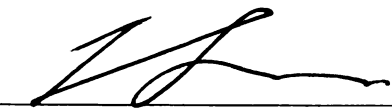


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EFFECTS OF HUMAN ACTIVITIES ON BIRDS ACROSS
LANDSCAPES IN THE MIDWEST

By

Christopher Andrew Lepczyk

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
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2002

ABSTRACT

EFFECTS OF HUMAN ACTIVITIES ON BIRDS ACROSS LANDSCAPES IN THE MIDWEST

By

Christopher Andrew Lepczyk

Fluctuations of bird abundances in the Midwestern U.S. have been attributed to such factors as supplemental feeding, landscape change, habitat fragmentation, and depredation. A common underlying aspect of these and other factors that may be responsible for influencing bird abundances is the role of private landowners that live in the landscapes being investigated. Because private landowners are the ultimate controllers of their land, they may be carrying out a variety of actions that could, if taken cumulatively across large areas and over time, influence bird abundances and distributions. Taking an interdisciplinary approach towards understanding the role of private landowners on birds, the main objectives of the study were to: 1) Discern the role of landowners' activities and perceptions towards birds on a selected group of three landscapes; 2) Test for differences in activities and perceptions across the rural-to-urban gradient comprising the three landscapes; 3) aggregate results to the landscape level and, 4) Examine if the relative abundance and diversity of bird species across landscapes was related to landowner activities and human influences.

To address objectives 1 through 3 I surveyed all ~1,700 private landowners living in three landscapes in Southeastern Michigan, where >90% of land is privately owned. The three landscapes represent urban, suburban, and rural landscapes based on their geographic locations, average land parcel sizes, and socio-demographic compositions. For the final objective I analyzed 402 landscapes across the entire Midwest.

Of the 969 landowners that responded (58.5% response rate), 920 (95%) carried out at least one activity (of eight measured) on their land that can have a potential impact on birds, with the average landowner carrying out four. Collectively, 66% of landowners fed birds, 46% provided bird houses, 26% had outdoor cats, 55% planted or maintained vegetation explicitly for birds, 49% applied fertilizer, 73% gardened, 72% landscaped, and 25% applied pesticides or herbicides. The number/landowner of bird feeders, bird houses, and outdoor cats was greatest in the rural landscape and least in the urban. However, densities (#/ha) of feeders, houses, and cats showed an inverse trend, with the greatest densities occurring in the urban landscape. In terms of perceptions, the typical landowner indicated that the number of birds had increased over time and that having bird diversity on their property was very important, but that they were only slightly willing to change their land use for the benefit of birds. Across the three landscapes there were significant differences in both the proportion and the magnitude of landowner activities as well as landowner perceptions towards birds. Aggregating all landowners across the landscapes indicates that a minimum of 25% to 40% of the landowners were involved in each of the eight activities.

Across all Midwest landscapes there was a negative relationship between avian diversity and (1) the number of housing units and (2) the amount of anthropogenic land cover. Most bird species investigated displayed significant relationships with the level of human influence on the landscape. However no relationships existed based on the natural history classifications of diet and nest. Overall, the results reinforce the need to include human activities in the conservation, management, and research of birds across landscapes, while at the same time providing a significant contribution towards the integration of socioeconomic and ecological research.

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In memory of Eric Wynn Cox (1969-1999), wildlife ecologist, naturalist, and friend.

PREFACE

The research which comprises this dissertation is the culmination of nearly six years of work, thought, and discussions about how people, wildlife, socioeconomics, and landscape ecology, are all interrelated. During this time I explored many avenues of inquiry, seeking to better understand how people influence the world around them. As with all research, some of these avenues were dead ends, while others were a bounty of reward. By the end of my studies all of these avenues had not only provided me with many new perspectives, but had provided many new and unique opportunities, which I feel extremely fortunate to have partaken in while here at Michigan State University.

In many ways a dissertation can be likened to standing on the shoulders of giants. The work and research which I undertook could not have been completed without countless years of ecological research prior to my endeavors, nor could it have been completed without the assistance of a great many people. First of all, I would like to extend my gratitude to all of the administrative staff both in the Department of Fisheries and Wildlife and in the Program for Ecology, Evolutionary Biology, and Behavior. In particular I am especially grateful to Jane Thompson, Julie Traver, Jim Brown, and Pat Ressler. Without the assistance of Jane and Julie the entire process could not have run so smoothly. I would also like to extend my thanks to Dan Brown, Kay Gross, Nan Johnson, and Pat Soranno, who served as members of my doctoral committee. These four individuals provided critical feedback on my work and offered many interesting insights on the research, for which I am thankful. One additional individual who served as an

unofficial committee member (i.e., the fifth Beetle if you will) and statistical consultant was Angela Mertig. Aside from her coauthor duties, Angie spent a great deal of time discussing research, the philosophy of science, and what it means to lead a collegial and intellectual life, which all too often are missing from the formal graduate education. Of course, little could have been accomplished without the assistance of my major advisor, Jianguo (Jack) Liu. Many years ago Jack took a chance by allowing me to switch from my previous research track in physiological ecology to landscape ecology. Not only did Jack allow me to pursue new directions, but he has always provided many unique opportunities to interact with colleagues and attend a number of scientific meetings. Finally, Jack provided a completely different view of research and academics than my previous experiences, which has helped to shape my thinking about teaching, research, and academics as a whole.

Two people that deserve particular mention during my years at MSU are Daniel Rutledge and Marc Linderman. When I first arrived at MSU I would scarcely have believed that Daniel would be one of the most important people I would meet. Not only was Daniel a great friend and weight lifting partner, but he was one of the most creative and insightful scientists I met in graduate school (or elsewhere). I look forward to many years of interesting work and friendship beyond those spent at MSU. Similarly, Marc was more help than he'll ever know in regards to remote sensing and GIS questions. But it was Marc's wide interests and desire for intellectual discourse that I appreciated most. To Daniel and Marc, thanks for the many years of great discussions and your friendship.

One person who arrived late in my tenure at MSU, but helped see me through the end of my dissertation was Rebecca Christoffel. Rebecca has been a great friend since I

met her as a Masters student at the University of Wisconsin and is one of the sharpest naturalist and broadest thinkers I met during that time. Thanks for everything all of these years!

Over the course of my time in Jack's lab there were many other graduate students, faculty members, and labmates that deserve specific mention. These people were not just colleagues, but many were good friends. In Jack's lab these people included Li An, Amanda McDonald, Ed Laurent, Jialong Xie, Kiersten Kress, Scott Bearer, Kim Hall, and Anita Morzillo. Others in both the Fisheries and Wildlife Department and the EEBB program include Robert Holsman, Peter Bull, Sam Riffell, Paul Keenlance, Joe Gathman, Kristen Genet, Laura Granack, Meera Iyer, Rich Kobe, and Mike Walters.

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I could not have pursued a number of interesting avenues with my research without the support of a United States Environmental Protection Agency Science To Achieve Results (STAR) Graduate Fellowship (Grant no. U-91580101-0) and the original financial contributions provided by a Michigan Agricultural Experiment Station grant and a Michigan State University College of Social Science Grant to J. Liu, A. Mertig, and P. Soranno, and an N.S.F. CAREER Award to J. Liu. In addition I wish to acknowledge the

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Beyond those individuals directly involved in my doctoral research, I owe a great debt of gratitude to many teachers, professors, and colleagues that I met over the years who helped shape my thinking and views. These people include Boyd Wilson, Ed Hansen, Al Kniss, Peter Arcese, Scott McWilliams, Bill Karasov, Greg and Kathy Murray, and Eugene Odum. In each of your own ways you helped to foster my intellectual development and curiosity.

In closing there remains one final group of individuals to whom I count on for their love, support, and friendship. First, my wife Jean, who has provided a listening ear when I have a down day, has been ceaseless in her endeavors to educate me about birds, animals, and plants, and has given more of herself over the years than I can ever repay. Second, to my brothers Peter and Tim, whom I can always count on for an evening of

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TABLE OF CONTENTS

LIST OF TABLES.....	xii
LIST OF FIGURES.....	xiv
INTRODUCTION.....	1
CHAPTER 1	
LANDOWNERS AND CAT PREDATION ACROSS RURAL-TO-URBAN	
LANDSCAPES.....	7
Abstract.....	8
Introduction.....	9
Methods.....	13
Results.....	19
Discussion.....	22
Acknowledgments.....	28
References.....	29
Figure Legends.....	41
CHAPTER 2	
ASSESSING LANDOWNER ACTIVITIES THAT INFLUENCE BIRDS	
ACROSS RURAL-TO-URBAN LANDSCAPES.....	45
Abstract.....	46
Introduction.....	48
Methods.....	53
Results.....	59
Landowner Socio-demographic Composition.....	59
Landowner Activities.....	60
Correspondence Between Activities.....	63
Comparison of Landowners Participating in Activities Versus	
Non-Participants.....	63
Discussion.....	69
Specific Activities.....	70
Differences in Activities Across Landscapes.....	75
Hypotheses Tested.....	77
Comparison of Landowners Participating in Activities versus Nonparticipants....	78
Conclusion.....	78
Acknowledgments.....	79
Literature Cited.....	80
Figure Legends.....	97

CHAPTER 3	
LANDOWNER PERCEPTIONS AND ACTIVITIES RELATED TO BIRDS	
ACROSS RURAL-TO-URBAN LANDSCAPES.....	105
Abstract.....	106
Introduction.....	108
Methods.....	110
Results.....	113
Discussion.....	116
Acknowledgments.....	119
References.....	119
Figure Legends.....	123
CHAPTER 4	
BIRD DIVERSITY ACROSS A LANDSCAPE: INTEGRATING AND	
COMPARING PUBLISHED DATA WITH LANDOWNER OBSERVATIONS.....	126
Abstract.....	127
Introduction.....	128
Methods.....	129
Results.....	132
Discussion.....	133
Acknowledgments.....	135
Literature Cited.....	136
CHAPTER 5	
THE HUMAN INFLUENCE ON BIRDS ACROSS LANDSCAPES.....	
Abstract.....	157
Introduction.....	158
Methods.....	160
Breeding Bird Survey.....	164
Species Selection.....	164
Land Cover and Housing Data.....	165
Landscape Analysis.....	165
Statistical Analysis of Breeding Bird Data Across the Landscapes.....	166
Results.....	167
Discussion.....	169
Acknowledgments.....	171
Literature Cited.....	175
Figure Legends.....	176
SYNTHESIS AND CONCLUSIONS.....	188
APPENDIX A	
LANDOWNER SURVEY.....	201

APPENDIX B
EXAMPLE OF SURVEY COVER LETTER TO LANDOWNER.....210

APPENDIX C
POST CARD NOTIFICATION TO LANDOWNER.....212

APPENDIX D
EXAMPLE OF SECOND SURVEY COVER LETTER TO LANDOWNER.....214

BIBLIOGRAPHY216

LIST OF TABLES

Table 1.1	Summary information for free-ranging cat owners by landscape.....	35
Table 1.2	Predation rates for free-ranging cat owners by landscape.....	36
Table 1.3	Landscape level results of the proportional range of landowners allowing cats outdoors, the number of possible cats that are predatory, the density per linear kilometer of predatory cats, and the total number of birds killed under differing estimation procedures.....	37
Table 1.4	Bird species reported to be depredated by outdoor cats and the number of different respondents identifying each species.....	39
Table 1.5	Age and education of free-ranging cat owners by landscape.....	40
Table 2.1	Summary statistics of socio-demographic information by landscape.....	89
Table 2.2	Occupations of respondents by landscape.....	90
Table 2.3	Time engaged in providing bird feed and houses by landscape.....	91
Table 2.4	Number of landowners in each landscape that planted specific types of vegetation.....	92
Table 2.5	Number and percent of landowners involved in gardening, landscaping, fertilizing, and applying herbicides or pesticides.....	93
Table 2.6	Percent of landowners that carried out each activity in combination.....	94
Table 2.7	Minimum and maximum percent of landowners across all landscapes engaged in each activity.....	95
Table 2.8	Comparison of landowners involved in a given activity versus those not involved based upon selected socio-demographic factors.....	96
Table 3.1	Landowner perceptions and attitudes across landscapes.....	121
Table 3.2	Percent of landowners involved in each activity across landscapes.....	122
Table 4.1	All possible species, as denoted by different survey methods.....	138
Table 4.2	Comparison of all surveys with all possible combinations.....	156

Table 5.1	Bird species selected for population trend analysis.....	181
Table 5.2	NLCD land cover classes.....	182
Table 5.3	Descriptive statistics of anthropogenic land cover and housing in the landscapes encompassing the 402 BBS routes.....	183
Table 5.4	Regression analysis of proportion of individuals occupying a landscape relative to the total number of housing units.....	184
Table 5.5	Regression analysis of proportion of individuals occupying a landscape relative to total amount of anthropogenic land cover.....	185
Table 5.6	Multiple regression analysis of proportion of individuals occupying a landscape relative to both the total amount of anthropogenic land cover and the total number of housing units.....	186
Table 5.7	Route-regression analyses of all BBS routes across the Midwest region.....	187

LIST OF FIGURES

Figure 1.1	Location of the three study landscapes in Southeastern Michigan.....	42
Figure 1.2	Frequency distribution of the number of cats reported to be allowed outdoors per landowner.....	43
Figure 1.3	Number of bird feeders per landowner versus number of birds depredated per week per cat.....	44
Figure 2.1	Location of the three study landscapes in Southeastern Michigan.....	98
Figure 2.2	Frequency distribution of the number of bird feeders per landowner for landowners that fed birds.....	99
Figure 2.3	Number (A) and density (B) of bird feeders across the three landscapes among landowners that fed birds.....	100
Figure 2.4	Number of landowners feeding birds each month.....	101
Figure 2.5	Frequency distribution of the number of bird houses per landowner for landowners that had bird houses.....	102
Figure 2.6	Number (A) and density (B) of bird houses across the three different landscapes among landowners that had bird houses.....	103
Figure 2.7	Number of activities each landowner is engaged in versus the number of respondents.....	104
Figure 3.1	Locations of the three landscapes (each 39.4 km) in southeast Michigan, USA, where the survey was conducted.....	124
Figure 3.2	The importance of bird diversity versus the number of activities landowners engage in.....	125
Figure 5.1	Locations of all 402 Breeding Bird Survey (BBS) routes across the Midwest United States.....	189
Figure 5.2	Total bird diversity (# of species) versus the total number of housing units.....	190
Figure 5.3	Total bird diversity (# of species) versus anthropogenic land cover.....	191

Figure 5.4	Proportion of individuals occupying each landscape versus the total number of housing units for each of the twelve species.....	192
Figure 5.5	Proportion of individuals occupying each landscape versus the total amount of anthropogenic land cover for each of the twelve species.....	193

INTRODUCTION

Ecologists have long recognized that human beings directly and indirectly influence the ecosystems and landscapes that surround them (Leopold 1949, Odum 1959). However, it was not until the latter portion of the twentieth century that ecologists had begun to quantify the degree to which humans were influencing the world's ecosystems and landscapes (Vitousek et al. 1986, Vitousek et al. 1997, Pimm 2001). With this increased accounting came an increased awareness that detailed information on how humans interact and influence the different ecosystems and landscapes was urgently needed. Because of this need, there has been a substantial increase in interdisciplinary ecological research that incorporates socioeconomics, human demography, and human dimensions techniques (Liu 2001), as well as designating long-term ecological research sites in urban locations (Parlange 1998) to understand the interrelationship between humans and landscapes. This dissertation is one such attempt to add a piece of knowledge towards our understanding of how humans influence landscapes.

Throughout the world, one group of species that has experienced a host of responses to human influences across a multitude of ecosystems and landscapes is birds. From extinction (Pimm 2001), to population increases, to slow population declines, nearly all bird species displaying these phenomena have some relationship to human influence. Within the United States bird populations have experienced marked declines and fluctuations during the past 30 years. In fact, current estimates indicate that over 25% (204) of the bird species in the United States have declining populations (Audubon 2002). These population declines have been attributed to a host of interrelated factors,

including habitat fragmentation and loss (Robbins et al. 1989, Fahrig 1997, Askins 2000, Donovan and Flather 2002), nest predation (see Heske et al. 2001 for review), cowbird parasitization (Robinson et al. 1995), and increased mortality on their wintering-grounds (Rappole and McDonald 1994, Basili and Temple 1999). However, while many bird species are experiencing population declines, a number of other bird species are displaying large population increases. For instance, in Michigan the American Crow (Corvus brachyrhynchos) has been exhibiting a significant increase of nearly 2% per year over the past twenty years (Sauer et al. 2001). Along similar lines of reasoning for population declines, there are a number of interrelated factors responsible for these increases, including supplemental feeding and housing (Brittingham and Temple 1988, Doherty and Grubb 2002), and increased amount of edge habitat. Although both population increases and decreases have been attributed to a wide number of proximate causes, in most cases the underlying ultimate influence is humans.

Although more than 65% of the land in the United States (Dale et al. 2000), and 90% in Southern Michigan, is in private ownership, one overlooked cause of human influence on birds and their ecosystems is the private landowner. More 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. Hence, the major goal of this dissertation was to begin to address how landowners influence birds through their activities across landscapes and to utilize the findings to make predictions about bird species across different landscapes. To investigate this goal, the primary objectives of the research were to:

- 1) Discern the role of landowners' activities and perceptions towards birds on a selected group of three landscapes;
- 2) Test for differences in activities and perceptions across the rural-to-urban gradient comprising the three landscapes;
- 3) Aggregate landowner activity results to the landscape level; and,
- 4) Examine if the relative abundance and diversity of bird species across landscapes was related to landowner activities and human influences.

These four primary objectives are addressed through a total of five chapters focusing on Southeast Michigan and the entire Midwest that compose this dissertation. The first four chapters are based on an in-depth survey (Appendix A) administered to 100% (~1,700 people) of the private landowners on three North American Breeding Bird Survey routes in Southeast Michigan that can be classified as rural, suburban, and urban landscapes, respectively. The final chapter of this dissertation attempts to utilize the three commonly engaged in activities of feeding birds, providing bird houses, and allowing house cats outdoors, as found in Chapters One and Two, in order to make general predictions about bird abundance and diversity across 402 landscapes surrounding Breeding Bird Survey routes of eight Midwest states.

The first chapter (Chapter One) focuses on the landowner activity of allowing house cats (Felis catus) outdoors and its potential influence on birds. While house cats are widely recognized as a conservation threat to birds, as indicated by several classic articles (Churcher and Lawton 1987, Coleman and Temple 1993), there has been little effort to investigate how they are spread across landscapes or how they relate to socio-

demographic factors. Hence, the objective of Chapter One is to both quantify aspects of outdoor house cats and relate them to landowner characteristics.

Chapter Two moves beyond the activity of allowing house cats outdoors to investigate seven additional landowner activities that have been described or implicated in the literature as having an influence on bird abundances and populations. These seven additional activities include providing bird food, providing bird houses, planting and maintaining vegetation for the benefit of birds, gardening, landscaping, applying fertilizer, and applying pesticides or herbicides. The objective of Chapter Two is to quantify the level of participation of these seven activities in order to understand general landowner behavior that can influence birds across landscapes.

The focus of Chapter Three is how the eight landowner activities measured in Chapters One and Two are related to landowner perceptions of birds on their land. Specifically, landowner activities were classified as positive or negative based on *a priori* expectations and then related to five measures of how landowners perceive birds on their land and their willingness to change their behavior for the benefit of birds. The specific landowner perceptions that were investigated include the view that bird numbers have changed over time, the importance of bird diversity, the number of birds living in the vicinity of the property, interest in tax easements or abatements in exchange for preserving bird habitat, and willingness to alter one's land use for the benefit of birds. Thus, the objective of Chapter Three was both to quantify landowner perceptions and relate them to how many positive and negative activities the landowners were engaged in on their property.

The objective of Chapter Four is to describe all bird species observed by

landowners in comparison to other published sources in order to compose a complete bird list for the study area. Because landowners have the ability to see many species on their property which scientists and managers do not, they may provide different estimates of how many species frequent a landscape.

Finally, Chapter Five investigate how bird diversity and the relative abundance of selected bird species relates to two measures of human influence, the number of housing units present on the landscape and the total amount of anthropogenic land cover, across 402 landscapes encompassing Breeding Bird Survey routes of the Midwest. In addition, the chapter investigates how two important natural history characteristics, diet type and nest location, are related to the relative abundance across landscapes. These two natural history categories were selected based on the results of landowner activities found in Chapters One and Two. Specifically, food and nest supplementation as well as the presence of outdoor house cats were found to occur at high frequencies across all three landscapes in Southeast Michigan, suggesting that they could differentially influence birds based on their major diet and nest types. Thus, the final chapter represents a first attempt to integrate specific landowner activities from a subset of landscapes in order to make general predictions at a larger scale.

Each of the five chapters is written in a slightly different style, dependent upon where they have been or will be submitted for publication. Specifically, Chapter One is written in the style of *Biological Conservation*, where it is currently in revision and is expected to be accepted and published in 2003; Chapter Two is written in general journal article format and will be submitted to an appropriate journal, such as *Environmental Management*, following acceptance of the dissertation; Chapter Three has been published

as a conference proceedings (Lepczyk et al. 2002) for the 2002 United Kingdom-International Association for Landscape Ecology meeting held in Norwich England; Chapter Four is written in the style of the *Journal of Field Ornithology*, where it will be submitted as a field note following acceptance of the dissertation; and, Chapter Five is written in the style of *Ecological Applications*, where it will be submitted upon the addition of further data analyses. Contributing to the chapters are a variety of coauthors, which include Dr. Jianguo Liu (Chapters 1, 2, 3, and 5), Dr. Angela Mertig (Chapters 1, 2, and 3), Dr. Volker Radeloff (Chapter 5), and Dr. Curtis Flaherty (Chapter 5).

CHAPTER 1

LANDOWNERS AND CAT PREDATION ACROSS RURAL-TO-URBAN LANDSCAPES

ABSTRACT

Fluctuations of bird abundances have been attributed to such factors as supplemental feeding, landscape change, and habitat fragmentation. Notably absent from consideration, however, is the role of private landowners and their actions, such as owning free-ranging domestic cats (*Felis catus*; cats allowed free access to the outdoors). To understand the impacts of cat predation on birds, we surveyed all 1,694 private landowners living on three breeding bird survey (BBS) routes (~120 km) that represent a continuum of rural-to-urban landscapes in Southeastern Michigan, where the majority (>90%) of land is privately owned. Our data indicate that among the 58.5% of landowners that responded, one quarter of them owned outdoor cats. On average a cat depredated between 0.7 and 1.4 birds per week. A total of 23+ species (12.5% of breeding species) were on the list of being killed, including two species of conservation concern (Eastern Bluebirds and Ruby-throated Hummingbirds). Across the three landscapes there were ~800 to ~3,100 cats, which kill between ~16,000 to ~47,000 birds during the breeding season, resulting in a minimum of ~1 bird killed/km/day. While the number and density (#/ha) of free-ranging cats per landowner differed across the rural to urban landscapes, depredation rates were similar. Landowner participation in bird feeding showed no relationship with the number of free-ranging cats owned. Similarly, selected demographic characteristics of landowners were not significantly related to the number of free-ranging cats owned. Our results, even taken conservatively, indicate that cat predation plays an important role in fluctuations of bird populations and should receive more attention in wildlife conservation and landscape studies.

INTRODUCTION

Since the mid 1960s, long-term data on breeding birds have indicated that many species are declining or fluctuating throughout the Midwest and Eastern United States (Robbins et al. 1989, Terborgh 1989). These declines and fluctuations have been attributed to factors such as habitat fragmentation and destruction (Robbins et al. 1989, Donovan and Flather 2002), landscape change (Flather & Sauer 1996), and direct mortality due to events (e.g., culling by farmers) on the wintering-grounds of the neotropics (Rappole & McDonald 1994, Basili & Temple 1999). Largely absent from consideration in the potential mechanisms responsible for influencing breeding bird abundances are the landowners that live in the landscapes being investigated. Because private landowners are the ultimate controllers of their land, they may be carrying out a wide variety of actions that could influence bird abundances and distributions. Their cumulative and collective effects across large areas and over time may be even more drastic. Furthermore, landowners living in rural landscapes may carry out activities at different levels than those in urban landscapes. Such differences may in part explain the substantial variations in bird abundances and diversity often noted along urban to rural gradients or in urban contexts (e.g., Emlen 1974, Hohtola 1978, Cam et al. 2000).

Because of the potential for significant landowner effects on birds, there has been increased attention directed towards the integration of social and economic components into questions of avian distributions (Hostetler 1999). However, until recently ecologists have largely ignored the human components in ecological research (Lubchenco et al. 1991, Gallagher & Carpenter 1997, Vitousek et al., 1997, Liu 2001). As a result,

ecologists' understanding of how humans interact with and influence different ecosystems, and the species they contain, is still in its early stage (Redman 1999). To move beyond this basic level, ecologists are increasingly incorporating socioeconomics, human demography, and social science techniques, such as social surveys, to understand the interrelationship between humans and the ecosystems within which they live (Turner et al. 1996, Liu et al. 1999, Liu et al. 2001). As human behaviors are the direct force affecting ecosystems, it is essential to incorporate human behaviors into the understanding of ecological patterns such as abundance and diversity of bird species.

One specific behavior that could negatively impact breeding birds is allowing domestic cats (Felis catus) free access to the outdoors. Although free-ranging domestic cats (i.e., house cats that have free access to the outdoors; a.k.a. outdoor cats) predominantly depredate small mammals (Fitzgerald & Turner 2000), birds constitute a large secondary source of prey (Coman & Brunner 1972, Pearre & Maass 1998). While the fact that cats prey upon birds is unquestioned, the degree to which they negatively impact bird populations (or any prey species) has been a point of contention in the literature (Barratt 1998). Because domestic cats have coexisted with humans for centuries, Fitzgerald & Turner (2000) argue that any continental population of birds that could not withstand predation by cats would have been extirpated long ago. Another perspective holds that cats are simply occupying the role of a natural predator. That is, cats are assumed to fill a role similar to that of species such as raccoons (Procyon lotor), skunks (Mephitis mephitis), and raptors. A final point that has been made is that people simply observe avian depredation by cats more than other natural phenomena because it takes place during the day time and often close to the house, which results in the

assumption that cats are reducing bird populations (see Patronek 1998 for details).

Countering the previous points is the fact that domestic cats are subsidized predators and are thus likely to have a larger total effect on bird species. Specifically, humans provide domestic cats a level of maintenance that other predators do not receive (Coleman & Temple 1993). As a result they may exist in higher densities and exert a greater predatory effect than natural predators. Second, cats are opportunistic predators (Coman & Brunner 1972), both in terms of time and habitat location (Barratt 1997), meaning they will depredate a prey item if they encounter it. Third, in many human-dominated landscapes where top-level predators are absent, domestic cats may be extolling an even larger predatory effect due to a mesopredator release effect (Crooks & Soulé 1999, Risbey et al. 2000). The mesopredator release effect is simply the situation in which top level predators have either been greatly reduced or extirpated, resulting in an increase of second-tier predators, such as skunks, raccoons, and domestic cats. Fourth, cats often depredate birds more during the breeding months when nestlings and fledglings are bountiful (Eberhard 1954, Dunn & Tessaglia 1994). Fifth, cats may be directly competing with avian predators, such as American Kestrels (Falco sparverius), Northern Harriers (Circus cyaneus) and Red-tailed Hawks (Buteo jamaicensis; George 1974). Finally, even very low cat depredation could negatively impact the breeding success and viability of a species (Crooks & Soulé 1999).

As part of a larger effort to understand and integrate the social and ecological factors influencing breeding bird abundances among different rural to urban landscapes (Lepczyk et al. 2002, Chapters 2 and 3), we sought to address the roles of free-ranging cats and the landowners that own them. Specifically, we were interested in ascertaining:

1) the proportion of landowners that allow their cats outside; 2) the number and density (cats/ha) of cats each household owned that were allowed access to the outside; 3) how many dead or injured birds a week the cats brought in during the breeding season (i.e., April through August); 4) what cat predation rates were at the landscape level; 5) what bird species were brought home by the cats; and, 6) if differences existed across a rural to urban gradient.

Aside from understanding the six aforementioned issues, we also tested three *a priori* hypotheses. Our first hypothesis was that because bird feeders may act to magnify local bird densities, a relationship would exist between both the number and density of bird feeders and cat depredation rates. We predicted that as the number and/or density of bird feeders increased there would be a related increase in the number of birds depredated per cat. In addition, because the role of domestic cats as predators has received widespread attention among academic and professional organizations (Cooper Ornithological Society's resolution on Public Policies Regarding Feral and Free-ranging Cats [<http://cooper.org/cos/67thResolutions.htm>] and American Bird Conservancy's Resolution on house cats [<http://www.abcbirds.org/cats/Resolution.PDF>]), non-academic venues (e.g., National Audubon Society Resolution on Cats [<http://www.audubon.org/local/cn/98march/cats.html>]; Wisconsin Natural Resources Magazine [<http://www.wnrmag.com/stories/1996/dec96/cats.htm>] (1996), veterinarians, and non-profit educational programs (e.g., American Bird Conservancy's *Cats Indoors!* [<http://www.abcbirds.org/cats/catsindoors.htm>]), we also sought to integrate our results with demographic parameters of the landowners to test two other hypotheses. Specifically, we hypothesized that the number of free-ranging cats would be a function of

a landowner's age and educational level. In the case of a landowner's age we predicted a positive relationship between age and number of free-ranging cats they would own, since the impetus to keep cats indoors has been a relatively recent phenomenon that likely influences younger landowners more than older landowners. Likewise, we predicted a negative relationship between education and free-ranging cats, such that the more education a landowner had the fewer free-ranging cats they would own. We based this prediction on the grounds that many public and private organizations as well as veterinarians have strongly advocated keeping cats indoors and that the more education a landowner has the greater the chance that they have been exposed to such a message.

METHODS

To address the research questions, test our hypotheses, and match the scale of study areas with locations where long-term data on bird abundance and distribution have been collected (Vogt et al. 2002), we used three breeding bird survey (BBS) routes (route numbers 53, 167, and 168) in Southeastern Michigan, United States (Figure 1.1), where >90% of the land is privately owned. We chose these three routes because they represent a continuum from rural to urban landscapes, based on their geographic locations, average land parcel sizes, and socio-demographic compositions. Specifically, route 53 (hereafter termed Rural) is very rural, has a low population density, large land parcels, and is removed from any large city center or urban location. Route 168 (hereafter termed Urban) ranges from being very suburban to being urban, has a high population density, small land parcels, 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, has intermediate population density and land parcel sizes, and runs 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.

To integrate information about human behaviors into the understanding of landowner impacts on bird abundance, we conducted a social survey of landowners. For our study, 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 the landowners through a combination of driving each route and using county tax records and plat maps. Utilizing this combined approach we identified a total of 1,694 private landowners (331 on Rural, 390 on Suburban, and 973 on Urban).

