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Assessing Landowner Activities Related to Birds Across Rural-to-Urban Landscapes

CHRISTOPHER A. LEPCZYK*
ANGELA G. MERTIG
JIANGUO LIU
Department of Fisheries and Wildlife
Michigan State University
East Lansing, MI 48824-1222, USA

ABSTRACT / Fluctuations of bird abundances in the Midwest region of the United States have been attributed to such factors as landscape change, habitat fragmentation, depredation, and supplemental feeding. However, no attempt has been made to estimate the collective role of landowner activities that may influence birds across a landscape. To investigate how landowners might influence birds when the majority (> 90%) of land is privately owned, we surveyed all 1694 private domestic landowners living on three breeding bird survey routes (~120 km) that represent a continuum of rural-to-urban landscapes in Southeastern Michigan from October through December 2000. Our survey was designed to investigate (1) the proportion of landowners involved in bird feeding, providing bird houses, planting or maintaining vegetation for birds, gardening, landscaping, applying fertilizer, and applying pesticides or herbicides; (2) whether differences existed between urban, suburban, and rural landowner activities; and (3) whether landowners that carried out a given activity were sociodemographically different from those who did not. Of the 968 respondents (58.5% response rate), 912 (94%) carried out at least one of the activities on their land and the average landowner carried out 3.7 activities. A total of 65.6% fed birds, 45.7% provided bird houses, 54.6% planted or maintained vegetation for birds, 72.7% gardened, 72.3% landscaped, 49.3% applied fertilizer, and 25.2% applied pesticides or herbicides. Significant differences existed between the landscapes, with rural landowners having more bird houses and applying pesticides or herbicides in greater frequency. Similarly, urban landowners had a greater density of bird feeders and houses, but planted or maintained vegetation in the lowest frequency. Participation in activities varied by demographic factors, such as age, gender, and occupation. Scaling each activity to all landowners, including nonrespondents, across all landscapes indicates that between 14% and 82% of landowners may be engaged in a particular activity, with application of pesticides or herbicides having the least potential involvement (13.9%–55.4%) and gardening having the greatest potential involvement (40.1%–81.6%). Taken collectively, our results indicate that landowners are both intentionally and unintentionally engaged in a wide range of activities that are likely to influence bird populations.

The realization that humans modify and create ecosystems and landscapes is not new (e.g., see Odum 1959). Traditionally, however, this realization was limited to such systems as agriculture, pasture, orchards, and urban areas (Vitousek and others 1997). By the end of the twentieth century, such a narrow view of human interaction was eclipsed by the knowledge that humans were having drastic impacts on all of the world's ecosystems (McDonnell and Pickett 1993, Daily 1997, Vitousek and others 1997). Although ecologists now recognize the scale at which humans influence the global ecology, many have largely ignored the human component in ecological systems research and instead focused on natural or pristine systems without humans (Gallagher and Carpenter 1997, Liu 2001). The consequence of ignoring the human component is that ecologists' understanding of how humans interact and influence different ecosystems is still in its early stages (Redman 1999). Notably, however, ecologists are increasingly incorporating socioeconomics, human demography, and human dimensions techniques, as well as designating long-term ecological research sites in urban locations to understand the interrelationship between humans and the ecosystems within which they live (Parlange 1998, Liu and others 1999, Liu and others 2001).

Although incorporating the human component is important for all ecological research, it is especially pertinent in locations where ecologists have gathered long-term data on species abundance and distribution (Vogt and others 2002) because it allows for a more holistic view of the system being studied and helps to explain the data. Although a wide variety of long-term data sets exist, one that has been used extensively in ecological research is the North American Breeding

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*Author to whom correspondence should be addressed.

Bird Survey (BBS) (e.g., Böhning-Gaese and others 1993, James and others 1996, Cam and others 2000). The BBS is a continent-wide annual survey that is conducted along secondary roads randomly located throughout the United States and Canada. Surveys have been conducted since 1966 on individual routes that are each 39.4 km long. Each route consists of 50 point counts that are 0.8 km apart, where a competent observer records all birds seen or heard within 0.4 km of the stop (Peterjohn and Sauer 1993).

The BBS has been instrumental in documenting declines in many breeding bird species since its inception (Robbins and others 1989, Terborgh 1989). Although the causes and extent of many declines have been controversial (James and others 1996, James 1998), they have generally been attributed to a variety of interrelated factors, including habitat fragmentation and destruction (Robbins and others 1989, Donovan and Flather 2002), landscape change (Flather and Sauer 1996), nest predation (see Heske and others 2001 for review), cowbird parasitism (Robinson and others 1995), and direct mortality due to events (e.g., culling by farmers) on the wintering grounds of the neotropics (Rappole and McDonald 1994, Basili and Temple 1999). Notably absent from the potential mechanisms considered responsible for influencing breeding bird abundances are the landowners that live in the proximity of the BBS routes. Specifically, because private landowners are the ultimate controllers of their land, they may be carrying out a wide variety of actions that could, if taken cumulatively across large areas, either positively or negatively influence bird abundances and distributions. Because of the potential for significant landowner effects, there has been increased attention directed towards the integration of social and economic components into questions of avian distributions (Hostetler 1999).

In directing attention towards how landowners may be influencing avian species it is first important to consider what specific activities they may be pursuing on their land. Arguably, the most important factors to focus on are those that alter or affect the habitat used by birds or directly impact bird species. These factors include alteration or maintenance of vegetation, introduction of exotic predators, chemical application, landscaping, gardening, and food and nesting supplementation, each of which has a known relationship to birds, or has been highly promoted as having a relationship. For instance, in the case of bird feeding, it is a highly promoted activity (e.g., Stokes and Stokes 1987, Sargent and Carter 1999) that potentially alters the natural food regimen by locating large caches of energy-dense food in easy to forage locations throughout the year. Similarly, in the case of bird houses (i.e., nest boxes), it is a highly promoted activity (Sargent and Carter 1999) designed to encourage birds, especially cavity-nesting birds, to breed. As with feeding and providing bird houses, the planting and maintenance of vegetation as well as gardening and landscaping are highly promoted activities, designed to alter or maintain the habitat for use by birds (Sargent and Carter 1999). Exotic predators (e.g., house cats [*Felis catus*]), also play a key role in negatively impacting bird species (Churcher and Lawton 1987, Coleman and Temple 1993, Lepczyk and others 2003). Fertilizing is another common activity that can increase or decrease bird habitat through changes in plant productivity, invertebrate populations, and toxicity (see Vickery and others 2001 for review). In the case of pesticide and herbicide application, there is a long history of negative impacts associated with bird species (e.g., Carson 1962). Specifically, pesticides and herbicides can both directly and indirectly influence bird populations (Newton 1995) by affecting birds' growth, development, and survival (Bishop and others 1998a,b, Brickle and others 2000), as well as through reducing or altering the food supply (i.e., invertebrates; Blackburn and Arthur 2001).

