AVIAN INVENTORY AND MONITORING AT ARROWWOOD NATIONAL WILDLIFE REFUGE, NORTH DAKOTA (1995-1998)

J. SCOTT DIENI
Redstart Consulting
403 Deer Road
Evergreen, Colorado 80439

AND

PAULETTE SCHERR
Arrowwood National Wildlife Refuge
7745 11th St. SE
Pingree, North Dakota 58476

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SUMMARY

In 1995, a breeding bird inventory and monitoring program was initiated at Arrowwood National Wildlife Refuge, North Dakota. Surveys were conducted annually through 1998 from an extensive point count array permanently located across four management units (n = 162). The goal of the program was to obtain a comprehensive inventory of the breeding bird community over time, in association with habitat features common to the refuge. We also explored potential biases of using roadside point counts to estimate bird community parameters.

A total of 76 bird species were identified across 7371 observations over four years, including 40 passerines, 5 raptor species, and 22 waterbird species. Clay-colored Sparrows, Brown-headed Cowbirds and Red-winged Blackbirds were the most commonly observed landbirds; Mallards, Ring-billed Gulls and Blue-winged Teals were the most commonly observed waterbirds. Common Yellowthroats and Bobolinks were the only species that showed consistent declines in relative abundance and distribution over the course of the program, which may warrant further investigation. Several waterfowl species exhibited cyclical patterns in abundance, while many other species exhibited strong yearly variation in counts.

The influence of special habitat characteristics was explored, including the effects of wetlands and woodlands on species diversity and abundance. Point counts with wetlands or woodlands tended to have greater numbers of species, although the effect varied with year. Relative abundance of several species was positively associated with the presence of mature trees, including Mourning Doves, Western Kingbirds, Brown Thrashers, Yellow Warblers and American Goldfinches, while Sedge Wrens, Savannah's Sparrows and Grasshopper Sparrows were negatively associated with the presence of trees. A host of species were also observed on the refuge that require wooded habitats, including Red-tailed Hawks, Great-horned Owls, cavity nesting species such as Wood Ducks, woodpeckers, Tree Swallows, House Wrens, and black-capped Chickadees, and canopy dwellers such as Common Grackles, Baltimore Orioles and Warbling Vireos.

Native mixed-grass prairie was the dominant habitat type, occurring at 76% of the point count stations. Landbird species richness was not significantly associated with mixed-grass prairie cover. The abundance of Clay-colored Sparrows was positively associated with mixed-grass prairie cover (r_s = 0.401), as were Willow Flycatchers (r_s = 0.219), Song Sparrows (r_s = 0.231), and Yellow Warblers (r_s = 0.224). The presence of encroaching snowberry may be factor favoring these shrub-nesting species. Only Savannah Sparrow abundance responded negatively with mixed-grass prairie cover (r_s = -0.305). Bird species complements and relative abundance are presented for other habitat types.

We explored the bias of using roadside point counts to sample breeding bird populations. Fifty-nine percent of survey stations were established directly on roads, while the remaining were randomly placed at distances of 100, 200, 300 and 400 m away from roads. Roadside stations tended to have a mosaic of habitat types, partly due to the inclusion of woodlands (riparian, shelterbelt or farmstead groves) and wetlands (permanent and ephemeral). The number and complement of species observed on-road were similar to that observed off-road. Relative abundance estimates for commonly observed species were also similar on-road versus off-road, both within and among years. Only the relative abundance of Savannah Sparrows, Grasshopper Sparrows, and Western Meadowlark was associated with survey station road position, but the effect was small ($eta < 0.06$). Although there was a clear bias in habitat features sampled using roadside counts, the overall effect on the measurement of the bird community appears to be negligible.

INTRODUCTION

In 1995, refuge personnel initiated a breeding bird inventory at Arrowwood National Wildlife Refuge (NWR), North Dakota. An extensive array of point count survey stations was permanently established across four management units, and breeding bird surveys were conducted annually through 1998. The program's primary goal was to obtain a comprehensive inventory of the breeding bird community using the refuge over time, in association with habitat features common to the refuge. Our objective with this report is to provide a summary of those data to assist refuge personnel with outlining options and setting priorities for future inventory and management activities at Arrowwood NWR. Specifically, data were treated in the following manner: (1) refuge-wide inventory (species list), (2) describing short-term trends in population abundance and distribution, and (3) habitat associations and selection, emphasizing native mixed-grass prairie and the influence of woodland and wetland habitats on diversity and abundance.

An additional objective that is of particular interest to the USFWS Region 6 Nongame Migratory Bird Program concerns the bias of roadside counts on the measurement of avian populations at a wildlife refuge setting. Our objective here was to relate estimates of species diversity and relative abundance to survey station position relative to the road system. This was done both within and among years to determine if trends were similar on-road versus off-road. The road system at Arrowwood NWR consists mostly of narrow "two-tracks" or "trails", and as such, we would expect little direct influence on counts relating to distinct habitat discontinuities (Hanowski and Niemi 1995, Hutto et al. 1995, Keller and Fuller 1995, Rotenberry and Knick 1995) or vehicle noise (Reijnen et al. 1995) associated with main roads. Rather, our data set contains habitat information that allowed us to examine the bias of roadside counts in terms of habitats sampled, i.e., are some habitats and habitat characteristics more likely to be sampled using roadside point counts, and in turn, how does this influence the measurement of associated bird populations.

METHODS

Study area. – Arrowwood NWR is located along the James River in Foster and Stutsman Counties in east-central North Dakota (47°26′N, 98°86′W; elev. ca. 450 m). The refuge lies on the western edge of the drift prairie, where the topography is characteristic of glacially created plains, with terrain that ranges from mildly undulating to hilly. The climate is continental and semiarid, with long, cold, winters, and warm, wet summers. Most precipitation (about 49 cm annually) falls during the growing season.

Arrowwood NWR consists of native mixed-grass prairie (3323 ha) and seeded grasslands (1325 ha), croplands (316 ha), woodlands (48 ha), wetlands (51 ha), and wetland impoundments (1433 ha). Grassland vegetation is dominated by nonnative species, including Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*), some quackgrass (*Elytrigia repens*) and leafy spurge (*Euphorbia esula*). Native grasses include western wheatgrass (*Pascopyrum smithii*), green needle grass (*Stipa viridula*), big bluestem (*Andropogon gerardii*), little bluestem (*Shizachyrium scoparius*), blue grama (*Bouteloua gracilis*) and switchgrass (*Panicum virgatum*). Wheatgrasses, alfalfa (*Medicago sativa*) and sweet clover (*Melilotus officinalis*) were the principal species seeded for dense nesting cover. Western snowberry *(Symphoricarpos occidentalis*) is a common encroaching native shrub in grassland habitats.

Woodland habitats are mostly riparian, but also occur as shelterbelt and farmstead groves. Common riparian trees include green ash (*Fraxinus pennsylvanica*), eastern cottonwood (*Populus deltoides*), American elm (*Ulmus americana*), and box elder (*Acer negundo*). Shelterbelts commonly possess green ash and Russian olive (*Elaeagnus commutata*), Chinese elm (*U. parvifolia)*, Rocky Mountain juniper (*Juniperus scopulorum*), chokecherry (*Prunus virginiana*), and Siberian pea (*Caragana arborescens*).

Bird and habitat sampling. - Permanent survey stations were systematically established along the tertiary road system (narrow "two-tracks" about 2-m wide) among four contiguous management units (n = 162). Stations were separated by a minimum of 200 m to ensure that most bird observations were independent. Ninety-five stations were located directly on-road, while 67 were situated off-road at randomly selected distances of 100, 200, 300, or 400 m (Table 1).

Bird populations were sampled using fixed-radius point counts (Hutto et al. 1986). This method assumes that detection probabilities for each species are relatively constant among habitats and years. Surveys were conducted once annually during June from 1995 through 1998. (Surveys continued into mid-July in 1996 due to wet and windy conditions.) Surveys were conducted for a 5-min period, beginning immediately upon arrival at each station. Bird surveys began 15-30 min prior to local sunrise and typically lasted until 0930-1000 h CDT. Surveys were not conducted during periods of inclement weather, e.g., rainy conditions or winds > 24 kph. During each 5-min point count, the number of individuals detected for each bird species within a 100-m radius were tallied and recorded. Birds flying over or through a point count were recorded separately. However, birds circling above the station (e.g., swallows) were considered valid detections.

The relative proportion of each habitat cover type was estimated within 100-m radius from the center of each point count station. Nine habitat cover types were used: (1) native mixed-grass prairie, (2) tame grass (areas now seeded to dense nesting cover that were previously farmed), (3) alfalfa cropland, (4) other cropland (small grains or row crops - may vary from year to year), (5) seeded natives (seeded in the last ten years), (6) wetland marshes, (7) riparian woodlands, (8) native tree clumps (farmstead groves), and

(9) shelterbelts. Habitat changes/conversion at each point count station were noted each year.

Data analysis. – All statistical analyses were conducted using SPSS v. 7.5 for Windows (SPSS 1996). Frequency of detection and relative abundance (adjusted per 100 ha) were summarized for each species by year. Diversity was indexed using simple species richness[1] (count of species) per station for landbirds and waterbirds separately. Landbirds are defined here as including all terrestrial species excluding raptors. Waterbirds include all non-passerine species principally tied to aquatic habitats (grebes, Pelecaniformes, waders, waterfowl, rails and most Charadriiformes). Species detected only once during the survey period were not included in species richness analyses.

