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# COMPARISON OF LINE-TRANSECT, SPOT-MAP, AND POINT-COUNT SURVEYS FOR BIRDS IN RIPARIAN HABITATS OF THE GREAT BASIN

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Abstract.—Riparian areas of the western United States are important breeding and migration habitats for migrant landbirds. To develop reliable methods for surveying and monitoring riparian avifaunas, we evaluated the relative efficiency and comparability of fixed-width line transects, spot mapping, and fixed-radius point counts. Intensive, single-visit spot mapping yielded greater species richness and higher total relative abundances than line transects for all riparian habitats combined, but these differences largely disappeared when comparisons were made within habitat types (meadow, willow, and aspen). There were no differences in numbers of species or relative abundances in comparisons between transects and point counts. Transects and point counts conducted once per plot missed many birds compared with two-visit samples. We recommend that monitoring programs for birds in western riparian habitats provide substantive, standardized training for observers, and use either fixed-width line transects or fixed-radius point counts with at least two visits per site for breeding season surveys.

**COMPARACIÓN DE MONITOREOS POR TRANSECTOS LINEARES, MAPAS DE PUNTOS, Y CONTEOS POR PUNTOS PARA AVES EN HÁBITATS RIPARIOS DE LA GRAN CUENCA.**

Sinopsis—Areas riparias del oeste de los Estados Unidos de Norteamérica son hábitats de anidaje y de migración críticamente importantes para aves terrestres migratorias. Evaluamos la eficiencia relativa y la comparabilidad de transectos de ancho fijo, mapas de punto y conteos dentro de radios de diámetro fijo para desarrollar métodos confiables para monitorear avifaunas riparias. Los mapas de puntos producidos por una visita de esfuerzo intensivo indicaron mayores riquezas de especies y mayores abundancias relativas totales que los transectos para todos los hábitats combinados, pero estas diferencias desaparecieron notablemente cuando las comparaciones se hicieron dentro de los mismos tipos de hábitats (vegas, bosques de *Salix* sp., y bosques de *Populus tremuloides*). No hubo diferencias en número de especies o en las abundancias relativas en las comparaciones entre los transectos y los conteos por puntos. Los transectos y los conteos por puntos conducidos una vez por parcela no detectaron muchas aves al compararlos con muestras de dos visitas. Recomendamos que los programas de monitoreos de aves en hábitats riparios del oeste le provean entrenamiento sustancial y estandarizado a los observadores, y que usen ya sea transectos de ancho fijo o conteos de punto en áreas de radio fijo con al menos dos visitas por lugar para monitorear la temporada reproductiva.

Riparian habitats constitute less than one percent of western landscapes but harbor the most species-rich avifaunas found in arid and semi-arid portions of the western United States (Knopf et al. 1988, Saab et al. 1995). The importance of western riparian areas as breeding and migration habitats for Neotropical migrant landbirds has generated a need for efficient, reliable methods to survey and monitor riparian avifaunas (Dobkin 1994, Knopf and Samson 1994, Saab et al. 1995).

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Although attention has been focused on methodologies to survey birds (Bibby et al. 1992, Ralph and Scott 1981, Ralph et al. 1995, Verner 1985), there is little agreement on which sampling techniques are most appropriate for specific habitats. The three most widely used techniques (see Bibby et al. 1992) are line transects (either fixed-width or variable-width), circular-plot point counts (either fixed-radius or unlimited radius), and spot-map methods.

Riparian habitats of the arid Intermountain West and desert Southwest tend to be linear and relatively narrow. Widths of riparian zones in the Great Basin are typically <150 m (Dobkin and Wilcox 1986, Dobkin et al. 1995, Grayson 1993) and appear well suited to line transects for surveys of breeding avifaunas (Dobkin and Wilcox 1986). Few comparative studies of survey methods have been conducted in western riparian habitats (Anderson and Ohmart 1981, Szaro and Jakle 1982), however, and no comparisons have been undertaken previously in the Intermountain West.