We administered a mail survey instrument between October and December of 2000 following the Total Design Method (Dillman 1978, 2000). The survey instrument and procedures were fully evaluated for ethical appropriateness by the Michigan State University Committee on Research Involving Human Subjects prior to mailing. To encourage responses we established a toll-free telephone line for landowners to contact us with any questions and offered prize drawings as an incentive. Briefly, an initial survey was mailed during the first week of October 2000 (Appendix A and B). A

reminder/thank you postcard was sent out two weeks later (Appendix C). Finally, a second survey was sent out two weeks after the postcard to those who had not responded to the prior mailings (Appendix D).

Our 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 December 31, 2000 were not included in any analyses. If landowners owned multiple parcels that were not connected to one another, then 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, then 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 that 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 the impact of free-ranging cats on bird abundance we asked the following questions in our survey: (1) How many cats does your household own that are allowed access to the outside? (2) If you or members of your household own cats that are allowed access to the outside, approximately how many dead or injured birds a week do

all the cats bring in during the spring and summer months (April through August) (0, 1, 2-3, 4-5, 6-7, 8-9, 10-15, 16-20, more than 20)? (3) Can you or anyone in your household identify any of the bird species brought home by your cat(s) (yes, no, unsure)? (4) Please list the names of the bird species that your cat(s) has brought home during the spring and summer months on the lines below. With regard to the number and density of bird feeders the following questions were asked: (5) Does anyone in your household feed birds on your property (yes, no)? (6) How many bird feeders do you have on your property? (7) Approximately how large is your parcel of land? Finally, to ascertain basic demographic statistics of the landowners we asked the following questions: (8) In what year were you born? (9) Are you: Male, Female? (10) How many people currently live in your household? (11) 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 general equivalency diploma; Some college, but no degree; Associates degree in college; Bachelor's degree; Master's, professional, or doctoral degree)? The six educational choices offered were a condensation of the nine categories used in the United States Census form that pooled post-baccalaureate degrees together.

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, we took the arithmetic mean if a respondent put a range. In a single case a respondent put a question mark for the number of cats allowed access to the outdoors. Because all subsequent questions that were contingent upon the number of cats were answered as owning an outdoor cat, we conservatively assumed that the landowner had at least one cat. However, in cases where landowners had no cats allowed access to

the outdoors, but answered questions contingent on the fact that they did own them, we converted the values 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. For the bird species brought home by the cats we corrected all spelling/grammatical mistakes and made the following assumptions based on colloquial terminology and bird descriptions compared to known species in the surrounding landscape. Redbirds and red birds were assumed to be Northern Cardinals (Cardinalis cardinalis). Turtle doves and doves were assumed to be Mourning Doves (Zenaida macroura). Honey-sucking birds and hummers were assumed to be Ruby-throated Hummingbirds (Archilochus coubris), as no other hummingbirds inhabit Michigan. Canary, yellow canary, wild canary, yellow finch, and golden finch were assumed to be American Goldfinches (Carduelis tristis). Crackles or crackens were assumed to be Common Grackles (Quiscalus quiscula). Red finches and red-breasted finches were assumed to be Purple Finches (Carpodacus purpureus). Finally, barn sparrow was changed to Sparrow, even though it is most likely a House Sparrow, because of the potential for misidentification.

Because of the potential for under-reporting cat depredation (see Discussion), we initially calculated a predation rate based on all landowners that had outdoor cats, even if they indicated predation rates of zero (Predation Rate 1, hereafter termed PR1). However, we also calculated a second predation rate (Predation Rate 2, hereafter termed PR2) based only on landowners that had outdoor cats for which they reported one or more birds killed or injured per week. Given the uncertainty related to the number of cats and their associated predation rates with regard to the non-respondents, we used several

different estimates of non-respondent outdoor cat ownership to provide a plausible range when scaling-up the results to the landscape level. To estimate the total number of birds depredated over the breeding season in each landscape we considered non-respondents from three perspectives: (1) non-respondents have the same number of outdoor cats as respondents, (2) non-respondents have 50% the number of outdoor cats as respondents, and (3) non-respondents have 150% the number of outdoor cats as respondents. Under each assumption we applied both rates of predation, such that under Predation Rate 1 the total number of birds killed over the breeding season = (number of non-respondents) × (mean number of cats/landowner) × (weekly predation rate) × (22 weeks) + (number of birds killed over 22 weeks from respondents). In the case of Predation Rate 2 we calculated the total number of birds killed over the breeding season = (number of non-respondents) × (proportion of landowners that had cats that killed or injured one or more bird a week) × (mean number of cats/landowner) × (weekly predation rate) × (22 weeks) + (number of birds killed over 22 weeks from respondents). We estimated the potential proportion of landowners involved in allowing their cats outdoors across each landscape by assuming that all non-respondents did not have cats allowed outdoors (minimum estimate) and then assuming that they all did have cats allowed outdoors (maximum).

Statistical analyses were performed using the multivariate general linear hypothesis module in SYSTAT 5.03 (Wilkinson 1992). All density measures were calculated using the parcel sizes reported by the landowners. Response rate and the proportion of landowners owning outdoor cats across each landscape were compared using a two-way contingency table with a Pearson Chi-square test statistic. Comparisons between cat and non-cat owners were carried out using t-tests, while comparisons across

landscapes were carried out with ANOVA. Landscape differences were compared using Tukey's HSD procedure (Zar 1996). Data are reported as means $\pm$ SE (as 100% of the population was sampled, but only ~59% responded), unless otherwise noted, with a p -value of 0.05 considered significant.

Of the 1,694 landowners initially identified, 40 were removed from consideration because they were a business or church, had property outside the sampling region, already responded based on another parcel of land within the study landscapes, or their address information was incorrect, thus reducing the corrected population size to 1,654. Among these 1,654 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

A total of 253 (26.1%) landowners had cats that were allowed access to the outside. Of these 253 landowners, 71 (33.5%) were in the Rural landscape, 75 (32.2%) were in the Suburban landscape, and 107 (20.5%) were in the Urban landscape, indicating a significantly different proportion of respondents due to the lower frequency in the Urban landscape ($\chi^2 = 19.09$; $df = 2$; $p = 0.00007$). The total number of free-ranging cats across all landscapes was 656 (Table 1.1), ranging from 1 to 30 per landowner with a mean of 2.59 ± 0.20 per landowner (Figure 1.2). Overall, the mean number of free-ranging cats per landowner was significantly different by landscapes ($F = 6.175$; $df = 2$,

250; $p = 0.0024$; Table 1.1), but specific landscape differences were only significant between the Rural and Urban landscapes ($p = 0.0013$). Similarly, the density of cats (#/ha) was significantly different by landscape ($F = 9.74$; $df = 2, 239$; $p = 0.000086$), with the Urban landscape being different from both the Rural ($p = 0.00045$) and the Suburban landscapes ($p = 0.00086$; Table 1.1).

Of the 253 landowners owning outdoor cats, the mean number of birds depredated per cat per week (PR1) across all landscapes was 0.683 ± 0.12 ($n = 245$) and were similar among all landscapes ($F = 0.213$; $df = 2, 242$; $p = 0.808$; Table 1.2). Recalculating predation rates based only on landowners that had outdoor cats (PR2) for which they reported one or more birds killed or injured per week reduced the sample size to 118 (Table 1.2). Of these 118 landowners, the mean number of birds depredated per cat per week (PR2) across all landscapes was 1.42 ± 0.22 (Table 1.2). As with PR1 above, PR2 was similar among all three landscapes ($F = 0.567$; $df = 2, 115$; $p = 0.57$; Table 1.2). Based upon PR1 the overall average total number of birds killed per cat during the breeding season was 15 compared to an overall average of 32 using PR2 (Table 1.2). Summing each individual cat's predation rate over the breeding season indicated that the total number of birds killed across the three landscapes was 3,680 (Table 1.2). Depredation rates were not correlated with the number of bird feeders located on each landowner's property ($r^2 = 0.015$; $p = 0.10$; Figure 1.3), and were not influenced by landscape type (landscape $\times$ number of bird feeders; $F = 0.281$, $df = 2, 180$; $p = 0.756$). Similarly, depredation rates were not correlated with the density (#/ha) of bird feeders ($r^2 < 0.001$; $p = 0.631$). Scaling the proportion of landowners that have outdoor cats to the landscape level (by incorporating assumptions about non-respondents) indicates that

between 15% and 56% of landowners potentially have outdoor cats (Table 1.3). At the landscape level the total number of predatory outdoor cats ranged from ~800 to ~3,100, which killed between ~16,000 and ~47,000 birds (Table 1.3).

Of the 118 landowners that reported their cats killing or injuring one or more birds a week, 75 (63.6%) were able to identify specific species of birds brought home by their cats. Twenty three unique species of birds or groups of birds were identified by the landowners (Table 1.4), which is undoubtedly a conservative estimate (see Discussion section). The species identified in greatest numbers were Sparrows and Blue Jays (Cyanocitta cristata), while the least common were Dark-eyed (Slate-colored var.) Junco (Junco hyemalis) and the Tufted Titmouse (Baeolophus bicolor; Table 1.4).

In terms of landowner demography, the average age ($n = 241$) of the respondents owning outdoor cats was 51.3 ± 0.86 years compared to 50.4 ± 0.51 years for respondents not owning outdoor cats ($n = 690$), indicating no significant difference in age ($t = 0.905$; $df = 929$; $p = 0.366$). Similarly, there were no differences in age among free-ranging cat owners across the three landscapes ($F = 0.633$; $df = 2, 238$; $p = 0.532$; Table 1.5). In addition there was no relationship between respondent's age and the number of cats allowed access to the outdoors ($r^2 < 0.0005$; $p = 0.925$). With regard to educational level there was a significant difference among free-ranging cat owners across the landscapes ($F = 26.897$; $df = 2, 238$; $p < 0.000005$; Table 1.5), but not between free-ranging cat owners and non free-ranging cat owners ($F = 1.650$; $df = 1, 926$; $p = 0.199$) nor was there an interaction between free-ranging cat ownership and landscape type ($F = 0.083$; $df = 2, 926$; $p = 0.921$). The significant difference in educational level among owners of free-ranging cats was found to be between Rural and Suburban, and Suburban and Urban

landscapes, but not between the Rural and Urban landscapes. Similarly, there was no relationship between respondent's educational level and the number of cats allowed access to the outdoors ($r^2 < 0.002$; $p = 0.461$).

DISCUSSION

Overall, our results indicate that free-ranging domestic cats depredated a minimum of 12.5% of the known breeding bird species (based on 23 of ~184), including two species of conservation concern (Eastern Bluebird and Ruby-throated Hummingbird). In the case of the Eastern Bluebird, the location of the three landscapes represents an area of Michigan where the species is rarest and not always identified on bird atlas survey routes (Brewer et al. 1991). Ruby-throated Hummingbirds are the only species of hummingbirds that breed in Michigan and are not typically associated with cat predation given their small body size. Aside from the Eastern Bluebird and Ruby-throated Hummingbird, the species depredated in our study are concordant with other studies that most of the birds being taken by cats were ground or low brush feeders (Table 1.4) and typically associated with bird feeders and suburban landscapes (Mead 1982, Dunn & Tessaglia 1994, Carss 1995, Barratt 1997). Although the species group of Sparrows could not be broken down into species, it is very likely that the dominant species observed was the House Sparrow (Passer domesitcus). Sparrows were also the most commonly observed depredated species found in England and Australia (Churcher and Lawton 1987, Barratt 1997).

Although no extremely rare species or species of state or national concern were identified by landowners, that does not mean that cats were not preying upon them. In fact several factors would lend support to the fact that other species are likely being depredated. First, because only two-thirds of landowners were able to identify the birds brought home by their cats, it is very probable that other species were taken in the properties of the remaining one-third of landowners that acknowledged cat depredation. Second, the ability of respondents to identify birds correctly is unknown. People are most familiar with common and brightly colored species. Furthermore, most people tend to use general colloquial terms, such as Sparrows. Because the ability to discern specific Sparrow species can be very difficult (Sibley 2000) and other sparrows such as the Chipping Sparrow (Spizella passerina) often occur in residential areas, it is very likely that the group “Sparrows” in Table 1.4 consisted of at least two to three separate sparrow species. Thus, there is most certainly a detection bias among the respondents. Third, respondents only identified birds that were brought home by their cats. Thus, no measure of what species may have been consumed in the field were recorded. Fourth, cats often depredate nestlings (Churcher & Lawton 1987, Dunn & Tessaglia 1994), which can be very difficult to identify, especially if very young or recently hatched. Finally, cats are opportunistic predators, suggesting that they are likely to prey upon any species that is present in its territory. As a result of these factors, the observed species and species groups being depredated are almost certainly an underestimate of the true number of species. Keeping these points in mind, our estimate of the number of species depredated should be considered quite conservative.

At the landscape scale the total number of outdoor cats and the number of birds killed over the breeding season is quite wide ranging, depending upon the assumptions regarding non-respondents. Under the assumption that only respondents had outdoor cats, there were only 656 cats reported (Table 1.1) and 3,680 birds killed over the breeding season. However, as discussed below, it is unrealistic to assume that non-respondents had no outdoor cats. Using three different estimates of non-respondent cat numbers (Table 1.3), along with the two predation rates, yielded an estimate of between ~16,000 and ~47,000 birds killed during the breeding season across the three landscapes. Considering that the three landscape routes cover ~120 kilometers (each BBS route is 39.4 km long), even the low estimate of birds killed represents nearly one bird killed per day per kilometer ($16,000 \text{ birds} / 120 \text{ km} / 22 \text{ weeks} / 7 \text{ days} = 0.87 \text{ birds killed per km per day}$).

There were several notable differences observed across the three landscapes selected in this investigation. Specifically, landowners in the urban landscape were significantly less likely to own free-ranging cats than were landowners in either the rural or suburban landscape. However, in terms of the number of free-ranging cats per landowner a steady decline existed from the rural landscape to the urban landscape (Table 1.1), even though only the rural and urban landscape were significantly different from one another. Landowners in the urban landscape, however, had significantly higher densities of free-ranging cats (i.e., they had more cats per hectare) than did landowners in either the rural or suburban landscapes (Table 1.1). This increase in cat densities from rural-to-urban landscapes is similar to what was recently found by Haskell et al. (2001), where greater cat densities were associated with greater housing densities in urban landscapes.

Ultimately, while predation rates displayed no difference across the landscapes (Table 1.2), the greater number of landowners in the urban landscape, coupled with greater cat densities, is one of the main reasons for a greater total predatory effect in the urban landscape (Tables 1.1 and 1.3).

Because cat predation is often witnessed at bird feeders (Dunn & Tessaglia 1994) and bird feeders can act to magnify bird densities, we had predicted that there would be a positive correlation between bird feeder number or density and depredation rates.

However, we found no support for this hypothesis. The lack of a relationship may be due to the fact that there are relatively few landowners that both allow their cats outdoors and feed birds or that place bird feeders in accessible places for cats. Regardless of the specific reason(s) why we found no support for our hypothesis, the lack of correlation is important in that it suggests that bird feeding is not exacerbating predation rates by cats.

Similar to our first hypothesis, we found no relationships between age or education of the respondents and the number of free-ranging cats owned, indicating that our last two hypotheses should also be rejected. The fact that age and educational level show no relationship with the number of cats allowed access to the outdoors is somewhat troubling. Given the amount of attention being directed toward keeping domestic cats indoors by private interest groups, veterinarians, public school systems, and professional scientific organizations, we had predicted a positive effect of age and a negative effect of education on the number of cats allowed access to the outdoors. Instead we found no relationship, suggesting that either the information is not reaching the targeted audience, or that there is a general indifference to the role of cats as predators. One additional reason may be that people may know not to let cats outdoors, but not act accordingly (i.e.,

action does not follow knowledge). The only factor that showed any relationship with the number of free-ranging cats was household size (i.e., number of people living in a residence). Although not explicitly tested as an *a priori* hypothesis, we investigated the effect of household size simply as a possible demographic factor. The positive relationship between the number of people living at a residence and the number of cats is not totally surprising as larger residences are more likely to have children who own pets. One caveat of our study is that landowners may have underestimated the number of cats they allow access to the outside. Such a result was found in a similar study of landowners in Wisconsin (Coleman & Temple 1993). This underestimate may be due to incomplete knowledge or a desire to positively bias answers that the respondent felt were associated with negative connotations (Dillman 1978). In addition, we found that a very common volunteered response among landowners that had no outdoor cats was that either their neighbors owned outdoor cats or that feral cats were present in the vicinity of their land. Given the frequency of these responses relative to the number of landowners that reported owning outdoor cats suggests that at least some landowners under reported or chose not to report the number of outdoor cats they owned. Thus, just as our estimate of bird diversity is likely to be conservative, so is our estimate of free-ranging cat density. As a result, the actual number of free-ranging cats is in all likelihood larger than our estimate.

Besides the potential underestimate of outdoor cats, our study almost certainly underestimated the predation rate. This underestimate can be attributed to the following points. First, only 47% of outdoor cat owners indicated that their cat(s) brought home dead or injured birds. It is improbable that the remaining 53% of landowners' cats simply did not prey upon birds. Second, respondents based their cat's predation rate only on the

birds actually brought home or visible to them, thus missing birds killed and/or consumed in the field. Third, just as with outdoor cat ownership, respondents may have underestimated the predation rate as they associate it with negative connotations. As a result, the actual predation rate and hence total number of birds killed are most certainly underestimates. Even in the face of such underestimates our study demonstrates the significant impact of outdoor cats on birds.

While we can not specifically conclude that cats are depredating rare or threatened species in the three landscapes, there is a strong likelihood that they are impacting some species of concern. The fact that both Eastern Bluebirds and Ruby-throated Hummingbirds were listed indicates that some species of concern are being captured. Furthermore, given the opportunistic predatory nature of cats coupled with one third of respondents' inability to discern bird species suggests that our finding of 23 species or groups of birds being depredated by free-ranging cats is a conservative estimate. Similarly, by incorporating the potential for undercount of cats by respondents and the lack of any evaluation of feral cats, the number of cats per landowner is also likely to be a conservative estimate. Given these factors it is noteworthy to point out that a number of additional bird species that merit special concern are along the three BBS routes and/or in the surrounding landscape. These species include three listed as special concern in Michigan [Western Meadowlark (*Sturnella neglecta*), Hooded Warbler (*Wilsonia citrina*), and Prothonotary Warbler (*Protonotaria citrea*)], one species that is listed as threatened by the State of Michigan [Yellow-throated Warbler (*Dendroica dominica*)], three that the U.S. Fish and Wildlife Service designated as being of management concern [Henslow's Sparrow (*Ammodramus henslowii*), Cerulean Warbler (*Dendroica cerulea*)],

Golden-winged Warbler (Vermivora chrysoptera)], and species that are at the edge of their range, such as the Dickcissel (Spiza americana) (Adams et al. 1988, Brewer et al. 1991)]. A number of other special concern, threatened, and endangered bird species occur within the vicinity of the study areas, but can be considered at lower potential for free-ranging cat depredation due to either their large body sizes or nesting locations [e.g., Red-shouldered Hawk (Buteo lineatus)].

In terms of management and conservation implications, our results, even taken conservatively, indicate that free-ranging cats are killing a large number and wide range of bird species. Our results also highlight the fact that there is still an urgent need to educate landowners and policy makers regarding the negative impacts of free-ranging cats. Furthermore, our study illustrates how important private landowners are in influencing the ecosystem around them. Only by incorporating their knowledge, decisions, and actions into ecological research can ecologists fully understand the complex nature of populations and ecosystems on the landscape.

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Table 1.1. Summary information for free-ranging cat owners by landscape. Values are means $\pm$ SE, with values in parentheses indicating the sample size. Superscript letters represent significant differences between landscapes: a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban.

	Landscape			Average
	Rural	Suburban	Urban	
Free-ranging cats (#/landowner) ^c	3.62 $\pm$ 0.37 (71)	2.56 $\pm$ 0.36 (75)	1.94 $\pm$ 0.30 (107)	2.59 $\pm$ 0.20 (253)
Total # of free-ranging cats	257	192	207	656*
Cat density (#/ha) ^{b,c}	1.19 $\pm$ 0.22 (66)	1.37 $\pm$ 0.24 (75)	3.43 $\pm$ 0.53 (101)	2.18 $\pm$ 0.25 (242)

*The number is a total, not an average.

Table 1.2. Predation rates for free-ranging cat owners by landscape. Values are means $\pm$ SE, with values in parentheses indicating the sample size.

	Landscape			Average
	Rural	Suburban	Urban	
Predation rate 1 (#birds killed/cat/week)	0.77 $\pm$ 0.32 (67)	0.58 $\pm$ 0.13 (72)	0.70 $\pm$ 0.15 (106)	0.68 $\pm$ 0.12 (245)
Predation rate 2 (#birds killed/cat/week)	1.48 $\pm$ 0.59 (35)	1.09 $\pm$ 0.22 (38)	1.65 $\pm$ 0.31 (45)	1.42 $\pm$ 0.22 (118)
Total birds killed (#/cat) under predation 1	16.99	12.64	15.40	15.02
Total birds killed (#/cat) under predation 2	32.52	23.95	36.27	31.19
Total birds killed by cats during breeding	1,138	910	1,632	3,680*

*The number is a total, not an average.

Table 1.3. Landscape level results of the proportional range of landowners allowing cats outdoors, the number of possible cats that are predatory, the density per linear kilometer of predatory cats, and the total number of birds killed under differing estimation procedures. The three assumptions are that (1) non-respondents have 50% the number of cats as respondents, (2) non-respondents have the same number of cats as respondents, and (3) non-respondents have 150% the number of cats as respondents. Each assumption was estimated with both predation rates.

	Landscape			
	Rural	Suburban	Urban	Total
Potential range of landowners having cats	21.7-56.9	19.8-58.3	11.3-56.1	15.3-56.8*
Total number of cats (#/ln km)				
(assumption 1 & predation 1)	465 (11.8)	379 (9.6)	619 (15.7)	1,463 (12.4)
(assumption 1 & predation 2)	290 (7.3)	205 (5.2)	325 (8.3)	820 (6.9)
(assumption 2 & predation 1)	673 (17.1)	566 (14.4)	1,032 (26.2)	2,271 (19.2)
(assumption 2 & predation 2)	419 (10.6)	307 (7.8)	542 (13.7)	1,267 (10.7)
(assumption 1 & predation 1)	881 (22.4)	753 (19.1)	1,444 (36.6)	3,078 (26.0)
(assumption 3 & predation 2)	549 (13.9)	408 (10.4)	758 (19.2)	1,714 (14.5)
Total birds killed				
(assumption 1 & predation 1)	4,664	3,295	7,981	15,939
(assumption 1 & predation 2)	5,356	3,340	9,483	18,179
(assumption 2 & predation 1)	8,190	5,679	14,329	30,260

Table 1.3. Continued.

(assumption 2 & predation 2)	9,573	5,770	17,333	32,677
(assumption 3 & predation 1)	11,716	8,064	20,678	40,458
(assumption 3 & predation 2)	13,791	8,201	25,184	47,176

*The number is an average, not a total.

Table 1.4. Bird species reported to be depredated by outdoor cats and the number of different respondents identifying each species.

Bird Species	# of Observations
American Goldfinch (<u>Carduelis tristis</u>)	6
American Robin (<u>Turdus migratorius</u>)	12
Barn Swallow (<u>Hirundo rustica</u>)	4
Blackbird ¹	2
Black-capped Chickadee (<u>Poecile atricapilla</u>)	8
Blue Jay (<u>Cyanocitta cristata</u>)	14
Common Grackle (<u>Quiscalus quiscula</u>)	1
Eastern Bluebird (<u>Siala sialis</u>)*	6
European Starling (<u>Sturnus vulgaris</u>)	5
Finch ¹	3
House Finch (<u>Carpodacus mexicanus</u>)	1
House Sparrow (<u>Passer domesticus</u>)	1
Mourning Dove (<u>Zenaida macroura</u>)	6
Northern Cardinal (<u>Cardinalis cardinalis</u>)	2
Nuthatch ¹	2
Purple Finch (<u>Carpodacus purpureus</u>)	2
Ruby-throated Hummingbird (<u>Archilochus coubris</u>)*	3
Dark-eyed (Slate-colored var.) Junco (<u>Junco hyemalis</u>)	1
Song Sparrow (<u>Melospiza melodia</u>)	1
Sparrow ¹	51
Swallow ¹	3
Tufted Titmouse (<u>Baeolophus bicolor</u>)	1
Wren ¹	2

¹ Two or more possible species could be interpreted, thus species level information not presented.

* Denotes species of conservation concern.

Table 1.5. Age and education of free-ranging cat owners by landscape. Values are means $\pm$ SE, with values in parentheses indicating the sample size. Superscript letters represent significant differences between landscapes: a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban.

	Landscape			Average
	Rural	Suburban	Urban	
Respondent Age	51.4 $\pm$ 1.67 (68)	52.6 $\pm$ 1.47 (72)	50.3 $\pm$ 1.35 (101)	51.3 $\pm$ 0.86 (241)
Respondent Educational level ^{1,a,b}	3.09 $\pm$ 0.17 (67)	4.22 $\pm$ 0.17 (72)	3.58 $\pm$ 0.14 (102)	3.64 $\pm$ 0.10 (241)

¹Educational level was a categorical response from 1 to 6 (see Methods) with a higher number indicating more education.

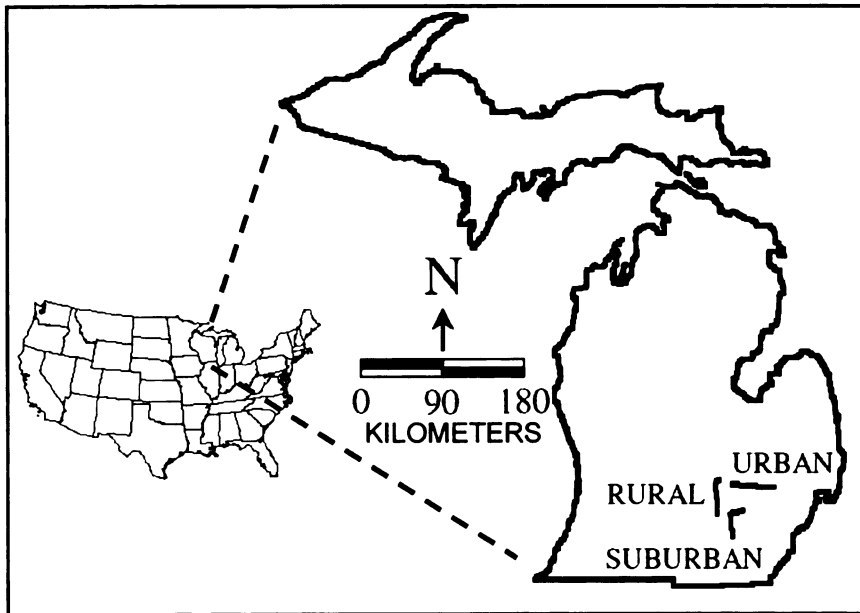
FIGURE LEGENDS

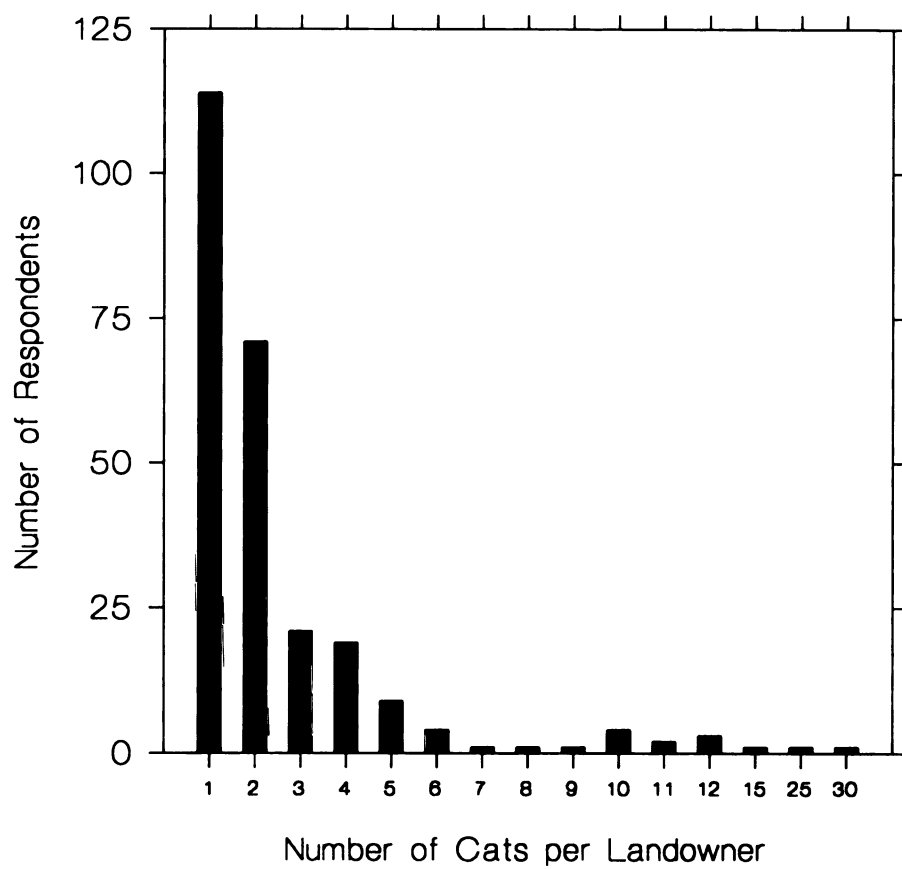
Figure 1.1 Location of the three BBS routes/study landscapes in Southeastern Michigan.

