IMPROVING AVIAN DIVERSITY IN URBAN AREAS THROUGH DESIGN AND PLANNING: A SYSTEMATIC REVIEW OF RELEVANT LITERATURE TO INFORM EVIDENCE-BASED PRACTICE

By

LINDSAY REYNOLDS

(Under the direction of Alfred Vick)

ABSTRACT

The conversion of native habitats to urbanized area is a primary threat to biodiversity and contributes to an increased rate of extinction. With the world population expected to reach 9.3 billion by 2050 the pressure of urbanization on biodiversity will continue to increase. Avian diversity is particularly threatened by urbanization. Avian communities i across the globe are becoming homogenized as habitat is lost and urban areas convert native habitats into conventional landscapes. This study conducted a systematic literature review of ecological, planning and design research to determine design and planning techniques that improve native avian diversity in the urban areas. The results of the study provide guidelines that designers and planners can use to improve avian diversity, as well as, a tested example of how systematic literature reviews can be conducted to inform design and planning fields. The methodologies used in this study should be employed as a platform to encourage effective, knowledgeable collaboration between science, planning and design fields.

INDEX WORDS: Biodiversity Loss, Avian Diversity, Evidence-Based Practice, Ecological Design, Conservation Planning, Systematic Literature Review, Urban Design, Landscape Architecture

IMPROVING AVIAN DIVERSITY IN URBAN AREAS THROUGH DESIGN AND PLANNING: A SYSTEMATIC REVIEW OF RELEVANT LITERATURE TO INFORM EVIDENCE-BASED PRACTICE

By

LINDSAY REYNOLDS

B.S. Humboldt State University, 2002

A Thesis proposal submitted to the Graduate Faculty of The University of Georgia in Partial Fulfillment of the Requirements for the Degree

MASTERS IN LANDSCAPE ACHITECTURE

ATHENS, GEORGIA

2013

© 2013

Lindsay Reynolds

All Rights Reserve

IMPROVING AVIAN DIVERSITY IN URBAN AREAS THROUGH DESIGN AND PLANNING: A SYSTEMATIC REVIEW OF RELEVANT LITERATURE TO INFORM EVIDENCE-BASED PRACTICE

by

LINDSAY REYNOLDS

Major Professor: Alfred Vick

Committee: Jon Calabria
Rosanna Rivero
Jennifer Ceska

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
August 2013

TABLE OF CONTENTS

LIST OF TABLES vi

LIST OF FIGURES viii

CHAPTER

1 INTRODUCTION 1

Urbanization and Biodiversity Loss 1

Urbanization and its affect on avian diversity 4

Landscape Architecture, Urban Planning and Biodiversity Loss 6

The Role of Ecology in Design and Planning Fields 10

Evidence-based practice in design and planning fields 18

Research Questions and Objectives 20

2 SYSTEMATIC REVIEW METHODOLOGY 22

Addressing the need for evidence 23

Planning and Conducting the Review 24

Literature Search Strategy 25

Literature Inclusion 27

Data Extraction 27

Data Analysis and Synthesis 30

3 RESULTS 34

Literature Search Results 34

Literature Synthesis Results 40

4 DISCUSSION AND CONCLUSIONS 43

Use of systematic literature review to inform evidence-based practice 43

Methods to improve avian diversity in urban areas 45

5 LITERATURE CITED 71

6 APPENDICES 81

A Search string scoping 81

B Result of systematic review and relevant literature used in data synthesis and analysis. 86

LIST OF TABLES

T able 2.1. Elements of a reviewable question, normally a permutation of: 'Does intervention/exposure (I/E) applied to populations of subjects (P) produce outcome (O)?' 24

Table 2.2. Final Search Strategy and Inclusion Criteria for systematic literature review to determine how to improve avian diversity in urban areas. 26

Table 2.3. Intervention practice category definitions used in the extraction of data from the relevant literature. 28

Table 2.4. Quality ranking definitions used to assess both qualitative and quantitative studies used in systematic literature review to determine how to improve avian diversity in urban areas. 29

Table 2.5. Description of suggested method and technique categories. 30

Table 3.1. Total and percentage of avian category and season measured in relevant research from results of a systematic literature review to determine how to improve avian diversity in urban areas 37

Table 3.2. Total and percentage of suggested methods by intervention practice from results of a systematic literature review to determine how to improve avian diversity in urban areas. 38

Table 3.3. Quality of both quantitative and qualitative studies based on intervention practice from results of a systematic literature review to determine how to improve avian diversity in urban areas. 39

Table 3.4. Final eight action categories defined by the coding of the suggested methods from results of a systematic literature review to determine how to improve avian diversity in urban areas. 41

Table 3.5.Total and percentage of each action category by suggested method scale categories. From results of a systematic literature review to determine how to improve avian diversity in urban areas. 42

LIST OF FIGURES

Figure 3.1. Number of relevant articles by publication year from results of a systematic literature review to determine how to improve avian diversity in urban areas. 34

Figure 3.2. Number of articles for top six publication titles from results of a systematic literature review to determine how to improve avian diversity in urban areas. 36

Figure 3.3. Number of articles for the final nine landscape categories from results of a systematic literature review to determine how to improve avian diversity in urban areas. 36

CHAPTER 1

INTRODUCTION

Urbanization and Biodiversity Loss

Urbanization is defined as "the process of human settlement that gradually transfers wildlands uninhabited by humans into lands containing some degree of permanent human presence. Urbanization is continuous, and the range of human settlement patterns is often referred to as a gradient of urbanization or the rural-urban gradient (Marzluff et al., 2001)." The conversion of native habitats due to urbanization is a primary threat to biodiversity (Wilcove et al., 1998; Brown and Laband, 2006) and contributes to increased rate of extinction (Lawton and May, 1995). Current extinction rates are estimated to be 100 to 1,000 times greater than pre-human rates and 5-20% of species within the major taxonomic groups have gone extinct (Chapin III et al., 2000). By the year 2050 approximately 70% of the world population will live in an urban environment (United Nations, 2011). With the world population expected to reach 9.3 billion by 2050 (United Nations, 2010) the pressure of urbanization on the world's biodiversity is only going to increase (Dramstad, 1996; Clergeau et al., 1998).

The impact of urbanization on biodiversity stems from a combination of habitat degradation, habitat loss, loss of ecosystem function, urban heat island effect, invasive or exotic species competition or high human disturbance. The different relationships between species richness and urbanization have been described in three hypotheses. The Productivity hypothesis (Gaston, 2005) predicts a positive correlation, the Ecosystem

Stress hypothesis (Rapport et al., 1985) predicts a negative correlation and the intermediate-disturbance (Connell, 1978) predicts a negative quadratic relationship. After testing these hypotheses across multiple gradients of human influence, Lepczyk et al. (2008) found that an increase in urban land cover supported the ecosystem-stress hypothesis or a negative correlation between species richness and urbanization.

Research has shown that species are going extinct and biological communities are changing due to urbanization. In urban ecosystems, changes in biodiversity can directly affect human communities by degrading ecological services and limiting socio-economic growth and function. A well-studied example is the outbreak of invasive bark beetles in United States. Invasive bark beetles feed directly on coniferous trees and vector fungal pathogens (Lee et al., 2007b). As with many invasive species, they outcompete native bark beetles, changing the biodiversity of the habitats they infest. The ecological impacts of bark beetle invasions are: loss of native faunal diversity, changes in forest stand characteristics and composition, alterations to water supply, carbon storage and nutrient cycling and an increased risk of wildfire. The socio and economic impacts of bark beetle infestations include the loss or degradation of a natural resource that communities rely on for their livelihood and others use to enhance their quality of life. The combination of their long life cycle and the difficulty in managing multiple invasive species has caused considerable damage to our nation’s forests, including urban forests (Lee et al., 2007b). In Newcastle, Wyoming, 333 infested Siberian elms had to be removed and in 2006, one million acres of forest in Colorado was affected by Mountain Pine Beetle (*Dendroctonus ponderosae*) and spread to 1.5 million by 2007 (Lee et al., 2007b; Hayes and Lundquist, 2009).

Unfortunately, the impacts of biodiversity loss are often not as visible and straightforward as the bark beetle example. The process of biodiversity loss and extinction is far more complicated and can take years to detect. Lose of floral and faunal diversity has consequences that can affect ecological function and ecosystem services that are important for human communities. In aquatic ecosystems, loss of biodiversity can directly affect nutrient levels, increase pollution and reduce water quality (Cardinale, 2011). Changing native plant communities increases presence of alien pests, and decreases native plant diversity and native bird richness. In his book Bringing nature home: How you can sustain wildlife with native plants, Tallamy documents that the use of invasive and exotic plant species in landscaping, reduces native insect richness (2009).

It can be hard for many people to appreciate the relationship of biodiversity and human health when it is presented as an ecosystem service, such as purification of air and water, pollination of plants, detoxification and decomposition of waste and the generation and renewal of soil fertility, including nutrient cycling. Much easier to grasp is the role of nature in improving the health and well-being of humans. The ability to view nature on a daily basis can reduce stress, improve mental health, decrease violence, and even increase the rate of recovery after surgery (Jackson, 2003). Recent studies also support the importance of bird and plant richness in improving personal or neighborhood well-being. For urban green space users, certain aspects of psychological well-being of increased with an increase in plant and bird richness (Fuller et al., 2007). Neighborhood well-being increased when neighborhoods had an increase in bird species, vegetative cover and lower urban development (Luck et al., 2011). Avian diversity is very important in urban areas, not only for the services they provide (pest control, seed dispersal, human well-being), but they are also a highly visible taxa, which facilitates easy recognition of biodiversity or species diversity.

Urbanization and its affect on avian diversity

Birds, as a taxonomic group, are one of the most well studied groups because they are highly visible and because of the variety of studies that can address avian species and populations. Birds occupy many niches within a given natural community and represent many trophic levels, therefore, their presence or absence can reveal much about the health of the environment. The decline of peregrine falcons (*Falco pereginus*) in the 1950's caused alarm in the scientific community, leading to the discovery that DDT (**d**ichloro**d**iphenyl**t**richloroethane) was bioaccumulating in the environment and compromising reproductive health/performance of avian species. DDT was originally utilized as an insecticide in agricultural areas and to control mosquitoes in cities and small towns. Particularly for birds of prey, DDT caused eggshells to thin, which were then crushed under the weight of a brooding adult (Ratcliffe, 1967; Hickey and Anderson, 1968). The effects of DDT also affected other wildlife and organisms in all trophic levels through bioaccumulation.

While DDT had an acute effect on many bird populations, habitat loss or fragmentation caused by urbanization is far more complex to measure: although the impact can be just as great. The extinction of the passenger pigeon (*Ectopistes migratorius*) and the Carolina parakeet (*Conuropsis carolinensis*) due to American Settlement is an example of how the conversion of habitats can have detrimental effects on entire populations (Askins, 2000). Historically, the extinction of the passenger pigeon was attributed to high harvest rates. However, further research found that the passenger pigeon was dependent on masts of nut trees in the Midwestern United States. The availability of large masts is dependent on the age of a stand. Passenger pigeons were able to move as food resources declined and were not tied to certain place, unlike a Bald Eagle (*Haliaeetus leucocephalus*), which might be tied to a historic nest site. As deforestation moved westward across the US, resources were depleted and the succession of second-growth forests was too slow to produce the masts needed for the passenger pigeon to survive (Askins, 2000). Research on the contemporary effects of urbanization has revealed similarly complex relationships.

The effect of urbanization on the configuration and composition of native habitats directly impacts avian diversity, richness and abundance (Clergeau et al., 1998; Jokimaki and Kaisanlahti-Jokimaki, 2003; Lepczyk et al., 2008; Fontana, 2011). Numerous studies have shown that richness and diversity decrease with increasing urbanization. Abundance, dominated by a few synatropic or urban-exploiter species, increases with increasing urbanization, and specialist species decrease with increasing urbanization (Emlen, 1974; Beissinger and Osborne, 1982; Clergeau et al., 1998; Fontana, 2011). Across the globe, urban areas support the same community of species, usually dominated by aggressive, exotic species such as House Sparrow (*Passer domesticus*), Rock Dove (*Columba livia*), Mourning Dove (*Zenaida macroura*) and European Starling (*Sturnus vulgaris*). For example, in Vancouver, British Columbia exotic species and building nesters (including the species listed above) had the highest relative abundance compared to native species and other nesting guilds (Melles et al., 2003). Carlson (2006) found that neotropical migrant richness was influenced by vegetation cover (course or fine) and breeding bird richness increased with size of the forest patch.

The growing understanding that biodiversity is not only important for ecological process and services, but also for human well-being has made the concern over avian diversity loss a growing conservation issue. Many organizations, government agencies and even homeowners are taking steps to reduce the effects of human disturbance and urbanization on avian diversity. One approach is to change the way we alter habitats and ecosystems and reverse the damage we have done. Restoration projects attempt to do this, but in order to change the way we alter our natural world, particularly in urban areas, there must be an understanding of the history of landscape design and urban planning.

Landscape Architecture, Urban Planning and Biodiversity Loss

Throughout the history of American settlement, the values and aesthetics of landscape designers and planners defined the towns and cities we live in today. Landscape architects, designers and planners have also had a significant influence on the ecological function of urban ecosystems. The plans and designs of our urban environment will continue to change through time. To ensure that planners and designers have a positive influence on the environment, their effect on biodiversity should be considered.

The history of city planning and design in the United State was greatly influenced by the values and aesthetics of 18th and 19th century designers. From the urban park to the private garden, to the pattern of subdivisions, the way our urban landscape has been designed is primarily rooted in picturesque style (Rogers, 2001). Developed in the late eighteen century, the picturesque style aimed to design a perfect landscape, one that remained in control but also had elements and forms of 'wild' nature. The designs incorporated rolling topography with gentle curves, groves of trees and open lawns. The end result was edited nature, which was aesthetically pleasing and highly desirable. The picturesque style was adopted by Frederick Law Olmsted and applied to many public and private sites, most notably New York's Central Park. Olmsted valued the agrarian quality of the style and wanted to give growing cites a place where citizen could enjoy the scenic quality of a pastoral landscape, without leaving the city (Howett, 1998; Ignatieva and Stewart, 2009; Rogers, 2001).

In the late 19th and early 20th centuries, the influence of the Beaux-Arts and neoclassical movement began to influence urban plans for America's growing metropolitan areas, including Chicago and Washington DC. Deemed the City Beautiful Movement, designers of this time aimed to make cities more monumental with grand plazas and boulevards, and favored geometric and classic forms (Rogers 2001). The picturesque style that Olmsted favored when he designed the pastoral landscapes of Buffalo's and Boston's city park systems was omitted in these new city beautiful plans. Although, Beaux-Arts aesthetic may have created some of the grand civic centers we enjoy today, such as the National Mall, it also created further fragmentation in our cities by arbitrarily crisscrossing cities with streets and plazas, ignoring natural corridors. The growing use of automobiles also fueled the redesign of urban centers as well as expanding the boundaries of our cities. (Rogers, 2001)

In the early 20th century, the Regional Planning Association of America greatly influenced the design of suburban or planned communities that were growing outside of city centers. The mission of these planned communities was to provide a place to play and work. Private property lines were replaced with shared open spaces and easy access for the growing population of commuters. These communities also returned to the picturesque style that Olmsted favored. The curvilinear form, groups of trees, and green lawns were adopted, romantically, by newly established suburban developments (Rogers, 2001). The growing field of landscape architecture produced many professional designers that worked with private companies to secure the picturesque conditions for suburban life (Olmsted, 1914). The aesthetics of early planned communities like Radburn, New Jersey, were appealing to the public, giving them a sense of being in nature without the challenges of the wilderness. This aesthetic has become what we consider American and consequently has been adopted throughout the world as towns become “Americanized.”

The combination of the growing or sprawling suburbs and the densification of city centers led to an incredible loss or degradation of habitat and increased fragmentation (Marzluff and Donnelly, 2001). This habitat loss was a direct consequence of the conversion of native habitat to impervious surface, but was also due to the picturesque or formal landscaping that was employed in suburban developments, open spaces and private estates. Although seemingly natural in form, many of these landscapes used a much smaller, introduced plant pallet that what would not have been found pre-development. The structure and composition of these designed landscapes would also differ from the native habitats, with lawns making up 75-95% of urban parks and 52-80% of residential greenspace (Ignatieva and Stewart, 2009). The consequence of applying such a limited range of styles and plant pallets to all of our urban areas has created a homogenous ecosystem that can be found in urban areas across the nation (Ignatieva and Stewart, 2009). Even for the native habitat remnants that remained in urban areas as a result of fragmentation, alteration of disturbance regimes and increase in pollution would greatly alter the remaining habitat found in these remnants and the species they could support (Moorcroft, 2009).

The effect of America's growing cities on environmental quality and native diversity did not go unnoticed by leaders in the environmental movement. George Perkins Marsh's early writings warned that human intervention was altering climate, topography and habitat of species (Marsh, 1984). By the mid 20th century, many would agree with him and begin to redefine the role of humans to the land. As the father of Wildlife Management and a lifelong naturalist and educator, Aldo Leopold had a clear understanding of how important communities were to the land, and in the tradition of Emerson and Thoreau, Leopold was not afraid to share his values and ethics. His book A Sand County Almanac challenged the way Americans treated land and all that inhabited it. In it he defined land ethic, most simply stated: "The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, and animals, or collectively: A land ethic changes the role of *Homo sapiens* from conqueror of the land-community to plain member and citizen of it. It implies respect for his fellow-members, and also respect for the community as such"(1949). Undoubtedly, Silent Spring by Rachel Carson would put the environmental movement into full gear, and interestingly, it was the loss of biodiversity that caused the nation to truly question what we were doing to our environment (1963).

The 1960's brought the first federal environmental acts, such as the Clean Water Act, National Environmental Policy Act and The Endangered Species Act (Rogers, 2001). These acts pushed designers and planners to think beyond form and style because of the need to fulfill the requirements of these policies. The work of designers and planners of that time also pushed the field to try new methods. Ian McHarg was one of the first professional landscape architects to weave science into planning and design methodology. He developed an overlay style that analyzed environmental variables, such as water resources and critical habitats, to determine the most environmentally sound planning approach for any particular site/region. Together with other similar minded planners and designers of the time, new ecological ways to approach a site design became available to professionals and students alike (McHarg, 1969). These new approaches have been classified as ecological design, sustainable design, permaculture design or green design.

The influence of McHarg, Leopold, Carson and those like them, may have changed perspectives and improved techniques, but biodiversity and habitat loss are still a conservation issue in our urban areas. The consequence of design and planning choices that originally shaped our urban areas are still in effect. Using the knowledge base created by McHarg, ecological principles need to be further understood and applied in planning and design fields.

The Role of Ecology in Design and Planning Fields

For the fields of landscape architecture and planning, the role of science is inherent, even if it is not apparent. Landscape design fields have always had a connection with horticulture, agriculture, engineering and plant sciences. Early explorers traveled the world building their botanical collections and in America, many of these specimens were displayed in greenhouses, gardens and eventually adapted for landscapes. However, the field of ecology was absent from both planning and design fields until the early 20th century. In the 1920's and 30's, Warren Manning, Jens Jensen and OC Simonds were some of the first landscape architects to embrace the use of native plants. This small cohort of landscape architects were strong proponents of the natural look, although they may not have understood the full ecological importance of using native plants (Howett 1998). Their influence help to expand plant pallets and change the perspective of what beautiful was. From the mid 1970's to the present, Darrel Morrison's prairie restoration and design projects in Wisconsin, New York and Texas have showcased how native plants can be used to add beauty and ecological function to a landscape (Karson, 2012). In the 1960's, McHarg pushed the idea that using ecology in design would provide answers that communities needed to make their environment healthier. His methodologies became a part of landscape architecture and planning curriculums and were the basis for the development of geographic information systems (GIS). However, many could not settle with the idea that design could be quantifiable and based primarily on scientific factors (Howett, 1998).

