Revista Brasileira de Ornitologia 26(2): 116–122.
June 2018

ARTICLE

Bird surveys in grasslands: do different count methods present distinct results?

Carla Suertegaray Fontana[1,3], Eduardo Chiarani[1], Luciana da Silva Menezes[2], Christian Borges Andretti[1] & Gerhard Ernst Overbeck[2]

[1] Laboratório de Ornitologia, Escola de Ciências, Programa de Pós-Graduação em Zoologia, Museu de Ciências e Tecnologia, Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS), Porto Alegre, RS, Brazil.
[2] Laboratório de Estudos em Vegetação Campestre, Programa de Pós-Graduação em Botânica, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre, RS, Brazil.
[3] Corresponding author: carla@pucrs.br

Received on 29 January 2018. Accepted on 02 July 2018.

ABSTRACT: We compared two methods routinely used to conduct bird community surveys: point counts and transects. Our aim was to look for differences between these two methods regarding detection of bird richness and abundances. Additionally, we analyzed if one of the methods provided higher correlation of bird data with vegetation structure as an important habitat descriptor. From September 2014 to January 2015, we surveyed birds in 264 point counts and 258 transects spread across the southern Brazilian grasslands. We conducted one method in direct sequence of the other, in the same place with the same observers and at the same weather conditions. We standardized data to eliminate the effort bias caused by area covered and time employed in each method. Total abundance of birds recorded by the two methods did not differ (point counts 4753 and transects 4436, $P = 0.31$), but we found a significant difference in species richness (point counts 187 and transects 173, $P = 0.01$). Abundance of birds sampled with the transect method showed a slightly higher correlation with vegetation height ($r^2 = 0.07$; $P = 0.004$) than the point counts method ($r^2 = 0.03$; $P = 0.05$). While results from both methods were similar, richness detection was more effective in point counts, indicating that this method might be more useful than it currently is. We discuss potential factors that may influence effectiveness of both methods and suggest issues that should be addressed in further research in order to develop standardized sampling methods for bird communities.

KEY-WORDS: Brazil, fixed-radius point-counts, fixed-width transects, SESA grasslands, standard survey, vegetation parameters.

INTRODUCTION

Grasslands are one of the most threatened ecosystems of the Earth (Azpiroz *et al.* 2012). Precise information about grassland degradation and its effects on biodiversity, ecosystem services and economic potential can support conservation and management plans, thus contributing to the conservation of habitats, plant and animal populations. Birds are an important part of the grasslands' biodiversity and, due to their sensitivity to environmental changes, a good indicator of degradation (Mekonen 2017).

To better comprehend the impacts of land use change on birds, studies are required at both local and regional scales. In South America recent efforts have addressed important questions about the effects of agriculture, urbanization, livestock and exotic trees forestation on grassland birds (Codesido *et al.* 2008, Dias *et al.* 2013, Isacch *et al.* 2014, Cardoni *et al.* 2015, Silva *et al.* 2015, Azpiroz & Blake 2016, Dotta *et al.* 2016, Fontana *et al.* 2016). Currently, however, researches apply different field methods for their bird censuses. This makes it difficult to measure additional impacts on bird communities and/or populations or even compare results at a wider spatial scale.

The application of different methods to survey and measure bird species richness and abundances, limiting the potential for comparisons among studies, is a frequent concern in ornithology (see Buckland 2006, Iknayan *et al.* 2014, Matsuoka *et al.* 2014 for different approaches). So far, point counts (*e.g.*, fixed radius method) and line transects (*e.g.*, fixed width method) figure as the two most used methods to census birds (Diefenbach *et al.* 2003). Attempts to standardize the usage of those methods and a complete description of them were published by Ralph & Scott (1981), Ralph *et al.* (1995), Bibby *et al.* (2000), and reviewed by Matsuoka *et al.* (2014).

