Research Article

Representation of Landcover Along Breeding Bird Survey Routes in the Northern Plains

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ABSTRACT The North American Breeding Bird Survey (BBS) is used extensively to make inferences about populations of many North American bird species and is increasingly being used for avian conservation planning. How well BBS routes represent the landscape is poorly known, even though accuracy of representation could significantly affect inferences made from BBS data. We used digital landcover data to examine how well landcover within 400-m buffers around BBS routes represented the surrounding landscape (the route neighborhood) for 52 routes in the Prairie Pothole Region of North Dakota and South Dakota. Differences in composition between landcover along BBS routes and the route neighborhood were not statistically significant for upland cover classes. The area of temporary and seasonal wetland basins was accurately represented by BBS routes in our study area, but the area of semipermanent and permanent wetland basins was significantly underrepresented along BBS routes. Number of wetland basins and upland patches was higher along routes. Area of urban, forest, and hay landcover classes was higher along routes, although differences were not statistically significant. Amount of bias in landcover representation was negatively correlated with the proportion of each landcover type in the study area, but bias was not correlated with area of the route neighborhoods. Differences between landcover along BBS routes and the route neighborhood were primarily attributable to increased anthropogenic activity along roads and siting of roads away from relatively large, deep water bodies. Our results suggest that inferences made from BBS data in our study region are likely biased for species that are associated with deeper-water habitats or are strongly influenced by landscape fragmentation. Inferences made from BBS data for species associated with uplands or shallow wetlands are less likely to be biased because of differences in landcover composition. (JOURNAL OF WILDLIFE MANAGEMENT 71(7):2258–2265; 2007)

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The North American Breeding Bird Survey (BBS) is an annual, continent-wide survey that is the primary source of information regarding populations of many North American bird species. Surveys are conducted by recording all birds seen and heard at 50 stops along roadside transects. Routes are constrained to secondary roads and starting points were randomly located within one-degree blocks of latitude and longitude (Bystrak 1981); approximately 3,000 routes are surveyed once annually. Initially designed to monitor population trends (Bystrak 1981), data from the BBS are increasingly being used as a source of information for conservation planning (e.g., Rich et al. 2004, Thogmartin et al. 2004, Niemuth et al. 2005, Sauer et al. 2005*b*). However, if habitat (i.e., the biotic and abiotic features used by birds) along BBS routes is not representative of habitat in the surrounding landscape, perceived composition and size of bird communities represented by BBS data may be biased. This may be particularly important as BBS data are used to estimate populations and set goals and priorities for bird conservation (i.e., Rich et al. 2004, Rosenberg and Blancher 2005). Consequently, assessing how well habitats along BBS routes represent habitats in the surrounding landscape is a high priority (O'Connor et al. 2000, Rosenberg and Blancher 2005, Thogmartin et al. 2006).

Results of the few studies that have addressed this question are inconsistent, due in part to differences in spatial extent and methods of the studies and spatial and thematic resolution of landcover data used in analyses. Bart et al. (1995) compared the amount of forest cover within buffers 0–140 m and 140–280 m from roads to the amount of forest in their western Ohio, USA, study region and found less forest cover within 140 m of roads. Keller and Scallan (1999) compared cover types and habitat features within buffers 0–200 m from BBS routes to cover types within buffers 200–1,600 m from BBS routes in Maryland and Ohio, USA, and found several significant differences in composition, particularly for cover types and features associated with human activities. Lawler and O'Connor (2004) compared values of a suite of environmental and landcover characteristics in 640-km^2 hexagonal cells with and without the starting point of consistently surveyed BBS routes across the conterminous United States; differences were few and varied with location and the spatial extent of assessment. We build on these previous efforts by examining representation of BBS routes in a region dominated by agriculture, grasslands, and wetlands. By using digital landcover data for our entire study region (Fig. 1) we were able to compare landcover along BBS routes to the entire landscape within the study region rather than larger samples