Defining how ecology plays a role in the 21st century begins with addressing the gap in knowledge between designers, planners, developers, politicians, conservation biologists and landscape ecologists (Melles, 2003; Germaine et al., 1998). Applying ecological principles in design and planning fields has always been riddled with questions of how ecological principles and concepts can be adapted to improve human environments and maintain the aesthetics of an artistically built environment. Sprin (1997) said, "it is important to distinguish the insights ecology yields as a description of the world, on the one hand, from how these insights have served as a source of prescriptive principles and aesthetic values on the other." which suggests a balance between ecological function and ecological aesthetic. However, this statement also suggests that there is an inadvertent confusion about what ecology is and how it can support design and planning.

Ecology is defined as the "study of the relationships between organisms and their environment". The research conducted in this field includes life processes, distribution and abundance of organisms and movement of materials and energy through communities. Confusion arises when terms like "environmental", "natural" and "sustainable" are used interchangeably with "ecological" and scientific definitions like "theory", "law" and "hypothesis" are used incorrectly. Joan Nassauer, one of the largest advocates of ecological design, says in defining urban ecological design "ecological refers broadly to the socio-environmental sciences that can provide knowledge to inform action" (2012). Although there is a human component in ecology, disciplines such as sociology and psychology measure the human component and address the response of humans to more than their physical environment. When researchers change definitions to suite their study design, further confusion arises and results can become questionable.

One explanation for this confusion is that some planners and designers draw from other disciplines, like ecology, without accepting or understanding the context on which those disciplines are based. Consequently, ecological design and planning can be confused with eco-revelatory design or environmental art, which are inspired by ecological concepts such as erosion or succession, but don not always provide ecological function. Spirn says "There has been a tendency, however, to move directly from these insights to prescription and proscription, citing "ecology" as an authority in much the same way that "nature" was employed in the past to derive "laws" for landscape design and to define a single aesthetic norm, in this case "the ecological aesthetic." To say that landscape architects should be careful not fall into the use of a single “ecological aesthetic” is to ignore the contemporary relevancy of the field and the reality of our impact on the ecology of a place. Ecological principles should inform the function of a design within the landscape and not solely the aesthetic. It is dangerous to ignore them for the sake of not being pigeon-holed in an aesthetic. As an analogy, architects use structural engineering to make artistic visions come to life, and be structurally sound. However, if architects allowed engineering to solely inform a building’s aesthetics, a building would be deemed non-functional and inhabitable.

Landscape architects and urban planners have embraced other scientific fields, which has improved the quality of their work and benefited their profession. For example, hydrology is the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere. In the planning and design fields, hydrologic research has informed new approaches to stormwater management, wetland restoration and improving water quality. Landscape architects, engineers and planners employ these proven methods because they improve water for humans and the environment. Regardless of the aesthetic, ecology should be used in the same respect as hydrology; it should dictate the application of design or planning methods and should be used as a standard to measure the success of those methods.

The development of the field of landscape ecology has helped to bridge ecological and design professions. Research in landscape ecology aims to answer questions related to how temporal or spatial scale variables influences the ecological communities within a landscape (Wu, 2008). The evolution of landscape ecology is rooted in the theory of island biogeography defined by MacArthur and Wilson (1967). The theory of island biogeography proposes that species diversity on an island is a balance between immigration and extinction, and that there is a direct relationship between island size and distance to source populations (isolation). Adapted to urban environments, this theory describes the effect of fragmentation and habitat loss. For example, most species have a patch size threshold and as patches become smaller there is a decrease in the species that the remnant patch can support (Hanaski, 1994).

The difference between landscape ecology principles and cultural geography or ecology principles, is that landscape ecology principles can always be applied (to inform planning, design and management of landscapes) (Ahern, 2005). Landscape ecology terms and definitions are also similar to those used in design and planning. For example, the ecological relationship of a landscape can be described at multiple scales from local to landscape to regional, just as design methodologies vary from a site to a region (Wu, 2008). Dramstad et al's (1997) book Landscape Ecology Principles in Landscape Architecture and Land-use Planning provided a simplified applicable version of larger landscape ecology principles. Patch Size, Edge and Corridor principles were presented in a graphic way as to be easily understood at any scale, and case studies covered in the second part examined their application. Although the book was well received and gave a clear overview of landscape ecology principles, its application and facilitation in building collaboration between disciplines fell short (Melles, 2003; Ahern, 2005; Lovell and Johnston, 2009).

To facilitate the integration of landscape ecology and landscape architecture Ahern developed three stages to follow (2005):

1. Articulation of basic theory and first principles
2. Intellectual questions and dialogue
3. Reciprocal integration

The first stage is crucial to reduce the confusion between landscape architects, planners and ecologist. Since ecological research is informing planning and design, it is up to those professions to incorporate design and planning terminology and concepts into their methodologies. It is also important that designers and planners practice the second stage and engage in an intellectual dialogue with ecologists researching the habitats, ecosystems or ecoregions they plan to work in. The third stage is important to progress the collaboration, and so that ecologist can focus their future research. Methods that practice these stages include; designed experiments, ecological design and conservation planning.

Designed experiments are one methodology that can exercise these stages and progress the desired collaboration. The complexities of designing ecological research in urban environments has driven some researchers to work with urban planners and designers to develop projects that measure effectiveness or impacts of a design on variables of interest. The collaboration opens research doors for ecologists who are limited by urban areas, and also informs designers of how their designs function, post construction (Felson and Pickett, 2005). One example of this approach is the Jordan Cove Urban Watershed Project. The 7.3 hectare (ha) subdivision was divided into two watersheds, with one area being constructed using traditional practices and the other with best management practices. The stormwater in each watershed was monitored for 6-10 years to assess the treatment of non-point source pollution by development style. They found that the best management practice neighborhood was significantly more effective at reducing runoff (Clausen, 2007). This project was a perfect example of how to inform not only the ecologists interested in learning about the effects of development, but also designers, developers and the community. The range of questions that could be answered using this approach is not limited by design style or dependent variables, only by a lack of collaboration.

Ecological design is another approach utilized by planners, architects and landscape architects and in theory should bring collaboration with ecological and social sciences. Sim Van der Ryn and Stuart Cowan first coined the term “ecological design” in their 1997 book *Ecological Design.* Although not a new idea, it was the first time all the “eco” approaches, like green design, permaculture, ecological engineering and others had been merged. The ecological design method used will depend on who the practitioner is. For example, in architecture, ecological design refers to the design of sustainable buildings, which aim to reduce their impact on the environment variables such as air quality and water use. In planning, ecological design (or planning) is based on McHarg’s methodologies and aims to guide land-use and development plans to reduce impacts on ecological process or ecosystem services. For landscape architects, ecological design ranges from the use of native plants to river restoration projects. Although, ecological design is being applied in a variety of design and planning professions, there appears to be no set of guiding principles or standards to develop a sound ecological design. As a step forward in the development of a standardized methodology, by the end of 2013 the sustainable sites initiative will release a guideline and rating system for developers and landscape architects. The guidelines will provide steps that can be taken (and credited) to reduce the impact to sites. Some of the guidelines highlight the conservation and restoration of habitats (SIS, 2009).

A final approach to combine the three stages define by Ahern is conservation planning. Conservation planning is defined as "the whole process of identifying assets that merit conservation through to implementing conservation actions and assessing their efficacy" (Barmuta et al., 2001). In urban areas where the preservation and restoration of natural areas is important, conservation planning can provide a framework to make ecologically sound decisions for both planners and designers. Current literature supports the need for conservation planning to reduce the loss of native habitats and to ensure quality of life for urban residence (Grimm, 2000; Stokes et al., 2010; Fontana et al., 2011). However, the results of a recent study measuring the extent that local planners addressed conservation issues indicated that 14-20% of the 116 planning departments surveyed spent no time on conservation planning (Miller et al., 2009).

For all these methods to be successful, the scale of a project or site should be defined and accepted by all fields. The importance of landscape scale in conservation has forced researchers to be conscious of the definition of "landscape" they use for their plans and research. The use of "landscape" has also been suggested in design and planning fields as a common variable (Lovell and Johnston, 2009; Nassauer, 2012). To use "landscape" to develop a comprehensive methodology across disciples an accepted definition must be agreed upon. Trombulak and Baldwin define landscape as a "collection of habitat patches sufficient enough in size to allow population processes to take place at a multigenerational time scale." In general, a landscape contains a relatively distinct assemblage of plants and animals (2010). Because ecological design considers a human component, cultural and economic variables related to the human landscape should also be addressed within the scope of an accepted "landscape" definition.

In conclusion, to facilitate conservation planning, ecological design and designed experiments, the access to and synthesis of ecological and planning research must be standardized and tested. Ecologists want their research to be used by planners and designers to improve the way we alter landscapes, while designers and planners want ecological research to attune to the aesthetic and socio-economic needs of a community. Evidence-based practices (EBP) or designs (EBD) are underutilized approaches that could be used as a platform to bring multiple disciplines together. Through this approach, a standardized methodology could be adopted to synthesize research from multiple disciplines to inform practice, and hopefully encourage research that better facilitates an accepted standardized methodology.

Evidence-based practice in design and planning fields

The integration of ecological research into design and planning fields must be based on a methodology that can be applied retrospectively. Evidence-based practice and design are approaches that hold promise for an effective collaboration between fields. The evidence-based model was developed in the medical community after unstandardized methodologies were jeopardizing the quality of care patients were receiving (Sutherland 2004). In general, evidence-based methodology includes developing a question, conducting a rigorous systematic review of the literature, identifying the literature that is both relevant and of high quality, extracting data (in most cases quantitative data), synthesize or analyze data, and reporting results. For medical practitioners, the ability to have the most up to date treatment research is crucial in the health care industry. Evidence-based methodology was a way to standardize how medical research was being applied across the board. It also improved the way medical research was being conducted. The introduction of systematic reviews and meta-analyses in medical research pushed researchers to apply tested methodologies so that multiple studies could be used to improve sample size and statistical analysis could be conducted. While a true understanding of how other discipline's work may be unrealistic, evidence-based practice infrastructure provides a well-established transmission of information. The success of the evidence-based model within the health care industry is a testimony to the potential the model could have in design and planning fields.

The need for an evidence-based model in design and planning has also become clear as current methodologies fall short in reaching conservation goals. Sutherland (2004) found in a survey of 61 management actions applied to a protected wetland in England, that only 2% were based on verifiable scientific evidence, and 77% were based on anecdotal resources, such as personal experience, personal references and common sense. Although personal experience can be an unmatched resource, if it is never put into a form in which others can use and test, that resource can become outdated and lead to poor management or planning actions (Sutherland, 2004). Personal experience is also very difficult to present in a manner that supports the need for funds, application of techniques or change in policy. If methods are not placed under a certain expectation of quality and available for analysis by other researchers and practitioners, then results can never be evaluated and used to support future efforts.

In landscape architecture and planning, EBP has yet to be embraced, although methods that would support an evidence-based model are being utilized. For example, The Sustainable Sites Initiative's (2009) guidelines and performance benchmarks utilized peer-reviewed literature and experts in the fields of hydrology and soil science. As for general practitioners, (e.g. professional landscape architects working in firms or city planning offices and university faculty) the use of an evidence-based methodology is still underutilized. Of 286 full time landscape architecture faculty members, only 6% published one or more peer-reviewed papers a year and nearly half had published no peer-reviewed papers in a ten-year period (Brown and Corry, 2011). If faculty members are not disseminating sound, verifiable information, even to solely benefit continued research, it is hard to expect research to be applied in general practice. Evidence-based methods can help guide research in design and planning and help align their research with research being conducted in relevant scientific fields.

Research Questions and Objectives

The goals of this study are to: 1) to test the efficacy of an established systematic review methodology to inform evidence-based practice in planning and design fields and 2) Synthesize the results of the systematic review methodology to develop design and planning approaches that improve avian diversity in urban areas.

Primary Question:

How can design and planning improve avian diversity in urban areas?

Secondary Questions:

1. Does research measuring the effects of urbanization on avian diversity reveal design or planning techniques that can improve avian diversity?

2. Which implemented ecological design and conservation planning techniques improve avian diversity in urban areas?

Objectives:

A. Conduct a synthesis of relevant literature to inform landscape designers and planners using evidence-based practice to improve avian diversity.

B. Bridge the biological conservation knowledge gap between planners, landscape architects and policy makers.

C. Demonstrate how systematic reviews can be conducted to inform design and planning fields.

The subsequent chapters of this study will outline and explain the evidence-based systematic literature review methodology. Including how it was used to address both goals of this study. The results of the literature review are presented, as well as a discussion of the efficacy of the review methodology to inform evidence-based practice. Finally, the results of the methods and techniques extracted from the articles are presented with a discussion of how they should be applied as well as directions for future research.

CHAPTER 2

SYSTEMATIC REVIEW METHODOLOGY

The evidence-based systematic literature review methodology used in this study is adapted from the Collaboration for Environmental Evidence's (CEE) Guideline for systematic reviews in Environmental Management (CEBC 2010). Adapted from the evidence-based medicine model, it has been altered to fit the methodologies and metrics used in environmental management research. With the basic understanding that planning and landscape architecture are forms of environmental management, the guidelines can be easily used to answer questions related to these fields. The guidelines outline five stages to following when developing and conducting a review of literature in environmental management:

1. Addressing the need for evidence
2. Planning the review
3. Conducting the review
4. Reporting conduct and results
5. Depositing and disseminating outcomes

This study followed stages 1 through 4, with this thesis being the report of the results. The CEE has an online library where researchers can report and deposit their results into a central database. Researchers are also encouraged to submit draft protocols and reviews to the CEE to receive feedback on how to improve the review.

Addressing the need for evidence

The topic or issue to address will vary depending on the needs of the community and stakeholders that are involved in the systematic review. The introductory chapter of this thesis explained the significance of avian diversity to both ecosystem and human health. The need to improve avian diversity in urban areas is apparent and design and planning practices could be improve by using the results of a systematic review of the relevant literature.

Once the topic or issue to address is established, the development of a closed-framed question is important to direct a review team and the literature review. The CEE guideline outlines that the question development should be based on the needs of the community conducting the review. Due to the time and funding constraints that come with thesis development, the community and stakeholder component was excluded from this study. However, the importance of stakeholder and community input should not be ignored if this methodology is to be applied in a professional or community setting. In addition to the user group and the review team, the stakeholder group includes persons or organization that might be affected by the outcome of the review. Stakeholders should be included in the question development and in providing expertise and potential sources of information. Input from user and stakeholder groups during question development and their support of the review and its' outcome will help ensure the review's completion and implementation, even in the face of adversity.

The question should have four definable elements, referred to as PICO or PECO (Population, Intervention/Exposure, Comparator, Outcome) (Table 2.1). An example question would be: 'do pollinator gardens increase native butterfly diversity in fragmented public parks?' Where P=butterfly population, I=pollinator gardens, C=no gardens or other types of gardens, and O=Increased butterfly diversity. Using this study's definable elements, a primarily research question was developed; 'how can landscape design and planning improve avian diversity in urban areas?'

Table 2.1. Elements of a reviewable question, normally a permutation of: 'Does intervention/exposure (I/E) applied to populations of subjects (P) produce outcome (O)?'

Question Element	**Definition**
Subject Population	Unit of study (e.g., ecosystem, species) that should be defined in terms of the subject(s) to which the intervention will be applied
Intervention/ exposure	Proposed management regime, policy, action or the environmental variable to which the subject population are exposed.
Comparator	Either a control with no intervention/exposure or an alternative intervention
Outcome	All relevant objectives of the proposed intervention that can be reliably measured. Outcome of concern that might result from exposure to an environmental variable.

Planning and Conducting the Review

The planning of the review includes developing a review team, a search strategy and a review protocol. Please refer to the CEE guidelines to further understand the importance of testing and revising the search and review protocols to complete an effective and comprehensive review. For example, the guidelines suggest a pilot search strategy and that multiple people on the review test the extraction criteria team for consistency. For this study the review team included myself. To ensure that my review was effective and comprehensive, I developed a literature search strategy and literature inclusion criteria before conducting the final literature search and literature inclusion. I also determined the data extraction variables before conducting the data extraction and synthesis.

Literature Search

The development of a literature search strategy is critical in reducing publication bias and balancing the sensitivity and specificity of the search results. It is important to include relevant papers in the search and to initially exclude papers that are too broad to be included.

As an iterative process, the search strategy began by defining keywords from the four elements of the primary research question of this study: Ecological Design, Conservation Planning, Avian Diversity, and Urban. Search categories and associated search terms were developed based on these keywords (Table 2.2). The most effective string of search terms and syntax was evaluated using Web of Science database, which includes the Science Citation Index Expanded (1945-present), Social Sciences Citation Index (1956-present), and Arts & Humanities Citation Index (1975-present). Combined, the database offers a wide selection of science, planning and design journals.

The results were evaluated for relevancy and compared to an existing annotated bibliography of articles on how to support avian diversity in urban landscapes (Urbanova, 2009). A record of search scoping process is available in Appendix A, with the final search string presented in Table 2.2. The selected search string was then run in 12 academic databases (Table 2.2), with all the results being managed in EndNote 4.0. The results of the final literature search are presented in chapter 3.

Table 2.2. Final Search Strategy and Inclusion Criteria for systematic literature review to determine how to improve avian diversity in urban areas.

Search Category	**Search Terms**
Urban Terms:	Urbanized, city, metropolitan, exurban, suburban
Avian Terms:	Bird, birds, avian, avifauna,
Ecological Terms:	Diversity, richness, composition, ecology
Design/Planning Terms:	Ecological design, conservation planning, green design, open space planning, design, planning, best management practices

Final Search String
Topic or Text = (urbanization OR city OR metropolitan OR exurban OR suburban) AND (avian diversity OR avian richness OR bird diversity OR bird richness OR avifauna OR avian ecology) AND ("ecological design" OR conservation OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices" OR urban land use)

Search Databases
1. EBSCOhost Research Databases: Academic Search Complete, Art and Architecture Complete, Environmental Complete, Garden, Landscape and Horticulture Index, GreenFILE, Humanities International Complete, Science and Technology Collection, Urban Studies Abstracts, Wildlife and Ecology Studies.
2. Web of Science
3. JSTOR

Literature Inclusion Criteria
1. Avian communities and populations are the primary subject of the research and exclude articles that measured terrestrial vertebrates, general biodiversity and all other taxa.

2. Diversity or richness is used as a primary metric to measure changes in avian populations in the study.

3. One of the following was included: design, planning or management recommendations developed from results, a significant increase or decline in metric due to a planning or design practice, or significant increase or decline in metric due to specific land use/management practice.

4. The study was conducted or focused on a specific urban area or urban gradient.

Literature Inclusion

The four elements of the primary research question were used to develop a list of four inclusion criteria that were applied to the results of the final literature search (Table 2.2). The initial results were first evaluated by article title so that book reviews, proceedings from conferences and other titles that did not meet one of the four criteria could be excluded. Those in question were then evaluated by their abstract and finally by reading the full text. Data was then extracted from the final list of relevant articles.

Data Extraction

The extraction of data from the relevant literature included recording: the descriptive and intent variables, quality of studies, and suggested methods. Both descriptive and intent variables help describe the current research being conducted to help inform practice and research. For example, if the studies specifically address one family of birds, or one part of the world, then the literature review would suggest future research in those areas not included in the studies. The quality of the studies from literature review can be used to both support systematic reviews and to assess the validity of the methods and techniques developed from the review. For example, if a large percentage of high quality studies were included in the review, this would give support for incorporating systematic reviews in future planning and design projects.

