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Integrating published data and citizen science to describe bird diversity across a landscape

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Summary

1. Knowledge of species diversity across a landscape is essential for answering ecological questions and developing conservation and management goals and protocols. However, data on species occurrence are often limited, with the consequence that species lists are incomplete.
2. As a means to develop a complete species occurrence list for an urbanizing landscape in south-eastern Michigan, USA, all bird species accounts from four public and private organizations were integrated, and all officially documented rare birds added. A citizen science approach was then used to develop an independent species list from *c.* 1700 landowner surveys.
3. The specific goals of the research were to: (i) develop a complete list of species occurrence across a landscape; (ii) ascertain what percentage of the total species pool landowners could collectively identify; (iii) identify species that had not been noted in the census data sets but could be corroborated; (iv) compare the percentage overlap among different bird censuses; and (v) assess the potential value of casual (i.e. citizen science) records to bird distribution studies.
4. The resulting list comprised 318 individual bird species, which was 8·5% greater than any of the individual lists. Landowners identified 171 bird species (*c.* 54%) and had > 50% overlap with all existing databases. In addition, landowners identified 10 species noted only in a single database of rare or vagrant species. The percentage overlap of species across the five different lists ranged from 35% to 66%, with the differences stemming largely from different protocols. Subsetting the data for one county within the landscape reduced the unique species to 294, which was approximately equivalent to the existing county species list.
5. *Synthesis and applications*. The findings highlight the value of surveying private landowners as a means of detecting species presence/absence in numerous inaccessible locations, and the important role landowners can play in providing species occurrence information. Similarly, the results indicate the need to use multiple data sources for establishing a list of potential species occurrence for the conservation and management of biological resources.

Key-words: BBS, breeding bird survey, CBC, Christmas bird count, citizen science, monitoring, private land, volunteers

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Introduction

Whilst the list of species that may occur in a given area appears to be a basic requirement for conservation management, in many instances species presence/absence is virtually unknown aside from basic field guides, range maps and wildlife–habitat relationships (Scott & Jennings 1998). As a result of this paucity of information, there has been a marked increase in attempts to develop basic species diversity and presence/absence data through such approaches as Gap Analysis Program (GAP) analyses (Scott *et al*. 1987), monitoring programmes [e.g. North American Breeding Bird Survey (BBS); Peterjohn & Sauer 1993], and citizen science programmes (e.g. Frogwatch USA; MacKenzie *et al*. 2002). Although these attempts have increased our understanding of what species are present and where they occur on a landscape, they may provide only a partial picture of species presence/absence, because of the possible lack of temporal trends, inability to

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detect cryptic, rare or vagrant species, lack of monitoring effort, and inability to access private lands.

One group of species for which there exists a wealth of information is birds. In North America the existing information is available from the Christmas Bird Counts (CBC; National Audubon Society 2002), the North American BBS, state lists of rare birds and state breeding bird atlases. Notably, however, each of these sources of information only provides a partial list of potential species, because they may only focus on breeding species (e.g. state breeding bird atlases), only collect species information near roads (e.g. BBS) or may miss a number of migratory species (e.g. CBC). Because the habitat in a landscape is important not only to breeding species but also to species that migrate through it, use it as a stopover site or accidentally occur on it (e.g. as a result of inclement weather), establishing a complete list of all potential species' occurrences is essential for both conservation efforts and avian natural history.

Monitoring programmes frequently miss species that occur on private land. Because private lands represent a large proportion of the landscape in many locations throughout the world, it is essential to understand what species occur on them. Thus first-hand observations by landowners can be of great benefit because landowners have access to many locations from which others are restricted and therefore landowners may encounter species not otherwise detected. As a result, such landowner/private citizen monitoring programmes as Project Feederwatch (Hochachka *et al*. 1999; Lepage & Francis 2002) and Garden BirdWatch (Toms 2003), which make use of landowner knowledge in developing species occurrence lists, are of paramount importance. However, one limitation of citizen science monitoring programmes is their volunteer nature. Specifically, citizen science approaches that ask for volunteers without targeting all landowners or an entire geographical area may have the unintended consequence of being biased towards only those individuals interested in birds.