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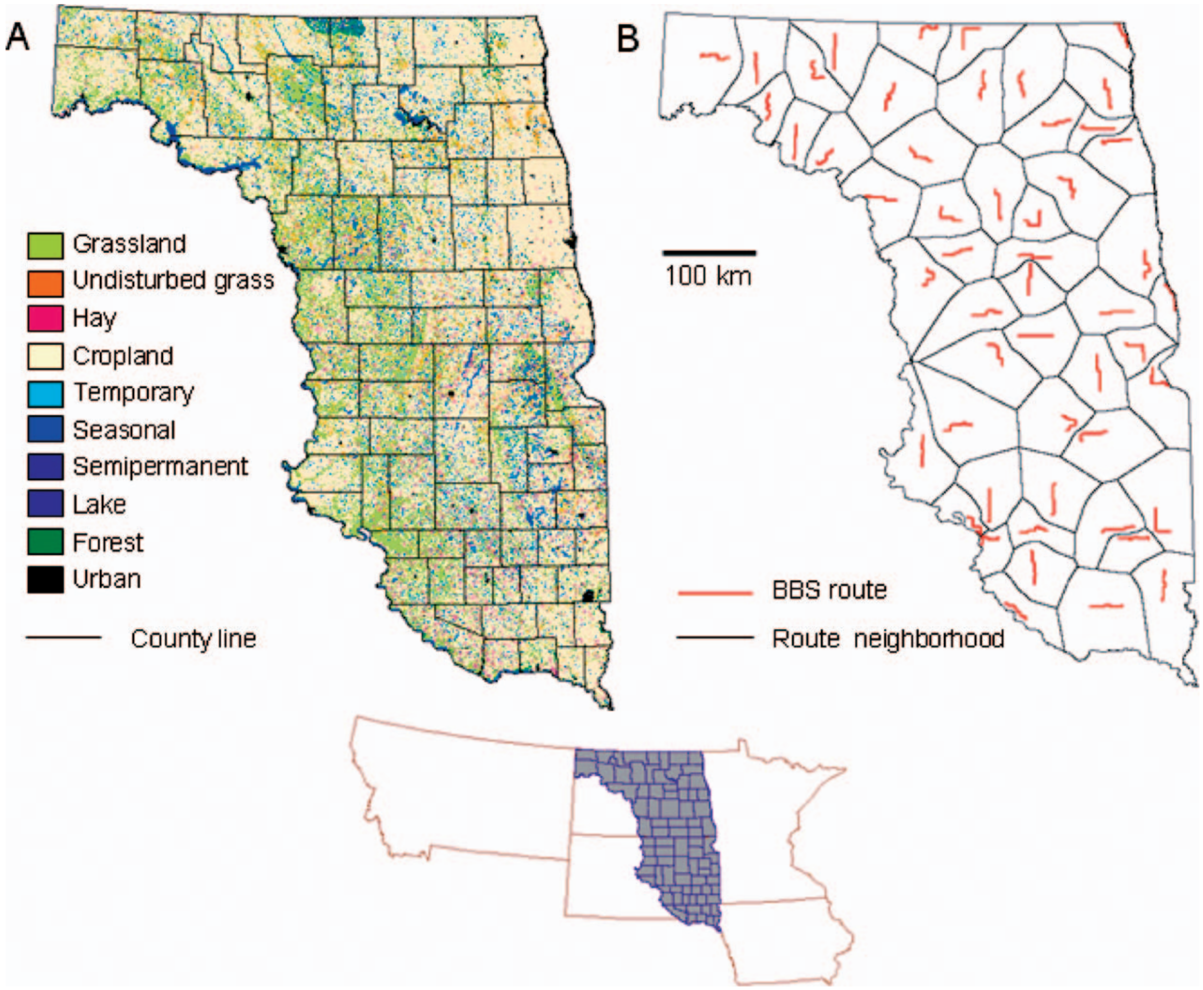

Figure 1. (A) Landcover classification for Prairie Pothole Region of North Dakota and South Dakota, USA. (B) Location of North American Breeding Bird Survey (BBS) routes and route neighborhoods. Landcover data were derived from satellite images acquired from May 1992 through September 1996.

of the landscape. Landcover data provided insight into broad-scale components of bird habitat, specifically the composition and configuration of the landscape relative to upland cover classes and wetlands. The comparatively fine spatial and thematic resolution of our landcover data enabled us to assess differences that would not have been possible using landcover data with coarser spatial and thematic resolution. In addition, we designed our analysis to provide insight into factors associated with bias and provide direction for possible actions to address bias.