The descriptive variables used to assess the scope the research included: author, title, publication date (year), publication, publication category, country, city, state, level II ecoregions for North American studies (Omernik 1987), biome (Olson et al 2001), landscape or habitat being addressed and landscape category. The intent variables used to assess the focus of the research included: intervention, avian group being addressed, season and metric(s) measured in study. A set of six intervention categories was used to describe the differences in design and planning practice (Table 2.3).

Table 2.3. Intervention practice category definitions used in the extraction of data from the relevant literature.

Category	**Definition**
Conservation Planning	Planning to conserve biological and ecological resources
Golf Course Design	Design associated with creating golf courses
Landscape Design	Design of natural and human elements on local scale sites
Urban Design	Design of urban landscapes and form
Urban Planning	Planning of urban land-uses, transportation or political boundaries
Wetland design	Design of functional aquatic systems

To assess the quality of the research, the studies were categorized as either quantitative or qualitative; in a few cases both categories were used. Predetermined high and low quality categories were used to assess the quality of both study types (Table 2.4). For quantitative studies, data is collected and analyzed through a pre-established research design. The quality of that design can be measured by how well the researchers accounted for error and bias in their sampling, as well as how large their relative sample size was. For example, high quality studies incorporated techniques such as double observation methodologies, randomized sampling and appropriate statistical analysis.

Qualitative studies by nature can be more subjective. In general, they are not placed under the same scrutiny as quantitative studies and therefore can carry less validity. However, qualitative studies can inform planners and designers on the perspectives or behaviors of communities and the values of the topic being addressed. Therefore, the quality of these studies are based not on the how they collected data, but on which studies they are basing their narrative or opinions on, and how the author(s) utilize that information to support their position. For example, a low quality study would not provide case studies or quantitative studies to support suggested planning or design techniques or opinions.

Table 2.4. Quality ranking definitions used to assess both qualitative and quantitative studies used in systematic literature review to determine how to improve avian diversity in urban areas.

Qualitative Studies	
Low	Does not us quality research or studies to support perspectives presented in narrative
High	Uses quality research or studies to support perspectives presented in narrative
Quantitative Studies	
Low	Combination of unstandardized sampling methodology used and/or biased data collection practiced. Measure to reduce confounding variables or error not taken. Inappropriate analyses applied to data
High	Standardized proven sampling methodologies utilized and/or unbiased data collection practiced and measures taken to reduce confounding variables and error. Appropriate analyses conducted for data collected.

The final step in the data extraction was recording the suggested methods that planners or designers can utilize in practice. *A priori* categories were established based on research areas and scales most common in planning and design practice. The categories included: Landscape Pattern, Land Use Pattern, Development Best Management Practices (BMP), Flora Pallet and Composition, Policy, Education and

Research, and Human Use and Disturbance (Table 2.5). The development of *a priori* categories assisted in the analysis of the suggested methods.

Table 2.5. Description of suggested method and technique categories.

Suggested Method Categories	Definition
Landscape Pattern	Composition and configuration of habitats within the landscape addressed
Land Use Pattern	Composition and configuration of land use within the landscape addressed
Development BMP	Specific measures to be applied to development practices
Flora Composition and Configuration	Flora or plant habitat diversity, structure and arrangement addressed
Policy, Education and Research	Policy actions, educational programs and research needs addresses
Human Use and Disturbance	Human use (recreation, supplemental feeding, traffic) of landscapes addressed

Data Analysis and Synthesis

The analysis and synthesis reports on two types of results; 1) The effectiveness of the systematic review methodology to inform evidence-based practice, based on descriptive and intent variables and 2) An analysis of the suggested methods to inform planning and design practice on how to improve avian diversity in urban. This analysis also provides direction for future research.

To assess the effectiveness of the systematic review methodology to inform evidence-based practice, the results of the literature search were analyzed to determine what percent of the final literature search (in total and by database) were used in the analysis and synthesis. In addition, the total and percentage of the relevant literature data was analyzed by publication, publication category, country, ecoregion, biome, and landscape category to determine the scope of research. Finally, the total and percentage of low and high quality studies, as well as the percentage by study type (qualitative or quantitative) were calculated.

The synthesis of the suggested methods began with consolidating the six suggested method categories down to four. Landscape pattern and land use pattern were grouped into a general landscape scale category (Landscape Scale). Development BMP and flora pallet and composition categories were consolidated into a local scale category (Local Scale). These scales are used in many ecological research studies to assess if a certain species or community responds more to landscape or local variables. Landscape scale, for the purposes of this study, is not associated with a specific measurement but to methods that would address the configuration or composition of heterogeneous land uses. Local scale applies to homogenous land use and the elements within that land use. Policy, education and research (PER), and human use and disturbance (HUD) remained independent categories.

To give an overview of how the suggested method categories and intervention practices were related, the total and percentage of the suggested methods was determined for each intervention practice (see Table 2.3). These results will help planners and designers working in a specific field (i.e. urban planning) to know which method categories will best inform their practice.

Further analysis examined the suggested methods extracted from each article using qualitative coding methodology. Developed as an approach in grounded theory, qualitative coding methodology is primarily practiced in social and health sciences

(Glaser and Strauss, 1967). In general, qualitative methodology uses both inductive and deductive thinking to establish theories or conclusions from a dataset. With the use of coding, which focuses on reoccurring words or phrases, the development of categories remains unbiased. As an iterative process, the suggested methods in this study were first evaluated with open coding by defining the main action suggested in each method. For example, conserve large natural areas or reduce invasive species. The resulting list was then evaluated using axial coding, where similar actions were grouped and redefined as new categories. This process continued until a final list of eight distinct actions was established; these actions are described in the results chapter.

To measure the variability and value of the actions recorded for each article, a score of one was given to each action under the landscape and/or local scale suggested methods. For example, Merola-Zwarties and DeLong's (2005) article Avian species assemblages on New Mexico golf courses: surrogate riparian habitat for birds*?* had two actions suggested under the landscape scale and two actions suggested under the local scale, for a total score of four. The total score was tallied and the percentage by scale was calculated for each of the eight action categories. These results describe which actions were suggested the most and at which scale they occurred.

The systematic literature review was conducted between January and March 2013. The result of the review, literature inclusion and data extraction and synthesis are presented in chapter 3

CHAPTER 3

RESULTS

The results of the systematic review were used to address both goals established for this study. The first goal was to test the efficacy of the systematic review methodology to inform evidence-based practice in planning and design fields. Three types of variables were analyzed to address this goal: descriptive variables or characteristics of the studies, the intent of research, and quality of studies. By assessing the characteristics, intent and quality of the research, the results of the analysis provide validity to the scientific and planning research used in the review analysis .Theses results also provide direction for future research.

The second goal was to use the results of the systematic review to strengthen existing methods and develop new methods that planners and designers can use to improve avian diversity in urban areas. The results of the suggested method synthesis and coding provide a guideline for planners and designers interested in addressing avian diversity and biological health in their community. These results also establish baseline knowledge across multiple fields to improve the quality of professional practice, and to avoid using outdated methods.

Literature Search Results

The literature search produced a total of 4,369 articles from the 12 academic databases (Table 2.2). The JSTOR database returned the most results with 2,117, followed by the EBSCO multi-database search (1960) and Web of Science (292). After reviewing the literature for relevancy, a total of 173(4%) of the articles were included in the data extraction and analysis (Appendix B). Of the relevant articles, most came from Web of Science (92), followed by the EBSCO multi-database search (54) and JSTOR (27).

Descriptive variables

The year of publication of the 173 relevant articles ranged from 1976 to 2012, increasing from one article in 1976 to 15 articles in 2012. The largest number of articles came from 2007 (17) (Figure 3.1.)

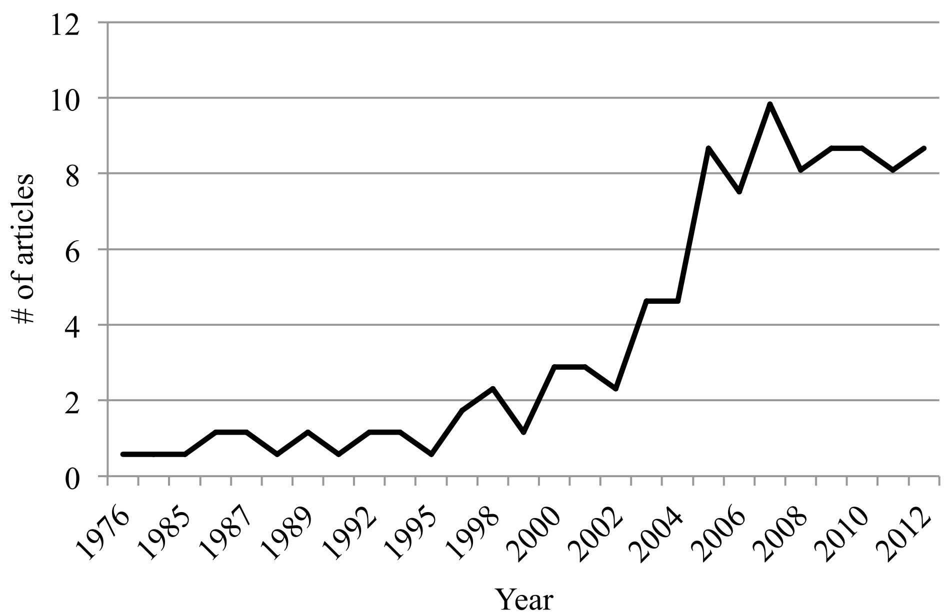

Figure 3.1. Number of relevant articles by publication year from results of a systematic literature review to determine how to improve avian diversity in urban areas.

Forty-two percent of the articles came from Landscape and Urban Planning Journal (Figure 3.2), and 66 % of the articles were categorized as a biological or ecological publication. A total of 29 countries were represented in the studies. North

America was the most represented country at 46.8%, followed by Australia (10.4%) and Canada (6.9%). For studies conducted in North America, most were conducted in Arizona (8%), however 29 states were represented in the studies. Of the 50 North

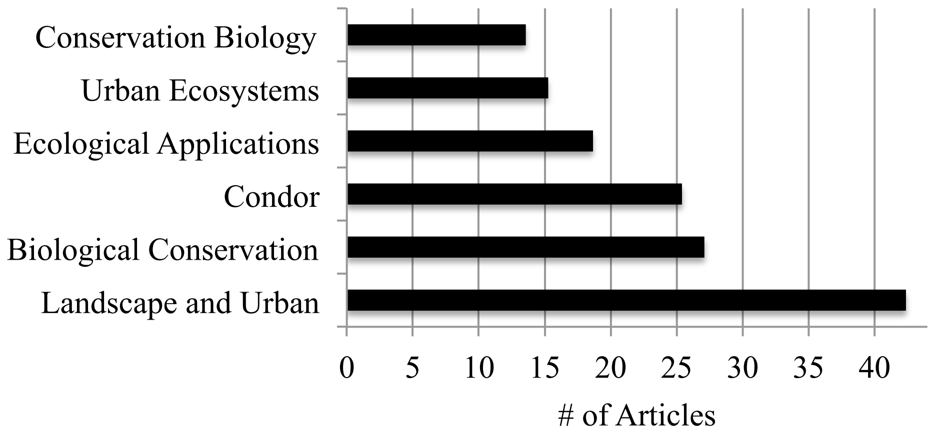

Figure 3.2. Number of articles for top six publication titles from results of a systematic literature review to determine how to improve avian diversity in urban areas.

American ecoregions , 14 were represented in the studies, with most located in the contiguous United State. The warm desert was represented the most (8%), followed by: the southeastern USA plains (6%); Mediterranean California (5%); Mississippi alluvial (5%); southeast USA coastal plains (5%); mixed wood plains (5%); and central USA plains (5%). Eleven out of the 15 world biomes were represented in the studies. The world biome most represented was temperate broadleaf and mixed forests (42%), followed by Mediterranean forests, woodlands and scrub (14.5%). Combined tropical biomes represented about 13% of the studies, and desert and xeric shrublands represented 9%.

Forty-one landscape types were defined during the review, ranging from golf courses to urban lake systems to exurban deciduous forests. These landscape types were then categorized into nine landscape categories, including rural-urban gradient, native remnant or fragment, and residential neighborhood. Rural-urban gradient was the most studied landscape (24%), and golf courses the least studied (3%). The total number of articles for all the landscape categories is shown in Figure 3.3.

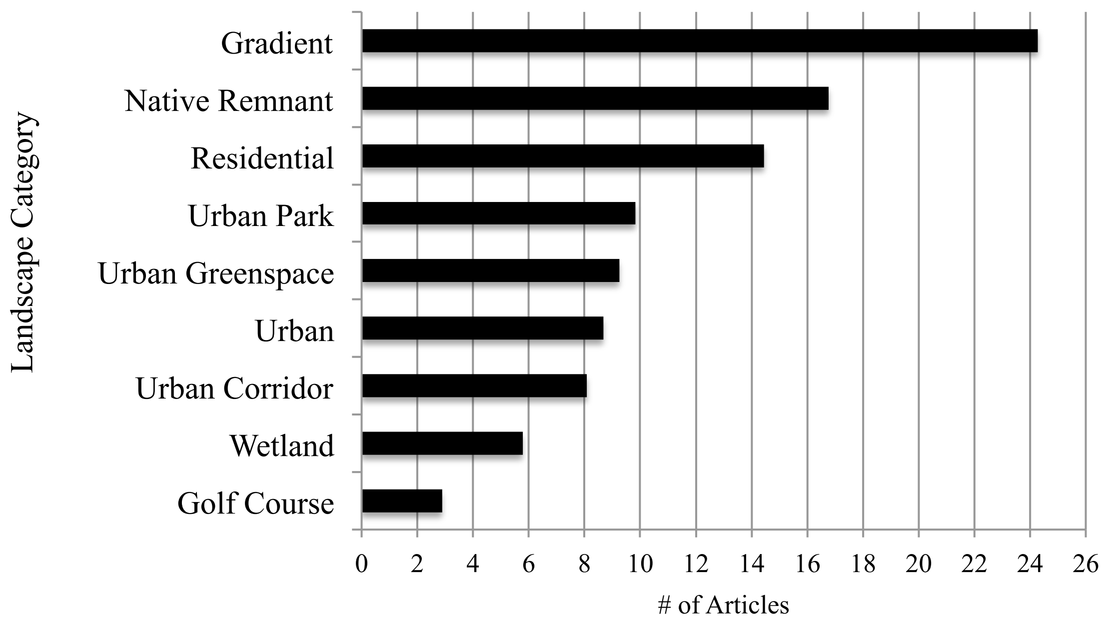

Figure 3.3. Number of articles for the final nine landscape categories from results of a systematic literature review to determine how to improve avian diversity in urban areas.

A total of eight avian categories and seven season combinations were recorded from the relevant literature. The avian category and season most studied was landbirds in the breeding season, followed by all birds in the breeding season. Year round studies represented 18% of the studies, with 63% of those focused on landbirds. Native landbirds, waterbirds, and obligate species (desert scrub birds, grassland birds and cavity-nesters) were each 5% of the studies. Diurnal raptors were only studied in one paper, representing 1% of the studies (Table 3.1).

Table 3.1. Total and percentage of avian category and season measured in relevant research from results of a systematic literature review to determine how to improve avian diversity in urban areas

	Season*									
Avian Category	*B*	*B,M*	*B,NB*	*B,NB M*	*M*	*NB*	*NB, M*	*N/A*	*Total*	*%*
Landbirds	60.0	2.0	9.0	20.0	8.0	2.0	3.0	--	104.0	60.1
All birds	12.0	1.0	1.0	8.0	--	3.0	--	4.0	29.0	16.8
Passerine Birds	8.0	1.0	1.0	--	1.0	--	--	--	11.0	6.4
Native Landbirds	6.0	--	1.0	1.0	--	--	--	--	8.0	4.6
Waterbirds	3.0	--	2.0	1.0	--	2.0	--	--	8.0	4.6
Obligate Species	5.0	--	--	2.0	--	1.0	--	--	8.0	4.6
Single Species	3.0	--	--	--	--	--	--	--	3.0	1.7
Diurnal Raptors	--	--	1.0	--	--	--	--	--	1.0	0.6
N/A	1.0	--	--	--	--	--	--	--	1.0	0.6
Total	98.0	4.0	15.0	32.0	9.0	8.0	3.0	4.0	173.0	
%	56.6	2.3	8.7	18.5	5.2	4.6	1.7	2.3		

*B=Breeding, M=Migratory, NB=Non-breeding

Intent of Research

The intent of the research or intervention (referring back to elements of the questions) was either a design action or planning action. A total of six interventions were identified through the studies: conservation planning, golf course design, landscape design, urban design, urban planning, and wetland design. Of the six intervention categories, urban design and conservation planning represented a total of 80% of all the studies. Landscape design was the intent of 13% of the studies. (Table 3.2)

Table 3.2. Total and percentage of suggested methods by intervention practice from results of a systematic literature review to determine how to improve avian diversity in urban areas.

	Landscape Scale		**Local Scale**		**PER***		**HUD***		**All Methods**	
	Total	*%*	*Total*	*%*	*Total*	*%*	*Total*	*%*	*Total*	*%*
Conservation Planning	54.0	44.6	20.0	24.7	6.0	33.3	3.0	27.3	83.0	35.9
Golf Course Design	2.0	1.7	3.0	3.7	1.0	5.6	--	--	6.0	2.6
Landscape Design	5.0	4.1	22.0	27.2	3.0	16.7	3.0	27.3	33.0	14.3
Urban Design	4.0	3.3	7.0	8.6	--	--	--	--	11.0	4.8
Urban Planning	56.0	46.3	29.0	35.8	8.0	44.4	4.0	36.4	97.0	42.0
Wetland Design	0.0	--	--	--	--	--	1.0	9.1	1.0	0.4
Total	121.0		81.0		18.0		11.0		231.0	
%	52.4		35.1		7.8		4.8			

*PER=Policy, Education, and Research, HUD=Human Use and Disturbance

Quality of Studies

Of the two types of studies (qualitative or quantitative), over 94% were quantitative. However, there were four studies (2.3%) that had both quantitative and qualitative components. Of the quantitative studies, 134 (80%) were high quality studies.

Only 33 (20%) were low quality, mostly due to an incomplete research design description, confounding variables, or small sample sizes. Most of the high quality quantitative studies were focused on conservation planning 58 (43.3%) or urban planning 53 (39.6%). Combined urban design, landscape design and golf course design represented 17% of the high quality quantitative studies (Table 3.3).

Table 3.3. Quality of both quantitative and qualitative studies based on intervention practice from results of a systematic literature review to determine how to improve avian diversity in urban areas.

Quantitative Studies

	Quality					
Intervention	*High*	*%*	*Low*	*%*	*Total*	*%*
Conservation Planning	58.0	43.3	9.0	27.3	67.0	40.1
Golf Course Design	2.0	1.5	1.0	3.0	3.0	1.8
Landscape Design	15.0	11.2	6.0	18.2	21.0	12.6
Urban Design	6.0	4.5	--	--	6.0	3.6
Urban Planning	53.0	39.6	16.0	48.5	69.0	41.3
Wetland design	--	--	1.0	3.0	1.0	0.6
Total	134.0		33.0		167.0	

Qualitative Studies

	Quality					
Intervention	*High*	*%*	*Low*	*%*	*Total*	*%*
Conservation Planning	1.0	14.3	--	--	1.0	0.6
Golf Course Design	--	--	--	--	--	0.0
Landscape Design	4.0	57.1	1.0	33.3	5.0	3.0
Urban Design	--	--	--	--	--	0.0
Urban Planning	2.0	28.6	1.0	33.3	3.0	1.8
Wetland design	--	--	1.0	33.3	1.0	0.6
Total	7.0		3.0		10.0	

Qualitative studies represented only 10 (6%) of the total studies, and of these only seven were of high quality. Of the high quality studies, four (57%) were focused on landscape design and two (29%) on urban planning. Only one article focused on wetland design, and it happened to include both quantitative and qualitative objectives. Unfortunately, both parts of the study were of low quality. None of the qualitative studies focused on golf course design or urban design (Table 3.3).