As a means to develop an overall bird richness list across a landscape, I sought to utilize a method that incorporated both existing bird census data as well as a citizen science approach to gather bird observations by landowners living in the landscape. Specifically the goals of this study were to: (i) develop a complete list of species occurrences across a landscape that is facing rapid urbanization; (ii) ascertain what percentage of the total species pool landowners could collectively identify; (iii) identify species that had previously not been noted in the census data sets but could be corroborated; (iv) compare the percentage overlap among different bird surveys and censuses across a landscape; and (v) assess the potential value of such citizen science records to bird distribution studies.

Materials and methods

To address the research goals, and as part of a larger investigation of landowner effects on birds (Lepczyk, Mertig & Liu 2002; Lepczyk, Mertig & Liu 2004a,b), I focused on landowners living along three active BBS routes (route numbers 53, 167 and 168) in a heterogeneous and human-dominated landscape (the Greater Huron River Watershed) undergoing rapid urbanization (for complete landscape details see Rutledge & Lepczyk 2002) in south-eastern Michigan, USA (see the Appendix). In selecting landowners to whom a survey would be administered, I chose all private landowners whose property abutted the road along which each of the three BBS routes were conducted. I identified all private landowners by driving each route and using both county tax records and plat maps (i.e. county maps that delineate the ownership, size and location of land parcels). Utilizing these three approaches I identified a total of 1694 private landowners (331 on route 53, 390 on route 167 and 973 on route 168).

I administered the survey instrument between October and December of 2000 following the total design method (Dillman 1978), which uses a personalized multiple mailing approach and incentives in order to achieve the largest possible response rate. The survey instrument and procedures were evaluated fully for ethical appropriateness by the Michigan State University (East Lansing, MI) Committee on Research Involving Human Subjects prior to mailing. To encourage responses I established a toll-free telephone line for landowners to contact me with any questions and offered prize drawings as an incentive. Briefly, an initial survey was mailed during the first week of October 2000. A postcard reminder/thank you was sent out 2 weeks later. Finally, a second survey was sent out 2 weeks after the postcard.

My sampling framework was designed to capture only private landowners, hence any survey returned from a church, business or public land owner that might have accidentally been included in the initial sample was removed from the study. Similarly, surveys that were returned as undeliverable by the United States Postal Service (USPS), where the recipient was deceased or where different landowners had the same address as another landowner and were returned as undeliverable by the USPS, were removed from the sample. Surveys received after 31 December 2000 were not included in any analyses. If landowners owned multiple parcels that were not connected to one another, they were asked to complete the survey in relation to only one of the parcels. However, if the landowner owned multiple parcels that were all contiguous with one another, they were asked to fill out the survey in relation to the entire block of land. Surveys that were returned blank (i.e. not filled out) or contained notes indicating no interest in participating in the survey were considered a non-response. Similarly, landowners who called to indicate they were unable or had no desire to participate in the survey were considered non-respondents. Non-respondents were included in the final corrected sample size.

To ascertain what bird species landowners had observed on their property I asked the following two questions. (i) Can you name any of the bird species you typically

Table 1. Data sets used for compiling and comparing bird species across the Greater Huron River Watershed. Values denoted by an * indicate the maximum number of years for which data have been collected, but not all locations have been collected continuously over this time period

Data set name	Abbreviation	No. of years run	Type of data	Compiled by
Birds of Washtenaw County	BOW	15	Presence/absence	Literature and survey review
Christmas Bird Counts	CBC	101*	Abundance	National Audubon Society
Michigan Breeding Bird Atlas	MIBBA	6	Presence/absence	Kalamazoo Nature Center
North American Breeding Bird Survey	BBS	35*	Abundance	US Fish and Wildlife Service

see on your property [two check boxes, yes or no]? (2) If 'Yes', please write down the names of the species observed. The open-ended question format was used to avoid leading the respondents regarding what species they had encountered on their property.

