



Urban wildlife ecology and conservation: A brief history of the discipline

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Abstract. Urban wildlife ecology and conservation is a discipline worldwide in scope. Although some attention was given the subject in the early to mid-1900s, most activity in the field is of more recent origin. Many European countries have active programs and activities, including the United Kingdom-Man and the Biosphere (UK-MAB) Urban Forum and The Wildlife Trusts of England, the United Nations Educational, Scientific, and Cultural Organization's MAB Program, and urban ecology research in Germany and Poland. The Netherlands' concept of "ecological landscapes" introduced a new approach to design of urban open space. Durban, South Africa followed with "D'MOSS," a metropolitan open space system founded on the principles of island biogeography theory. The park connector network of Singapore combines principles of conservation biology and landscape planning. Urban wildlife programs and activities exist in the United States at the federal, state, and local levels as well as in private conservation organizations. The Wildlife Society established an Urban Affairs and Regional Planning Committee in the mid-1970s that later became the Urban Wildlife Committee and then evolved into the Urban Wildlife Working Group. Urban wildlife research is providing knowledge of wildlife and plant populations and communities in urban areas that hopefully will lead to better understanding and greater sustainability of urban ecosystems.

Keywords: urban, wildlife, ecology, conservation, history

Introduction

Wildlife conservation is rooted in game management and according to Leopold (1933), game management for conservation purposes was first practiced in Asia by Kublai Khan of the Mongol Empire during the latter half of the 13th century. Kublai Khan prohibited the taking of game animals between March and October. Regulation of hunting activity was an early European practice and such regulation formed the base of game management in North America where setting of bag limits (number of game birds or animals to be taken daily by a hunter) and hunting season dates were formulated during the 1800s (Bolen and Robinson, 2003). In North America, game management as a science began in the 1930s with publication of the first textbook, *Game Management* (Leopold, 1933).

Since the 1930s, there has been a gradual broadening of the field from a focus on game management to a focus on wildlife ecology and management. Flowing from this broader focus has been greater attention to urban ecology and conservation (Hadidian and Smith, 2001). In the discussion that follows, I view "urban wildlife" in a broad sense to include non-domestic vertebrates and invertebrates of urban and urbanizing areas. This includes wildlife, and plant associates, of the built up downtown area, suburbia, and urban-rural fringe of cities, towns, and villages. I review international and United States programs and activities and highlight knowledge gained from urban wildlife research efforts. Lastly, I reflect briefly on

the future with some predictions and perceived needs to advance the discipline of urban wildlife conservation that I think would enhance life for humans as well as wildlife.

International programs and activities

The United Kingdom (UK) has been active in the urban arena for many years. Shenstone (1912) described the flora of building sites in London and later Fitter (1945) presented a natural history of that city (a similar work for New York City was reported by Kieran, 1959). George Barker was the first urban coordinator of the Nature Conservancy Council, now English Nature (the UK government's nature conservation agency), and summarized European urban wildlife programs for a national symposium held in 1986 (Barker, 1987). He also was instrumental in establishing the United Kingdom-Man and the Biosphere (UK-MAB) Urban Forum in 1990. The Urban Forum "is a network of specialists, practitioners and thinkers involved with nature conservation in urban areas. Its mission is to raise awareness, stimulate research, influence policy, improve the design and management of urban systems, and push urban biodiversity and nature conservation up the social and political agenda" (UK-MAB Urban Forum, 2003). Dr. David Goode has been particularly active in the London area (Goode, 1991), first with the Greater London Council, and later with The London Ecology Unit, which he directed. He was instrumental in initiating a series of handbooks to draw attention to urban ecology issues. First in the series was *Ecology and Nature Conservation in London* (Greater London Council, 1984) followed by a guide describing how to create habitats in urban areas (Baines and Smart, 1991). Additional handbooks were prepared on the wildlife of London boroughs. Peter Shirley became active in urban wildlife with the Urban Wildlife Trust in Birmingham. He remains active in the urban arena with The Wildlife Trusts, a network of 47 local Wildlife Trusts working to protect wildlife in urban and exurban habitats throughout the UK (The Wildlife Trusts, 2003). Dr. Steve Harris of the University of Bristol developed an early research program focused on urban red fox (*Vulpes vulpes*) ecology (Harris, 1977, 1981; Harris and Rayner, 1986).

The Netherlands introduced the concept of "ecological landscapes" as a new approach to design of urban open space in the late 1960s (Ruff, 1987). Ecological processes such as plant succession and concepts such as the linking of diversity and stability are adopted as bases of design. Emphasis also is placed on use of native species, resulting in a less formal and more natural appearance. Such ecological landscapes integrate passive and active recreation, serve environmental education functions, and better assist in the conservation of plants and wildlife. Landscape architects and urban conservationists in other countries became interested in the concept. Notable in this regard is work in the United Kingdom (Baines, 1985, 1986; Brookes, 1998) and the United States (Diekelmann and Schuster, 1982; Thompson and Steiner, 1997; Link, 1999).

Other European work has been ongoing for some time. The United Nations Educational, Scientific, and Cultural Organization's MAB Program for many years maintained an urban ecosystems component. It now maintains an urban group to stimulate discussion and information exchange within the MAB program (UNESCO, 2003). In Germany, Dr. Herbert Sukopp and colleagues at the Technical University of Berlin have devoted considerable effort to urban ecology, particularly plant communities (Sukopp, 1990). In

Poland, Dr. Maciej Luniak and colleagues of the Polish Academy of Sciences have maintained a research program for many years focused particularly on birds and invertebrates (Luniak, 1990).