The point count method, first descripted by Blondel *et al.* (1970) to census forest birds, is considered the most widely used technique to survey terrestrial birds in North America. The method requires an experienced observer and consists in recording all birds detected in a specific amount of time (*e.g.*, 5, 10, 15 or 20 min) within an unlimited or limited distance (point radius) (Diefenbach *et al.* 2003). The line transect method has been suggested as a more suitable method for sampling open landscapes. It also requires experienced observers, but in this case the sampling is active: by using one or several lines the researcher walks through the pre-determined distance, recording all birds. This method can be applied with different distances, widths and different number of transects (Järvinen 1978, Järvinen & Väisänen 1979).

Despite some controversy on the usefulness of both techniques to assess bird populations, in consequence of the specific detectability of each bird species (Buckland *et al.* 2001, Buckland 2006), point counts and/or transects (with their different versions), continue to be used to estimate abundances of birds. Both methods likely are much used due to their easy applicability in different habitat types and because they are unpretentious and cheap techniques. For their application, only one good observer and good binoculars are required, and they can be easily adapted according to the researcher's specific goals. However, standardization seems useful to define optimal protocols for the methods that allows for comparable results.

In this study, conducted in the south Brazilian grassland region, our main goal is to compare bird survey data gathered by point and transect methods regarding species richness and relative abundance value and, with this, to evaluate how comparable the results are. As structure and composition of bird communities are frequently linked to habitat characteristics, such as vegetation structure (Recher 1969, Karr & Roth 1971, Willson 1974, Marone 1991, Patterson & Best 1996, Marone *et al.* 1997, Azpiroz & Blake 2016), we additionally recorded parameters that describe physical features of the grasslands to test if the two methods for bird sampling resulted in differences regarding the relation of bird data and habitat parameters. We predict that if the bird community parameters were similar using point counts or transects, then the results on the effect of habitat variables should show similar patterns. In this case, independent of the bird census method used, results would be comparable and applicable for bird population monitoring.

METHODS

We conducted fieldwork from October of 2014 to January of 2015 in areas under good conservation status spread throughout the entire south Brazilian grassland region (from Paraná to Rio Grande do Sul states) (Fig. 1). This region encompasses the grasslands in the south of the Atlantic Forest Biome and in the Pampa Biome, covering the different grassland physiognomies of the south Brazilian grasslands (Overbeck *et al.* 2007). A general description of the study region can be found in Azpiroz *et al.* (2012) who use the term "northern Campos" for the Pampa grasslands and the term "Brazilian upland