We assessed landcover in 400-m buffers surrounding 52 BBS routes in the Prairie Pothole Region of North Dakota and South Dakota, USA. We compared landcover in these buffers to landcover in the landscape surrounding each route, which we call the route neighborhood. Our study had two primary objectives. First, we assessed how well landcover in 400-m buffers along BBS routes in our study area represented the route neighborhoods. Second, we determined if bias in landcover representation along BBS routes was associated with the area of the route neighborhood or the amount of each landcover type in the study region.

STUDY AREA

The study area was the portion of North Dakota and South Dakota east or north of the Missouri River, approximating the Prairie Pothole Region, or the Bird Conservation Region (BCR) 11 portion, of the 2 states (Fig. 1). The landscape surface was formed by glacial action and was characterized by numerous depressional wetlands and prairie flora (Bluemle 1991). The climate was cool and dry and soils were typically heavy. The study area contained large blocks of native prairie, >3 million acres of land enrolled in the Conservation Reserve Program (Reynolds et al. 2006), and approximately 2.7 million depressional wetlands (Fig. 1). Consequently, the study area is of continental importance to a variety of grassland- and wetland-dependent birds.

METHODS

We used digital landcover data (Fig. 1A, Table 1) derived from the classification of Thematic Mapper satellite images (30-m resolution) acquired from May 1992 through September 1996. Classification accuracy of satellite imagery for upland cover classes exceeded 80% (C. R. Loesch, United States Fish and Wildlife Service, unpublished data). We obtained wetland information from the National

Table 1. Definitions of metrics used in analysis of landscape composition in the Prairie Pothole Region of North Dakota and South Dakota, USA. Landcover data were derived from satellite images acquired from May 1992 through September 1996.

Landscape metric	Description
Grassland (%)	Mix of native grass, forb, or scattered, low shrub species on untilled prairie; typically grazed or hayed annually.
Undisturbed grass (%)	Mix of cool-season grass and forb species planted on previously cropped land; generally undisturbed but may be hayed or grazed intermittently.
Hayland (%)	Mix of alfalfa and cool-season grass species hayed once or twice annually.
Cropland (%)	Tilled and planted with small grains or row crops that are harvested annually; includes fallow fields.
Forest (%)	Area of landscape classified as forest cover.
Urban (%)	Area of landscape classified as urban lands.
Patches/km^2	No. of upland patches/km^2, where a patch was defined as a group of data pixels with $\geq$1 side in common and classified into the same landcover category.
Basins/km^2	No. of wetland basins (all water regimes)/km^2.
Temporary (%)	Area of wetland basins[a] in which surface water is present for brief periods during the growing season but the water table is otherwise well below the soil surface.
Seasonal (%)	Area of wetland basins[a] in which surface water is present for extended periods, especially early in the growing season, but is absent by the end of the season in most yr.
Semipermanent (%)	Area of wetland basins[a] in which surface water persists throughout the growing season in most yr. When surface water is absent, the water table is at or near the soil surface.
Permanent (%)	Area of wetland basins[a] in which surface water is present throughout the yr in all yr.

[a] Derived from National Wetlands Inventory data.

Wetlands Inventory (NWI) digital database, which provided finer thematic and spatial resolution for wetlands than would have been possible using satellite imagery. We integrated NWI data into the landcover grid as individual depressional wetland basins identified by the most permanent water regime within each basin (Table 1; Cowardin et al. 1995). Minimum size of individual wetland basins was 0.09 ha when integrated into the landcover grid. We acquired digitized location data for the 52 BBS routes in the Prairie Pothole portion of North Dakota and South Dakota (Fig. 1B) from the National Atlas of the United States (http://nationalatlas.gov). We buffered each route by 400 m, which is the maximum distance at which visually detected birds are recorded on BBS stops (Robbins et al. 1986). We then used resulting polygons, which we refer to as route buffers, to clip landscape information for each route from the landcover grid. Landcover attributes included in analysis focused primarily on composition. We also included density of wetland basins and upland patches (Table 1) as simple indices of landscape configuration.