Durban, South Africa created a Metropolitan Open Space System (D'MOSS) in the mid-1980s in an effort to improve the long-term quality of life for residents and retain some of the original plant and animal communities with continued development (Roberts, 1994). The plan was founded on the principles of island biogeography theory and consists of core reserves, connecting corridors, and buffers. Core reserves are indigenous community types where conservation is the primary function; they are linked by connecting corridors. Buffer areas are other open spaces, such as sports fields, golf courses, parks, cemeteries, industrial parks, private gardens, and road and rail rights-of-way.

The Durban example is part of a growing trend worldwide in urban open space development focused on providing wildlife habitat as well as human recreation in such areas. Another example is the park connector network of Singapore that combines principles of conservation biology and landscape planning. Based on two research reports (Briffett *et al.*, 1997, 1999; Briffett *et al.*, 2000) published guidelines for implementing multiple-use green corridors in Singapore. Briffett *et al.* (2000) discussed planning, design, and management considerations for such areas and presented a number of case studies worldwide that influenced their recommendations for Singapore.

In recent years, a focus on urban ecology has emerged in Australia. Urban Ecology Australia, a non-profit, community-based urban environmental organization, was founded in 1991 "to promote and create ecologically integrated human settlements" (Urban Ecology Australia, 2003). In 1998, the Australian Research Centre for Urban Ecology was established "to help increase our understanding of the ecology, restoration and management of urban natural areas throughout Australia and the world" (Australian Research Centre for Urban Ecology, 2004). An active research program, the Suburban Wildlife Research Group, is housed in the Australian School of Environmental Studies of Griffith University, Nathan (Rollinson and Jones, 2002; Jones and Neelson, 2003; Rollinson *et al.*, 2003).

United States programs and activities

Early leaders of wildlife conservation in the United States provided guidance to the urban wildlife discipline. Leopold (1933) stated "A pair of wood thrushes [*Hylocichla mustelina*] is more valuable to a village than a Saturday evening band concert, and costs less." Rudolf Bennitt, first president of The Wildlife Society, summarized the 1946 North American Wildlife and Natural Resources Conference and stated: "I still look forward to the day when we shall hear men discuss the management of songbirds, wildflowers, and the biota of a city. . ." (Bennitt, 1946).

Increased attention was focused on urban wildlife in the 1960s. Raymond Dasmann (1966) spoke of "old conservation," concerned mainly with quantity of natural resources, and "new conservation," dealing principally with clean air and water, open space, outdoor recreation, and quality of the human environment, particularly the urban environment, where most people live. He pointed out that generations of humans were growing up in cities with no roots in the land and little experience in the natural world. Dasmann felt

that the wildlife profession was too closely identified with game animals and hunters, and was too narrow-minded. He stated that more wildlife biologists should "... get out of the woods and into the cities. They must work with city and metropolitan regional planners, with landscape architects and all others concerned with the urban environment to make the cities and metropolitan regions, the places where people live, into environments where each person's everyday life will be enriched to the maximum extent possible by contact with living things and natural beauty" (Dasmann, 1966). Three papers dealing with wildlife in urban environments were presented at the 1967 North American Wildlife and Natural Resources Conference (Davey, 1967; Stearns, 1967; Twiss, 1967).

Federal government

In 1983, federal agencies had no substantial urban wildlife programs identified as such (Lyons and Leedy, 1984). Only the U. S. Fish and Wildlife Service (FWS) reported a designated urban wildlife program in that year. Funding for the program steadily declined between 1980 and 1983. The FWS recognized the importance of the urban environment at least as early as 1968 by sponsoring a conference on the subject in that year (Bureau of Sport Fisheries and Wildlife, 1968). Later, in 1986, the FWS was the major sponsor of the symposium, "Integrating Man and Nature in the Metropolitan Environment." Frank Dunkle, then Director, stated "The Service has a mission: '... to conserve, protect, and enhance fish, wildlife, and their habitats for the *continuing benefit of the American people.*' Noting that three-quarters of our citizens live in urban areas, what is more fitting than a mission that recognizes urban wildlife and their habitats?" (Dunkle, 1987). The FWS manages the National Wildlife Refuge System and several of the refuges are located in urban areas, notably John Heinz at Tinicum on the outskirts of Philadelphia, Pennsylvania; Bayou Sauvage, within the city limits of New Orleans, Louisiana; Minnesota Valley, within the metropolitan area of Minneapolis-St. Paul, Minnesota; and Don Edwards San Francisco Bay refuge in California (U.S. Fish and Wildlife Service, 2004). In 1999, the FWS initiated its "Urban Treaty for Migratory Bird Conservation," to help municipal governments conserve migratory birds. The first two treaties were signed with New Orleans, Louisiana, and Chicago, Illinois. Philadelphia, Pennsylvania, and Houston, Texas, have been added to the program and plans are to expand the network (U.S. Fish and Wildlife Service, 2003).

In 1985, the National Park Service (NPS) renamed its Washington, D.C.-based Ecological Services Laboratory for the national capital region. The new name, the Center for Urban Ecology, was created to better describe the types of services that the region's natural science program provides. Among its activities are programs dealing with air and water resources, soils and agronomy, pest management, vegetation, and wildlife in NPS urban parks. The stated mission of the Center is "*to provide scientific guidance, technical assistance and education for the preservation, conservation and enhancement of park resources within urbanizing landscapes*" (National Park Service, 2004).

State government

Six state wildlife agencies reported the existence of designated urban wildlife programs in 1983 (Lyons and Leedy, 1984). The principal functions of those programs were extension,

public education, and management. Only three states reported that research was a part of their program activities. Davis (2000) presented results of a follow-up state agency survey. He reported nine states having established programs in 2000 (an increase of three since 1983). Seven states eliminated urban programs during the time period. Twenty-four states were addressing urban wildlife issues in 2000 (14 were doing so in 1983). As examples, three programs are briefly highlighted here.

