

Does the presence of an observer affect a bird's occurrence rate or singing rate during a point count?

Richard L. Hutto,¹  and Russell R. Hutto

Division of Biological Sciences, University of Montana, Missoula, Montana 59812, USA

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ABSTRACT. The approach or presence of an observer may affect the behavior of nearby birds, rendering them either more or less detectable than when no observer is present due to a change in singing rates. To test whether there are systematic detection biases associated with the presence of an observer during point count bird surveys, we compared the occurrence and singing rates of birds during a 10-min period immediately preceding the time when an observer arrived to conduct a count and during the formal count itself by extracting song information from autonomous sound recorders. We obtained recordings of 36 species of birds detected at ≥ 5 locations in one of three vegetation types, including burned conifer forest, green conifer/riparian streamside forest, and riparian bottomland/marshland. We found that species richness and both the probability of occurrence and singing rate for any of the species recorded were unaffected by the presence of an observer. In addition, the probability of occurrence did not differ significantly among four 2.5-min recording sessions during 10-min counts when an observer was present. Thus, the presence of an observer did not appear to introduce any detectable systematic bias that would make bird lists or unadjusted occurrence rates inaccurate on that basis alone. In addition, rates of bird occurrence across 2.5-min temporal subsets of a 10-min count did not vary in a systematic way that would violate the assumption of equal occupancy across adjacent time periods as sometimes used to build detection histories in occupancy modeling.

RESUMEN. ¿La presencia de un observador afecta la tasa de ocurrencia o canto de un ave durante un conteo por puntos?

El acercamiento o la presencia de un observador puede afectar el comportamiento de las aves cercanas, haciéndolas más o menos detectables que cuando no hay ningún observador debido a un cambio en las tasas de canto. Para probar si hay sesgos sistemáticos de detección asociados con la presencia de un observador durante los estudios de conteo por puntos de aves, comparamos las tasas de ocurrencia y canto de las aves durante un período de 10 minutos inmediatamente anterior al momento en que llegó un observador para realizar un conteo y durante el conteo formal mismo extrayendo información de canciones de grabadoras de sonido autónomas. Obtuvimos registros de 36 especies de aves detectadas en \geq cinco ubicaciones en uno de los tres tipos de vegetación, incluyendo bosques de coníferas quemados, coníferas verdes/bosques en galería riparios y tierras bajas ribereñas/ pantanos. Encontramos que la riqueza de especies y la probabilidad de ocurrencia y la tasa de canto para cualquiera de las especies registradas no se vieron afectadas por la presencia de un observador. Además, la probabilidad de ocurrencia no difirió significativamente entre cuatro sesiones de grabación de 2.5 minutos durante conteos de 10 minutos cuando un observador estuvo presente. Por lo tanto, la presencia de un observador no parecería introducir ningún sesgo sistemático detectable que hiciera que las listas de aves o las tasas de ocurrencia no ajustadas fueran inexactas sólo sobre esa base. Además, las tasas de ocurrencia de aves en subgrupos temporales de 2.5 minutos de un recuento de 10 minutos no variaron en una manera sistemática que violaría la suposición de ocupación igual a través de períodos de tiempo adyacentes, como a veces se usa para construir historias de detección en el modelado de ocupación.

Key words: autonomous recording unit, bird survey, detectability, observer effect, occupancy, passive acoustic sampling, point count, singing rate

Individuals belonging to a wide range of wildlife species will move away upon the approach of a human observer (Gutzwiller et al. 1998). Nevertheless, the allometry of behavior (Dial et al. 2008) dictates that because smaller organisms have a higher power-to-mass ratio, they are inherently more mobile and less threatened by the approach

of what might otherwise be a potential threat. This means that larger species of birds are more likely than smaller species to react to the approach of a human (Fernández-Juricic et al. 2001), which is why survey techniques such as point counts or transects are more likely to be effective survey tools for small landbird species than for relatively large shorebirds, waterfowl, or grouse. Importantly, because small landbirds should be relatively

¹Corresponding author. Email: hutto@mso.umt.edu

unaffected by observers, data associated with landbird surveys are thought to meet an important assumption that individuals do not respond to observers to an extent that their movement affects their probability of detection or their profiles of detection distances.