Defining the surrounding landscape to which we compared BBS route buffers was complicated by the different ways in which BBS data are used. Even though one-degree blocks of latitude and longitude were used to place BBS routes in a quasi-systematic manner (Bystrak 1981, Sauer et al. 2003), inferences are typically made from route data and aggregated and applied to a variety of units larger than degree blocks. We determined how well individual routes represented the landscape surrounding them under the working assumption that if individual routes accurately represented the landscape around them, the sums of multiple routes, whatever the number or combination, would likely also be accurate. In addition, we analyzed data within a single BCR to avoid high variance and dissimilarities in landcover composition that might occur using units that crossed BCR boundaries. We linked routes to the surrounding landscape by creating route neighborhoods (Fig. 1B), which we generated by assigning all landcover data within our study region to the nearest BBS route using the EUCALLOCATION command within the GRID module of ArcInfo Geographic Information System (GIS) software. All locations within a route neighborhood, regardless of classification, were closer to the route to which they are assigned than any other route; resulting polygons are roughly equivalent to the spatial neighborhoods Thogmartin et al. (2004) created around BBS routes. Our technique ensured that no portions of the study area overlapped or were excluded from analysis, as would be the case if we paired and compared route buffers to equally sized areas elsewhere in the landscape. The area of the 52 route neighborhoods we created ranged from 1,450 km^2 to 8,275 km^2 ($\bar{x} = 4{,}311$ km^2, SE = 228 km^2). Even though allocation of BBS routes in the Dakotas was consistent in terms of routes per degree block, variation in size of route neighborhoods enabled us to assess if representation of landcover along BBS routes varied with size of route neighborhoods, which we use as a surrogate for route density. We used this to gain some insight into whether increased density of BBS routes in our region might reduce bias in landcover representation.

We analyzed landcover classes as percent coverage, with the exception of upland patch density and wetland basin density, which we analyzed as number per square kilometer. We used a paired Wilcoxon signed-rank test (Zar 1996) to assess the statistical significance of differences between landscape metrics for BBS route buffers and route neighborhoods. We present percent change and standard errors around means for values calculated from route buffers and route neighborhoods to further illustrate results. We also determined the value of each metric across the entire study region, which we used as a benchmark when reporting estimates from route buffers and neighborhoods. We used linear regression to analyze the relationship between values calculated from route buffers and route neighborhoods. Regression analysis allowed us to assess overall agreement in values from the 2 groups as indicated by slope of the