The Missouri Urban Biology Program was created in 1978 with three primary objectives: (1) to “network” information regarding natural history topics to the general public, (2) to assist public and private landowners regarding habitat management, and (3) to acquire significant habitats in or around metropolitan areas (Werner and Tylka, 1984). The program also constructed urban nature centers to provide outdoor-oriented educational opportunities to urbanites. Such centers are now located in St. Louis, Kansas City, Springfield, and Jefferson City (Thorne and Witter, 2001).

Washington’s urban wildlife program was initiated in 1981. According to Penland (1987), overall functions of the program included: (1) urban habitat management, (2) urban species management, and (3) information & education.

Three important steps led to formation of the Arizona urban wildlife program (Shaw and Supplee, 1987): (1) creation of a habitat evaluation program in 1979, (2) creation of a nongame division in 1983, and (3) adoption of an urban wildlife policy in 1986. The habitat evaluation program was established with an objective of incorporating wildlife habitat requirements into land management activities. Habitat specialists in urbanizing areas of the state review development proposals and provide information on wildlife values to local governments and developers. An important component of the nongame division was creation of the Arizona Nongame Data Management System, which includes location files of sensitive and threatened animal and plant species used in agency habitat reviews. The policy statement provided an explicit acknowledgment of the agency’s concern for urban wildlife. Shaw and Supplee (1987) stressed the importance of the wildlife agency working in concert with local planning and zoning departments, and other public and private groups.

Local government

I am unaware of any study or survey summarizing urban wildlife programs of local governments. The examples that follow, however, illustrate what a few cities and counties are doing.

In New York City, a new division, the Natural Resources Group, was created in the Department of Parks and Recreation in 1984 (Nilon *et al.*, 1987). The group’s primary focus early on was developing management plans for natural areas within city parks. Wildlife-related recreation and nature interpretation are important components of the plans. The first such plan was prepared for 1,094-ha Pelham Bay, the largest park in the city. Areas suitable for wildlife management and nature interpretation were located by determining the habitat potential of mapped vegetation units.

The Natural Resources Group also is involved with habitat restoration. New York City manages a 10,800-ha park system, 3,600 ha of which are designated natural areas consisting of habitat fragments that are used heavily by people. Some problems noted in these areas are air and water pollution, siltation and eutrophication of freshwater systems, soil compaction

and erosion, loss of herbaceous and shrub layers in forests, and invasion of native communities by exotic plants. Two types of restoration practices are implemented: (1) restoration of degraded ecosystems and habitats, and (2) creation of new habitat. Work focuses on forests, meadows, freshwater wetlands, and salt marshes (Matsil and Feller, 1996).

Portland Audubon Society initiated an effort to establish a metropolitan wildlife refuge system in the mid-1980s (Houck, 1991). As the program evolved, it became evident that public interest was broader than just wildlife. Concern also included loss of open space, lack of a coordinated recreational trails system, lack of an integrated regional environmental education program, and absence of a regional land acquisition strategy. The metropolitan refuge system was inadequate to address all of these. In 1989, the regional planning body, known as Metropolitan Service District, which included the city of Portland and the surrounding tri-county urbanized area, instituted a regional natural areas program that evolved into the Metropolitan Greenspaces Program. The purpose of the program was to ensure a cooperative regional system of natural areas, open space, trails and green spaces for wildlife and people. A report, *Protecting Open Space: A Review of Successful Programs and Landowner Perspectives*, covered regulatory and non-regulatory strategies for protecting open spaces for people and wildlife throughout the United States, and including one example each from South Africa, Canada, France, and New Zealand (Brooks and Wortman, 1999).

Montgomery County, Maryland established a natural resources planning and management program in the mid-1980s that elevated ecological concepts and principles within the local government (Hench *et al.*, 1987). A comprehensive program now plans for and manages the county's natural resources through the Countywide Planning Division and the Natural Resources Division of the Department of Park and Planning (Montgomery County Department of Park and Planning, 2004).

Colleges and universities

North American colleges and universities were surveyed in 1985 to ascertain urban wildlife programs and activities in those institutions (Adams *et al.*, 1987). About 2% of wildlife research budgets was devoted to urban wildlife studies in 1983-1984. Few schools (9%) offered specific courses in urban wildlife, but most (78%) included the topic in other wildlife courses. The greatest percentage of time (32%) of extension personnel was devoted to animal damage-nuisance control. Public adult-youth group education was the highest priority for additional extension effort if more funds were available. A follow-up survey (Adams and Grammer, 2000) concluded "There appears to be limited preparation by academia and agencies to address urban wildlife management issues now and in the future." I think we can say that some progress has been made but much more needs to be done.

Private conservation organizations

National Institute for Urban Wildlife. The Urban Wildlife Research Center (renamed the National Institute for Urban Wildlife) was founded in 1973 as a private, non-profit scientific and educational organization dedicated to wildlife conservation in urban, suburban, and urbanizing areas (Adams, 1989). Unfortunately, funding for the organization could not be

sustained and it closed in 1995. Most of the work of the Institute resulted in some form of publication—scientific, technical, semi-technical, or popular—for various audiences. Many of its publications are still available (Adams and VanDruff, 1998). Examples include an early literature review (Leedy, 1979), planning considerations for fish and wildlife (Leedy *et al.*, 1978, 1981; Adams and Dove, 1989), proceedings of two national symposia on urban wildlife (Adams and Leedy, 1987, 1991), and two educational primers (Adams and Dove, 1984; Leedy and Adams, 1984). From 1975 until its closing, the Institute conducted annual open exchanges in conjunction with the North American Wildlife and Natural Resources Conference. The meetings were designed to provide an opportunity for those interested in urban wildlife to get together and discuss programs, policies, and research and management activities.