As part of a larger study of riparian avifaunas in the northwestern Great Basin (Dobkin et al. 1995, 1998), we evaluated the relative efficiency and comparability of results derived from three different survey methods for estimating avian species richness and relative abundances. We made paired comparisons between fixed-width line transects and the spot-map method, and between fixed-width line transects and fixed-radius point counts.

## METHODS

*Study site.*—This study was conducted on Hart Mountain National Antelope Refuge in southeastern Oregon (42°25′N, 199°40′W). All surveys were conducted in June and July of 1992 and 1993. We characterized riparian study plots as meadow, willow, or aspen, based on dominant vegetation. Meadows were composed mainly of grasses and sedges <1 m in height (see Dobkin et al. 1998) and ranged from 75–300 m in width. Willow areas consisted of dense but discontinuous clumps of *Salix lemmonii, S. geyeriana,* and *S. scouleriana* up to 4 m in height and were only 10–30-m wide. Riparian woodlands composed of aspen (*Populus tremuloides*) 8–15 m in height (Dobkin et al. 1995) varied from 20–100 m in width. All riparian plots were surrounded by sagebrush (*Artemisia* spp.) shrubsteppe.

*Fixed-width line transects versus spot maps.*—We conducted paired comparisons between transects and spot maps on 12 plots selected to represent typical meadow (6 plots), willow (3 plots), and aspen (3 plots) riparian habitats. Observers were balanced between methods and among plots so that the same observer did not conduct transects and spot maps within a paired comparison. Spot mapping was conducted within one week of the paired line-transect survey. Woody riparian plots were sampled in 1992 and meadow plots were sampled in 1993.

Each fixed-width line transect ran parallel to the stream channel for 150 m, extended for 50 m on each side of the transect line, and was marked by stakes at 50 m intervals along its length. For spot maps, each transect was divided into six 50 × 50-m (2500 $m^2$) subplots (Fig. 1), and each subplot boundary was marked laterally and perpendicularly at 50 m

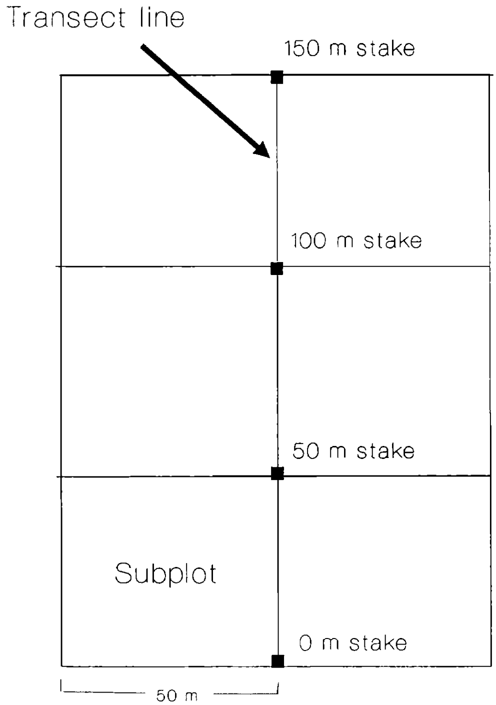


FIGURE 1. Schematic diagram of sample plots for comparison of fixed-width line transect surveys and spot-map surveys in linear riparian habitats. Each transect (150 × 100 m) was marked by stakes at 50 m intervals, and the entire transect was divided into six 50 × 50 m subplots for spot mapping.

from each stake. The six spot maps encompassed the same total area as the fixed-width line transect (15,000 $m^2$).

For line transects, all birds detected by sight or sound were classified as within or beyond 50 m of the transect line, and locations of all birds within 50 m of the transect line were mapped. Detections beyond 50 m were excluded from comparisons with results from spot mapping. Two transect surveys were conducted on each plot within 6 h of sunrise on consecutive mornings; results of these two surveys were combined for each plot and compared with results from the single-visit spot map. Relative abundances from transects were estimated as the maximum number of each species detected based on the two consecutive visits.