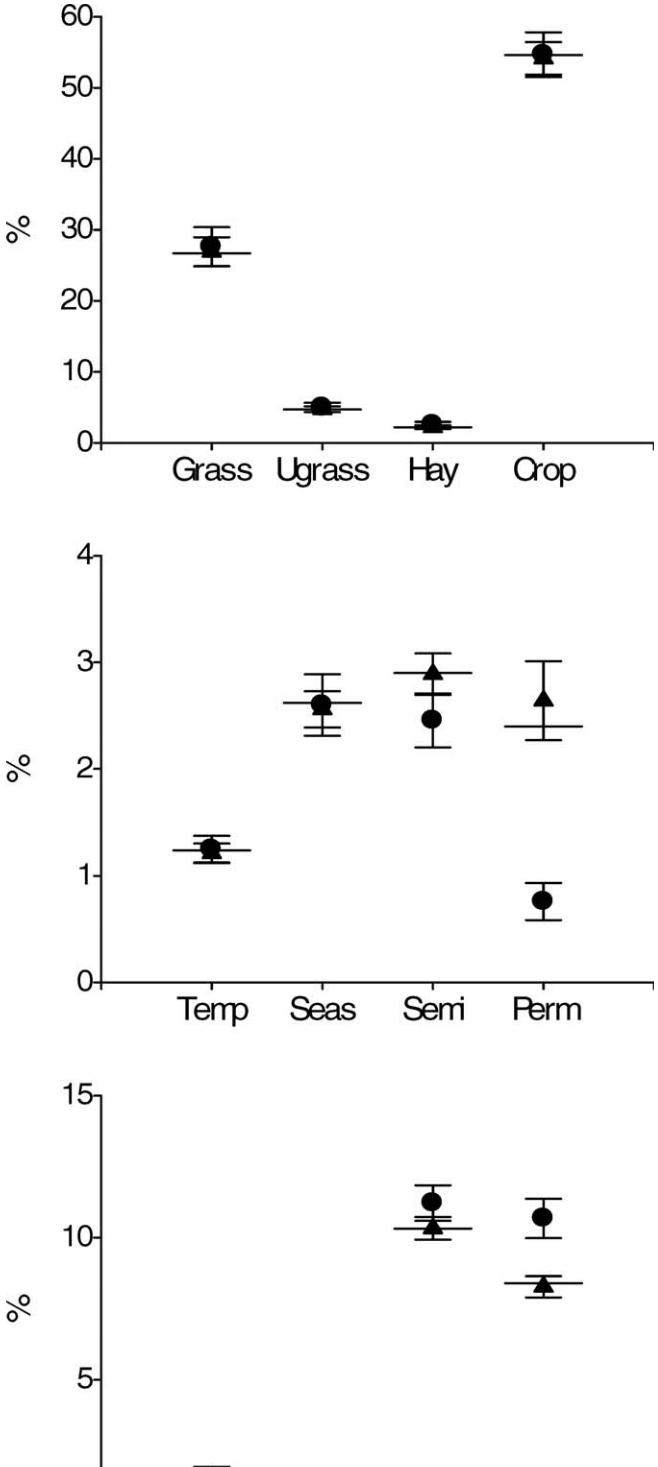

Figure 2. Mean value (circle ± SE) for landscape metrics in route buffer within 400 m of 52 North American Breeding Bird Survey (BBS) routes and mean value (triangle ± SE) for landscape metrics in route neighborhood around 52 BBS routes in the Prairie Pothole Region of North Dakota and South Dakota, USA. Widest horizontal lines represent value for each metric across the entire study region. All values represent percentage of land in each class, except for wetland basins and upland patches, which represent density (no./km^2). Grass = grassland; Ugrass = undisturbed grassland; Hay = hayland; Crop = cropland; Temp = temporary; Seas = seasonal; Semi = semipermanent; and Perm = permanent wetland basins. Landcover data were derived from satellite images acquired from May 1992 through September 1996.

regression line, consistency of agreement as measured by the coefficient of determination value, and the effect of departures from agreement as shown by outliers. We used Spearman's rank correlation to determine if differences between route buffers and route neighborhoods were associated with the area of each route neighborhood. This allowed us to assess if accuracy of representation was influenced by route density. We also used Spearman's rank correlation to determine if the overall percent difference in landcover composition between route buffers and route neighborhoods for the 10 landcover classes was associated with the amount of each landcover class in the entire study area. This allowed us to assess if uncommon landcover types were less likely to be accurately represented along BBS routes. For these correlations we used the absolute value of differences because we were interested in the degree of bias rather than the direction. We used Number Cruncher Statistical System, Version 2004 (Hintze 2004) for statistical analyses.

RESULTS

Landscapes along BBS routes in our study area were typically dominated by cropland, followed by grassland and lesser amounts of undisturbed grass, hayland, wetlands, forest, and urban areas (Fig. 2). Route buffers covered an average of 0.89% (range 0.39–2.15%) of route neighborhoods. Composition of landscapes within 400-m route buffers was not statistically different from composition of the route neighborhoods and was similar to the landscape as a whole for most characteristics we sampled (Table 2; Fig. 2). Area of urban, forest, and hay landcover classes was nominally higher along BBS routes than in the route neighborhood, but the relationship was not statistically significant; extreme values for a few cases contributed to overestimation of urban and forest cover in route buffers (Fig. 3). Area of semipermanent wetlands and permanent wetlands was underrepresented along BBS routes and density of wetland basins and upland patches was higher along BBS routes (Table 2, Fig. 2).