National Wildlife Federation. The National Wildlife Federation also was involved early on with urban wildlife conservation, primarily with initiation of its Backyard Wildlife Habitat Program in 1973 (Tufts, 1987) and publication of *Gardening With Wildlife* the following year (National Wildlife Federation, 1974). Tufts and Loewer (1995) authored a follow-up to the latter publication. The Backyard Wildlife Habitat Program remains popular. It is designed to educate and motivate citizens to enhance urban wildlife habitat in their own backyards, and it certifies backyard habitats that meet established criteria. Some 4,700 habitats were certified in 1986 (Tufts, 1987). The number grew to 22,500 in 1998 and 46,000 by July 2004 (National Wildlife Federation, 2004). The concept has expanded to other private organizations (The Humane Society of the United States, 2004), as well as state wildlife agencies (Penland, 1987; Bender, 2004).

Other organizations. The Trust for Public Land, a national land conservation organization founded in 1972, shifted greater attention to urban areas in 1994 with its Green Cities Initiative. This initiative was developed to better meet the park and open space needs of people residing in urban areas (The Trust for Public Land, 1994). The Humane Society of the United States developed an urban wildlife program in the mid-1990s. Two major efforts of that program are to promote nonlethal methods of resolving conflicts between people and wildlife in urban areas and to operate an Urban Wildlife Sanctuary Program (The Humane Society of the United States, 2004). The sanctuary program helps to reduce the negative impact of urban development on wildlife and to educate urban residents about wildlife and habitat needs. It is similar to the National Wildlife Federation's Backyard Wildlife Habitat Program. The Fund for Animals and several other organizations have programs dealing with urban wildlife, particularly with regard to conflict resolution (Hadidian and Smith, 2001).

Professional societies

The Wildlife Society responded to the call by early leaders for greater attention to urban areas with creation of an Urban Affairs and Regional Planning Committee in the mid-1970s, which later was shortened to the Urban Wildlife Committee. The committee has been quite active over the years, and here I review some of its major activities. In 1983, members of the committee prepared a policy statement on urban wildlife that was adopted by Council

of The Wildlife Society on 11 October of that year. The statement pointed out that wildlife is an important component of the urban environment and... "that urban areas containing wildlife habitat constitute a better environment for people than areas largely devoid of wildlife... Studying, planning for, and managing urban wildlife and related resources represent a logical and needed expansion of traditional professional wildlife management" (The Wildlife Society, 2003).

The committee conducted two surveys of urban programs. The first was a survey of state conservation agencies within the United States (Lyons and Leedy, 1984) reviewed above under "State government." The second surveyed North American colleges and universities to ascertain urban wildlife programs and activities in those institutions (Adams *et al.*, 1987). It was reviewed above under "Colleges and universities."

The committee prepared and published a report entitled "Guidelines for Implementing Urban Wildlife Programs Under State Conservation Agency Administration" (Tylka *et al.*, 1987). The report was adopted by Council of The Wildlife Society in March 1986, endorsed by the International Association of Fish and Wildlife Agencies in September 1986, and distributed by the latter association to all state wildlife agency directors. The report recommended four main elements for a well-rounded urban wildlife program: (a) inventory and research, (b) planning and management, (c) public information, education, and extension services, and (d) urban habitat acquisition, development, preservation, restoration, and conservation.

The committee assisted the American Society of Landscape Architects in developing a policy statement on wildlife in 1988. In 1996, the urban wildlife committee evolved into the Urban Wildlife Working Group of The Wildlife Society. It currently has about 130 members. Major activities in recent years have been sponsorship of symposia at annual meetings of The Wildlife Society.

Scientific publications of The Wildlife Society have included increasing attention to the urban environment in recent years (Figure 1). In addition, the last two editions of the Society's "techniques manual" contained a chapter on urban wildlife (VanDruff *et al.*, 1994; Adams *et al.*, 2005).

Urban wildlife research

Urban wildlife research was first summarized comprehensively by Leedy (1979). Other reviews include Adams (1988, 1994), Dawe (1990), VanDruff *et al.* (1994), and Adams *et al.* (2005). Marzluff *et al.* (2001) provided a recent synthesis of urban bird research.

Most of the wildlife research conducted in urban areas has dealt with bird-habitat associations (DeGraaf and Wentworth, 1986; DeGraaf, 1987, 1991). We know less about population biology, including reproduction, mortality, and ecological sinks. Some patterns, however, have emerged. Urbanization fragments the landscape. It destroys habitat for many species, modifies habitat of others, and creates new habitat for some species. Habitat specialists are most severely impacted; some habitat generalists do well. This pattern seems to hold for birds (Aldrich and Coffin, 1980), mammals (VanDruff and Rowse, 1986), amphibians and reptiles (Cochran, 1989), and invertebrates (Arnold and Goins, 1987). Currently, there is considerable interest in habitat patches, corridors, and island biogeography theory.