Although small birds are thought to be relatively unaffected by the presence of an observer, observations of both attraction and avoidance (Darras et al. 2019) suggest that there might be systematic biases associated with the presence of an observer during bird surveys. Whether the movement of birds in response to human observers is enough to affect bird survey results is an important question. Perhaps the closest we can get to making an observer invisible and then compare survey results with and without the observer present is to use autonomous recording systems. Indeed, more than 93% of landbird detections are aural (based on 302,134 bird detections for which detection cue information was available in the USFS Northern Region Landbird Monitoring Program database). Autonomous recording data might, therefore, allow comparison of the results of bird surveys between times when an observer is present and absent.

Autonomous recording units allow determination of both the presence of bird species and their singing rates. Recordings can, therefore, be used to assess whether the presence of an observer affects either the probability that a species is detected or a bird's overall singing rate or the temporal pattern of its singing rate changes when an observer is present. If the presence of an observer affects any of these measures, the accuracy of bird survey data may be compromised because overall bird detection rates are biased or because there is bias due to systematic changes in detection rates across 2.5-min time periods within a 10-min count.

Brandes (2008) suggested that a potentially fruitful research direction would be to set up autonomous recording units (ARUs) to record before and after an observer arrives at a sampling location, and use the data to determine whether standard field sampling techniques might be sensitive to the presence of an observer. Bye et al. (2001) had, in fact, already deployed autonomous recorders at four locations in the grasslands of Kansas and found that neither species richness nor total

numbers of bird vocalizations differed significantly between 5-min periods when an observer was present and an hour later in the absence of an observer. Subsequently, Campbell and Francis (2012) deployed 16 microphone arrays in old fields of Ontario and found no effect of observers on either the presence of birds or their locations.

In contrast to previous ARU studies (Bye et al. 2001, Campbell and Francis 2012) conducted in low-statured vegetation, we deployed ARUs across three different western forest types and compared sound recordings made during and immediately preceding point count surveys. The incorporation of vegetation types that have not been studied previously is important because results may be habitat or region specific (Darras et al. 2019). Specifically, we tested whether there were significant differences in either the overall probability of occurrence or the mean singing rate of the more commonly detected bird species, and whether the probability of occurrence for any species varied significantly across 2.5-min sessions during 10-min surveys.

METHODS

Description of ARUs and field methods. We used programmable, battery-operated, digital autonomous recording units developed by the Bioacoustics Research Program at the Cornell Lab of Ornithology (Ithaca, NY). A detailed description and pictures of these units can be found in the Methods section of Hutto and Stutzman (2009). Ten ARUs were deployed at 65 points in forests near Missoula, Montana, from 30 May to 4 July 2007. Data from 10 deployments were unavailable for analysis because the recorders were not operating when the observer arrived to conduct a point count; half were damaged by elk (*Cervus canadensis*) and the rest failed for unknown reasons. We used long-term landbird monitoring points that were originally located on tertiary roads behind locked gates in the 1990s, and we included formal point counts as part of the design to incorporate normal human behavior associated with a count. A previous on-road/off-road comparison of bird survey results (Hutto et al. 1995) revealed no effect of infrequently traveled tertiary roads

on bird community composition. ARUs were placed about 10 m from roads to reduce conspicuousness and minimize walking distance with car batteries, mounting posts, and recorders. To determine whether vegetation structure had an effect on our results, we distributed survey points in three habitat types (see photos in Hutto and Stutzman 2009), including burned mixed-conifer forest (open with little vegetation obstruction, 30 successful deployments), green mixed-conifer/riparian streamside forest (moderately dense mid- and upper canopy, 15 successful deployments), and mixed cottonwood bottomland/marshland (dense understory and canopy, 10 successful deployments). Deployments occurred in three-day rotations, with initial deployment during the afternoon of the first day. The main ARU housing and a second microphone were mounted ~1 m above ground on separate metal posts about 2-m apart (see Hutto and Stutzman 2009; Fig. 1). The ARU was then powered up, and the date, local GPS time of day, location, habitat type, GPS location, ARU number, and name of observer were recorded before the unit switched into a standby (non-recording) mode after 5 min until it began recording again at 05:00 for a continuous 5-h period on each of the following two mornings. To allow time for birds to get used to the relatively intrusive recorders, we waited until one of the two subsequent mornings between 06:00 and 10:00 for an observer to approach and conduct a 10-min count using a basic point count protocol (Ralph et al. 1995).