Literature Synthesis Results

The recorded suggested methods were placed into one of four categories: landscape scale, local scale, policy, education and research (PER), and human use and disturbance (HUD). A total of 231 suggested methods were extracted from the 173 studies, with 45 (26%) of the articles having methods that fit into more than one category (Table 3.2). Just over half of the methods were categorized as landscape scale, and 81 (35%) were categorized as local scale methods. Combined, PER (18) and HUD (11) methods only represented 12% of all the methods suggested.

The results of each suggested method category by intervention practice is shown in Table 3.2. Conservation planning and urban planning practices represented 90% of the landscape scale methods. These practices also represented the largest percentage (60.5%) of the local scale methods. In addition, landscape design practice represented another 27.2 % of local scale methods. Urban planning practice had the highest percentage of methods for both PER (44.4%) and HUD (36.4%).

The coding results defined eight distinct actions from the suggested methods (Table 3.4). A total of 302 actions were counted for all the articles with an average of 1.75 and a range of 1 to 5 actions per article. Habitat structural diversity, large area

Table 3.4. Final eight action categories defined by the coding of the suggested methods from results of a systematic literature review to determine how to improve avian diversity in urban areas.

Action	Definition
Habitat structural Diversity	These methods all suggest increase structural habitat diversity, such as increasing shrub layer, mid-height tree diversity, stem density, etc.
Large Area Conservation/Creation	These methods suggest the conservation, restoration or creation of large natural areas. These would be considered patches on a landscape scale, but actual size of patch would need either landscape or local planning or design approaches
Use of Native Plants	These methods all suggest the maintenance of native plants in a given region, replacement of ornamental or exotic landscaping species with native plants, etc.
Heterogeneous Landscape Planning	The methods suggest planning and implementation of a functional heterogeneous landscape and the methods to compose and configure different land uses. May include the development of urban-agricultural parks, age and structure of natural and residential areas, the addition of wetland habitats to urban areas, etc.
Natural Area Connectivity	Methods suggest the connection of natural spaces, through different types of natural corridors
Development practice	Suggested development threshold or best management practice. Includes housing density thresholds, road and trail development measurements, etc.
Buffer Creation	The methods suggest the creation of buffers, their size and quality for multiple land uses, including golf courses, parks, riparian areas, residential, etc. Similar to development practices, they can also be incorporated post development, through restoration and land acquisition.
Improve Matrix Habitat	Specific methods for the urban matrix, but not including specific landscaping suggestions (native plant use and habitat diversity). These include the addition of canopy cover, street tree design, etc.

conservation and creation, and use of native plants were the most suggested actions. Most actions were recommended for landscape scale methods (59.9%). Local scale actions represented 40.1% of the actions and of those, habitat structural diversity and use of native plants equaled almost 90% (Table 3.5).

These results give planners and designers a guideline of which action is most suitable for specific scales or practices. Landscape scale actions were, not surprisingly, most appropriate for planning practices. Local scale actions focused on plant structure and plant use. Although, these results support methods already being used in practice, the next chapter will discuss the details of the eight actions and how they can bridge scales or practices.

Table 3.5.Total and percentage of each action category by suggested method scale categories. From results of a systematic literature review to determine how to improve avian diversity in urban areas.

	Landscape Scale		**Local Scale**		**All Scales**	
Action Category	*Total*	*%*	*Total*	*%*	*Total*	*%*
Habitat structural Diversity	4	2.2	61	50.4	65	21.5
Large Area Conservation/Creation	50	27.6	2	1.7	52	17.2
Use of Native Plants	4	2.2	47	38.8	51	16.9
Heterogeneous Landscape Planning	33	18.2	2	1.7	35	11.6
Natural Area Connectivity	25	13.8	1	0.8	26	8.6
Buffer Creation	25	13.8	1	0.8	26	8.6
Development practice	22	12.2	2	1.7	24	7.9
Improve Matrix Habitat	18	9.9	5	4.1	23	7.6
Total	181		121		302	
%	59.9		40.1			

CHAPTER 4

DISCUSSION AND CONCLUSIONS

Use of systematic literature review to inform evidence-based practice

The literature review resulted in a breadth of research focused on the subject of avian diversity in urban areas. The initial large search result was due to the relatively broad nature of the question. As stated by the CEE guidelines, the resulting small percentage of relevant articles (2-5%) is normal when the question falls on the broad side of the spectrum (CEBC 2010). The 173 relevant articles used in this study were not limited to specific publications, fields of study, specific years, or a single database, indicating that the search methodology successfully included the most relevant studies from multiple fields. The top six publications focused on planning, conservation, ecology, socio-environmental, and ecological management.

With 11 of the 15 world's biomes being represented in the studies, the methods that are developed from this review can be applied to urban areas in many regions of the world. However, for planners and designers, understanding how different ecosystems or biomes affect diversity and then being able to adjust their practice to account for those differences, will make their practice more successful. For example, a landscape design practice may vary depending on whether the ecosystem is mixed broadleaf forest or semi-arid cold desert. The differences in practice based on biomes or ecoregions will be addressed later in the discussion.

The research focused primarily on landbirds during the breeding season. Landbirds are the easiest group of birds to study due to established sampling methodologies, such as point counts, and well understood life histories. It is easy to study birds during the breeding season because individuals are tied to specific areas; breeding males are vocally and visually establishing territories and brooding birds can easily be monitored on nests. In addition, breeding data collected on fecundity, productivity, nesting success, and causes of mortality are extremely important in understanding population dynamics and management needs. However, over the last two decades, we have gained a better understanding of the importance of the non-breeding and migratory seasons to population health and dynamics. For example, avian ecologists have learned that the use of pesticides in South American agricultural areas is affecting Swainson’s hawk (*Buteo swansonii*) populations during the non-breeding and migratory seasons (Goldstein, 1999). The number of year-round studies represented in this review show that the entire life history of populations are being addressed, but more research should focus on either specific times of the year, or differences between seasons. This information could better inform planners and designers of how they can provide resources for the throughout year, supporting all communities that use a given landscape.

The literature review results showed that the majority of the studies were of high quality. These results provide support for the use of the extracted data to develop new methods, or support the application of existing methods. However, the few studies on golf courses, urban design, and wetland design were of low quality. To improve methods for these practices, future research should adopt higher quality research design methods and focus on constructed wetlands, restoration, park design or golf course design.

A significantly higher percentage of the studies were quantitative, meaning that the research design primarily aimed to test physical responses of birds to environmental variables. As opposed to qualitative studies, which are more subjective, quantitative studies provide results that can be applied to specific environments. In many cases, the studies provided thresholds tied to specific landscape modifications. As more research is conducted, standardized quantitative research methods should address threshold variability to support appropriate recommendations.

Finally, the small percentage of qualitative studies included in the review was in part due to the a priori literature inclusion criteria (Table 2.2), which stipulated that a study must focus on a specific urban area. Most qualitative studies focus on broad issues that might affect multiple locations, and as a result some were not included in the analysis. If more qualitative studies are to be included in evidence-based planning, their research design should include measurable ecological variables, in addition to sociological and psychological variables. As stated in the introduction, the variable definition of 'landscape' can make collaboration between fields difficult. Qualitative researchers should adopt accepted definitions and use the most tested methodologies in their field so that their studies may be repeated, and their results can be included in the collection of relevant literature.

Methods to improve avian diversity in urban areas

The relevant literature provided quality data and recommendations. The eight actions that resulted from the coding of the recorded suggested methods represent specific ways that planners and designers can inform evidence-based practice. The results of the synthesis show that, adding habitat structural diversity and native plants at a local scale, and conserving or creating large natural areas on landscape scale, are the most effective ways to improve diversity. Under each action, there are specific methods and principles that further explain their importance. Planners and designers should understand each of the eight actions individually, but also how to apply them in proper combination.

The increase in avian diversity resulting from the application of these actions will vary depending on the location and the degree urbanization. With increasing urbanization, there is a decrease in richness and an increase in avian density, primarily due to greater abundances of urban-exploiters or loss of habitat. In highly urbanized areas, it would be unrealistic to fully restore the pre-settlement avian community. However, any increase in native species diversity could be considered a success, especially if there is a focal species of concern. In natural areas threatened by urbanization, these actions can maintain or improve the existing native diversity.
The specific actions are important because they were shown to support an increase in avian diversity on a given landscape. The following discussion will cover the results and recommendations presented by the relevant literature for each of the eight actions, in order from the most recommend to the least recommended:

- Habitat structural diversity
- Large area conservation and creation
- Use of native plants
- Heterogeneous landscape planning
- Natural area connectivity
- Development practice
- Buffer zone creation
- Improve matrix habitat.

Habitat Structural Diversity

The importance of habitat structural diversity was presented by 40% of the relevant studies in the literature review, more than any other action. Habitat structure refers to both landscape and vegetation structure, and on multiple scale. Research on biological populations often shows significant responses are either seen at a landscape or local scale, but rarely both. Habitat structural diversity actions were suggested more often at a local scale (94%), indicating that not only are decreases in bird diversity most likely linked to local scale effects, but that on a local scale planners and designers can successfully increase avian diversity. Understanding how habitat structure supports different avian communities can help planners and designers see why conventional urban landscapes have decreased avian diversity.

A number of specific actions addressed ways to increase avian diversity between and within landscape and vegetation structure. These actions include: maintaining or creating native understory; adding vertical and horizontal structural complexity; increasing vegetation density; adding foliage height diversity; increasing snag densities, increasing tree height, mid-tree height and tree diversity; and increasing habitat heterogeneity. These actions often go hand in hand, and many can be achieved with thoughtful planning and design. Understanding the difference between landscape and vertical structure is necessary in order to apply these actions.

Landscape structure or horizontal structure refers to the cover, density, and distribution of a habitat across the landscape. On a local scale, horizontal structure within a habitat patch may be present due to gap dynamics, soil and precipitation variation, or disturbance events. For example, the loss of a canopy individual, be it a Giant Redwood

(*Sequoia sempervirens*) or Big Mountain Sagebrush (*Artemisia tridentata*), will allow understory species to dominate. In addition, as canopy individuals are lost, the distribution of that canopy species across the landscape may become clumped or random. These local scale structural changes provide variable understory habitats, and consequently provide microhabitats in an otherwise continuous landscape. In mature or old growth forests, this process is called gap dynamics and because of this process, older aged forests usually support higher biodiversity.

On a landscape scale, variation in horizontal structure between patches is due to topography, soil and precipitation variation, or large disturbance events. For example, due differing amounts of solar radiation, north-facing aspects usually support different habitats than south facing aspects, which can create horizontal heterogeneity. Similarly, the bottom of ravine will generally be cooler and contain more surface or groundwater, supporting a much different habitat than a ridge top. Even in a grassland ecosystem, differences in soil type and slight changes in topography will support different communities of grasses. On a landscape scale, these breaks in habitat increase horizontal structure and can increase diversity. On a local scale or within patches, horizontal structural diversity can be created with the specific actions mentioned in this section. See the section below on heterogeneous landscape planning for more details on how to create horizontal structural diversity within an urban ecosystem.

Vegetation structure or vertical structure describes the way vegetation is arranged in a 3-dimensional space, and is measured through habitat strata (e.g. ground, understory, canopy and emergent layers). The heights of these strata will vary with by ecosystem. For example, in a shrub steppe ecosystem dominated by *Artemisia* species, canopy height is on average 3.3ft. Conversely, in tropical moist broadleaf forest, canopy height can average 130ft, and emergent canopy can average 270ft. Regardless of the total vertical height, the diversity of vegetation between and within each strata is directly related to the avian community the habitat as a whole can support. Vegetation structure provides breeding substrates, nesting material, foraging areas, perches for hunting and defending territories, structures to hide from predators, shelter from inclement weather, and safe roost sites. Consequently, when one or more of these resources is missing from the vegetation structure of a habitat (i.e. shrub nesting substrate), then certain species cannot be supported, lowering diversity. For example, an even-aged stand of pines, like those created by a pine plantation, provides limited vertical structure and diversity. Only a limited number of bird species utilize the canopy of pines for foraging and nest.

Fortunately, there are simple ways to improve structural diversity in urban ecosystems. One of the easiest ways is by reducing the percentage of lawns in urban areas. The high use of lawns in residential and civil landscapes completely removes the ground, shrub, and understory layers. An estimated 27.6 million acres of lawn covers the United States, it is not surprising that we are homogenizing our avian community not only across the country, but also across the globe (Ignatieva and Stewart, 2009). As a ground layer, lawns decrease plant diversity down to a very few species, outcompete native species, can require large amounts of resources, do not support healthy arthropod communities, and soil biota (Byrne, 2007). Conversely, a native habitat ground layer can contain multiple species of herbaceous forbs and short grasses, which can support multiple species of invertebrates, add nutrients to and build soil, promote healthy soil function, and provide ecosystem services like ground water regeneration.

Adding more understory plants of varying structure, height, and density can be accomplished simply by planting more shrubs, allowing areas to undertake succession, or retaining native understory. Kalinowski and Johnson (2010) showed that shrub cover >11% had a positive influence on diversity, especially when tree cover was less than 49%. In forested ecosystems, maintaining an understory layer extending from native remnants throughout residential and urban green spaces will provide much needed breeding, foraging, and cover habitat for ground and shrub nesting birds. It will also provide foraging opportunities and cover for migratory and non-breeding flocks. Most studies that measured habitat structure used percent cover and woody plant richness as metrics (Schwartz, 2008; Donnelly and Marzluff, 2006) and found that an increase in percent cover and plant richness, and a decrease in percent lawn were correlated with increase in diversity. For example, Schwatrz (2008) found that intensively managed parks had zero percent annual cover, 20% woody cover and 85% lawn cover, and also had the lowest average richness measure.

Gray areas in urban environments, such as road medians, sidewalk green strips, small underutilized parks, or entry lawns are ideal places to increase understory shrub cover. Thoughtful consideration of maintenance needs and growth patterns of shrub species used in these areas can decrease the costs to maintain these areas. Money that would be used to mow, water, fertilize, and apply pesticides to these unused gray areas can be put to more pressing management issues.

The importance of increasing vertical structure continues up the strata (e.g. mid-story, canopy). By adding complexity and plant richness to any layer avian diversity will be increased. In temperate conifer forests, Donnelly and Mazluff (2006) found that an average of 9.8 trees/ha and composition of 23% conifers increased avian diversity. Additionally in conifer forests, simply balancing conifers and deciduous trees, and retaining second growth forests with high percentage of snags increased diversity (Blewett, 2005; Fontana, 2011,). In desert xeric shrublands, the combination of 10 trees and 20 native shrubs within 100m radius increased diversity (Lerman, 2011).

If ecologists want to better inform planners and landscape architects on how to add habitat structure, research should quantify the level of complexity or structural differences for different ecosystems. For example, in grassland ecosystems much of the structural diversity in native habitats is contained in riparian areas. A landscape architect wanting to create native riparian structural complexity and diversity along a managed urban waterway, such as an irrigation canal, may ask the following questions. What plant pallet should be utilized and in what densities to create a structurally diverse habitat similar to a native riparian woodland? What would be the difference in plant richness between vertical strata? How does the plant richness within strata vary in form and function? Researchers in the fields of ecology and avian biology should aim to answer these questions so that planners and designers may hone their skills within a given ecoregion. Additionally, planners and designers should also ask these questions of local experts, who have insight into local habitats and could give guidance on the structural needs of local avian communities.

Large Area Conservation and Creation

The conservation and creation of large areas of native habitat is the most effective landscape scale action to maintain or improve avian diversity. Large areas of natural habitat are not as affected by edge effects, human disturbance, and invasive plant species (Rosenberg et al., 1997). Over one-third of the studies in the literature review measured remnant area (also referred to as fragment or patch area), and determined that it influenced diversity more than any other landscape scale variable. As a general rule, no matter where you are in the world, conserving, restoring, or expanding large natural areas will improve diversity. It is a simple guideline that requires very little understanding of other ecological or sociological factors.

What is considered large, or conversely too small, can be answered in part by the results of the literature review. The largest remnant areas measured in the studies ranged from 0.16ha to 38,000ha (Daniels and Kirkpatrick, 2006; Jones and Bock, 2002). The smallest was a measurement of a large residential garden, while the largest was conserved open space on the rocky mountain front. In residential neighborhoods, a large garden will not support source populations or the same amount of richness as a large reserve outside of the city core. However, expanded to a landscape scale, many large garden areas can improve local diversity. At a regional scale, where natural areas outside of a city core are taken into consideration, conserving areas as large as 38,000ha is reasonable. In addition, large reserves close to city boundaries can be important source areas for population utilizing inner city remnants.

For practice includes the development of a master plan, land acquisition, land management planning, or a restoration effort, a minimum area of 10ha can improve diversity, but areas >50ha were on average the suggested minimum for most ecosystems (Lorenzetti and Battisti ,2007; Smith, 2007; Reidy et al., 2009). In desert, chaparral, and grassland ecosystems >100ha would maintain more native diversity and support breeding populations (Berry et al., 1998; Forman et al., 2002). In forested regions, retaining 60% forested area for every 100ha, or on average >40% canopy cover (Blewett and Marzluff, 2005) and maintaining a distance of 67m from roads will increase diversity (Minor and Urban, 2010).

The size of areas is important, but designers should also consider the shape, habitat quality, isolation and adjacent land use of remnants. Considering the shape of large areas can reduce the effects of urbanization that can decrease the functionality of remnants that would otherwise be considered large. For example, a long, narrow remnant can increase edge effects, predation, and brood parasitism (Wilcove, 1985). In addition, large areas that contain degraded and fragmented habitat patches can reduce biological and ecological function. Actions that can improve the habitat quality and ecological function of a large area include: retaining mature forest, increasing abundance of snags, providing large areas of shrubs and patches of habitat in different successional times (Posa and Sodhi, 2006; Blewett and Marzluff, 2005; Lee et al., 2007a; Forman et al., 2002).

Remnants that are highly isolated, especially smaller ones that contain sink populations, are at a higher risk of local extinction, turnover, and fragmentation effects (MacArthur and Wilson, 1967). Further fragmentation or loss of habitat in highly isolated remnants could reduce their ability to support any native populations, there by decreasing overall ecological function. Therefore, increasing the number of remnants of any size will improve avian diversity and decrease the vulnerability of any specific remnant.

Finally, it is very important to take into consideration the impact of the landscape surrounding a native remnant. If at all possible, development or land use should be low intensity, such as certain agricultural land uses. To maintain a functional core, human disturbance and access should be limited to the edges, and those edges should be varied and gradual. Managed landscaping close to edges should contain as many native plants as possible to limit the dissemination of invasive species into the remnant core. Although many of these points are discussed in other action sections, their importance in maintaining or improving diversity relative to large remnant areas needed to be noted.

Use of Native Plants

Using native plants is the third most suggested action recommended by the relevant literature, and is also the second most suggested for local scale suggested methods. The majority of the studies found that areas with more native plants supported more avian diversity, and recommended simply to use native trees, increase native understory, and remove exotic and invasive species. It should be understood that as with any other action discussed in this study, if a native plant can be used, it would only increase the success of that action. The consequence of not using or conserving native plant species leads directly to the degradation of ecosystems and loss of native biodiversity, primarily due to the spread of exotic or invasive species,.