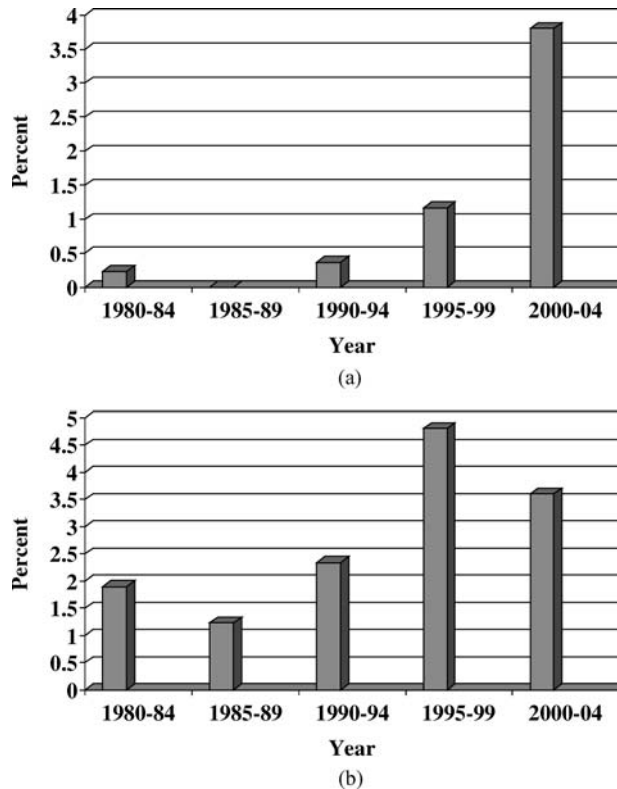


Figure 1. Proportion of papers dealing with urban wildlife published in the Journal of Wildlife Management (a) and Wildlife Society Bulletin (b) during the past 24 years. Comments and Replies were omitted from (a) and Departments and Features were omitted from (b). Data for the second half of 2003 and all of 2004 were projected from the rate for the first half of 2003.

The study of birds and other species along development gradients from city centers to suburbia to outlying exurban areas has increased in recent years. Most work has been done on birds. A consistent pattern reported from Finland (Jokimäki and Suhonen, 1993), Poland (Zalewski, 1994), United States (Blair, 1996), Italy (Rolando *et al.*, 1997), and Canada and France (Clergeau *et al.*, 1998) is decline of native species and increase of invasive exotic species with increasing urbanization. Total abundance and species richness of lizards in Tucson, Arizona, decreased as housing density increased (Germaine and Wakeling, 2001) and relative abundance of butterflies generally decreased with degree of urbanization (Blair and Launer, 1997).

Other research shows that species richness generally declines with increasing urbanization and species composition of the community changes, with loss and decline of native species and the addition of exotic species (Emlen, 1974; Walcott, 1974; Beissinger and Osborne, 1982; DeGraaf, 1987). At some intermediate stages of development, however, species richness may actually be higher than for pre-development conditions. For example, Batten (1972) described changes in bird life over a 140-year time period (1830–1970) on

Table 1. Species composition (partial) and richness of the breeding bird community in a northern Virginia study area in 1942 (mature deciduous forest habitat) and in 1979 (wooded residential habitat). Adapted from Aldrich and Coffin (1980)

Species	Territories per 100 ha	
	1942	1979
Red-eyed vireo	111	Absent
Ovenbird	95	Absent
Wood thrush	82	5
Scarlet tanager	39	Absent
Hooded warbler	32	Absent
Acadian flycatcher	16	Absent
Eastern wood pewee	16	Absent
Cardinal	13	100
Mockingbird	Absent	53
Song sparrow	Absent	53
Blue jay	13	47
European starling	Absent	45
Gray catbird	Absent	45
American robin	Absent	42
House sparrow	Absent	42
Total species	23	29

an 817-ha area undergoing urbanization in northwest London, England. He stated, “The number of species breeding regularly when the area was less than 1% urbanised varied from 67 to 72; but was 71 at 10%, 64 at 30%, 53 at 50% and 43 at 65% urbanisation.” He suggested that partial development of the area (up to 10%) may have increased bird species diversity because of newly created habitat. Aldrich and Coffin (1980) compared breeding bird use of a 38.5-ha mature eastern deciduous forest tract in Fairfax County, Virginia, in 1942, with bird use of the same tract in 1979, after it had become a well-established residential community. In 1942, 23 species were recorded in the study area; 29 were documented in 1979. Critically important, however, was a noted change in community composition. Typical forest birds present in 1942, but absent or lacking in 1979, included wood thrush, red-eyed vireo (*Vireo olivaceus*), ovenbird (*Seiurus aurocapillus*), and scarlet tanager (*Piranga olivacea*) (Table 1). Gray catbird (*Dumetella carolinensis*), American robin (*Turdus migratorius*), and house sparrow (*Passer domesticus*) were numerous in 1979, but were absent from the area in 1942. Biologists make a distinction between local species richness and regional species richness. As this example points out, increased local richness resulting from low-level development typically reflects the addition of many common species with generally stable or increasing populations. Regional species richness typically declines with development, and many species at the regional scale have declining populations. They are in greater need of conservation than common generalist species.

Other changes in animal community structure occur with urbanization. Biomass and density of animals typically increase, and reduced migration of birds is common, resulting from milder urban climate, more snow- and ice-free days, and food availability. These factors also contribute to a longer breeding season in the metropolitan environment. Artificial light in urban areas may alter circadian activity, affecting, for example, the singing activity of birds. Artificial light also may disorient hatchling sea turtles. Animals in urban areas often show tameness toward people. Adams *et al.* (2005) discussed four factors that shape urban animal communities: (1) direct impact of urbanization, (2) landscape patterns resulting from urbanization, (3) synurbization, and (4) introduction of species. Direct impact may be rapid or long-term. Regardless, the process of urbanization results in loss and modification of habitat. The size, configuration, and spatial arrangement of habitat patches, and the effectiveness of corridor linkages of urban habitat patches with rural surroundings describe landscape patterns. Synurbization refers to species adjustment to the urban environment. Examples include the Eurasian blackbird (*Turdus merula*) in Poland, hooded crow (*Corvus corone*) in Moscow, red fox in England, and white-tailed deer (*Odocoileus virginianus*) in the United States. Introduction of exotic species, intentionally and unintentionally, has occurred on all continents. Many of these flourish in the urban environment. Examples include house sparrow, European starling (*Sturnus vulgaris*), and rock dove (*Columba livia*) in North America, and Canada goose (*Branta canadensis*) and Mandarin duck (*Aix galericulata*) in many European cities.