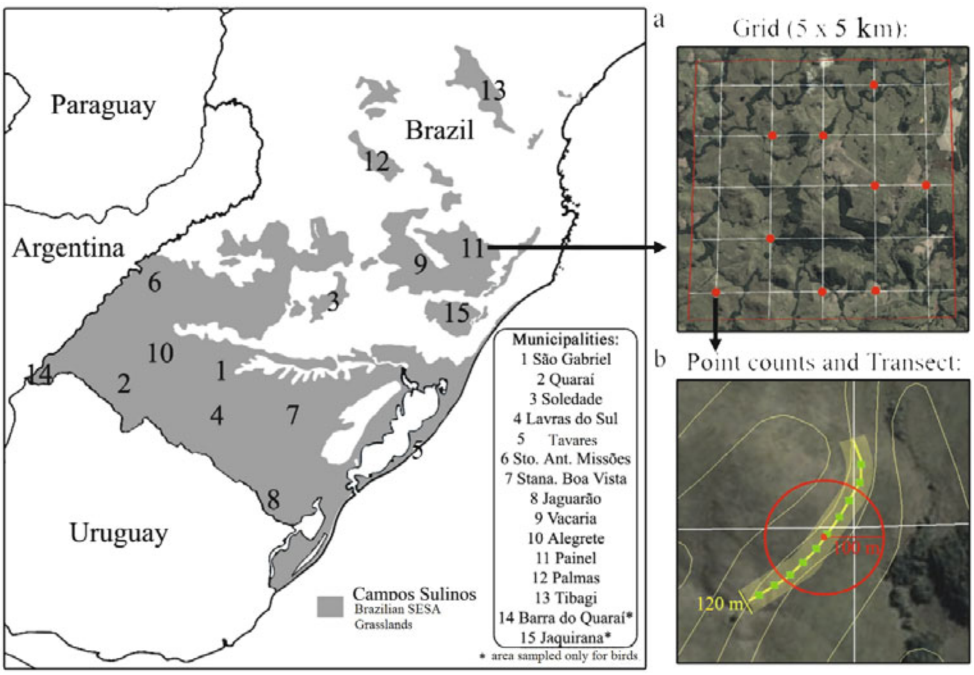

Figure 1. Distribution of the study sites in the Campos Sulinos grasslands in southern Brazil (part of the SESA grasslands) and (**A**) a schematic view of one of the 25 km^2 grid with (**B**) a schematic representation of the sampling unit. The red circle represents the point count (radius 100 m), the hatched yellow line represent the transect (120 m width) and green light squares represent the sampling units for vegetation sampling. Thin yellow lines in (**B**) are terrain level curves.

grasslands" for the highland grasslands in the Atlantic Forest Biome. The region makes part of the grasslands of southeastern South America (SESA) that extend further to the south and west.

Fifteen areas dominated by natural grasslands were selected for bird sampling throughout the study region; vegetation sampling was conducted in thirteen of those areas. The sampling design followed the Rapeld System (Magnusson *et al.* 2013) that is recommended by the Brazilian Program on Biodiversity Research (PPBIO), with some adaptations. In each area, an imaginary grid of 5 × 5 km was draw, with five horizontal and five vertical lines equally distant 1 km. Per grid, nine out of the total of twenty-five intersections were randomly selected, using a stratified approach that considered three different landscape positions (hilltop, slope, depression) in their approximate importance in each area. All grasslands were under grazing and situated in well-conserved regions with low land cover change (Fig. 2).

Birds sampling

We conducted bird sampling twice in each plots: using point counts of 10 min and 100 m radius (represented by red circle in Fig. 1B) and using transects of 250 × 120 m (60 m each side or observer; yellow hatched area in Fig. 1B). The average time for transect sampling was 9.4 ± 2.2 min. The surveys were conducted under homogeneous weather conditions and at the same time of the day by the same two observers (E.C. and C.B.A.), totalizing 264 points and 258 transects.

Vegetation structure sampling

Physical vegetation structure was quantified to characterize the habitat. In each plot, structure was recorded in 10 sampling units of 1 × 1 m, equally distributed in the center of the 250 m transect used for bird sampling (light green squares in Fig. 1B). We measured vegetation height in five points (four corners and center) in each sampling unit. In addition, inside the sampling units we estimated, in percentage, cover of bare soil, dead vegetation (dead biomass) and total live vegetation (green biomass).

Statistical analysis

We standardized bird data by relativizing abundance and richness data recorded at each point or transect by evaluated area and by the time spent in the respective sampling to eliminate effort bias. We used Wilcoxon signed rank test (for paired samples) to compare the results stemming from application both sampling units, using for abundance only the maximum number of individuals recorded in the two samples of each point and transect. We evaluated the relationship between descriptors of vegetation structure and bird abundance and richness with non-linear regression (for the thirteen areas were vegetation data was available). Analysis were carried out in the R program (R Core Team 2016) and BioEstat (Ayres *et al.* 2007).

RESULTS

We recorded 4753 individuals of 187 species in point counts, and 4436 individuals of 173 species in transects. There were 158 species shared between the two methods, 29 species were recorded only in point counts, and 15 only in transects (Table 1). The two methods did not differ in abundance of birds recorded (Wilcoxon signed rank test: V = 4623; P = 0.31), but they resulted in a significant difference in richness (Wilcoxon signed rank test: V = 5028; P = 0.01) (Fig. 3). All relationships between bird community parameters and environmental parameters were very weak (r^2 < 0.07). For data from both methods, the relation between bird communities and vegetation height was significant. For the point count method, the relationship among bird richness and cover of bare soil was significant (Table 2).

Figure 2. Examples of grasslands from southern Brazil. Grasslands landscape in Alegrete, Rio Grande do Sul state (Pampa Biome, left); grasslands landscape in Palmas, Paraná state (Atlantic Forest Biome, right). Photo author: Christian B. Andretti.