To ensure data quality I edited the landowner responses as follows. All spelling and grammatical mistakes were corrected and incomplete names that had only one possibility were completed (e.g. cardinal became northern cardinal). If a landowner used an outdated species name or colloquial wording it was converted to currently accepted nomenclature (e.g. sparrow hawk changed to American kestrel). Incomplete wording, from which no distinct species or taxonomic group could be discerned (e.g. the word 'black' could not be discerned as any species), was removed. Similarly, if a species was listed for which no (i) field guides (e.g. Sibley 2000) indicated it to be even remotely in the proximity of the study area, (ii) existing data set concurred, (iii) literature search could confirm, (iv) personal observation could be made or (v) records existed from the Michigan Bird Records Committee (MBRC) data set, it was removed from the list. Finally, if the response was ambiguous, such that it could be interpreted as one of several species, the response was excluded.

Four existing data sets were acquired to develop species lists and compare species' occurrences across the Greater Huron River Watershed landscape (Table 1 and see the Appendix). These data sets were the Michigan Breeding Bird Atlas (MIBBA) accounts for Ingham, Jackson, Livingston, Monroe, Oakland, Washtenaw and Wayne counties (Brewer, McPeek & Adams 1991; see the Appendix); all active and inactive routes of the North American BBS that were censused from 1966 to 2001 (routes 53, 66, 67, 68, 167, 168; state code = 49); all CBC from 1900–01 (year 1) to 2000–01 (year 101) for CBC circles Ann Arbor (MIAA), Detroit (MIDE), Hartland (MIHA), Pontiac (MIPO), Waterford (MIOX), Waterloo State Recreation Area (MIWA) and Ypsilanti (MI0C) (National Audubon Society 2002); and 293 of 297 bird occurrences (four species were either extinct or could not be reasonably verified) published in *The Birds of Washtenaw County, Michigan* (BOW; Kielb, Swales & Wolinski 1992). BOW is an exception to the normal standard of bird species lists in that it is a compilation of all possible species determined through regular field surveys, detailed review of published and unpublished data and unpublished observations at a county level (for further details see Kielb, Swales & Wolinski 1992). I excluded data from the Great Backyard Bird Count and Project FeederWatch because of the small number of participants within the study area. Only data that contained complete common or species names from these four data sets was used for analysis. Escaped and exotic species noted in the surveys were included in the species lists and subsequent analyses. Four separate species lists were compiled from the four data sets and landowner survey for analysis across the Greater Huron River Watershed. The first list was the overall list that included all species' occurrences, including ones that were suspect from the four data sets because of rarity and lack of acceptable confirmation with the MBRC, as well as rare birds documented by the MBRC that occur in the seven counties of the study area but were not found in any of the existing surveys. The second list was the corrected list that included only species' occurrences that could be corroborated, including MBRC records. The third list was the comparative list that contained all corroborated birds minus the species identified by the MBRC that were not found in any of the existing surveys. Finally, the fourth list was Washtenaw County, which was a subset of the comparative list containing only records from the data sets that occurred in Washtenaw County (see the Appendix). I used the comparative and Washtenaw County lists for comparisons among the data sets. All scientific and common names that had changed over time were updated to currently accepted American Ornithologists' Union terminology.

Results

The overall list of birds observed on the Greater Huron River Watershed landscape, compiled from the five data sets and the MBRC, comprised 318 species (see the Appendix). However, five species, barnacle goose *Branta leucopsis*, California gull *Larus californicus*, chuck-will's-widow *Caprimulgus carolinensis*, three-toed woodpecker *Picoides tridactylus* and tricolored heron *Egretta tricolor*, which were identified in the four published data sets, could not be verified by MBRC, possibly because they were misprints, rare or vagrants. Thus, taking a conservative estimate, the total corrected richness list comprised 313 species. Of these 313 species, 15 were identified only in the MBRC, yielding a total of 298 species in the comparative list. A total of 294 species was identified within Washtenaw County (see the Appendix).