A boost to the study of urban ecology occurred in 1997 when the National Science Foundation added two urban ecosystems to its Long-Term Ecological Research program (National Science Foundation, 2004). The long-term ecology of Baltimore, Maryland, and Phoenix, Arizona, are now being studied under this program. Such studies should help us to better understand human interactions with other components of urban ecological systems leading, hopefully, to greater sustainability of human-dominated systems.

In recent years, a focus on “biodiversity” has emerged in the conservation community. In discussing the importance of maintaining biological diversity, Murphy (1988) pointed out that, “Our urban centers can be viewed as bellwethers of our global environmental fate. Our success at meeting the challenges of protecting biological diversity in urban areas is a good measure of our commitment to protect functioning ecosystems worldwide. If we cannot act as responsible stewards in our own backyards, the long-term prospects for biological diversity in the rest of this planet are grim indeed.” Savard *et al.* (2000) discussed three biodiversity concepts considered important to management of urban ecosystems: (1) hierarchy of scale (genetic diversity, species diversity, and community diversity), (2) role of species in the community and species preferences by people, and (3) habitat fragmentation-habitat quality. Using methodology that combined island biogeography theory and metapopulation theory, Rudd *et al.* (2002) conducted a connectivity analysis that looked at habitat corridor connections among green spaces and analyzed the best potential networks to link them in Greater Vancouver, British Columbia, Canada. The approach should be more effective than randomly selected networks because it considers habitat value of each green space (based on size and nearness to other green spaces). Plant biodiversity was recently studied in Berlin, Germany (Zerbe *et al.*, 2003) and Maestas *et al.* (2003) discussed the issue in connection with rural residential development in the Rocky Mountain region of the United States.

Greater effort in recent years also has focused on human-wildlife conflict resolution in urban areas. Although much work remains, research is yielding greater knowledge that should result in better management approaches (Hadidian *et al.*, 1997; Conover, 2001; Adams *et al.*, 2004, 2005).

A look to the future

I think it is most likely that urbanization will continue into the foreseeable future. Without thoughtful planning, the process will continue to alter, fragment, and isolate wildlife habitat. Humans growing up in urban areas tend to be isolated from natural processes and biotic events. Education programs directed toward urban residents can help to reverse this trend. I think we are likely to see increased adoration and preservation of nature as values of the urban public, and broadening demand for husbandry and veterinary-like services for individual wild animals in local populations. Also, I predict a continued trend toward greater local government involvement in wildlife conservation. For example, in Ohio, Toledo Metroparks, which manages the 1,495-ha Oak Openings Preserve Metropark, recently tested several methods of restoring much of the original habitat. Prior to European settlement, the Oak Openings ecological region of northwestern Ohio and southeastern Michigan encompassed over 40,000 ha of oak (*Quercus* spp.) savanna, oak woodland, and wet prairie. In the late 1800s, land clearing for agriculture, logging of oaks, draining of wet prairies, and fire suppression altered much of the area. Field testing showed that controlled burning, overstory thinning, and other restoration treatments were effective in increasing native species diversity and restoring historic structure in degraded Oak Openings communities. Abella *et al.* (2001) concluded "Restoration, combined with key land purchases, has a central role in the future ecological health of the northwest Ohio Oak Openings region in an increasingly urbanizing landscape."

Another example is the city of Boulder, Colorado, which owns and manages about 14,600 ha of open space and mountain parklands, some 3,240 ha of which are montane forests dominated by ponderosa pine (*Pinus ponderosa*). The forests consist mostly of young, small-diameter trees in dense stands because of fire suppression and logging over the last 100 years. The city of Boulder has developed a forest management plan designed to restore variability in forest structure and disturbance processes that mimics historical processes to the extent possible and practical. The plan calls for thinning many of the current stands. Once pine stands are thinned, prescribed fire will be used to maintain conditions in a more historically natural state. The low-intensity surface fires will promote greater diversity in the vegetation, will enhance nutrient cycling, and will reduce tree encroachment on the forest-grassland boundary. The city recognizes that successful implementation of the plan depends upon support by local residents and adherence to air quality standards in the area. A recent survey showed that 72% of Boulder residents support use of prescribed fire as a management tool to enhance ecological values and to reduce fire hazards (Brown *et al.*, 2001). Other examples of greater local government involvement in wildlife conservation include the Natural Resources Group of New York City's Department of Parks and Recreation (Nilon *et al.*, 1987), and the Department of Recreation and Parks of Howard County, Maryland (Belensky and Norman, 2000).

I think we need a better understanding of, and programs addressing, wildlife damage management and bird feeding, along with better knowledge of the impact of urbanization on wildlife. Considerable urban green space will continue to be set aside and more thought needs to be given to restoring and managing this space. A newsletter, *The Urban Open Space Manager*, published by Urban Wildlife Resources, Columbia, Maryland, helps to address this need.

I think it would be helpful if we could define a human “social need” for wildlife and nature. There is some evidence of this to date. A “nature restoration hypothesis” has been proposed that incorporates the notion that natural views of trees and other plants tend to reduce human stress and anxiety (Ulrich, 1979). In their urban landscapes, people prefer trees, especially, over other plants, and neighborhood parks with a more informal, natural, and diverse landscape character are preferred to those with a less natural, more formal character (Gold, 1986). Green environments may help to improve behavior of children with attention-deficit hyperactivity disorder (Kuo and Faber Taylor, 2004). Doctors and allied medical professionals are recognizing the health benefits of companion animals—mostly cats and dogs to date, but perhaps the same can be said of wild animals when people enjoy them as wild animals. Research has shown that animal association may contribute to higher first-year survival following coronary heart disease and to reduction in blood pressure, heart rate, and anxiety level in healthy individuals (Bustad, 1987). These data indicate that wildlife and nature are not luxury value items that one can address only after meeting more pressing basic human needs. They are pointing to the fact that wildlife and nature are, in fact, important basic human needs. More data of this nature will strengthen conservationists’ appeals to governmental authorities to weigh wildlife and nature more heavily in decision-making processes.