Table 1. Bird species recorded only by point counts (29 species) or transects (15 species), from a total of 202 registered species in the southern Brazilian grasslands, with the respective number of individuals (*n*) and frequency of occurrence. Between parenthesis is the number of point counts or transects in which the species was recorded from a total of 258 transects and 264 points sampled. Scientific names and species taxonomic sequence follow Piacentini *et al.* (2015). Asterisk indicates grassland specialists (*sensu* Azpiroz *et al.* 2012).

Species	Method	*n*	Frequency
Chauna torquata	Point count	2	0.008 (1)
Dendrocygna autumnalis	Point count	2	0.008 (1)
Dendrocygna bicolor	Transect	2	0.008 (1)
Cygnus melancoryphus	Point count	31	0.008 (1)
Cairina moschata	Point count	1	0.008 (1)
Anas flavirostris	Transect	1	0.008 (1)
Anas georgica	Point count	4	0.015 (2)
Ardea cocoi	Transect	2	0.016 (2)
Egretta thula	Point count	3	0.015 (2)
*Elanus leucurus**	Point count	1	0.008 (1)
*Circus buffoni**	Transect	2	0.008 (1)
*Geranoaetus melanoleucus**	Point count	1	0.008 (1)
Aramides ypecaha	Transect	1	0.008 (1)
Pardirallus maculatus	Point count	1	0.008 (1)
Pardirallus sanguinolentus	Transect	1	0.008 (1)
Himantopus melanurus	Transect	5	0.016 (2)
*Bartramia longicauda**	Transect	11	0.023 (3)
Jacana jacana	Point count	3	0.015 (2)
Cypseloides senex	Point count	4	0.015 (2)
Heliomaster furcifer	Point count	1	0.008 (1)
Chloroceryle americana	Point count	1	0.008 (1)
Nystalus chacuru	Point count	2	0.008 (1)
Picumnus cirratus	Point count	2	0.008 (1)
*Cariama cristata**	Transect	3	0.016 (2)
Psittacara leucophtalma	Point count	6	0.008 (1)
Pionipsitta pileata	Transect	4	0.016 (2)
*Geositta cunicularia**	Transect	4	0.023 (3)
Phacellodomus ruber	Transect	4	0.008 (1)
Phacellodomus ferrugineigula	Point count	2	0.008 (1)
Synallaxis albescens	Transect	2	0.008 (1)
Elaenia flavogaster	Transect	2	0.008 (1)
*Polystictus pectoralis**	Point count	2	0.008 (1)
*Gubernetes yetapa**	Point count	1	0.008 (1)
Cyanocorax caeruleus	Point count	5	0.023 (3)
Riparia riparia	Point count	2	0.008 (1)
Turdus leucomelas	Point count	2	0.008 (1)
Amblyramphus holosericeus	Point count	5	0.008 (1)
Chrysomus ruficapillus	Point count	21	0.023 (3)
Coereba flaveola	Point count	6	0.023 (3)

Species	Method	*n*	Frequency
Pipraeidea melanonota	Point count	2	0.008 (1)
Pipraeidea bonariensis	Point count	10	0.045 (6)
Gubernatrix cristata	Point count	4	0.015 (2)
*Sporophila pileata**	Point count	1	0.008 (1)
*Sporophila palustris**	Transect	2	0.008 (1)

Table 2. Results of non-linear regression (r^2) between environmental variables and parameters recorded in different bird census methods. Significant regressions ($P \leq 0.05$) are in bold and marked with "*".

	Abundance		**Richness**	
	Point count r^2 (P)	**Transect** r^2 (P)	**Point count** r^2 (P)	**Transect** r^2 (P)
Vegetation height (cm)	0.03 (**0.05***)	0.07 (**0.004***)	0.002 (0.65)	0.02 (0.15)
Vegetation cover (%)	0.02 (0.14)	0.01 (0.24)	0.03 (0.09)	0.01 (0.26)
Bare soil (%)	0.01 (0.20)	0.02 (0.16)	0.05 (**0.02***)	0.01 (0.24)
Dead vegetation (%)	0.01 (0.23)	0.01 (0.24)	0.01 (0.31)	0.006 (0.44)