Table 2. Comparison of species richness from different census methods for the Greater Huron River Watershed. The number of species in common is the number of species present in both lists (numerator) divided by the total number of unique species present on either list (denominator) with the number in parentheses representing the percentage

	Census			
Census	Landowner	BBS	CBC	BOW
BBS	103/192 (53·6)			
CBC	116/205 (56·6)	71/203 (35·0)		
BOW	171/293 (58·4)	124/293 (42·3)	147/296 (49·7)	
MIBBA	136/234 (58·1)	120/203 (59·1)	108/241 (44·8)	196/296 (66·2)

Table 3. Comparison of species richness from different census methods for Washtenaw County alone. The number of species in common is the number of species present in both lists (numerator) divided by the total number of unique species present on either list (denominator) with the number in parentheses representing the percentage

	Census			
Census	Landowner	BBS	CBC	BOW
BBS	81/153 (52·9)			
CBC	84/171 (49·1)	63/186 (33·9)		
BOW	120/293 (41·0)	114/293 (38·9)	134/294 (45·6)	
MIBBA	84/162 (51·9)	110/130 (84·6)	69/192 (35·9)	126/293 (43·0)

A total of 968 (58·6% response rate) landowners responded to the survey, of which 834 (86·2%) identified at least one bird species that frequented their land (for survey response details see Lepczyk, Mertig & Liu 2004a,b). Collectively, the landowners identified 171 species of birds, comprising 53·8%, 54·6% and 57·4% of the overall, corrected and comparative lists, respectively. Notably, while all of the species identified by the landowners had been observed in at least one of the species list, a total of 10 species (see the Appendix) were rare or vagrants and only observed in BOW. Within Washtenaw County, the landowners identified 120 species of birds, comprising 40·8% of all species.

Of the 298 species from the comparative species list, 124 (41·6%) were recorded along the BBS routes, 150 (50·3%) were recorded in the CBC circles, 293 (98·3%) were seen in BOW and 199 (66·8%) were recorded in the MIBBA (see the Appendix). The number and percentage of species that overlapped among methods ranged from 35·0% to 66·2% (Table 2). In the case of Washtenaw County (i.e. 294 species), 114 (38·8%) were recorded along the BBS routes, 135 (45·9%) were recorded in the CBC circles, 293 (99·7%) were seen in BOW and 126 (42·9%) were recorded in the MIBBA (see the Appendix). Similarly, the number and percentage of species that overlapped among methods ranged from 33·9% to 84·6% (Table 3).

Discussion

Combining all available data sets and landowner responses resulted in a species occurrence list that was at least 8·5% greater than any single previous estimate for the Greater Huron River Watershed, but equivalent to the previous estimates for Washtenaw County. However, if the unique BOW survey was not included in the analysis, the combined species occurrence list for the Greater Huron River Watershed was at least 42% greater than any existing list (range 42–227%), with landowners identifying *c.* 61% of the all species. These findings for the Greater Huron River Watershed highlight the need for integrating multiple species occurrence data sets for establishing a complete species list across a landscape or region, especially in the majority of locations that do not have a county survey such as BOW. The need for integrating multiple data sets in the development of a single species occurrence list is also apparent by the fact that while there was a moderate level of species overlap across databases, the percentage overlap did not exceed *c.* 66% for the entire landscape (Table 2) and *c.* 85% for Washtenaw County (Table 3). The differences in percentage overlap are probably the result of several factors. First, the different censuses were carried out at different times during the year, thus picking up species that only occur or pass through the landscape during a specific part of the year. Secondly, each survey had inherent biases. For instance, BBS routes are less likely to capture birds that are nocturnal or avoid roads. Finally, each census method or database had been established for a different purpose, thereby focusing on a relatively narrow pool of birds (e.g. MIBBA). Notably, even when the goal was to record all species occurring in one location (BOW), there were still slight differences among the data sets within Washtenaw County.