The aforementioned human activities could have cumulative effects on bird species distributions; however, they have not been quantified in detail across landscapes, along BBS routes, or in conjunction with one another. For instance, the U.S. Department of the Interior has conducted a number of surveys (e.g., U.S. Department of the Interior and others 1997, 2002) to measure levels of wildlife recreation, including bird feeding. However, these surveys are aggregated at geopolitical units and report number of people participating in a given activity, thus providing no details on potential differences across landscapes or among landowners. Similarly, the Cornell Laboratory of Ornithology conducts Project Feeder Watch (e.g., Wells and others 1998) each week during the winter months in North America seeking to estimate the abundance of birds. A disadvantage of the feeder watch program is that it again provides very little spatial or landowner data. Furthermore, such surveys as Project Feeder Watch have been directed towards amateur ornithologists and birders, and therefore may not be representative of the typical landowner.

Besides the lack of detailed information, avian research in human-dominated systems has been focused on, and continues to be directed toward, the effects that landscape structure have on bird distributions (Blair 1996, Marzluff and others 1998, Hostetler and Holling 2000) and not on what landowners are actually doing to influence birds. Given the fact that a wide number of businesses exist that sell bird-related products (e.g., bird food, bird houses), coupled with the great volume of information from public and private organizations directed at landowners to encourage bird use and visitation (e.g., Terres 1953, DeGraaf and Witman 1979, Stokes and Stokes 1987, Tufts and Loewer 1995, Sargent and Carter 1999), it is possible that many more landowners are involved in activities that could influence bird abundances than might be implied from such research as the National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior and others 1997, 2002). However, even in the face of this likelihood, no data exist that seek to address what activities landowners are either intentionally or unintentionally engaged in on their land or how they may be correlated, especially across large spatial scales.

Besides simply investigating what activities landowners may be carrying out on their land, it is also essential to investigate whether there are sociodemographic factors that differentiate those landowners involved in a given activity from those who are not. If differences exist, they may be valuable in targeting management and conservation efforts on both private lands and public locations that have a large private land component nearby. Thus, it is relevant to consider how factors such as age, sex, household size, education, occupation, and income are related to the specific activities. For instance, men and women often exhibit differences of opinion with regard to species conservation (Kellert and Berry 1987, Czech and others 2001). Integrating the sociodemographic component into the analyses not only provides a clearer picture of what may be related to specific actions, but can also provide more precise information about whom to focus on with regard to conservation planning, modeling avian populations, and management.

As part of a larger effort to understand the social and ecological factors influencing breeding bird abundances along BBS routes (Lepczyk and others 2002, Lepczyk and others 2004), we sought to investigate specific activities that private domestic (nonbusiness) landowners were likely carrying out on their land across a rural-to-urban gradient of landscapes. These activities included feeding birds, providing bird houses, planting and maintaining vegetation for the benefit of birds, gardening, landscaping, fertilizing, and applying pesticides and herbicides. With regard to these activities, we were specifically interested in discerning (1) the proportion of landowners involved in each activity; (2) whether participation in an activity was correlated to participation in another activity; (3) the number and density of bird feeders and houses; (4) whether differences existed between urban, suburban, and rural landowner activities; and (5) whether the population of landowners that carried out a given activity was sociodemographically different from the population of landowners that did not carry out the activity.

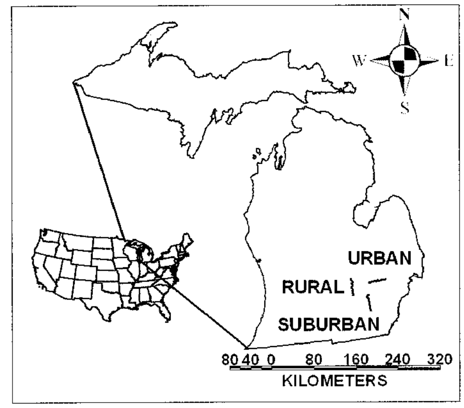

Figure 1. Location of the three Breeding Bird Survey (BBS) routes in Southeastern Michigan where the landowner survey was conducted. Route 53 is Rural, route 167 is Suburban, and route 168 is Urban. Each BBS route is 39.4 km long.

Methods

Study Area

We selected study areas where long-term data on bird abundance and distribution have been collected by choosing three BBS routes (route numbers 53, 167, and 168) in Southeastern Michigan, United States (Figure 1), where more than 90% of the land is privately owned. We chose these three routes because they represent a continuum from rural to relatively urban landscapes, based on their geographic locations, average land parcel sizes, and sociodemographic compositions. Specifically, route 53 (hereafter termed Rural) is very rural, has a low population density (27 people/km^2; 2000 Census of the four township area), large land parcels (mean size of 18.2 ha; see Results), and is removed from any large city center or urban location. Route 168 (hereafter termed Urban) ranges from being very suburban to urban, has a high population density (376 people/km^2; 2000 Census of the four township area), small land parcels (mean size of 3.4 ha; see Results), and transects or parallels residential locations and city centers. Finally, route 167 (hereafter termed Suburban) straddles the demographic differences between routes 53 and 168 by being suburban, with intermediate population density (110 people/km^2; 2000 Census of the five township area) and land parcel sizes (mean size of 7.9 ha; see Results), and runs

Table 1. Survey questions pertaining to landowner activities and sociodemographic composition

(1) Does anyone in your household feed birds on your property (yes, no)?
(2) In which months of the year do you or members of your household feed birds (January through December)?
(3) How many bird feeders do you have on your property?
(4) Approximately how many years have you or members of your household been feeding birds?
(5) Do you plan to continue feeding birds on your property in the future (yes, no, unsure)?
(6) Are there any bird houses on your property (yes, no)?
(7) How many bird houses do you have?
(8) Approximately how many years have you had bird houses on your property?
(9) Do you plan to continue having bird houses on your property in the future (yes, no, unsure)?
(10) Have you planted vegetation or maintained landscaping on your property in order to benefit or encourage use by birds (yes, no)?
(11) (Referring to question 10) What types of vegetation have been planted (check all that apply: fruit trees or bushes, ornamental shrubs or bushes, vines, other [please specify])?
(12) Which of the following activities do you carry out on your land (check all that apply: gardening, landscaping, fertilizing, spraying pesticides or herbicides, other [please specify])?
(13) Approximately how large is your parcel of land (ACRES)?
(14) About how long have you owned or lived on this parcel of land (YEARS)?
(15) In what year were you born (19__)?
(16) Are you: Male, Female?
(17) How many people currently live in your household?
(18) What is your primary occupation? (Categorized according to 1990 U.S. Census [U.S. Department of Commerce 1993]: (1) managerial and professional specialty; (2) technical, sales, and administrative support; (3) service; (4) farming, forestry, and fishing; (5) precision production, craft, and repair; and (6) operators, fabricators, and laborers. An additional category was used to incorporate respondents who were not employed, which included homemakers, widows, students, disabled persons, those on public assistance, and retired individuals who did not specify a previous occupation.)
(19) Do you have a house or residential structure on your land (yes, no)?
(20) What is the approximate size of the house or residence (less than 1000 square feet, 1000 to 1499 square feet, 1500 to 1999 square feet, 2000 to 2499 square feet, 2500 to 2999 square feet, 3000 to 3499 square feet, 3500 square feet or larger, unsure [unsure excluded from analyses])?
(21) What is the highest level of school completed or degree you have received (Some school completed, but no high school diploma; High school graduate or GED (general equivalency diploma); Some college, but no degree; Associate's degree in collge; Bachelor's degree; and, Master's, professional, or doctoral degree)?

parallel to (but never intersects) large residential and city center locations. In addition, all three routes occur in a heterogeneous and human-dominated region that is undergoing rapid urbanization (Rutledge and Lepczyk 2002), which is representative of many other regions in North America. The last reason for selecting these three routes is that they remain active BBS routes, monitored annually by the United States Fish and Wildlife Service, which allows for future evaluations to be conducted, and hence, comparisons made over time.