We used simple correlation coefficients (Pearson r and Spearman r_s) to the gauge the relationship between habitat variables and bird community parameters of interest. Habitat variables included the percent cover of native prairie, distance from the nearest road, and the presence or absence of woodlands or wetlands at a station. The latter variables were treated as dummy variables (data coded 0 for absent or 1 for present) which allowed them to be used in parametric analyses. Species richness and abundance were also tested for road effects, while simultaneously examining year effects and road-year interaction using multivariate analysis of variance (MANOVA) with a repeated measures design (Norusis 1990). "*Eta*" was used as a measure of effect size, which can be interpreted similarly to the Pearson correlation coefficient as a measure of linear association or measure of strength. Both *eta* and Pearson *r* can vary between 0.0 and 1.0 (*r* can also vary between 0.0 and –1.0 for negative associations) and can be interpreted as the following: the larger the absolute value, the stronger the relationship or magnitude of difference (e.g, for year effects, *eta* measures the degree of average difference among years).

Trends in relative abundance for common species were examined descriptively and tested for year effects using MANOVA procedures[2]. Variation in counts across years was characterized for each species by estimating coefficients of variation ($CV = SD/\bar{x} \bullet 100$) across the 4-year period, and taking their average across all plots. Note that for trends, abundance for each species was summarized only across stations that the species was detected at least once.

Species composition was compared each year between on-road and off-road stations (≥ 200 m from the nearest road) using the Sϕrensen coefficient of community similarity (Brower and Zar 1984), which yielded a percent similarity in bird species composition:

$$CC_s = 2c/(s_1 + s_2),$$

[1] Species richness is the simplest measure of diversity (Brower and Zar 1984) and was chosen because it is more easily and accurately measured, but still highly correlated with the commonly used Shannon diversity index (Verner and Larson 1989).

[2] This does not test the statistical significance of a linear trend (such as route regression), but rather if any year is significantly different from the rest (much like ANOVA for comparison among several independent groups).

where c is the number of species shared among treatments, and s_1 and s_2 are species richness values for each treatment (on-road or off-road). The similarity index could range from 0% (no similarity in species composition) to 100% (identical species complements)[3].

The significance level for all statistical tests was set at an α-level of 0.05 (P-value). Experiment-wide error rate was not controlled due to the exploratory nature of this analysis, i.e., there is a high likelihood that some results deemed statistically significant may have occurred simply due to chance[4]. The individual point count station was treated as the sample unit for most analyses.

RESULTS AND DISCUSSION

Point count distribution. – A total of 162 point count stations were initially established at fixed locations across four management units (Table 1, p. 15). Sixty-nine percent were dominated by native mixed-grass prairie. Tame grass was the next dominant habitat (10% of stations). Woodland habitats occurred at 19% of the stations, while wetland habitats occurred at 9%. Woodlands were the dominant habitat at 7% of the stations riparian), while wetlands were the dominant habitat at only one station.

Bird species inventory. – A total of 76 bird species were identified during the survey period (Table 2). Of these, 12 (16%) were detected only once (Table 3). Clay-colored Sparrows, Brown-headed Cowbirds and Red-winged Blackbirds were the three most commonly observed landbird species, respectively (Alpha code and scientific names are provided in Appendix A). Clay-colored Sparrows were also the most frequently encountered species, occurring on an average of 79% of the stations each year. Five raptor species were observed overall, but only occasionally, averaging < 1 observations annually. Northern Harriers were the most frequently detected hawk, followed by Swainson's and Red-tailed hawks. Two owl species were observed during the program (Great-horned and Short-eared owls), but only once each. Twenty-two waterbird[5] species were identified, including ten species of waterfowl. Mallards were the most common waterbird, followed by Ring-billed Gulls. However, the latter were clumped in distribution, occurring on an average of < 1 stations annually (Refer to Appendix B for species locations by point count station). Ten landbird species were encountered on >

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[3] 48 on-road stations were randomly selected for this portion of the analysis to equal the number of off-road point counts. Only those species with five or more independent observations were included in this portion of the analysis.

[4] We recommend that more attention be placed on the strength and pattern of relationships evaluated here rather than on tests of statistical significance. Failure to obtain a statistically significant result does not prove that no relationship exists (it almost certainly does, to some degree); conversely, results may be statistically significant, but ecologically inconsequential where relationships (effect sizes) are found to be weak.

[5] Killdeer and Upland Sandpipers are treated here as landbirds with regards to species richness analyses.

20% of the stations annually. Conversely, no species of waterbird were encountered on more than 12% of the plots annually. (Caution is warranted when making comparisons in abundance and frequency, which requires an assumption of equal detectability among species and habitats using fixed-radius points, which is not realistic for most, if not all, species.)

Population trends. – Only two species showed consistent declines in relative abundance over the survey period (Table 4). Common Yellowthroats declined from an average relative density of 31 individuals per 100 ha in 1995 to only 13.5 per 100 ha in 1998 (slope = -5.7 individuals per year). Common Yellowthroats showed an even greater decline in the frequency of stations detected (Fig. 1, p. 25). Bobolinks declined from 41.5 to 25.1 individuals per 100 ha over the survey period (slope = -4.8 individuals per year).

Of the species examined (n = 24), 15 had significant year effects in counts, while all showed considerable variability in relative abundance among years (CV range = 74 – 198%). Mallards, Gadwalls and Blue-winged Teals showed almost cyclical fluctuations in relative abundance with high points occurring during 1995 and 1997. Willow Flycatchers were relatively common in most years, but were conspicuously absent in 1997. Conversely, Least Flycatchers were rarely encountered most years, with the exception of 1997, where they were commonly observed. Only counts for Clay-colored Sparrows were relatively consistent across the survey period. Drastic variations over time may reflect the nomadic nature of many grassland species (S. Jones, pers. comm.), and the opportunistic nature of ephemeral wetland species. Unfortunately, we should expect greater stability from the woodland species; the extreme variability of several of these species may reflect short-comings of the fixed-radius point count method (Barker and Sauer 1995), particularly when only a single visit is conducted each year[6]. Moreover, bird surveys were begun 30 min prior to local sunrise. This may have added greater variability to the data by including this early morning period because of heightened activity of many species, sometimes referred to as the "dawn chorus". Ralph et al. (1993) recommend waiting until sunrise where bird activity becomes relatively stable through late morning (Verner and Ritter 1986), thus eliminating a potential source of variation.

Special habitat components. – We examined the influence of special habitat components on species richness. Overall, 59% of the point counts consisted of a mosaic of habitat cover types. Point counts with mixed habitats averaged 6.1 landbird species versus 5.3 species at stations that were of one cover type (Table 5). However, the effect varied according to year, especially in 1995, where there was effectively no difference in species richness. Waterbird species richness was also higher at stations that were a mosaic of habitats, although the effect was subtle. The improved species richness observed here relates principally to the presence of woodlands (riparian, shelterbelts or farm groves), and to a lesser extent, wetlands (both permanent and ephemeral). Waterbird richness was

[6] However, when the goal is to estimate the total number of species in a study area, visiting more points rather than revisiting the same points may be more efficient (see USDI Fish and Wildlife Research Bulletin, No 46, 1993).

demonstrably higher on plots with wetlands present, although the effect varied according to year, with 1997 having the greatest differential in species richness. The presence of wetlands also increased the number of landbird species, although again, the effect varied with year. The interactions between species richness and year are fairly subtle and statistical significance may simply be due to our relatively large sample size. Nonetheless, these interactions may reflect perhaps an underlying dynamic in the physical or biotic nature of wetlands that varies among years. The summer of 1993 broke a long and semi-serious drought cycle, and since then, Arrowwood has flooded every spring with most wetlands maintaining high water conditions through 1998. Many seasonal and most semi-permanent wetlands are still presently flooded, and additional vegetation appears around these wetlands each year. The winter of 1996-1997 was unusually long and hard, with snow amounts near 250 cm and excellent spring run-off. Whether this had any profound effect on the bird community is impossible to say, although the annual precipitation or even the period from January - June doesn't seem to exhibit much of a pattern that would explain differences in 1997 for waterbirds.

The presence of woodland habitats had a moderate influence on landbird species richness, where there were 18% more species at stations with trees, on average. Overall, there was no effect of woodlands on waterbird richness, as might be expected (cavity-nesters excepted). However, there was an interaction between the presence of trees and year. During 1995 and 1997, waterbird richness was greater at stations without trees; during the other years, the converse was true. Reasons for this are unclear. We would expect that woodland habitats in themselves would be stable, but instead, this variability may relate to the presence of wetlands. It would be informative to examine the simultaneous influence of wetlands and woodlands, but sample size constraints preclude this.