Collectively the landowners identified > 50% of the species listed in each database (Table 2) and of all potential species across the Greater Huron River Watershed. Similarly, within Washtenaw County alone the

landowners identified *c.* 50% of species listed in each database except BOW (*c.* 41%). While several species listed by landowners were excluded because they could not be corroborated (e.g. common raven *Corvus corax*), landowners did report 10 species that had previously been noted only by the MBRC or in the literature and hence included in BOW. Specifically, these species included the barn owl *Tyto alba*, American magpie *Pica hudsonia*, summer tanager *Piranga rubra*, bohemian waxwing *Bombycilla garrulous*, black-throated blue warbler *Dendroica caerulescens*, magnolia warbler *Dendroica magnolia*, bay-breasted warbler *Dendroica castanea*, blackpoll warbler *Dendroica striata*, blackburnian warbler *Dendroica fusca* and the palm warbler *Dendroica palmarum*. Although a number of bird species that landowners identified were excluded in the present study because of a lack of corroborating evidence, that does not mean they were not present. Specifically, these species could be rare or vagrants and could potentially serve to identify locations within the landscape where more in-depth investigations or follow-up surveys would be worthwhile.

Surveying people about bird species and bird activities has been a commonly used technique to gain information (Cowie & Hinsley 1988; Brittingham & Temple 1989; Dunn & Tessaglia 1994; Cannon 1999). Although surveying people about bird activities and abundances provides a wealth of information, one potential drawback of many surveys is that they target a very narrow group of people. Specifically, nearly all previous surveys have either been administered to amateur birders and ornithologists and people who participated in these activities (Brittingham & Temple 1989; Wiedner & Kerlinger 1990), or have sought volunteers (e.g. Project Feeder Watch; Wells *et al*. 1998). As a result these methodologies may be biased towards those people who are interested in birds. In contrast, the method utilized in this study targeted all people in a specific geographical location, without regard to their demonstrated interest in birds, leading to a higher rate of participation among landowners who could identify a bird species (86·2%) than among all Michigan residents specifically interested and engaged in any wildlife watching activity, including bird watching (32%; US Department of the Interior Fish & Wildlife Service & US Department of Commerce US Census Bureau 2001). In addition, conducting surveys of landowners can potentially provide more information on bird occurrences and abundances in landscapes where land ownership is predominantly private, as in this study where > 90% of the land was privately owned. A final benefit is that surveying a general populace can provide information on new species' occurrences across a landscape, thus allowing for more targeted censuses by trained ornithologists to corroborate the sightings. This is particularly true in locations where exceptionally detailed surveys (e.g. BOW) are absent.

The citizen science approach utilized here does have several potential pitfalls. For example, there may remain a bias in the representation of respondents as not every landowner responded. A case in point is a recent study in Great Britain that found non-respondents to a mail survey were more likely to have had no bird nests present on their property (Bland, Tully & Greenwood 2004). Also, landowners may misidentify species. Lastly, this approach does not incorporate any measure of bird abundance, observer effort or bias towards either conspicuous or rare species. However, there are still many benefits to a targeted mailing to all landowners. First, this method allows for access to areas and habitats (e.g. private gardens) that are not generally well surveyed. Secondly, it is a cost-effective data collection method. Thirdly, by involving all private landowners the method serves as an instrument of public education about species diversity, conservation and the value of the land, which may lead to participation in more rigorous surveys. Fourthly, this type of survey is good for providing a quick 'snapshot' of bird presence in an area and therefore could be a cost-effective method (compared with hiring professional ornithologists) if a species list is required or if knowledge gaps of a species range need to be filled, particularly at finer spatial scales. This could be especially relevant to high-profile and easy-to-identify species. Ultimately, then, the method of coupling existing data with landowner knowledge is a simple and easy method for improving knowledge about species presence/absence.

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Supplementary material

The following supplementary material is available for this article online:

Appendix S1. All possible species, as denoted by different survey methods, for the Greater Huron River Watershed landscape.

Appendix S2. All possible species, as denoted by different survey methods, for Washtenaw County

Figure S1. Location of bird censuses in south-eastern Michigan, USA.

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