For spot maps, locations of all birds detected were mapped in subplots. A 50-m rope was then dragged through the herbaceous portion of each subplot to flush elusive species. Mapping was further supplemented by using playbacks of rail vocalizations in the morning and evening at the 0-m stake and at the 100-m stake (Fig. 1). The recording consisted of approximately 2 min of Sora (*Porzana carolina*) vocalizations followed by approximately 1 min of Virginia Rail (*Rallus limicola*) vocalizations from Peterson (1993). We estimated the number of rails on each subplot as the maximum detected based on all surveys.

We knew from our concurrent and previous studies in the region that avian abundance and species richness varied with structural complexity of the riparian habitat. Based on preliminary sampling exercises, we standardized durations of line transects at 15 min for each meadow plot, 20 min for each willow plot, and 25 min for each aspen plot. As a result of two preceding years of work in the meadow plots (Dobkin et al. 1998), we standardized the duration of spot mapping at 45 min for each meadow plot. Although only 7–8 min were spent physically in each subplot, views of the entire meadow plot were unobstructed and enabled observers to continue detecting and mapping birds on adjacent subplots; functionally, each subplot was sampled for at least 30 min. Duration of spot mapping was standardized at 270 min for each woody riparian plot, with 45 min spent in each subplot.

Paired comparisons were made between transects and spot maps on each of the six meadow plots. Six paired comparisons were made between transects and spot maps within willow and within aspen by conducting two sets of surveys (with different observers—see *Statistical analysis*) separated by at least one month on each woody riparian plot.

*Fixed-width line transects versus fixed-radius point counts.*—We conducted 40 paired surveys of transects and point counts on 20 plots (see *Statistical analysis*) selected to represent typical meadow (3 plots), willow (4 plots), and aspen (13 plots) riparian habitats. Each plot was surveyed twice on consecutive mornings in 1993. Observers alternated between methods on each plot, and alternated the order in which each method was used. Transects and point counts were conducted concurrently on each plot because we knew from past experience that bird activity varied with weather conditions and insolation. Passive cues exchanged between observers during concurrent surveys were negligible because 58% of all detections were made by sound, and observers in woody riparian plots were obscured from each other by vegetation. Observers were trained to avoid visual contact during surveys and did not discuss sampling results until after consecutive-day surveys were completed.

Fixed-width line transects were conducted as described above. Two point-count circles, each with a radius of 50 m, were established within each 150 × 100-m transect (Fig. 2). Point counts were conducted by mapping all detections within 50 m of the circle's center. All detections >50 m from the point count center also were recorded, but not mapped. Taken together, the two point counts sampled five percent more area than the line transect. All detections beyond 50 m from the transect line or point-count center were excluded from comparisons between methods.

Survey durations were standardized for each of the three riparian habitats as described above, and to ensure equivalent sampling effort for each method. Duration for line transects in meadows was 15 min, and each of the two corresponding point counts lasted 7.5 min. Willow transects were

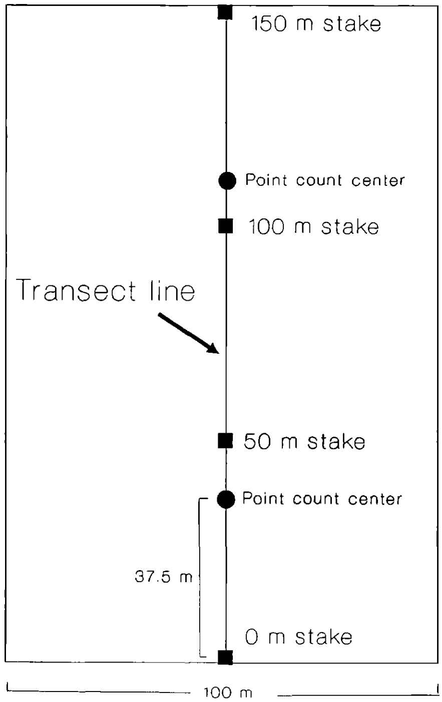


FIGURE 2. Schematic diagram of sample plots for comparison of fixed-width line transect surveys and fixed-radius point count surveys in linear riparian habitats. Each transect (150 × 100 m) was marked by stakes at 50 m intervals. Circular point count plots (50 m radius) were centered 37.5 m from each end of the transect line.

conducted for 20 min, and each of the two corresponding point counts lasted 10 min. Survey times in aspen were 25 min for transects and 12.5 min for each point count. Because sampling effort was equivalent between transects and point counts, results from each pair of consecutive surveys were analyzed separately rather than combined as in the spot map versus transect comparisons.