Finally, we need to better define the role of wildlife in outdoor recreation while at the same time maintain naturalness of the wildlife resource. We need comprehensive and integrated conservation plans and better use of adaptive management. I think our focus should be on lessening the impact of urbanization on wildlife, not on attracting wildlife to urban areas.

References

- Abella, S.R., Jaeger, J.F., Gehring, D.H., Jacksy, R.G., Menard, K.S. and High, K.A. (2001) Restoring historic plant communities in the Oak Openings region of northwest Ohio. *Ecological Restoration* **19**, 155–160.
- Adams, C.E. and Grammer, M. (2000) A study to determine the degree of preparedness by academia and state wildlife agencies to facilitate urban wildlife management. Presented at the symposium “Thirty Years of Urban Wildlife Management: Directions for a New Millennium,” held in conjunction with The Wildlife Society’s Annual Meeting, Nashville, Tennessee, 12–16 September. (Abstract published)
- Adams, L.W. (1988) Some recent advances in urban wildlife research and management. In *Proceedings of the Third Southeastern Nongame and Endangered Wildlife Symposium* (R.R. Odom, K.A. Riddleberger and J.C. Ozier, eds.), pp. 213–224. Georgia Department of Natural Resources, Social Circle, USA.
- Adams, L.W. (1989) National Institute for Urban Wildlife. *Environmental Conservation* **16**, 276–277.
- Adams, L.W. (1994) *Urban Wildlife Habitats: A Landscape Perspective*. University of Minnesota Press, Minneapolis, USA.
- Adams, L.W. and Dove, L.E. (1984) *Urban Wetlands for Stormwater Control and Wildlife Enhancement*. National Institute for Urban Wildlife, Columbia, Maryland, USA.

- Adams, L.W. and Dove, L.E. (1989) *Wildlife Reserves and Corridors in the Urban Environment: A Guide to Ecological Landscape Planning and Resources Conservation*. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Adams, L.W. and Leedy, D.L., (eds.) (1987) *Integrating Man and Nature in the Metropolitan Environment*. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Adams, L.W. and Leedy, D.L., (eds.) (1991) *Wildlife Conservation in Metropolitan Environments*. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Adams, L.W. and VanDruff, L.W. (1998) Introduction. *Urban Ecosystems* **2**, 63.
- Adams, L.W., Hadidian, J. and Flyger, V. (2004) Movement and mortality of translocated urban-suburban grey squirrels. *Animal Welfare* **13**, 45–50.
- Adams, L.W., Leedy, D.L. and McComb, W.C. (1987) Urban wildlife research and education in North American colleges and universities. *Wildlife Society Bulletin* **15**, 591–595.
- Adams, L.W., VanDruff, L.W. and Luniak, M. (2005) Managing urban habitats and wildlife. In *Techniques for Wildlife Investigations and Management* (C.E. Braun, ed.), sixth edition, pp. 714–739. The Wildlife Society, Bethesda, Maryland, USA.
- Aldrich, J.W. and Coffin, R.W. (1980) Breeding bird populations from forest to suburbia after thirty-seven years. *American Birds* **34**, 3–7.
- Arnold, R.A. and Goins, A.E. (1987) Habitat enhancement techniques for the El Segundo blue butterfly: an urban endangered species. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 173–181. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Australian Research Centre for Urban Ecology. (2004) Australian Research Centre for Urban Ecology. (<http://arcue.botany.unimelb.edu.au>).
- Baines, C. (1985) *How to Make a Wildlife Garden*. Elm Tree Books, London, UK.
- Baines, C. (1986) *The Wild Side of Town*. Elm Tree Books and BBC Publications, London, UK.
- Baines, C. and Smart, J. (1991) *A Guide to Habitat Creation*. Packard Publishing Limited, Chichester, UK.
- Barker, G.M.A. (1987) European approaches to urban wildlife programs. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 183–190. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Batten, L.A. (1972) Breeding bird species diversity in relation to increasing urbanization. *Bird Study* **19**, 157–166.
- Beissinger, S.R. and Osborne, D.R. (1982) Effects of urbanization on avian community organization. *Condor* **84**, 75–83.
- Belensky, B.L. and Norman, P.C. (2000) The role of local government in urban wildlife management: the Howard County, Md. model. Presented at the symposium “Thirty Years of Urban Wildlife Management: Directions for a New Millennium,” held in conjunction with The Wildlife Society’s Annual Meeting, Nashville, Tennessee, 12–16 September. (Abstract published)
- Bender, K.C. (2004) Texas wildscapes: landscaping for wildlife. In *Proceedings of the 4th International Symposium on Urban Wildlife Conservation* (W.W. Shaw, L.K. Harris and L. VanDruff, eds.), pp. 267–269. University of Arizona, Tucson, USA.
- Bennett, R. (1946) Summarization of the eleventh North American Wildlife Conference. *Transactions of the North American Wildlife Conference* **11**, 511–518.
- Blair, R.B. (1996) Land use and avian species diversity along an urban gradient. *Ecological Applications* **6**, 506–519.
- Blair, R.B. and Launer, A.E. (1997) Butterfly diversity and human land use: species assemblages along an urban gradient. *Biological Conservation* **80**, 113–125.
- Bolen, E.G. and Robinson, W.L. (2003) *Wildlife Ecology and Management*. 5th ed. Prentice Hall, Upper Saddle River, New Jersey, USA.
- Briffett, C., Yuen, B. and Marrs, C.B. (2000) *Multiple-Use Green Corridors in the City: Guidelines for Implementation*. Nature Society, Singapore.
- Briffett, C., Kong, L., Yuen, B. and Sodhi, N. (1997) *The Planning and Ecology of Park Connector Systems in Urban Areas: Pilot Study Based on Ulu Pandan Canal, Clementi, Singapore*. National University of Singapore, Singapore.
- Briffett, C., Kong, L., Yuen, B. and Sodhi, N. (1999) *Nature in Urban Areas: the Planning and Ecology of Green Corridor Systems in Singapore*. National University of Singapore, Singapore.