Data extraction protocol. We tallied the identity and number of songs during 2.5-min subsets of a 10-min count using headphones while looking at sound spectrograms (Fig. 1) generated by Raven Pro (Cornell Lab of Ornithology, Ithaca, NY). We tallied the numbers of songs of each species recorded during the 10-min period when an actual point count was conducted and during a 10-min period prior to the point count. For the latter, we used a 10-min period that was as close as possible to the 10-min point count period, but not so close that we could detect any noise associated with the arrival of an observer at the point. We reasoned that a 10-min period close in time to the formal point count would be best for comparison with the point count period because environmental

conditions independent of the presence of an observer would be similar. We also reasoned that the 10-min period immediately preceding the point count would be more suitable for comparison than the 10-min period following the point count because lag effects from the presence of an observer might last for an extended period. Although recordings with an observer present always followed recordings without an observer present, the two recording periods used for comparison were so close to one another in time that there was little chance that any significant difference from before to during a count could be due to a time-of-day effect.

Statistical analyses. Using data for all species detected and from only those species detected on at least five points in each habitat, we conducted paired *t*-tests to determine whether mean species richness differed between 10-min recording sessions conducted prior to and during the presence of an observer. For each species detected on at least five points, we used a chi-square analysis to determine whether the proportion of counts when a species was detected differed significantly between 10-min periods when an observer was or was not present. We also used a chi-square analysis to determine whether the probability of occurrence differed significantly among the four 2.5-min sessions during 10-min counts when an observer was present. Because most species did not occur in each of the three habitat types, we were unable to conduct meaningful two-way (habitat \times occurrence rate or song rate) analyses. We also tested whether singing rates differed between when an observer was and was not present by conducting *t*-tests using data from all points (regardless of habitat) where a species was detected either before or during a formal point count. Lastly, we used the combined data from all sites where a species was detected during a formal point count to determine whether mean singing rates differed significantly across the four successive 2.5-min sessions during 10-min counts.

RESULTS

Overall, the ARUs detected 74 species, with 36 detected on at least five of the before–after recording sessions in at least one of the habitat types (Table 1). The mean