*Statistical analysis.*—Data were analyzed with the SPSS statistical package (Norusis 1993). Assumptions of normality and homoscedasticity were tested with normal probability plots and $F_{max}$-tests. Data transformations were applied where necessary to satisfy the assumptions of parametric analyses, but frequently failed to produce suitable distributions. As a result, nonparametric statistics were employed in such cases and used for all similar comparisons to facilitate interpretation of the results. All means are reported ±1 standard error.

Resampling of plots appears to introduce a bias due to lack of independence between measurements, but the focus of our analysis is a statistical comparison between the two sampling methods, not the accuracy of estimated avian abundances. We do not use the original measurements of the paired samples, but only the difference within each pair of measurements, so that the data analyzed are samples composed of difference-scores (Zar 1984). The most important source of bias derives from observer knowledge of the sample plot (e.g., Bibby et al. 1992, Eagles 1981, Verner and Ritter 1988), which leads to true lack of independence between measurements. Our sampling design ensured that individual observers were always balanced between sampling methods within paired comparisons. In principle, we could have collected 20 paired samples from a single plot using 20 different pairs of observers to produce 20 independent paired comparisons of the two methods. Such an analysis, although statistically valid, would have lacked the increased generality that derives from distributing (balanced) sampling effort across a greater number of sites, which we attempted to do within the constraints imposed by field logistics.

## RESULTS

*Fixed-width line transects versus spot maps.*—We detected 934 individuals of 48 species for both methods combined (Appendix). Spot-map surveys detected more species per plot ($\bar{x}$ = 10.1 ± 1.1 versus 8.5 ± 0.9; paired-sample *t*-test, $t = 2.18$, df = 17, $P = 0.04$). Total avian relative abundances per plot also were greater with spot-map surveys ($\bar{x}$ = 28.2 ± 3.7 versus 23.7 ± 2.7), but the difference between methods was marginally significant ($t = 1.84$, df = 17, $P = 0.08$). Sixteen species were detected by both methods on enough plots to test individually ($n \geq 6$ for Wilcoxon matched-pairs signed-ranks tests; Sokal and Rohlf 1981); abundances of 12 of these species did not differ between methods (Table 1). Relative abundances were greater for American Robins on spot-map surveys ($P =$ 0.02), but greater for Tree Swallows on line transects ($P = 0.04$); greater abundances of Warbling Vireos and Yellow Warblers on spot-map surveys (Table 1) were marginally significant ($0.05 < P < 0.10$). The remaining 32 species combined showed a significant trend toward greater probability of detection on spot-map surveys (Sign test, $P = 0.03$).

Comparisons between methods within each type of riparian habitat indicated an apparent tendency toward more species and higher total relative abundances on spot-map surveys (Fig. 3). None of these apparent differences, however, was statistically significant (Wilcoxon matched-pairs signed-ranks tests, $P > 0.10$), except for a greater mean number of species detected on spot-map surveys in aspen ($P = 0.07$).

*Fixed-width line transects versus fixed-radius point counts.*—We detected 1369 individuals belonging to 47 species for both methods combined (Appendix). There were no significant differences between transects and point counts in number of species per plot ($\bar{x}$ = 6.1 ± 0.5 versus 6.0 ± 0.5, respectively; $t = 0.36$, df = 39, $P = 0.72$), or for total relative abundance per plot ($\bar{x}$ = 13.3 ± 1.2 versus 13.3 ± 1.1, $t = 0.07$, df = 39, $P =$ 0.94). Abundances of 18 of 20 species that could be tested individually ($n \geq 6$) did not differ between the two methods (Table 2). Warbling

TABLE 1. Comparison between line-transect and spot-mapping surveys for species with at least six paired comparisons for all riparian habitats combined (Wilcoxon matched-pairs signed-ranks, $n$ = 18 paired comparisons).