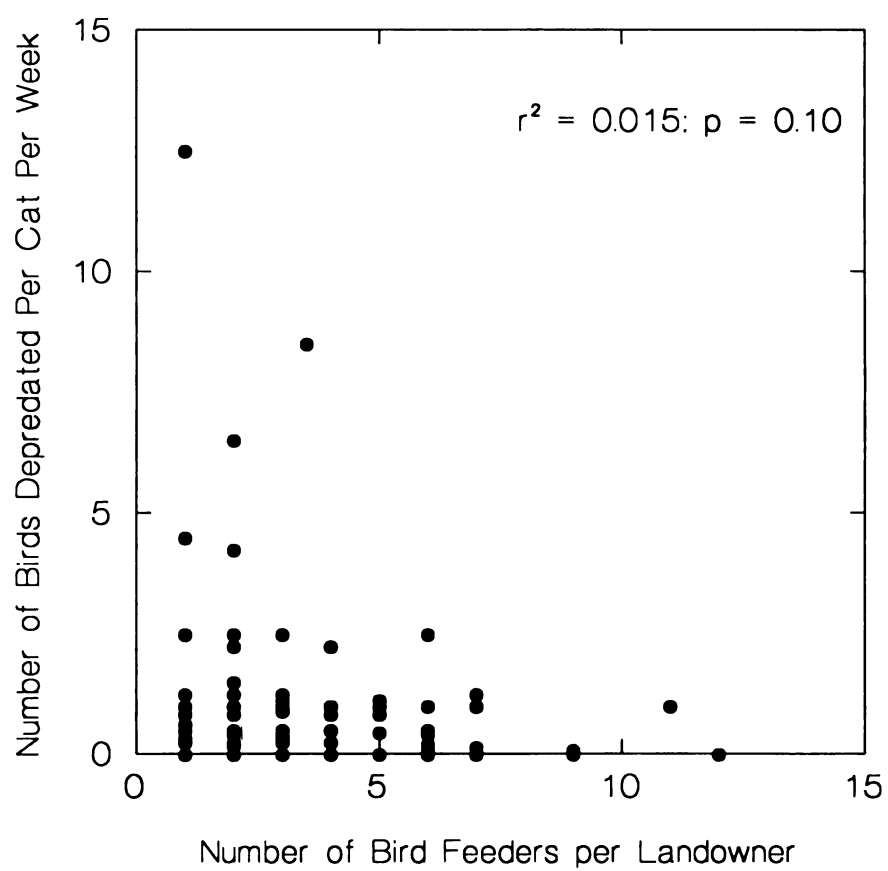
Route 53 is Rural, route 167 is Suburban, and route 168 is Urban. Each BBS route is 39.8 km in length.

Figure 1.2. Frequency distribution of the number of cats reported to be allowed outdoors per landowner.

Figure 1.3. Number of bird feeders per landowner versus number of birds depredated per week per cat.







CHAPTER 2

ASSESSING LANDOWNER ACTIVITIES THAT INFLUENCE BIRDS ACROSS RURAL-TO-URBAN LANDSCAPES

ABSTRACT

Fluctuations of bird abundances in the Midwest region of the United States have been attributed to such factors as supplemental feeding, landscape change, habitat fragmentation, and depredation. However, no attempt has been made to estimate the collective role of landowner activities on birds across a landscape. To investigate how landowners might influence birds when the majority (>90%) of land is privately owned, we surveyed all 1,694 private landowners living on three breeding bird survey (BBS) routes (~120 km) that represent a continuum of rural-to-urban landscapes in Southeastern Michigan. 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) the magnitude of bird feeders and houses, 3) if differences existed in the activities across BBS routes; and, 4) if landowners that carried out a given activity were socio-demographically different from those who did not. Of the 969 respondents (58.6% response rate), 920 (95%) carried out at least one of the activities on their land and the average landowner carried out four activities. A total of 65.6% fed birds, 45.7% provided bird houses, 54.6% planted or maintained vegetation, 72.7% gardened, 72.3% landscaped, 49.3% applied fertilizer, and 25.2% applied pesticides or herbicides. Significant differences existed among the landscapes as well as between landowners involved in a given activity versus those not involved in that activity. Scaling the activities to the landscape level indicates that at least 14% of the landowners are involved in each activity, and for most activities at least 25%-40% are involved. Taken collectively, our results

indicate that landowners are both intentionally and unintentionally engaged in a wide number of activities that can have profound influences on birds at the landscape scale.

INTRODUCTION

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 et al. 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 et al. 1997). While 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 to move beyond this basic level (Parlange 1998, Liu et al. 1999, Liu et al. 2001).

While 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 et al. 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 Bird Survey (BBS; e.g., Böhning-Gaese et al. 1993, James et al. 1996, Cam et al. 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 et al. 1989, Terborgh 1989). While the causes and extent of many declines have been controversial (James et al. 1996, James 1998), they have generally been attributed to a variety of interrelated factors, including habitat fragmentation and destruction (Robbins et al. 1989), landscape change (Flather and Sauer 1996), nest predation (see Heske et al. 2001 for review), parasitization (Robinson et al. 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 (i.e., integrated) 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 food and nesting supplementation, alteration or maintenance of vegetation, introduction of exotic predators, chemical application, landscaping and gardening, 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 regime by locating large caches of energy dense food in easy to forage locations throughout the year. Similarly, in the case of bird houses, 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, Chapter 1). Fertilizing is another common activity that can both increase and decrease bird habitat through changes in plant productivity, invertebrate populations and toxicity (see Vickery et al. 2001 for review). In the case of pesticide and herbicide application, they have 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 et al. 1998a,b, Brickle et al.

2000), as well as through reducing or altering the food supply (invertebrates; Blackburn and Arthur 2001).

While the aforementioned factors may appear self-evident as influential to bird species, 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 et al. 1997) addressing such issues of wildlife recreation as bird feeding. However, these surveys are aggregated at geopolitical units and measured by 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 et al. 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 these systems have on bird species (Marzluff et al. 1998) and not on what the 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, Sargent and Carter 1999, Tufts and Loewer 1995), it is highly likely that many

more landowners are involved in activities that could influence bird abundances than previously believed. 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 if there are socio-demographic factors that differentiate those landowners involved in a given activity from those that are not. The reason for this importance is that 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 et al. 2001). Integrating the socio-demographic 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 on whom to focus 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 et al. 2002, Chapters 1 and 3), we sought to investigate specific activities that private landowners were likely carrying out on their land. These activities included feeding birds, providing bird houses, planting and maintaining vegetation for 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) if participation in the activities was correlated, (3) the number and density of bird feeders and houses, (4) if differences existed in activity participation across routes of different socio-demographic character, and (5) if the population of landowners that carried out a given activity were socio-demographically different from the population of landowners that did not carry out the activity. In addition we sought to test a set of three *a priori* hypotheses relating the specific activities to socio-demographic factors. Specifically, that the age of the landowners involved in (1) bird feeding, (2) providing bird houses, and (3) planting and maintaining vegetation would be significantly older than those landowners not participating in these activities. We predicted an older age based upon the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior et al. 1997) which found an increasing percent of respondents that partook in these activities as age increased.

METHODS

To address the research questions, test our hypotheses, and match the scale of study areas with locations where long-term data on bird abundance and distribution have been collected (Vogt et al. 2002), we used three breeding bird survey (BBS) routes (route numbers 53, 167, and 168) in Southeastern Michigan, United States (Figure 2.1), where >90% of the land is privately owned. We chose these three routes because they represent a continuum from rural to urban landscapes, based on their geographic locations, average land parcel sizes, and socio-demographic compositions. Specifically, route 53 (hereafter

termed Rural) is very rural, has a low population density, large land parcels, and is removed from any large city center or urban location. Route 168 (hereafter termed Urban) ranges from being very suburban to being urban, has a high population density, small land parcels, 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 and land parcel sizes, and runs 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.

To integrate information about human behaviors into the understanding of landowner impacts on bird abundance, we conducted a social survey of landowners. For our study, 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 the landowners through a combination of driving each route and using county tax records and plat maps. Utilizing this combined approach we identified a total of 1,694 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). The survey instrument and procedures were fully evaluated for ethical appropriateness by the Michigan State

University Committee on Research Involving Human Subjects prior to mailing. To encourage landowners to respond to the survey we also established a toll-free telephone line and offered an incentive prize drawing. Briefly, an initial survey (Appendix A and B) was mailed during the first week of October 2000. A postcard reminder/thank you was sent out two weeks later (Appendix C). Finally, a second survey was sent out two weeks after the postcard (Appendix D).

Our 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 December 31, 2000 were not included in any analyses. If landowners owned multiple parcels that were not connected to one another, then 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, then 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 that 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 the activities that landowners were involved with on their land that

could influence bird species along BBS routes we asked the following questions in our survey: (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 the previous question) 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))?

Following the questions related to specific landowner activities we sought to acquire basic socio-demographic information about respondents by asking the following questions: (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? (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 1,000 square feet, 1,000 to 1,499 square feet, 1,500 to 1,999 square feet, 2,000 to 2,499 square feet, 2,500 to 2,999 square feet, 3,000 to 3,499 square feet, 3,500 square feet or larger, unsure)? (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; Associates degree in college; Bachelor's degree; and, Master's, professional, or doctoral degree)?

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. Questions that were contingent upon a previous question being answered, but which 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. For the open-ended question of primary occupation we categorized the responses into seven classes. The first six classes correspond to the six broad categories defined in the 1990 U.S. Census (U.S. Department of Commerce 1993). Specifically, these occupations are (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. The remaining class consisted of respondents who were not employed, which included homemakers, stay-at-home parents, widows, students, disabled persons, those on public assistance, and retired individuals with no indication of previous occupation. If the respondent chose not to indicate their

occupation (n = 47), were under the age of eighteen (n = 1), or where no logical category could be determined (n = 16; e.g., one respondent listed their occupation as “leader,” which provided no details to appropriately classify him/her) the occupation category was left blank.

Statistical analyses were performed using SYSTAT 10 (SPSS 2000). Initial comparisons across BBS routes were carried out with ANOVA, with route differences compared using Tukey’s HSD procedure (Zar 1996). For route comparisons based on the proportion of landowners engaged in an activity a two-way contingency table with a Pearson Chi-square test was used. Similarly, comparisons of respondents based on gender and occupation across routes were analyzed with one- and two-way contingency tables with a Chi-square test statistic. Correlations between each possible pair of activities were compared with a two-way contingency table using a Chi-square test statistic. Initial comparisons between the population of landowners involved in a given activity and the population that was not, in relation to age, number of people in the household, education, and house size, were analyzed using a t-test. If a significant difference between the two populations was found then a general linear model that incorporated the factor of route was tested. Similarly, if route was found to be a significant term, then the model with the interaction between route and the socio-demographic factor was tested. For comparisons between the two populations based on gender and occupation a two-way contingency table was utilized. With regard to the question about approximate size of the residence we excluded the “unsure” category from all analyses. Data are reported as means $\pm$ SE (as 100% of the population was sampled, but only ~59% responded), unless otherwise noted, with a *p*-value of ≤ 0.05 considered

significant.

Of the 1,694 landowners initially identified, 40 were removed from consideration because they were a business or church, had property outside the sampling region, already responded based on another parcel of land within the study landscapes, or their address information was incorrect, thus reducing the corrected population size to 1,654. Among these 1,654 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 Socio-demographic Composition

Respondents varied in age from 13 to 93, with the average being 50.6 years old (Table 2.1). There was a significant difference in ages across the three landscapes ($F = 6.64$; $df = 2, 927$; $p = 0.0013$), in which the Suburban and Urban landscapes differed ($p = 0.0021$) and the Rural and Urban landscapes marginally differed ($p = 0.054$). Household size ranged from 0 to 8 persons, with an average of 2.85 people per household (Table 2.1). No differences existed across the landscapes based upon household size ($F = 0.33$; $df = 2, 932$; $p = 0.721$). Of the 934 respondents who reported their gender, 498 (53.3%) were male and 436 (46.7%) were female (Table 2.1). Over all landscapes there was a significant difference ($\chi^2 = 4.12$; $df = 1$; $p = 0.042$) in the proportion of respondents based on gender, but this disappeared when route was included ($\chi^2 = 1.66$; $df = 2$; $p = 0.44$;

Table 2.1). The average respondent had some college education, but no degree (Table 2.1) with the amount of education ranging from those with no formal diploma at the high school level to those with graduate and professional degrees. Overall, the educational level was significantly different by landscape ($F = 30.39$; $df = 2, 929$; $p < 0.0000005$) and among each pair of landscapes ($p < 0.001$). A total of 907 (95.2%) respondents indicated that they had a house or residential structure on their land. The average respondent's house size was between 1,500 and 2,000 ft² (139.4 and 185.9 m²; Table 2.1), but varied significantly by route ($F = 25.27$; $df = 2, 864$; $p < 0.0000005$). Specifically, the Suburban landscape differed from both the Urban landscape ($p = 0.000002$) and the Rural landscape ($p = 0.000003$). The average respondent had a land parcel of 7.8 ha (Table 2.1), but varied significantly by landscape ($F = 14.41$; $df = 2, 936$; $p = 0.000001$), with the Rural landscape differing from the Suburban ($p = 0.0033$) and the Urban ($p = 0.000002$) landscapes. The types of occupations were significantly different ($\chi^2 = 70.17$; $df = 12$; $p < 0.0000005$) across the three landscapes as evidenced by the drastic differences in proportions per occupation (Table 2.2).

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. Of these 635 landowners, the percent that fed birds in each landscape was quite similar ($\chi^2 = 0.455$; $df = 2$, $p = 0.80$): 64.6% (137 of 212) for Rural, 67.4% (157 of 233) for Suburban, and 65.2% (341 of 523) for Urban. The number of bird feeders ranged from 1 to 17.5, with an average of 2.98 ± 0.08 (Figure 2.2). On the basis of the land owned by

respondents, the average respondent had 5.78 ± 0.51 bird feeders/ha. Both the number ($F = 3.31$; $df = 2, 617$; $p = 0.037$; Figure 2.3A) and density ($F = 16.89$; $df = 2, 599$; $p < 0.0000005$; Figure 2.3B) of bird feeders varied significantly across all landscapes. With regard to specific landscape differences, there was a marginal difference in the number of bird feeders between the Rural and Urban landscapes ($p = 0.06$), and significant differences in bird feeder density between Suburban and Urban landscapes ($p = 0.000004$) and the Rural and Urban landscapes ($p = 0.000026$). The average landowner fed birds 9.30 ± 0.13 ($N = 627$) months out of the year and had been feeding birds on their property for 11.04 ± 0.44 ($N = 626$) years (Table 2.3). 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 2.4). A significant difference existed across landscape ($F = 4.09$; $df = 2, 624$; $p = 0.017$) based on the number of months per year that landowners fed birds (Table 2.3); this was due to a significant difference between the Urban and Suburban landscapes ($p = 0.012$). No difference existed across landscapes ($F = 1.38$; $df = 2, 623$; $p = 0.25$) based on number of years that landowners had been feeding birds (Table 2.3). Nearly all landowners (96.4%) that fed birds expressly indicated that they will continue feeding birds into the future.

A total of 442 (45.7%) landowners had at least one bird house on their property, with the percent of landowners along each route showing a similar proportion of involvement (45.8% for Rural, 50.6% for Suburban, and 44.2% for Urban; $\chi^2 = 2.732$; $df = 2$; $p = 0.26$). The number of bird houses ranged from 1 to 48, with an average of 3.76 ± 0.19 (Figure 2.5). On the basis of the land owned by respondents, the average landowner had 5.17 ± 0.62 bird houses/ha. Both the number ($F = 8.02$; $df = 2, 439$; $p = 0.00038$;

Figure 2.6A) and density ($F = 5.33$; $df = 2, 429$; $p = 0.0052$; Figure 2.6B) of bird houses were significantly different across the three landscapes. Specific route differences existed between both the Rural and Urban landscapes ($p = 0.00019$) and the Rural and Suburban landscapes ($p = 0.036$) for the number of bird houses (Figure 2.6A), while on a per unit area basis only the Urban and Suburban landscapes ($p = 0.0038$) were different. The average landowner had a bird house on their land for 9.35 ± 0.54 ($N = 438$) years (Table 2.3). No difference existed across landscapes ($F = 0.94$; $df = 2, 435$; $p = 0.39$) based on number of years that landowners had bird houses on their land (Table 2.3). As with bird feeding, nearly all landowners (96.4%) that 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 bird use. The proportion of landowners that planted or maintained vegetation on their property was significantly different across the three landscapes ($\chi^2 = 6.113$; $df = 2$; $p = 0.047$), which was due to the lower proportion in the Urban landscape (51.1% for Urban, 57.9% for Suburban, 59.9% for Rural). 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.” Of the respondents indicating which types of vegetation they planted 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 2.4). Proportionally, across landscapes there was no difference 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 (Table 2.4; $\chi^2 = 6.26$; $df = 2$; $p = 0.044$). Specifically, the Suburban landscape had a far greater proportion of respondents that planted ornamental shrubs and bushes than the Rural or Urban landscapes (Table 2.4). In contrast, landowners along the Suburban landscape planted a lower proportion of vines than Rural or Urban respondents (Table 2.4).

Out of 912 respondents that answered the question about gardening, landscaping, fertilizing, and spraying pesticides or herbicides 861 (94.4%) carried out at least one of the activities (Table 2.5). No difference existed across the landscapes in the frequency of respondents that 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 2.5). However, there was a significant difference in the frequency of respondents that applied pesticides or herbicides across landscapes ($\chi^2 = 22.17$; $df = 2$; $p = 0.000015$), with the greatest frequency on the Rural landscape and the least on the Urban landscape (Table 2.5).

Correspondence Between Activities

The seven activities investigated allowed for 21 (($N - 1$)!) pairwise comparisons, of which 16 were significantly related with one another (Table 2.6).

Comparison of Landowners Participating in Activities Versus Non-Participants

The average age ($N = 615$) of the respondents that fed birds was 51.7 ± 0.54 years compared to 48.5 ± 0.77 years for respondents not feeding birds ($N = 305$), yielding a significant difference in age ($t = 3.401$; $df = 918$; $p = 0.0007$) and support for the

prediction that landowners that feed birds would be older than those who do not.

Whether or not a landowner fed birds, based on their age, remained significantly different ($F = 11.28$; $df = 1, 916$; $p = 0.00082$) with the incorporation of the insignificant categorical variable of landscape ($F = 0.16$; $df = 2, 916$; $p = 0.85$). The household size of landowners that fed birds was 2.85 ± 0.06 compared to 2.86 ± 0.08 that did not feed birds, indicating no significant difference ($t = -0.077$; $df = 923$; $p = 0.94$). In terms of education, landowners that fed birds had a lower level of formal education (3.42 ± 0.06 ; see Methods for description) compared to landowners that did not feed birds (3.71 ± 0.08), resulting in a significant difference ($t = -2.81$; $df = 920$; $p = 0.005$). Educational level between respondents that fed birds and those that did not remained significantly different ($F = 9.19$; $df = 1, 918$; $p = 0.0025$) with the inclusion of landscape, which was a significant variable ($F = 0.81$; $df = 2, 918$; $p = 0.44$). A gender difference existed when comparing respondents that fed birds versus those not feeding birds ($\chi^2 = 4.37$; $df = 1$; $p = 0.037$); a greater percentage of women indicated that they feed birds than men (58.1% women vs. 41.9% men). The significant difference remained for gender ($F = 4.25$; $df = 1, 920$; $p = 0.04$) when landscape was included, which was not a significant variable ($F = 0.21$; $df = 2, 920$; $p = 0.81$). Landowners that fed birds did not differ with regard to occupation compared to landowners that did not feed birds ($\chi^2 = 8.70$; $df = 6$; $p = 0.19$). Finally, no difference existed between the two groups based upon the size of the house or residence ($t = -0.065$; $df = 855$; $p = 0.95$).

The average age ($n = 430$) of the respondents that had bird houses on their property was 52.3 ± 0.64 years compared to 48.8 ± 0.60 years for respondents not having bird houses ($n = 487$), yielding a significant difference in age ($t = 3.999$; $df = 915$; $p =$

0.000069). This difference provides support for the second prediction that landowners providing bird houses would be significantly older than those who did not. The significant difference in ages remained ($F = 14.62$; $df = 1, 913$; $p = 0.00014$) with the incorporation of landscape, which was not significant ($F = 0.86$; $df = 2, 913$; $p = 0.42$). Landowners that had bird houses had an average of 2.79 ± 0.07 living in their residence versus 2.92 ± 0.06 people those without, yielding no difference ($t = -1.490$; $df = 920$; $p = 0.14$). Similarly, no difference existed ($t = -0.372$; $df = 917$; $p = 0.71$) between respondents that had bird houses (3.51 ± 0.07) and those that did not (3.55 ± 0.07) based upon educational level. The approximate size of the residences (1,500 to 2,000 sq. ft.) were similar between landowners that had bird houses and those that did not ($t = 0.514$; $df = 853$; $p = 0.61$). No gender difference existed between landowners that provided bird houses and those that did not ($\chi^2 = 1.99$; $df = 1$; $p = 0.16$). Similarly, no difference existed based upon occupation between landowners that provided bird houses and those that did not ($\chi^2 = 3.82$; $df = 6$; $p = 0.70$).

Landowners that planted or maintained vegetation on their property were on average significantly older (51.7 ± 0.59 versus 48.9 ± 0.66 ; $t = 3.159$; $df = 916$; $p = 0.0016$) than landowners that did not. This age difference supports the third prediction that landowners involved in planting and maintaining vegetation would be older than those who do not. The significant difference remained ($F = 8.16$; $df = 1, 914$; $p = 0.0044$) with the significant incorporation of landscape ($F = 3.35$; $df = 2, 914$; $p = 0.036$). No significant interaction occurred between landscape and whether or not a landowner planted or maintained vegetation ($F = 1.37$; $df = 2, 912$; $p = 0.26$). The average number of people living in households that planted or maintained vegetation was 2.81 ± 0.06

compared to 2.90 ± 0.07 in households that did not plant or maintain vegetation, indicating no difference ($t = -1.007$ $df = 921$; $p = 0.31$). Similarly, no difference existed ($t = 0.052$; $df = 918$; $p = 0.96$) between respondents that planted vegetation (3.53 ± 0.06) and those that did not (3.52 ± 0.07) based upon educational level. The approximate size of the residences (1,500 to 2,000 sq. ft.) were similar between landowners that planted and maintained vegetation and those that did not ($t = -0.196$; $df = 854$; $p = 0.84$). A gender difference existed between landowners that planted and maintained vegetation and those that did not, with female respondents indicating they participated more frequently than male respondents ($\chi^2 = 8.00$; $df = 1$; $p = 0.0047$). This gender difference remained ($F = 7.79$; $df = 1$, 918; $p = 0.005$) with the significant incorporation of landscape ($F = 3.71$; $df = 2$, 918; $p = 0.025$), but did not have a significant interaction with gender ($F = 0.44$; $df = 2$, 916; $p = 0.64$). No difference existed in the proportion of landowners planting and maintaining vegetation based upon their occupation ($\chi^2 = 4.37$; $df = 6$; $p = 0.63$).

Landowners that gardened were slightly older (50.9 ± 0.5 vs 49.1 ± 0.9) than landowners that did not, but not significantly so ($t = 1.802$; $df = 881$; $p = 0.072$). Landowners that gardened had a similar number of people in their household as non-gardeners (2.9 ± 0.05 versus 2.8 ± 0.09), indicating no difference ($t = 1.358$; $df = 883$; $p = 0.17$). The level of formal education between landowners that gardened (3.5 ± 0.06) and those that did not (3.6 ± 0.10) were similar ($t = -0.826$; $df = 881$; $p = 0.41$). Landowners that gardened had similar sized residences as those that did not ($t = -0.064$; $df = 824$; $p = 0.95$). A gender difference existed between landowners that gardened and those that did not, with female respondents participating in greater frequency than male respondents (χ^2

= 10.16; $df = 1$; $p = 0.0014$). This difference remained significant ($F = 10.39$; $df = 1$, 880; $p = 0.0013$) when the insignificant variable of landscape ($F = 0.75$; $df = 2$, 880; $p = 0.47$) was incorporated into the model. No difference existed in the proportion that gardened based upon their occupation ($\chi^2 = 8.53$; $df = 6$; $p = 0.20$).

Landowners that landscaped their property were significantly younger (49.1 ± 0.52) than landowners that did not (54.1 ± 0.85 ; $t = -4.961$; $df = 881$; $p = 0.000001$). The addition of landscape to the model was not significant ($F = 1.41$; $df = 2$, 879; $p = 0.25$), while age remained significant ($F = 24.75$; $df = 1$, 879; $p = 0.000001$). Similarly, landowners that landscaped had significantly ($t = 2.486$; $df = 883$; $p = 0.013$) more people living in their residences (2.9 ± 0.05 versus 2.7 ± 0.09). The addition of landscape to the model was not significant ($F = 1.35$ $df = 2$, 881; $p = 0.26$). Landowners that landscaped had marginally more education than landowners that did not (3.60 ± 0.06 versus 3.38 ± 0.09 ; $t = 1.915$; $df = 881$; $p = 0.056$). In terms of house size, landowners that landscaped had significantly larger homes (1,500 to 2,000 ft^2 compared to 1,000 to 1,500 ft^2) than landowners that did not ($t = 4.505$; $df = 824$; $p = 0.000008$). The difference remained based on house size ($F = 18.94$; $df = 1$, 822; $p = 0.000015$) when the insignificant term of landscape was included ($F = 0.08$; $df = 2$, 822; $p = 0.92$). There was no difference in the proportion of men or women that landscaped and those that did not ($\chi^2 = 2.70$; $df = 1$; $p = 0.10$). However, a difference existed in the proportion of landowners that landscaped based upon their occupation ($\chi^2 = 25.28$; $df = 6$; $p = 0.0003$), with managerial and professional respondents participating in the greatest frequency and the farming, forestry, and fishery respondents participating in the lowest frequency. The difference remained ($F = 4.15$; $df = 6$, 846; $p = 0.00041$) with the addition of landscape, which was not

significant ($F = 0.16$; $df = 2, 846$; $p = 0.85$).

Landowners that applied fertilizer on their property were the same age (50.4 ± 0.63) as those that did not (50.4 ± 0.64), indicating no difference ($t = -0.210$; $df = 881$; $p = 0.83$). Similarly, there was no difference in the number of people living in the residences of those that fertilized (2.9 ± 0.07) compared to those that did not (2.8 ± 0.07 ; $t = 1.584$; $df = 883$; $p = 0.11$). No difference existed ($t = -0.243$; $df = 881$; $p = 0.81$), in terms of education, between landowners that fertilized and those that did not. Likewise no difference existed between landowners that fertilized compared to those that did not based upon the size of the residence ($t = 1.260$; $df = 824$; $p = 0.21$). No difference existed in the proportion of each gender that fertilized or not ($\chi^2 = 0.79$; $df = 1$; $p = 0.38$). However, a difference existed in the proportion of landowners that fertilized based upon their occupation ($\chi^2 = 12.72$; $df = 6$; $p = 0.048$), with the managerial and professional respondents participating in the greatest frequency and the service respondents participating in the lowest frequency. This significant difference based on occupation remained ($F = 2.22$; $df = 6, 846$; $p = 0.040$), with the addition of landscape, which was not significant ($F = 0.29$; $df = 2, 846$; $p = 0.75$).

Landowners that applied pesticides and/or herbicides to their property were of a similar age (51.4 ± 0.9) as those that did not (50.1 ± 0.5 ; $t = 1.256$; $df = 881$; $p = 0.21$). Similarly, no difference existed in the size of the household between those that applied pesticides and those that did not ($t = 0.985$; $df = 883$; $p = 0.32$). Likewise no difference existed in the educational level of landowners that applied pesticides compared to those that did not ($t = 1.067$; $df = 881$; $p = 0.29$). However, landowners that applied pesticides and/or herbicides did have significantly larger homes than landowners that did not apply

them ($t = 2.716$; $df = 824$; $p = 0.0067$). The significant difference in house size remained ($F = 5.99$; $df = 1, 822$; $p = 0.015$) with the significant incorporation of landscape ($F = 8.09$; $df = 2, 822$; $p = 0.00033$). There was no significant interaction between landscape and whether or not a landowner applied pesticides and/or herbicides based upon house size ($F = 1.91$; $df = 2, 820$; $p = 0.15$) when the interaction term was added to the model. No difference existed in the proportion of each gender that applied pesticides and/or herbicides compared to those that did not ($\chi^2 = 0.06$; $df = 1$; $p = 0.80$). A difference did exist in the proportion of landowners that applied pesticides and/or herbicides based on their occupation ($\chi^2 = 34.20$; $df = 6$; $p = 0.000006$), with the managerial and professional respondents participating in the greatest frequency and the service respondents participating in the lowest frequency. The difference remained significant ($F = 4.48$; $df = 6, 846$; $p = 0.00018$) with the incorporation of landscape, which was significant ($F = 7.02$; $df = 2, 846$; $p = 0.00095$). However, there was no interaction ($F = 0.73$; $df = 12, 834$; $p = 0.72$) between landscape and occupation when it was included in the model.

DISCUSSION

Of greatest note, our results highlight the fact that cumulatively across the landscape a significant portion (~50% or more) of landowners are both intentionally and unintentionally engaged in activities that can influence avian populations, except for pesticide and/or herbicide application. 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 non-respondents were not engaged in any activity), the

percent of landowners across the landscape engaged in an activity remains large (Table 2.7). On the other hand, taking a liberal approach, which assumes that every non-respondent was engaged in each activity, the percent of landowners involved in any of the activities becomes extremely large (Table 2.7). Although it is implausible that all non-respondents are engaged in each of the activities, it is also unlikely that all non-respondents 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.

Because the landscapes of Southern Michigan are 90% privately owned (Rutledge 2001), the proportion of landowners engaged in each activity covers a large portion of the total landscape. Consequently, at both the individual land parcel and the landscape scales, landowners are in all likelihood having a large and sustained influence on avian, and other wildlife species, abundances and populations. Furthermore, as the spatial patterns of human habitation in this portion of Michigan are not random, but tend towards aggregation near natural amenities, such as bodies of water (Walsh 2000), which are also used by bird species, the effects could be more pronounced.

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 the landscape might contain feeders (U.S. Department of the Interior et al. 1997). 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 landscape that has bird feeders, but the density with which they occur. In terms of temporal feeding patterns, our finding that landowners feed an average of nine out of twelve months a year is greater than the national average reported by the USFWS (U.S. Department of the Interior et al. 1997). However the observation that most bird feeding done in the winter months mirrors that of other studies (Cowie and Hinsley 1988). As our findings suggest, the proportion of landowners that are involved or potentially involved (Table 2.7) in bird feeding, coupled with the density of feeders and length of time the feeders have been present, is great enough that at the landscape scale there is likely a positive effect on species that either are obligate seed foragers (i.e., granivores), such as Northern Cardinals (Richmondia cardinalis), or can utilize 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, and oranges), 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, that may well translate into higher

survival rates and population numbers for species that can utilize them.

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 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 reported having bird houses on their land, even taken conservatively (Table 2.7), indicates that a large portion of the landscape has supplemental housing opportunities for birds. While our survey did not evaluate whether or not each bird house was being used each year, the high per parcel densities (Figure 2.4B) coupled with their long-term presence indicates that bird houses are likely at least aiding in the presence and survival of some species. Moreover, if potential nesting habitat (e.g., snags, dead trees, low shrubs) has been lost on the landscape, the establishment of bird houses may provide a compensatory mechanism by which species are able to either continue persisting on the landscape or experience slower declines than would be so if no bird houses were present.

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 that actually carry out these activities. The closest estimate to be found is from the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation, which found that approximately 15% of the individuals it surveyed planted or maintained vegetation for the benefit of wildlife (U.S. Department of the Interior et al. 1997).