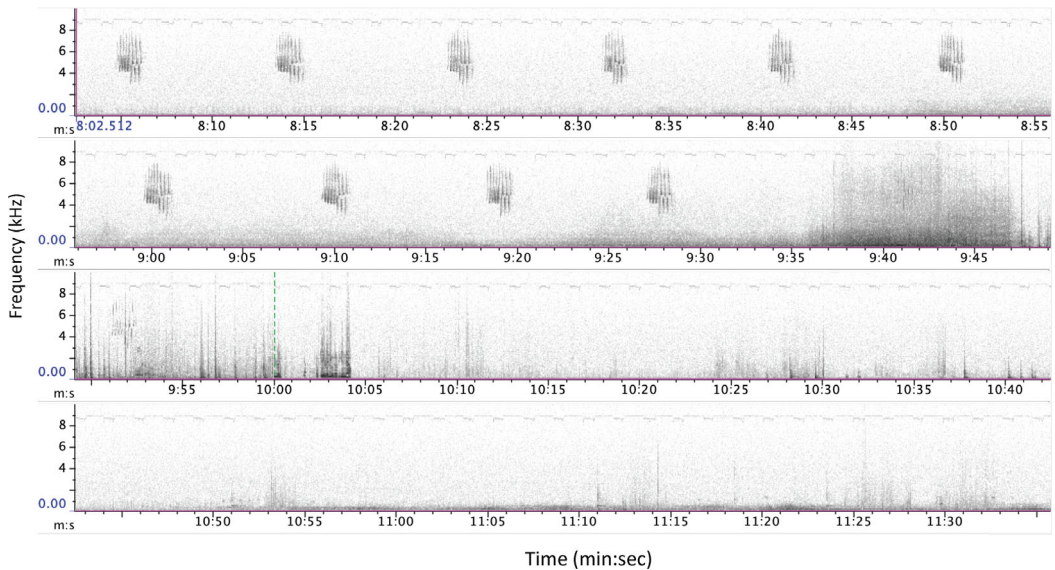


Fig. 1. Sonogram illustrating how a MacGillivray's Warbler stopped singing abruptly upon the arrival of an observer at the recording station. The low-frequency noise from 9:37 to 9:47 was caused by the arrival of a vehicle to this roadside station, and the spiked pulses from 9:48 to 10:04 were caused by footsteps of the approaching observer. This was the only instance where we detected this kind of sudden disappearance of song upon the arrival of an observer. [Colour figure can be viewed at wileyonlinelibrary.com]

number of species detected (species richness) did not differ significantly between 10-min recording sessions conducted before or during which an observer was present (7.45 vs. 7.53 species, respectively; $t_{54} = -0.3$, $P = 0.81$; Fig. 2). Restricting our analysis to include only species detected on at least five points, we still found no difference in species richness (6.56 vs. 6.80 species, respectively; $t_{54} = -0.8$, $P = 0.43$; Fig. 2). Considering the three vegetation types separately, species richness did not differ between recording sessions when an observer was or was not present (burned forest, 5.67 vs. 5.57 species, $t_{29} = 0.3$, $P = 0.81$; green forest, 9.80 vs. 9.93 species, $t_{14} = -0.3$, $P = 0.80$; riparian bottomland, 9.30 vs. 9.80 species, $t_9 = -0.6$, $P = 0.54$).

Composite statistics such as species richness can mask the presence of significant differences associated with individual species, so we also examined responses of individual species. Only once did singing stop abruptly (the species effectively disappeared) upon arrival of an observer, and there was no additional singing during the 10-min point count (e.g., see sonogram of MacGillivray's

Warbler, *Geothlypis tolmiei*; Fig. 1). Indeed, overall probabilities of occurrence did not differ significantly between the two recording periods for any of the 36 species included in our analysis (chi-square tests, $P > 0.05$; Table 1). There were also no clear habitat-based differences for any species that occurred in more than one habitat type (Table 1).

Lazuli Bunting (*Passerina amoena*) was the only species that sang significantly less when an observer was present than when an observer was absent (18.7 vs. 8.4 songs per 10-min period, respectively; $t_9 = 2.8$, $P = 0.02$). The mean number of songs per 10-min survey period did not differ significantly for any other species between when an observer was or was not present (Table 1; paired t -tests, $P \geq 0.05$). Even the bunting results were not significant if we use a conservative Bonferroni adjustment for multiple tests because the P -value indicating significance would have dropped from 0.05 to 0.001 (0.05/36). Finally, the mean number of songs in each of the four 2.5-min listening periods during the 10-min recording session when an observer was present did not differ significantly among

Table 1. Probabilities of occurrence and mean song rates for 36 bird species during the 10-min period immediately prior to the arrival of an observer and during the 10-min period with an observer present and conducting a formal point count. Unadjusted *P*-values were based on chi-square analyses for occurrence data and *t*-tests for song rate data.