| | Number of paired comparisons | | | |
|---|---|---|---|---|
| Species | Line transect > spot mapping | Line transect < spot mapping | Nonzero ties | $P$ |
| Northern Flicker | 4 | 4 | 0 | 1.00 |
| Dusky Flycatcher | 6 | 4 | 0 | 0.80 |
| Tree Swallow | 6 | 1 | 1 | 0.04[a] |
| House Wren | 4 | 5 | 1 | 0.59 |
| American Robin | 1 | 9 | 3 | 0.02[a] |
| European Starling | 3 | 1 | 3 | 0.72 |
| Warbling Vireo | 1 | 6 | 0 | 0.06[b] |
| Yellow Warbler | 2 | 7 | 3 | 0.07[b] |
| Savannah Sparrow | 4 | 4 | 0 | 0.53 |
| Song Sparrow | 4 | 5 | 0 | 0.95 |
| White-crowned Sparrow | 2 | 4 | 2 | 0.35 |
| Red-winged Blackbird | 4 | 4 | 1 | 0.73 |
| Western Meadowlark | 2 | 4 | 0 | 0.35 |
| Brewer's Blackbird | 3 | 4 | 1 | 0.74 |
| Brown-headed Cowbird | 2 | 6 | 0 | 0.14 |
| Bullock's Oriole | 2 | 4 | 2 | 0.25 |

[a] $P < 0.05$.
[b] $P < 0.10$.

Vireo abundance was greater ($P$ = 0.02) on point-count surveys, but abundances of White-crowned Sparrows appeared marginally greater ($P$ = 0.09) on line transects (Table 2). The remaining 25 species combined showed no significant trend ($P$ = 0.33).

Comparisons between methods within each type of riparian habitat found no statistically significant differences ($P > 0.10$) for species richness or total relative abundance (Fig. 4).

## DISCUSSION

Spot-map surveys are time-intensive but have been viewed as more accurate than line transects or point counts, and often have been used as a standard against which to measure the relative accuracy of other survey methods (e.g., references in Verner and Milne 1990). Although we assumed that spot-map results would be the closest approximations to true abundances among the three survey methods, our goal was to examine the comparability of results among the three methodologies, and thus was not dependent on assumptions regarding relative accuracy. We emphasize that we used these methods to assess relative abundances of species, not actual densities, which can be highly variable and unreliable when extrapolated from these methods (Verner 1985; Verner and Ritter 1985, 1988).

The assumption of greater accuracy for spot-map methods has been

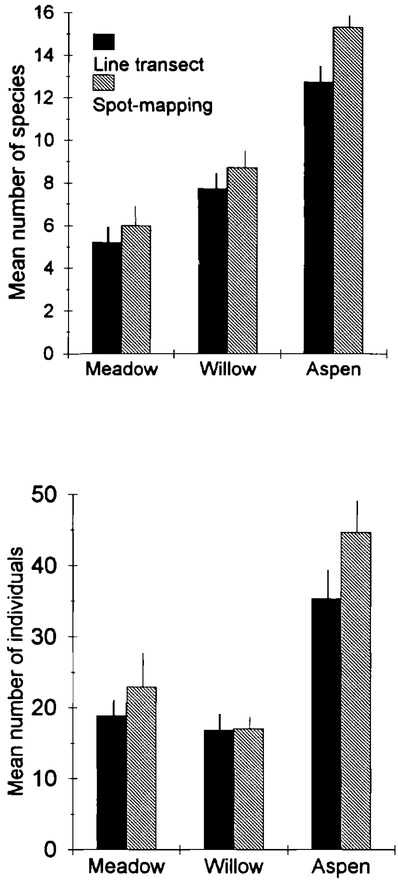


FIGURE 3. Number of species and number of individuals detected ($\bar{x} \pm$ SE) by fixed-width line transects compared with spot mapping in meadow, willow, and aspen riparian habitats.