Invasive species in our landscapes can; displace native plants that support local prey resources, increase frequency and risk of wildfires, increase soil erosion, increase extinction risk of endangered and threatened species, and reduce agricultural production and property values. From Kudzu (*Pueraria lobata*,) to Chinese Privet (*Ligustrum sinense*) to Cheat Grass (*Bromus tectorum*), invasive species have escaped beyond their intended locations and now are wreaking havoc on local ecosystems, and creating management and eradication budgets estimated in the billions per year (Center for Invasive Species Management, 2012). Although many of these invasive species were introduced inadvertently, according to the Virginia Cooperative Extension, close to 85% of the invasive plant species in the US had a horticultural origin (Niemiera and Von Holle, 2007). Although many of our ornamental plants may not show invasive tendencies, there are many that are naturalizing in local forests and are becoming invasive, like Mimosa Trees (*Albizia julibrissin*) and Bradford pears (*Pyrus calleryana*), which outrageously are still sold at national retailers for the zones in which they are invasive. The other important point to make is that there is no guarantee that an ornamental plant, faced with the right environment, will not show invasive tendencies. For example, in the Florida Everglades, the paperbark tea tree (*Melaleuca quinquenervia*) did not show invasive tendencies, until water levels were artificially dropped and the new drier conditions allowed the tree to take over areas that were once inundated. Large areas of native grasses have been totally replaced by tea tree forest that cannot support many of the animals native to The Everglades (Tallamy, 2007). Essentially, this ornamental tree that was once non-invasive has deteriorated large areas of Florida's most treasured natural resource.

Another consequence of not using native plants, which is less associated with the spread of invasive species, is the shift from native plant communities to those dominated by ornamentals. The shift in a plant community changes prey species or other food resources available to native bird communities, primarily through the loss of native arthropods. This loss is because native plants and native arthropods have evolved together. Consequently, many arthropod species are specialist, relying on certain plant species or families for food or reproduction. When exotic species replace native species in our urban environments we lose many of the specialist arthropod species that rely on those native plants, as well as many of the native predators the rely on those arthropods for survival or help keep insect populations in check. Tallamy (2007) goes into detail on how important first trophic level insect herbivorous and other arthropods are to a local food web, particularly to birds. Over 96% of bird species rely on arthropods during all or part of their life history. Some people assume that birds are strictly granivores or frugivores. However, flycatchers are obligate insectivores and other birds like sparrows shift their diet from granivorous to insectivorous in the breeding season. This change to a high protein diet facilitates egg production, hatchling growth, and fuels the energy demands associated with migration and breeding (Newton and Brockie, 2003).

The importance of native plants seems to be understood in planning and design fields, but their use can be limited by client demands, budgets, availability, and traditional design principles. Planners or designers should strive to understand the local habitats and plant communities of their region, or seek out local experts in plant ecology or botany. Simply being educated on which plants are invasive, or have potential for being invasive, and then demanding native plants, supporting native plant nurseries, and informing native plant propagators as to what works and what clients want, could change the economics of the retail industry. Furthermore, creating a platform for planners and designers to provide information back to propagators and retailers would increase the efficiency of this process. Finally, educating landowners on the importance of native plants could encourage them to request native plants.

Heterogeneous Landscape Planning

Heterogeneous landscape planning was suggested 35 times in the relevant literature, primarily on a landscape scale. As an action, increasing heterogeneity in urban landscapes is fairly broad and would in reality be supported by other actions described by this study. However, when planners and designers are assessing the landscape at hand, it is important to consider how the juxtaposition, density, and composition of land use can improve avian diversity.

The urban mosaic of patches, corridors, and the matrix creates a landscape context that inherently contains edges and a juxtaposition of conflicting land uses. In some respects, blocking out land uses is necessary, but as many of the papers pointed out, encouraging smart heterogeneous landscape planning can improve avian diversity. As mentioned in the previous section on habitat structural diversity, creating more complexity on a local scale through horizontal and vertical structure can increase avian diversity. Heterogeneous landscape planning increases horizontal complexity on a landscape scale. Varying land uses to allow for different types of habitats in some way mimics the variability of natural habitats caused by disturbance regimes and topography. For example, certain disturbances such as fire will trigger secondary succession. As the disturbed area increases in age, the structure and habitat will change, providing different resources for different species. Because of this process, a forest that has had fires on a frequency of 10-50 years will naturally become a mosaic of patches and corridors within a matrix of successional forests of varying ages. The urban mosaic has the ability to function in the same way.

There are a number of actions planners and designers can apply to provide multiple habitats and all aim to create heterogeneity. Turner (2003) suggested that varying building density combined with restoring or retaining native vegetation would increase the diversity of habitats for different species. For example, suburban areas tend to have higher heterogeneity created through a mix of parks, residential areas, greenways, recreation trails, and low-density commercial areas. To improve on a conventional suburban plan, a greater mix of managed park space and natural areas should be added, and parks woven into higher density residential areas should contain multiple natural habitats (Caula et al., 2008).

When acquiring or restoring open spaces, planning for multiple native habitats composed of varying age and structure will help improve diversity. The addition and juxtaposition of multiple native habitats in the matrix can increase habitat availability for migrants. For example, in temperate broadleaf and mixed forests, fall migrants heavily used mature edge-dominated and early successional forests (Rodewald and Brittingham, 2004). Also, providing a mixture of dense vegetation, open vegetation, and managed yards along developed river corridors was shown to increase waterbird diversity (Calnpbell, 2008). Finally, the addition of urban agricultural areas and community gardens adds landscape heterogeneity and in the studies showed these areas had more diversity then city parks or cemeteries (Andersson et al., 2007).

Planners and designers should work with the natural landscape to provide a variety of habitats. They should also create a variety of built environment elements through the use of different densities, configurations, and compositions. Future ecological research on heterogeneous landscape planning should focus on how different juxtapositions of built environment elements and habitats can improve diversity. This line of research should also consider differences between ecosystems.

Natural Area Connectivity

Connecting native habitat patches is important to maintain healthy, genetically viable populations. The theory of island biogeography states that patch size and isolation determines the persistence of the population on an island. Although terrestrial habitat islands do not respond in exactly the same way as marine islands, the ability of populations to move between patches is important to reduce local extinctions and maintain diversity. Multiple studies have shown that isolation distance and time since isolation were important factors in determining native bird diversity (Soule et al., 1988; Huste and Boulinier, 2007). As urban areas continue to sprawl into existing natural and agricultural areas, reducing the impact of isolation on remnants is extremely important.

The literature suggested increasing natural area connectivity through actions like creating “green” networks, limiting gaps in vegetation, conserving natural corridors, and conserving small natural patches. Applying these recommendations can be as straightforward as preserving small native remnants between the larger patches creating “stepping stones”, maintaining natural corridors like riparian buffers, or simply limiting fragmentation. These suggestions are not new options for land managers tasked with conserving biological populations. However, over the last two decades, corridors have been the ‘go to’ method to create natural area connectivity, and reduce the effects of fragmentation (Dramstead et al., 2007).

Corridors have traditionally been defined as a narrow strip of land, which connects habitat patches, and differs from the matrix on either side (Rosenberg et al., 1997). The goal of creating or maintaining natural corridors in urban areas is to provide either a structural corridor that allows animals to move between patches, or a functional corridor that provides the habitat needed for survival and reproduction. Also, differences in size, shape, and spatial context of corridors affect the conservation value of natural area connections. Ideally, all corridors would provide both structural and functional benefits; however not all corridors provide the benefits for which they are intended. The use of corridors has been brought into question due to the confusion in application and definition. Over the past decades, defining the difference between structural and functional corridors has been the goal of professionals to aid land planning and wildlife conservation.

It is important for planners and designers to understand how to increase the value of connections, and the differences between types of connections. Fischer and Lindenmayer (2007) defined three types of connectivity: habitat, landscape, and ecological.

1. Habitat connectivity joins areas necessary for the persistence of specific species of concern (i.e. breeding, foraging, roosting areas). Depending on the species, the connectivity can occur on a local or landscape scale. Understanding life history requirements of species of concern, such as home range, dispersal distance, and foraging guild, will help planners and designers determine which scale to work at.
2. Landscape connectivity is the spatial connection of native vegetation through a human perspective, and is determined through human defined land cover.

Landscape connectivity may maintain native land cover between patches, but does not always contribute to habitat or ecological connectivity.

3. Ecological connectivity facilitates ecological processes between native remnants. These processes include trophic relationships, hydroecological flows, dispersal mechanisms, and pollination (Tallamy, 2007).

When plans call for corridor creation, the designs are often based on landscape connectivity, which does not require an understanding of population habitat requirements or ecological processes. To make urban conservation actions more successful and cost effective, being able facilitate all three connections should be a goal.

To improve avian diversity in urban areas, natural area connectivity needs to provide resources for species throughout the year and facilitate in the persistence of the native avian communities. Planners and designers should look for linear habitats or small patches that still contain (or could be restored to) quality native habitat. Assessing habitat structure, invasive plant presence, and edge ratio are appropriate local scale variables to determine the quality of connections. Because edge effects can extend hundreds of meters into a patch of any size, connections should have low area to edge ratio. Many corridors such as a hedgerows and windbreaks contain zero percent interior habitat, which is required for many species that are often limited in urban ecosystems. When creating "green" networks, creating/acquiring patches with native habitats will provide more structural diversity and support native plants, as opposed to creating managed park spaces. If possible, linear habitats or small patches should also be within a matrix that contains elements that could enhance those habitats, such as native tree canopy, minimal disturbance, and variable edges.

A number of the studies from the review suggested limiting the gap between patches to 45m (Shanahan et al., 2011; Tremblay, 2009). This threshold should be applied when there is a need to break a natural corridor, or transect a patch with development (e.g. roads, bridges and trails). Varying the edge created by these developments, and allowing for canopy cover will reduce the effect of fragmentation on those connections. Additionally, while a single gap may be manageable for an individual moving along a corridor, the presence of multiple gaps can deter birds from using areas that would otherwise appear to be suitable (Tremblay, 2009). For natural area connections to be successful, structural and functional corridors, as well as small patches need to be created or maintained.

Development Practice

Development practice actions suggested by the relevant literature included development thresholds or best management practices. Specifically, the literature suggested actions that addressed building density thresholds, greenway implementation, reducing human development disturbance, and development intensity adjacent to natural areas. For all actions, the maintenance of existing natural areas or corridors is essential; however when development must occur, it is best to refer to the development practice actions discussed in this section.

The appropriate building density or neighborhood development practice which best conserves ecosystem services and biodiversity is constantly in questions for planners and designers. Conventional thought is that cluster communities or areas of high building density will reduce sprawl and conserve natural areas; however cluster communities were recommended by only two studies (Gagne and Fahrig, 2011; Litteral and Wu, 2012). In general, most of the studies found that a reduction of building density maintained native avian diversity. This does not suggest that we should sprawl into the wilderness and live exclusively in exurban developments. Because even low density development in exurban areas was enough to begin the shift to a more synanthropic avian community. Most of the studies evaluated the effect of development on avian communities in native habitat fragments. Therefore, the building densities and development practices suggested by the studies pertain to natural fragments or open areas of any size. For example, even in highly urbanized areas, reducing development intensity near native patches can increase diversity.

On a landscape scale the studies found that native diversity could be maintained by; keeping housing densities below or between 250-619 houses/square kilometers (km^2) (Tratalos et al., 2007); maintaining 52% urban landcover (Donnelly and Marzluff, 2006); or maintaining less than 25 houses within a 100m of an intact woodlot would (Frisen, 1995). For development adjacent to intact forested habitat, there should be a reduction in impervious surface, smaller house sizes, and a natural buffer should be established (see buffer creation). For development in wetland areas, community piers should be established whenever possible and only low density development should be established within 1500m of a riparian corridors. For estuarine habitats, development should be between 5-14% within 500m, and <25% within 1000m (DeLuca et al., 2004). In areas that contain high quality grassland or savannah habitat, like those found on the Rocky Mountain front, development should remain below 5% (Berry et al., 1998).

When developing greenways and other recreational systems, trails should be placed on the edge of native remnants, because edge effects can extend 100 meters or more into native habitat (Nickens, 2003; Miller et al., 1998). If this type of trail placement is not an option, trails should be narrow, ideally a dirt footpath when possible, and no greater than two meters. Additionally, buffers should be between 300-600m at a minimum. Where greenway vegetation buffers need to be fewer than 300m wide, nodes containing native habitat should be conserved along the greenway (Mason et al., 2007). Managed or landscaped areas, (especially mowed areas adjacent to the trail) should be minimized or avoided if possible. Finally, areas adjacent to greenways should practice low development intensity.

Development practice can improve avian diversity if these actions are combined with the conservation or creation of large native remnants, natural areas connections, and local scale actions. Developers, planners, and designers must apply development practice actions on a local scale, but within the context of the landscape scale. For example, if an individual developer applies low-density development practices within the recommended distance from a shoreline, but a neighboring developer does not, the benefits of that best management practice could be lost.

Buffer Zone Creation

Twenty-six of the relevant studies suggest buffer zone creation and provided width threshold to be applied in practice. Buffers are important in biological conservation and environmental health because they provide a protective area that reduces edge effects, non-native species invasion, and facilitates ecological function (Fisher and

Lindenmayer). One of the most common and recognizable buffer zones is a riparian buffer that extends at varying widths beyond the banks of a stream or river. Riparian vegetated strips can act at as a corridor for birds, but environmentally, they protect aquatic resources by reducing erosion and runoff, providing habitat for aquatic organism, and improving water quality. Other buffer zones include natural buffers that surround protected areas, agricultural buffers on field edges and irrigation canals, and windbreaks in open landscapes. Depending on the landscape, planners and designers should apply buffers to native remnants to reduce the impact of human development on areas that are important for avian diversity and ecosystem services.

The studies in the relevant literature that considered buffers also aimed to determine minimum thresholds to inform planers and designers. In general, buffers of native vegetation should be implemented between human land uses and natural areas. More specifically, heavily used human land uses should maintain a buffer greater than 200m when they are adjacent to native remnants and 100m when those land uses are adjacent to residential areas (Litteral and Wu, 2012; McKinney et al., 2006). Palomino and Carrascal (2007) found that minimum thresholds for development and roads were 400m and 300m, respectively. Forest reserves should extend at least 67m away from roads to support more native avian diversity (Minor and Urban, 2010), and urban land uses between 200m and 1800m of quality native remnants should be limited (Dunford and Freemark, 2005). Low-density development zones around remnants that contain native landscaping can reduce invasion by non-native plants. For riparian areas, the literature recommends maintaining the widest buffer possible, maintaining tree cover within 450m of waterway (Hennings and Edge, 2003), and minimizing development within 1500m (Miller et al., 2003). For shorelines and estuarine habitats, 500m buffers should be maintained (DeLuca et al., 2004) . Greenways should be between 300m and 600m wide with trails less than 2m and no mowed areas (Mason et al., 2007) (see section on development practice).

Buffer zones are a conservation tool that can easily be planned for and applied in urban areas. Legislation in most cities already require a minimum buffer next to waterways; however these recommended buffers are usually too small, especially for avian diversity. As urban areas continue to expand into native remnants it is recommended that; large areas are protected, quality native remnants are prioritized and the largest buffer is applied. When development is inevitable, low-density development, trails, and recreational parks, as opposed to high-density or high use areas, should be designed adjacent to quality native remnants.

Improve Matrix Habitat

The creation and conservation of natural areas or natural area connections should be of the highest priority in urban planning and design. However, the development of the built environment, as well as catering to the needs of human communities, usually takes precedence over the creation of these areas. It is only when natural areas are thought to improve human well-being that they receive full consideration. Consequently, the matrix of the landscape is where planner and designer efforts are focused. In conservation fields, the matrix has often been ignored as land already lost. Recently, studies have measured the effect of land uses within the matrix. These studies have found that the matrix is not a stagnant background, hopeless in its ability to contribute to conservation actions. As described in the previous sections on large area conservation and creation, and natural area connectivity, the interaction between a remnant and adjacent areas is significant. Simply put, the influence of the matrix can either enhance our natural areas or severely degrade them.

The actions from this section focus on the need to improve the interface between remnants and the matrix, and to think of the matrix as a potential extension of native elements. Some of these actions were discussed in the heterogeneous landscape planning section, including the addition of a variety of habitats of varying age and structure. The research also suggested that in forested regions, maintaining canopy cover in the matrix reduces the effects of fragmentation for species that utilize the canopy (Marzluff and Ewing, 2001; Stagoll et al., 2010; Suarez-Rubio and Thomlinson, 2009).

Because of the variety of land uses occurring in the matrix, there is no one size fits all approach to planning and design. Variability in the matrix habitat is largely driven by the decisions of private landowners. In residential areas, a developer may make the final decision regarding the type landscaping across multiple acres, or individual residents may make those decisions within their quarter acre lot. State and city agencies may have a say in how sites are developed through the use of zoning laws and ordinances, but these regulations can change at a municipal boundary. Although, native fragments that are surrounded by an agricultural matrix supported higher diversity (Kennedy et al., 2010), the crop type and management techniques used by a landowner can change drastically at a fence line and affect diversity.

In general, improving the matrix involves finding creative ways to provide managed landscapes that can be used by native bird communities. The combination of many of the previously mentioned actions can be applied to the matrix.

Conclusions

The primary research question for this study is ‘how can design and planning improve avian diversity in urban areas?’ Historically, approaches to biological conservation have been focused on landscape scale approaches, including large area conservation and corridor creation, and have primarily focused on natural areas. Consequently, biological conservation has been practiced more by land managers and less by urban planners and designers. The ecological principles and concepts that land managers use to make conservation decisions are constantly changing due to ongoing research in the fields of landscape ecology, species biology, and conservation ecology. If urban planners and designers wish to address biological conservation in an effective way, it is essential that they consult current research, and incorporate it to their practice. The systematic review used in this study is a way to improve evidence-based practice and establish methods that align with our current understanding of ecological systems.

The results of the literature review give support for the use of systematic literature reviews in design and planning fields. High quality research dominated the relevant literature, and the studies represented a large scope of research. The actions that were determined through the coding process were not novel ideas, but supported methods that are already being applied in certain planning and design practices. The ability of the literature review to include existing relevant actions, expand on their efficacy, or show that they have become irrelevant, is another testimony to the review methodology. Planners and designers should use this methodology to address environmental or landscape management issues raised by their community.

The relevant literature analyzed through the systematic review focused specifically on the loss of avian diversity due to urbanization, and how planners and designers can change their practice to reduce that loss. Therefore, studies related to human-induced mortality by domestic and feral cats, or bird-glass collisions were minimally covered by the relevant literature. These topics are primarily concerned with individual mortality, which is hard to extrapolate to a decline in population. For example, there is evidence that bird-glass collisions annually kill billions of birds worldwide, however there are few studies that record a decline in a species population due to glass collisions. One article measured architectural and landscape risk factors associated with bird-glass collisions (Klem et al., 2009), and recommend reducing the use of sheet glass of any size. However, the study's results did not provide significant suggestions on how to improve diversity. The loss of individuals is not to be ignored, and human-induced mortality should be addressed when possible. More research should be conducted on these topics, and the results should suggest how planners, designers and policymakers can reduce individual bird mortality. Those results could support any effort put towards reducing the loss of habitat, which is still the greatest threat to avian populations.