Species	Percentage of 10-min counts with a detection						Mean singing rate (number/10-min count)						
	Burned forest (<i>N</i> = 30)			Green forest (<i>N</i> = 15)			Riparian bottomland (<i>N</i> = 10)			All sites combined			
	Before	During	<i>P</i>	Before	During	<i>P</i>	Before	During	<i>P</i>	Before	During	<i>P</i>	
Ring-necked Pheasant, <i>Phasianus colchicus</i>	—	—	—	—	—	—	30.0	40.0	0.64	5	1.20	2.20	0.50
Mourning Dove, <i>Zenaidura macroura</i>	13.3	13.3	1.00	—	—	—	50.0	50.0	1.00	13	3.15	6.77	0.08
Hairy Woodpecker, <i>Dryobates villosus</i>	10.0	13.3	0.69	20.0	20.0	1.00	—	—	—	10	4.20	2.50	0.50
Northern Flicker, <i>Colaptes auratus</i>	36.7	26.7	0.41	13.3	20.0	0.62	50.0	40.0	0.65	28	2.46	2.68	0.82
Olive-sided Flycatcher, <i>Contopus cooperi</i>	10.0	16.7	0.45	—	—	—	—	—	—	8	9.38	10.13	0.47
Western Wood-Pewee, <i>Contopus sordidulus</i>	10.0	6.7	0.64	—	—	—	50.0	60.0	0.65	11	20.18	31.91	0.23
Willow Flycatcher, <i>Empidonax traillii</i>	—	—	—	—	—	—	40.0	40.0	1.00	6	27.00	24.00	0.54
Hammond's Flycatcher, <i>Empidonax hammondi</i>	13.3	10.0	0.69	53.3	53.3	1.00	—	—	—	15	7.13	6.27	0.71
Cassin's Vireo, <i>Vireo cassinii</i>	—	—	—	40.0	40.0	1.00	—	—	—	9	12.44	14.00	0.89
Warbling Vireo, <i>Vireo gilvus</i>	13.3	6.7	0.39	40.0	46.7	0.71	10.0	30.0	0.26	17	10.12	10.41	0.95
Black-billed Magpie, <i>Pica hudsonia</i>	—	—	—	—	—	—	60.0	40.0	0.37	9	41.56	20.78	0.19
Common Raven, <i>Corvus corax</i>	33.3	30.0	0.78	33.3	33.3	1.00	—	—	—	22	8.59	9.50	0.70
Black-capped Chickadee, <i>Poecile atricapillus</i>	—	—	—	—	—	—	30.0	30.0	1.00	5	1.80	4.20	0.27
Mountain Chickadee, <i>Poecile gambeli</i>	—	—	—	6.7	26.7	0.14	—	—	—	6	2.00	12.33	0.17
Red-breasted Nuthatch, <i>Sitta canadensis</i>	—	—	—	20.0	26.7	0.67	—	—	—	10	2.50	1.80	0.65
House Wren, <i>Troglodytes aedon</i>	23.3	20.0	0.75	—	—	—	—	—	—	11	29.55	20.27	0.35
Golden-crowned Kinglet, <i>Regulus satrapa</i>	—	—	—	40.0	20.0	0.23	—	—	—	9	8.56	2.22	0.14
Ruby-crowned Kinglet, <i>Regulus calendula</i>	—	—	—	40.0	40.0	1.00	—	—	—	9	29.33	29.11	0.96
Mountain Bluebird, <i>Sialia currucoides</i>	30.0	26.7	0.77	—	—	—	—	—	—	12	3.33	5.42	0.44
Townsend's Solitaire, <i>Myadestes townsendi</i>	20.0	16.7	0.74	—	—	—	—	—	—	8	8.25	4.25	0.47
Swainson's Thrush, <i>Catharus ustulatus</i>	—	—	—	40.0	33.3	0.71	—	—	—	10	12.10	22.50	0.32
American Robin, <i>Turdus migratorius</i>	33.3	26.7	0.57	60.0	53.3	0.71	40.0	40.0	1.00	31	9.42	5.61	0.13
Cassin's Finch, <i>Haemorhous cassinii</i>	3.3	13.3	0.16	—	—	—	—	—	—	6	2.67	1.00	0.47
Red Crossbill, <i>Loxia curvirostra</i>	20.0	16.7	0.74	6.7	26.7	0.14	—	—	—	10	8.40	19.80	0.05
Pine Siskin, <i>Spinus pinus</i>	36.7	20.0	0.15	46.7	73.3	0.14	—	—	—	13	6.23	2.15	0.19
Chipping Sparrow, <i>Spizella passerina</i>	—	—	—	—	—	—	—	—	—	25	12.28	8.24	0.38