The relationship between individual relative abundance and special habitat conditions are shown in Table 6. Although there were several statistically significant relationships, most were weak to only moderate in strength. Not surprisingly, woodland nesting species, particularly Mourning Doves, Western Kingbirds, Brown Thrashers, Yellow Warblers and American Goldfinches, responded positively to the presence of woodlands, with the notable exception of the cavity-nesting Tree Swallow ($r = 0.021$). (The latter may be explained by the presence of 70+ nest boxes widely distributed along trails, fence lines, as well as woodlands; nest boxes were occupied almost exclusively by tree swallows.) Conversely, some grassland species such as Sedge Wrens, Savannah's and Grasshopper sparrows were negatively correlated with the presence of trees, albeit weakly so. The implications of woodland habitats in the native prairie goes far beyond what these results indicate. Many of the woodland species listed in Table 6 were commonly observed in open, non-forested areas (thus the relatively weak relationships shown in Table 5). They nonetheless require the presence of nearby wooded habitats, and would otherwise be largely absent from the refuge without the presence of these habitats. Moreover, there were less commonly observed species listed in Table 3 that are largely restricted to wooded habitats, such as Red-tailed Hawks, Great-horned Owls, cavity-nesting species such as woodpeckers, Tree Swallows, House Wrens and Black-

capped Chickadees, in addition to deciduous canopy dwellers such as Black-billed Cuckoos, Warbling Vireos, Common Grackles and Baltimore Orioles

There were several positive relationships between the presence of wetlands and the abundance of several species, predictably Mallards, Blue-winged Teals, and Red-winged Blackbirds. Conversely, Bobolinks, Clay-colored and Grasshopper sparrow abundance all had a negative (though weak) relationship with the presence of wetlands. The occupancy of wetlands (and woodlands) within the boundaries of a station reduces the availability of other suitable habitats which probably explains many of these negative, but weak relationships.

Native mixed-grass prairie relationships. - Native mixed-grass prairie was the dominant habitat type, occurring on 76% of the stations. Of these, 59% were completely covered by native prairie. We examined the relationship between the native prairie cover and bird community parameters of interest, but in doing so, only used stations that did not possess woodlands or wetlands, thus only open habitats were employed such as native prairie, alfalfa and other croplands, seeded native grasses and tame grass. With these restrictions, native prairie cover ranged from 0 – 100% ($n = 112$). Landbird species richness (averaged across years) was not significantly related to % native prairie cover; regardless, the relationship was positive, but weak at best ($r_s = 0.143$, $P = 0.134$). The relationships between native prairie cover and relative abundance are shown in Table 6. Clay-colored Sparrows showed the strongest relationship, possessing greater relative abundance at stations with more native prairie cover ($r_s = 0.401$). This is of interest since Clay-coloreds are thought to be associated with open, ecotonal areas with scattered shrubs or thickets (Knopf 1996). Knapton (1994) describes their breeding habitat as the following: "Common species of open shrubland, thickets along waterways, second-growth areas, and forest edges and burns (Root 1968, Godfrey 1986)".

Shrub-using Willow Flycatchers ($r_s = 0.219$), Song Sparrows ($r_s = 0.231$) and Yellow Warblers ($r_s = 0.224$) also responded positively to increasing native prairie cover, but to a lesser extent. Conversely, only Savannah Sparrows responded negatively to increasing native prairie cover ($r_s = -0.305$). Savannah Sparrows inhabit open, typically grassy habitats, but also cultivated fields, including especially alfalfa (Wheelwright and Rising 1993), preferring mesic micro-habitats with dense grass development (Wiens 1969). Savannah Sparrows apparently do not avoid habitats with some shrub development, but do avoid areas with extensive forest cover (Wheelwright and Rising 1993).

Native mixed-grass prairie at the Arrowwood refuge complex is considered here as native only because the sod has not been previously broken for agriculture. Unfortunately, much of the vegetation in these areas are dominated by cool season exotics, particularly Kentucky bluegrass and smooth brome, while encroaching snowberry provides an ever-increasing shrub component to grasslands. The inclusion of snowberry and perhaps non-native forbs such as sweet clover may explain somewhat the positive response of shrub-associated bird species, particularly Clay-colored Sparrows, which were the most dominant landbird species on the refuge (as was native prairie the most dominant habitat type). In southwest Manitoba, most Clay-colored nests were constructed in snowberry (*n*

= 125); only 5% of the nests were not supported, at least in part, by snowberry branches (Knapton 1994). We roughly estimate that ca. 75% of the native prairie at Arrowwood has some snowberry present, and perhaps 25% has very thick patches.

Other habitat dominants. – Tame grass was second most dominant habitat type (10% of stations), followed by riparian (7%) and cropland (4%). Seeded natives were the dominant habitat at only one station. Species complements and their relative abundance (adjusted per 100 ha per year) habitat type are shown in Table 7 for survey stations possessing a single habitat type. Red-winged Blackbirds were the most commonly observed landbird species in alfalfa and cropland habitats, while Savannah Sparrows and Brown-headed Cowbirds were the dominant landbirds at stations covered by tame grass. Horned Larks were mostly restricted to croplands. Mallards were the dominant waterbird in croplands and tame grass, while pintails were mostly restricted to stations dominated by alfalfa.

Road bias. – Of the 162 point count stations, 59% were located on-road. Table 8 shows the distribution of point counts relative to the special habitat characteristics previously described. Fifty-eight percent of the point counts were of mixed habitats on-road, while only 6% of the stations located 400 m off-road had mixed habitats. There is a moderate relationship ($r = 0.413$, $P = 0.000$) between distance from road and the probability of a point count station having multiple habitat types. This can, in part, be related to the presence of woodland and wetland habitats within the boundaries of a point count station. On-road stations were more likely to possess woodland and wetland habitats than off-road, particularly versus 300 and 400 m. In summary, on-road stations contained a greater diversity of habitats than off-road stations, demonstrating a bias in habitats selected using roads as a basis for point count selection.

As was determined earlier, species richness tended to be greater at stations with woodlands or wetlands present. Moreover, abundance of some species was affected by the presence of these habitat types. Given the bias of habitat selection using the road stations, we should expect differences in bird community parameters estimated on-road versus off-road. However, we were not able to detect any meaningful relationships between bird community parameters and the location of point count stations relative to roads. Overall, the mean community similarity in species observed was 84% (SE = 1.6, n = 4 years) on-road versus off-road. We do not feel that this difference is great; we would expect some difference simply to chance observations, rather than to a road effect. Across all years, only Wood Ducks, Red-tailed Hawks, and House Wrens were restricted to stations located on-road (of those species observed on five or more independent occasions).

We found no meaningful relationships between species richness and distance from road ($eta < 0.10$) (Table 9). Species richness varied significantly among years for both waterbird and landbird richness, controlling for distance from road. However, interactions between year and distance from road were not significant ($eta < 0.02$, $P > 0.05$), suggesting that patterns in species richness over time did not differ according to the location of point count stations relative to roads. Similar patterns were observed for

abundance parameters. Only Savannah Sparrows, Grasshopper Sparrows, and Western Meadowlarks had significant road effects on relative abundance, but the relationships were extremely weak (*eta* < 0.06). Twelve of the 24 species examined showed significant year effects in abundance, but only the Common Yellowthroat and Western Meadowlark had significant year-road effect interactions, but again, the effect was extremely weak (*eta* < 0.06).

Potential biases of roadside counts have recently become an important topic, having implications with regards to the inferential capabilities of several national avian monitoring schemes (e.g., Breeding Bird Survey, US Forest Service point count monitoring programs on National Forest land), as well as local monitoring programs that employ roadside point counts. Most studies in the literature have examined the direct influence of roadside surveys on estimates of population parameters. These studies employed paired on-road/off-road point count designs, controlling for habitat and other local factors, in an effort to determine the immediate influence of roads in terms of discontinuities in habitats found bordering roads (Hanowski and Niemi 1995, Hutto et al. 1995, Keller and Fuller 1995, Rotenberry and Knick 1995). The magnitude of road bias varied among studies. Rotenberry and Knick (1995) found no indications of roadside count bias in shrub-steppe and grassland habitats of southwestern Idaho, with the exception of Western Meadowlarks, which were more commonly observed along roads. They attributed this to what they called the "fence effect", where meadowlarks conspicuously perch on fences that tend to border many roads in western rangelands. This may also explain why meadowlarks in this study were more commonly observed on roads, although the effect was subtle ($r = -0.218$, $P = 0.005$). Studies of road bias in forested habitats typically found greater species richness and abundance estimates on roads, favoring forest edge species, in particular (Hanowski and Niemi 1995, Hutto et al. 1995, Keller and Fuller 1995). They generally attributed the effect to habitat changes associated with the presence of roads (and also the possibility of increased sightability), and that the effect could be mitigated somewhat by choosing narrower secondary roads, and to be aware of the habitat relationships of the species surveyed.

The road system at Arrowwood NWR consists mostly of very narrow tertiary roads in mostly open grassland habitats, and as such, it is fairly safe to assume that the roads themselves would have little impact on estimates of bird community parameters, which was also suggested by other work in grassland habitats (Hutto et al. 1995, Rotenberry and Knick 1995). However, there is the potential for bias in where roads are placed that may favor some habitats over others. In the eastern Great Plains, secondary roads commonly divide areas of different land ownership, and therefore, possibly different land-use practices. We demonstrated this to some degree at Arrowwood, where roadside point counts were more likely to possess multiple habitats. In addition, isolated woodland habitats were more prevalent along roads in the form of shelterbelts and riparian habitats. Wetland habitats were also more prevalent along roads at Arrowwood NWR, but to a lesser degree. This is partly because roads at Arrowwood also serve as dikes for several small and large drainages. In addition, the area between the impoundments and boundary can be quite narrow, which puts the riparian zone within the plot on the road.