Survey Design, Implementation, and Questions

To determine information about human behaviors along BBS routes, we conducted a social survey of private, domestic (nonbusiness) landowners (see Lepczyk 2002 and Lepczyk and others 2004 for additional details). We chose all private landowners who owned property immediately adjacent to the road along which each of the three BBS routes is run. We identified landowners through a combination of driving each route and using county tax records and plat maps (i.e., county maps that delineate the ownership, size, and location of land parcels). Using this combined approach, we identified a total of 1694 private landowners (331 on Rural, 390 on Suburban, and 973 on Urban). We administered the survey instrument between October and December of 2000 following the Total Design Method (Dillman 1978, 2000), which uses multiple mailings to increase survey response. To further encourage landowners to respond to the survey, we offered an incentive prize drawing. On the entire survey, we used 21 questions that were related to landowner activities and sociodemographic composition (Table 1).

Data Processing and Statistical Analyses

In cases where the respondents did not explicitly follow the survey instructions, we edited the data as follows. For fill-in-the-blank questions that asked for a single numeric response, but for which the respondent put a range, we took the arithmetic mean as the value. When respondents indicated that they had participated

Table 2. Landowner sociodemographic composition across landscapes: values, except gender, are means ± SE, with numbers in parentheses indicating the sample size

	Landscape			
	Rural	Suburban	Urban	Average
Respondent age[b]	51.7 ± 0.96 (206)	52.8 ± 0.85 (221)	49.2 ± 0.60 (503)	50.6 ± 0.44 (930)
Number of people in residence	2.80 ± 0.09 (207)	2.90 ± 0.09 (220)	2.84 ± 0.06 (508)	2.85 ± 0.05 (935)
Gender (M; F)	112; 94	110; 112	276; 230	498; 436
Respondent educational level[1,a,b,c]	3.03 ± 0.09 (204)	4.09 ± 0.11 (223)	3.46 ± 0.06 (505)	3.52 ± 0.05 (932)
Size of house or residence[2,a,b]	3.12 ± 0.10 (180)	3.82 ± 0.09 (203)	3.03 ± 0.06 (484)	3.23 ± 0.05 (867)
Parcel size (ha)[a,c]	18.21 ± 3.67 (206)	7.85 ± 1.36 (231)	3.44 ± 1.21 (502)	7.76 ± 1.10 (939)

[1]Educational level was a categorical response from 1 to 6 (see Table 1), with a higher number indicating a higher level of education.
[2]Size of house or residence was a categorical response from 1 to 7 (see Table 1), with a higher number indicating greater amount of living area.
Superscript letters represent significant differences between landscapes based on a Tukey HSD post-hoc test as follows: [a]Rural differs from Suburban, [b]Suburban differs from Urban, and [c]Urban differs from Rural.

in an activity longer than they had owned their land, the response was converted to the length of time that the property was owned. Questions that were contingent upon a previous question being answered, but that had not been answered, were converted to blank (i.e., no data) entries. In the cases where respondents were asked for only a single response to a categorical question, but filled in two blanks, we used a coin toss to decide the answer. We estimated the potential proportion of landowners involved in each activity across all landscapes by assuming that all nonrespondents did not participate in an activity (minimum estimate) and then assuming that they all did participate in an activity (maximum estimate).

We conducted all statistical analyses using SYSTAT 10 (SPSS 2000). Comparisons of the sociodemographic composition of all respondents across the three landscapes were conducted with analysis of variance (ANOVA), using a Tukey's HSD post-hoc test (Zar 1996), and contingency tables, using a Pearson Chi-square test. Specifically, comparisons of age, number of people in the household, education, size of house, and land parcel size were made with ANOVA, whereas comparisons of gender and occupation were made using one- and two-way contingency tables. The proportion of landowners engaged in each activity was compared across the three landscapes using a two-way contingency table with a Pearson Chi-square test. For bird feeding and housing, we analyzed the number, density, and time involved across the three landscapes with ANOVA, using a Tukey's HSD post-hoc test. To assess the relationships between participation in an activity with each of the others, a series of two-way contingency analyses were conducted, resulting in 21 pairwise comparisons. To compare the population of landowners involved in each activity (i.e., participants) against the population that was not involved (i.e., nonparticipants), in relation to age, number of people in the household, education, and house size, we used a two-tailed t-test. For comparisons between the two populations based on gender and occupation, a two-way contingency table was used. Data are reported as means ± SE (because 100% of the population was sampled, but only ~59% responded), unless otherwise noted, with a p-value of ≤ 0.05 considered significant.

Survey Response Rate

After removing ineligible responses (e.g., from a business rather than from a domestic landowner; from an individual who owned land outside the sampling region), nondeliverables, and multiple responses (e.g., from landowners who had already responded based on another parcel of land within the sampling region), the final population size of landowners was 1654. Among these 1654, we received 968 completed surveys, yielding a 58.5% response rate. Response rates in different landscapes were 64.8% for Rural (212 of 327), 61.5% for Suburban (233 of 379), and 55.2% for Urban (523 of 948), which were significantly different ($\chi^2 = 11.11$; df = 2; $p = 0.0039$).

Results

Landowner Sociodemographic Composition

The average respondent was 50.6 years old (range 13–93); average age, differed across the three landscapes ($F = 6.64$; df = 2, 927; $p = 0.0013$; Table 2), with Suburban respondents being older than Urban respondents ($p = 0.0021$). The average household size was 2.85 persons per household (range 0–8) and was the same across landscapes ($F = 0.33$; df = 2, 932; $p = 0.72$; Table 2). Overall, 53.3% of respondents were male and 46.7% were female, resulting in a greater proportion of

Table 3. Occupations of respondents across landscapes[a]

	Landscape		
	Rural	Suburban	Urban
Total number of respondents	201	220	483
Managerial and professional specialty	42 (20.9)	92 (41.8)	158 (32.7)
Technical, sales, administration support	30 (14.9)	23 (10.5)	77 (15.9)
Service	12 (6.0)	6 (2.7)	22 (4.6)
Farming, forestry, fishing	25 (12.4)	10 (4.5)	7 (1.4)
Precision production, craft, and repair	18 (9.0)	20 (9.1)	55 (11.4)
Operators, fabricators, laborers	23 (11.4)	7 (3.2)	50 (10.4)
Not employed	51 (25.4)	62 (28.2)	114 (23.6)

[a]The percent of respondents (based on proportion of column total) that worked in a given occupation within a route are indicated in parentheses. For information on delineation of occupations, see Methods.