Table 1. Continued

Species	Percentage of 10-min counts with a detection						Mean singing rate (number/10-min count)						
	Burned forest (N = 30)		Green forest (N = 15)		Riparian bottomland (N = 10)		All sites combined						
	Before	During	P	Before	During	P	Before	During	P				
Song Sparrow, <i>Melospiza melodia</i>	—	—	—	20.0	13.3	0.62	40.0	60.0	0.37	10	12.10	7.10	0.29
Dark-eyed Junco, <i>Junco hyemalis</i>	60.0	73.3	0.27	26.7	20.0	0.67	—	—	—	27	19.81	24.48	0.52
Red-winged Blackbird, <i>Agelaius phoeniceus</i>	—	—	—	—	—	—	90.0	60.0	0.12	9	22.56	16.89	0.13
Brown-headed Cowbird, <i>Molothrus ater</i>	3.3	13.3	0.16	26.7	33.3	0.69	50.0	70.0	0.36	18	4.50	5.83	0.34
MacGillivray's Warbler, <i>Geothlypis tolmiei</i>	43.3	50.0	0.61	53.3	46.7	0.72	—	—	—	26	20.23	20.42	0.97
Common Yellowthroat, <i>Geothlypis trichas</i>	—	—	—	—	—	—	60.0	70.0	0.64	7	30.57	42.57	0.29
Yellow Warbler, <i>Setophaga petechia</i>	—	—	—	46.7	46.7	1.00	90.0	90.0	1.00	17	22.71	26.71	0.26
Yellow-rumped Warbler, <i>Setophaga coronata</i>	20.0	23.3	0.75	60.0	46.7	0.46	—	—	—	22	7.91	4.00	0.06
Western Tanager, <i>Piranga ludoviciana</i>	30.0	33.3	0.78	66.7	73.3	0.69	—	—	—	23	12.52	8.04	0.17
Lazuli Bunting, <i>Passerina amoena</i>	—	—	—	33.3	26.7	0.69	—	—	—	10	18.70	8.40	0.02

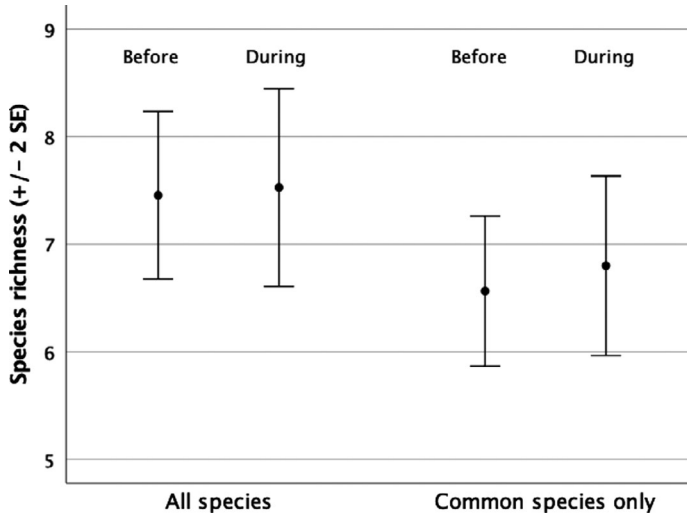


Fig. 2. Mean species richness (± 2 SE) recorded in 10-min sessions before and during which an observer was present. The left pair is based on data from all species detected and the right pair from species that were detected on at least five counts.

listening periods for any species (ANOVAs, $P > 0.05$) (Table 2).

DISCUSSION

We found that species richness and both the probability of occurrence and singing rate for all but one of the 36 species we recorded were unaffected by the presence of an observer. Even the change in singing rate of one species (Lazuli Bunting) would not have been significant if we had used a conservative correction to adjust P values downward to account for multiple comparisons, so we believe it is safe to conclude that there were no significant effects of the presence of an observer on bird singing rates. In another study addressing this question, Bye et al. (2001) also found no difference in either species richness or the combined singing rates for grassland birds in a Kansas prairie, although Dickcissels (*Spiza americana*), Field Sparrows (*Spizella pusilla*), and Grasshopper Sparrows (*Ammodramus savaannarum*) gave significantly fewer calls in the presence of an observer, and Eastern Meadowlarks (*Sternella magna*) uttered significantly more calls in the presence of an observer. These few single-species differences should be interpreted with caution, however, because Bye et al. (2001) sampled only four points, and the differences

were based on chi-square analyses where the numbers of songs were used as independent counts. Moreover, Bye et al. (2001) noted that because their recordings in the presence of an observer preceded their recordings in the absence of an observer, their results may have been biased toward lower song rates in the absence of an observer. In the other similar study, Campbell and Francis (2012) found no difference in the positions of old-field birds when an observer was either present or absent, and no difference in the number of individuals or species detected or in the onset of singing. Thus, the results of studies to date suggest that the presence of observers has no significant effect on either the occurrence or singing rates of birds detected during point counts.