Taking the minimum estimate of landowners in our survey that planted or maintained

vegetation to be 32% (Table 2.7), our findings are double the previous estimate. Notably, however, comparing individuals and “wildlife” from the USFWS survey with landowners and birds from our survey is tenuous as they are not exact synonyms. Furthermore, landowners in Southeast Michigan may be quite different than the average national respondent. Given the large portion of landowners engaged in planting or maintaining vegetation, 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 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, while our survey only broke categories down into vines, fruit bearing plants, ornamentals, and “other,” and not exotic versus native, it is likely that a large portion of the landowners that planted vegetation did plant exotic species.

While gardening and landscaping may be viewed as similar to planting and maintaining vegetation, they are inherently different activities. Furthermore, we specifically framed the question about planting and maintaining vegetation 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 2.6). While 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 utilize the habitat. Ultimately, whether gardening is beneficial or detrimental to birds overall is unknown, but our data indicate that regardless of its influence that it is a highly 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 et al. 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 et al. 2001). Although half of the landowners (Table 2.5) applied fertilizer to their property, we did not ascertain the type of fertilizer used, the frequency of input, or where it was applied on the property. Regardless, the fact remains that at the landscape scale (Table 2.7) landowners are inputting a large amount of fertilizer that may directly or indirectly influence bird species.

Since Rachel Carson's seminal work Silent Spring (Carson 1962), there has been a steady track of research identifying the effects of pesticides and herbicides on bird species. Although many of the most notable chemicals (e.g., Chlordane, DDT, etc.) have been phased out of use, there remain a number of current chemicals that are displaying direct effects on the growth and development of birds (Bishop et al. 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 et al. 1994, Newton

1995). Thus, our finding that one in four landowners apply pesticides or herbicides to their land represents somewhere between 14% to 55% (Table 2.7) of the landscape that may be unsuitable or less suitable as bird habitat, assuming equal size parcels. Moreover, the applications were most proliferate along the Rural landscape and among landowners that are primarily farmers, and thus had larger land parcels. As a result, many potential habitat locations may be less suitable than indicated through either land cover (Rutledge 2001) or parcel size.

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 (Chapter 1). 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 (Figure 2.7). Moreover, the majority of these activities show strong correlation with one another (Table 2.6) indicating that there are likely synergistic effects of these activities.

Differences in Activities Across Landscapes

Across the three landscapes we found many marked differences in both the landowners and the activities they engaged in. Specifically, we found differences in the age, education, house size, occupation, and parcel size across the three routes (Tables 2.1 and 2.2). Similarly, we found significant differences in the number and density of bird feeders (Figures 3A and 3B), the months spent feeding (Figure 2.4), the number and density of bird houses (Figures 2.6A and 2.6B), the proportion of landowners that planted or maintained vegetation for birds (Table 2.4), the proportion that planted ornamentals

and vines (Table 2.4), and the use of pesticides (Table 2.5). However, we found no differences in either the gender of the respondent or the number of residents living on the property (Table 2.1). Similarly, we found no difference in the proportion of landowners that feed birds or have bird houses, the length of time that landowners supplied bird food or houses, or in the proportions that planted fruit, gardened, landscaped, or fertilized (Table 2.5).

The result of differences across 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 (Figure 2.3A) and houses (Figure 2.6A) as well as showed the greatest propensity to plant or maintain vegetation for birds (Table 2.4) and use pesticides and herbicides (Table 2.5). On the other hand, the Rural landowners had the lowest density of bird feeders (Figure 2.3B), which is likely due to their larger parcel size, and had bird houses on their property the shortest amount of time. As a result, Rural landowners are influencing their land in such a way as to encourage bird habitation, but are using chemical inputs that may have a certain counteracting effect.

Landowners living in the Suburban landscape had been involved in providing bird food and houses (Table 2.3) the longest (or similarly as long) as well as showed the greatest propensity to plant ornamental vegetation (Table 2.4). However, the Suburban landowners had the lowest densities of bird feeders (Figure 2.3B) and houses (Figure 2.6B), spent the least months feeding per year (Table 2.3), and planted the least amount of vines (Table 2.4). The result of these activities indicates that suburban landowners have a long-term interest in promoting bird habitat.

In the case of the Urban landowners, they had the greatest density of bird feeders

(Figure 2.3B) and houses (Figure 2.6B), spent the most months feeding birds (Table 2.3), and had bird houses as long as the Suburban landowners. On the other hand, Urban landowners had the lowest number of bird feeders (Figure 2.3A) and houses (Figure 2.6A), planted or maintained vegetation the least, and had the lowest pesticide and herbicide application (Table 2.5). While the numbers of feeders and houses were lower, they were at very high densities. Coupled with the high density of supplementation is also the fact that Urban landowners used the lowest amount of pesticides and herbicides, which together could result in more highly suitable habitat for birds than might be previously thought. Taken together the differences in activities across the landscapes lend credence for the differences in bird abundances and diversity often noted along urban to rural gradients or in urban contexts (e.g., Emlen 1974, Hohtola 1978, Cam et al. 2000)

Hypotheses Tested

Based upon the 1996 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (U.S. Department of the Interior et al. 1997) we had predicted that landowners involved in (1) bird feeding, (2) providing bird houses, and (3) planting and maintaining vegetation for birds would be older than nonparticipants. As our results highlight, we found that for each of these three activities the landowners that participated were significantly older than the nonparticipants, yielding support for our predictions. Specifically, landowners that fed birds were 51.7 ± 0.54 years old compared to 48.5 ± 0.77 years for landowners that did not feed birds. Similarly, landowners that had bird houses on their property were 52.3 ± 0.64 years old compared to 48.8 ± 0.60 years for landowners that did not have bird houses on their property. Finally, landowners that

planted or maintained vegetation on their property were 51.7 ± 0.59 years old versus 48.9 ± 0.66 for landowners that did not plant or maintain vegetation on their property.

Comparison of Landowners Participating in Activities versus Nonparticipants

Although a number of differences were found between landowners that carried out a given activity and those that did not, there was no consistent trend or factor that explained the differences across all activities (Table 2.8). For example, while a significant difference in age was found for four of the activities, the landowners engaged in them were not always significantly older. Besides the lack of consistent socio-demographic factors that could explain the activities it is also important to note the fact that most of the activities had only one or two socio-demographic variables that resulted in a difference (Table 2.8). The lack of general trends among socio-demographic factors across the different activities is not an unusual finding given the wide range of activities investigated. However, as a consequence, the lack of general trends does indicate that management and conservation programs cannot be targeted to a specific subset of landowners based upon these factors.

Conclusion

The overall implications of our findings are that individual landowners are engaged in a multitude of activities, that when taken collectively, are almost certainly having some form of influence on avian species in particular and wildlife in general. While the levels of these activities varied across the landscapes, they were carried out on all landscapes and are not particularly unique to either Southeastern Michigan or the

Midwest. As a result our findings have direct relevance to the approximately 66% of the United States land that is in private ownership (Dale et al. 2000) as well as in any location where there is a large private land component. Moreover, because these activities likely have synergistic effects that both positively and negatively influence birds species in particular, and wildlife in general, our findings highlight the need to investigate the large scale and interactive nature of these activities.

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Table 2.1. Summary statistics of socio-demographic information by landscape. Values, except gender, are means $\pm$ SE, with values in parentheses indicating the sample size. Superscript letters represent significant differences between landscapes: a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban.

	Landscape			Average
	Rural	Suburban	Urban	
Respondent Age ^b	51.7 $\pm$ 0.96 (206)	52.8 $\pm$ 0.85 (221)	49.2 $\pm$ 0.60 (503)	50.6 $\pm$ 0.44 (930)
Number of People in Residence	2.80 $\pm$ 0.09 (207)	2.90 $\pm$ 0.09 (220)	2.84 $\pm$ 0.06 (508)	2.85 $\pm$ 0.05 (935)
Gender (M, F)	112, 94	110, 112	276, 230	498, 436
Respondent Educational level ^{1,a,b,c}	3.03 $\pm$ 0.09 (204)	4.09 $\pm$ 0.11 (223)	3.46 $\pm$ 0.06 (505)	3.52 $\pm$ 0.05 (932)
Size of House or Residence ^{2,a,b}	3.12 $\pm$ 0.10 (180)	3.82 $\pm$ 0.09 (203)	3.03 $\pm$ 0.06 (484)	3.23 $\pm$ 0.05 (867)
Parcel Size (ha) ^{a,c}	18.2 $\pm$ 3.67 (206)	7.85 $\pm$ 1.36 (231)	3.44 $\pm$ 1.21 (502)	7.76 $\pm$ 1.10 (939)

¹Educational level was a categorical response from 1 to 6 (see Methods), with a higher number indicating a higher level of education.

²Size of house or residence was a categorical response from 1 to 7 (see Methods), with a higher number indicating greater amount of living area.

Table 2.2. Occupations of respondents by landscape. 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 please see Methods.

	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)

Table 2.3. Time engaged in providing bird feed and houses by landscape. Values are means $\pm$ SE, with values in parentheses indicating the sample size. Superscript letters represent significant differences between landscapes: a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban.

	Landscape			Average
	Rural	Suburban	Urban	
Months per year feeding birds ^b	9.27 $\pm$ 0.27 (135)	8.72 $\pm$ 0.26 (157)	9.58 $\pm$ 0.17 (335)	9.30 $\pm$ 0.13 (627)
Number of years feeding birds	10.81 $\pm$ 0.95 (134)	12.31 $\pm$ 1.03 (156)	10.54 $\pm$ 0.56 (336)	11.04 $\pm$ 0.44 (626)
Number of years having bird houses	7.95 $\pm$ 0.72 (95)	9.74 $\pm$ 0.76 (116)	9.74 $\pm$ 0.91 (227)	9.35 $\pm$ 0.54 (438)

Table 2.4. Number of landowners in each landscape that planted specific types of vegetation. The percent of respondents (based on proportion of column total) that planted each type of vegetation within a landscape are indicated in parentheses. Superscript letters represent significant differences between landscapes: a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban.

	Landscape			
	Rural	Suburban	Urban	Total
Number of respondents that planted or maintained vegetation ^a	126	135	263	524
Fruit trees or bushes	86 (68.3)	97 (71.9)	179 (68.1)	362 (69.1)
Ornamental shrubs or bushes ^a	89 (70.6)	112 (83.0)	188 (71.5)	389 (74.2)
Vines ^a	59 (46.8)	44 (32.6)	114 (43.3)	217 (41.4)
Other	54 (42.9)	58 (43.0)	97 (36.9)	209 (39.9)

Table 2.5. Number and percent (in parenthesis) of landowners involved in gardening, landscaping, fertilizing, and applying herbicides or pesticides. Superscript letters represent significant differences between landscapes: a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban.

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

Table 2.6. Percent of landowners that carried out each activity in combination. Numbers in parentheses indicate sample size.

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)*	-

* $p < 0.000005$

† $p < 0.05$

Table 2.7. Minimum and maximum percent of landowners across all landscapes engaged in each activity. Minimum percent is based on the number of respondents carrying out a given activity divided by total survey sample size (N = 1,654). Maximum percent is based on the number of respondents carrying out a given activity plus the number of non-respondents (n = 686) divided by the total survey sample size.

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

Table 2.8. Comparison of landowners involved in a given activity versus those not involved based upon selected socio-demographic factors. A check mark indicates a significant difference was observed between the two groups.

Activity	Socio-demographic Factors					
	Age of Respondent	# 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					✓	✓

FIGURE LEGENDS

Figure 2.1. Location of the three 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 39.8 km in length.

Figure 2.2. Frequency distribution of the number of bird feeders per landowner for landowners that fed birds.

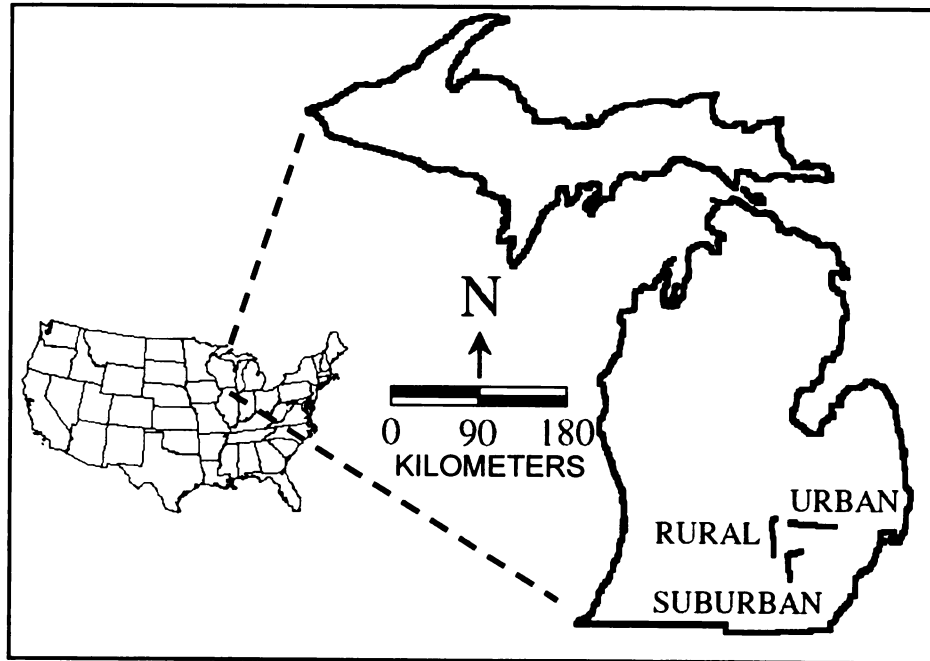
Figure 2.3. Number (A) and density (B) of bird feeders along the three different BBS routes among landowners that fed birds.

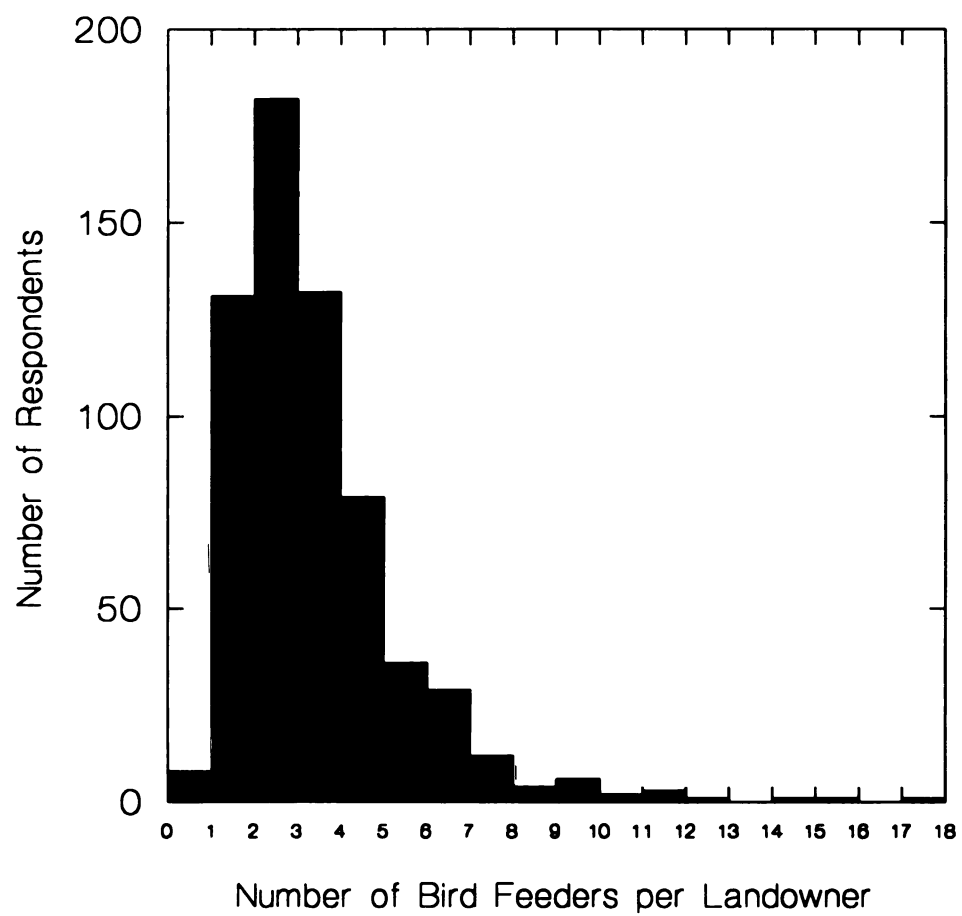
Figure 2.4. Number of landowners feeding birds each month. The three routes are denoted as follows: Rural (●), Suburban (▲), Urban (◆), and the total of all routes (■).

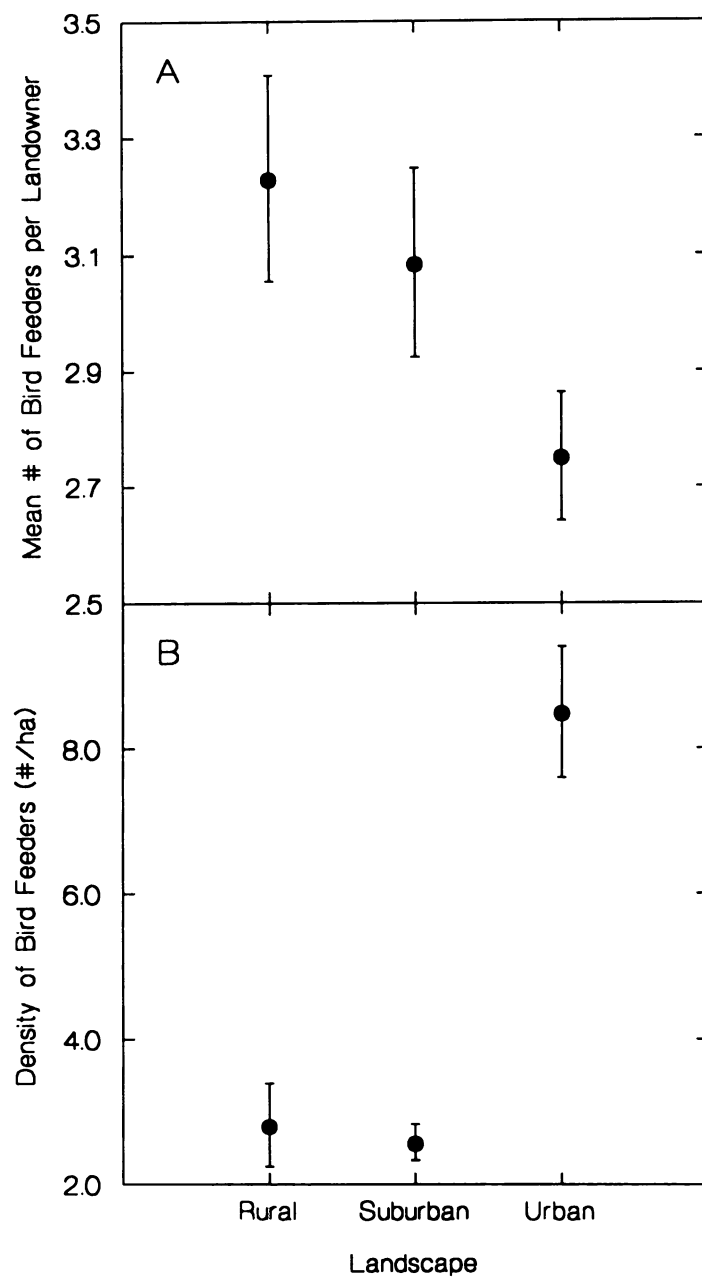
Figure 2.5. Frequency distribution of the number of bird houses per landowner for landowners that had bird houses.

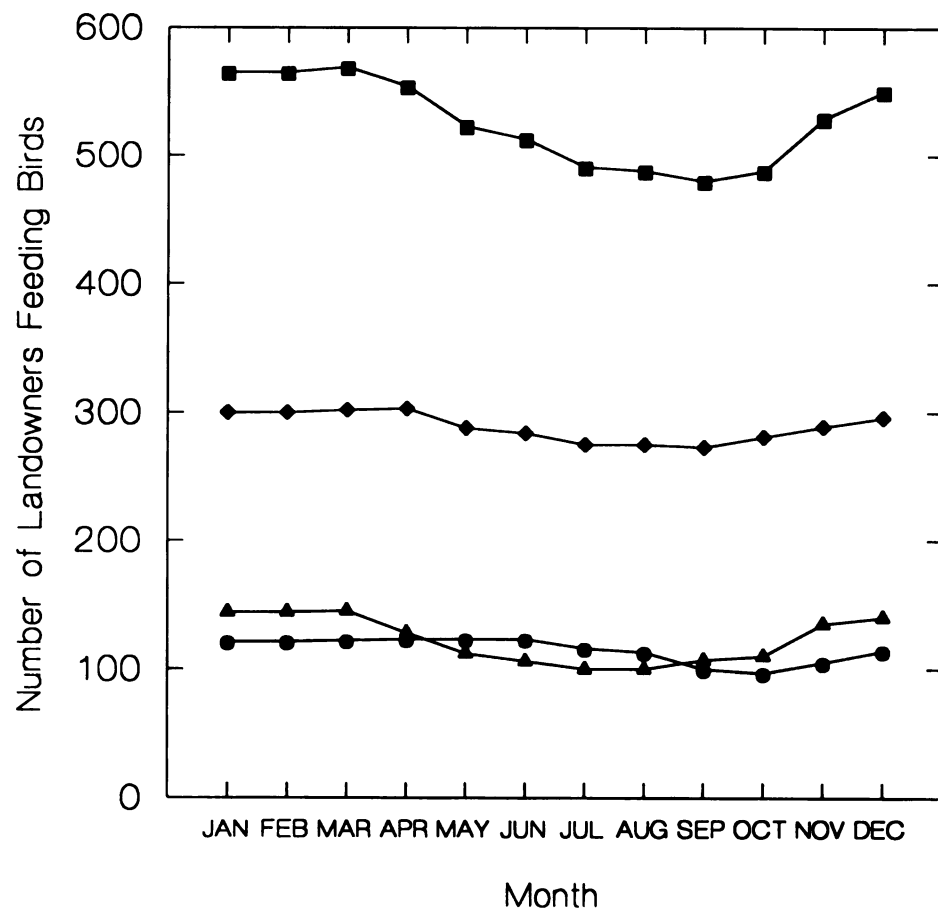
Figure 2.6. Number (A) and density (B) of bird houses along the three different BBS routes among landowners that had bird houses.

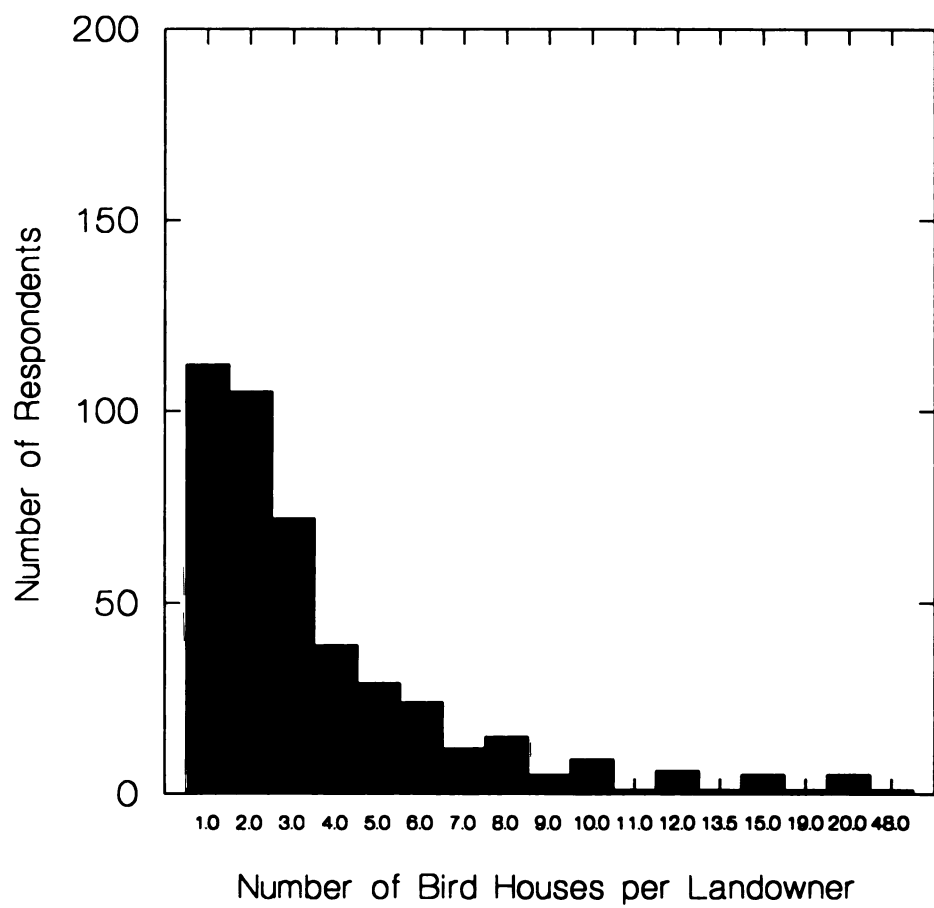
Figure 2.7. Number of activities each landowner is engaged in by the number of respondents.

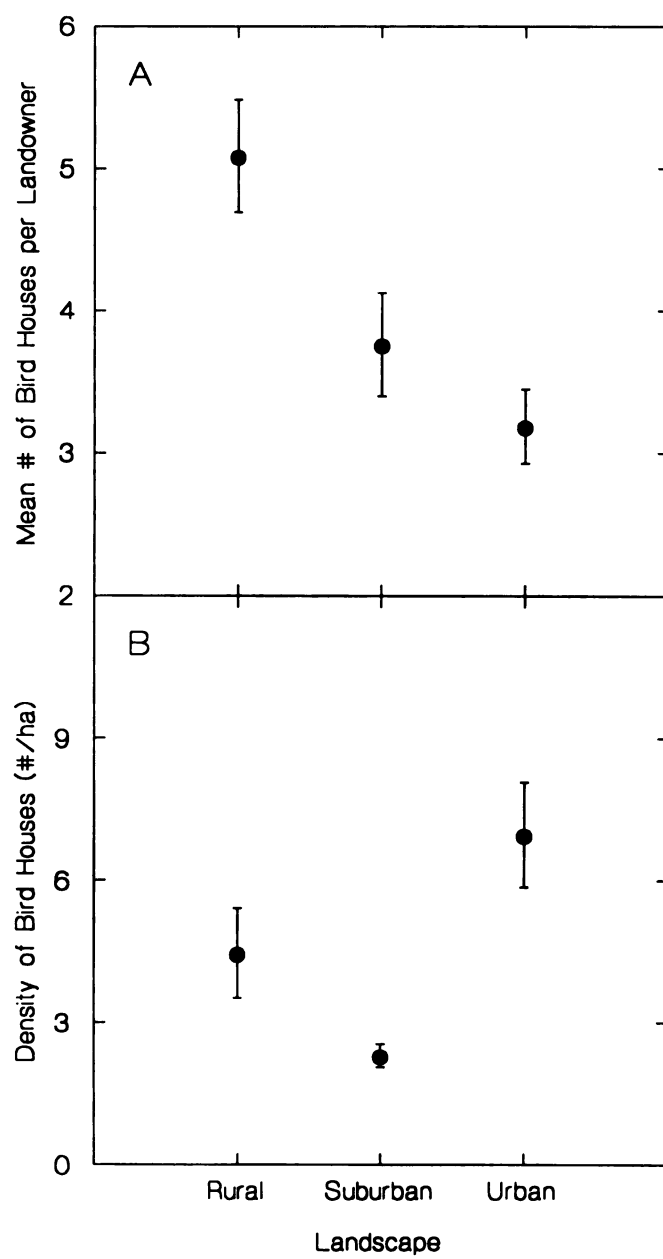


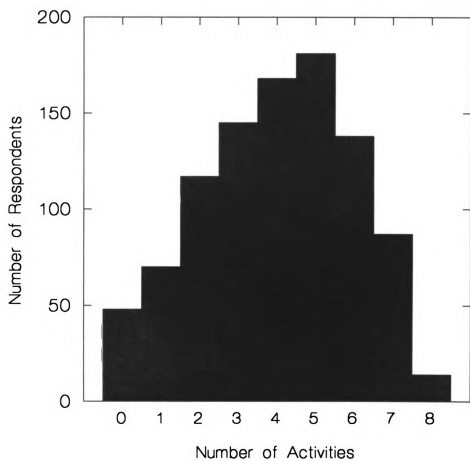












CHAPTER 3

LANDOWNER PERCEPTIONS AND ACTIVITIES RELATED TO BIRDS ACROSS RURAL-TO-URBAN LANDSCAPES

ABSTRACT

Fluctuations of bird abundances in the Eastern and Midwest regions of the United States have been attributed to such factors as supplemental feeding, landscape fragmentation, and depredation. Underlying these factors, but notably absent from consideration, is the role of private landowners. To investigate how landowners perceive and may influence birds, we surveyed all ~1,700 private landowners living on three North American Breeding Bird Survey (BBS) routes (~120 linear km) in Southeastern Michigan, USA, that represent a continuum of rural-to-urban landscapes. Our survey assessed both the landowners' perceptions about birds and the activities in which they were engaged. Of the 969 (59% response rate) respondents, the typical landowner indicated that the number of birds frequenting their property had increased over time and that having bird diversity on their property was very important. Large numbers of landowners engaged in activities assumed to have positive effects on birds: feeding birds (66%), providing bird houses (46%), and maintaining vegetation specifically for birds (54%). A substantial minority, however, engaged in activities with negative implications for birds: 49% applied fertilizer on their land, 25% applied pesticides or herbicides on their land, and 26% of landowners had outdoor house cats. While 95% of landowners were engaged in at least one activity that had possible implications for bird numbers, the average landowner was only slightly willing to change their land use practices for the benefit of birds. Overall, landowners who had more favorable perceptions of birds also tended to engage in a significantly greater number of activities that could have positive effects on birds. Interestingly, however, landowners' perceptions of birds were largely

unrelated to whether they engaged in activities with negative implications for birds or not. Across the three landscapes there were significant differences in landowner perceptions and activities. Our results indicate that landowners tend to perceive birds positively, but are engaged in a wide variety of positive and negative activities that both intentionally and unintentionally have profound influences on birds at the landscape scale.

INTRODUCTION

Bird populations throughout the Midwest and Eastern portions of the United States have displayed marked fluctuations in recent decades (Robbins *et al.*, 1989). These changes have generally been attributed to such interrelated factors as habitat fragmentation and destruction (Donovan & Flather, 2002), landscape change (Flather & Sauer, 1996), nest predation (Heske *et al.*, 2001), cowbird parasitization (Robinson *et al.*, 1995), and direct mortality due to events (e.g., culling by farmers) on the wintering-grounds of the neotropics (Basili & Temple, 1999). A common denominator underlying these factors, but notably absent from consideration among the potential mechanisms responsible for influencing breeding bird abundances, are the landowners that live in the landscapes being investigated.