male respondents ($\chi^2 = 4.12$; df = 1; $p = 0.042$). However, the gender difference disappeared when landscape was included in the analysis ($\chi^2 = 1.66$; df = 2; $p = 0.44$; Table 2). The average respondent had some college education, but no degree. Respondent education differed across the landscapes (F = 30.39; df = 2, 929; $p < 0.0001$), and among each pair of landscapes ($p < 0.001$), with Suburban respondents having achieved the highest educational levels and the Rural respondents having the least (Table 2). A total of 907 (95.2%) respondents had a house or residential structure on their land, with the average house size being between 1500 and 2000 ft^2 (139.4 and 185.9 m^2; Table 2). However, house size differed across the landscapes (F = 25.27; df = 2, 864; $p < 0.0001$), with Suburban homes being larger than both Urban ($p < 0.0001$) and Rural ($p < 0.0001$) homes. The average respondent's land parcel was 7.8 ha (range 0.0063–566.8), and differed across the landscapes (F = 14.41; df = 2, 936; $p < 0.0001$; Table 2), with Rural parcels being larger than Suburban ($p = 0.003$) and the Urban ($p < 0.0001$) parcels. Respondent occupation differed across the landscapes ($\chi^2 = 70.17$; df = 12; $p < 0.0001$) as evidenced by the drastic differences in proportions per occupation (Table 3).

Landowner Activities

A total of 635 (65.6%) landowners fed birds on their land, with 620 using at least one bird feeder, and the remaining 15 presumably putting food only on the ground. The percent that fed birds in each landscape was the same ($\chi^2 = 0.455$; df = 2, $p = 0.80$; Table 4). Of the landowners who fed birds the total number of bird feeders reported across all landscapes was 1845 (Table 4), ranging from 1 to 17.5 per parcel with a mean of 2.98 bird feeders per parcel, yielding a mean density of 5.78 bird feeders/ha. Both the number (F = 3.31; df = 2, 617; $p = 0.037$) and density (F = 16.89; df = 2, 599; $p < 0.0001$) of bird feeders differed across landscapes (Table 4), with the Urban landscape having marginally fewer feeders than the Rural landscape ($p = 0.06$) but having greater densities than either the Suburban ($p < 0.0001$) or Rural ($p < 0.0001$) landscapes. The average landowner fed birds 9.30 (N = 627) months a year, but this differed across the landscapes (F = 4.09; df = 2, 624; $p = 0.017$; Table 4), with Suburban landowners feeding fewer months than Urban landowners ($p = 0.012$). Furthermore, the average landowner had been feeding birds for 9.81 (N = 618) years (Table 4), which was similar across all landscapes (F = 1.65; df = 2, 615; $p = 0.19$). However, the proportional number of years spent bird feeding, relative to the number of years the landowner had owned or lived on their property, was 0.70 (N = 618), which differed across the landscapes (F = 4.12; df = 2, 615; $p = 0.017$), with landowners in Rural feeding for proportionally fewer years than landowners on the Urban ($p = 0.035$) and Suburban ($p = 0.021$) landscapes (Table 4). Bird feeding occurred with the greatest frequency during the winter months and the least during the summer months and showed a similar pattern across all three landscapes (Figure 2). Nearly all landowners (96.4%) who fed birds indicated that they will continue feeding birds in the future.

A total of 442 (45.7%) landowners had at least one bird house on their property, with the percent of landowners in each landscape showing a similar proportion of involvement ($\chi^2 = 2.732$; df = 2; $p = 0.26$; Table 4). Of the landowners who had bird houses, the total number of bird houses reported across all landscapes was 1660.5, ranging from 1 to 48 per parcel with a mean of 3.76 bird houses per parcel, yielding a mean density of 5.17 bird houses/ha (Table 4). Both the number (F = 8.02; df = 2, 439; $p = 0.0004$) and density (F = 5.33; df = 2, 429; $p = 0.0052$) of bird houses differed across the landscapes, with the Rural landowners having more bird houses than either the Urban ($p = 0.0002$) or the

Table 4. Landowner participation in providing bird feeders and houses across landscapes: values, except total number of bird feeders and houses, are means ± SE, with numbers in parentheses indicating the sample size

	Landscape			
	Rural	Suburban	Urban	Average
Total number of bird feeders	433	484.5	927.5	1,845
Percent of landowners feeding birds	64.6 (137 of 212)	67.4 (157 of 233)	65.2 (341 of 523)	65.6 (635 of 968)
Number of bird feeders per parcel	3.26 ± 0.20 (133)	3.15 ± 0.18 (154)	2.79 ± 0.10 (333)	2.98 ± 0.08 (620)
Density (no./ha) of bird feeders per parcel[b,c]	2.82 ± 0.57 (130)	2.58 ± 0.25 (152)	8.50 ± 0.90 (320)	5.78 ± 0.51 (602)
Months per year feeding birds[b]	9.27 ± 0.27 (135)	8.72 ± 0.26 (157)	9.58 ± 0.17 (335)	9.30 ± 0.13 (627)
Number of years feeding birds	9.29 ± 0.70 (133)	10.96 ± 0.75 (155)	9.48 ± 0.53 (330)	9.81 ± 0.37 (618)
Proportion of time feeding birds[a,c]	0.63 ± 0.03 (133)	0.73 ± 0.03 (155)	0.72 ± 0.02 (330)	0.70 ± 0.013 (618)
Total number of bird houses	493.5	440	727	1,660.5
Percent of landowners with bird houses	45.8 (97 of 212)	50.6 (118 of 233)	44.2 (231 of 523)	45.7 (442 of 968)
Number of bird houses per parcel[a,c]	5.09 ± 0.61 (97)	3.76 ± 0.32 (117)	3.19 ± 0.19 (228)	3.76 ± 0.19 (442)
Density (no./ha) of bird houses per parcel[b]	4.46 ± 0.95 (94)	2.30 ± 0.24 (116)	6.97 ± 1.11 (222)	5.17 ± 0.62 (432)
Number of years having bird houses	7.28 ± 0.70 (95)	9.20 ± 0.76 (115)	8.10 ± 0.60 (221)	8.21 ± 0.40 (431)
Proportion of time having bird houses[a,c]	0.53 ± 0.03 (95)	0.64 ± 0.03 (115)	0.64 ± 0.02 (221)	0.61 ± 0.02 (431)

Superscript letters represent significant differences between landscapes based on a Tukey HSD post-hoc test as follows: [a]Rural differs from Suburban, [b]Suburban differs from Urban, and [c]Urban differs from Rural.

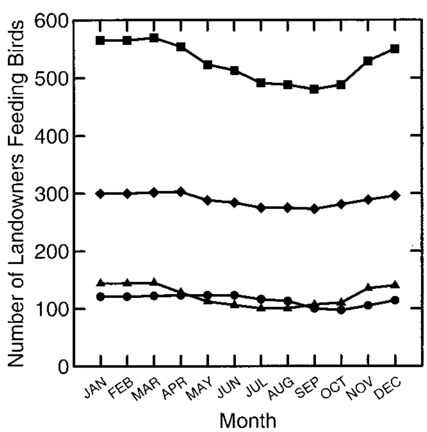

Figure 2. Number of landowners feeding birds each month. The landscapes are denoted as follows: Rural (●), Suburban (▲), Urban (♦), and the total of all routes (■).