Most species of birds detected during point counts are relatively small and, as noted in the introduction, are relatively mobile and not threatened by the approach of larger organisms, including humans. Observers should, therefore, be able to conduct surveys or behavioral observations without introducing significant effects on bird behavior. The same cannot be said of larger landbird species (e.g., grouse, quail, and most raptors), and we suspect that point count data involving such species would be strongly biased against detection (especially visual detection) in the

Table 2. Probabilities of occurrence in each of four 2.5-min listening periods across 10-min counts during which an observer was present. Unadjusted *P*-values determined from chi-square analyses.

Species	Probability of occurrence in 2.5-min (<i>N</i> = 55)				<i>P</i>
	Period 1	Period 2	Period 3	Period 4	
Ring-necked Pheasant, <i>Phasianus colchicus</i>	3.6	5.5	0.0	3.6	0.42
Mourning Dove, <i>Zenaida macroura</i>	10.9	9.1	12.7	10.9	0.95
Hairy Woodpecker, <i>Dryobates villosus</i>	5.5	7.3	5.5	3.6	0.87
Northern Flicker, <i>Colaptes auratus</i>	9.1	12.7	10.9	12.7	0.92
Olive-sided Flycatcher, <i>Contopus cooperi</i>	7.3	5.5	5.5	7.3	0.96
Western Wood-Pewee, <i>Contopus sordidulus</i>	9.1	7.3	9.1	9.1	0.98
Willow Flycatcher, <i>Empidonax traillii</i>	9.1	7.3	7.3	5.5	0.91
Hammond's Flycatcher, <i>Empidonax hammondi</i>	18.2	9.1	5.5	9.1	0.16
Cassin's Vireo, <i>Vireo cassinii</i>	7.3	3.6	5.5	1.8	0.55
Warbling Vireo, <i>Vireo gilvus</i>	5.5	12.7	10.9	16.4	0.34
Black-billed Magpie, <i>Pica hudsonia</i>	1.8	7.3	1.8	5.5	0.37
Common Raven, <i>Corvus corax</i>	12.7	10.9	14.5	10.9	0.93
Black-capped Chickadee, <i>Poecile atricapillus</i>	5.5	1.8	1.8	1.8	0.56
Mountain Chickadee, <i>Poecile gambeli</i>	5.5	7.3	3.6	3.6	0.79
Red-breasted Nuthatch, <i>Sitta canadensis</i>	1.8	3.6	7.3	1.8	0.37
House Wren, <i>Troglodytes aedon</i>	12.7	10.9	7.3	9.1	0.80
Golden-crowned Kinglet, <i>Regulus satrapa</i>	1.8	0.0	3.6	1.8	0.57
Ruby-crowned Kinglet, <i>Regulus calendula</i>	10.9	14.5	14.5	9.1	0.77
Mountain Bluebird, <i>Sialia currucoides</i>	7.3	5.5	9.1	5.5	0.85
Townsend's Solitaire, <i>Myadestes townsendi</i>	1.8	1.8	5.5	5.5	0.56
Swainson's Thrush, <i>Catharus ustulatus</i>	7.3	5.5	7.3	9.1	0.91
American Robin, <i>Turdus migratorius</i>	20.0	20.0	12.7	14.5	0.65
Cassin's Finch, <i>Haemorhous cassinii</i>	3.6	1.8	1.8	1.8	0.89
Red Crossbill, <i>Loxia curvirostra</i>	7.3	5.5	5.5	7.3	0.96
Pine Siskin, <i>Spinus pinus</i>	5.5	7.3	7.3	1.8	0.55
Chipping Sparrow, <i>Spizella passerina</i>	12.7	21.8	16.4	14.5	0.60
Song Sparrow, <i>Melospiza melodia</i>	9.1	7.3	10.9	5.5	0.75
Dark-eyed Junco, <i>Junco hyemalis</i>	27.3	30.9	25.5	27.3	0.93
Red-winged Blackbird, <i>Agelaius phoeniceus</i>	9.1	9.1	9.1	9.1	1.00
Brown-headed Cowbird, <i>Molothrus ater</i>	14.5	9.1	14.5	20.0	0.45
MacGillivray's Warbler, <i>Geothlypis tolmiei</i>	23.6	29.1	25.5	23.6	0.90
Common Yellowthroat, <i>Geothlypis trichas</i>	9.1	9.1	10.9	9.1	0.98
Yellow Warbler, <i>Setophaga petechia</i>	27.3	20.0	25.5	23.6	0.83
Yellow-rumped Warbler, <i>Setophaga coronata</i>	7.3	18.2	14.5	7.3	0.19
Western Tanager, <i>Piranga ludoviciana</i>	27.3	21.8	18.2	27.3	0.61
Lazuli Bunting, <i>Passerina amoena</i>	9.1	9.1	5.5	9.1	0.87