Regardless of the habitat bias observed here, there was in practical terms, no road effect, either in terms of the magnitude of counts, or in patterns of counts over time. The question that is of interest is how far can we extrapolate from these results to areas outside of the refuge. Our guess is that a similar habitat bias would occur along secondary (county) roads in the eastern prairie, but as our results suggest, there would be little over all bias in the estimation of relative abundance or their trends. (However, county roads are generally 2 – 3 times wider, and are typically bordered by steep ditches that may provide grassland and/or wetland habitat that would otherwise not be present in adjacent fields.) At the very least, our results suggest that there would be little bias in using tertiary road systems on other wildlife refuges of the eastern great plains. Moreover, conditions become increasingly dryer proceeding west in the prairie. As a result, both woodlands and wetlands decline in distribution, while rangelands become increasingly more predominate, thus we would expect even less road bias in habitats sampled than that of the eastern Great Plains.

There is also the issue of whether habitat changes along roads mirror those off-road. Unfortunately, we have no data to address this question at Arrowwood NWR. Keller and Scallan (1999) found little difference in the way habitat types changed over time (mid 1960s to late 1980s) on-road versus off-road along Breeding Bird Survey routes in Ohio. The only notable differences related to the degree of urbanization along roads, and also an increase in the number of ditches channeling water off-road, as a result of agricultural development. The former is unlikely to be a significant factor in the northern prairie in general, and obviously not a factor on national wildlife refuges.

RECOMMENDATIONS

1) Two bird species showed declines in relative abundance and distribution (Common Yellowthroat and Bobolink), which may warrant further investigation in the form of the following: (1) focus specifically on these species (especially Common Yellowthroats) to determine if in fact, their populations are declining on the refuge, and if so, (2) investigate possible reasons why their populations are declining that are perhaps related to management activities at Arrowwood NWR. An examination of Breeding Bird Survey data regionally might be instructive (http://www.mbr.nbs.gov:80/bbs/bbs.html). Beware that four years is probably not enough time to generate reliable trend estimates.

2) Native mixed-grass prairie is the dominant habitat at Arrowwood NWR. However, many shrub-related passerines are utilizing this habitat which is probably related to the encroachment of snowberry. It may be worth investigating the degree of shrub development in this habitat type, and how it may be influencing the distribution and abundance of grassland bird species, particularly Upland Sandpipers, Savannah, Grasshopper, Le Conte's, and Nelson's Sharp-tailed sparrows, Dickcissels, and Bobolinks. Note that most of these species were not explored further here simply because they were rarely counted. Perhaps their low abundance is somehow related to the condition of mixed-grass prairie habitats at Arrowwood NWR

3) Coulee habitats were not sampled in this inventory, but are certainly worth investigating. Coulees possess woody shrubs such as juneberry (*Amelanchier alnifolia*), silver buffaloberry (*Shepherdia canadensis*), and chokecherry, and may possess unique bird associations worth describing. We recommend using the area search method (protocol in Ralph et al. 1993) to get an idea of the species composition and breeding status from a random sample of coulee habitats found on the refuge.

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LITERATURE CITED

AMERICAN ORNITHOLOGISTS' UNION. 1998. Checklist of North American birds. 7th edition. American Ornithologist's Union. Washington D.C.

BARKER, R. J., AND J. R. SAUER. 1995. Statistical aspects of point count sampling, p. 125-130. *In* C. J. Ralph, J. R. Sauer, and S. Droege, eds., Monitoring bird populations by point counts. USDA For. Serv. Gen. Tech. Rep., PSW-149.

BROWER, J. E., AND J. H. ZAR. 1984. Field and laboratory methods for general ecology. Wm. C. Brown Company Publishers, Dubuque, IA.

GODFREY, W. E. 1986. The birds of Canada. Natl. Mus. Nat. Sci., Ottawa.

HANOWSKI, J. M., AND G. J. NIEMI. 1995. A comparison of on- and off-road bird counts: do you need to go off road to count birds accurately? J. Field Ornithol. 66:469-483.

HUTTO, R. L., S. M. PLETSCHET, AND P. HENDRICKS. 1986. A fixed-radius point count method for nonbreeding and breeding season use. Auk 103:593-602.

HUTTO, R. L., S. J. HEJL, J. F. KELLY, AND S. M. PLETSCHET. 1995. A comparison of bird detection rates derived from on-road vs. off-road point counts in northern Montana, p. 103-110. *In* C. J. Ralph, J. R. Sauer, and S. Droege, eds., Monitoring bird populations by point counts. USDA For. Serv. Gen. Tech. Rep., PSW-149.

KELLER, C. M. E., AND M. R. FULLER. 1995. Comparison of birds detected from roadside and off-road point counts in the Shenandoah National Park, p. 111-115. *In* C. J. Ralph, J. R. Sauer, and S. Droege, eds., Monitoring bird populations by point counts. USDA For. Serv. Gen. Tech. Rep., PSW-149.

KELLER, C. M. E., AND J. T. SCALLAN. 1999. Potential roadside biases due to habitat changes along breeding bird survey routes. Condor 101:50-57.

KNAPTON, R. W. 1994. Clay-colored sparrow (*Spizella pallida*). *In* A. Poole, and F. Gill, eds., The birds of North America, no. 120. Acad. Nat. Sci. Philadelphia.

KNOPF, F. L. 1996. Prairie legacies-birds, p. 135-148. *In* F. B. Samson, and F. L. Knopf, eds., Prairie conservation: preserving North America's most endangered ecosystem. Island Press, Washington D.C.

NORUSIS, M. J. 1990. SPSS advanced statistics user's guide. SPSS Inc. Chicago, IL.

RALPH, C. J., G. R. GEUPEL, P. PYLE, T. E. MARTIN, AND D. F. DESANTE. 1993. Handbook of field methods for monitoring landbirds. USDA For. Serv. Gen. Tech. Rep., PSW-144.

REIJNEN, R., R. FOPPEN, C. TER BRAAK, AND J. THISSEN. 1995. The effects of car traffic on breeding bird populations in woodland. III. Reduction of density in relation to the proximity of main roads. J. Appl. Ecol. 32:187-202.

ROOT, O. M. 1968. Clay-colored sparrows, p. 1186-1208. *In* A. C. Bent, ed., Life histories of the birds of North America. U.S. Natl. Mus. Bull. 237.

ROTENBERRY, J. T., AND S. T. KNICK. 1995. Evaluation of bias in roadside point count surveys of passerines in shrubsteppe and grassland habitats in southwestern Idaho, p. 99-101. *In* C. J. Ralph, J. R. Sauer, and S. Droege, eds., Monitoring bird populations by point counts. USDA For. Serv. Gen. Tech. Rep., PSW-149.

SPSS. 1996. SPSS 7.5 for Windows. SPSS Inc., Chicago, IL.

VERNER, J., AND L.V. RITTER. 1986. Hourly variation in morning point counts of birds. Auk 103:117-124.

VERNER, J., AND T. A. LARSON. 1989. Richness of breeding bird species in mixed-conifer forests of the Sierra Nevada, California. Auk 106:447-463.

WHEELWRIGHT, N. T., AND J. D. RISING. 1993. Savannah sparrow (*Passerculus sandwichensis*). *In* A. Poole, and F. Gill, eds., The birds of North America, no. 45. Acad. Nat. Sci. Philadelphia.

WIENS, J. A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithol. Monogr. No. 8.

Table 1. Distribution of point count survey stations, Arrowwood NWR, North Dakota.

Variable	Freq.	%	Variable	Freq.	%
Management Unit			Dominant Habitat[1]		
Arrowwood Lake	58	36	Alfalfa	4	2
Depuy Marsh	21	13	Cropland	7	4
Jim Lake	45	28	Native mixed-grass prairie	111	69
Mud Lake	38	23	Riparian	11	7
Total	162		Seeded natives	1	<1
			Tame grass	16	10
Road Status			"Urban"	1	<1
Off-road	67	41	Wetland	1	<1
On-road	95	59	Converted[2]	10	6
Distance from road			Presence of Wetlands[1]		
100 m	16	24	Absent	147	91
150 m	3	4	Present	15	9
200 m	16	24			
300 m	14	21	Habitat Mosaic[1]		
400 m	18	27	Mixed	66	41
			Homogeneous	95	59
Presence of Trees[1]			Converted[2]	1	<1
Absent	131	81			
Present	31	19			

[1] Within 100-m radius point count
[2] Habitat conversion over the course of the survey period.

Table 2. Breeding bird survey summary, Arrowwood NWR, North Dakota.

Survey results	Summary
No. of point count stations	162
No. of years surveyed	4 (1995 – 1998)*
No. of visits per year	1
No. of observers overall	1 (P. Scherr)
Time of year surveyed	June – early July
Total observations	7371
Flyovers	285 (4%)
Within 100 m radii	7086 (96%)
Within 50 m radii	3838 (52%)
Unknown species	4 (< 1%)
Ave. detections / station / year	11.5
Total species	76
Landbird	49 (65%)
Passerine	40 (53%)
Raptor	5 (7%)
Strigidae	2 (3%)
Waterbird	22 (29%)
Waterfowl	10 (13%)
Most abundant species	
Landbird	CCSP
Waterbird	MALL
Species detected once	12 (16%)
Flyover species only	1 (DCCO)

* Stations 157-162 were not visited in 1997 due to time constraints

Table 3. Relative abundance and distribution averaged among years for each bird species encountered (listed by lifeform in order of decreasing abundance).