This study identifies and discusses eight actions that practitioners in design and planning fields can utilize to reduce the negative impacts of habitat loss and urbanization on native bird diversity. The actions discussed in this study can be applied on multiple scales, and can be used in combination with each other. They can also be as simple as using native plants on local sites. It is imperative for designers and planners to understand why these actions work and apply them appropriately. Through this understanding they can reduce the impact of new developments on native bird populations. The appropriate application of the actions can also improve more than bird populations. The conservation and creation of native habitats provides more opportunity for local residents to experience “nature”, improving their health and well-being. Ecosystem services, such as air purification and pollination would also improve with the addition of habitat and restoration of native avian diversity.

In conclusion, this study has highlighted that landscape architects and planners should be aware of current ecological research and that the role of ecology is essential to sustain and improve our natural and human communities. Furthermore, it has also provided a platform to facilitate the way ecological research informs evidence-based practice, and through example has provided actions to conserve avian diversity.

LITERATURE CITED

Ahern J. (2005) Integration of landscape ecology and landscape architecture: an evolutionary and reciprocal process. Issues & Perspectives in Landscape Ecology:307.

Andersson E., Barthel S., Ahrne K. (2007) Measuring Social-Ecological Dynamics behind the Generation of Ecosystem Services. Ecological Applications 17:1267 1278.

Askins R. (2000) Restoring North America's birds: lessons from landscape ecology; illustrations by Julie Zickefoose New Haven: Yale University Press

Barmuta L.A.L.S.E. (2011) Bridging the gap between 'planning' and 'doing' for biodiversity conservation in freshwaters. Freshwater Biology 56:180-195.

Beissinger, S.R., Osborne, D.R., (1982) Effects of urbanization on avian community organization. Condor 84, 75-83.

Berry M.E., Bock C.E., Haire S.L. (1998) Abundance of Diurnal Raptors on Open Space Grasslands in an Urbanized Landscape. The Condor 100:601-608.

Blewett C.M., and Marzluff J.M. (2005) Effects of urban sprawl on snags and the abundance and productivity of cavity-nesting birds. Condor 107:678-693.

Brown R.D. and Corry R.C. (2011) Evidence-based landscape architecture: The maturing of a profession. Landscape and Urban Planning 100:327-329.

Brown, R.M. and D.N. Laband. (2006) Species imperilment and spatial patterns of development in the United States. Conservation Biology 20:239–244.

Burke D.M. and Nol E. (2000) Landscape and Fragment Size Effects on Reproductive Success of Forest-Breeding Birds in Ontario. Ecological Applications 10:1749 1761.

Byrne L.B. (2007) Habitat structure: A fundamental concept and framework for urban soil ecology. Urban Ecosystems 10:255-274.

Calnpbell M.O.N. (2008) The Impact of Vegetation, River, and Urban Features on Waterbird Ecology in Glasgow, Scotland. Journal of Coastal Research 24:239 245.

Cardinale B.J. (2011) Biodiversity improves water quality through niche partitioning. Nature 472:86-89.

Carlson C.E. (2006) The relationship between breeding bird community structure in urban forest patches and the human-mediated resources in the surrounding residential matrix. University of Georgia, Thesis.

Carson R. (1963) Silent Spring Hamish Hamilton, London.

Centre for Evidence-Based Conservation (CEBC). 2010. Guidelines for Systematic Review in Environmental Management. Version 4.0. Environmental Evidence: www.environmentalevidence.org/Authors.htm

Chapin III F.S., Zavaleta E.S., Eviner V.T., Naylor R.L., Vitousek P.M., Reynolds H.L., Hooper D.U., Lavorel S., Sala O.E., Hobbie S.E., Mack M.C., Diaz S. (2000) Consequences of changing biodiversity. Nature 405:234.

Chetkiewicz C.-L.B., St. Clair C.C., Boyce M.S. (2006) Corridors for Conservation: Integrating Pattern and Process. Annual Review of Ecology, Evolution & Systematics 37:317-342.

Clausen J.C. (2007) Jordan Cover Watershed Project Final Report, University of Connecticut, Storrs, CT.

Clergeau, P., Savard, J.P.L., Mennechez, G., & Falardeau, G. (1998) Bird Abundance and Diversity along an Urban-Rural Gradient: A Comparative Study between Two Cities on Different Continents. Condor, 100(3), 413-425.

Connell, J.H. (1978) Diversity in tropical rain forests and coral reefs. Science 199:1302-1310.

Caula S., Marty P., and Martin J.L. (2008) Seasonal variation in species composition of an urban bird community in Mediterranean France. Landscape and Urban Planning 87:1-9.

Daniels G.D., Kirkpatrick J.B. (2006) Does variation in garden characteristics influence the conservation of birds in suburbia? Biological Conservation 133:326-335.

DeLuca W.V., Studds C.E., King R.S., Marra P.P. (2008) Coastal urbanization and the integrity of estuarine waterbird communities: Threshold responses and the importance of scale. Biological Conservation 141:2669-2678.

Dramstad W.E., Olson J.D., Forman R.T.T. (1996) Landscape ecology principles in landscape architecture and land-use planning. Harvard University Graduate School of Design, Washington, D.C. Island Press

Donnelly R., Marzluff J.M. (2006) Relative importance of habitat quantity, structure, and spatial pattern to birds in urbanizing environments. Urban Ecosystems 9:99-117.

Dunford W., Freemark K. (2005) Matrix matters: Effects of surrounding land uses on forest birds near Ottawa, Canada. Landscape Ecology 20:497-511.

Emlen, J.T., (1974) Urban bird community in Tucson, Arizona - derivation, structure, regulation. Condor 76, 184-197.

Felson A.J., Pickett S.T. (2005) Designed Experiments: New Approaches to Studying Urban Ecosystems. Frontiers in Ecology and the Environment 3:549-556.

Fischer J., Lindenmayer D.B. (2007) Landscape modification and habitat fragmentation: a synthesis. Global Ecology & Biogeography 16:265-280.

Fontana S., Sattler T., Bontadina F., Moretti M. (2011) How to manage the urban green to improve bird diversity and community structure. Landscape & Urban Planning 101:278-285.

Forman R.T.T., Reineking B., Hersperger A.M. (2002) Road Traffic and Nearby Grassland Bird Patterns in a Suburbanizing Landscape. Environmental Management 29:782-800.

Friesen L.E. (1995) Effects of residential development of forest-dwelling neotropical migrant songbirds. Conservation Biology 9:1408-1414.

Fuller R.A., Warren P.H., Armsworth P.R., Barbosa O., Gaston K.J. (2008) Garden bird feeding predicts the structure of urban avian assemblages. Diversity and Distributions 14:131-137.

Gagne S.A., Fahrig L. (2011) Do birds and beetles show similar responses to urbanization? Ecological Applications 21:2297-2312.

Gaston, K. J. (2005) Biodiversity and extinction: species and people. Progress in Physical Geography 29:239–247.

Germaine S.S., Rosenstock S.S., Schweinsburg R.E., Richardson W.S. (1998) Relationships among Breeding Birds, Habitat, and Residential Development in Greater Tucson, Arizona. Ecological Applications 8:680-691.

Glaser, B.G. and Strauss, A.L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. Chicago: Aldine Pub. Co.

Goldstein, M. I., Lacher, T. r., Woodbridge, B. B., Bechard, M. J., Canavelli, S. B., Zaccagnini, M. E., and Hooper, M. J. (1999). Monocrotophos-induced mass mortality of Swainson's hawks in Argentina, 1995-96. Ecotoxicology, 8(3), 201 214.

Glaser, B.G. and Strauss, A.L. (1967). The Discovery of Grounded Theory: Strategies for Qualitative Research. Chicago: Aldine Pub. Co.

Gonzalez, A., (2000) Community relaxation in fragmented landscapes: The relation between species richness, area and age. Ecology Letters 3, 441 448.

Grimm N.B., Grove J.M., Pickett S.T., Redman C.C. (2000) Integrated approaches to long-term studies of urban ecological systems.

Hanski I. (1994) Patch-occupancy dynamics in fragmented landscapes. Trends in Ecology & Evolution 9:131-135.

Hayes, J.L. Lundquist, J.E., comps. (2009). The Western Bark Beetle Research Group: a unique collaboration with Forest Health Protection—proceedings of a symposium at the 2007 Society of American Foresters conference. Gen. Tech. Rep. PNW-GTR-784. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 134 p.

Hennings L.A., Edge W.D. (2003) Riparian bird community structure in Portland, Oregon: Habitat, urbanization, and spatial scale patterns. Condor 105:288-302.

Hickey, J.J. and Anderson. D.W. (1968) Chlorinated hydrocarbons and eggshell changes in raptorial and fish-eating birds. Science 162:271-273.

Howett C. (1998) Ecological Values in Twentieth-Century Landscapes Design: A History and Hermenuties. Landscape Journal 17:80-98.

Huste A., Boulinier T. (2007) Determinants of local extinction and turnover rates in urban bird communities. Ecological Applications 17:168-180

Ignatieva M. and Stewart G.H. (2009) Homogeneity of urban biotopes and similarity of landscape design language in former colonial cities, in: M. J. McDonnell, A.K. Hahs and J.H. Brueste (Ed.), Ecology of cities and towns: A comparative approach, Cambridge University Press. pp. 399-421.

Jackson L.E. (2003) The relationship of urban design to human health and condition. Landscape and Urban Planning 64:191-200.

Jokimaki J. and Kaisanlahti-Jokimaki M.L. (2003) Spatial similarity of urban bird communities: a multiscale approach. Journal of Biogeography 30:1183-1194.

Jones Z.F., Bock C.E. (2002) Conservation of grassland birds in an urbanizing landscape: A historical perspective. Condor 104:643-651.

Kalinowski R.S., Johnson M.D. (2010) Influence of Suburban Habitat on A Wintering Bird Community in Coastal Northern California The Condor 112:274-282.

Karson, Robin, prod. (2012) Designing in the Prairie Spirit: A conversation with Darrel Morrison. Library of American Landscape History. 21 May 2013 <http://www.florentinefilms.org/DesigningInThePrairieSpirit-id-101.html>.

Kennedy C.M., Marra P.P., Fagan W.F., Neel M.C. (2010) Landscape matrix and species traits mediate responses of Neotropical resident birds to forest fragmentation in Jamaica. Ecological Monographs 80:651-669.

Klem Jr D., Farmer C.J., Delacretaz N., Gelb Y., Saenger P.G. (2009) Architectural and landscape risk factors associated with bird-glass collisions in an urban environment. Wilson Journal of Ornithology 121:126-134.

Lawton, J.H. and May, R.M. (eds) (1995) Extinction Rates. Oxford University Press, Oxford

Lee J., Kwak I.S., Lee E., Kim K.A. (2007a) Classification of breeding bird communities along an urbanization gradient using an unsupervised artificial neural network. Ecological Modeling 203:62-71.

Lee, J.C., Haack, R.A., Negrón, J.F., Witcosky, J.J., Seybold, S.J. (2007b) Invasive bark beetles, Forest Insect & Disease Leaflet 176. Washington DC: U.S. Department of Agriculture, Forest Service.

Lepczyk C.A., Flather C.H., Radeloff V.C., Pidgeon A.M., Hammer R.B., Liu J. (2008) Human Impacts on Regional Avian Diversity and Abundance. Conservation Biology 22:405-416.

Leopold A. (1949) A Sand County almanac, and Sketches here and there / illustrated by Charles W. Schwartz, New York : Oxford University Press, 1949.

Lerman S.B., Warren P.S. (2011) The conservation value of residential yards: linking birds and people. Ecological Applications 21:1327-1339.

Litteral J., Wu J. (2012) Urban landscape matrix affects avian diversity in remnant vegetation fragments: Evidence from the Phoenix metropolitan region, USA. Urban Ecosystems 15:939-959.

Lorenzetti E., Battisti C. (2007) Nature reserve selection on forest fragments in a suburban landscape (Rome, central Italy): Indications from a set of avian species. Landscape Research 32:57-78.

Lovell S.T., Johnston D.M. (2009) Designing Landscapes for Performance Based on Emerging Principles in Landscape Ecology. Ecology & Society 14:1-24.

Luck G.W., Davidson P., Boxall D., Smallbone L. (2011) Relations between urban bird and plant communities and human well-being and connection to nature. Conservation Biology: The Journal Of The Society For Conservation Biology 25:816-826.

MacArthur R.H., Wilson E.O. (1967) The theory of island biogeography [by] Robert H. MacArthur and Edward O. Wilson Princeton, N.J., Princeton University Press, 1967.

Marsh G.P. (1864) Man and Nature or Physical Geography as Modified by Human Action. Charles Scribner, New York.

Marzluff J.M., Bowman R., Donnelly R. (2001) Avian ecology and conservation in an urbanizing world / edited by John Marzluff, Reed Bowman, Roarke Donnelly Boston : Kluwer Academic Publishers, 2001.

Marzluff J.M., Ewing K. (2001) Restoration of fragmented landscapes for the conservation of birds: A general framework and specific recommendations for urbanizing landscapes. Restoration Ecology 9:280-292.

Mason J., Moorman C., Hess G., Sinclair K. (2007) Designing suburban greenways to provide habitat for forest-breeding birds. Landscape and Urban Planning 80:153-164.

McCaffrey R.E. and Mannan R.W. (2012) How scale influences birds' responses to habitat features in urban residential areas. Landscape and Urban Planning 105:274-280

McHarg I. (1969) Design with Nature. Natural History Press, Garden City, NY.

McKinney R.A., McWilliams S.R., Charpentier M.A. (2006) Waterfowl-habitat associations during winter in an urban North Atlantic estuary. Biological Conservation 132:239-249.

Melles S., Glenn S., Martin K. (2003) Urban Bird Diversity and Landscape Complexity: Species--environment Associations Along a Multiscale Habitat Gradient. Conservation Ecology 7(1):5

Merola-Zwartjes M., DeLong J.P. (2005) Avian species assemblages on New Mexico golf courses: surrogate riparian habitat for birds? Wildlife Society Bulletin 33:435-447.

Miller S.G., Knight R.L., Clinton K.M. (1998) Influence of Recreational Trails on Breeding Bird Communities. Ecological Applications 8:162-169.

Miller J.R., Wiens J.A., Hobbs N.T., Theobald D.M., Thompson-Hobbs N. (2003) Effects of human settlement on bird communities in lowland riparian areas of Colorado (USA). Ecological Applications 13:1041-1059.

Miller J.R., Groom M., Hess G.R., Steelman T., Stokes D.L., Thompson J., Bowman T., Fricke L., King B., Marquardt R. (2009) Biodiversity Conservation in Local Planning. Conservation Biology 23:53-63.

Milliken A.C.W., and C. Hayes. (2005) Bird Habitat Conservation at Various Scales in the Atlantic Coast Joint Venture. pp. 231-235.

Minor E., Urban D. (2010) Forest bird communities across a gradient of urban development. Urban Ecosystems 13:51-71.

Moorcroft P.R. (2009) Chapter IV.4: Biodiversity Patterns in Managed and Natural Landscapes, Princeton University Press. pp. 445-457.

Nassauer J.I. (2012) Perspective Essay: Landscape as medium and method for synthesis in urban ecological design. Landscape and Urban Planning 106:221-229.

Newton, I., & Brockie, K. (2003). The speciation and biogeography of birds; illustrations by Keith Brockie. Amsterdam ; Boston : Academic Press.

Nickens T.E. (2003) Living on the Edges. Audubon 105:80.

Niemiera, A.X. and B. Von Holle. (2007) Invasive Plants – A Horticultural Perspective. Virginia Cooperative Extension, publication 426-080. Virginia Polytechnic Institute and State University, Blacksburg, VA. 6pp

Olmsted F.L. (1914) The Town-Planning Movement in America. Annals Of The American Academy Of Political And Social Science:172.

Olson, D., E. Dinerstein, E. Wikramanayake, N. Burgess, G. Powell, E. Underwood, J. D'amico, I. Itoua, H. Strand, J. Morrison, C. Loucks, T. Allnutt, T. Ricketts, Y. Kura, J. Lamoreux, W. Wettengel, P. Hedao, and K. Kassem. (2001) Terrestrial ecoregions of the world – A new map of life on Earth. Bioscience 51 (11): 933-938.

Omernik, J.M. (1987) Ecoregions of the conterminous United States. Annals of the Association of American Geographers 77(1):118-125.

Palomino D., Carrascal L.M. (2007) Threshold distances to nearby cities and roads influence the bird community of a mosaic landscape. Biological Conservation 140:100-109

Posa M.R.C., Sodhi N.S. (2006) Effects of anthropogenic land use on forest birds and butterflies in Subic Bay, Philippines. Biological Conservation 129:256-270.

Reidy J.L., Thompson III R.R., Peak R.G. (2009) Factors Affecting Golden-Cheeked Warbler Nest Survival in Urban and Rural Landscapes. Journal of Wildlife Management 73:407-413.

Rich, T. D., C. J. Beardmore, H. Berlanga, P. J. Blancher, M. S. W. Bradstreet, G. S. Butcher, D. W. Demarest, E. H. Dunn, W. C. Hunter, E. E. Iñigo-Elias, J. A. Kennedy, A. M. Martell, A. O. Panjabi, D. N. Pashley, K. V. Rosenberg, C. M. Rustay, J. S. Wendt, T. C. Will. (2004) Partners in Flight North American Landbird Conservation Plan. Cornell Lab of Ornithology. Ithaca, NY.

Rapport, D. J., H. A. Regier, and T. C. Hutchinson. (1985) Ecosystem behavior under stress. The American Naturalist 125:617–640.

Ratcliffe, D.A. (1967) Decrease in eggshell weight in certain birds of prey. Nature 215:208-210.

Rogers E.B. (2001) Landscape design: a cultural and architectural history. Harry N. Abrams, New York.

Rosenberg. D. K. Noon, B. R. and Meslow. E. C. (1997) Biological corridors: form, function and efficacy. Bio-science 47: 677 687.

Shanahan D.F., Miller C., Possingham H.P., Fuller R.A. (2011) The influence of patch area and connectivity on avian communities in urban revegetation. Biological Conservation 144:722-729.

Shwartz A., Shirley S., and Kark S. (2008) How do habitat variability and management regime shape the spatial heterogeneity of birds within a large Mediterranean urban park? Landscape and Urban Planning 84:219-229.

Smith P.G.R. (2007) Characteristics of urban natural areas influencing winter bird use in southern Ontario, Canada. Environmental Management 39:338-352.

SoulÉ M.E., Bolger D.T., Alberts A.C., Wright J., SorlCe M., Hill S. (1988) Reconstructed Dynamics of Rapid Extinctions of Chaparral-Requiring Birds in Urban Habitat Islands. Conservation Biology 2:75-92.

Sprin A.W. (1997) The Authority of Nature: Conflict and Confusion in Landscape Architecture, in: J. Wolschke-Bulmahn (Ed.), Nature and ideology : natural garden design in the twentieth century Dumbarton Oaks Research Library and Collection, Washington, D

Stagoll K., Manning A.D., Knight E., Fischer J., Lindenmayer D.B. (2010) Using bird-habitat relationships to inform urban planning. Landscape and Urban Planning 98:13-25.

Stokes D.L., Hanson M.F., Oaks D.D., Straub J.E., Ponio A.V. (2010) Local Land-Use Planning to Conserve Biodiversity: Planners,Äô Perspectives on What Works. Conservation Biology 24:450-460.

Suarez-Rubio M., Thomlinson J.R. (2009) Landscape and patch-level factors influence bird communities in an urbanized tropical island. Biological Conservation 142:1311-1321.

Sustainable Sites Initiative (SIS). (2009) The Sustainable Sites Initiative: Guidelines and Performance Benchmarks 2009. Available at http://www.sustainablesites.org/report.