presence of an observer. In their original discussion of fixed-radius point counts, Hutto et al. (1986) highlighted this problem with respect to some common Mexican landbird species on fixed-radius counts. Specifically, species like Gray Silky-flycatchers (*Ptilononyx cinereus*) and Lilac-crowned Parrots (*Amazona finschi*) were rarely detected within 25 m, but commonly detected at greater distances, as were "...pigeons, doves, woodpeckers, jays, and other species that produce frequent,

long-range vocalizations and are otherwise either rare, or common but repulsed by an observer's presence" (Hutto et al. 1986: 597).

In the only existing analysis of sound location using a 8-microphone array, Campbell and Francis (2012) found no evidence of bird movement between the time an observer was absent to when the observer was present. Although our analysis also suggests that the species we recorded with ARUs were not affected by the presence of an observer, we

caution that relatively short-distance movements toward or away from an observer cannot be detected from sound recordings alone. The same birds may have been present prior to and during a count, but may have moved some distance away from the point upon arrival of an observer even though they were still close enough to be recorded. For example, the largest bird detected in our sound recordings (Ring-necked Pheasant, *Phasianus colchicus*) is a species that most certainly moves away from approaching observers, but was just as likely to be detected with or without an observer present because its call can be detected at great distances. Thus, detection of bird vocalizations alone cannot be used to infer the absence of observer effects on bird behavior, so our results do not remove the need for care (e.g., Hutto 2016) when considering whether there might be inherent biases due to bird movement when constructing distance profiles for use in distance sampling (Thomas et al. 2010).

Although our results may not carry important implications for distance sampling, they do carry implications that are relevant for occupancy modeling (MacKenzie et al. 2006). In occupancy modeling, consecutive time periods are often used as independent samples of occupancy to create detection histories, and a key assumption is that occurrence rates do not differ significantly among time periods. In other words, a species that has an actual 50% occupancy rate during a 2.5-min period should reveal an unbiased estimate of that rate across the four 2.5-min time periods. The presence of unequal song rates across 2.5-min time periods within a recording session would suggest that the treatment of time periods as independent samples for the purposes of establishing an occupancy estimate may suffer from inherent bias. We detected no significant differences in occurrence rates across the 2.5-min sessions for the 10-min periods when an observer was present. Thus, the effect of observer presence on the probability of bird occurrence during a 10-min count is also insignificant and would not appear to violate the occupancy modeling assumption of equal occupancy across adjacent time periods.

Our use of tertiary roads for point count locations may have introduced a roadside bias because birds along roads might be more

accustomed to human presence than birds in more remote locations, but we feel that this is unlikely because our locations were behind locked gates and relatively free from human traffic. Although we did not detect clear habitat-based differences in our study, habitat structure has been found to affect alert distances of several species of birds at other locations (Fernández-Juricic et al. 2001). As such, the effect of observers on bird occurrence or singing behavior across larger numbers of recording sessions in a wider variety of vegetation types might reveal significant effects that we were unable to detect with our limited sampling effort. There may also be regional differences in the responses of birds to humans because of differences in, for example, hunting pressure. Nevertheless, our results suggest that sound production by smaller species of landbirds that are typically targeted by point counts seems to be little affected by the presence of an observer.

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