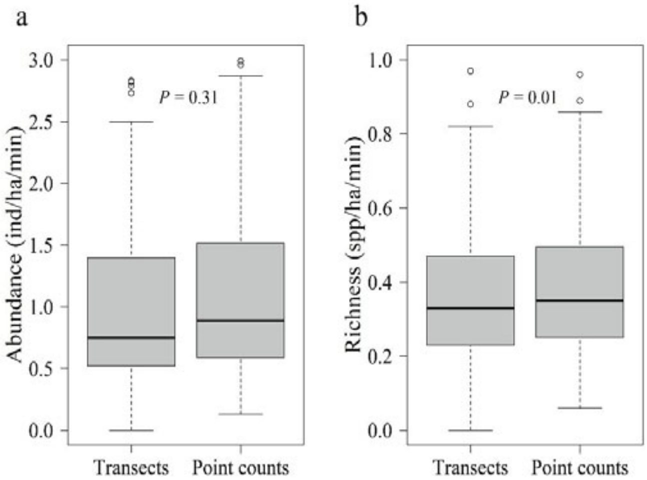

Figure 3. Bird abundance (**A**) and richness (**B**) recorded in transects and point counts in the southern Brazilian grasslands. The line in each box represents the median; top and bottom of each box represent upper and lower quartiles, respectively; whiskers represent maximum and minimum values; circles represent outliers. The *P*-value is based on Wilcoxon signed rank test (for paired samples).

DISCUSSION

There is a considerable body of literature and discussion on gains and losses when using points or transects to survey birds, resulting mostly from studies in the northern hemisphere and in forests (see Emlen 1971, Ralph *et al.* 1995). To date this is the first study that evaluates the effectiveness of the two main bird survey methods (point and transect method) for South American grassland birds. In our study, we standardized all variables that – according to literature – have effects on census results, such as time of the day, survey length, the area covered and the number of observers (*e.g.*, Ralph *et al.* 1993, Ralph *et al.* 1995, Nichols *et al.* 2000). This means that our data contains little sources of bias due to variation of study parameters. We conducted sampling at a large number of strip transects with fixed width and at points with a fixed radius, always in the same period of the year (spring/summer) and at the same time of the day. Additionally, as our study grids covers the whole range of south Brazilian grasslands, an expressive part of SESA grasslands, our results are representative of a large region with a species-rich bird community (more than 200 species).

We found that the point count and the transect method, at least in the way they were conducted in this study, led to similar results regarding bird community structure in SESA grasslands. Point count method has a slight advantage over the transect method when the objective of the study is to evaluate bird species richness. Possibly, standing researchers can pay more attention to songs and movements. Rodrigues & Prado (2018) found that point counts were better than transects to estimate bird species richness in a vegetation gradient in the Brazilian savanna, especially in shrublands and grasslands. This result is especially relevant when we consider that the transect method was one of the most frequently applied method in grasslands of North America between 1985 and 2001 (Diefenbach *et al.* 2003) and is commonly applied in grasslands in South America (*e.g.*, Marone 1991, Isacch *et al.* 2003, Fontana *et al.* 2016). For three North-American grassland bird species, detection probabilities were low for transect distances longer than 25 m for most observers and species, and about 60% of birds were missed by observers at distances longer than 50 m (Diefenbach *et al.* 2003). The increase in visual detections by flushing, considered to be an advantage of transects (Golding & Dreitz 2016), can be reduced because the observer may not detect all individuals that were scared away, were not heard or kept silent (Rodrigues & Prado 2018).

The point method registered almost twice as many exclusive species than the transect method; however, most of these species that were not shared between methods occurred only once or twice. This difference might be a result of stochastic phenomena that should be investigated in further studies, but could also be related to the significantly higher species richness that was recorded using the point count method. Additionally, we registered birds from the border of forests in both methods. This result should be consequence of specific site features, as trees or small forest patches that were present close to some sampling plots. No strong differences were found when analyzing the number of grasslands specialists (*sensu* Azpiroz *et al.* 2012) which totaled only five exclusive species for each method.