Sutherland W.J., Pullin A.S., Dolman P.M., Knight T.M. (2004) The need for evidence based conservation. Trends in Ecology & Evolution 19:305-308.

Tallamy D.W. (2007) Bringing nature home : how native plants sustain wildlife in our Gardens. Portland, OR. Timber Press.

Tratalos J., Fuller R.A., Evans K.L., Davies R.G., Newson S.E., Greenwood J.J.D., Gaston K.J. (2007) Bird densities are associated with household densities. Global Change Biology 13:1685-1695.

Tremblay M.A., St. Clair C.C. (2009) Factors affecting the permeability of transportation and riparian corridors to the movements of songbirds in an urban landscape. Journal of Applied Ecology 46:1314-1322.

Trombulak, S.C. and Baldwin, R.F. (2010) Landscape-scale Conservation Planning. New York, New York. Springer

Turner W.R. (2003) Citywide biological monitoring as a tool for ecology and conservation in urban landscapes: the case of the Tucson Bird Count. Landscape and Urban Planning 65:149-166.

United Nations (2001) World Population Prospects, the 2010 Revision. Web. 06 Mar.2012.<http://esa.un.org/unpd/wpp/Documentation/publications.htm>.

United Nations (2011) Urban Population, Development and the Environment 2011 Wall Chart. UN News Center. UN, Oct. 2011. Web. 06 Mar. 2012. <http://www.un.org/esa/population/publications/2011UrbanPopDevEnv_Chart/ubanpopdevenv2011wallchart.html>.

Urbanova T. (2009) How to Support Avian Diversity in an Urban Landscape: A Bibliography. Journal of Planning Literature 24:123-136.

Van der Ryn S., Cowan S. (1996) Ecological design. Island Press, Washington,

Walz U. (2011) Landscape Structure, Landscape Metrics and Biodiversity. Living Reviews in Landscape Research 5:1-35.

Wilcove D.S. (1985) Nest Predation in Forest Tracts and the Decline of Migratory Songbirds. Ecology 66:1211-1214.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips, and E. Losos. (1998) Quantifying threats to imperiled species in the United States. Bio- Science 48:607–615

Wu, J. (2008) Landscape ecology. In: S. E. Jorgensen (ed), Encyclopedia of Ecology. Elsevier, Oxford.

APPENDICES

Appendix A. Search String Scoping

Search Category	Search Terms
Urban Terms	urban, urbanized, city, metropolitan, exurban, suburban
Avian Terms	bird, birds, avian, avifauna,
Ecological Terms	diversity, richness, composition, ecology
Design/Planning Terms	ecological design, conservation planning, green design, open space planning, design, planning, best management practices

Search #	Search String	Number of Hits (Web of Science)	Change from Previous
1	Topic=Urban* AND Avian AND Diversity AND (Ecolog* Design OR Conservation Plan*)	37	none
2	Topic=(Urban*or City) AND Avian AND Diversity AND (Ecolog* Design OR Conservation Plan*)	37	Added City as Urban Synonym

3	Topic=(Urban*or City) AND (Avian or bird*) AND Diversity AND (Ecolog* Design OR Conservation Plan*)	137	added bird* as avian synonym
4	Topic=(Urban*or City) AND (Avian or bird*) AND Diversity AND ("Ecological Design" OR "Conservation Planning")	11	added parenthesis to ecological design and conservation planning to specify phrases
5	Topic=(Urban*or City) AND (Avian or bird*) AND Diversity AND ("Ecological Design" OR "Conservation Planning")	15	Added richness to metric option
6	Topic=(Urban*or City) AND (Avian or bird*) AND ("Ecological Design”)	1	Took out Metric and conservation planning phrase
7	Topic=(Urban*or City) AND (Avian or bird*) AND ("Conservation Planning”)	28	Changed Ecological Design for Conservation Planning
8	Topic=(Urban*or City) AND (Avian or bird*) AND (Design OR Planning)	330	Changed conservation planning phrase to broad (design or planning)
9	Topic=(Urban*or City) AND (Avian or bird*) AND (Diversity OR Richness) AND (Design OR Planning)	140	Added Metrics back to search

10	Topic=(Urban*or City OR Exurban OR Suburban) AND (Avian or bird*) AND (Diversity OR Richness) AND (Design OR Planning)	143	Added more Urban Synonyms
11	Topic=(Urban*or City OR Exurban OR Suburban OR Develop*) AND (Avian or bird*) AND (Diversity OR Richness) AND (Design OR Planning)	377	Added develop* as final urban synonym
12	Topic=(Urban*or City OR Exurban OR Suburban OR Develop*) AND (Avian or bird*) NOT Influenza AND (Diversity OR Richness) AND (Design OR Planning)	367	Added NOT influenza
13	Topic=(Urban*or City OR Exurban OR Suburban OR Develop*) AND (Avian or bird*) NOT Influenza AND (Diversity OR Richness) AND (Design OR Plann*)	309	Added wildcard asterisk to Planning
14	Topic=(Urban*or City OR Exurban OR Suburban) AND (Avian or bird*) NOT Influenza AND (Diversity OR Richness) AND (Design OR Plann*)	134	Removed Develop*
15	Topic=(Urban*or City OR Exurban OR Suburban) AND (Avian or bird*) NOT Influenza AND (Diversity OR Richness) NEAR/2 Avian AND (Design OR Plann*)	22	Added NEAR Operator to Diversity or Richness
16	Topic=(Urban*or City OR Exurban OR Suburban) AND (Avian or bird*) NOT Influenza AND (Diversity OR Richness) NEAR/2 (Avian OR Bird*) AND (Design OR Plann*)	75	Adjusted NEAR Operator Phrase

17	Topic=(Urban*or City OR Exurban OR Suburban OR Metropolitan) AND (Avian or bird*) AND (Diversity OR Richness) AND (Design OR Plann*)	125	simplified metric and bird syntax, added metropolitan to urban synonyms
18	Topic=(Urban*or City OR Exurban OR Suburban OR Metropolitan) AND (Avian OR bird*OR avifauna) AND (Diversity OR Richness OR composition) AND (*design OR Plann* OR "ecological design" OR "Conservation Planning" Or "Open space Planning")	143	added all original terms
19	Topic=(Urban*or City OR Exurban OR Suburban OR Metropolitan) AND (Avian OR bird*OR avifauna) AND (Diversity OR Richness OR composition) AND (Design OR Plann* OR "ecological design" OR "Conservation Planning" Or "Open space Planning")	152	remove * on design
20	Topic=(urban OR urbanized OR city OR metropolitan OR exurban OR suburban) AND Topic=(bird* OR avian OR avifauna) AND Topic=(diversity OR richness OR composition OR ecology OR "ecological research") AND Topic=("ecological design" OR conservation OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices")	395	added ecology terms t to include ecological research of urban bird populations
21	Topic=(urban OR urbanized OR city OR metropolitan OR exurban OR suburban) AND Topic=(bird* OR avian OR avifauna) AND Topic=(diversity OR richness OR composition OR ecology OR "ecological research") AND Topic=("ecological design" OR design OR planning OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices")	184	removed conservation term and added design and planning as general broad term

22	Topic=(urban OR urbanized OR city OR metropolitan OR exurban OR suburban) AND Topic=(bird* OR avian OR avifauna) AND Topic=(diversity OR richness OR composition OR ecology OR "ecological research") AND Topic=("ecological design" OR conservation OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices")	201	Revised 20 again, by adding NOT bird
23	Topic=(urbanization OR city OR metropolitan OR exurban OR suburban) AND Topic=(bird* OR avian OR avifauna) AND Topic=(diversity OR richness OR composition OR ecology OR "ecological research") AND Topic=("ecological design" OR conservation OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices")	287	removed urban to eliminate broad articles and changed urbanized to urbanization
24	TS=(urbanization OR city OR metropolitan OR exurban OR suburban) AND TS=(avian diversity OR avian richness OR bird diversity OR bird richness OR avifauna OR avian ecology) AND TS=("ecological design" OR conservation OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices" OR land use)	309	combined avian and ecology terms and added land use to planning and design terms
25	TS=(urbanization OR city OR metropolitan OR exurban OR suburban) AND TS=(avian diversity OR avian richness OR bird diversity OR bird richness OR avifauna OR avian ecology) AND TS=("ecological design" OR conservation OR "conservation planning" OR "green design" OR "open space planning" OR "best management practices" OR urban land use)	292	added urban to land use

Appendix B. Result of systematic review and relevant literature used in data synthesis and analysis.

Andersson E., Barthel S., Ahrne K. (2007) Measuring Social-Ecological Dynamics behind the Generation of Ecosystem Services. Ecological Applications 17:1267-1278. 2.

Antos M.J., Fitzsimons J.A., Palmer G.C., White J.G. (2006) Introduced birds in urban remnant vegetation: Does remnant size really matter? Austral Ecology 31:254-261.

Askins R.A., Philbrick M.J. (1987) Effect of Changes in Regional Forest Abundance on the Decline and Recovery of a Forest Bird Community. The Wilson Bulletin 99:7-21.

Austen M.J.W., Francis C.M., Burke D.M., Bradstreet M.S.W. (2001) Landscape Context and Fragmentation Effects on Forest Birds in Southern Ontario. The Condor 103:701-714.

Banning A.E., Bowman J.L., Vasilas B.L. (2009) Effects of Long Piers on Birds in Tidal Wetlands. Journal of Wildlife Management 73:1362-1367.

Berry M.E., Bock C.E., Haire S.L. (1998) Abundance of Diurnal Raptors on Open Space Grasslands in an Urbanized Landscape. The Condor 100:601-608.

Blair R. (2004) The effects of urban sprawl on birds at multiple levels of biological organization. Ecology and Society 9:21.

Blair R.B. (1996) Land use and avian species diversity along an urban gradient. Ecological Applications 6:506-519.

Blair R.B., Johnson E.M. (2008) Suburban habitats and their role for birds in the urban-rural habitat network: points of local invasion and extinction? Landscape Ecology 23:1157-1169.

Blewett C.M., Marzluff J.M. (2005) Effects of urban sprawl on snags and the abundance and productivity of cavity-nesting birds. Condor 107:678-693.

Bock C.E., Jones Z.F., Bock J.H. (2008) The oasis effect: Response of birds to exurban development in a southwestern savanna. Ecological Applications 18:1093-1106.

Borgmann K.L., Rodewald A.D. (2004) Nest Predation in an Urbanizing Landscape: The Role of Exotic Shrubs. Ecological Applications 14:1757-1765.

Burghardt K.T., Tallamy D.W., Gregory Shriver W. (2009) Impact of Native Plants on Bird and Butterfly Biodiversity in Suburban Landscapes. Conservation Biology 23:219-224.

Burke D.M., Nol E. (2000) Landscape and Fragment Size Effects on Reproductive Success of Forest-Breeding Birds in Ontario. Ecological Applications 10:1749-1761.

Butcher G.S., Niering W.A., Barry W.J., Goodwin R.H. (1981) Equilibrium Biogeography and the Size of Nature Preserves: An Avian Case Study. Oecologia 49:29-37.

Calnpbell M.O.N. (2008) The Impact of Vegetation, River, and Urban Features on Waterbird Ecology in Glasgow, Scotland. Journal of Coastal Research 24:239-245.

Catterall C.P., Cousin J.A., Piper S., Johnson G. (2010) Long-term dynamics of bird diversity in forest and suburb: decay, turnover or homogenization? Diversity and Distributions 16:559-570.

Caula S., Hvenegaard G.T., Marty P. (2009) The influence of bird information, attitudes, and demographics on public preferences toward urban green spaces: The case of Montpellier, France. Urban Forestry & Urban Greening 8:117-128.

Caula S., Marty P., Martin J.L. (2008) Seasonal variation in species composition of an urban bird community in Mediterranean France. Landscape and Urban Planning 87:1-9.

Caula S.A., Sirami C., Marty P., Martin J.-L. (2010) Value of an urban habitat for the native Mediterranean avifauna. Urban Ecosystems 13:73-89.

Chamberlain D.E., Gough S., Vaughan H., Vickery J.A., Appleton G.F. (2007) Determinants of bird species richness in public green spaces. Bird Study 54:87-97.

Chapman K.A., Reich P.B. (2007) Land use and habitat gradients determine bird community diversity and abundance in suburban, rural and reserve landscapes of Minnesota, USA. Biological Conservation 135:527-541.

Chari K.B., Abbasi S.A., Ganapathy S. (2003) Urbanization and the more-individuals hypothesis. Aquatic Conservation-Marine and Freshwater Ecosystems 13:373-386.

Chiron F., Julliard R. (2007) Responses of Songbirds to Magpie Reduction in an Urban Habitat. Journal of Wildlife Management 71:2624-2631.

Clergeau P., Savard J.-P.L., Mennechez G., Falardeau G. (1998) Bird Abundance and Diversity along an Urban-Rural Gradient: A Comparative Study between Two Cities on Different Continents. The Condor 100:413-425.

Cooper D.S. (2002) Geographic associations of breeding bird distribution in an urban open space. Biological Conservation 104:205.

Croci S., Butet A., Georges A., Aguejdad R., Clergeau P. (2008) Small urban woodlands as biodiversity conservation hot-spot: a multi-taxon approach. Landscape Ecology 23:1171-1186.

Crooks K.R., Suarez A.V., Bolger D.T. (2004) Avian assemblages along a gradient of urbanization in a highly fragmented landscape. Biological Conservation 115:451.

Dallimer M., Rouquette J.R., Skinner A.M.J., Armsworth P.R., Maltby L.M., Warren P.H., Gaston K.J. (2012) Contrasting patterns in species richness of birds, butterflies and plants along riparian corridors in an urban landscape. Diversity and Distributions 18:742-753.

Daniels G.D., Kirkpatrick J.B. (2006) Does variation in garden characteristics influence the conservation of birds in suburbia? Biological Conservation 133:326-335.

DeLuca W.V., Studds C.E., King R.S., Marra P.P. (2008) Coastal urbanization and the integrity of estuarine waterbird communities: Threshold responses and the importance of scale. Biological Conservation 141:2669-2678.

DeLuca W.V., Studds C.E., Rockwood L.L., Marra P.P. (2004) Influence of land use on the integrity of marsh bird communities of Chesapeake Bay, USA. Wetlands 24:837-847.

Donnelly R., Marzluff J.M. (2004) Importance of reserve size and landscape context to urban bird conservation. Conservation Biology 18:733-745.

Donnelly R., Marzluff J.M. (2006) Relative importance of habitat quantity, structure, and spatial pattern to birds in urbanizing environments. Urban Ecosystems 9:99-117.

Dowd C. (1992) Effect of Development on Bird Species Composition of Two Urban Forested Wetlands in Staten Island, New York. Journal of Field Ornithology 63:455-461.

Duffield J.M. (1986) Waterbird Use of a Urban Stormwater Wetland System in Central California, USA. Colonial Waterbirds 9:227-235.

Dunford W., Freemark K. (2005) Matrix matters: Effects of surrounding land uses on forest birds near Ottawa, Canada. Landscape Ecology 20:497-511.

Fernandez-Juricic E. (2000) Local and regional effects of pedestrians on forest birds in a fragmented landscape. Condor 102:247-255.

Fernandez-Juricic E. (2004) Spatial and temporal analysis of the distribution of forest specialists in an urban-fragmented landscape (Madrid, Spain) - Implications for local and regional bird conservation. Landscape and Urban Planning 69:17-32.

Fernández-Juricic E. (2000) Avifaunal Use of Wooded Streets in an Urban Landscape. Conservation Biology 14:513-521.

Filippi-Codaccioni O., Clobert J., Julliard R. (2009) Urbanisation effects on the functional diversity of avian agricultural communities. Acta Oecologica-International Journal of Ecology 35:705-710.

Filippi-Codaccioni O., Devictor V., Clobert J., Julliard R. (2008) Effects of age and intensity of urbanization on farmland bird communities. Biological Conservation 141:2698-2707.

Fokidis H.B. (2011) Homeowners associations: Friend or foe to native desert avifauna? Conservation concerns and opportunities for research. Journal of Arid Environments 75:394-396.

Fontana C., Burger M., Magnusson W. (2011a) Bird diversity in a subtropical South-American City: effects of noise levels, arborisation and human population density. Urban Ecosystems 14:341-360.

Fontana S., Sattler T., Bontadina F., Moretti M. (2011b) How to manage the urban green to improve bird diversity and community structure. Landscape and Urban Planning 101:278-285.

Forman R.T.T., Reineking B., Hersperger A.M. (2002) Road Traffic and Nearby Grassland Bird Patterns in a Suburbanizing Landscape. Environmental Management 29:782-800.

Fox S.-J.C., Hockey P.A.R. (2007) Impacts of a South African coastal golf estate on shrubland bird communities. South African Journal of Science 103:27-35.

Francl K.E., Schnell G.D. (2002) Relationships of Human Disturbance, Bird Communities, and Plant Communities Along the Land-Water Interface of a Large Reservoir. Environmental Monitoring & Assessment 73:67-93.

Friesen L.E. (1995) Effects of residential development of forest-dwelling neotropoical migrant songbirds. Conservation Biology 9:1408-1414.

Fuller R.A., Warren P.H., Armsworth P.R., Barbosa O., Gaston K.J. (2008) Garden bird feeding predicts the structure of urban avian assemblages. Diversity and Distributions 14:131-137.

Gagne S.A., Fahrig L. (2010) The trade-off between housing density and sprawl area: Minimising impacts to forest breeding birds. Basic and Applied Ecology 11:723-733.

Gagne S.A., Fahrig L. (2011) Do birds and beetles show similar responses to urbanization? Ecological Applications 21:2297-2312.

Gavareski C.A. (1976) Relation of Park Size and Vegetation to Urban Bird Populations in Seattle, Washington. The Condor 78:375-382.

Germaine S.S., Rosenstock S.S., Schweinsburg R.E., Richardson W.S. (1998) Relationships among breeding birds, habitat, and residential development in Greater Tucson, Arizona. Ecological Applications 8:680-691.

Grover D.R., Slater P.J. (1994) Conservation value to birds of remnants of mekakeuca forest in suburban Brisbane. Wildlife Research 21:433-444.

Hale B., Steen-Adams M.M., Predick K., Fisher N. (2005) Ecological Conservation Through Aesthetic Landscape Planning: A Case Study of the Lower Wisconsin State Riverway. Environmental Management 35:381-395.

Harris J., Nix H., Munyenyembe F., Hone J. (1989) Determinants of bird population in an urban area. Australian Journal of Ecology 14:549-557.

Hennings L.A., Edge W.D. (2003) Riparian bird community structure in Portland, Oregon: Habitat, urbanization, and spatial scale patterns. Condor 105:288-302.

Heyman E., Gunnarsson B. (2011) Management effect on bird and arthropod interaction in suburban woodlands. BMC Ecology 11:8-16.

Hodgkison S.C., Hero J.M., Warnken J. (2007) The conservation value of suburban golf courses in a rapidly urbanising region of Australia. Landscape and Urban Planning 79:323-337.

Hostetler M., Duncan S., Paul J. (2005) Post-construction effects of an urban development on migrating, resident, and wintering birds. Southeastern Naturalist 4:421-434.

Huste A., Boulinier T. (2007) Determinants of local extinction and turnover rates in urban bird communities. Ecological Applications 17:168-180.

Ikin K., Knight E., Lindenmayer D., Fischer J., Manning A. (2012) Linking bird species traits to vegetation characteristics in a future urban development zone: implications for urban planning. Urban Ecosystems 15:961-977.

Jones Z.F., Bock C.E. (2002) Conservation of grassland birds in an urbanizing landscape: A historical perspective. Condor 104:643-651.