Landowners are of particular relevance to understanding bird abundances because they are the ultimate controllers of their land. As such, landowners' perceptions of birds and their land as well as the types of activities they engage in on their land can have significant repercussions for the birds that frequent or inhabit landscapes containing large amounts of private land. Furthermore, landowners living in rural landscapes may perceive both birds and their land differently than landowners in more urbanized landscapes, or they may carry out activities at different levels. Such differences may in part explain the substantial variations in bird abundances and diversity often noted along urban to rural gradients or in urban contexts (Hohtola, 1978; Cam *et al.*, 2000). Because of the potential for significant landowner effects on birds there has been increased

attention directed towards the integration of social components into questions of avian distributions (Hostetler, 1999).

In directing attention toward how landowners may be influencing avian species it is important to consider what specific activities landowners 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 which directly impact birds. These include food and nesting supplementation, alteration or maintenance of vegetation, introduction of exotic predators, chemical application, landscaping and gardening, each of which has a known or strongly suspected relationship to birds.

Aside from understanding the degree to which landowners are involved in activities on their land, it is also of particular relevance to understand how they perceive birds. As is noted in social-psychological theory, attitudes toward some object (e.g., birds) typically precede actions taken with regard to that object (Ajzen & Fishbein, 1980). Thus, if landowners perceive birds or their land in positive or environmentally friendly ways then it follows that they will likely engage in activities that they perceive to positively influence birds. Furthermore, if landowners have positive perceptions of birds they may also be more willing to alter their behavior for the benefit of birds.

As part of a larger effort to understand and integrate the social and ecological factors influencing breeding bird abundances in different types of landscapes (Chapters 1 and 2), we sought to address the role of specific private landowner perceptions and activities. These perceptions and activities included: perception of changes (if any) in bird numbers on their property; the importance placed on bird diversity; observation of the number of birds that occur on the land; willingness to alter land use for the benefit of

birds; interest in tax easements or abatements; and participation in feeding birds, providing bird houses, planting and maintaining vegetation for the benefit of birds, gardening, landscaping, fertilizing, applying pesticides and herbicides, and allowing house cats (*Felis catus*) outdoors. Specifically, we were interested in ascertaining: 1) the perceptions of landowners; 2) the proportion of landowners involved in each activity; 3) if differences existed across a rural-to-urban gradient; and, 4) how landowner perceptions were related to the activities they engaged in that have possible ramifications for bird numbers.

METHODS

To address our research questions we chose three active North American breeding bird survey (BBS) routes (routes 53, 167, and 168) in Southeastern Michigan, USA (Figure 3.1), where >90% of the land is privately owned and undergoing rapid urbanization (Rutledge & Lepczyk, 2002). We chose these three routes in particular because they represent a continuum of landscapes from rural to urban, based on their geographic locations, average land parcel sizes, and socio-demographic compositions. The landscapes can be classified as Rural (route 53), Suburban (route 167), and Urban (route 168). In these study landscapes, we identified all private landowners who owned property immediately adjacent to the road along which the three BBS routes are run. In addition to personally driving all routes, we utilized county plat maps and tax records, identifying a total population of 1,694 private landowners (331 on Rural, 390 on Suburban, and 973 on Urban).

We administered a mail survey instrument between October and December of 2000 following the Total Design Method (Dillman, 1978). To encourage responses we established a toll-free telephone line for landowners to contact us with any questions and offered prize drawings as an incentive. Briefly, an initial survey was mailed during the first week of October 2000, followed by a postcard reminder/thank you two weeks later. Finally, a second survey was sent out two weeks after the postcard to landowners who had not responded to the prior mailings.

To ascertain what the landowners' attitudes and perceptions were and what activities they were involved with on their land that could influence bird species we asked the following questions on our survey: (1) Since you have owned or lived on your property, do you think that the number of birds visiting it during the summer months has: (decreased substantially, decreased slightly, stayed about the same, increased slightly, increased substantially, unsure)? (2) Having a variety of different bird species on or near your property is: (very unimportant, somewhat unimportant, somewhat important, very important, unsure)? (3) About how many different bird species are you aware of that live on or in the vicinity of your property? (4) Would you be willing to change how you use your land if it would help support bird species (definitely unwilling, possibly unwilling, possibly willing, definitely willing, unsure)? (5) If the government offered easements or tax abatements in exchange for preserving your land for birds or wildlife would you be interested (very disinterested, mildly disinterested, mildly interested, very interested, unsure)? (6) Does anyone in your household feed birds on your property (yes, no)? (7) Are there any bird houses on your property (yes, no)? (8) Have you planted vegetation or maintained landscaping on your property in order to benefit or encourage use by birds

(yes, no)? (9) Which of the following activities do you carry out on your land (gardening, landscaping, fertilizing, spraying pesticides or herbicides)? (10) How many cats does your household own that are allowed access to the outside? To investigate relationships between activities and perceptions and attitudes we developed an a priori classification that divided activities into two groupings based on their suspected impact upon bird numbers: positive activities consisted of bird feeding, providing bird houses, planting vegetation, gardening, and landscaping; negative activities consisted of applying fertilizer, spraying pesticide or herbicide, and allowing house cats outdoors. Participation in each activity was scored a "1" and non-participation was scored a "0"; each of the two groupings represents a summation of these separate activity scores (range 0 to 5 for positive activities; range 0 to 3 for negative activities).

Statistical analyses were performed using SYSTAT 10. We treated any "unsure" answers, except for number 1 above, as falling in the middle of the scale of answers for the relevant questions (i.e., 1 to 5, with unsure coded as a 3). Initial comparisons across landscapes were carried out with ANOVA, using a Bonferonni post hoc test for specific landscape differences. For landscape comparisons based on the proportion of landowners engaged in an activity a two-way contingency table with a Pearson Chi-square test was used. Principal components analysis was used to assess if our a priori classification of landowner activities matched the reported behaviors of landowners (i.e., did those reporting a positive activity also tend to report other positive activities and so on). Relationships between the perception of changes in bird numbers, importance of bird diversity, willingness to change land use, and interest in tax abatements and positive or negative activities were analyzed using a forward stepwise general linear model, in which

activities were the dependent variables. Specifically, a model was first tested with the perception versus the activity. If this simple model was significant then the categorical variable of landscape was added. Similarly, the landscape by perception interaction was only investigated if the previous route model was found significant. In the case of the number of different birds that landowners believed occurred on their land relative to their engagement in positive or negative activities, a linear regression was used, followed by a general linear model that included landscape if the relationship was significant. Data are reported as means $\pm$ SE (as 100% of the population was sampled, but only ~59% responded), unless otherwise noted, with a p-value of ≤ 0.05 considered significant.

Of the 1,694 landowners initially identified, 40 were removed from consideration because they were a business or church, had property outside the sampling region, already responded based on another parcel of land within the study landscapes, or their address information was incorrect, thus reducing the corrected population size to 1,654. Among these 1,654 we received 968 completed surveys, yielding a 58.5% response rate. Response rates per landscape 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 ($\chi^2_2 = 11.11$, $p = 0.0039$).

RESULTS

While landowners on average believed that the number of birds visiting their property during the summer months had slightly increased over time, the perception varied significantly across the three landscapes (Table 3.1). Similarly, having bird

diversity on one's property was viewed as somewhat to very important across all landscapes, but did vary significantly (Table 3.1). Of the landowners that were aware of at least one or more bird species living on or near their property, the average respondent could identify between sixteen and seventeen species; this showed no variation across the landscapes (Table 3.1). In regards to landowner attitudes towards altering their land for the benefit of bird species, the average landowner was slightly willing, but this varied across the landscapes (Table 3.1). Correspondingly, landowners were slightly interested in tax easements across the landscapes (Table 3.1).

Of the 968 landowners that responded, 95% (n = 920) were involved in at least one of the eight activities that were measured, with the average landowner engaged in 4.0 ± 0.06 of the activities. The percent of landowners involved in each activity ranged from ~20% to ~74%, depending upon the activity and the landscape (Table 3.2).

Proportionally, across the landscapes there were significant differences in the number of landowners that planted vegetation, applied pesticides and herbicides, and allowed their house cats outdoors (Table 3.2).

A principal components analysis of the activities resulted in three separate components, with bird feeding, bird houses, planting vegetation and gardening associated with the first component, fertilizing and applying pesticides or herbicides associated with the second component, and allowing house cats outdoors associated with the third component. The activity of landscaping split its loading across the three components. By considering both components two and three as negative activities for birds, our *a priori* categorization, at least in terms of reported participation by landowners, appears to be a reasonable one.

The average landowner was engaged in 3.0 ± 0.05 positive activities (of a possible 5) and 1.0 ± 0.03 negative activities (of a possible 3). Across landscapes no differences existed in the number of positive activities ($F_{2, 965} = 1.1, p = 0.33$), whereas a difference did exist in the number of negative activities ($F_{2, 965} = 8.7, p = 0.0002$). Specifically, the number of negative activities decreased from the rural landscape to the urban landscape, with a significant difference existing between both the rural and urban landscapes ($p = 0.0005$) and the suburban and urban landscapes ($p = 0.017$).

Landowner perceptions were also statistically related to their participation in the activities. Landowners who were more likely to perceive increases in bird numbers over time were also more likely to engage in activities with positive impacts on birds ($F_{5, 950} = 25.4, p < 0.000001$). Likewise, those landowners who felt that bird diversity on their land was the most important were also those more likely to engage in positive activities ($F_{4, 944} = 50.4, p < 0.000001$; Figure 3.2), as were those with greater awareness of different bird species that live on or near their property ($r^2 = 0.04, p = 0.00001$), those who were more willing to change their land use for the benefit of bird species ($F_{4, 906} = 15.9, p < 0.000001$), and, those with greater interest in easements or tax abatements ($F_{4, 937} = 13.6, p < 0.000001$). There was no effect of landscape type ($p > 0.05$) on these relationships.

In contrast to the positive activities, several different patterns were displayed with regard to the negative activities. Specifically, landowners who were more likely to perceive increases in the number of birds on their land were also those more likely to engage in negative activities ($F_{5, 950} = 5.3, p = 0.00009$). However, the perception that bird diversity was important displayed a non-linear relationship with the number of negative activities, resulting in a significant relationship ($F_{4, 944} = 4.3, p = 0.002$; Figure

3.2). No relationship existed between (1) the number of birds that landowners were aware of on their property ($r^2 = 0.0005$, $p = 0.6$), (2) the interest in changing one's land use to benefit birds ($F_{4, 906} = 1.7$, $p = 0.1$), or (3) the interest in tax easements or abatements ($F_{4, 937} = 1.6$, $p = 0.2$), relative to the number of negative activities that the landowners' were engaged in. Both of the significant relationships reported above were significantly different across the three landscapes ($F_{2, 952} = 7.8$, $p = 0.0004$, for changes in the number of birds on one's land; $F_{4, 942} = 4.6$, $p = 0.001$ for importance of bird diversity), but displayed no interaction ($p > 0.05$) with landscape.

DISCUSSION

Landowners, in general, tended to perceive birds in a positive manner. For instance, the majority of landowners believed that the number of birds frequenting their land had increased over time and that bird diversity was somewhat to very important (Table 3.1). Similarly, landowners expressed a slight interest in both altering their land use for the benefit of birds and accepting tax easements or abatements for such change (Table 3.1). Aside from perceiving birds positively, landowners also engaged in an average of four activities (of a possible eight) that can potentially influence birds. The most predominant activities were gardening, landscaping, and bird feeding (Table 3.2). Notably, however, every activity was engaged in by >25% of the landowners (Table 3.2), indicating that cumulatively across a landscape the landowner activities are likely great enough to influence bird abundances and populations. For example, the 25% of

landowners that applied pesticides or herbicides may be influencing the invertebrate food sources that a number of bird species rely upon (Brickle *et al.*, 2000).

The relationships between landowner perceptions and activities displayed several interesting tendencies. Landowners that perceived higher numbers of birds over time, were aware of more species, held more positive attitudes about bird diversity, and were more willing to change their land use or accept tax easements were all also engaged in a greater number of the positive activities (e.g., Figure 3.2). However, our findings were substantially more ambivalent with regard to participation in negative activities. Only two of the perceptions showed any relationship to participation in negative activities: perception of the change in bird numbers and the importance of bird diversity. Interestingly, the more a landowner perceived increases in bird numbers, the more likely were they also to engage in activities that could possibly negatively affect those numbers. The relationship between landowner evaluation of bird diversity and participation in negative activities was likewise interesting, revealing no straightforward (albeit statistically positive) connection between the two. One likely explanation for these findings might be that even negative activities result in a landowner being outdoors and actively engaged in observing changes on their land and the species that frequent it. While a similar line of reasoning could be used with the positive activities, it should be noted that all of these activities (except general landscaping and gardening, which were not specifically asked with reference to birds) are deliberately done to benefit birds. Thus, it is unlikely that landowners first engaged in these activities prior to having specific perceptions about birds; rather they likely began to engage in the positive activities as a result of their positive perceptions.

Across the rural-to-urban continuum of landscapes there were marked differences, both in terms of perceptions (Table 3.1) and activities (Table 3.2). Rural landowners indicated that bird numbers changed to a larger degree than did the landowners in the other two landscapes. Conversely, rural landowners placed a lower level of importance on bird diversity and were less willing to alter their land use relative to suburban landowners. Rural landowners were also more likely to engage in specific activities than were suburban and urban landowners: planting vegetation, applying fertilizer, and applying pesticides/herbicides (Table 3.2). It is noteworthy that two of these activities have potentially quite negative ramifications for bird species.

Overall, our results indicate that landowners perceive birds positively and are engaged in a host of activities that can directly and indirectly influence avian populations. A relatively strong association between attitude and behavior was detected for the positive activities, indicating the potential for providing landowners with educational information that promotes positive behavior in regards to birds. Finally, our findings highlight the urgent need for inclusion of private lands as part of the research agenda in wildlife, avian, and landscape ecology. Because public agencies and private organizations are increasingly encouraging private land management our findings are particularly timely as they point to the need to assess the cumulative repercussions of activities carried out by numerous individual landowners.

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Table 3.1. Landowner perceptions and attitudes across landscapes. Values are means ($\pm$ SE) that can range from 1 to 5, with higher numbers reflecting more positive perceptions of bird numbers and greater support for diversity, changing land use and tax easements. *P*-value is based on ANOVA with superscripts indicating significant differences between landscapes (a = Rural and Suburban, b = Suburban and Urban, and c = Rural and Urban).

	Landscape			<i>p</i> -value
	Rural	Suburban	Urban	
Change in # of birds over time	3.7 $\pm$ 0.08	3.4 $\pm$ 0.07	3.4 $\pm$ 0.05	3.5 $\pm$ 0.04
Importance of bird diversity	4.1 $\pm$ 0.06	4.3 $\pm$ 0.06	4.3 $\pm$ 0.04	4.2 $\pm$ 0.03
# of bird species on property	17.6 $\pm$ 1.4	18.5 $\pm$ 1.3	15.3 $\pm$ 0.9	16.6 $\pm$ 0.6
Willing to change land use	3.4 $\pm$ 0.08	3.7 $\pm$ 0.07	3.6 $\pm$ 0.05	3.5 $\pm$ 0.04
Interest in tax easements	3.5 $\pm$ 0.08	3.8 $\pm$ 0.08	3.7 $\pm$ 0.05	3.7 $\pm$ 0.04

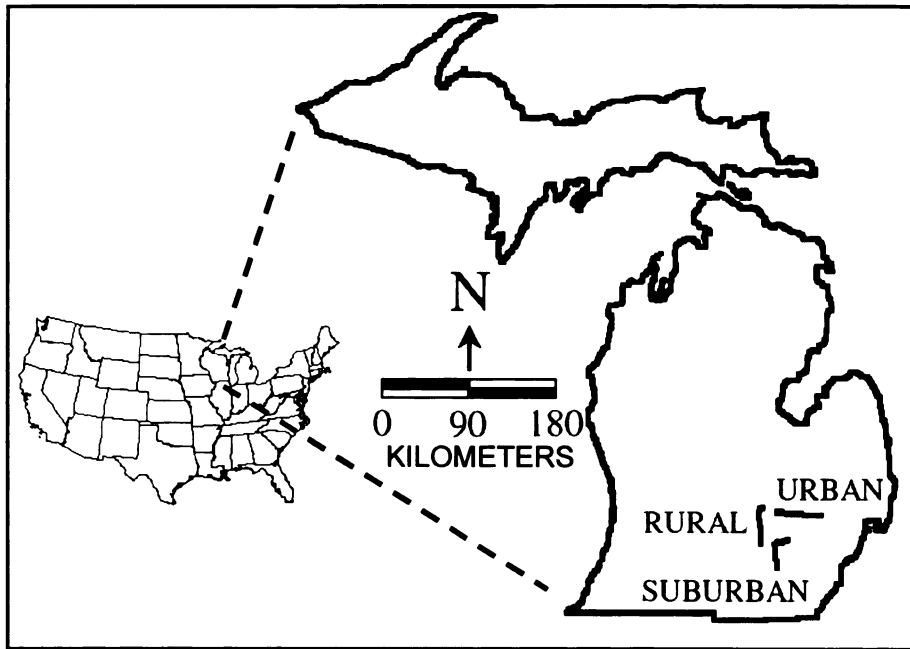
Table 3.2. Percent of landowners involved in each activity across landscapes. *P*-value is based on χ^2 test statistic.

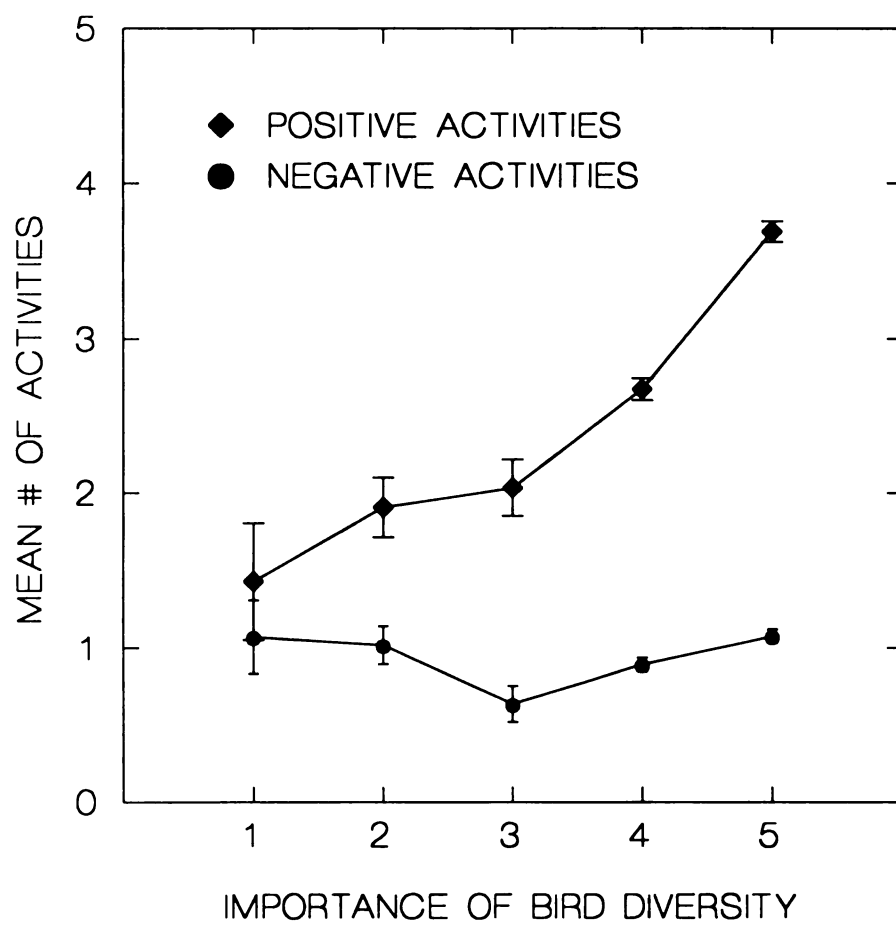
	Landscape				<i>p</i> -value
	Rural	Suburban	Urban	Total	
Bird Feeding	64.6	67.4	65.2	65.6	0.80
Bird Houses	45.8	50.6	44.2	45.7	0.26
Plant Vegetation	59.9	57.9	51.1	54.6	0.047
Garden	76.5	71.0	72.0	72.7	0.38
Landscape	68.4	73.7	73.2	72.3	0.39
Fertilize	49.5	48.7	49.6	49.3	0.97
Pesticide/Herbicide	36.7	27.2	19.7	25.2	0.00002
Outdoor Cats	33.5	32.2	20.5	26.1	0.00007

FIGURE LEGENDS

Figure 3.1. Locations of the three landscapes (each 39.4 km) in southeast Michigan, USA, where survey was conducted.

Figure 3.2. The importance of bird diversity versus the number of activities landowners engage in. Larger scores indicate greater importance of diversity.





CHAPTER 4

BIRD DIVERSITY ACROSS A LANDSCAPE: INTEGRATING AND COMPARING PUBLISHED DATA WITH LANDOWNER OBSERVATIONS

ABSTRACT

Knowledge of bird diversity across a landscape is important not just for natural historians and ornithologists, but also for use in answering many ecological and conservation questions. Numerous public data sets exist that provide presence/absence information on species occurrences, but no single one captures all the diversity. As a means to develop a complete species occurrence list for an urbanizing landscape in Southeastern Michigan, I combined the existing data of four public and private organizations, all officially documented rare birds, and surveyed ~1,700 landowners. The specific goals were to (1) develop a complete list of species occurrences across a landscape, (2) ascertain what percent of the total species pool landowners could collectively identify, (3) identify species that had not been noted in the census data sets, but could be corroborated, and (4) compare the percent overlap among different bird censuses. The resulting list comprised 289 bird species, which is 30% greater than any of the single existing lists. Landowners identified 171 bird species (~60%) and had >50% overlap with all existing databases. In addition, landowners identified five species not previously noted in existing lists, but corroborated in the literature. The percent overlap of species across the five different lists ranged from 35% to 67%, with the differences stemming largely from different protocols. Overall, the findings highlight the need to use multiple data sources for establishing a list of potential species occurrence as well as the importance that landowners can play in providing bird occurrence data.

INTRODUCTION

Understanding the overall bird diversity across a landscape is important not just for natural historians and ornithologists, but also for use in answering many ecological questions and developing conservation plans. In numerous landscapes throughout North America there exists a wealth of information on what bird species occur on or in the vicinity of a landscape. This existing information is in such forms as the Christmas Bird Counts (CBC), the North American Breeding Bird Survey (BBS), state lists of rare birds, and state breeding bird atlases. Notably, however, each of the existing forms of information may only provide a partial list of species that can occur on a landscape over time, due to the fact that they are only interested in breeding species (e.g., state breeding bird atlases), only collect species information near roads (e.g., BBS), or may collect information at a time of the year that misses a number of migratory species (e.g., CBC). Because the habitat on 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., due to inclement weather), establishing a complete list of all potential species occurrences is essential.

As a means to develop an overall bird diversity list across a landscape I sought to incorporate both existing bird census data as well as to utilize observations of landowners that live on the landscape. Specifically my goals were to: 1) develop a complete list of species occurrences across a landscape that is facing rapid urbanization; 2) ascertain what percent of the total species pool landowners could collectively identify; 3) identify species that had previously not been noted in the census data sets, but could be

corroborated; and, 4) compare the percent overlap among different bird surveys and censuses across a landscape.

METHODS

To address the research goals, and as part of a larger investigation on landowner effects on birds (Lepczyk et al. 2002, Chapters 1, 2, and 3), I focused on landowners living along three active BBS routes (route numbers 53, 167, and 168) in a heterogeneous and human dominated landscape undergoing rapid urbanization (see Rutledge 2000 and Rutledge and Lepczyk 2002 for complete landscape details) in Southeastern Michigan, United States. In selecting landowners to whom the survey would be administered, I chose all private landowners that owned property immediately adjacent to the road along which each of the three BBS routes are conducted. I identified all private landowners using a three-tiered approach. First, I drove all routes and recorded addresses (either from the mail box or from the house). Second, I identified all possible landowners living adjacent to the roads using the most recent plat maps available for each county. Third, I identified all parcels of land adjacent to the roads using tax records from each county's equalization office. Utilizing these three approaches I identified a total of 1,694 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). The survey instrument and procedures were fully evaluated for ethical appropriateness by the Michigan State University Committee on Research Involving Human Subjects prior to mailing. To

encourage responses I established a toll-free telephone line for landowners to contact us with any questions and offered prize drawings as an incentive. Briefly, an initial survey was mailed during the first week of October 2000 (Appendix A and B). A postcard reminder/thank you was sent out two weeks later (Appendix C). Finally, a second survey was sent out two weeks after the postcard (Appendix D).

Any survey returned from a church, business or public land owner was removed from the sample. 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 December 31, 2000 were not included in any analyses. If landowners owned multiple parcels that were not connected to one another then they were asked to complete the survey in relation to only one of the parcels. Consequently, in the case of isolated multi-parcel landowners our methodology is a conservative estimate of landowner knowledge. However, if the landowner owned multiple parcels that were all contiguous with one another then 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 that called to indicate they were unable or had no desire to participate in the survey were considered non-respondents. Non-respondents are included in the final corrected sample size.

To ascertain what bird species landowners had observed on their property I asked the following two questions: 1) "Can you name any of the bird species you typically see

on your property (two check boxes: yes or no)?”, and 2) “If “Yes,” please write down the names of the species observed.” The open-ended question format was used to avoid leading the respondents in 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 antiquated species name (e.g., Baltimore Oriole changed to Northern Oriole) or colloquial wording (e.g., Sparrow Hawk changed to American Kestrel) it was converted to currently accepted nomenclature. 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) were removed. Similarly, if a species was listed that no: 1) field guides (e.g., Sibley 2000) indicated to be even remotely in the proximity of the study area; 2) existing data set concurred with; 3) literature search could confirm; 4) personal observation could be made; or, 5) records existed from the Michigan Bird Records Committee (MBRC), then it was removed from the list. Finally, if two or more species could be assumed from the response, I excluded it from consideration.

Four existing data sets were acquired to develop a complete species list and compare species occurrences on the landscape. These data sets were, the Michigan Breeding Bird Atlas (Brewer et al. 1991), all active and inactive routes of the North American Breeding Survey (routes: 53, 66, 67, 68, 167, 168), all Christmas Bird Count circles (routes: Ann Arbor, Detroit, Hartford, Pontiac, Waterford, Waterloo State Recreation Area, Ypsilanti), and all bird occurrences published in The Birds of Washtenaw County, Michigan (Kielbaso et al. 1992). 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 different surveys were included in the list and subsequent analyses. Species occurrences listed in the four data sets that were suspect, due to both rarity and lack of acceptable confirmation with the MBRC were included in the overall bird list, but were excluded from the corrected and comparative lists. In the case of rare birds documented by the MBRC that occur within the landscape, but not found in any of the existing surveys, I included them only in the overall bird list. All scientific and common names that had changed over time were updated to currently accepted AOU terminology.

RESULTS

The total combined number of birds observed on the landscape comprising the five data sets and the MBRC was 294 (Table 4.1). 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), that were identified in the four published data sets, are likely either misprints or outside of the study area as the records could not be verified by MBRC, thus reducing the total corrected diversity to 289 species. Of the 289 species, 23 were identified only in the MBRC, yielding a total of 266 for comparison between surveys.

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 et al. 2002, Chapters 1, 2, and 3). Collectively, the landowners identified 171 species of birds, comprising 58.2%, 59.2%, and 64.3% of the full, corrected, and comparative lists, respectively. Notably, landowners identified four species that did not occur in any of the four published surveys, but were corroborated by the MBRC. These were the American Magpie (Pica hudsonia), Barn Owl (Tyto alba), Bohemian Waxwing (Bombycilla garrulus), and Summer Tanager (Piranga rubra).

Of the comparative species list (i.e., 266 species), the number that the other four surveys recorded were: 124 (44.9%) along the BBS routes, 148 (53.6%) in the CBC circles, 220 (79.7%) seen in Washtenaw county, and 198 (71.7%) in the Michigan Breeding Bird Atlas (Table 4.1). The number and percent of species that overlapped each method ranged from 35.0% to 67.2% (Table 4.2).

DISCUSSION

Overall, by combining all available data sets and the landowner responses resulted in a species occurrence list that was at least 30% greater than any single previous estimate. This substantially larger list is likely due to 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. Second, because of the nature of the survey locations there are inherent habitat biases. For instance, BBS routes are very unlikely to capture such birds as forest interior specialists. Finally, each census method or database has been established for different reasons, thereby having a narrower scope of birds that it focuses on (e.g., MIBBA). However, the

>30% increase over the list established in The Birds of Washtenaw County, Michigan (Kielbaso et al. 1992) is somewhat surprising as this list does incorporate both rare species and non-breeding species occurrences. Moreover, all the species that made up the extra 30%, except the American Magpie, Barn Owl, Bohemian Waxwing, and Summer Tanager, were noted in the three state, federal, or Audubon data sets. As a result, this finding alone highlights the need for integrating multiple species occurrence databases for establishing a complete species list across a landscape or region. Integrating multiple databases into a single species occurrence list can also be highlighted by the fact that while there was a moderate level of species overlap (Table 4.2) across databases, the percent overlap did not exceed ~66%. The difference in percent overlap is most certainly due to differences in the timing and methodology of censusing (e.g., summer vs. winter). For instance, Christmas Bird Counts are conducted in December, during which time the migrant breeding species captured by the BBS are almost assuredly gone.

Collectively the landowners were able to identify >50% of the species listed in each database and were able to identify nearly 60% of the potential species. Moreover, while several species listed by landowners were excluded because they could not be corroborated, (e.g., Common Raven, Corvus corax), they did report five species that had only previously been noted by the MBRC. Although a number of bird species that landowners identified were excluded in the present study due to lack of corroborating evidence, they could potentially serve to identify locations on the landscape where more in-depth investigations or follow-up surveys could take place.

Surveying landowners and people in regard to bird species and bird activities has been a commonly used technique to gain information (Cowie and Hinsley 1988,

Brittingham and Temple 1989, Dunn and Tessaglia 1994). Although surveying people in regards to bird activities and abundances provides a wealth of information, one potential drawback of many previous surveys is that they target a very narrow group of people. Specifically, nearly all previous surveys have either been administered to amateur birders, ornithologists, or people who participated in these activities (e.g., Brittingham and Temple 1989, Wiedner and Kerlinger 1990), or otherwise have sought volunteers (e.g., Project Feeder Watch; Wells et al. 1998). As a result these methodologies may be biased towards only people who are interested in or research birds. Thus, one potential benefit of the results and method utilized in this study is that it aimed at a geographical location and not a specific group of people. In addition, conducting surveys of landowners can potentially provide more information on bird occurrences and abundances in landscapes that have a predominance of private lands. 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.