Although both survey method showed very low correlation with physical vegetation structure, data obtained with the point count method presented two significant correlations. In contrast, the transect method showed only one significant correlation. If bird communities are to be used as informative for habitat degradation (Mekonen 2017), it is important that the bird data effectively reflects habitat structure. Our data indicates that the point method proved to be slightly better, but of course the correlation values are too low to allow for more detailed interpretation – possibly a consequence of the overall good conservation state of our sampled landscapes. As it is known that many bird species respond to vegetation structure (Derner *et al.* 2009), it seems interesting to conduct comparative studies, with standardized methods as in ours, at sites with contrasting habitat conditions or along stronger environmental gradients. In our study, all grasslands were grazed under similar levels, which means that they were structurally rather uniform. In order to be able to direct land-management, conservation and restoration decisions regarding the role of grassland vegetation structure for bird preservation, it seems especially interesting to compare grasslands with different history of land use (*i.e.* primary *vs*. secondary grasslands, Leidinger *et al.* 2017), or grasslands under different types of management, such as grazing (in different intensities), and fire (*e.g.*, Fedrigo *et al.* 2018, Overbeck *et al.* 2018).

Our study is the first attempt to compare the most used bird surveys methods in grasslands of South America. This will be helpful as a proposal for standardization of sampling methods in the future, in a way that economy of data acquisition and exactness in the estimation of population trends can be best balanced. Such standardization is important for biodiversity monitoring, which should allow for the integration of data (interdisciplinary or not) in order to be employed for land-use management and conservation decisions (Magnusson *et al.* 2013).

Many types of different counting techniques have been previously used to estimate relative abundance and population trends of grassland birds in southern South America. In consequence, comparability of studies is poor and application of results from single studies in conservation at a broader scale difficult (Isacch *et al.* 2014, Azpiroz & Blake 2016, Fontana *et al.* 2016, Dias *et al.* 2017). Despite transects method which at current is more commonly used for recording community of birds in open habitats, we emphasize that point counts with limited radius, as presented in this study, appears to be a very useful technique for future surveys of grassland birds in SESA. We indicate that most questions meriting the effort required to carry out point counts also merit serious attempts to estimate detection probabilities associated with the counts, as already pointed by Nichols *et al.* (2000). Future studies should focus on the discrepancy of probabilities of detection in different methods, including the question if any method favors specific species or functional groups, and what consequences for density estimates stem from this. Additionally, the question of the scale-dependency of the different methods should still be addressed.

ACKNOWLEDGEMENTS

Authors thank the more than 100 landowners of the study areas, Eduardo Vélez-Martin for assistance with selection and implementation of sampling sites and Valério D. Pillar for overall coordination of the research network. This study was developed within the PPBio *Campos Sulinos* network, financed by MCTIC through grant CNPq 457447/2012-5 to G.E.O and CNPq 457475/2012-9 to C.S.F. C.S.F. and G.E.O. receive support from CNPq (Processes 309438/2016-0 and 310022/2015-0, respectively).

REFERENCES

Ayres M., Ayres-Jr M., Ayres D.L. & Santos A.A.S. 2007. *BioEstat 5.0: aplicações estatísticas nas áreas das ciências biológicas e médicas*. Belém: Sociedade Civil Mamirauá (MCT-CNPq).

Azpiroz A.B. & Blake J.G. 2016. Associations of grassland birds with vegetation structure in the northern Campos of Uruguay. *Condor* 118: 12–23.

Azpiroz A.B., Isacch J.P., Dias R.A., Di Giacomo A.S., Fontana C.S. & Palarea C.M. 2012. Ecology and conservation of grassland birds in southeastern South America: a review. *Journal of Field Ornithology* 83: 217–246.

Bibby C.J., Burgess N.D., Hill D.A. & Mustoe S.H. 2000. *Bird census techniques*. London: Academic Press.

Blondel J., Ferry C. & Frochot B. 1970. La méthode des indices ponctuels d›abondance (I.P.A.) ou des relevés d›avifaune par "stations d'écoute". *Alauda* 38: 55–71.

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

Buckland S.T. 2006. Point-transect surveys for songbirds: robust methodologies. *Auk* 123: 345–357.

