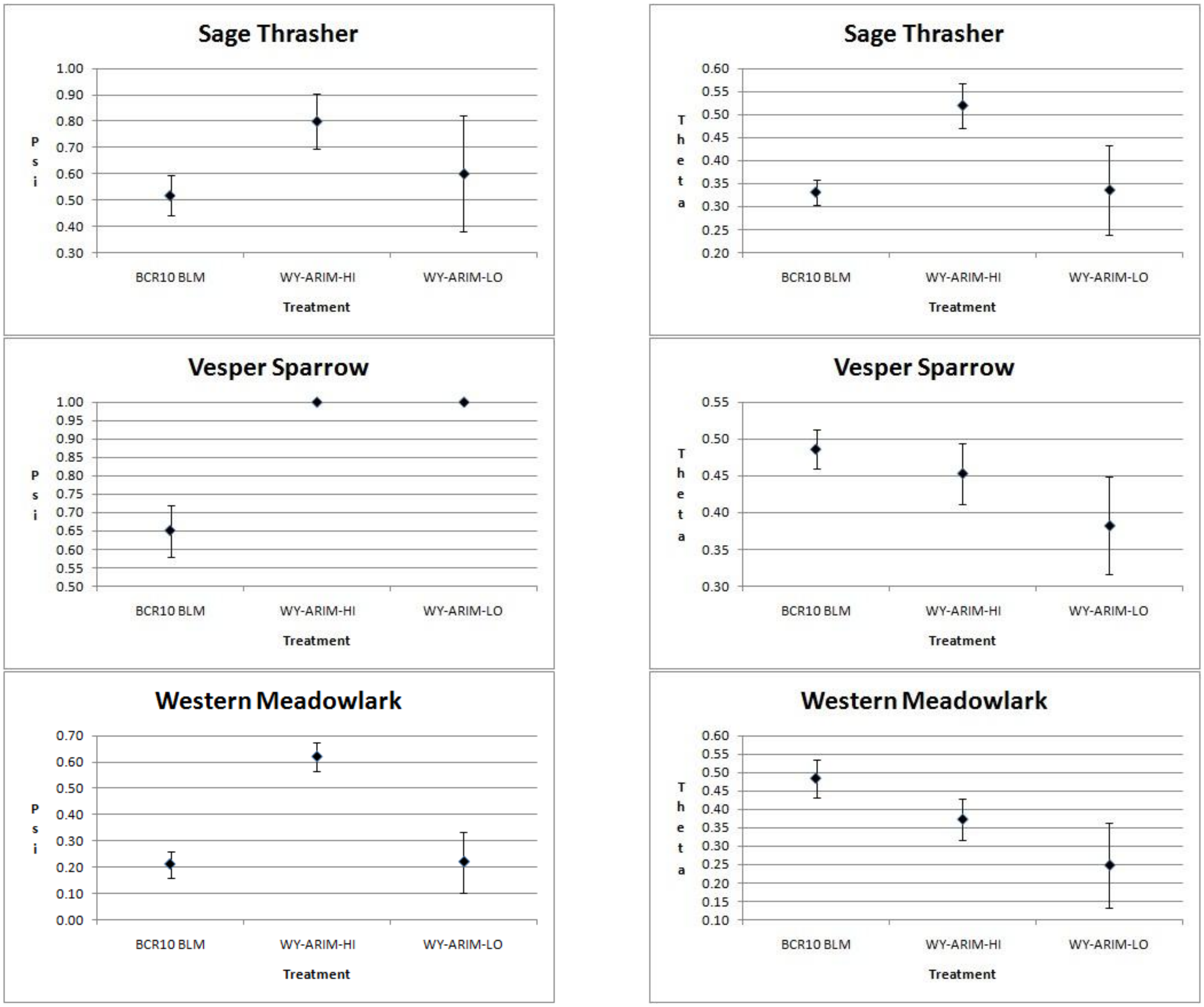


Figure 2. Estimated proportion of sample units occupied (Psi) and the proportion of points occupied given that the species was detected on the transect (Theta) for species on all BLM lands within BCR10 (BCR10 BLM), the high-development region of the Atlantic Rim study area (WY-ARIM-HI), and the low-development region of the Atlantic Rim study area (WY-ARIM-LO) in 2010. Error bars represent the standard errors associated with the estimates.

DISCUSSION

The similarity in total species richness and priority species richness across the two Atlantic Rim treatments is unsurprising considering the treatment (different intensities of energy development) has yet to be fully implemented. Individual species occupancy rates did vary between treatment groups with some species demonstrating increased occupancy while others demonstrated reduced occupancy within the low and high-development areas. Because the response within treatment groups was mixed among the suite of species investigated, overall richness of the two areas was very similar.

As new infrastructure continues to be constructed in order to facilitate resource extraction we expect some species inhabiting the Atlantic Rim area to be positively affected while others will be negatively affected. Past research has shown that species which forage in open areas where seeds may collect as a result of prevailing winds (e.g., Horned Lark) can be positively impacted by higher road densities. Additionally, some species (e.g., Brewer's Sparrow) may be negatively affected by habitat fragmentation and disturbance to surrounding vegetation (Ingelfinger and Anderson 2004).