Suburban landowners ($p = 0.036$), and the Urban landowners having a greater density than Suburban landowners ($p = 0.0038$). The average landowner had a bird house on their land for 8.21 (N = 431) years (Table 4), which was similar across all landscapes ($F = 1.45$; df = 2, 428; $p = 0.24$). However, the proportional number of years in which landowners had bird houses, relative to the number of years the landowner had owned or lived on their property, was 0.61 (N = 431), which differed across the landscapes ($F = 4.03$; df = 2, 428; $p = 0.018$), with Rural landowners having bird houses proportionally fewer years than Urban ($p = 0.019$) and Suburban ($p = 0.047$) landowners (Table 4). As with bird feeding, nearly all landowners (96.4%) who had bird houses on their property planned to continue having them.

A total of 529 (54.6%) respondents planted vegetation or maintained landscaping on their property in order to benefit or encourage use by birds. The proportion of landowners who planted or maintained vegetation on their property differed across the landscapes ($\chi^2 = 6.113$; df = 2; $p = 0.047$), because of the lower proportion in the Urban landscape (Table 5). Of the 529 respondents, 524 indicated that they planted at least one type of the following vegetation: fruit trees or bushes, ornamental shrubs or bushes, vines, or "other." Specifically, 69.1% planted fruit trees or bushes, 74.2% planted ornamental shrubs or bushes, 41.4% planted vines, and 39.9% planted "other" types of vegetation (Table 5). Across the landscapes, no difference existed in the frequency of planting fruit trees and bushes ($\chi^2 = 0.65$; df = 2; $p = 0.72$) or "other" types of vegetation ($\chi^2 = 1.99$; df = 2; $p = 0.37$), but there was a difference in frequency of planting both ornamental shrubs and bushes ($\chi^2 = 7.27$; df = 2; $p = 0.026$) and vines ($\chi^2 = 6.26$; df = 2; $p = 0.044$). Specifically, a greater proportion of Suburban landowners planted ornamental shrubs and bushes than Rural or Urban landowners (Table 5). In contrast, landowners along the Suburban landscape planted a lower proportion of vines than Rural or Urban landowners did (Table 5).

Table 5. Landowner participation in planting and maintaining vegetation for the benefit of birds across landscapes: the percent of landowners (based on proportion of column total) in each landscape who planted specific types of vegetation is listed with sample sizes in parentheses[a]

	Landscape			
	Rural	Suburban	Urban	Total
Number of landowners who planted vegetation or maintained landscaping for birds	127	135	267	529
Percent of landowners planting or maintaining vegetation for birds*	59.9	57.9	51.1	54.6
Number of landowners who planted specific types of vegetation	126	135	263	524
Fruit trees or bushes	68.3 (86)	71.9 (97)	68.1 (179)	69.1 (362)
Ornamental shrubs or bushes*	70.6 (89)	83.0 (112)	71.5 (188)	74.2 (389)
Vines*	46.8 (59)	32.6 (44)	43.3 (114)	41.4 (217)
Other	42.9 (54)	43.0 (58)	36.9 (97)	39.9 (209)

[a]Asterisks (*) represent significant differences in proportions across the landscapes based on a two-way contingency table.

Table 6. Landowner participation in gardening, landscaping, fertilizing, and applying pesticides or herbicides across landscapes; numbers are percent of landowners with sample sizes in parentheses[a]

	Landscape			
	Rural	Suburban	Urban	Total
Number of landowners carrying out an activity	196	224	492	912
Gardened	76.5 (150)	71.0 (159)	72.0 (354)	72.7 (663)
Landscaped	68.4 (134)	73.7 (165)	73.2 (360)	72.3 (659)
Fertilized	49.5 (97)	48.7 (109)	49.6 (244)	49.3 (450)
Applied pesticide or herbicide*	36.7 (72)	27.2 (61)	19.7 (97)	25.2 (230)

[a]Asterisks (*) represent significant differences in proportions across the landscapes based on a two-way contingency table.

Of 912 respondents who answered the question about gardening, landscaping, fertilizing, and spraying pesticides or herbicides, 861 (94.4%) carried out at least one of the activities. No difference existed across the landscapes in the frequency of landowners who gardened ($\chi^2 = 1.92$; df = 2; $p = 0.38$) landscaped ($\chi^2 = 1.90$; df = 2; $p = 0.39$), or fertilized ($\chi^2 = 0.06$; df = 2; $p = 0.97$; Table 6). However, there was a difference in the frequency of respondents who applied pesticides or herbicides across landscapes ($\chi^2 = 22.17$; df = 2; $p < 0.0001$), with the greatest frequency on the Rural and the least on the Urban (Table 6).

Overall, 912 (94.4%) landowners were engaged in at least one of the seven activities investigated, with the average landowner engaged in 3.73 ± 0.06 (Figure 3). No difference existed across the landscapes in the average number of activities ($F = 1.98$; df = 2, 965; $p = 0.14$).

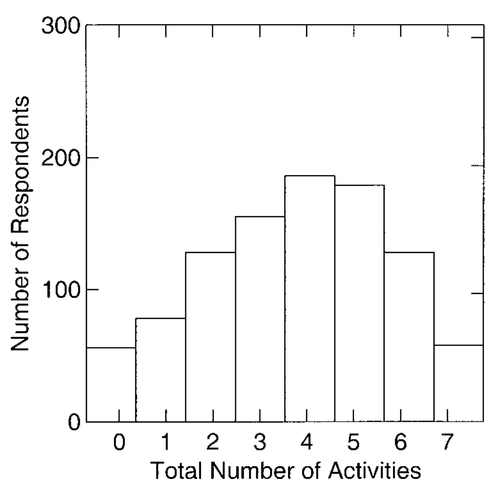

Figure 3. Total number of activities each landowner is engaged in by the number of respondents.

Correspondence Between Activities

There was a significant relationship between participation in each activity for 16 of the 21 possible activity pairings (Table 7). A high degree of overlap existed among all of the activities, with the notable exception that those who participated in feeding or housing of birds were no more or less likely than other landowners to apply fertilizer or pesticides. Among all pairwise

Table 7. Pairwise comparisons of landowner activities: values represent the percent of landowners who carried out both activities in combination, with sample sizes indicated in parentheses[a]

Activity	Feeding	Houses	Plant vegetation	Garden	Landscape	Fertilize	Pesticide
Feeding	—						
Houses	39.3 (948)*	—					
Plant vegetation	44.7 (948)*	33.2 (948)*	—				
Garden	55.1 (901)*	40.6 (900)*	49.0 (902)*	—			
Landscape	52.4 (901)*	37.8 (900)†	44.9 (902)*	55.0 (912)†	—		
Fertilize	34.7 (901)	24.8 (900)	30.8 (902)†	37.6 (912)†	40.1 (912)*	—	
Pesticide	18.2 (901)	12.9 (900)	16.3 (902)†	19.4 (912)	20.0 (912)†	20.8 (912)*	—

[a]Significant correlations between activities are indicated for $p < 0.05$ (†) and $p < 0.0001$ (*).