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Table 4.1. All possible species, as denoted by different survey methods. Survey = landowner survey, BBS = breeding bird survey,

CBC = Christmas bird count, MIBBA = Michigan breeding bird atlas, BOW = birds of Washtenaw County.

Common Name	Scientific Name	Survey	BBS	CBC	BOW	MIBBA	Total
Acadian Flycatcher	<u>Empidonax virescens</u>	X	X		X	X	4
Alder Flycatcher	<u>Empidonax alnorum</u>		X		X	X	3
American Bittern	<u>Botaurus lentiginosus</u>		X		X	X	3
American Black Duck	<u>Anas rubripes</u>	X	X	X	X	X	5
American Coot	<u>Fulica americana</u>	X	X	X	X	X	5
American Crow	<u>Corvus brachyrhynchos</u>	X	X	X	X	X	5
American Goldfinch	<u>Carduelis tristis</u>	X	X	X	X	X	5
American Kestrel	<u>Falco sparverius</u>	X	X	X	X	X	5
American Magpie	<u>Pica hudsonia</u>	X					1
American Pipit	<u>Anthus rubescens</u>				X		1
American Redstart	<u>Setophaga ruticilla</u>	X	X		X	X	4
American Robin	<u>Turdus migratorius</u>	X	X	X	X	X	5
American Tree Sparrow	<u>Spizella arborea</u>	X		X	X	X	4
American White Pelican	<u>Pelecanus erythrorhynchos</u>					X	1
American Wigeon	<u>Anas americana</u>			X	X	X	3

Table 4.1. Continued.

American Woodcock	<u>Scolopax minor</u>	X	X	X	4
Baird's Sandpiper	<u>Calidris bairdii</u>		X	X	2
Bald Eagle	<u>Haliaeetus leucocephalus</u>	X		X	3
Bank Swallow	<u>Riparia riparia</u>	X	X	X	4
Barn Owl	<u>Tyto alba</u>	X			1
Barn Swallow	<u>Hirundo rustica</u>	X	X	X	3
Barnacle Goose [†]	<u>Branta leucopsis</u>			X	1
Barred Owl	<u>Strix varia</u>	X		X	4
Barrow's Goldeneye*	<u>Bucephala islandica</u>				
Bay-breasted Warbler	<u>Dendroica castanea</u>	X		X	2
Bell's Vireo	<u>Vireo bellii</u>			X	1
Belted Kingfisher	<u>Ceryle alcyon</u>	X	X	X	5
Bewick's Wren	<u>Thryomanes bewickii</u>			X	1
Black and White Warbler	<u>Mniotilta varia</u>	X		X	3
Black Rail	<u>Laterallus jamaicensis</u>			X	1
Black Tern	<u>Chlidonias niger</u>	X	X	X	4
Black-bellied Plover	<u>Pluvialis squatarola</u>			X	1

Table 4.1. Continued.

Black-billed Cuckoo	<u>Coccyzus erythrophthalmus</u>		X	X	X	4
Blackburnian Warbler	<u>Dendroica fusca</u>	X		X		2
Black-capped Chickadee	<u>Poecile atricapilla</u>	X	X	X	X	5
Black-crowned Night-heron	<u>Nycticorax nycticorax</u>	X		X	X	4
Black-headed Grosbeak*	<u>Pheucticus melanocephalus</u>					
Blackpoll Warbler	<u>Dendroica striata</u>	X		X		2
Black-throated Blue Warbler	<u>Dendroica caerulescens</u>	X		X		2
Black-throated Gray Warbler*	<u>Dendroica nigrescens</u>					
Black-throated Green Warbler	<u>Dendroica virens</u>	X		X	X	3
Blue Jay	<u>Cyanocitta cristata</u>	X	X	X		5
Blue-gray Gnatcatcher	<u>Polioptila caerulea</u>	X	X	X	X	4
Blue-headed Vireo	<u>Vireo solitarius</u>	X	X	X	X	4
Blue-winged Teal	<u>Anas discors</u>	X	X	X	X	5
Blue-winged Warbler	<u>Vermivora pinus</u>		X	X	X	3
Bobolink	<u>Dolichonyx oryzivorus</u>	X	X	X	X	4
Bohemian Waxwing	<u>Bombycilla garrulus</u>	X				1
Bonaparte's Gull	<u>Larus philadelphia</u>	X	X	X	X	4

Table 4.1. Continued.

Boreal Chickadee	<u>Poecile hudsonica</u>	X			1
Brambling*	<u>Fringilla montifringilla</u>				
Brewer's Blackbird	<u>Euphagus cyanocephalus</u>	X	X	X	4
Broad-winged Hawk	<u>Buteo platypterus</u>	X		X	2
Brown Creeper	<u>Certhia americana</u>	X		X	4
Brown Thrasher	<u>Toxostoma rufum</u>	X	X	X	4
Brown-headed Cowbird	<u>Molothrus ater</u>	X	X	X	5
Bufflehead	<u>Bucephala albeola</u>	X		X	4
California Gull*	<u>Larus californicus</u>	X			1
Canada Goose	<u>Branta canadensis</u>	X	X	X	5
Canada Warbler	<u>Wilsonia canadensis</u>			X	2
Canvasback	<u>Aythya valisineria</u>	X		X	4
Cape May Warbler	<u>Dendroica tigrina</u>			X	1
Carolina Wren	<u>Thryothorus ludovicianus</u>	X	X	X	5
Caspian Tern	<u>Sterna caspia</u>		X	X	2
Cattle Egret	<u>Bubulcus ibis</u>	X			2
Cedar Waxwing	<u>Bombycilla cedrorum</u>	X	X	X	5

Table 4.1. Continued.

Cerulean Warbler	<u>Dendroica cerulea</u>	X		X	X	3
Chestnut-sided Warbler	<u>Dendroica pensylvanica</u>	X	X		X	3
Chimney Swift	<u>Chaetura pelagica</u>	X	X	X	X	4
Chipping Sparrow	<u>Spizella passerina</u>	X	X	X	X	5
Chuck-will's-widow†	<u>Caprimulgus carolinensis</u>				X	1
Cliff Swallow	<u>Petrochelidon pyrrhonota</u>	X	X		X	3
Common Goldeneye	<u>Bucephala clangula</u>	X		X	X	3
Common Grackle	<u>Quiscalus quiscula</u>	X	X	X	X	5
Common Loon	<u>Gavia immer</u>	X	X	X	X	3
Common Merganser	<u>Mergus merganser</u>	X	X	X	X	3
Common Moorhen	<u>Gallinula chloropus</u>			X	X	2
Common Nighthawk	<u>Chordeiles minor</u>	X	X	X	X	4
Common Redpoll	<u>Carduelis flammea</u>	X		X	X	4
Common Snipe	<u>Galinago galinago</u>	X	X	X	X	5
Common Tern	<u>Sterna hirundo</u>				X	1
Common Yellowthroat	<u>Geothlypis trichas</u>	X	X	X	X	5
Connecticut Warbler	<u>Oporonis agilis</u>			X	X	1

Table 4.1. Continued.

Cooper's Hawk	<u>Accipiter cooperii</u>	X	X	X	X	5
Dark-eyed Junco	<u>Junco hyemalis</u>	X		X		3
Dickcissel	<u>Spiza americana</u>		X		X	2
Double-crested Cormorant	<u>Phalacrocorax auritus</u>	X		X	X	4
Downy Woodpecker	<u>Picoides pubescens</u>	X	X	X	X	5
Dunlin	<u>Calidris alpina</u>				X	2
Eastern Bluebird	<u>Sialia sialis</u>	X	X	X	X	5
Eastern Kingbird	<u>Tyrannus tyrannus</u>	X	X		X	4
Eastern Meadowlark	<u>Sturnella magna</u>	X	X	X	X	5
Eastern Phoebe	<u>Sayornis phoebe</u>	X	X	X	X	5
Eastern Screech-owl	<u>Otus asio</u>	X	X	X	X	5
Eastern Towhee	<u>Pipilo erythrophthalmus</u>	X	X	X	X	5
Eastern Wood-pewee	<u>Contopus virens</u>	X	X		X	4
Eurasian Wigeon*	<u>Anas penelope</u>					
European Starling	<u>Sturnus vulgaris</u>	X	X	X	X	5
Evening Grosbeak	<u>Coccothraustes vespertinus</u>	X		X	X	3
Field Sparrow	<u>Spizella pusilla</u>	X	X	X	X	5

Table 4.1. Continued.

Forster's Tern	<u>Sterna forsteri</u>	X	X	X	3
Fox Sparrow	<u>Passerella iliaca</u>	X	X	X	4
Franklin's Gull	<u>Larus pipixcan</u>	X			1
Fulvous Whistling-Duck*	<u>Dendrocygna bicolor</u>				
Gadwall	<u>Anas strepera</u>	X	X	X	3
Glaucous Gull	<u>Larus hyperboreus</u>	X			1
Glossy/White-faced Ibis ^{†*}					
Golden Eagle	<u>Aquila chrysaetos</u>	X	X	X	3
Golden-crowned Kinglet	<u>Regulus satrapa</u>	X	X	X	4
Golden-winged Warbler	<u>Vermivora chrysoptera</u>		X	X	2
Grasshopper Sparrow	<u>Ammodramus savannarum</u>	X		X	2
Gray Catbird	<u>Dumetella carolinensis</u>	X	X	X	5
Gray-cheeked Thrush	<u>Catharus minimus</u>		X		1
Great Black-backed Gull	<u>Larus marinus</u>	X			1
Great Blue Heron	<u>Ardea herodias</u>	X	X	X	5
Great Crested Flycatcher	<u>Myiarchus crinitus</u>	X	X	X	4
Great Egret	<u>Ardea alba</u>	X	X	X	5

Table 4.1. Continued.

Great Horned Owl	<u>Bubo virginianus</u>	X	X	X	X	X	5
Greater Scaup	<u>Aythya marila</u>	X		X	X	X	4
Greater White-fronted Goose	<u>Anser albifrons</u>			X			1
Greater Yellowlegs	<u>Tringa melanoleuca</u>				X	X	2
Green Heron	<u>Butorides virescens</u>	X	X		X	X	4
Green-tailed Towhee*	<u>Pipilo chlorurus</u>						
Green-winged Teal	<u>Anas crecca</u>			X	X	X	3
Hairy Woodpecker	<u>Picoides villosus</u>	X	X		X	X	5
Henslow's Sparrow	<u>Ammodramus henslowii</u>		X		X	X	3
Hermit Thrush	<u>Catharus guttatus</u>	X		X	X	X	3
Herring Gull	<u>Larus argentatus</u>	X		X	X	X	4
Hooded Merganser	<u>Lophodytes cucullatus</u>	X		X	X	X	4
Hooded Warbler	<u>Wilsonia citrina</u>	X			X	X	3
Horned Grebe	<u>Podiceps auritus</u>			X	X	X	2
Horned Lark	<u>Eremophila alpestris</u>	X	X		X	X	5
House Finch	<u>Carpodacus mexicanus</u>	X	X		X	X	5
House Sparrow	<u>Passer domesticus</u>	X	X		X	X	4

Table 4.1. Continued.

House Wren	<u>Troglodytes aedon</u>	X	X	X	4
Iceland Gull*	<u>Larus glaucoides</u>				
Indigo Bunting	<u>Passerina cyanea</u>	X	X	X	5
Kentucky Warbler	<u>Oporonis formosus</u>			X	2
Kildeer	<u>Charadrius vociferus</u>	X	X	X	5
King Rail*	<u>Rallus elegans</u>				
Lapland Longspur	<u>Calcarius lapponicus</u>		X	X	2
Lark Sparrow	<u>Chondestes grammacus</u>			X	1
Least Bittern	<u>Ixobrychus exilis</u>		X	X	4
Least Flycatcher	<u>Empidonax minimus</u>	X	X	X	4
Least Sandpiper	<u>Calidris minutilla</u>			X	2
Lesser Black-backed Gull	<u>Larus fuscus</u>		X		1
Lesser Scaup	<u>Aythya affinis</u>	X		X	4
Lesser Yellowlegs	<u>Tringa melanoleuca</u>			X	3
Lincoln's Sparrow	<u>Melospiza lincolnii</u>			X	2
Little Blue Heron	<u>Egretta caerulea</u>			X	1
Loggerhead Shrike	<u>Lanius ludovicianus</u>	X	X		2

Table 4.1. Continued.

Long-eared Owl	<u>Asio otus</u>	X	X	X	3
Louisiana Waterthrush	<u>Seiurus motacilla</u>		X	X	2
Magnolia Warbler	<u>Dendroica magnolia</u>	X		X	2
Mallard Duck	<u>Anas platyrhynchos</u>	X	X	X	5
Marsh Wren	<u>Cistothorus palustris</u>	X	X	X	5
Merlin	<u>Falco columbarius</u>	X	X	X	3
Monk Parakeet	<u>Myiopsitta monachus</u>			X	1
Mourning Dove	<u>Zenaida macroura</u>	X	X	X	5
Mourning Warbler	<u>Oporonis philadelphia</u>			X	2
Mute Swan	<u>Cygnus olor</u>	X	X	X	5
Nelson's Sharp-tailed Sparrow*	<u>Ammodramus nelsoni</u>				
Northern Flicker	<u>Colaptes auratus</u>	X	X	X	5
Northern Bobwhite	<u>Colinus virginianus</u>	X	X	X	5
Northern Cardinal	<u>Richmondia cardinalis</u>	X	X	X	5
Northern Gannet*	<u>Morus bassanus</u>				
Northern Goshawk	<u>Accipiter gentilis</u>	X	X	X	3
Northern Harrier	<u>Circus cyaneus</u>	X	X	X	5

Table 4.1. Continued.

Northern Mockingbird	<u>Mimus polyglottos</u>	X	X	X	X	5
Northern Oriole	<u>Icterus galbula</u>	X	X	X	X	4
Northern Parula	<u>Parula americana</u>		X			1
Northern Pintail	<u>Anas acuta</u>	X		X	X	4
Northern Rough-winged Swallow	<u>Stelgidopteryx serripennis</u>	X	X		X	3
Northern Saw-whet Owl	<u>Aegolius acadicus</u>	X		X	X	3
Northern Shoveler	<u>Anas clypeata</u>			X	X	3
Northern Shrike	<u>Lanius excubitor</u>	X		X	X	3
Northern Waterthrush	<u>Seiurus noveboracensis</u>				X	2
Oldsquaw	<u>Clangula hyemalis</u>			X	X	2
Olive-sided Flycatcher	<u>Contopus cooperi</u>				X	1
Orange-crowned Warbler	<u>Vermivora celata</u>				X	1
Orchard Oriole	<u>Icterus spurius</u>	X	X		X	4
Osprey	<u>Pandion haliaetus</u>	X		X	X	3
Ovenbird	<u>Seiurus aurocapillus</u>	X		X	X	4
Pacific Loon*	<u>Gavia pacifica</u>					
Palm Warbler	<u>Dendroica palmarum</u>	X			X	2

Table 4.1. Continued.

Pectoral Sandpiper	<u>Calidris melanotos</u>			X	X	2
Peregrine Falcon	<u>Falco peregrinus</u>	X	X			3
Philadelphia Vireo	<u>Vireo philadelphicus</u>			X		1
Pie-billed Grebe	<u>Podilymbus podiceps</u>	X	X	X	X	5
Pileated Woodpecker	<u>Dryocopus pileatus</u>	X	X		X	3
Pine Grosbeak	<u>Pinicola enucleator</u>	X	X	X		3
Pine Siskin	<u>Carduelis pinus</u>	X	X	X	X	5
Pine Warbler	<u>Dendroica pinus</u>			X	X	2
Prairie Warbler	<u>Dendroica discolor</u>			X	X	2
Purple Finch	<u>Carpodacus purpureus</u>	X	X	X	X	4
Purple Martin	<u>Progne subis</u>	X	X	X	X	4
Red Crossbill	<u>Loxia curvirostra</u>		X	X		2
Red-bellied Woodpecker	<u>Centurus carolinus</u>	X	X	X	X	5
Red-breasted Merganser	<u>Mergus serrator</u>	X	X	X		3
Red-breasted Nuthatch	<u>Sitta canadensis</u>	X	X	X		4
Red-eyed Vireo	<u>Vireo olivaceus</u>	X	X	X	X	4
Redhead	<u>Aythya americana</u>	X	X	X	X	4

Table 4.1. Continued.

Red-headed Woodpecker	<u>Melanerpes erythrocephalus</u>	X	X	X	X	5
Red-shouldered Hawk	<u>Buteo lineatus</u>	X	X	X	X	5
Red-tailed Hawk	<u>Buteo jamaicensis</u>	X	X	X	X	4
Red-winged Blackbird	<u>Agelaius phoeniceus</u>	X	X	X	X	5
Ring-billed Gull	<u>Larus delawarensis</u>	X	X	X	X	5
Ring-necked Duck	<u>Aythya collaris</u>		X	X		2
Ring-necked Pheasant	<u>Phasianus colchicus</u>	X	X	X	X	5
Rock Dove	<u>Columba livia</u>	X	X	X	X	5
Rock Wren	<u>Salpinctes obsoletus</u>				X	1
Rose-breasted Grosbeak	<u>Pheucticus ludovicianus</u>	X	X	X	X	5
Ross's Goose*	<u>Chen rossii</u>					
Rough-legged Hawk	<u>Buteo lagopus</u>		X	X	X	3
Rough-winged Swallow	<u>Stelgidopteryx serripennis</u>				X	1
Ruby-crowned Kinglet	<u>Tegulus calendula</u>	X	X	X	X	3
Ruby-throated Hummingbird	<u>Archilochus colubris</u>	X	X		X	4
Ruddy Duck	<u>Oxyura jamaicensis</u>	X	X	X	X	4
Ruddy Turnstone	<u>Arenaria interpres</u>				X	1

Table 4.1. Continued.

Ruffed Grouse	<u>Bonasa umbellus</u>	X	X	X	X	5
Rufou/Allen's Hummingbird*:*	<u>Selasphorus</u>					
Rusty Blackbird	<u>Euphagus carolinus</u>		X	X		2
Sabine's Gull*	<u>Xema sabini</u>					
Sandhill Crane	<u>Grus canadensis</u>	X	X	X	X	5
Savannah Sparrow	<u>Passerculus sandwichensis</u>		X	X	X	3
Scarlet Tanager	<u>Piranga olivacea</u>	X	X	X	X	4
Scissor-tailed Flycatcher*	<u>Tyrannus forficatus</u>					
Sedge Wren	<u>Cistothorus platensis</u>		X		X	3
Semipalmated Plover	<u>Charadrius semipalmatus</u>				X	2
Semipalmated Sandpiper	<u>Calidris pusilla</u>				X	2
Sharp-shinned Hawk	<u>Accipiter striatus</u>	X		X	X	4
Short-billed Dowitcher	<u>Limnodromus griseus</u>				X	1
Short-eared Owl	<u>Asio flammeus</u>			X	X	2
Snow Bunting	<u>Plectrophenax nivalis</u>	X		X	X	4
Snow Goose	<u>Chen caerulescens</u>	X		X	X	4
Snowy Egret	<u>Egretta thula</u>	X			X	2

Table 4.1. Continued.

Snowy Owl	<u>Nyctea scandiaca</u>	X	X	X	3
Solitary Sandpiper	<u>Tringa solitaria</u>	X		X	3
Song Sparrow	<u>Melospiza melodia</u>	X	X	X	5
Sora	<u>Porzana carolina</u>		X	X	4
Spotted Sandpiper	<u>Actitis macularia</u>		X	X	3
Sprague's Pipit*	<u>Anthus spragueii</u>				
Summer Tanager	<u>Piranga rubra</u>	X			1
Surf Scoter	<u>Melanitta perspicillata</u>		X		1
Swainson's Hawk*	<u>Buteo swainsoni</u>				
Swainson's Thrush	<u>Catharus ustulatus</u>	X	X	X	3
Swallow-tailed Kite	<u>Elanoides forficatus</u>				
Swamp Sparrow	<u>Melospiza georgiana</u>		X	X	4
Tennessee Warbler	<u>Vermivora peregrina</u>			X	1
Thayer's Gull	<u>Larus thayeri</u>		X		1
Thick-billed Murre*	<u>Uria lomvia</u>				
Three-toed Woodpecker†	<u>Picoides tridactylus</u>				1
Tree Swallow	<u>Tachycineta bicolor</u>	X	X	X	4

Table 4.1. Continued.

Tricolored Heron [†]	<u>Egretta tricolor</u>				X	1
Trumpeter Swan	<u>Cygnus buccinator</u>		X		X	2
Tufted Duck*	<u>Aythya fuligula</u>					
Tufted Titmouse	<u>Parus bicolor</u>	X	X	X	X	5
Tundra Swan	<u>Cygnus columbianus</u>	X		X	X	3
Turkey Vulture	<u>Cathartes aura</u>	X	X	X	X	5
Upland Sandpiper	<u>Bartramia longicauda</u>		X	X	X	3
Varied Thrush*	<u>Ixoreus naevius</u>					
Veery	<u>Catharus fuscescens</u>		X	X	X	3
Vesper Sparrow	<u>Poocetes gramineus</u>	X	X	X	X	5
Virginia Rail	<u>Rallus limicola</u>		X	X	X	3
Warbling Vireo	<u>Vireo gilvus</u>	X	X	X	X	4
Western Kingbird*	<u>Tyrannus verticalis</u>					
Western Meadowlark	<u>Sturnella neglecta</u>		X	X	X	3
Western Sandpiper	<u>Calidris mauri</u>				X	1
Whip-poor-will	<u>Caprimulgus vociferus</u>	X			X	3
White-breasted Nuthatch	<u>Sitta carolinensis</u>	X	X	X	X	5

Table 4.1. Continued.

White-crowned Sparrow	<u>Zonotrichia leucophrys</u>	X	X	X	4
White-eyed Vireo	<u>Vireo griseus</u>		X	X	2
White-rumped Sandpiper	<u>Calidris fuscicollis</u>			X	1
White-throated Sparrow	<u>Zonotrichia albicollis</u>	X	X		3
White-winged Crossbill	<u>Loxia leucoptera</u>		X	X	3
White-winged Scoter	<u>Melanitta fusca</u>		X		1
Wild Turkey	<u>Meleagris gallopavo</u>	X	X	X	5
Willow Flycatcher	<u>Empidonax traillii</u>	X	X	X	4
Wilson's Warbler	<u>Wilsonia pusilla</u>			X	1
Winter Wren	<u>Troglodytes troglodytes</u>	X	X	X	4
Worm-eating Warbler	<u>Helmitheros vermivora</u>			X	1
Wood Duck	<u>Aix sponsa</u>	X	X	X	5
Wood Thrush	<u>Hylocichla mustelina</u>	X	X	X	4
Yellow Rail	<u>Coturnicops noveboracensis</u>			X	1
Yellow Warbler	<u>Dendroica petechia</u>	X	X	X	3
Yellow-bellied Flycatcher	<u>Empidonax flaviventris</u>			X	1
Yellow-bellied Sapsucker	<u>Sphyrapicus varius</u>	X	X	X	3

Table 4.1. Continued.

Yellow-billed Cuckoo	<u>Coccyzus americanus</u>	X	X	X	X	4
Yellow-breasted Chat	<u>Icteria virens</u>		X	X	X	3
Yellow-crowned Night Heron	<u>Nyctanassa violacea</u>				X	1
Yellow-headed Blackbird	<u>Xanthocephalus xanthocephalus</u>			X	X	2
Yellow-rumped Warbler	<u>Dendroica coronata</u>	X		X		3
Yellow-throated Vireo	<u>Vireo flavifrons</u>	X	X	X	X	4
Yellow-throated Warbler	<u>Dendroica dominica</u>	X		X	X	3
Total Species Observed		171	124	150	220	201

*Species identified only in the MBRC records, not in any of the surveys.

†Species that either could not be corroborated by MBRC records or likely occurred outside of study area.

‡Differentiation between two species could not be determined.

Table 4.2. Comparison of all survey/counts with all possible combinations. The number of species in common is the number of species present in both lists being compared, with the number in parentheses representing the percent.

Routes Compared	Number of Species in Common
Landowners vs. BBS	103 (53.6%)
Landowners vs. CBC	116 (57.1%)
Landowners vs. BOW	157 (67.1%)
Landowners vs. MIBBA	134 (57.0%)
BBS vs. CBC	71 (35.3%)
BBS vs. BOW	115 (50.2%)
BBS vs. MIBBA	118 (57.8%)
CBC vs. BOW	134 (57.3%)
CBC vs. MIBBA	107 (44.8%)
BOW vs. MIBBA	168 (67.2%)

CHAPTER 5

THE HUMAN INFLUENCE ON BIRDS ACROSS LANDSCAPES

ABSTRACT

Bird populations across the United States have been exhibiting notable fluctuations, both positive and negative, over the past 30 years. While a host of mechanisms have been put forth to explain the causes of the fluctuations, the ultimate factor is generally human influence. However, there has been a paucity of research investigating the influence of humans across multiple landscapes and regions. To address this paucity we investigated two human influences, the total area of anthropogenic land cover and the number of housing units, in relation to avian species diversity and the trends of 12 species occupying landscapes across the entire Midwest of the United States. We hypothesized that (1) species diversity would be maximum at intermediate levels of human influence, based on intermediate disturbance theory; (2) the amount of human influence should affect the proportion of individuals from the global population of each of the 12 species occupying each landscape; and, (3) if birds do display a relationship with anthropogenic land cover and the number of housing units, then those species that can utilize the supplemental food and shelter as well as escape predation, should have greater population trends than species that cannot utilize these resources. Across the entire Midwest a negative relationship existed between avian diversity and both the total number of housing units and the total amount of anthropogenic land cover, with the latter having a greater effect. Ten of the twelve species investigated displayed weak to strong relationships with the level of human influence, but differed between the two measures (housing units and anthropogenic land cover). No significant differences existed between the relationship a species exhibited with regard to the total number of housing

units and the total amount of anthropogenic land cover based upon major diet or nesting location. Overall, results indicate that humans are having a significant influence on bird populations, but that they are not dependent upon natural history factors of diet type and nest location.

INTRODUCTION

Throughout the United States bird populations have undergone marked declines and fluctuations over the past 30 years. In fact, current estimates indicate that over 25% (204) of the bird species in the U.S. have declining populations (Audubon 2002), including several Neotropical migrants and forest breeding bird species. In the Midwestern and Eastern portion of the U.S., these population declines have been attributed to a host of interrelated factors, including habitat fragmentation and loss (Robbins et al. 1989, Fahrig 1997, Askins 2000, Donovan and Flather 2002), nest predation (see Heske et al. 2001 for review), cowbird parasitization (Robinson et al. 1995), and increased mortality on the wintering-grounds (Rappole and McDonald 1994, Basili and Temple 1999). Notably, however, while many bird species are experiencing population declines, others are exhibiting large population increases. For instance, in Michigan the populations of American Crow (Corvus brachyrhynchos) have increased nearly 2% per year over the past twenty years (Ray Adams, personal communications, Sauer et al. 2001). Along similar lines of reasoning for population declines, there are a number of interrelated factors responsible for these increases, including supplemental feeding (Brittingham and Temple 1988, Doherty and Grubb 2002), and increased amount of edge habitat. Although both population increases and decreases have been attributed to a wide number of proximate causes, in most cases the underlying ultimate influence is humans.

Because humans influence nearly every ecosystem on the planet (Vitousek et al. 1997), they are increasingly being recognized as important components of the ecosystem

(McDonnell and Pickett 1993, Liu et al. 1999, Liu et al. 2001). Concomitant with this increased recognition of the human component has been a recent increase in the research directed towards addressing how humans' influence bird species. Such research covers a gamut of topics, ranging from the subtle effects (*sensu* Russell 1993) of repeated human intrusions into bird habitat (Gutzwiller et al. 1997, Gutzwiller et al. 2002) to the influence of urbanization (see Marzluff 2001 for review). However, with rare exception, these studies have been at relatively fine scales (Miller et al. 2001) or only considered a small number of landscapes. While these fine scale studies have provided critical details elucidating the factors that influence population parameters such as survival and fecundity, they have not addressed the larger scale issue of human influences on bird species across multiple landscapes. Given the fact that the U.S. population is expected to increase by 65 million people between 1995 and 2025 (Fischer and Heilig 1997), coupled with the historical trend towards population decentralization resulting in urban and rural sprawl, it is essential to understand human influences on birds across multiple landscapes in order to improve conservation efforts.

Two separate, but interrelated, human influences that have been demonstrated to affect birds at local scales, but have not been investigated across multiple landscapes are the influence of landowner activities and the level of human domination of the landscape. In the case of landowner activities, this refers to the actions taken by private landowners on their property that can directly, or indirectly, influence birds, such as supplemental feeding and housing, application of chemicals, and modification of vegetation. Taken cumulatively across a landscape these landowner activities can result in a significant source of impact on bird populations. For example, in three Southeastern Michigan landscapes, it was found that over 65% of landowners fed birds and nearly half had bird houses (Lepczyk et al. 2002, Chapter 2). Moreover, while the landowners in the three landscapes displayed some variation in levels of participation, they all had a very large

proportion of the total landowner population involved in the activities. Because of these high activities levels, birds that can utilize the positive benefits of habitat modification, such as supplemental food and nesting locations, may have increasing or stable populations. Furthermore, birds that can use bird houses or nest higher in the canopy may escape the negative effects of increased predation due to house cats. On the other hand, the level of human domination across a landscape is simply a measure of the degree to which human influence is present on the landscape. Because human influence can be measured in a number of ways, human domination can include such factors as the amount of land cover devoted to human use, the human population size and its spatial distribution, number of roads, etc.

As part of a larger effort to understand the human influence on breeding birds (Lepczyk et al. 2002, Chapter 1, 2, and 3), we sought to investigate how the level of human domination across landscapes influences avian diversity as well as different foraging and nesting guilds of birds. Specifically, we were interested in: 1) determining how avian diversity changes in relation to two measures of human domination, anthropogenic land cover and housing units; and, 2) comparing the population trends of 12 specific bird species based on anthropogenic land cover and housing unit number. We selected anthropogenic land cover and housing units as a general measure of human land use across landscapes, which while related, are in fact different. Specifically, anthropogenic land cover is a general measure of anthropogenic land cover and land use classes, whereas housing units are a measure of physical structures on the landscape, portions of which are often obscured in maps that have any forested areas (Radeloff et al. 2002). Furthermore, bird abundance and behavior may be quite different in relation to

anthropogenic land cover and housing units, as people can directly affect birds near their housing unit (Chapters 1, 2, and 3).