challenged recently, and should be regarded as questionable because of observer and analyst variability (Bibby et al. 1992, Verner and Milne 1990). To minimize sources of observer variation (Verner and Milne 1990), we provided our observers with detailed instruction and extensive training, and balanced the effort of each observer over all plots within comparisons between survey methods. Spot-map surveys generally follow a protocol of repeated visits to each plot over the course of a breeding season (Robbins 1970) to develop a single composite map of individual avian territories; analyst variability is introduced through the process of combining plot maps from these multiple visits. We eliminated this source of variation by conducting only a single spot-map survey of each plot. The trade-off between sources of error introduced by analyst variability versus

TABLE 2. Comparison between 150 × 100-m line transects and 50-m radius point counts for species with at least six paired comparisons for all riparian habitats combined (Wilcoxon matched-pairs signed-ranks, $n$ = 40 paired comparisons).

| | Number of paired comparisons | | | |
|---|---|---|---|---|
| Species | Line transect > point count | Line transect < point count | Nonzero ties | $P$ |
| Red-naped Sapsucker | 5 | 3 | 3 | 0.53 |
| Northern Flicker | 6 | 7 | 11 | 0.65 |
| Western Wood-Pewee | 2 | 4 | 7 | 0.75 |
| Dusky Flycatcher | 9 | 10 | 4 | 0.87 |
| Tree Swallow | 4 | 4 | 3 | 0.67 |
| House Wren | 9 | 9 | 7 | 0.46 |
| American Robin | 14 | 10 | 6 | 0.49 |
| European Starling | 2 | 3 | 5 | 0.69 |
| Warbling Vireo | 2 | 11 | 5 | 0.02[a] |
| Yellow Warbler | 9 | 9 | 4 | 0.43 |
| Green-tailed Towhee | 6 | 5 | 1 | 0.62 |
| Brewer's Sparrow | 3 | 3 | 2 | 0.75 |
| Vesper Sparrow | 3 | 3 | 1 | 0.75 |
| Savannah Sparrow | 1 | 5 | 2 | 0.29 |
| White-crowned Sparrow | 7 | 2 | 0 | 0.09[b] |
| Red-winged Blackbird | 3 | 4 | 1 | 1.00 |
| Brewer's Blackbird | 4 | 8 | 1 | 0.24 |
| Brown-headed Cowbird | 3 | 3 | 3 | 1.00 |
| Bullock's Oriole | 5 | 2 | 1 | 0.24 |
| Cassin's Finch | 4 | 8 | 0 | 0.24 |

[a] $P < 0.05$.
[b] $P < 0.10$.

insufficient sampling effort is difficult to assess in our study, and it can be argued that compilation of multiple spot-map surveys for each of our plots would have produced significantly different results. Based on several years of intensive work in these plots and other comparable habitats in the region, we do not believe that the results of a multiple-visit spot-map protocol would have been greatly different. Our objective was to assess results of three sampling methods that were reasonably comparable in the required amount of logistic effort. Conducting multiple, time-intensive, spot-map surveys for each plot is simply not logistically feasible for most monitoring and survey efforts.

Szaro and Jakle (1982) found reasonable comparability between variable circular-plots and spot-map methods in southwestern riparian habitats composed of willow and *Tamarix* thickets. They repeatedly surveyed a single riparian plot with both methods and found that estimated overall abundances were 17% greater with spot-map methods, but that species lists were equivalent. Anderson and Ohmart (1981) compared variable-distance transects and variable circular-plots in a honey mesquite (*Prosopis glandulosa*) stand and in other riparian habitats similar to those studied by Szaro and Jakle (1982) in the same region. Their results also indicated