Table 8. Potential range (%) of landowners involved in each activity across all landscapes

Activity	Minimum	Maximum
Bird feeding	38.4	79.9
Bird houses	26.7	68.2
Plant or maintain vegetation	32.0	73.5
Garden	40.1	81.6
Landscape	39.8	81.3
Fertilize	27.2	68.7
Apply pesticides or herbicides	13.9	55.4

Minimum percent is based on the number of respondents carrying out a given activity divided by total survey sample size ($n = 1654$). Maximum percent is based on the number of respondents carrying out a given activity plus the number of nonrespondents ($n = 686$) divided by the total survey sample size.

comparisons, the percent of landowners who were involved in each pair of activities ranged from 12.9% to 55.1%.

Potential Range of Landowners Involved in Activities

The incorporation of nonrespondent landowners provides a potential range, similar to a confidence interval, of the proportion of all landowners involved in each activity across the three landscapes. Among all seven activities, the percent of landowners involved ranged from a minimum of 13.9% (applying pesticides and herbicides) to a maximum of 81.6% (gardening). However, with the exception of applying pesticides and herbicides, all activities were partaken in by more than one in four landowners (Table 8).

Comparison of Landowners Participating in Activities Versus Nonparticipants

Pooling landowners across all landscapes into two groups, those who participated in an activity and those who did not, we found differences in at least one sociodemographic difference for each of the seven activities measured. Specifically, the landowners who fed birds, provided bird houses, and planted or maintained vegetation were older than those who did not, whereas landowners who landscaped were younger than those who did not landscape (Table 9). The number of people living in the household differed only among landowners who landscaped, with those who landscaped having a greater number of people (Table 9). Gender differences were found between the two groups of landowners involved in bird feeding, planting or maintaining vegetation, and gardening. Specifically, the landowners involved in these three activities were more likely to be women (Table 9). Educational differences were found between the two groups of landowners for those involved in bird feeding, with landowners that fed being older than those that did not. House sizes differed between the two groups of landowners involved in landscaping and applying pesticides and herbicides, with landowners involved in these two activities having larger homes than those who did not (Table 9). Finally, occupational differences were found between the two groups of landowners for those who landscaped, fertilized, and applied pesticides and herbicides, based on differences in the percent who were farmers (Table 9).

Discussion

Of greatest note, our results highlight the fact that cumulatively across the landscape a large portion of landowners are both intentionally and unintentionally engaged in activities that can influence avian populations (~50% or more for several activities). Even taking a conservative approach, which assumes that only the landowners involved in at least one of the activities investigated responded to the survey (i.e., all nonrespondents were not engaged in any activity), the percent of landowners across the landscape engaged in an activity remains large (Table 8). On the other hand, taking a liberal approach, which assumes that every nonrespondent was engaged in each activity, the percent of landowners involved in any of the activities becomes extremely large. Although it is implausible

Table 9. Comparison of landowners participating in activities versus nonparticipants based on sociodemographic factors[a]

Activity	Factor	Participant	Nonparticipant	Statistic	df	*p*-value
Feeding	Age	51.7 ± 0.5	48.5 ± 0.8	3.401	918	0.0007
	People	2.9 ± 0.1	2.9 ± 0.1	−0.077	923	0.94
	Gender	63.1, 69.6	36.9, 30.4	4.37	1	0.037
	Education	3.4 ± 0.1	3.7 ± 0.1	−2.81	920	0.005
	House Size	3.2 ± 0.1	3.2 ± 0.1	−0.065	855	0.95
	Occupation	61.9, 71.1, 66.7, 66.7, 62.4, 64.6, 72.7	38.1, 28.9, 33.3, 33.3, 37.6, 35.4, 27.3	8.70	6	0.19
Houses	Age	52.3 ± 0.6	48.8 ± 0.6	3.999	915	0.0001
	People	2.8 ± 0.1	2.9 ± 0.1	−1.490	920	0.14
	Gender	44.2, 48.8	55.8, 51.2	1.99	1	0.16
	Education	3.5 ± 0.1	3.6 ± 0.1	−0.372	917	0.71
	House Size	3.3 ± 0.1	3.2 ± 0.1	0.514	853	0.61
	Occupation	45.3, 41.9, 53.8, 52.4, 46.7, 48.7, 50.0	54.7, 58.1, 46.2, 47.6, 53.3, 51.3, 50.0	3.82	6	0.70
Plant Vegetation	Age	51.7 ± 0.6	48.9 ± 0.7	3.159	916	0.0016
	People	2.8 ± 0.1	2.9 ± 0.1	−1.007	921	0.31
	Gender	51.4, 60.7	48.6, 39.3	8.00	1	0.0047
	Education	3.5 ± 0.1	3.5 ± 0.1	0.052	918	0.96
	House Size	3.2 ± 0.1	3.2 ± 0.1	−0.196	854	0.84
	Occupation	57.6, 57.7, 59.0, 64.3, 53.8, 48.1, 53.8	42.4, 42.3, 41.0, 35.7, 46.2, 51.9, 46.2	4.37	6	0.63
Garden	Age	50.9 ± 0.5	49.1 ± 0.9	1.802	881	0.072
	People	2.9 ± 0.1	2.8 ± 0.1	1.358	883	0.17
	Gender	68.3, 77.9	31.7, 22.1	10.16	1	0.0014
	Education	3.5 ± 0.1	3.6 ± 0.1	−0.826	881	0.41
	House-Size	3.3 ± 0.1	3.3 ± 0.1	−0.064	824	0.95
	Occupation	71.6, 68.6, 76.9, 73.2, 68.6, 67.6, 79.7	28.4, 31.4, 23.1, 26.8, 31.4, 32.4, 20.3	8.53	6	0.20
Landscape	Age	49.1 ± 0.5	54.1 ± 0.9	−4.961	881	0.0001
	People	2.9 ± 0.1	2.7 ± 0.1	2.486	883	0.013
	Gender	70.0, 74.9	30.0, 25.1	2.70	1	0.10
	Education	3.6 ± 0.1	3.4 ± 0.1	1.915	881	0.056
	House Size	3.4 ± 0.1	2.9 ± 0.1	4.505	824	< 0.0001
	Occupation	76.2, 81.8, 71.8, 51.2, 77.9, 70.3, 64.2	23.8, 18.2, 28.2, 48.8, 22.1, 29.7, 35.8	25.28	6	0.0003
Fertilize	Age	50.4 ± 0.63	50.4 ± 0.64	−0.210	881	0.83
	People	2.9 ± 0.07	2.8 ± 0.07	1.584	883	0.11
	Gender	51.2, 48.2	48.8, 51.8	0.79	1	0.38
	Education	3.5 ± 0.1	3.6 ± 0.1	−0.243	881	0.81
	House Size	3.3 ± 0.1	3.2 ± 0.1	1.260	824	0.21
	Occupation	48.6, 52.9, 51.3, 75.6, 44.2, 50.0, 48.6	51.4, 47.1, 48.7, 24.4, 55.8, 50.0, 51.4	12.72	6	0.048
Pesticide	Age	51.4 ± 0.9	50.1 ± 0.5	1.256	881	0.21
	People	2.9 ± 0.09	2.8 ± 0.1	0.985	883	0.32
	Gender	25.8, 25.1	74.2, 74.9	0.06	1	0.80
	Education	3.6 ± 0.1	3.5 ± 0.1	1.067	881	0.29
	House Size	3.5 ± 0.1	3.2 ± 0.1	2.716	824	0.0067
	Occupation	26.6, 21.5, 25.6, 63.4, 20.9, 18.9, 25.5	73.4, 78.5, 74.4, 36.6, 79.1, 81.1, 74.5	34.20	6	< 0.0001