To investigate the aforementioned relationships, we formulated 3 *a priori* hypotheses. First, because human domination or impacts to the landscape are a form of disturbance we hypothesize that the relationship between avian diversity and both anthropogenic land cover and housing units should form a hump-shaped (inverse quadratic) curve. Our basis for a hump-shaped relationship is that completely natural and completely anthropogenic landscapes are likely to have fewer species than at an intermediate level where anthropogenic factors may be encouraging a greater number and mixture of habitats. Hump-shaped relationships of species diversity are relatively common along productivity gradients and there is evidence that such relationships occur along other gradients in ecology (Mittelbach et al. 2001). Second, we hypothesize that the proportion of individuals from a given species occupying a particular landscape, out of the total population, will be functionally related to the amount of anthropogenic land cover and number of housing units. This second hypothesis is based on recent research which found that the proportion of individuals occupying a given landscape, from the total population, are related to the amount of fragmentation occurring in the landscape (Donovan and Flather 2002). Furthermore, because previous investigations (Lepczyk et al. 2002, Chapter 1 and 2) have found that across landscape private landowners are supplementing food and shelter, as well as introducing exotic predators (i.e., house cats) and applying pesticides, that species should respond differentially based on natural history characteristics. Thus, our third hypothesis is that if birds do display a relationship with anthropogenic land cover and the number of housing units, then those species that

can utilize the supplemental food and shelter as well as escape predation, should have greater relative abundances than species that cannot utilize these resources. Based upon the third hypothesis, we predicted that with regard to diet, omnivores should have the greatest population trends, followed by granivores and lastly, insectivores. Similarly, we predicted that with regard to nesting location, birds that nest in cavities should have the greatest population trends, followed by canopy, shrub, and ground nesters, respectively.

METHODS

Breeding Bird Survey

Initiated in 1966, the BBS is continental scale roadside survey of breeding birds in the United States and Canada (Sauer et al. 2001). Surveys are carried out annually along secondary roads on permanently established routes, each of which is 25 miles (39.4 km) long. Three-minute point counts are conducted at 0.5 mile (0.8 km) intervals for a total of 50 point count stops per route. All birds heard or seen within a 0.25 mile (0.4 km) radius of each stop are recorded. The BBS provides data on avian abundance and is commonly used for assessments of avian populations trends (e.g., James et al. 1996). We selected all BBS routes that had been censused a minimum of four times during the 11-year period of 1987 to 1997 throughout the entire Midwest United States. This 11-year time period was chosen in order to be centered on 1992, which is the approximate time of the land cover data (see below). A total of 402 BBS routes, all located in the Midwestern United States, met these requirements (Figure 5.1).

Species Selection

The 12 species selected (Table 5.1) for testing hypothesis two and three were chosen based first upon diet, then by nesting location. Because humans can directly supplement both food and nests, these two natural history characteristics may play critical roles in determining a species abundance in a landscape. Diet categorization was based on Ehrlich et al. (1988), with the species selected having only one dominant diet grouping during the breeding season (i.e., no mixed categories, such as insectivore-frugivore, were considered). The 12 species were chosen to form three equally sized groups of omnivores, granivores, and insectivores, while at the same time trying to maximize for differences in nesting location. The four nesting groups, cavity, canopy, shrub, and ground, were based upon Marin (1995) and Ehrlich et al. (1988). Because there are relatively few truly omnivorous and granivorous species during the breeding season, this limited the potential pool of species to nine for granivores and five for omnivores, that occur in any significant frequency in the Midwest.

Land Cover and Housing Data

The digital National Land Cover Data (NLCD; Vogelmann et al. 2001) from the United States Geological Survey (USGS) provided the initial land cover and land use data for the study region. The NLCD data were derived from the early 1990s Landsat TM satellite data and is centered on 1992/93. The database consists of a 21 land cover classification (Table 5.2) scheme, at 30 m resolution, which was applied consistently over the U.S. Data were mapped in Albers Conic Equal Area projection, NAD 83.

The 1990 U.S. Census provided for the first time spatially detailed GIS coverages on housing density, human populations, and various sociological variables. Recent work has derived methods to calculate the number of housing units at the partial census block level for the Midwestern United States (Radeloff et al. 2000, 2001, 2002, Hammer et al. 2002). Housing units, which include houses, condominiums, and apartment buildings, are a more refined and relevant measure of human impacts than simply human population, as housing units are now increasing at a faster rate than population (Liu et al. 2003). Moreover, housing units take physical space on the land and are relatively permanent fixtures.

Landscape Analysis

To characterize the landscape surrounding each BBS route, a circular scene with a 19.7 km radius centered on the route ($\sim 1200 \text{ km}^2$) was clipped from both the NLCD landscape data and U.S. Census housing data (Flather and Sauer 1996, Donovan and Flather 2002). This 19.7 km radius circular landscape was chosen to ensure that each landscape completely contained the BBS route. Subsequently, the NLCD data for each BBS route (hereafter termed landscape) were reclassified into the three broad classes “water,” “anthropogenic,” and “natural,” land cover based upon their major land cover and land use descriptions of the source classes (Table 5.2). While arguably there are few, if any, locations in the Midwest that could be considered totally “natural” (Sanderson et al. 2002), the intent of classification was to broadly describe the landscapes relative to human impact. All landscape data operations were conducted using ArcInfo geographic information systems (GIS) and Erdas Imagine.

We used APACK (Mladenoff and DeZonia 2001) to estimate landscape structure metrics in the reclassified NLCD data for each landscape. Housing unit data was summarized for all partial census blocks in each landscape. Because of the circular nature of the landscapes, any partial census block that occurred at the edge of a landscape was included in the overall estimate. The landscape and housing unit metrics describe both the amount and arrangement of the anthropogenic factors in each landscape, of which our primary interest was the amount. Because a number of the metrics are associated with one another, they have a strong potential for collinearity. Thus, we first selected four primary landscape metrics: total anthropogenic land cover, mean anthropogenic patch size, total number of housing units, and mean number of housing units per partial census block, with the goal of selecting one land cover metric and one housing unit metric that were least correlated with one another. The two metrics that displayed the lowest degree of correlation were total amount of anthropogenic land cover and total number of housing units (Pearson correlation test; $\chi^2 = 3.60$; $df = 1$; $p = 0.06$). Hence, the total amount of anthropogenic land cover and total number of housing units were selected for the two metrics of human influence on the landscape.

Statistical Analyses of Breeding Bird Data Across the Landscapes

For the measurement of total species richness (defined as the number of unique species), the total number of species observed on each BBS route across all years measured was calculated. Linear and non-linear regression analyses were used in order to test whether a relationship existed between species diversity and (1) total number of housing units and (2) total amount of anthropogenic land cover. The two regression

techniques were used to establish whether a relationship existed, and then if it were better described by a simple linear model or an inverse quadratic model, thereby establishing support for a hump-shaped relationship.

The mean number of individuals for each of the 12 selected species (Table 5.1) on each route was determined first by selecting only the routes which had reported the species for a minimum of four censuses during the 1987 to 1997 time period. If a species occurred for a minimum of four censuses, a mean count of the individuals was taken over all years the species was present during the 11-year period for the route. Routes on which a species occurred in less than four censuses were eliminated from the analysis. The mean count of individuals for each bird species was summed across the landscapes and the proportion of individuals along each route was determined by dividing the mean count of individuals per route by the total count of individuals across all routes. The proportion of individuals of each species occupying each landscape was then regressed against the (1) total number of housing units and (2) total amount of anthropogenic land cover. All species displaying a significant relationship were then analyzed together by comparing the slopes of their relationships with the categorical variables of diet type and nest location using ANOVA, with a Bonferroni post-hoc test (Zar 1996), to investigate if their trends were related to these categories. The proportion of individuals on each route was arcsine square root transformed and the total number of housing units was log transformed to normalize the data (Sokal and Rohlf 1981).

Population trend estimates for the twelve species were also computed across the Fish and Wildlife Service Region 3, which corresponds to the eight state area of this study, from 1987 to 1997 using a route-regression approach (Geissler and Sauer 1990,

Sauer et al. 2001) that measures the percent change per year and weights the overall average according to the number of individual routes, while accounting for observer and other biases (Sauer et al. 1994). Significant trend estimates based on the entire region were similarly analyzed against the categorical variables of diet and nest. All statistical analyses were performed using SYSTAT 10 (SPSS 2000).

RESULTS

The landscape surrounding the 402 BBS routes exhibited a wide range of total anthropogenic area, mean anthropogenic patch size, number of anthropogenic patches, maximum anthropogenic patch size, and number of housing units (Table 5.3).

Bird diversity across landscapes displayed a weak, but significant, negative linear relationship to the total number of housing units ($r^2 = 0.053$; $p < 0.000005$; Figure 5.2). The relationship was not improved with a non-linear analysis ($r^2 = 0.052$). In the case of total anthropogenic land cover, bird diversity displayed a strong negative relationship ($r^2 = 0.434$; $p < 0.000005$; Figure 5.3). However, the relationship was not improved with a non-linear analysis ($r^2 = 0.27$).

The proportion of individuals occupying landscapes with different numbers of housing units displayed significant trends in ten of the twelve species (Table 5.4, Figure 5.4). Of the nine species showing a significant relationship, four displayed a negative relationship with increasing numbers of housing units and five displayed a positive relationship with increasing numbers of housing units (Table 5.4, Figure 5.4). Similarly, the proportion of individuals occupying landscapes with different amounts of

anthropogenic land cover displayed a significant relationship in ten of the twelve species (Table 5.5, Figure 5.5). Likewise, of the ten species showing a significant relationship, five displayed a negative relationship with increasing amounts of anthropogenic land cover and five displayed a positive relationship with increasing amounts of anthropogenic land cover (Table 5.5, Figure 5.5). Notably, the two species, American Goldfinch and House Finch, whose abundance was not related to anthropogenic land cover were different than the three species, American Crow, White-breasted Nuthatch, and Yellow Warbler, that showed no relationship with the number of housing units. Across the entire Midwest 11 of the 12 species displayed significant positive or negative population trends (Table 5.6). Of these 11 significant trends, six populations were declining and five were increasing.

The ten species that displayed a significant relationship with regard to the total number of housing units (Table 5.4) did not have significantly different slopes based upon diet ($F = 0.95$; $df = 2, 7$; $p = 0.43$) or nesting location ($F = 1.56$; $df = 3, 6$; $p = 0.29$). Similarly, the ten species that displayed a significant relationship with regard to the total amount of anthropogenic land cover (Table 5.5) did not have significantly different slopes based upon diet ($F = 2.91$; $df = 2, 7$; $p = 0.12$) or nesting location ($F = 0.11$; $df = 3, 6$; $p = 0.95$). Finally, the ten species that displayed significant population trends across the entire Midwest (Table 5.6) did not have significantly different population trends based upon diet ($F = 2.09$; $df = 2, 7$; $p = 0.19$) or nesting location ($F = 0.92$; $df = 3, 6$; $p = 0.48$). While no significant differences existed based upon diet, granivorous birds were the only one of the three groups that displayed a consistent trend in relation to human influence and Midwest population trend, which was positive. Again, while not significant, only

one nesting location category, canopy, displayed a consistent trend among all three analyses, which was positive.

DISCUSSION

In the Midwest U.S. declines in avian diversity are correlated with increases in both the number of housing units present on the landscape (Figure 5.2) and the total amount of anthropogenic land cover (Figure 5.3). However, the declines did not correspond any better to an inverse quadratic function than a linear function at the scale of the study and in relation to the type of disturbance investigated. Thus our first hypothesis that avian diversity would be greatest at intermediate levels of disturbance was not supported. While a negative relationship existed with both measures of human influence, the total amount of anthropogenic land cover showed a much stronger fit to the avian diversity data ($r^2 = 0.434$; Figure 5.3) than did the total number of housing units ($r^2 = 0.053$; Figure 5.2). Several possible reasons exist for this marked difference between the two measures. First, housing units could both positively and negatively influence the occurrence of birds near them, depending upon what types of activities the landowners are engaged in and what type of land cover surrounds them. Specifically, if the landowners across the entire Midwest are engaged in quite different levels of activities, there may be several different relationships in the data that have been obscured. In other words, both positive and negative relationships in bird diversity related to housing unit number may be occurring due to differential levels of activities that may positively and negatively influence bird abundances, which could ultimately result in little if any overall

pattern. Second, anthropogenic land cover may simply be a more robust measure of overall human influence than the number of housing units present on a landscape. A final reason may simply be that the number of housing units is too coarse of a measure across such large landscapes.

Overall, the abundance of bird species was related to anthropogenic land cover and the number of housing units, thus supporting the hypothesis that the relative abundance of a species will be functionally related to the amount of anthropogenic land cover and number of housing units. However, while a number of species did have significant relationships, many of them were rather weak. Specifically, although nine of the twelve bird species displayed significant relationships with regard to the number of housing units, only three, House Finch, American Goldfinch, and Mourning Dove, had large r^2 values (Table 5.4, Figure 5.4). Similarly, in the case of anthropogenic land cover, ten of the twelve bird species displayed significant relationships (Table 5.5). Notably, however, these ten species were different than those found in the housing unit analysis (Table 5.4 and 5.5). Of the ten species having a significant relationship with the amount of anthropogenic land cover, only four bird species, Horned Lark, House Wren, Mourning Dove, and Ovenbird displayed r^2 values that suggest a strong correlation. Only Mourning Doves and Ovenbirds exhibited significant relationships with both measures of human influence. In the case of both Mourning Doves and the remaining five species that showed any marked correlation with the human influences, all of them are generally believed to have strong positive or negative relationships with humans. For instance, Mourning Doves are readily found at most bird feeders and are more common in cities and urban areas than in more natural or wild locations. On the other hand, Ovenbirds are

an area-sensitive forest interior bird that occurs less frequently in more fragmented landscapes (Robinson et al. 1995). Across the entire Midwest, eleven of the twelve species had significantly increasing or decreasing populations, with only the American Goldfinch displaying no significant change in its population over the eleven years investigated (Table 5.6).

Comparing the birds that displayed significant relationships with the two measures of human influence, as well as those that had significantly increasing or decreasing population trends across the Midwest, with the natural history categories of diet and nest location, yielded no significant results. Thus, our hypothesis that diet type and nest location would be important explanatory factors was not supported. While diet was not an important explanatory factor, it is notable that the class of granivores was the only one of the three classes that consistently displayed a positive trend with human influence and across the entire Midwest. Similarly, in the case of nesting location, only the canopy nesters displayed a consistent relationship with human influence, and across the Midwest, which was positive. As a result, while non-significant, the findings of granivores and canopy nesters displaying positive relationships with human influence and across the Midwest suggest that they are best able to survive, and potentially thrive, in human-dominated landscapes.

Because the total number of housing units and total amount of anthropogenic land cover measure two different aspects of human influence, and thus may have different effects on the relative abundance of birds, they were investigated separately. However, given the rather weak and inconsistent results found by analyzing the two human influence factors separately we did investigate their combined effect on relative

abundance by carrying out an additional set of analyses using multiple regression. Thus, while not an *a priori* hypothesis, we tested to see if both factors together significantly influenced the relative abundance of each of the twelve species. Utilizing the multiple regression approach yielded a significant model for each of the twelve species (Table 5.7). While the multiple regressions did improve the r^2 estimates for some species, such as the Blue Jay and Brown Thrasher, they did not improve the r^2 estimates for other species, such as the House Finch or White-breasted Nuthatch, beyond the previous estimates. Thus, the multiple regressions did improve the relationships between relative abundance and the human influence factors for some species, but in most cases the models did not explain the data any further than the separate regression models. Interestingly, the two species which did exhibit a large increase in their r^2 estimates were the Blue Jay and the Brown Thrasher. In the case of the Blue, it is a species that is commonly associated with both backyard bird feeders, and hence housing units, as well as edges and anthropogenic land cover. On the other hand, Brown Thrashers are a species that have been exhibiting declines throughout the Midwest (Donovan and Flather 2002), and thus may be negatively impacted by both the presence of housing units and the conversion of natural land cover into anthropogenic land cover.

In general, the results do indicate that bird diversity and abundance across the landscapes of the Midwest are related to the amount of human influence present on the landscape. Given the large-scale nature of the analyses and the general metrics used, these relationships may well be improved with the inclusion of more specific landscape metrics and natural history data. Similarly, analyzing a larger pool of species with regard to natural history categories, might result in such factors as diet and nesting location

becoming important. Overall, then, the results indicate that humans are having a significant effect on bird populations, but that they are not dependent upon natural history relationships.

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Table 5.1. Bird species selected for population trend analysis.

Species	Diet	Nest
American Crow (<u>Corvus brachyrhynchos</u>)	Omnivore	Canopy
American Goldfinch (<u>Carduelis tristis</u>)	Granivore	Shrub
Blue Jay (<u>Cyanocitta cristata</u>)	Omnivore	Canopy
Brown Thrasher (<u>Toxostoma rufum</u>)	Omnivore	Shrub
Horned Lark (<u>Eremophila alpestris</u>)	Granivore	Ground
House Finch (<u>Carpodacus mexicanus</u>)	Granivore	Canopy
House Wren (<u>Troglodytes aedon</u>)	Insectivore	Cavity
Mourning Dove (<u>Zenaida macroura</u>)	Granivore	Canopy
Ovenbird (<u>Seiurus aurocapillus</u>)	Insectivore	Ground
Red-headed Woodpecker (<u>Melanerpes erythrocephalus</u>)	Omnivore	Cavity
White-breasted Nuthatch (<u>Sitta carolinensis</u>)	Insectivore	Cavity
Yellow Warbler (<u>Dendroica petechia</u>)	Insectivore	Canopy

Table 5.2. NLCD land cover classes.

Class Name	Subclass	Code	Recode
Water	open	11	water
	ice and snow	12	water
Developed	low intensity residential	21	human
	high intensity residential	22	human
	commercial/industrial/transportation	23	human
Barren	bare rock/sand/clay	31	natural
	quarries/strip mines/gravel pits	32	human
	transitional	33	natural
Forested Uplands	deciduous	41	natural
	evergreen	42	natural
	mixed	43	natural
Shrubland	shrubland	51	natural
Non-natural Woody	orchards/vineyards/other	61	human
Herbaceous Upland	grasslands/herbaceous	71	natural
Herbaceous Planted and	pasture/hay	81	human
Cultivated			
	row crops	82	human
	small grains	83	human
	fallow	84	human
	urban/recreational grasses	85	human
Wetlands	woody	91	natural
	emergent herbaceous	92	natural

Table 5.3. Descriptive statistics of anthropogenic land cover and housing in the landscapes encompassing the 402 BBS routes.

Measurement	Range	Mean $\pm$ SD	Median
Total anthropogenic land area (ha)	398-119,900	72,073 $\pm$ 36,971	82,496
Mean anthropogenic patch size (ha)	0.2-2,833	89 $\pm$ 241	22
Number of anthropogenic patches	42-14,886	3,960 $\pm$ 3,204	3,287
Maximum anthropogenic patch size (ha)	14-11,988	62,877 $\pm$ 41,680	72,040
Number of houses	265-978,189	22,341 $\pm$ 59,737	9,962

Table 5.4. Regression analysis of proportion of individuals occupying a landscape relative to the total number of housing units.

Species	n	slope	r ²	p-value
American Crow	397	0.003	0.009	0.064
American Goldfinch	398	0.01	0.10	<0.0000005
Blue Jay	400	0.004	0.017	0.009
Brown Thrasher	346	-0.009	0.056	0.000008
Horned Lark	290	-0.01	0.02	0.016
House Finch	223	0.039	0.29	<0.0000005
House Wren	354	0.006	0.022	0.004
Mourning Dove	387	0.013	0.13	<0.0000005
Ovenbird	160	-0.034	0.14	0.000001
Red-headed Woodpecker	240	-0.016	0.08	0.000007
White-breasted Nuthatch	270	0.001	0.0007	0.66
Yellow Warbler	281	-0.0006	0.0001	0.84

Table 5.5. Regression analysis of proportion of individuals occupying a landscape relative to total amount of anthropogenic land cover.

Species	n	slope	r ²	p-value
American Crow	397	-0.000000054	0.02	0.005
American Goldfinch	398	0.000000016	0.001	0.44
Blue Jay	400	-0.000000104	0.07	<0.0000005
Brown Thrasher	346	0.000000116	0.06	0.00001
Horned Lark	290	0.000000638	0.32	<0.0000005
House Finch	223	0.000000012	0.0001	0.86
House Wren	354	0.000000190	0.11	<0.0000005
Mourning Dove	387	0.000000300	0.4	<0.0000005
Ovenbird	160	-0.000000967	0.53	<0.0000005
Red-headed Woodpecker	240	0.000000118	0.02	0.04
White-breasted Nuthatch	270	-0.000000102	0.04	0.0009
Yellow Warbler	281	-0.000000136	0.02	0.0007

Table 5.6. Route-regression analyses of all BBS routes across the Midwest region. Note, sample size may be larger than number of landscapes analyzed.

Species	n	Trend	<i>p</i> -value
American Crow	510	1.77	<0.000005
American Goldfinch	509	0.27	0.53
Blue Jay	511	-1.54	0.00002
Brown Thrasher	460	-2.21	0.0003
Horned Lark	373	-1.52	0.04
House Finch	337	17.65	<0.000005
House Wren	457	1.20	0.0004
Mourning Dove	496	-0.61	0.07
Ovenbird	224	1.56	0.00002
Red-headed Woodpecker	346	-5.99	<0.000005
White-breasted Nuthatch	415	-1.53	0.04
Yellow Warbler	387	3.26	0.00001

Table 5.7. Multiple regression analysis of proportion of individuals occupying a landscape relative to both the total amount of anthropogenic land cover and the total number of housing units. Note, in each model the p -value was <0.001 .

Species	n	slope of constant	r^2
American Crow	397	0.34	0.04
American Goldfinch	398	0.0058	0.11
Blue Jay	400	0.027	0.13
Brown Thrasher	346	0.088	0.15
Horned Lark	290	0.052	0.36
House Finch	223	-0.10	0.29
House Wren	354	0.024	0.12
Mourning Dove	387	-0.0008	0.4
Ovenbird	160	0.12	0.53
Red-headed Woodpecker	240	0.12	0.11
White-breasted Nuthatch	270	0.045	0.05
Yellow Warbler	281	0.05	0.05

FIGURE LEGENDS

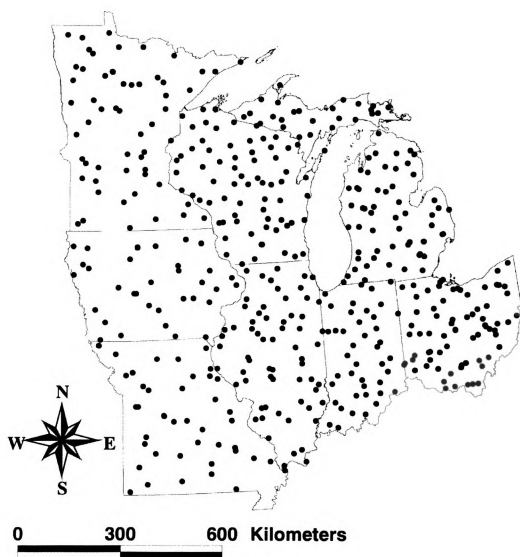
Figure 5.1. Locations of all 402 Breeding Bird Survey (BBS) routes across the Midwest United States.

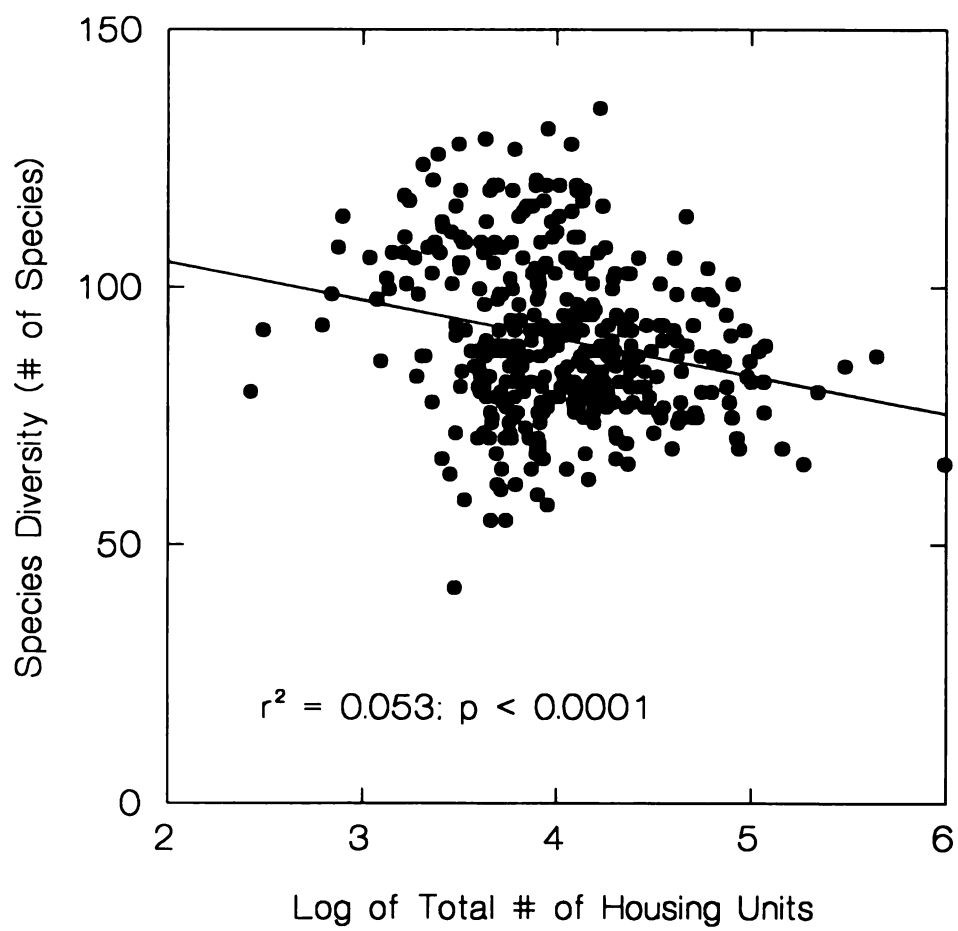
Figure 5.2. Total bird diversity (# of species) versus the total number of housing units.

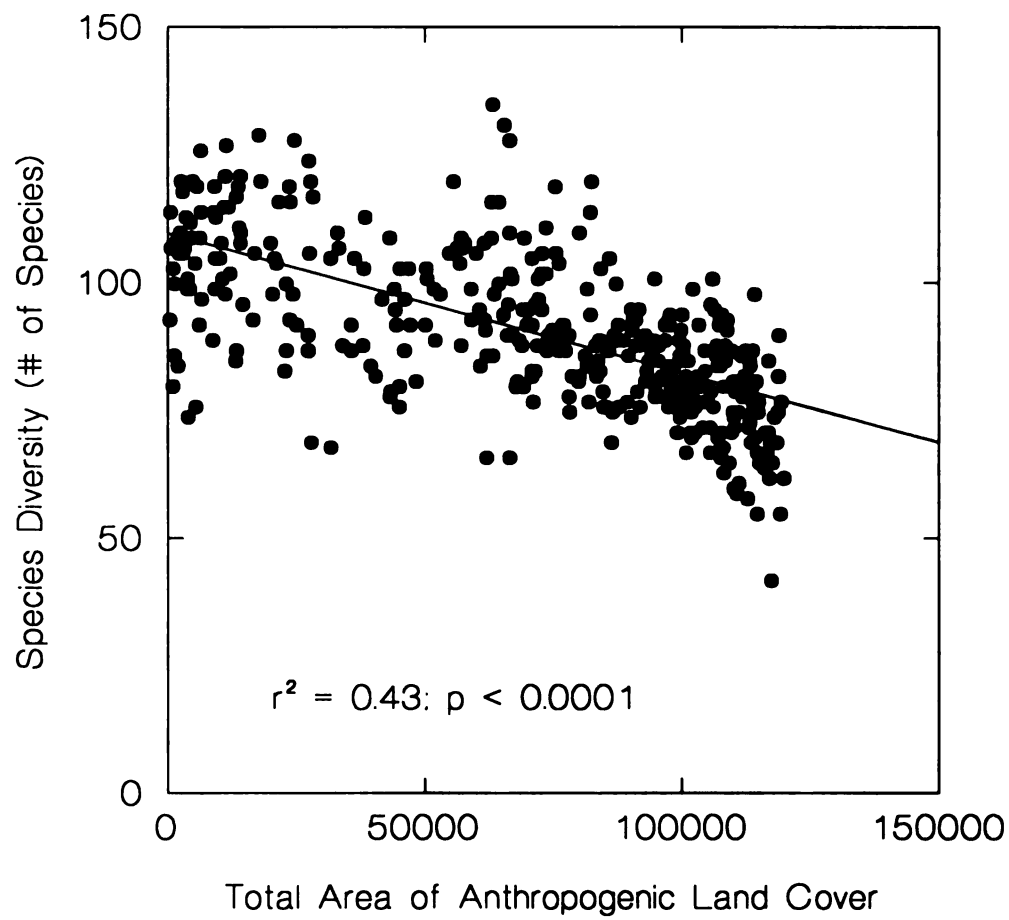
Figure 5.3. Total bird diversity (# of species) versus anthropogenic land cover.