Kalinowski R.S., Johnson M.D. (2010) Influence of Suburban Habitat on A Wintering Bird Community in Coastal Northern California The Condor 112:274-282.

Kath J., Maron M., Dunn P.K. (2009) Interspecific competition and small bird diversity in an urbanizing landscape. Landscape and Urban Planning 92:72-79.

Kennedy C.M., Marra P.P., Fagan W.F., Neel M.C. (2010) Landscape matrix and species traits mediate responses of Neotropical resident birds to forest fragmentation in Jamaica. Ecological Monographs 80:651-669.

Khera N. (2010) Biodiversity management for sustainable development of cities. Journal of Resources, Energy & Development 7:61-81.

Khera N., Mehta V., Sabata B.C. (2009) Interrelationship of birds and habitat features in urban greenspaces in Delhi, India. Urban Forestry & Urban Greening 8:187-196.

Kinzig A.P., Warren P., Martin C., Hope D., Katti M. (2005) The effects of human socioeconomic status and cultural characteristics on urban patterns of biodiversity. Ecology and Society 10:13.

Klem Jr D., Farmer C.J., Delacretaz N., Gelb Y., Saenger P.G. (2009) Architectural and landscape risk factors associated with bird-glass collisions in an urban environment. Wilson Journal of Ornithology 121:126-134.

LeClerc J.E., Cristol D.A. (2005) Are Golf Courses Providing Habitat for Birds of Conservation Concern in Virginia? Wildlife Society Bulletin 33:463-470.

Lee J., Kwak I.S., Lee E., Kim K.A. (2007) Classification of breeding bird communities along an urbanization gradient using an unsupervised artificial neural network. Ecological Modelling 203:62-71.

Lenth B.A., Knight R.L., Gilgert W.C. (2006) Conservation Value of Clustered Housing Developments. Conservation Biology 20:1445-1456.

Lerman S.B., Warren P.S. (2011) The conservation value of residential yards: linking birds and people. Ecological Applications 21:1327-1339.

Lerman S.B., Warren P.S., Gan H., Shochat E., Fenton B. (2012) Linking Foraging Decisions to Residential Yard Bird Composition. Plos One 7:1-8.

Leveau C.M., Leveau L.M. (2005) Avian community response to urbanization in the Pampean region, Argentina. Ornitologia Neotropical 16:503-510.

Litteral J., Wu J. (2012) Urban landscape matrix affects avian diversity in remnant vegetation fragments: Evidence from the Phoenix metropolitan region, USA. Urban Ecosystems 15:939-959.

Lorenzetti E., Battisti C. (2007) Nature reserve selection on forest fragments in a suburban landscape (Rome, central Italy): Indications from a set of avian species. Landscape Research 32:57-78.

Loss S.R., Ruiz M.O., Brawn J.D. (2009) Relationships between avian diversity, neighborhood age, income, and environmental characteristics of an urban landscape. Biological Conservation 142:2578-2585.

Luther D., Hilty J., Weiss J., Cornwall C., Wipf M., Ballard G. (2008) Assessing the impact of local habitat variables and landscape context on riparian birds in agricultural, urbanized, and native landscapes. Biodiversity and Conservation 17:1923-1935.

MacGregor-Fors I. (2008) Relation between habitat attributes and bird richness in a western Mexico suburb. Landscape and Urban Planning 84:92-98.

MacGregor-Fors I., Morales-Perez L., Schondube J.E. (2010) Migrating to the city: Responses of neotropical migrant bird communities to urbanization. Condor 112:711-717.

MacGregor-Fors I., Ortega-Alvarez R. (2011) Fading from the forest: Bird community shifts related to urban park site-specific and landscape traits. Urban Forestry & Urban Greening 10:239-246.

MacGregor-Fors I., Schondube J.E. (2011) Gray vs. green urbanization: Relative importance of urban features for urban bird communities. Basic and Applied Ecology 12:372-381.

MacGregor-Fors I., Schondube J.E. (2012) Urbanizing the wild: shifts in bird communities associated to small human settlements. Revista Mexicana De Biodiversidad 83:477-486.

Marzluff J.M., Ewing K. (2001) Restoration of fragmented landscapes for the conservation of birds: A general framework and specific recommendations for urbanizing landscapes. Restoration Ecology 9:280-292.

Marzluff J.M., Withey J.C., Whittaker K.A., Oleyar M.D., Unfried T.M., Rullman S., DeLap J. (2007) Consequences of Habitat Utilization by Nest Predators and Breeding Songbirds across Multiple Scales in an Urbanizing Landscape. The Condor 109:516-534.

Mason J., Moorman C., Hess G., Sinclair K. (2007) Designing suburban greenways to provide habitat for forest-breeding birds. Landscape and Urban Planning 80:153-164.

McCaffrey R.E., Mannan R.W. (2012) How scale influences birds' responses to habitat features in urban residential areas. Landscape and Urban Planning 105:274-280.

McKinney R.A., McWilliams S.R., Charpentier M.A. (2006) Waterfowl-habitat associations during winter in an urban North Atlantic estuary. Biological Conservation 132:239-249.

Melles S., Glenn S., Martin K. (2003) Urban Bird Diversity and Landscape Complexity: Species--environment Associations Along a Multiscale Habitat Gradient. Conservation Ecology 7:N.PAG.

Merola-Zwartjes M., DeLong J.P. (2005) Avian species assemblages on on New Mexico golf courses: surrogate riparian habitat for birds? Wildlife Society Bulletin 33:435-447.

Miller J.R., Wiens J.A., Hobbs N.T., Theobald D.M., Thompson-Hobbs N. (2003) Effects of human settlement on bird communities in lowland riparian areas of Colorado (USA). Ecological Applications 13:1041-1059.

Miller S.G., Knight R.L., Clinton K.M. (1998) Influence of Recreational Trails on Breeding Bird Communities. Ecological Applications 8:162-169.

Mills G.S., Dunning J.B., Jr., Bates J.M. (1989) Effects of Urbanization on Breeding Bird Community Structure in Southwestern Desert Habitats. The Condor 91:416-428.

Minor E., Urban D. (2010) Forest bird communities across a gradient of urban development. Urban Ecosystems 13:51-71.

Morimoto T., Katoh K., Yamaura Y., Watanabe S. (2006) Can surrounding land cover influence the avifauna in urban/suburban woodlands in Japan? Landscape and Urban Planning 75:143-154.

Morrison M.L., Scott T.A., Tennant T. (1994) Wildlife-Habitat Restoration in an Urban Park in Southern California. Restoration Ecology 2:17-30.

Nagy C., Bardwell K., Rockwell R.F., Christie R., Weckel M. (2012) Validation of a Citizen Science-Based Model of Site Occupancy for Eastern Screech Owls with Systematic Data in Suburban New York and Connecticut. Northeastern Naturalist:143-158.

Naithani A., Bhatt D. (2012) Bird community structure in natural and urbanized habitats along an altitudinal gradient in Pauri district (Garhwal Himalaya) of Uttarakhand state, India. Biologia 67:800-808.

Nassauer J.I. (2004) Monitoring the success of metropolitan wetland restorations: Cultural sustainability and ecological function. Wetlands 24:756-765.

Nickens T.E. (2003) Living on the Edges. Audubon 105:80.

Oliver A.J., Hong-Wa C., Devonshire J., Olea K.R., Rivas G.F., Gahl M.K. (2011) Avifauna richness enhanced in large, isolated urban parks. Landscape and Urban Planning 102:215-225.

Ortega-Alvarez R., MacGregor-Fors I. (2010) What matters most? Relative effect od urban habitat traits and hazards on urban parks birds. Ornitologia Neotropical 21:519-533.

Ortega-Álvarez R., MacGregor-Fors I. (2009) Living in the big city: Effects of urban land-use on bird community structure, diversity, and composition. Landscape & Urban Planning 90:189-195.

Palmer G.C., Fitzsimons J.A., Antos M.J., White J.G. (2008) Determinants of native avian richness in suburban remnant vegetation: Implications for conservation planning. Biological Conservation 141:2329-2341.

Palomino D., Carrascal L.M. (2005) Birds on novel island environments. A case study with the urban avifauna of Tenerife (Canary Islands). Ecological Research 20:611-617.

Palomino D., Carrascal L.M. (2007) Threshold distances to nearby cities and roads influence the bird community of a mosaic landscape. Biological Conservation 140:100-109.

Parrish M.C., Hepinstall-Cymerman J. (2012) Associations between multiscale landscape characteristics and breeding bird abundance and diversity across urban-rural gradients in Northeastern Georgia, USA. Urban Ecosystems 15:559-580.

Parsons H., Major R.E., French K. (2006) Species interactions and habitat associations of birds inhabiting urban areas of Sydney, Australia. Austral Ecology 31:217-227.

Pellissier V., Cohen M., Boulay A., Clergeau P. (2012) Birds are also sensitive to landscape composition and configuration within the city centre. Landscape and Urban Planning 104:181-188.

Pennington D.N., Blair R.B. (2011) Habitat selection of breeding riparian birds in an urban environment: untangling the relative importance of biophysical elements and spatial scale. Diversity & Distributions 17:506-518.

Pennington D.N., Hansel J., Blair R.B. (2008) The conservation value of urban riparian areas for landbirds during spring migration: Land cover, scale, and vegetation effects. Biological Conservation 141:1235-1248.

Phillips J., Nol E., Burke D., Dunford W. (2005) Impacts of housing developments on wood thrush nesting success in hardwood forest fragments. Condor 107:97-106.

Platt A., Lill A. (2006) Composition and conservation value of bird assemblages of urban 'habitat islands': Do pedestrian traffic and landscape variables exert an influence? Urban Ecosystems 9:83-97.

Poague K.L., Johnson R.J., Young L.J. (2000) Bird use of rural and urban converted railroad rights-of-way in southeast Nebraska. Wildlife Society Bulletin 28:852-864.

Porter E.E., Jason B., Blair R.B. (2005) Multiple Spatial-Scale Assessment of the Conservation Value of Golf Courses for Breeding Birds in Southwestern Ohio. Wildlife Society Bulletin 33:494-506.

Posa M.R.C., Sodhi N.S. (2006) Effects of anthropogenic land use on forest birds and butterflies in Subic Bay, Philippines. Biological Conservation 129:256-270.

Recher H.F. (1991) Long term changes in the relative abundances of birds in Kings Park,Perth, Western Australia. Conservation Biology 5:90-102.

Reidy J.L., Thompson Iii R.R., Peak R.G. (2009) Factors Affecting Golden-Cheeked Warbler Nest Survival in Urban and Rural Landscapes. Journal of Wildlife Management 73:407-413.

Reis E., López-Iborra G.M., Pinheiro R.T. (2012) Changes in bird species richness through different levels of urbanization: Implications for biodiversity conservation and garden design in Central Brazil. Landscape & Urban Planning 107:31-42.

Rodewald A.D. (2003) The Importance of Land Uses within the Landscape Matrix. Wildlife Society Bulletin 31:586-592.

Rodewald P.G., Brittingham M.C. (2004) Stopover habitats of landbirds during fall: Use of edge-dominated and early-successional forests. Auk 121:1040-1055.

Rodewald P.G., Brittingham M.C. (2007) Stopover habitat use by spring migrant landbirds: The roles of habitat structure, leaf development, and food availability. Auk 124:1063-1074.

Rodewald P.G., Matthews S.N. (2005) Landbird use of riparian and upland forest stopover habitats in an urban landscape. Condor 107:259-268.

Rosa S., Palmeirim J.M., Moreira F. (2003) Factors Affecting Waterbird Abundance and Species Richness in an Increasingly Urbanized Area of the Tagus Estuary in Portugal. Waterbirds: The International Journal of Waterbird Biology 26:226-232.

Rosenberg K.V., Terrill S.B., Rosenberg G.H. (1987) Value of Suburban Habitats to Desert Riparian Birds. The Wilson Bulletin 99:642-654.

Rottenborn S.C. (1999) Predicting the impacts of urbanization on riparian bird communities. Biological Conservation 88:289.

Ruthe J.S., Schaefer J.M. (1992) Avian Characteristics of an Urban Riparian Strip Corridor. The Wilson Bulletin 104:732-738.

Sandström U.G., Angelstam P., Mikusiński G. (2006) Ecological diversity of birds in relation to the structure of urban green space. Landscape & Urban Planning 77:39-53.

Santo T.L.D., Willson M.F. (2001) Predator Abundance and Predation of Artificial Nests in Natural and Anthropogenic Coniferous Forest Edges in Southeast Alaska. Journal of Field Ornithology 72:136-149.

Sattler T., Borcard D., Arlettaz R., Bontadina F., Legendre P., Obrist M.K., Moretti M. (2010) Spider, bee, and bird communities in cities are shaped by environmental control and high stochasticity. Ecology 91:3343-3353.

Schlesinger M.D., Manley P.N., Holyoak M. (2008) Distinguishing stressors acting on land bird communities in an urbanizing environment. Ecology 89:2302-2314.

Shanahan D.F., Miller C., Possingham H.P., Fuller R.A. (2011) The influence of patch area and connectivity on avian communities in urban revegetation. Biological Conservation 144:722-729.

Shultz A.J., Tingley M.W., Bowie R.C.K. (2012) A Century of Avian Community Turnover in an Urban Green Space in Northern California. The Condor 114:258-267.

Shwartz A., Shirley S., Kark S. (2008) How do habitat variability and management regime shape the spatial heterogeneity of birds within a large Mediterranean urban park? Landscape and Urban Planning 84:219-229.

Sinclair K.E., Hess G.R., Moorman C.E., Mason J.H. (2005) Mammalian nest predators respond to greenway width, landscape context and habitat structure. Landscape & Urban Planning 71:277-293.

Smith P.G.R. (2007) Characteristics of urban natural areas influencing winter bird use in southern Ontario, Canada. Environmental Management 39:338-352.

Snyder S., Miller J., Skibbe A., Haight R. (2007) Habitat Acquisition Strategies for Grassland Birds in an Urbanizing Landscape. Environmental Management 40:981-992.

Sodhi N.S., Briffett C., Kong L., Yuen B. (1999) Bird use of linear areas of a tropical city: implications for park connector design and management. Landscape and Urban Planning 45:123-130.

Sodhi N.S., Tien Ming L., Lian Pin K., Prawiradilaga D.M. (2006) Long-Term Avifaunal Impoverishment in an Isolated Tropical Woodlot. Conservation Biology 20:772-779.

Soh M.C.K., Sodhi N.S., Lim S.L.H. (2006) High sensitivity of montane bird communities to habitat disturbance in Peninsular Malaysia. Biological Conservation 129:149-166.

Sorace A. (2001) Value to wildlife of urban-agricultural parks: A case study from Rome urban area. Environmental Management 28:547-560.

SoulÉ M.E., Bolger D.T., Alberts A.C., Wright J., SorlCe M., Hill S. (1988) Reconstructed Dynamics of Rapid Extinctions of Chaparral-Requiring Birds in Urban Habitat Islands. Conservation Biology 2:75-92.

Stagoll K., Manning A.D., Knight E., Fischer J., Lindenmayer D.B. (2010) Using bird-habitat relationships to inform urban planning. Landscape and Urban Planning 98:13-25.

Strohbach M.W., Haase D., Kabisch N. (2009) Birds and the City: Urban Biodiversity, Land Use, and Socioeconomics. Ecology and Society 14:15.

Suarez-Rubio M., Leimgruber P., Renner S.C. (2011) Influence of exurban development on bird species richness and diversity. Journal of Ornithology 152:461-471.

Suarez-Rubio M., Thomlinson J.R. (2009) Landscape and patch-level factors influence bird communities in an urbanized tropical island. Biological Conservation 142:1311-1321.

Surasinghe T.D., De Alwis C. (2010) Birds of Sabaragamuwa University campus, Buttala, Sri Lanka. Journal of Threatened Taxa 2:876-888.

Toledo M., Donatelli R., Batista G. (2012) Relation between green spaces and bird community structure in an urban area in Southeast Brazil. Urban Ecosystems 15:111-131.

Trammell E.J., Weisberg P.J., Bassett S. (2011) Avian response to urbanization in the arid riparian context of Reno, USA. Landscape and Urban Planning 102:93-101.

Tratalos J., Fuller R.A., Evans K.L., Davies R.G., Newson S.E., Greenwood J.J.D., Gaston K.J. (2007) Bird densities are associated with household densities. Global Change Biology 13:1685-1695.

Traut A.H., Hostetler M.E. (2003) Urban Lakes and Waterbirds: Effects of Development on Avian Behavior. Waterbirds: The International Journal of Waterbird Biology 26:290-302.

Tremblay M.A., St Clair C.C. (2011) Permeability of a heterogeneous urban landscape to the movements of forest songbirds. Journal of Applied Ecology 48:679-688.

Tremblay M.A., St. Clair C.C. (2009) Factors affecting the permeability of transportation and riparian corridors to the movements of songbirds in an urban landscape. Journal of Applied Ecology 46:1314-1322.

Tucakov M.J. (2010) Species composition and number od breeding birds in urban parks in Novi Sad. Matica Srpska Proceedings for Natural Sciences / Zbornik Matice Srpske za Prirodne Nauke:143-149.

Turner W. (2001) Native birds are in trouble in Tucson. Is there hope? Vermilion Flycatcher 45:21-24.

Turner W.R. (2003) Citywide biological monitoring as a tool for ecology and conservation in urban landscapes: the case of the Tucson Bird Count. Landscape and Urban Planning 65:149-166.

Turner W.R. (2006) Interactions among spatial scales constrain species distributions in fragmented urban landscapes. Ecology and Society 11:16.

Vallejo B.M., Aloy A.B., Ong P.S. (2009) The distribution, abundance and diversity of birds in Manila's last greenspaces. Landscape and Urban Planning 89:75-85.

van Heezik Y., Smyth A., Mathieu R. (2008) Diversity of native and exotic birds across an urban gradient in a New Zealand city. Landscape and Urban Planning 87:223-232.

van Heezik Y.M., Dickinson K.J.M., Freeman C. (2012) Closing the Gap: Communicating to Change Gardening Practices in Support of Native Biodiversity in Urban Private Gardens. Ecology and Society 17:9.

van Rensburg B.J., Peacock D.S., Robertson M.P. (2009) Biotic homogenization and alien bird species along an urban gradient in South Africa. Landscape and Urban Planning 92:233-241.

Watson J.E.M., Whittaker R.J., Freudenberger D. (2005) Bird community responses to habitat fragmentation: how consistent are they across landscapes? Journal of Biogeography 32:1353-1370.

Wentworth J.M., DeGraaf R.M. (1986) Avian guild structure and habitat associations in suburban bird communities. pp. 399.

Wilcove D.S. (1985) Nest Predation in Forest Tracts and the Decline of Migratory Songbirds. Ecology 66:1211-1214.

Willis E.O. (2000) Ranking urban avifaunas (Aves) by number of localities per species in Sao Paulo, Brazil.

Wood K.A. (1996) Bird assemblages in a small public reserve and adjacent residential area at Wollongong, New South Wales. Wildlife Research 23:605-620.

Yaukey P.H. (1996) Patterns of avian population density, habitat use, and flocking behavior in urban and rural habitats during winter. Professional Geographer 48:70-81.

Yeoman F., Mac Nally R. (2005) The avifaunas of some fragmented, periurban, coastal woodlands in south-eastern Australia. Landscape and Urban Planning 72:297-312.

Young K.M., Daniels C.B., Johnston G. (2007) Species of street tree is important for southern hemisphere bird trophic guilds. Austral Ecology 32:541-550.

Zhou D.Q., Fung T., Chu L.M. (2012) Avian community structure of urban parks in developed and new growth areas: A landscape-scale study in Southeast Asia. Landscape and Urban Planning 108:91-102.