[a]Sociodemographic factors analyzed are: age of respondent (Age), number of people in the household (People), gender of the respondent (Gender), educational level of the respondent (Education), house size (House Size), and occupation of the respondent (Occupation). For Age, People, Education, and House Size, values are means ± SE and presented with a *t*-value for the Statistic. For Gender, values represent the percent male and female, whereas for Occupation they represent the percent (1) Managerial and Professional, Specialty, (2) Technical, Sales, Administration Support, (3) Service, (4) Farming, Forestry, Fishing, (5) Precision Production, Craft, and Repair, (6) Operators, Fabricators, and Laborers, and (7) Not Employed (see Table 3) and presented with a χ^2-value for the Statistic. Education is a categorical response from 1 to 6 (see Table 1), with a higher number indicating a higher level of education. Similarly, house size was a categorical response from 1 to 7 (see Table 1), with a higher number indicating greater amount of living area.

that all nonrespondents are engaged in each of the activities, it is also unlikely that all nonrespondents were nonparticipants in these activities. As a result, the actual percent of landowners engaged in each activity as reported here should fall within the range of conservative and liberal estimates.

Specific Activities

Although past studies related to bird feeding have investigated the frequency of feeder use by a species (Brittingham and Temple 1989), how long it takes birds to find a feeder (Wilson 2001), the role they play in disease transmission (Brittingham and Temple 1986), the degree to which they facilitate predation (Dunn and Tessaglia 1994, Giesbrecht and Ankney 1998), and the economics of bird feeding (Wiedner and Kerlinger 1990), there has existed only a vague knowledge of what percent of landowners are involved in bird feeding or the density of bird feeders (U.S. Department of the Interior and others 1997, 2002). Moreover, most previous attempts at discerning aspects of bird feeding through survey methodologies have focused only on birders and ornithologists, not the average landowner. Thus, our finding that two out of three landowners were engaged in feeding birds on their land not only provides concrete data on the proportion of the landowners who have bird feeders, but also the density of feeders as well. In terms of temporal feeding patterns, our finding that landowners feed an average of 9 of 12 months a year is greater than the national average reported by the USFWS (U.S. Department of the Interior and others 1997). However, the observation that most bird feeding is done in the winter months mirrors that of other studies (Cowie and Hinsley 1988). As our findings suggest, the proportion of landowners who are involved or potentially involved (Table 7) in bird feeding, coupled with the density of feeders and length of time the feeders have been present (Table 4), may be great enough at the landscape scale to positively affect species that either are obligate seed foragers (i.e., granivores), such as Northern Cardinals (*Richmondena cardinalis*), or can use seed in their diet (e.g., some omnivores), such as Blue Jays (*Cyanocitta cristata*), or that can forage on other foods provided by landowners (e.g., suet, nectar), such as woodpeckers and tanagers. Such positive effects have been noted by increased survival of Carolina Chickadees (*Poecile carolinensis*) and Black-capped Chickadees (*Poecile atricapillus*) during the winter in the Midwest (Brittingham and Temple 1988, Doherty and Grubb 2002). Ultimately, the findings highlight the point that bird feeding is a long-term and continuous activity that results in the landscape being covered with easily accessible, energy-dense sources of food for birds. However, the degree to which such levels of feeding translates into higher survival rates and population numbers for species that can utilize them remains to be quantified.

Providing bird houses is akin to providing bird feeders in that it helps to promote species visitation and habitation on one's property. Thus, just as with bird feeding, there exist many gray literature (i.e., not peer-reviewed) sources that promote the use of bird houses. In fact, bird houses are known to be used by nearly 50 bird species in North America (Payne and Bryant 1994). Thus, our finding that nearly half of the landowners had bird houses on their land is important for cavity nesting birds, especially in urban and suburban areas where cavities are in short supply, because they might aid breeding pairs of birds. Moreover, bird houses may be of particular importance for cavity nesters that are relatively rare (e.g., owls), if they can use them. Although our survey did not evaluate whether or not each bird house was being used each year, the high densities, especially in the Urban landscape (Table 4), coupled with their long-term presence suggests that bird houses are likely to be at least aiding in the presence and survival of some species.

Although an abundant amount of gray literature exists that encourages and/or explains the importance of planting and maintaining vegetation to attract birds (Sargent and Carter 1999, Tufts and Loewer 1995), relatively few estimates exist of the number of landowners who actually carry out these activities. The closest estimate is from the 2001 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, which found that approximately 14% of the individuals it surveyed maintained vegetation around their home for the benefit of wildlife (U.S. Department of the Interior and others 2002). Taking the minimum estimate of landowners in our survey who planted or maintained vegetation for birds to be 32% (Table 8), our findings are more than double the previous estimate. Notably, however, comparing individuals and "wildlife" from the USFWS survey with landowners and birds from our survey is tenuous because they are not exact synonyms. Furthermore, landowners in Southeast Michigan may be quite different from the average national respondent. It should also be noted that our survey did not measure how much of one's land is managed for birds. As a result, landowners who manage only a very small portion of their land for birds are weighted equally with landowners who manage all of their land for birds. Thus, for example, the nearly 55% of landowners in our sample who planted or maintained vegetation for the benefit of birds could potentially include landowners who planted a single tree with those who have an entire parcel devoted to birds.

Given the large portion of landowners engaged in planting or maintaining vegetation for birds, it is also essential to note what types of plants landowners may be encouraging on their property. In particular, if landowners are actively planting or maintaining vegetation for birds that is exotic, which includes many ornamentals, they could alter the breeding success of certain bird species (Schmidt and Whelan 1999). Aside from influencing the breeding success, birds can directly facilitate the dispersal of exotic species by consuming fruits or seeds and defecating or regurgitating them elsewhere (Hutchinson and Vankat 1998), thus facilitating the spread of exotic species across the landscape as is occurring with Autumn-olive (*Elaeagnus umbellata;* K. Winnett-Murray, personal communication). Thus, although our survey only broke categories down into vines, fruit-bearing plants, ornamentals, and "other," and not exotic versus native, it could be that a large portion of the landowners who planted vegetation did plant exotic species.

Although gardening and landscaping may be viewed as similar to planting and maintaining vegetation for birds, they are inherently different activities. Furthermore, we specifically framed the question about planting vegetation and maintaining landscaping with reference to birds, whereas the questions regarding gardening and landscaping were not specifically addressed with reference to birds. A difference was evident by the fact that less than 50% of landowners either gardened or landscaped in conjunction with planting and maintaining vegetation for the benefit of birds (Table 7). Although gardening and landscaping can be used to promote bird habitat (Terres 1953, Sargent and Carter 1999), that does not mean that they may not also cause reductions in habitat for some species, either through competition or simply because only certain species can use the habitat. Whether gardening is beneficial or detrimental to birds overall is unknown, but our data indicate that regardless of its influence, it is a prevalent activity.