Lifeform	Species	Count per 100 ha $\bar{x}$	Stations observed (%)	Lifeform	Species	Count per 100 ha $\bar{x}$	Stations observed (%)
Waterbird	MALL	8.0	12	Landbird	TRES	8.4	14
	RBGU	7.1	<1		AMGO	7.9	13
	BWTE	3.9	5		SOSP	7.1	18
	GADW	3.8	8		MODO	5.9	12
	BLTE	1.3	1		WEME	5.2	14
	NSHO	0.9	2		WIFL	4.6	11
	AMCO	0.6	1		CEDW	4.0	7
	WODU	0.6	<1		WEKI	3.1	8
	NOPI	0.6	<1		LEFL	2.2	6
	SORA	0.5	2		HOLA	2.0	3
	COSN	0.3	<1		VESP	1.9	4
	AWPE	0.3	<1		BRTH	1.8	5
	AGWT	0.3	<1		YHBL	1.7	2
	AMWI	0.3	<1		GRCA	1.6	4
	WEGR	0.2	<1		LCSP	1.5	4
	WILL	0.1	<1		BARS	1.4	3
	EAGR	P	<1		HOWR	1.2	2
	AMBI	P	<1		STGR	1.1	2
	HOME	P	<1		KILL	1.0	2
	AMAV	P	<1		UPSA	0.9	2
	COME	P	<1		AMRO	0.6	2
	DCCO	0[1]	0		NOFL	0.3	1
Raptor	NOHA	0.4	1		CHSP	0.3	<1
	SWHA	0.2	<1		CLSW	0.3	<1
	RTHA	0.2	<1		BBMA	0.2	<1
	GHOW	P	<1		EUST	0.2	<1
	SEOW	P	<1		STSP	0.2	<1
Landbird	CCSP	53.4	79		RNPH	0.2	<1
	BHCO	39.6	47		BCCH	0.2	<1
	RWBL	30.7	36		BAOR	0.2	<1
	BOBO	23.9	43		HAWO	0.1	<1
	COYE	19.0	45		WAVI	0.1	<1
	SEWR	18.6	34		AMCR	0.1	<1
	SAVS	17.2	33		BBCU	0.1	<1
	YWAR	14.5	29		EAPH	P	<1
	GRSP	13.9	31		PUMA	P	<1
	COGR	12.6	16		GRPA	P	<1
	EAKI	9.6	22		DICK	P	<1

P = observed once
[1] Flyover only

Table 4. Short-term trends in relative abundance (100 ha^{-1}) for the most commonly observed species. Mean abundance was calculated for each species each year across point counts *where* present (compare with Table 3). CV measures the relative variability in counts among years within each point count. COYE (slope = -5.7) and BOBO (-4.8) showed linear declines (see Fig. 1, p. 25).

Species	1995	1996	1997	1998	Ave. CV	*P*	*n* stations
GADW	21.5	4.3	25.8	14.6	181	0.000	37
MALL	46.9	3.5	27.2	16.2	178	0.000	55
BWTE	18.0	11.1	65.0	12.5	181	0.024	23
MODO	19.5	21.4	26.5	10.4	161	0.004	48
WIFL	28.6	15.6	0.0	16.9	165	0.000	49
LEFL	1.8	1.8	32.7	2.7	198	0.000	35
WEKI	14.7	12.2	18.4	6.5	186	0.075	39
EAKI	22.7	10.5	19.2	15.4	159	0.004	91
TRES	15.9	20.9	32.3	14.9	173	0.148	63
SEWR	28.9	33.3	29.3	21.4	134	0.038	102
BRTH	17.6	4.4	13.2	4.4	188	0.007	29
CEDW	18.9	34.2	26.9	16.5	161	0.296	27
YWAR	32.7	29.3	32.3	30.1	111	0.726	74
COYE	31.8	25.1	22.6	13.5	120	0.000	132
CCSP	52.2	56.3	56.6	58.1	74	0.630	155
SAVS	19.2	26.0	27.4	41.9	129	0.000	98
GRSP	15.6	25.1	23.8	22.6	143	0.054	99
SOSP	20.6	15.1	12.2	13.8	158	0.235	74
BOBO	41.5	31.8	32.4	25.1	123	0.009	119
RWBL	58.6	29.1	65.0	57.2	120	0.000	94
WEME	32.8	8.3	2.3	5.1	176	0.000	69
COGR	29.9	22.5	40.6	33.3	164	0.181	65
BHCO	75.2	28.6	55.4	25.8	137	0.000	138
AMGO	13.6	30.7	25.8	24.8	165	0.090	53

Table 5. The effects of special habitat characteristics on species richness. The influence of the presence of trees and wetland habitats, or whether the habitat at each station was homogeneous (of one habitat type). Values are means (SE) per point count.

Variable	1995	1996	1997	1998	Ave.	*P*
			Landbird Richness			
Habitat						
mosaic	6.2 (0.2)	5.7 (0.2)	6.9 (0.3)	5.7 (0.3)	6.1 (0.3)	1,2,3*
homogeneous	6.0 (0.2)	5.1 (0.2)	5.7 (0.2)	4.6 (0.2)	5.3 (0.3)	
Trees						
absent	5.8 (0.2)	5.0 (0.2)	5.8 (0.2)	4.7 (0.2)	5.3 (0.3)	1,2
present	7.1 (0.4)	6.5 (0.4)	7.4 (0.3)	6.4 (0.3)	6.8 (0.2)	
Wetland						
absent	6.0 0.2)	5.3 (0.2)	6.0 (0.2)	4.9 (0.2)	5.5 (0.3)	1,2,3
present	6.5 (0.6)	5.9 (0.5)	7.0 (0.8)	6.7 (0.4)	6.5 (0.2)	
			Waterbird Richness			
Habitat						
mosaic	0.6 (0.1)	0.2 (0.1)	0.7 (0.1)	0.3 (0.1)	0.4 (0.1)	1,2*
homogeneous	0.4 (0.1)	(0.1 (0.0)	0.5 (0.1)	0.1 (0.1)	0.3 (0.1)	
Trees						
absent	0.5 (0.1)	0.1 (0.0)	0.6 (0.1)	0.2 (0.1)	0.3 (0.1)	2,3*
present	0.4 (0.2)	0.3 (0.1)	0.3 (0.1)	0.3 (0.2)	0.3 (0.0)	
Wetland						
absent	0.4 (0.1)	0.1 (0.0)	0.4 (0.1)	0.1 (0.0)	0.3 (0.1)	1,2,3*
present	1.1 (0.2)	0.5 (0.2)	1.7 (0.3)	0.9 (0.4)	1.0 (0.2)	

[1] 1 denotes significant ($P < 0.05$) habitat effects, 2 denotes significant year effects, and 3 denotes significant habitat-year interactions.

* Box's test for equality of covariance matrices among groups was rejected ($P < 0.05$); interpret tests of significance with caution.

Table 6. Relationship (Pearson r and Spearman r_s)[1] between habitat variables and relative abundance averaged across years for the most commonly observed species. Those with significant relationships are denoted with an asterisk ($P < 0.05$).

Species	% Native Prairie r_s	Homogeneous habitat r	Presence of trees r	Presence of wetlands r
GADW	-0.054	-0.037	-0.091	0.163 *
MALL	0.041	-0.106	-0.071	0.376 *
BWTE	0.100	-0.150	-0.022	0.399 *
MODO	0.037	-0.112	0.473 *	-0.001
WIFL	0.219 *	0.082	0.236 *	0.063
LEFL	0.200 *	-0.008	0.135	0.155 *
WEKI	-0.045	-0.198 *	0.319 *	0.028
EAKI	-0.073	-0.123	0.195 *	-0.038
TRES	0.087	0.064	0.021	-0.089
SEWR	-0.173	-0.168 *	-0.215 *	0.118
BRTH	0.046	-0.204 *	0.404 *	0.153
CEDW	0.203 *	0.085	0.253 *	-0.022
YWAR	0.224 *	-0.026	0.542 *	0.148
COYE	0.163	0.003	-0.085	0.015
CCSP	0.401 *	0.077	0.035	-0.278 *
SAVS	-0.305 *	0.075	-0.296 *	-0.141
GRSP	-0.130	0.110	-0.181 *	-0.226 *
SOSP	0.231 *	-0.026	0.185 *	0.214 *
BOBO	-0.040	0.137	-0.263 *	-0.127
RWBL	0.060	-0.157 *	-0.112	0.432 *
WEME	-0.171	-0.201 *	-0.018	0.052
COGR	-0.036	-0.027	0.237 *	-0.036
BHCO	0.143	0.032	0.004	0.014
AMGO	0.206 *	-0.055	0.389 *	0.034

[1]Pearson and Spearman correlation coefficients are measures of strength of association, ranging in value from 0.0 (no relationship) to |1.0| (perfect relationship)

Table 7. Species complements observed at point count stations with only one habitat type (n = number of point counts). Values represent the average count per year adjusted per 100 ha. Interpret comparisons among habitats with caution, given low sample sizes for most habitats.