Cardoni D.A., Isacch J.P. & Iribarne O. 2015. Avian responses to varying intensity of cattle production in *Spartina densiflora* saltmarshes of south-eastern South America. *Emu* 115: 12–19.

Codesido M., González-Fischer C. & Bilenca D. 2008. Asociaciones entre diferentes patrones de uso de la tierra y ensambles de aves en agroecosistemas de la región pampeana, Argentina. *Ornitología Neotropical* 19: 575–585.

Derner J.D., Lauenroth W.K., Stapp P. & Augustine D.J. 2009. Livestock as ecosystem engineers for grassland bird habitat in the western Great Plains of North America. *Rangeland Ecology & Management* 62: 111–118.

Dias R.A., Bastazini V.A.G., Gonçalves M.S.S, Bonow F.C. & Müller S.C. 2013. Shifts in composition of avian communities related to temperate-grassland afforestation in southeastern South America. *Iheringia, Série Zoologia* 103: 12−19.

Dias R.A., Gianuca A.T., Vizentin-Bugoni J., Gonçalves M.S.S., Bencke G.A. & Bastazini V.A.G. 2017. Livestock disturbance in Brazilian grasslands influences avian species diversity via turnover. *Biodiversity and Conservation* 26: 2473–2490.

Diefenbach D.R., Brauning D.W., Mattice J.A. & Thompson-III F.R. 2003. Variability in grassland bird counts related to observer differences and species detection rates. *Auk* 120: 1168–1179.

Dotta G., Phalan B., Silva T.W., Green R. & Balmford A. 2016. Assessing strategies to reconcile agriculture and bird conservation in the temperate grasslands of South America. *Conservation Biology* 30: 618–627.

Emlen J.T. 1971. Population densities of birds derived from transect counts. *Auk* 88: 323–342.

Fedrigo J.K., Ataide P.F., Azambuja-Filho J., Oliveira L.V., Jaurena M., Laca E.A., Overbeck G.E. & Nabinger C. 2018. Temporary grazing exclusion promotes rapid recovery of species richness and productivity in a long-term overgrazed Campos grassland. *Restoration Ecology* 26: 677−685.

Fontana C.S., Dotta G., Kelm-Marques C., Repenning M., Agne C.E. & Santos R.J. 2016. Conservation of grassland birds in south Brazil: a land management perspective. *Natureza & Conservação* 14: 83–87.

Golding J.D. & Dreitz V.J. 2016. Comparison of removal-based methods for estimating abundance of five species of prairie songbirds. *Journal of Field Ornithology* 87: 417–426.

Iknayan K.J., Tingley M.W., Furnas B.J. & Beissinger S.R. 2014. Detecting diversity: emerging methods to estimate species diversity. *Trends in Ecology & Evolution* 29: 97–106.

Isacch J.P., Bo M.S., Maceira N.O., Demaría M.R. & Peluc S. 2003. Composition and seasonal changes of the bird community in the west Pampa grasslands of Argentina. *Journal of Field Ornithology* 74: 59–65.

Isacch J.P., Cardoni D.A. & Iribarne O.O. 2014. Diversity and habitat distribution of birds in coastal marshes and comparisons with surrounding upland habitats in southeastern South America. *Estuaries and Coasts* 37: 229–239.

Järvinen O. 1978. Estimating relative densities of land birds by point counts. *Annales Zoologici Fennici* 15: 290–293.

Järvinen O. & Väisänen R.A. 1979. Changes in bird populations as criteria of environmental changes. *Holarctic Ecology* 2: 75–80.

Karr J.R & Roth R.R. 1971. Vegetation structure and avian diversity in several new world areas. *American Naturalist* 105: 423–435.

Leidinger J.L.G., Gossner M.M., Weisser W.W., Koch C., Rosadio-Cayllahua Z.L., Podgaiski L.R., Duarte M.M., Araújo A.S.F, Overbeck G.E., Hermann J.M., Kollmann J. & Meyer S.T. 2017. Historical and recent land use affects ecosystem functions in subtropical grasslands in Brazil. *Ecosphere* 8: e02032.