The higher overall richness and site occupancy within the Atlantic Rim study area compared to other BLM lands within BCR 10 indicates that the Atlantic Rim represents important habitat for a number of species inhabiting sagebrush and semi-desert shrubland environments. This study did not investigate potential differences in landscape characteristics, habitat structure or management practices that might explain the difference in occupancy and species richness between the Atlantic Rim and other BLM lands within BCR 10. Future work to determine the factors influencing these differences could identify characteristics important for maintaining high species richness and occupancy rates. We believe this information would be extremely beneficial to BLM managers throughout BCR 10.

This project signifies an important first step in assessing the impact of energy development by obtaining data before the additional infrastructure development is completed. Continued monitoring during and after the implementation of the treatment will provide important information regarding the avian response to energy development within the Atlantic Rim. In particular, the ability to monitor overall avian community richness and the response of individual species to this development will guide land managers in determining optimal development intensities and locations for the future. Of particular importance, results from continued monitoring will inform managers on the effect of development on priority sagebrush-obligate species.

LITERATURE CITED

Alexander, J. D., J. L. Stevens, G. R. Geupel, and T. C. Will. 2008. Decision support tools: bridging the gap between science and management. Pages 283-291 *in* Proceedings of the Fourth International Partners in Flight Conference: Tundra to Tropics. 13 February-16 February, 2008, McAllen, TX, USA.

Baron, J. S., S. H. Julius, J. M. West, L. A. Joyce, G. Blate, C. H. Peterson, M. Palmer, B. D. Keller, P. Kareiva, J. M. Scott, and B. Griffith. 2008. Some guidelines for helping natural resources adapt to climate change. International Human Dimensions Programme on Global Environmental Change Update 2:46-52.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University Press, Oxford, UK.

Dreitz, V. J., P. M. Lukacs, and F. L. Knopf. 2006. Monitoring low density avian populations: An example using Mountain Plovers. Condor 108:700-706.

Environmental Systems Research Institute (ESRI). 1999. ArcGIS, version 9.2. Environmental Systems Research Institute, Incorporated, Redlands.

Farnsworth, G. L., K. H. Pollock, J. D. Nichols, T. R. Simons, J. E. Hines, and J. R. Sauer. 2002. A removal model for estimating detection probabilities from point-count surveys. Auk 119:414-425.

Hanni, D. J., C. M. White, J. A. Blakesley, G. J. Levandoski, and J. J. Birek. 2009. Field protocol for spatially-balanced sampling of landbird populations. Unpublished report. Rocky Mountain Bird Observatory, Brighton, CO, USA.

Holloran, M. J. 2005. Greater Sage-Grouse (Centrocercus urophasianus) Population Response to Natural Gas Field Development in Western Wyoming. Dissertation, University of Wyoming, Laramie, Wyoming, USA.

Ingelfinger, F., and S. Anderson. 2004. Passerine Response To Roads Associated With Natural Gas Extraction In A Sagebrush Steppe Habitat. Western North American Naturalist 64:385-395.

Lindenmayer, D. B., and G. E. Likens. 2009. Adaptive monitoring: a new paradigm for long-term research and monitoring. Trends in Ecology and Evolution 24:482-486.

Lyons, J. E., M. C. Runge, H. P. Laskowski, and W. L. Kendall. 2008. Monitoring in the context of structured decision-making and adaptive management. Journal of Wildlife Management 72:1683-1692.

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., 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, MA, USA.

Marsh, D. M., and P. C. Trenham. 2008. Current trends in plant and animal population monitoring. Conservation Biology 22:647-655.

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 modelling using multiple detection methods. Journal of Applied Ecology 45:1321-1329.

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

Pollock, K. H., J. D. Nichols, T. R. Simons, G. L. Farnsworth, L. L. Bailey, and J. R. Sauer. 2002. Large scale wildlife monitoring studies: statistical methods for design and analysis. Environmetrics 13:105-119.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, and T. C. Will. 2004. Partners in Flight North American landbird conservation plan. Cornell Lab of Ornithology, Ithaca, NY, USA.

Rosenstock, S. S., D. R. Anderson, K. M. Giesen, T. Leukering, and M. F. Carter. 2002. Landbird counting techniques: current practices and an alternative. Auk 119:46-53.

Sauer, J. R., and M. G. Knutson. 2008. Objectives and metrics for wildlife monitoring. Journal of Wildlife Management 72:1663-1664.

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

Thompson, W. L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. Auk 119:18-25.

Thompson, W. L., G. C. White, and C. Gowan. 1998. Monitoring vertebrate populations. Academic Press, San Diego, CA, USA.

US North American Bird Conservation Initiative Committee. 2000. Bird Conservation Regions descriptions: a supplement to the North American Bird Conservation Initiative: Bird Conservation Regions map. US Fish and Wildlife Service, Arlington, VA, USA.

2009. The State of the Birds, United States of America, 2009. U.S. Department of Interior, Washington, D.C., USA. <http://www.stateofthebirds.org/pdf_files/State%20of%20the%20Birds_FINAL.pdf>. Accessed 1 December, 2010.

White, C. M., N. J. Van Lanen, J. J. Birek, J. M. Stenger, J. A. Rehm-Lorber, D.C. Pavlacky Jr., J. A. Blakesley, R. A. Sparks, F. Cardone, and D. J. Hanni. 2011. Integrated Monitoring of Bird Conservation Regions (IMBCR): 2010 Annual Report. Rocky Mountain Bird Observatory. Brighton, Colorado, USA.

White, G. C., and K. P. Burnham. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study 46:120-139.

Witmer, G. W. 2005. Wildlife population monitoring: some practical considerations. Wildlife Research 32:259-263.