Correspondence between values from route buffers and route neighborhoods varied among metrics. Overall agreement between route buffers and route neighborhoods was highest for temporary wetlands with a regression line slope of 0.92, although consistency of agreement was low ($r^2 = 0.46$; Fig. 3). Conversely, consistency of agreement was relatively high ($r^2 = 0.70$) but biased (slope = 1.55) for density of upland patches (Fig. 3). Area of permanent wetlands showed the least consistency and greatest departure from perfect agreement (Fig. 3). The absolute values of differences in samples of landcover composition were negatively related to the proportion of each landcover type ($n = 10$) in the study area ($r_s = -0.68$, $P = 0.03$). Absolute values of differences in samples of landscape metrics were not correlated with the area of route neighborhoods, as the correlation for only 1 of the 12 landcover metrics approached statistical significance (grassland, $r_s = 0.26$, $P = 0.06$).

Table 2. Landscape metrics, number of North American Breeding Bird Survey (BBS) routes (out of 52) along which each metric was present in route buffer, mean percent difference in values along route buffers relative to route neighborhoods, and *P* values for differences between metrics in BBS route buffers and route neighborhoods in the Prairie Pothole Region of North Dakota and South Dakota, USA. Landcover data were derived from satellite images acquired from May 1992 through September 1996.

Landscape metric	Routes present (*n*)[a]	% difference	*P* value
Grassland	52	+2.6	0.93
Undisturbed grass	51	+5.3	0.99
Hayland	50	+16.4	0.66
Cropland	52	+0.98	0.51
Forest	43	+16.7	0.48
Urban	25	+48.5	0.28
Patches	52	+29.1	<0.001
Basins	52	+8.6	0.02
Temporary	52	+3.2	0.45
Seasonal	52	+1.6	0.40
Semipermanent	52	−15.0	0.02
Permanent	37	−71.2	<0.001

[a] All cover classes were present in all route neighborhoods.

DISCUSSION

Our results suggest that BBS data in our study region are unlikely to be biased for bird species associated with area of grassland, undisturbed grassland, cropland, temporary wetland basins, or seasonal wetland basins. The accurate representation of temporary and seasonal wetland basins may be particularly noteworthy because wetlands in general are frequently thought to be underrepresented on BBS routes (Bystrak 1981, Lawler and O'Connor 2004). However, semipermanent and permanent wetland basins, which were not as well represented by BBS routes, often have temporary and seasonal wetland zones along their periphery, which may be underrepresented. In addition, features of wetlands such as vegetation structure, water depth, and substrate also might differ between portions of a wetland adjacent to and >400 m from a road. Nominally greater abundance of urban, forest, and hay cover classes along BBS routes may bias inferences made from BBS data in our study area, even though these differences were not statistically significant. Lack of statistical difference may be attributable to the fact that higher values in buffers were caused by one or few extreme values, as well as the relative scarcity of these cover classes (0.7%, 1.0%, and 2.2% of total study area, respectively) and, in the case of urban cover, the infrequency that it was detected along BBS routes in our study area.

The differences we documented between BBS routes and route neighborhoods were primarily attributable to 2 factors: increased anthropogenic activity along roads and routing of roads away from relatively large, deep water bodies. Higher patchiness along roads was likely caused by presence of human dwellings (Keller and Scallan 1999), splitting of land ownership and uses by roads, and ease of access for a variety of landuse activities. Similarly, higher densities of wetland basins along BBS routes reflects splitting of wetland basins by roads and the presence of excavated basins (i.e., roadside ditches) along roads (Austin et al. 2000). Underrepresentation of semipermanent and permanent wetlands along BBS routes likely reflects routing of roads away from wetlands with these water regimes.