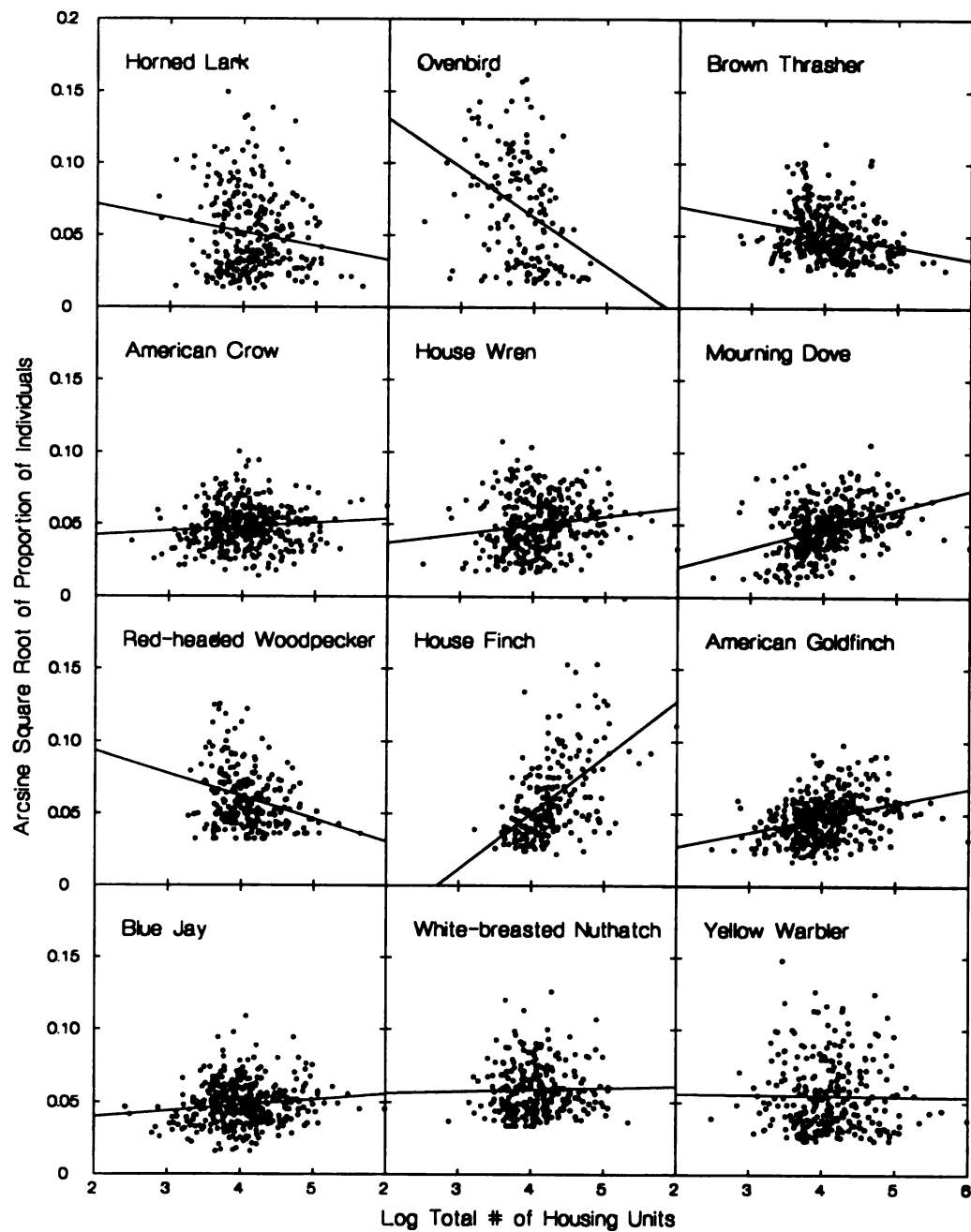
Figure 5.4. Proportion of individuals occupying each landscape versus the total number of housing units for each of the twelve species.

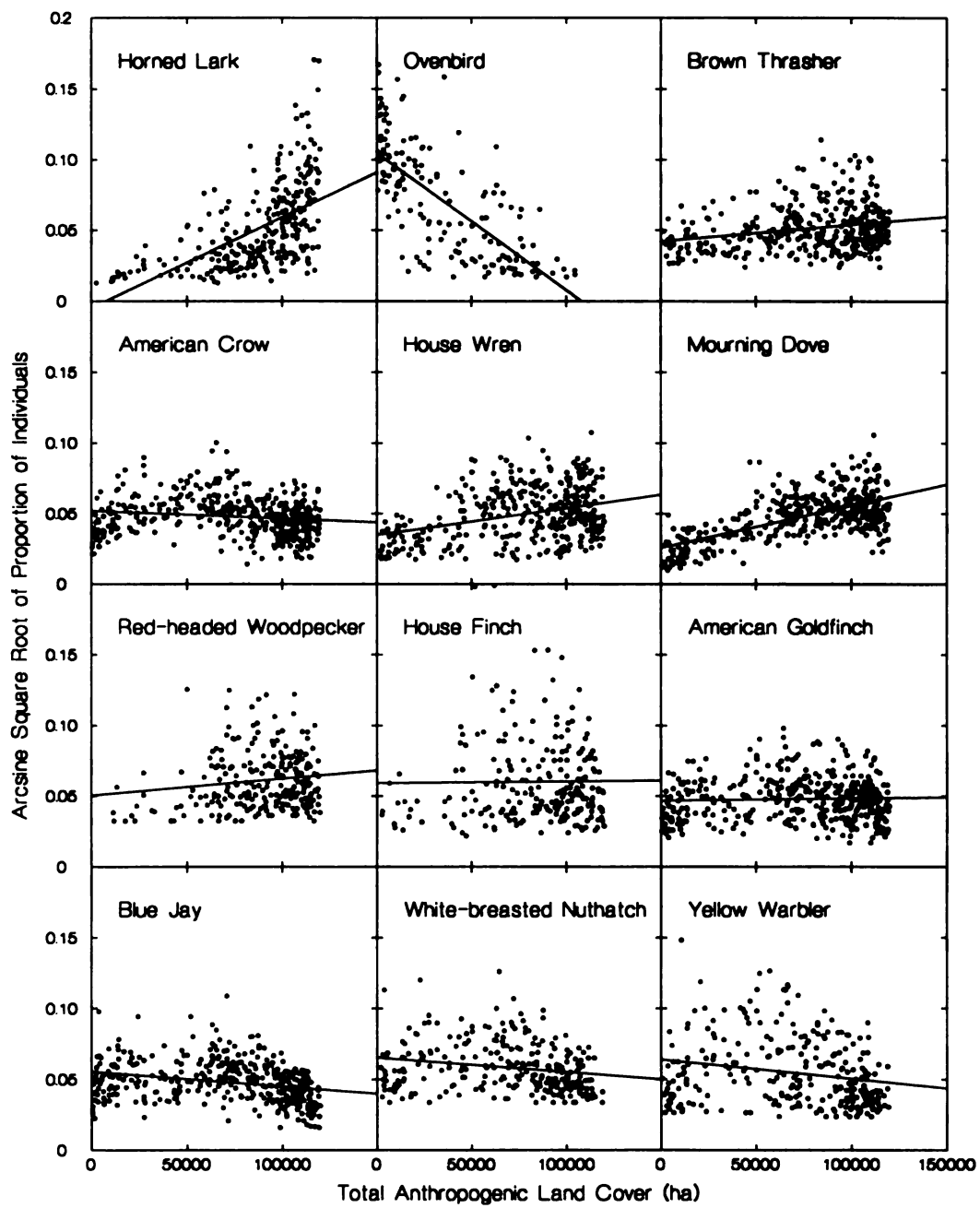
Figure 5.5. Proportion of individuals occupying each landscape versus the total amount of anthropogenic land cover for each of the twelve species.











SYNTHESIS AND CONCLUSION

A primary objective of the research presented in this dissertation was to understand the types and magnitudes of activities that landowners engage in on their property that can influence birds. As evidenced by Chapters One and Two, landowners are in fact engaged in a wide variety of activities that can both directly and indirectly influence birds across all landscapes. While the activities investigated were not exhaustive, the eight investigated are all known to have effects on birds. Furthermore, the research results presented here provide a set of data on which to base future research about how private landowners are both intentionally and unintentionally influencing bird species on or near their property.

Prior to this dissertation research, there were few, if any, publications about landowner activities that influence birds, aside from several government surveys and gray literature reports. Thus, one important finding of my research is simply understanding the degree to which landowners modify and influence their land intentionally for the benefit of birds. With regard to intentional modifications for the benefit of bird species, the activities of food and nest supplementation and planting vegetation are being carried out by approximately 50% or more of the landowners, indicating that cumulatively a very large proportion of landscape is being intentionally, but independently, managed for bird species. On the other hand landowners are engaged in a number of activities that have unintentional implications for bird species. For example, allowing cats outdoors and applying pesticides and herbicides are two activities that approximately 25% of landowners engaged in that have negative consequences for birds, which landowners are in all likelihood not engaged in with any intention of harming bird species. Such reasoning may in part explain why these negative activities showed no relationship with how landowners perceive birds on their property.

Related to what landowners do on their property that can influence bird species, a second objective of the research was to measure how landowners perceive birds on their property. Overall, a key finding of landowners' perceptions presented in Chapter Three was that the average landowner believed both bird diversity and having birds on one's land was important. Although landowners were only slightly interested in tax incentives or altering their land use for the benefit of birds, their overall positive perception of birds is a significant finding because it may be an avenue that can be pursued for better conservation and management of bird species. Landowner perceptions were also important in that as they increased so too did the number of positive activities that they engaged in on their land. The results strongly suggest that landowner perceptions about birds influence the number of positive activities that they engage in on their property. Again, this positive association indicates that targeting conservation and management efforts through the use of bird species may be an important aspect to consider.

Landowner perceptions also offer a potential new direction for ascertaining where species occur on the landscape. Because of the percent of land in private ownership throughout Southeast Michigan and the Midwest, the use of a mail survey to census bird species may be a very important tool. As Chapter Four highlights, landowners not only reported a large diversity of birds across the landscapes, but also identified many rare species that other surveys had missed. Thus, the use of mail surveys to census birds on private lands may not only be an important tool for establishing bird abundance data, but ultimately may prove to be more cost effective than other methods.

The last objective of this dissertation was to utilize the findings from the intensive landowner surveys on the three BBS routes presented in Chapters One and Two in order to make assumptions and predictions about bird populations across 402 BBS routes of the Midwest. The rationale for investigating the entire Midwest region was that a large sample size of BBS routes was needed in order to investigate actual impacts on bird populations, which could not have been accomplished with only the three original routes.

Thus, by assuming that the activities occurring along the three BBS routes in Southeastern Michigan were representative of all landscapes surrounding all 402 BBS routes in the Midwest, I predicted that both diet type and nest location would be key explanatory factors in the relationship between human influence and the relative abundance of birds. The 12 species selected for the analysis based on their diet type and nesting location exhibited varying degrees of relationships between human influence and their relative abundance. However the relationships among the birds relative abundance and level of human influence bore no relationship to either diet type or nest location. While diet type and nest location were not important explanatory factors, the results highlight two other key findings. First, bird diversity is related to both measures of human influence in a negative manner. In other words, as human influence on the landscape increased bird diversity decreased. Second, the relative abundance of most individual species investigated in Chapter Five exhibited either a positive or negative relationship with the degree of human influence present on a landscape, but did not exhibit a marked increase in the relationship when both measures were considered together.

As with all research projects there were both limitations and unforeseen shortcomings of the data presented in this dissertation. Although the overall goal of the dissertation research was to address how landowners influence birds through their behaviors and activities across landscapes and to utilize these findings to make predictions about bird species across an entire region, it was only partially achieved. Originally, an objective of the research was to connect the behaviors of the landowners along the three BBS routes with the bird abundance data from these routes, in order to relate changes in bird abundances with landowner activities. While the objective remains important, the scale at which the research was conducted does not allow for such direct integration to be made. Specifically, the BBS abundance data at the route level have both a great deal of variability and are difficult to estimate reliable population trends. As a

means to overcome the route level variability and partially integrate the data I made the assumption that the level of activities found in the three study landscapes of Southeastern Michigan were similar across the entire Midwest. I based this assumption on both the high levels of landowner activities across the three Southeastern Michigan landscapes and the results from recent Fish and Wildlife Service surveys of wildlife recreation that indicate a large portion of the Midwest population engages in feeding and watching birds. However, for future work an alternative method would be to greatly increase the number of BBS routes that are surveyed and simply sample fewer, but representative, landowners along a each route. Moreover, by increasing the number of BBS routes and decreasing the landowner sample size per route, broader conclusions about landowner activities could be made. Such increases in sampling would also allow for better comparative and predictive power across multiple landscapes.

A second limitation of this dissertation research is in the amount of detail obtained from the landowner survey. Because the overall goal of the survey was to obtain many general pieces of data about private landowners and their influence on birds a tradeoff was made between very specific details on a few topics or less detail on a greater number of topics. I selected the latter perspective largely because of how little information exists about private landowners and their influence on bird species. Thus, many pieces of information were somewhat unexpected, such as the fact that 55% of landowners planted or maintained vegetation for the benefit of birds. However, as the research indicates, each activity or perception could, and should, be explored in far greater depth.

A related limitation of the landowner survey is that it may be a biased measure of landowners. Obviously any methodology has a bias and it certainly is possible that the landowners who responded to the survey had a particular like or interest in birds. However, even if the survey was biased towards bird enthusiasts, the overall response rate of ~59% indicates that non-respondents do not need to be engaged in the activities in order for birds to be influenced on a large proportion of the landscape.

The limitations of the research were not only present in the landowner survey work, but were also present in the Midwest BBS analysis. Because the original objective was to connect landowner activities with bird abundances, I utilized the results from the landowner survey to make general predictions across all Midwest BBS routes. Although significant relationships were found between both bird diversity and the relative abundance of selected species with increased levels of human influence, no relationships were found in regard to nest location or diet type. Notably, however, many of the significant relationships were not very strong as interpreted by their r^2 values. A number of reasons can be offered as to why significant relationships were not found with regard to diet type and nest location, as well as with regard to the relative abundance analyses. First, the landscapes used for the analysis may themselves be biased in that they are circular rather than linear. As a result patches and houses that are far away from the BBS routes have an equal influence as those that lie directly on the BBS routes. Second, the study area for the research questions was based on a political boundary of the eight Midwest states, which does not follow any direct ecological boundary. Hence, the species investigated in the analyses may have shown different relationships if they were analyzed according to ecoregion or other ecological unit of analysis. Third, the species selected for the analysis were chosen based purely on their diet type and nest location, not on any known relationships with land cover or human influence. Thus, had the species been selected using additional criteria the results may well have been different. Similarly, had larger samples of species been selected for each natural history categories significant differences may have resulted.

Because the research presented in this dissertation addresses many data poor areas of ecology, there are perhaps more questions that have arisen from it than have been answered. Moreover, because the methodology used for the research did not allow for a direct coupling between landowners and the birds present on the three BBS routes of Southeastern Michigan, these types of questions are even more important now. To build

upon the work presented here requires addressing other topics and questions, such as those presented below:

- 1) What are the population consequences for birds when landowners allow their cats outdoors?
- 2) Is conservation education having any effect in reducing the number of outdoor and feral cats?
- 3) What are the motivations for landowners to engage in each of the activities on their property and do they consider the effects of the activities on birds or other wildlife species?
- 4) Do landowner activities interact with one another such that there are synergistic effects of multiple activities?
- 5) How do landowner activities and perceptions vary across a wider gradient of landscape types?
- 6) Are different levels of landowner activities related to differences in community composition of birds?
- 7) Does the cumulative sampling of landowners for the presence of birds on their land exhibit a similar relationship as a species-area curve?
- 8) Would diet type and nest location become important natural history categories if more species were investigated or a different geographical boundary was used?
- 9) How does the interaction of multiple human factors affect bird populations across different ecoregions?
- 10) Are there any natural history factors, such as body size or clutch size, that are important covariates in the relationship between bird abundance and human influence?

These ten questions which I have posed are by no means exhaustive. In fact each question, I hope, raises many more questions and interesting avenues of research to pursue. However, as the ten questions demonstrate, there are many challenges that remain as ecologists continue to integrate the human component into their research. Although the findings of this dissertation are but a first step in trying to integrate and synthesize people with landscapes, a number of important results were found.

Overall, the major finding of this dissertation research is that humans are, for better or worse, directly or indirectly, intentionally or unintentionally, influencing birds and the landscapes they live in. While the magnitudes may differ across landscapes, the simple fact remains that humans are having impacts on bird species. It is worth pointing out, however, that most individual landowners have little to no interest in negatively impacting bird species. Barring several pest species (e.g., House Sparrows or American Crows), landowners by and large are intentionally involved in a number of activities which they believe will positively influence birds. Thus, collectively, a number of activities that landowners engage in may very well benefit birds. The question remains, though, are these activities benefiting a relatively few number of species at a cost to other species that may have been present if the activities had not been conducted? Only by continuing to integrate the human component into ecological research can we answer this, and many other important ecological questions noted above. Ultimately, the work presented here provides an initial stepping stone upon which future research into the relationships between humans, bird populations, and landscapes can be built.

APPENDIX A

Michigan Birds on the Landscape

This survey focuses on land use change and bird populations in Southeastern Michigan. Please answer the questions in relation to the land described in the cover letter. If you have any questions please contact Christopher Lepezyk of Michigan State University toll-free at 1-877-745-7288.

Birds

First, we would like to ask you some questions about the birds living on your property and in your neighborhood.

1. Were you aware, prior to this survey, that you live on a survey route for monitoring bird populations? (Check one.)

☐ Yes
☐ No



1

2. Does anyone in your household feed birds on your property? (Check one.)

☐ Yes
☐ No (If 'No,' please skip to question 8)

3. In which months of the year do you or members of your household feed birds? (Check all that apply.)

☐ January ☐ May ☐ September
☐ February ☐ June ☐ October
☐ March ☐ July ☐ November
☐ April ☐ August ☐ December

4. How many bird feeders do you have on your property? _____ FEEDERS

5. Approximately how many years have you or members of your household been feeding birds? _____ YEARS

6. Do you plan to continue feeding birds on your property in the future? (Check one.)

☐ Yes
☐ No
☐ Unsure

7. What type(s) of food do you feed the birds? (Check all that apply.)

☐ Suet ☐ Sugar water/hummingbird nectar
☐ Thistle ☐ Bread
☐ Corn ☐ Oranges
☐ Sunflower seeds ☐ Commercial seed mixture
☐ Millet ☐ Other (Please specify) _____

2

8. Are there any bird houses on your property? (Check one.)

- ☐ Yes
☐ No (If 'No,' please skip to question 12)

9. How many bird houses do you have? _____ BIRD HOUSES

10. Approximately how many years have you had bird houses on your property? _____ YEARS

11. Do you plan to continue having bird houses on your property in the future? (Check one.)

- ☐ Yes
☐ No
☐ Unsure

12. Have you planted vegetation or maintained landscaping on your property in order to benefit or encourage use by birds? (Check one.)

- ☐ Yes
☐ No (If 'No,' please skip to question 14)

13. What types of vegetation have been planted? (Check all that apply.)

- ☐ Fruit trees or bushes
☐ Ornamental shrubs or bushes
☐ Vines
☐ Other (Please specify) _____



14. Does anyone in your household spend 5 minutes or more watching or trying to identify birds on your property or by your bird feeders or bird houses? This includes watching and observing birds from inside a house or on a porch or deck. (Check one.)

- ☐ Yes
☐ No (If 'No,' please skip to question 16)

15. If 'Yes,' how often do you or members of your household go birding on your property? (Check one.)

- ☐ Two or more times per week
☐ Once per week
☐ Two times per month
☐ Once per month
☐ Two or three times per year
☐ Once per year
☐ Unsure

16. On a typical day during the summer, approximately how many birds do you see on your property? (Check one.)

- ☐ Over 100 birds
☐ 50-100
☐ 25-49
☐ 10-24
☐ Fewer than 10
☐ None
☐ Unsure

17. Since you have owned or lived on the property, do you think that the number of birds visiting it during the summer months has? (Check one.)

- ☐ Increased substantially
☐ Increased slightly
☐ Stayed about the same
☐ Decreased slightly
☐ Decreased substantially
☐ Unsure

Please skip to question 19

25. How many cats does your household own that are allowed access to the outside? _____ CATS (If none, please skip to question 29)

26. If you or members of your household own cats that are allowed access to the outside, approximately how many dead or injured birds a week do all the cats bring in during the spring and summer months (April through August)? (Check one.)

- ☐ 0 ☐ 4-5 ☐ 10-15
☐ 1 ☐ 6-7 ☐ 16-20
☐ 2-3 ☐ 8-9 ☐ More than 20

27. Can you or anyone in your household identify any of the bird species brought home by your cat(s)? (Check one.)

- ☐ Yes
☐ No (If 'No,' please skip to question 29)
☐ Unsure (If 'Unsure,' please skip to question 29)

28. Please list the names of the bird species that your cat(s) has brought home during the spring and summer months on the lines below. If more space is needed, please use the blank area at the end of the survey.



Your Land

This next set of questions deals with how you use your land. Please remember to answer the questions in relation to the land described in the cover letter.

29. Approximately how large is your parcel of land? _____ ACRES

30. About how long have you owned or live on this parcel of land? _____ YEARS

31. In what type of area do you consider this land to be located? (Check one.)

- ☐ Rural area
☐ Developing rural area
☐ Suburban area
☐ Urban fringe area
☐ Urban area
☐ Unsure

32. In what ways do you make use of your land? (Check all that apply.)

- ☐ Residence
☐ Investment
☐ Agricultural production
☐ Recreation
☐ Development
☐ Other (Please specify) _____

33. 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) _____

34. Do you hunt on your land? (Check one.)

- ☐ Yes
☐ No

35 Do you have any woodlot(s) on your property? (Check one.)

- ☐ Yes
☐ No (If 'No,' please skip to question 38)

36. Approximately how many acres of woodlot do you have on your land? _____ ACRES

37. What do you plan to do with the woodlot(s) in the future?

Within the next 5 years (Check one.)

- ☐ Leave it as is
☐ Sell all or part of it
☐ Harvest it
☐ Increase its size
☐ Unsure
☐ Other (Please specify): _____

Within the next 10 years (Check one.)

- ☐ Leave it as is
☐ Sell all or part of it
☐ Harvest it
☐ Increase its size
☐ Unsure
☐ Other (Please specify): _____



9

38 Do you have any wetland(s) on your property? (Check one.)

- ☐ Yes
☐ No (If 'No,' please skip to question 41)

39. Approximately how many acres of wetland(s) do you have on your land? _____ ACRES

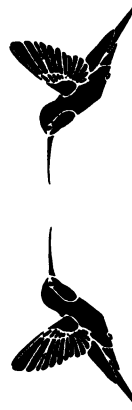
40. What do you plan to do with the wetland(s) in the future?

Within the next 5 years (Check one.)

- ☐ Leave it as is
☐ Sell all or part of it
☐ Fill it in
☐ Increase its size
☐ Unsure
☐ Other (Please specify): _____

Within the next 10 years (Check one.)

- ☐ Leave it as is
☐ Sell all or part of it
☐ Fill it in
☐ Increase its size



10

41. Do you have any non-agricultural fields or grasslands on your property?
(Check one)

- ☐ Yes
☐ No (If 'No,' please skip to question 44)

42. Approximately how many acres of non-agricultural fields or grasslands do you have on your land? _____ ACRES

43. What do you plan to do with the non-agricultural fields or grasslands in the future?

Within the next 5 years (Check one)

- ☐ Leave them the way they are
☐ Sell all or part of them
☐ Use them for agriculture
☐ Increase their size
☐ Unsure
☐ Other (Please specify): _____

Within the next 10 years (Check one)

- ☐ Leave them the way they are
☐ Sell all or part of them
☐ Use them for agriculture
☐ Increase their size
☐ Unsure



11

44. Are you familiar with the Conservation Reserve Program? (Check one)

- ☐ Yes
☐ No (If 'No,' please skip to question 47)

45. Do you own any property enrolled in the Conservation Reserve Program? (Check one)

- ☐ Yes
☐ No (If 'No,' please skip to question 47)

46. How many acres do you have enrolled? _____ ACRES

47. Please indicate how likely it is that you would sell or develop all or part of your land within the next five to ten years.
(Check the most appropriate response.)

- ☐ Extremely likely
☐ Quite likely
☐ Slightly likely
☐ Neither likely nor unlikely
☐ Slightly unlikely
☐ Quite unlikely
☐ Extremely unlikely

48. Would you prefer to sell all or just a part of your land?
(Check one.)

- ☐ All
☐ Part
☐ Either
☐ Unsure



12

49. If you were to sell all or part of your land, do you have a preference as to whom you would sell it to? (Check all that apply.)

- ☐ Developer
- ☐ Local farmer
- ☐ Corporate farmer/agribusiness
- ☐ A family
- ☐ Government or public agency
- ☐ A land conservancy
- ☐ Other (Please specify) _____
- ☐ No preference
- ☐ Unsure

50. How many separate buildings (e.g., houses, sheds, garages, etc.) are on your property? _____ BUILDINGS

51. Do you have a house or residential structure on your land? (Check one.)

- ☐ Yes
- ☐ No (If "No," please skip to question 54)

52. If "Yes," what is the approximate size of the house or residence?

(Check one.)

- ☐ Less than 1,000 square feet
- ☐ 1,000 to 1,499 square feet
- ☐ 1,500 to 1,999 square feet
- ☐ 2,000 to 2,499 square feet
- ☐ 2,500 to 2,999 square feet
- ☐ 3,000 to 3,499 square feet
- ☐ 3,500 square feet or larger
- ☐ Unsure



13

Background Information

In order for us to more fully understand the responses to the previous questions, we need to know a few things about your background. Remember that your responses are completely confidential and that neither your name nor address will be directly linked to your responses in any way.

53. In what year were you born? 19 _____.

54. Are you:

- ☐ Male
- ☐ Female

55. How many people currently live in your household? _____ PEOPLE

56. What is your primary occupation? _____

57. What is the highest level of school completed or degree you have received? (Check one.)

- ☐ Some school completed, but no high school diploma
- ☐ High school graduate or GED
- ☐ Some college, but no degree
- ☐ Associates degree in college
- ☐ Bachelor's degree
- ☐ Master's, professional, or doctoral degree

58. Would you like to receive a summary of the final results of this survey when it is completed?

- ☐ Yes
- ☐ No



Thank you for your participation!

14

If you have any other comments you would like to share with us, please use the space below or on the back of the survey. If you have any questions please contact Christopher Lepczyk toll-free at 1-877-745-7288.

Please use the enclosed addressed and stamped envelope or return this survey to:

Bird Surveys
Attn: Christopher Lepczyk
Department of Fisheries and Wildlife
13 Natural Resources Building
Michigan State University
East Lansing, MI 48824-1222



APPENDIX B

MICHIGAN STATE UNIVERSITY

**DEPARTMENT OF FISHERIES AND
WILDLIFE
13 NATURAL RESOURCES BUILDING
EAST LANSING • MICHIGAN • 48824-1222
(517) 355-4477
FAX (517) 432-1699**

October 3, 2000

«NAME»
«ADDRESS_1»
«CITY», «STATE» «ZIP»

Dear «NAME»:

You have been selected to participate in a research study that is exploring relationships between bird populations and land use in Southeastern Michigan. You were selected because you live or own property along or near «ROAD», in «CO» County, Michigan. Along this road is a monitoring route used to count the number of birds living in Michigan. We are particularly interested in learning about bird populations near your property. For this reason, we are asking for about 10 to 20 minutes of your time to complete the enclosed questionnaire regarding birds and land use in your area. As a resident or landowner, your input on issues involving land use is very important. Since we want to gather information that represents all residents and landowners in your area, your response is vital for the success of our project.

This survey is intended for the person in your household, ownership group, or trust who is at least 18 years of age and who makes most of the decisions regarding your land. If the person to whom this is addressed does not fit this description, please give this survey to a person in your household, ownership group, or trust who does. **If you do not currently reside or own land** as described above, we would appreciate it if you could return the survey to us with a note indicating this fact. If you received more than one survey--which could occur if you own more than one parcel of land within the area specified above--you should only fill out and return one of the surveys.

While your response to this questionnaire and any of the questions is completely voluntary, we feel that these issues are important enough to warrant contacting you. You indicate your voluntary agreement to participate by completing and returning the questionnaire. You may be assured of complete confidentiality. The survey has identifying information for mailing purposes only. This is so that we may check your name off of the mailing list when your survey is returned and also allows us to place your name in a **prize drawing** (see below). Your name and address will never be associated with your responses in any way. Your privacy will be protected to the maximum extent allowable by law.

For your convenience, we have included a postage-paid envelope for returning the survey. **All surveys completed and returned by October 31st, 2000 will be entered into a drawing for a \$100 gift certificate to Meijer.** If you cannot respond by October 31st we would still like to receive your survey as soon after that as possible so we can include your information in our results. I would be happy to answer any questions you might have. Feel free to call me toll free at 1-877-745-7288. Thank you for your assistance. Your contribution to the success of this study will be greatly appreciated.

Sincerely,

Christopher A. Lepczyk

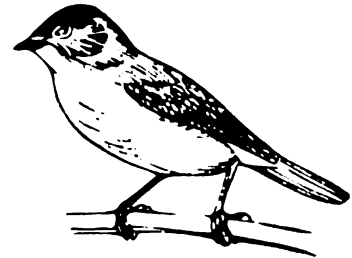
APPENDIX C

Dear Friend:

You were recently sent a questionnaire concerning bird populations and land use in Southeastern Michigan. If you have returned the questionnaire, ***thank you***. If you have not yet completed the questionnaire, please take a few minutes to do so now. Your input is very important for understanding Michigan's birds.

Sincerely,

Christopher Lepczyk
Project Coordinator
Department of Fisheries and Wildlife
Michigan State University
13 Natural Resources Building
East Lansing, MI 48824-1222



1-877-745-7288 (Toll Free)

Dear Friend:

APPENDIX D

MICHIGAN STATE UNIVERSITY

**DEPARTMENT OF FISHERIES AND WILDLIFE
13 NATURAL RESOURCES BUILDING
EAST LANSING • MICHIGAN • 48824-1222
(517) 355-4477
FAX (517) 432-1699**

November 3, 2000

«NAME»
«ADDRESS_1»
«PO_BOX»
«CITY», «STATE» «ZIP»

Dear «NAME»:

A few weeks ago you were mailed a survey about "Michigan Birds on the Landscape." As of today, we have not received your completed survey. If this letter and your completed survey have crossed in the mail, we would like to thank you for returning your survey. If you have not yet filled out the survey, we hope you will take the opportunity to do so now. We are sending another survey, along with a stamped return envelope, to make it easier for you to respond.

Michigan contains a highly diverse set of bird species. In order to understand how these bird species use different areas of Southeastern Michigan, it is essential that we hear from you. You were selected because you live or own property along or near «ROAD», in «CO» County, Michigan. Along this road is a monitoring route used to count the number of birds living in Michigan. Because this survey is being sent to relatively few people in Southeastern Michigan and because we need the results to represent all residents, it is very important that each person respond to this survey. We are interested in everyone's opinion. **It does not matter what your age is, how much property you own, or if you live on your property—your opinions are valued.** If you truly have no opinion on an issue, feel free to indicate that on the survey—but we still need your response in order to know this.

This survey is intended for the person in your household, ownership group, or trust who is at least 18 years of age and who makes most of the decisions regarding your land. If the person to whom this is addressed does not fit this description, please forward this survey to a person in your household who does. If you do not currently own or live on the property described, we would appreciate it if you could return the survey to us with a note indicating this fact.

You indicate your voluntary agreement to participate in this survey by completing and returning this questionnaire. You may be assured of complete confidentiality. The survey has an identification number that allows us to check your name off of the mailing list when your survey is returned. Your name and address will never be associated with your responses in any way.

If you respond by **November 17, 2000**, your name will be entered into a new **prize drawing to receive a \$50 gift certificate to K-Mart**. I would be more than happy to answer any questions you may have. Feel free to call me toll free at 1-877-745-7288. Thank you for your assistance—it is greatly appreciated.

Sincerely,

Christopher A. Lepczyk
Project Manager

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