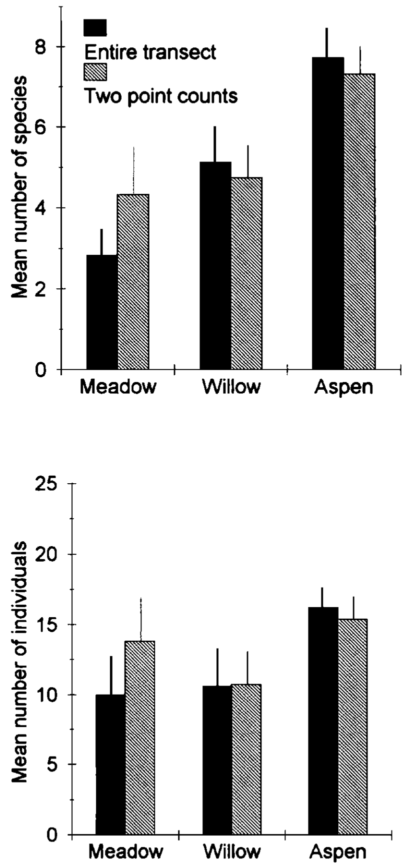


FIGURE 4. Number of species and number of individuals detected (x̄ ± SE) by fixed-width line transects (150 × 100 m) compared with pairs of fixed-radius (50 m) point counts in meadow, willow, and aspen riparian habitats.

reasonable comparability in density estimates and species lists for transects and circular plots of at least 30-m radius.

We found surprisingly close correspondence among all three methods in the linear riparian habitats we studied, and the few differences among methods exhibited no clear pattern. Tree Swallows probably were overestimated on line transects (and point counts) because of double counting individual birds performing long foraging flights (Manuwal and Carey 1991). The greater number of American Robins, Warbling Vireos, and Yellow Warblers detected on spot-map surveys compared with line transects may have resulted from the detection of more females, which tend to be less conspicuous than males and thus more likely to be detected by the more intensive survey method. We examined this possibility by recalculating relative abundances as the number of singing males plus the number of females in excess of males (Dobkin et al. 1995) for American Robins and Yellow Warblers (sexes could not be distinguished in Warbling Vireos) and found no significant differences (Wilcoxon matched-pairs signed-ranks tests, $P > 0.40$) between spot maps and transects for either species.

We had expected that movement of the observer along line transects would result in missed sight detections relative to stationary observers conducting point counts (Bibby et al. 1992 and references therein). For birds detected within 50 m of the transect line, however, overall results of these two methods were virtually indistinguishable for number of species and number of individuals. Warbling Vireos, as in the comparison of transects and spot maps, seemed to be underestimated by line transects. We believe that the most likely explanation is that stationary observers (spot-map and point-count methods) detected more female vireos than did observers moving along line transects.

None of the three methods we used was clearly more sensitive to detecting rare species in our plots. Each method accounted for a small number of unique detections (Appendix), nearly all of which appeared to be transient individuals that did not nest on the survey plots. Short-eared Owls, which were detected only on spot-map surveys in meadows, were the exception to this pattern, but they were detected by rope drags that flushed incubating birds, and the species would have been otherwise undetected by all three survey methods.

Evening playbacks of rail vocalizations did not appear to be effective for finding birds missed by the morning surveys. Of the four plots on which we detected Sora, only one bird was found solely on an evening survey. It appears that rails in these habitats are adequately sampled by standard morning survey methods (see also Marion et al. 1981).

In summary, both fixed-width line transects and fixed-radius point counts were far more efficient than spot mapping in the linear riparian habitats we studied because they required far less time per plot and provided comparable estimates of relative abundances and species composition. Although single-visit transects and point counts yielded comparable per-plot results, single-visit samples missed many birds (compare Figs. 3 and 4), as also has been shown for single-visit point counts in other woodland habitats (e.g., Petit et al. 1995). We found that three pairs of consecutive-morning transects per plot in the breeding season are required to detect >90% of the birds found on eight transects per season in these riparian habitats (Dobkin et al., unpubl.). Hence, we recommend that monitoring programs for birds in western riparian habitats provide substantive, standardized training for observers, and use either fixed-width line transects or fixed-radius point counts with at least two visits per site for breeding season surveys.