Fertilizer use can have both positive and negative impacts on bird species. Specifically, fertilizing can change the vegetation structure markedly, which affects nesting locations for grassland birds (see Vickery and others 2001 for review), whereby some species gain preferred habitat and other species lose it. Similarly, some types of fertilizer, such as manure, can increase bird abundances by increasing the soil-dwelling invertebrates, whereas inorganic fertilizer can cause decreases in both seed availability and soil invertebrates (Vickery and others 2001). Although half of the landowners (Table 6) applied fertilizer to their property, we did not ascertain the type of fertilizer used, the frequency of input, how much was applied, or where it was applied on the property. Regardless, the fact remains that a large portion of landowners are applying fertilizer to their land, which may directly or indirectly influence bird species.

Since Rachel Carson's seminal work *Silent Spring* (Carson 1962), a large body of research has been assembled that identifies negative effects of pesticides on birds. Although a number of detrimental chemicals (e.g., chlordane, DDT, etc.) have been phased out of use, many remain in use that have displayed direct effects on the growth and development of birds (Bishop and others 2000). Moreover, even if pesticides and herbicides display no effects on the birds themselves, they often have the indirect effect of reducing food availability (Pinowski and others 1994, Newton 1995). Thus, our finding that one in four landowners applied pesticides or herbicides to their land, reflecting somewhere between 14% to 55% (Table 8) of the landowners, could represent a wide range of the total landscape that may be unsuitable or less suitable as bird habitat, depending on what proportion of the land is treated. However, because we did not ascertain the type of pesticides and herbicides used, the frequency of input, how much was applied, or where it was applied on the property, it is not possible to estimate what percent of the landscape is truly degraded. Even with these caveats, it is important to note that pesticides and herbicides were most common along the Rural landscape and among landowners who are primarily farmers, who have larger land parcels. As a result, many potential habitat locations on farms or in rural landscapes may be less suitable than indicated through either land cover maps (Rutledge 2001) or parcel size information.

In addition to the seven landowner activities measured here, we previously found that 26.1% of the same landowners surveyed had house cats that were allowed outdoors (Lepczyk and others 2004). Considering the activity of allowing cats outdoors in conjunction with the other seven activities results in a total of 95% landowner participation in at least one of the activities, with the average landowner engaged in four. In addition, because the majority of these activities are correlated with one another (Table 7), there may be synergistic effects of the combined activities on birds. Of course, we should note that almost every activity we measured can have both positive and negative effects on the overall avian community and ecosystem. For instance, feeding birds may positively influence granivorous and omnivorous bird species by increasing their densities or

Table 10. Comparison of landowners involved in a given activity versus those not involved based upon selected sociodemographic factors[a]

	Sociodemographic factors					
Activity	Age of respondent	No. of people in house	Gender of respondent	Education of respondent	House size	Occupation of respondent
Bird feeding	√		√	√		
Provide bird houses	√					
Plant or maintain vegetation	√		√			
Garden			√			
Landscape	√	√			√	√
Apply fertilizer						√
Apply pesticides or herbicides					√	√

[a]A check mark indicates a significant difference was observed between the two groups.

survival, which could reduce the relative abundance and community composition of other species in the area through competition for nest sites, etc.

Differences in Activities Across Landscapes

Results from the three landscapes indicates that there is a marked difference across the rural-to-urban continuum. Specifically, landowners in the Rural landscape had the highest number of bird feeders and houses as well as showed the greatest propensity to plant or maintain vegetation for birds and to use pesticides and herbicides (Tables 4, 5, 6). On the other hand, Rural landowners had bird houses on their property for the shortest amount of time. Rural landowners are influencing their land in such a way as to encourage bird habitation, but are using chemical inputs that may have a counteracting effect.

Landowners living in the Suburban landscape have been involved in providing bird food and houses the longest (or similarly as long), both in absolute and proportional terms, as well as showed the greatest propensity to plant ornamental vegetation (Tables 4 and 5). However, they had the lowest densities of bird feeders and houses, spent the fewest months feeding per year, and planted the least amount of vines (Tables 4 and 5). These results indicate that Suburban landowners have participated in activities for a long period, but that their actual level of involvement in each activity is relatively low.

In the case of Urban landowners, they had the greatest density of bird feeders and houses, spent the most months feeding birds, and had bird houses as long as the Suburban landowners did (Table 4). On the other hand, Urban landowners had the lowest number of bird feeders and houses, planted or maintained vegetation for birds the least, and had the lowest pesticide and herbicide application (Tables 4, 5, 6). Although the numbers of feeders and houses were lower, they were at the highest densities. This high density was because of the small parcel sizes of the Urban landscape, which ultimately translates into a greater number of bird feeders. Coupled with the high density of supplementation is the fact that Urban landowners used the lowest amount of pesticides and herbicides, which together could result in more highly suitable habitat for certain bird species. Taken together, the differences in activities across the three landscapes may provide additional factors that can partially explain the differences in bird abundances and diversity often noted along urban-to-rural gradients or in urban contexts, such as the increase in bird densities and decrease in species richness from rural to urban areas (e.g., Emlen 1974, Hohtola 1978, Cam and others 2000).

Comparison of Landowners Participating in Activities Versus Nonparticipants

Although a number of differences were found between landowners who carried out a given activity and those who did not, there was no consistent trend or factor that explained the differences across all activities (Table 10). For example, although a significant difference in age was found for four of the activities, the landowners engaged in them were not always significantly older. However, our finding that landowners involved in bird feeding, providing bird houses, and planting and maintaining vegetation for birds were older than nonparticipants mirrors that of the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior and others 1997). Besides the lack of consistent sociodemographic factors that could explain the activities, it is also important to note the fact that most of the activities had only one or two sociodemographic variables that resulted in a difference (Table 10). The lack of general trends among sociodemographic factors across the different activities is not an unusual finding, given the wide range of activities investigated. Finally, although differences were found in sociodemographic factors between the two groups of landowners, the differences do not necessarily translate into biologically meaningful differences. For example, although landowners who fed birds were older than those who did not, the difference between the groups in average age was only 3 years, which may not be overly meaningful in terms of its effects on birds.

Conclusion

Our research has highlighted some important elements of how landowner decisions could impact bird communities. The overall implications of our findings are that individual landowners are engaged in a multitude of activities, which when taken collectively may have both positive and negative repercussions for avian species in particular and wildlife in general. The question remains, however, as to which species populations, at the regional level, are most affected by cumulative lot (i.e., land parcel) level decisions by humans. First, do differences in landowner activities across landscapes translate into differences in bird abundances and diversity? Second, do landowner activities act synergistically with one another? Third, how responsive are landowners to altering their activities in order to aid in the management of avian communities? Fourth, what are the factors that motivate landowners to carry out specific activities?

Although the levels of activities varied across the landscapes, they were carried out on all landscapes and are not particularly unique to Southeastern Michigan, the Midwest, or the United States. In other words, although the magnitude of the activities and their level of influence on birds may differ over geographic regions, our findings are relevant to the ~66% of the United States land that is in private ownership (Dale and others 2000) as well as any location where there is a large private land component. In particular, our findings are relevant to agencies and organizations that interact or work with private landowners because they point to the fact that people are indeed influencing bird habitat and that this can be improved upon or managed in order to have positive effects on bird populations.

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