Species	Alfalfa $n = 3$	Cropland $n = 7$	Native prairie $n = 70$	Seeded natives $n = 1$	Tame grass $n = 10$	Riparian $n = 10$	"Urban" $n = 1$
Waterbirds							
AWPE	0.0	0.0	0.0	0.0	0.0	1.6	0.0
AMBI	0.0	0.0	0.0	0.0	0.0	0.8	0.0
WODU	0.0	0.0	0.1	0.0	0.0	1.6	0.0
GADW	2.7	6.8	3.6	0.0	1.6	4.8	0.0
AMWI	0.0	0.0	0.2	0.0	0.0	2.4	0.0
MALL	2.7	31.8	5.5	0.0	4.0	4.0	0.0
BWTE	0.0	9.1	2.0	0.0	1.6	1.6	0.0
NSHO	0.0	1.1	0.5	0.0	0.0	0.8	0.0
NOPI	5.3	0.0	0.1	0.0	0.8	0.0	0.0
AGWT	0.0	2.3	0.3	0.0	0.0	0.0	0.0
COME	0.0	0.0	0.0	0.0	0.0	0.8	0.0
SORA	0.0	0.0	0.3	0.0	0.0	0.0	0.0
AMCO	0.0	1.1	0.2	0.0	0.0	0.0	0.0
WILL	0.0	0.0	0.0	0.0	0.8	0.0	0.0
COSN	0.0	0.0	0.2	0.0	0.0	0.0	0.0
RBGU	0.0	1.1	0.1	0.0	0.0	0.0	0.0
BLTE	0.0	1.1	1.7	0.0	0.0	0.0	0.0
Species	3	8	13	0	5	9	0
Raptors							
NOHA	0.0	0.0	0.8	0.0	0.0	0.0	0.0
SWHA	0.0	0.0	0.2	0.0	0.8	0.0	0.0
RTHA	0.0	0.0	0.3	0.0	0.0	0.0	0.0
SEOW	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Species	0	0	4	0	1	0	0
Landbirds							
GRPA	0.0	0.0	0.1	0.0	0.0	0.0	0.0
RNPH	0.0	0.0	0.1	0.0	0.0	0.0	0.0
STGR	0.0	2.3	1.8	0.0	0.0	0.0	0.0
KILL	0.0	4.5	0.5	0.0	0.0	0.0	0.0
UPSA	0.0	0.0	0.7	15.9	0.0	1.6	0.0
MODO	0.0	2.3	2.8	0.0	0.8	8.8	127.4
BBCU	0.0	0.0	0.0	0.0	0.0	0.8	0.0
HAWO	0.0	0.0	0.1	0.0	0.0	0.0	0.0
NOFL	0.0	0.0	0.2	0.0	0.8	0.0	0.0
WIFL	0.0	0.0	4.9	0.0	4.0	11.9	0.0
LEFL	0.0	0.0	2.5	0.0	0.8	2.4	0.0

Table 7. Continued for landbirds.

Species	Alfalfa $n = 3$	Cropland $n = 7$	Native prairie $n = 70$	Seeded natives $n = 1$	Tame grass $n = 10$	Riparian $n = 10$	"Urban" $n = 1$
Landbirds							
WEKI	0.0	3.4	1.5	0.0	0.8	1.6	39.8
EAPH	0.0	0.0	0.1	0.0	0.0	0.0	0.0
EAKI	0.0	3.4	8.9	0.0	7.2	20.7	15.9
WAVI	0.0	0.0	0.0	0.0	0.0	0.8	0.0
BBMA	0.0	0.0	0.3	0.0	0.0	0.8	0.0
AMCR	0.0	0.0	0.0	0.0	0.0	1.6	0.0
HOLA	0.0	22.7	0.3	0.0	0.0	0.0	0.0
PUMA	0.0	0.0	0.0	0.0	0.0	0.0	8.0
TRSW	2.7	5.7	9.1	0.0	5.6	13.5	15.9
CLSW	0.0	2.3	0.0	0.0	0.0	0.0	0.0
BARS	0.0	1.1	0.9	0.0	0.0	0.0	15.9
BCCH	0.0	0.0	0.2	0.0	0.0	0.0	0.0
HOWR	0.0	0.0	0.7	0.0	0.0	3.2	23.9
SEWR	10.6	17.1	16.6	15.9	22.3	3.2	0.0
AMRO	0.0	0.0	0.1	0.0	0.0	0.8	47.8
GRCA	0.0	0.0	1.8	0.0	0.0	3.2	8.0
BRTH	0.0	0.0	0.8	0.0	0.8	3.2	8.0
CEWA	0.0	0.0	4.3	0.0	0.0	6.4	111.5
YWAR	0.0	0.0	11.3	0.0	8.0	47.8	8.0
COYE	8.0	9.1	20.7	0.0	20.7	11.1	0.0
CHSP	0.0	0.0	0.0	0.0	0.0	0.8	39.8
CCSP	13.3	9.1	63.6	8.0	31.8	54.1	0.0
VESP	10.6	1.1	2.2	0.0	1.6	0.0	0.0
SAVS	13.3	14.8	17.3	63.7	43.8	4.0	0.0
GRSP	15.9	6.8	15.8	15.9	27.9	4.8	0.0
LCSP	0.0	0.0	1.0	0.0	1.6	0.0	0.0
STSP	0.0	1.1	0.0	0.0	0.0	0.0	0.0
SOSP	0.0	1.1	7.1	0.0	3.2	11.9	0.0
DICK	2.7	0.0	0.0	0.0	0.0	0.0	0.0
BOBO	15.9	11.4	28.9	39.8	35.0	8.8	0.0
RWBL	47.8	36.4	25.8	0.0	5.6	35.8	0.0
WEME	2.7	2.3	4.1	8.0	5.6	4.0	0.0
YHBL	0.0	0.0	1.1	0.0	0.0	0.0	0.0
COGR	0.0	18.2	8.6	0.0	9.6	15.9	191.1
BHCO	2.7	18.2	47.4	0.0	36.6	31.1	15.9
BAOR	0.0	0.0	0.0	0.0	0.0	0.8	15.9
AMGO	0.0	0.0	6.7	0.0	1.6	17.5	47.8
Species	12	22	39	7	23	31	17

Table 8. The relationship between the position of point count stations relative to roads and habitat characteristics. As the distance from a nearby road increased, the probability that the point count station occurred in a homogeneous habitat increased substantially, while the probability that woodlands and wetlands were present decreased to a lesser degree.

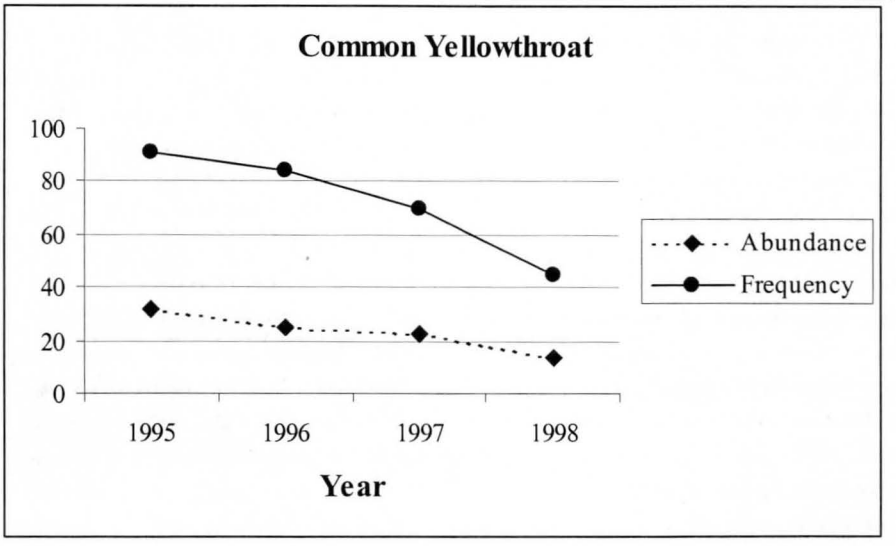
Variable (% of stations)		On-road	100 m	200 m	300 m	400 m	Total	*r*	*P*
Habitat	Mosaic	58	25	25	7	6	41	0.413	0.000
	Homogen.	42	75	75	93	94	59		
	n	95	16	16	14	17	158		
Trees	Absent	77	69	81	100	100	81	-0.213	0.007
	Present	23	31	19	0	0	19		
	n	95	16	16	14	18	159		
Wetlands	Absent	86	94	100	93	100	91	-0.170	0.030
	Present	14	6	0	7	0	9		
	n	95	16	16	14	18	159		

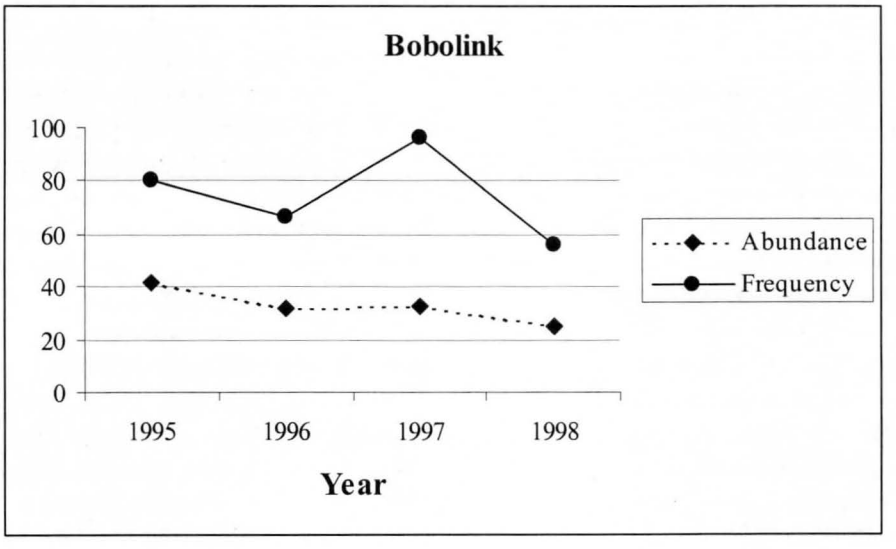
Table 9. The effects of point count location relative to roads on the estimation of bird community parameters.