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APPENDIX. Scientific names of species and the surveys on which they occurred.

| Species | Line transect | Spot mapping | Point count |
|---|---|---|---|
| Green-winged Teal (*Anas crecca*) | | x | |
| Mallard (*Anas platyrhynchos*) | x | x | |
| Northern Pintail (*Anas acuta*) | x | x | |
| Cinnamon Teal (*Anas cyanoptera*) | x | x | |
| Gadwall (*Anas strepera*) | x | | x |
| Turkey Vulture (*Cathartes aura*) | x | | x |
| Red-tailed Hawk (*Buteo jamaicensis*) | x | x | x |
| American Kestrel (*Falco sparverius*) | x | x | x |
| Sora (*Porzana carolina*) | x | x | x |
| Common Snipe (*Gallinago gallinago*) | x | x | x |
| Wilson's Phalarope (*Phalaropus tricolor*) | x | x | x |
| Mourning Dove (*Zenaida macroura*) | | | x |
| Short-eared Owl (*Asio flammeus*) | | x | |
| Common Nighthawk (*Chordeiles minor*) | | x | |
| *Selasphorus* spp. | x | x | x |
| Red-naped Sapsucker (*Sphyrapicus nuchalis*) | x | x | x |
| Downy Woodpecker (*Picoides pubescens*) | x | x | x |
| Hairy Woodpecker (*Picoides villosus*) | x | | x |
| Northern Flicker (*Colaptes auratus*) | x | x | x |
| Western Wood-Pewee (*Contopus sordidulus*) | x | x | x |
| *Empidonax* spp. | x | | x |
| Dusky Flycatcher (*Empidonax oberholseri*) | x | x | x |
| Cordilleran Flycatcher (*Empidonax occidentalis*) | x | | |
| Horned Lark (*Eremophila alpestris*) | x | | |
| Tree Swallow (*Tachycineta bicolor*) | x | x | x |
| Cliff Swallow (*Hirundo pyrrhonota*) | x | x | |
| American Crow (*Corvus brachyrhynchos*) | x | | x |
| Common Raven (*Corvus corax*) | x | | x |
| Rock Wren (*Salpinctes obsoletus*) | x | | x |
| House Wren (*Troglodytes aedon*) | x | x | x |
| Mountain Bluebird (*Sialia currucoides*) | x | x | x |
| Swainson's Thrush (*Catharus ustulatus*) | x | x | x |
| American Robin (*Turdus migratorius*) | x | x | x |
| Sage Thrasher (*Oreoscoptes montanus* | x | x | x |
| European Starling (*Sturnus vulgaris*) | x | x | x |
| Warbling Vireo (*Vireo gilvus*) | x | x | x |
| Red-eyed Vireo (*Vireo olivaceus*) | | x | |

APPENDIX. Continued.

| Species | Line transect | Spot mapping | Point count |
|---|---|---|---|
| Orange-crowned Warbler (*Vermivora celata*) | x | x | x |
| Yellow Warbler (*Dendroica petechia*) | x | x | x |
| MacGillivray's Warbler (*Oporornis tolmiei*) | x | x | |
| Wilson's Warbler (*Wilsonia pusilla*) | x | x | |
| Western Tanager (*Piranga ludoviciana*) | x | x | |
| Black-headed Grosbeak (*Pheucticus melanocephalus*) | x | x | x |
| Green-tailed Towhee (*Pipilo chlorurus*) | x | x | x |
| Spotted Towhee (*Pipilo maculatus*) | x | x | |
| Brewer's Sparrow (*Spizella breweri*) | x | x | x |
| Vesper Sparrow (*Pooecetes gramineus*) | x | x | x |
| Savannah Sparrow (*Passerculus sandwichensis*) | x | x | x |
| Fox Sparrow (*Passerella iliaca*) | x | x | x |
| Song Sparrow (*Melospiza melodia*) | x | x | x |
| White-crowned Sparrow (*Zonotrichia leucophrys*) | x | x | x |
| Red-winged Blackbird (*Agelaius phoeniceus*) | x | x | x |
| Western Meadowlark (*Sturnella neglecta*) | x | x | x |
| Brewer's Blackbird (*Euphagus cyanocephalus*) | x | x | x |
| Brown-headed Cowbird (*Molothrus ater*) | x | x | x |
| Bullock's Oriole (*Icterus bullocki*) | x | x | x |
| Cassin's Finch (*Carpodacus cassinii*) | x | x | x |
| Pine Siskin (*Carduelis pinus*) | x | | |