We were able to distinguish differences in representation of wetlands that varied among water regimes; such differences would not be distinguishable in landcover datasets with coarser thematic resolution (e.g., the National Land Cover Dataset 1992 [Vogelmann et al. 2001]). The ability to distinguish among wetlands with different water regimes has important implications for making inferences about bird populations and evaluating landscape characteristics because water regime influences use of wetlands by waterfowl (Cowardin et al. 1988, Reynolds et al. 2006), waterbirds (Kantrud and Stewart 1984, Naugle et al. 2001), shorebirds (Kantrud and Stewart 1984, Niemuth et al. 2006), and wetland-associated passerines (Kantrud and Stewart 1984). In addition, the presence and density of many species of grassland birds are influenced by grassland community composition and structure (Renken and Dinsmore 1987, Madden et al. 2000, Niemuth 2000); higher thematic resolution will increase the ability to evaluate populations of these species. Landcover data were susceptible to classification errors in all cover classes, but there is no reason to believe the error rate would differ between route buffers and route neighborhoods. However, landscape characteristics along routes may change over time at different rates than the surrounding landscape (Keller and Scallan 1999). In addition, differences in representation may vary with the scale of sampling (Bart et al. 1995). Regardless of thematic or spatial resolution, remotely sensed data will lack information about fine-grained features that are also important to birds. For example, edge habitat and special features such as fences may be more abundant along roads than off roads (Keller and Fuller 1995, Rotenberry and Knick 1995).

Interpretation and applicability of our results are influenced by the different ways in which BBS data are used. Results of BBS data have been presented in terms of geographic regions (Robbins et al. 1986); physiographic regions (Sauer et al. 2005*a*); states or provinces (Robbins et al. 1986); BCRs (Sauer et al. 2003); geopolitical polygons created by the intersection of BCRs and states, provinces, or territories (Rich et al. 2004); and inverse-distancing weighted interpolations (Sauer et al. 2005*a*). No matter what geographic unit is used, low consistency in agreement between route buffers and route neighborhoods for some landcover metrics reinforces the need for caution when making inferences from BBS data when few routes are involved.

In general, BBS routes in our study area were representative of the surrounding landscape. However, being representative can have drawbacks. For example, the majority of the study area was covered by cropland, where many grassland- and wetland-specialist bird species are infrequently encountered. Consequently, the relatively limited sampling of less common habitats might reduce the ability of the BBS to capture the true characteristics and dynamics of bird species restricted to these habitats.