	Distance from road			Year			Distance • Year Interaction		
Species	*eta*[1]	*F*	*P*	*eta*	*F*	*P*	*eta*	*F*	*P*
Species Richness									
Landbird	0.098	16.711	0.000	0.182	11.289	0.000	0.013	0.687	0.561
Waterbird	0.000	0.005	0.945	0.164	9.955	0.000	0.007	0.361	0.781
Relative Abundance									
GADW	0.000	0.074	0.785	0.070	3.819	0.011	0.018	0.948	0.419
MALL	0.002	0.267	0.606	0.089	4.955	0.003	0.009	0.475	0.700
BWTE	0.002	0.342	0.560	0.049	2.630	0.052	0.028	1.434	0.235
MODO	0.014	2.161	0.144	0.095	5.336	0.002	0.040	2.086	0.104
WIFL	0.001	0.081	0.776	0.172	10.545	0.000	0.019	0.992	0.398
LEFL	0.008	1.270	0.262	0.112	6.392	0.000	0.002	0.088	0.967
WEKI	0.024	3.724	0.055	0.037	1.934	0.126	0.005	0.268	0.848
EAKI	0.024	3.735	0.055	0.034	1.780	0.513	0.015	0.770	0.512
TRSW	0.020	3.194	0.076	0.044	2.350	0.075	0.012	0.597	0.618
SEWR	0.007	1.056	0.306	0.039	2.033	0.112	0.005	0.627	0.849
BRTH	0.020	3.147	0.078	0.070	3.807	0.011	0.009	0.455	0.714
CEDW	0.008	1.258	0.264	0.012	0.596	0.618	0.005	0.268	0.849
YWAR	0.023	3.574	0.061	0.011	0.547	0.651	0.010	0.533	0.660
COYE	0.002	0.339	0.561	0.084	4.661	0.004	0.058	3.121	0.028
CCSP	0.004	0.652	0.421	0.006	0.308	0.820	0.011	0.584	0.627
SAVS	0.049	7.977	0.005	0.127	7.378	0.000	0.005	0.267	0.849
GRSP	0.036	5.720	0.018	0.031	1.629	0.185	0.022	0.115	0.951
SOSP	0.016	2.542	0.113	0.010	0.497	0.685	0.010	0.514	0.673
BOBO	0.023	3.661	0.058	0.016	0.846	0.471	0.027	1.383	0.250
RWBL	0.002	0.309	0.579	0.153	9.163	0.000	0.014	0.736	0.532
WEME	0.059	9.579	0.002	0.334	25.410	0.000	0.060	3.207	0.025
COGR	0.013	2.047	0.155	0.032	1.667	0.176	0.007	0.361	0.781
BHCO	0.009	1.147	0.231	0.098	5.534	0.001	0.007	0.362	0.780
AMGO	0.005	0.788	0.376	0.069	3.763	0.012	0.041	2.191	0.091

[1]*eta* is a measure of effect size, which can be interpreted similarly to the Pearson correlation coefficient as a measure of linear association or measure of strength. Values range from 0.0 to 1.0 and can be interpreted as the following: the larger the absolute value, the stronger the relationship or magnitude of difference.

Figure 1. Declining trends in relative abundance and distribution for Common Yellowthroats and Bobolinks at Arrowwood NWR, North Dakota. Relative abundance is adjusted per 100 ha; relative frequency represents the percentage of stations detected, from the collection of stations that each species was detected at least once.





Appendix A. Alpha code, common and scientific name for all bird species observed during breeding bird surveys (1995 – 1998), Arrowwood NWR, North Dakota (listed taxonomically according to the AOU 1998).

Alpha Code	Common name, Scientific name	Alpha code	Common name, Scientific name
EAGR	Eared Grebe, *Podiceps nigricollis*	EAPH	Eastern Phoebe, *Sayornis phoebe*
WEGR	Western Grebe, *Aechmorphus occidentalis*	WEKI	Western Kingbird, *Tyrannus verticalis*
AWPE	American White Pelican, *Pelecanus erythrorhynchos*	EAKI	Eastern Kingbird, *Tyrannus tyrannus*
DCCO	Double-crested Cormorant, *Phalacrocorax auritus*	WAVI	Warbling Vireo, *Vireo gilvus*
AMBI	American Bittern, *Botaurus lentiginosus*	BBMA	Black-billed Magpie, *Pica Pica*
WODU	Wood Duck, *Aix Sponsa*	AMCR	American Crow, *Corvus brachyrhincos*
GADW	Gadwall, *Anas strepera*	HOLA	Horned Lark, *Eremophila alpestris*
AMWI	American Wigeon, *Anas americana*	PUMA	Purple Martin, *Progne subis*
MALL	Mallard, *Anas platyrhinchos*	TRES	Tree Swallow, *Tachycineta bicolor*
BWTE	Blue-winged Teal, *Anas discors*	CLSW	Cliff Swallow, *Petrochelidon pyrrhonota*
NSHO	Northern Shoveler, *Anas clypeata*	BARS	Barn Swallow, *Hirundo rustica*
NOPI	Northern Pintail, *Anas acuta*	BCCH	Black-capped Chickadee, *Poecile atricapillus*
AGWT	American Green-winged Teal, *Anas crecca*	HOWR	House Wren, *Troglodytes aedon*
HOME	Hooded Merganser, *Lophodytes cucullatus*	SEWR	Sedge Wren, *Cistothorus platensis*
COME	Common Merganser, *Mergus merganser*	AMRO	American Robin, *Turdus migratorius*
NOHA	Northern Harrier, *Circus cyaneus*	GRCA	Gray Catbird, *Dumetella carolinensis*
SWHA	Swainson's Hawk, *Buteo swainsoni*	BRTH	Brown Thrasher, *Toxostoma curvirostre*
RTHA	Red-tailed Hawk, *Buteo jamaicensis*	EUST	European Starling, *Sturnus vulgaris*
GRPA	Gray Partridge, *Perdix perdix*	CEDW	Cedar Waxwing, *Bombycilla cedrorum*
RNPH	Ringed-necked Pheasant, *Phasianus colchicus*	YWAR	Yellow Warbler, *Dendroica petechia*
STGR	Sharp-tailed Grouse, *Tympanucus phasianellus*	COYE	Common Yellowthroat, *Geothlypis trichas*
SORA	Sora, *Porzana carolina*	CHSP	Chipping Sparrow, *Spizella passerina*
AMCO	American Coot, *Fulica americana*	CCSP	Clay-colored Sparrow, *Spizella pallida*
KILL	Killdeer, *Charadrius vociferus*	VESP	Vesper Sparrow, *Pooecetes gramineus*
AMAV	American Avocet, *Recurvirostra americana*	SAVS	Savannah Sparrow, *Passerculus sandwichensis*
WILL	Willet, *Catoptrophorus semipalmatus*	GRSP	Grasshopper Sparrow, *Ammodramus savanarum*
UPSA	Upland Sandpiper, *Bartramia longicauda*	LCSP	Le Conte's Sparrow, *Ammodramus leconteii*
COSN	Common Snipe, *Gallinago gallinago*	STSP	Nelson's Sharp-tailed Sparrow, *Ammodramus nelsoni*
RBGU	Ringed-billed Gull, *Larus delawarensis*	SOSP	Song Sparrow, *Melospiza melodia*
BLTE	Black Tern, *Chlidonias niger*	DICK	Dickcissel, *Spiza americana*
MODO	Mourning Dove, *Zenaida macroura*	BOBO	Bobolink, *Dolichonyx oryzivorus*
BBCU	Black-billed Cuckoo, *Coccyzus erythropthalmus*	RWBL	Red-winged Blackbird, *Agelaius phoeniceus*
GHOW	Great-horned Owl, *Bubo virgianianus*	WEME	Western Meadowlark, *Sturnella neglecta*
SEOW	Short-eared Owl, *Asio flammeus*	YHBL	Yell.-hd. Blackbird, *Xanthocephalus xanthocephalus*
HAWO	Hairy Woodpecker, *Picoides villosus*	COGR	Common Grackle, *Quisculus quiscula*
NOFL	Northern Flicker, *Colaptes auratus*	BHCO	Brown-headed Cowbird, *Molothrus ater*
WIFL	Willow Flycatcher, *Empidonax traillii*	BAOR	Baltimore Oriole, *Icterus galbula*
LEFL	Least Flycatcher, *Empidonax minimus*	AMGO	American Goldfinch, *Carduelis tristis*

Appendix B. Species distribution by point count station and management unit. The location of all observed species is designated by management unit and point count number.

Species	Arrowwood Lake	Mud Lake	Jim Lake	Depuy Marsh
EAGR	58			
WEGR	2, 58			
AWPE	16	89		
AMBI	40	89		
WODU	8			
GADW	8, 13, 16, 22, 23, 24, 25, 26, 29, 30, 32, 35, 43, 46, 48, 55	59, 77, 81-83, 84, 89, 94	98, 102, 117, 119, 121, 123, 128, 139	144, 145, 148, 153, 155
AMWI	16	88		
MALL	2, 5, 6, 8, 11, 12, 15, 16, 17, 18, 19, 22, 23, 25, 26, 28, 30, 31, 37, 43, 45, 46, 48, 50, 51, 52, 53	60, 62, 63, 70, 80, 82, 84, 87, 90, 94, 95	116, 117, 120, 123, 125, 127, 128, 131, 132, 133	143, 144, 146, 149, 150, 155, 156
BWTE	8, 16, 23, 25, 43, 44, 45, 46, 47, 51	65, 68, 77, 88, 89	117, 122, 126, 128	144, 146, 151, 155
NOSH	8, 16, 23, 26, 45, 46, 51	59	117, 128	146
NOPI	23, 25		111, 117, 125	145
AGWT	23, 46		117	
HOME	58			
COME	16			
NOHA	14, 19, 33, 42, 45, 49	70		145, 149
SWHA	32	92	101, 119	
RTHA	54	81	132	
GRPA	54			
RNPH	55	62, 81	126	
STGR	14, 20, 23, 25, 47	86, 87		148, 162
SORA		87, 93	112, 117, 121, 122, 142	142
AMCO	2, 23	65, 77,	117, 126	144

Appendix B. Continued.