Magnusson W., Braga-Neto R., Pezzini F., Baccaro F., Bergallo H., Penha J., Rodrigues D., Verdade L.M., Lima A., Albernaz A.L., Hero J.M., Lawson B., Castilho C., Drucker D., Franklin E., Mendonça F., Costa F., Galdino G., Castley G., Zuanon J., Vale J., Santos J.L.C., Luizão R., Cintra R., Barbosa R.I., Lisboa A., Koblitz R.V., Cunha C.N. & Mendes-Pontes A.R. 2013. *Biodiversidade e monitoramento ambiental integrado*. Santo André: Áttema Editorial.

Marone L. 1991. Habitat features affecting bird spatial distribution in the Monte Desert, Argentina. *Ecología Austral* 1: 77–86.

Marone L., Casenave J.L. & Cueto V.R. 1997. Patterns of habitat selection by wintering and breeding granivorous birds in the central Monte desert, Argentina. *Revista Chilena de Historia Natural* 70: 73–81.

Matsuoka S.M., Mahon C.L., Handel C.M., Sólymos P., Bayne E.M., Fontaine P.C. & Ralph C.J. 2014. Reviving common standards in point-count surveys for broad inference across studies. *Condor* 116: 599–608.

Mekonen S. 2017. Birds as biodiversity and environmental indicator. *Advances in Life Science and Technology* 60: 16−22.

Nichols J.D., Hines J.E., Sauer J.R., Fallon F.W., Fallon J.E. & Heglund P.J. 2000. A double-observer approach for estimating detection probability and abundance from point counts. *Auk* 117: 393–408.

Overbeck G.E., Müller S.C., Fidelis A., Pfadenhauer J., Pillar V.D., Blanco C.C., Boldrini I.I., Both R. & Forneck E.D. 2007. Brazil's neglected biome: the south Brazilian Campos. *Perspectives in Plant Ecology, Evolution and Systematics* 9: 101–116.

Overbeck G.E., Scasta J.D., Furquim F.F., Boldrini I.I., Weir J.R. 2018. The south Brazilian grasslands – a South American tallgrass prairie? Parallels and implications of fire dependency. *Perspectives in Ecology and Conservation* 16: 24–30.

Patterson M.P. & Best L.B. 1996. Bird abundance and nesting success in Iowa CRP fields: the importance of vegetation structure and composition. *American Midland Naturalist* 135: 153−167.

Piacentini V.Q., Aleixo A., Agne C.E., Maurício G., Pacheco J.F., Bravo G.A., Brito G.R.R., Naka L.N., Olmos F., Posso S., Silveira L.F., Betini G.S., Carrano E., Franz I., Lees A.C., Lima L.M., Pioli D., Schunck F., Amaral F.R., Bencke G.A., Cohn-Haft M., Figueiredo L.F., Straube F.C. & Cesari E. 2015. Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee. *Revista Brasileira de Ornitologia* 23: 91–298.

R Core Team. 2016. *R: a language and environment for statistical computing*. Vienna: R Foundation for Statistical Computing.

Ralph C.J., Geupel G.R., Pyle P., Martin T.E. & DeSante D.F. 1993. *Handbook of field methods for monitoring landbirds*. Albany: UNL Faculty Publications.

Ralph C.J., Sauer J.R. & Droege S. 1995. *Monitoring bird populations by point counts*. Albany: Pacific Southwest Research Station.

Ralph C.J. & Scott J.M. 1981. *Estimating numbers of terrestrial birds, v. 6 (Studies in Avian Biology)*. Lawrence: Allen Press.

Recher H..F. 1969. Bird species diversity and habitat diversity in Australia and North America. *American Naturalist* 103: 75–80.

Rodrigues R.C. & Prado P.I. 2018. Sampling methods affect observed response of bird species richness to vegetation structure in Brazilian savannas. *Condor* 120: 402–413.

Silva T.W., Dotta G. & Fontana C.S. 2015. Structure of avian assemblages in grasslands associated with cattle ranching and soybean agriculture in the Uruguayan savanna ecoregion of Brazil and Uruguay. *Condor* 117: 53–63.

Willson M.F. 1974. Avian community organization and habitat structure. *Ecology* 55: 1017–1029.

Associate Editor: Gustavo S. Cabanne.