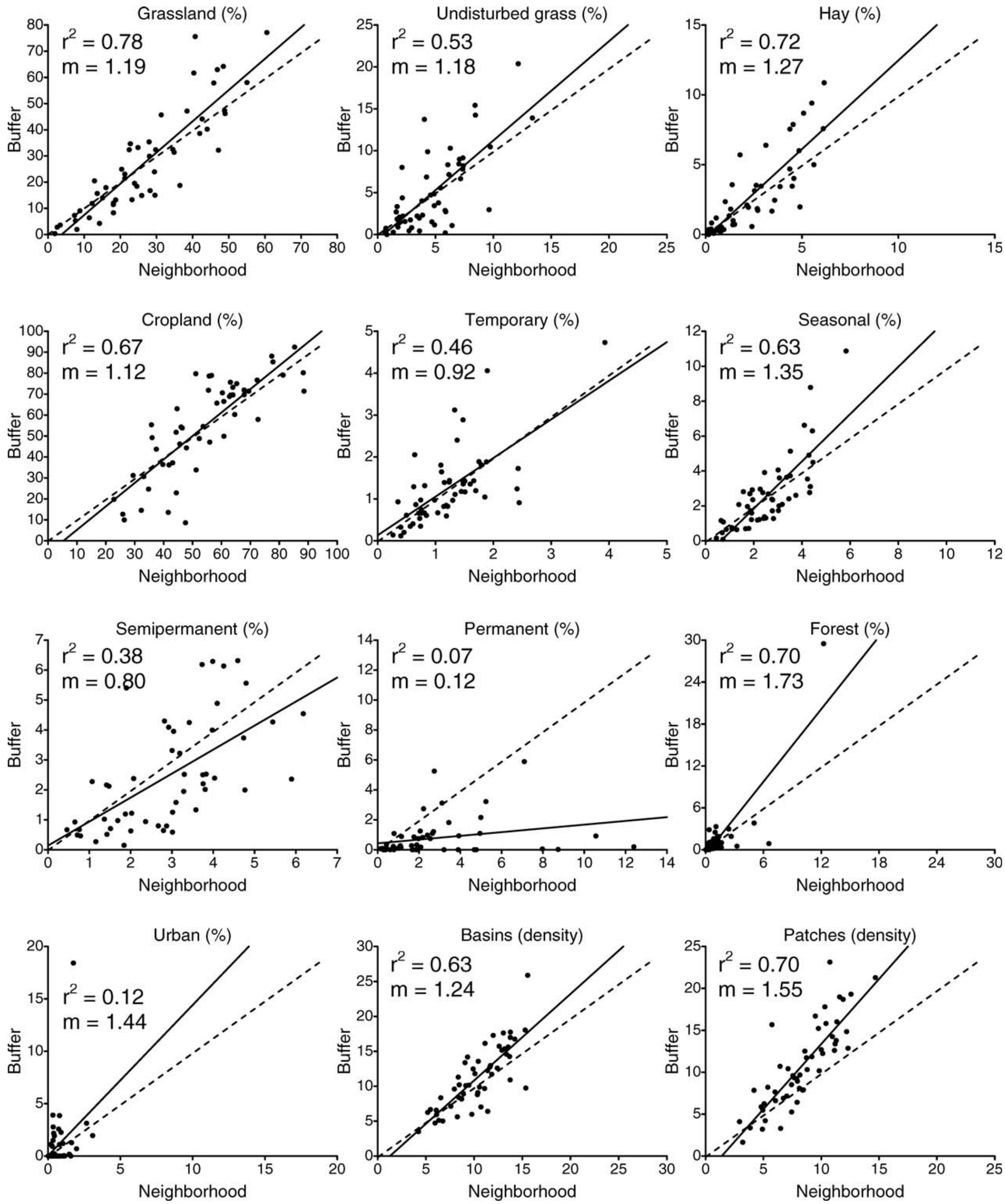

Figure 3. Plots, coefficient of determination, and slope (m) for relationships between 12 landscape metrics in route buffers (Buffer) within 400 m of 52 North American Breeding Bird Survey routes and corresponding route neighborhoods (Neighborhood) in the Prairie Pothole Region of North Dakota and South Dakota, USA. Solid line shows relationship fitted by least squares regression; dashed line has slope of 1, indicating perfect agreement between values in buffers and neighborhoods. Slopes >1 indicate a metric is overrepresented in route buffers; slopes <1 indicate the metric is underrepresented in route buffers. Landcover data were derived from satellite images acquired from May 1992 through September 1996.

MANAGEMENT IMPLICATIONS

Breeding Bird Survey routes in our study region likely undersample those species of waterbirds that prefer permanent and semipermanent wetlands (see Beyersbergen et al. 2004). Similarly, higher patchiness along BBS routes may lead to undersampling of grassland birds whose densities are negatively influenced by landscape fragmentation (see Ribic and Sample 2001). Therefore, population estimates should be tempered according to each species' response to these habitat types. In addition, impacts of broad-scale conservation actions and programs on these species may not be accurately known if BBS data are used to assess the effects of these actions.

Identifying bias in landcover representation is one step in correcting biases in inferences made from bird survey data; establishing surveys that more accurately represent the landscape is a logical next step. Our findings support the idea that habitat-specific surveys may be preferable to increasing the number of randomly placed BBS routes for surveying undersampled habitats and species in our study region (see also Sauer et al. 2003). If additional BBS routes are deemed necessary, landcover data with high thematic and spatial resolution will be a valuable aid in route placement. Biases such as we described are present in many surveys, and the willingness to identify and address biases has been a strength of the BBS program. Increasing availability and quality of digital landcover data and other ancillary information will help assure the continued success of the BBS and its value to bird conservation planning by providing context for BBS data in terms of environmental conditions and the surrounding landscape.

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