Species	Arrowwood Lake	Mud Lake	Jim Lake	Depuy Marsh
KILL	8, 23, 24, 45, 49, 51	59, 77, 81, 90	117	146, 153, 160
AMAV		89		
WILL	52			147, 148
UPSA	12, 22, 26, 35	59, 78, 91, 95	114, 115, 127	157
COSN	43	117	123	
RBGU	42, 56, 57			143, 149
BLTE	42, 46	89, 93	119	143, 144, 161
MODO	2-6, 8, 10, 11, 13, 15, 16, 19, 22, 31, 38, 41, 44, 50, 54, 56, 57	58, 63, 64, 65, 66, 67, 74, 76, 77, 80, 81, 95, 96	104, 106, 109, 115, 117, 118, 119, 124, 126, 133, 136	142, 143, 144, 158
BBCU			106	
GHOW				146
SEOW		93		
HAWO	11	79		
NOFL	2, 25, 42, 52, 53, 55			136
WIFL	2, 3, 5, 7, 8, 11-13, 15-17, 19, 21, 31, 39, 40	44, 61, 63, 64, 66-68, 70, 74-76, 79, 80, 82, 95, 96	102, 107-110, 113, 121-124, 133, 134, 136, 138	146, 156, 158
LEFL	1-3, 5-8, 10, 13, 15, 17, 19, 31, 57, 58	63, 64, 65, 71, 75, 76, 77, 80, 82, 95, 96	102, 108, 109, 121, 122, 130, 135	146, 156
EAPH			130	
WEKI	4, 5, 9, 12, 14, 19, 20, 31, 38-40, 49, 50, 52, 54-56	65, 67, 78, 92, 95, 96	114, 117, 120, 121, 124, 129, 133, 134, 138, 140	142, 146, 148, 150, 156, 162
EAKI	3, 4, 6-16, 18-21, 24, 25, 28-33, 36, 40, 41, 42, 45, 46, 48-52, 54, 55, 57	59, 63-55, 69, 74, 75, 76, 78, 81-85, 92, 93, 95, 96	100, 101, 102, 104-110, 113-115, 117-119, 122, 125, 127, 130, 132, 133, 135, 136, 138, 140	142, 146, 148, 149-152, 156, 158
WAVI	39	67		
BBMA	2, 15, 38, 39	64		
AMCR			104, 107	

Appendix B. Continued.

Species	Arrowwood Lake	Mud Lake	Jim Lake	Depuy Marsh
HOLA	22, 23, 24, 27, 29, 30, 36, 37, 48, 49, 50	72	103, 118	143, 148
PUMA	4			
TRSW	3-8, 11-14, 16, 18, 20, 35, 36, 38-51, 53, 55, 56, 58,	59-61, 65-68, 75-77, 80, 82-84, 94	108, 115, 116, 119, 120, 126, 127, 135, 136, 140	142, 145, 146, 148, 155, 157
CLSW	48, 50	59	122	
BARW	4, 6, 9, 26, 27, 31, 38, 47, 65, 69, 100, 105, 122, 124, 126, 128, 143	65, 69, 100, 105, 122, 124, 126, 128, 143	100, 105, 122, 124, 126, 128	143
BCCH	10, 52, 58	78		
HOWR	4, 8, 16, 57, 58	65	104, 106	158
SEWR	3, 10, 12, 15, 19-27, 29-33, 42, 47, 49, 50- 56	59-64, 66-80, 83-92	97-102, 111-117, 119-123, 125-133, 135-137, 140, 141	142, 144, 145, 147-154, 157, 159, 160-162
AMRO	4, 40, 44, 58,	65	117	
GRCA	2, 3, 4, 5, 7, 8, 11, 13, 15, 16, 31, 38, 39, 41, 58	63, 64, 65, 76, 80	102, 107, 108	156
BRTH	2, 4, 5, 11, 13, 14, 16, 17, 19, 31, 57	63, 65, 67, 71, 75, 77, 80, 82, 83, 95, 96	102, 108, 113, 117, 126, 133	156
EUST	11, 51			
CEWA	2, 4, 5, 6, 7, 8, 10, 11, 15, 16, 57, 58	64, 65, 67, 70, 76, 79, 80, 96	102, 104, 106, 107, 126, 130	158
YWAR	2-8, 10-17, 19, 21, 31, 33, 39, 40, 41, 44, 49, 52, 54, 55, 57, 58	59, 61, 63, 64, 65, 67-70, 74-77, 79, 80-82, 85, 92, 95, 96	102-109, 113, 117, 119, 121, 122, 124, 126, 130, 133-136, 138, 140	146, 156, 158
COYE	1-3, 6, 8-18, 21-34, 41, 44-57	59-85, 87-90, 92-96	98, 101-104, 106, 108-114, 116-128, 130-133, 135-140	142, 144-146, 148-158, 161, 162
CHSP	4, 40			

Appendix B. Continued.

Species	Arrowwood Lake	Mud Lake	Jim Lake	Depuy Marsh
CCSP	1-3, 5-22, 24-36, 38-57	59-96	97-141	142-162
VESP	1, 12, 18, 20, 23, 29, 31, 37, 38, 41-43	61, 70, 86	119, 120, 121, 125, 127, 129	142, 150, 153
SASV	1, 9, 12, 14, 16-18, 20, 23, 25, 27- 29, 32, 33-38, 41- 43, 45-48, 50, 51, 53, 55, 56	60, 61, 68-72, 81-84, 86, 87, 89-94	97, 98, 100-103, 105, 110-112, 114-118, 120, 123-125, 127-129, 131, 132, 136-139, 141	142, 144-155, 157, 159-162
GRSP	1, 14, 17-20, 25, 27, 29, 30, 33-38, 41-45,47-49, 51, 56	59-62, 66-69, 72, 73, 75, 78, 79, 81-83, 85-88, 90-92, 95, 96	97-101, 102, 105, 109, 111, 112, 114-118, 120, 121, 123-141	142, 144, 145, 147-151, 153-156, 158-162
LCSP	6, 14, 19, 52, 53,	68, 69, 73, 81, 86, 87, 89, 96	103, 105, 117, 126, 129, 130	142, 147, 149
STSP	25	72, 87	111	
SOSP	1, 2, 3, 5-8, 10, 11, 13, 15-17, 19, 21, 22, 28, 29, 31, 32, 39, 40, 41, 44, 46, 49, 51, 54, 57, 58	59, 61, 63, 64, 65, 68, 70-82, 84, 85, 87, 88, 92, 94, 96	102, 104, 107, 113, 117, 121, 122, 124, 126, 128, 133, 135, 140	142, 144, 146, 156, 158
DICK				153
BOBO	1, 3, 5, 6, 7, 9, 10, 12, 14, 17-20, 22-25, 27, 29, 30, 31, 32, 34-39, 41-56,	60, 61, 62, 66, 70, 72, 74, 74, 81- 93, 96	97-102, 105, 109, 111, 112, 114–134, 136-141	144, 145, 147-162
RWBL	2, 3, 5-16, 18-32, 35, 36, 40, 41, 46-48, 50, 51, 54-56	59, 61, 63, 65, 67, 68, 71-73, 77, 79, 80, 84, 85, 87-90, 94	99-101, 107, 109, 111-114, 116-118, 120-123, 126-128	142-146, 148-156, 158
WEME	1, 11, 12, 14, 17, 18, 20, 22-27, 31-33, 35, 36, 38, 41-43, 45, 47-56	81-84, 87, 89, 90-92, 95	97, 104, 107-109, 111, 114, 118, 120, 121,124, 126, 127, 135, 136, 138, 140	144, 146, 148, 150-152, 154-156
YHBL	5, 29, 46, 51	80, 87, 90	121, 122	144, 146, 150

Appendix B. Continued.

Species	Arrowwood Lake	Mud Lake	Jim Lake	Depuy Marsh
COGR	2, 4, 5, 8-19, 21-23, 29-33, 36, 38, 40, 43-46, 48-50, 52-54, 56, 58	63, 71, 80-82, 88, 92, 95	102, 113, 115, 117, 120, 121, 126, 128, 130, 132, 133	142, 146, 148, 150, 156, 158, 161, 162
BHCO	1–26, 28–32, 34, 35, 37-47, 49-58	59-61, 63-71, 73, 74, 76–88, 90, 92–96	97-103, 105, 107-111, 113-127, 129-131, 133, 134, 137, 138, 140	142 144, 146-152, 154-156, 158-161
BAOR	4, 5		113	
AMGO	2, 3, 4, 5, 8, 11, 13, 15, 19, 21, 26, 31, 39, 40, 52, 54, 57,	58, 61, 64-67, 71-76, 78, 81, 94-96	102-104, 106-110, 119, 124, 126, 130, 132, 135, 136, 138, 140	147, 151, 156, 158