- Brookes, J. (1998) *Natural Landscapes*. DK Publishing, Inc., New York, USA.
- Brooks, T. and Wortman, D. (1999) *Protecting Open Space: A Review of Successful Programs and Landowner Perspectives*. Metro, Portland, Oregon, USA.
- Brown, P.M., D'Amico, D.R., Carpenter, A.T. and Andrews, D. (2001) Restoration of montane ponderosa pine forests in the Colorado Front Range: A forest ecosystem management plan for the city of Boulder. *Ecological Restoration* **19**, 19–26.
- Bureau of Sport Fisheries and Wildlife. (1968) *Man and Nature in the City*. U.S. Department of the Interior, Washington, D.C., USA.
- Bustad, L.K. (1987) Historical perspective. In *Health Benefits of Pets: Program and Abstracts*, pp. 19–20. NIH Technology Assessment Workshop, 10–11 September, Bethesda, Maryland, USA.
- Clergeau, P., Savard, J.-P.L., Mennechez, G. and Falardeau, G. (1998) Bird abundance and diversity along an urban-rural gradient: a comparative study between two cities on different continents. *Condor* **100**, 413–425.
- Cochran, P.A. (1989) Historical changes in a suburban herpetofauna in DuPage County, Illinois. *Bulletin of the Chicago Herpetological Society* **24**, 1–7.
- Conover, M.R. (2001) *Resolving Human-Wildlife Conflicts: the Science of Wildlife Damage Management*. Lewis Publishers, Boca Raton, Florida, USA.
- Dasmann, R.F. (1966) Wildlife and the new conservation. *The Wildlife Society News* **105**, 48–49.
- Davey, S.P. (1967) The role of wildlife in an urban environment. *Transactions of the North American Wildlife and Natural Resources Conference* **32**, 50–60.
- Davis, J.M. (2000) Urban wildlife programs: an overview and the Texas model. Presented at the symposium “Thirty Years of Urban Wildlife Management: Directions for a New Millennium,” held in conjunction with The Wildlife Society’s Annual Meeting, Nashville, Tennessee, 12–16 September. (Abstract published)
- Dawe, G.F.M. (1990) *The Urban Environment: A Sourcebook for the 1990s*. Centre for Urban Ecology, Birmingham, UK.
- DeGraaf, R.M. (1987) Urban wildlife habitat research-application to landscape design. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 107–111. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- DeGraaf, R.M. (1991) Winter foraging guild structure and habitat associations in suburban bird communities. *Landscape and Urban Planning* **21**, 173–180.
- DeGraaf, R.M. and Wentworth, J.M. (1986) Avian guild structure and habitat associations in suburban bird communities. *Urban Ecology* **9**, 399–412.
- Dieckmann, J. and Schuster, R. (1982) *Natural Landscaping: Designing with Native Plant Communities*. McGraw-Hill Book Company, New York, USA.
- Dunkle, F.H. (1987) Urban wildlife and the Fish and Wildlife Service: meeting a growing challenge. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 5–7. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Emlen, J.T. (1974) An urban bird community in Tucson, Arizona: derivation, structure, and regulation. *Condor* **76**, 184–197.
- Fitter, R.S.R. (1945) *London’s Natural History*. Bloomsbury Books, London, UK.
- Germaine, S.S. and Wakeling, B.F. (2001) Lizard species distributions and habitat occupation along an urban gradient in Tucson, Arizona, USA. *Biological Conservation* **97**, 229–237.
- Gold, S.M. (1986) User characteristics and response to vegetation in neighbourhood parks. *Arboricultural Journal* **10**, 275–287.
- Goode, D.A. (1991) Wildlife in cities. In *Perspectives in Urban Ecology* (E.A. Webb and S.Q. Foster, eds.), pp. 7–21. Denver Museum of Natural History, Denver, Colorado, USA.
- Greater London Council. (1984) *Ecology and Nature Conservation in London*. Ecology Handbook 1. Greater London Council, London, UK.
- Hadidian, J. and Smith, S. (2001) Urban wildlife. In *The State of the Animals: 2001* (D.J. Salem and A.N. Rowan, eds.), pp. 165–182. The Humane Society of the United States, Washington, D.C., USA.
- Hadidian, J., Hodge, G.R. and Grandy, J.W. (eds.) (1997) *Wild Neighbors: the Humane Approach to Living with Wildlife*. Fulcrum Publishing, Golden, Colorado, USA.
- Harris, S. (1977) Distribution, habitat utilization and age structure of a suburban fox (*Vulpes vulpes*) population. *Mammalian Review* **7**, 25–39.

- Harris, S. (1981) The food of suburban foxes (*Vulpes vulpes*), with special reference to London. *Mammalian Review* **11**, 151–168.
- Harris, S. and Rayner, J.M.V. (1986) Urban fox (*Vulpes vulpes*) population estimates and habitat requirements in several British cities. *Journal of Animal Ecology* **55**, 575–591.
- Hench, J.E., Van Ness, K. and Gibbs, R. (1987) Development of a natural resources planning and management process. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 29–35. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Houck, M.C. (1991) Metropolitan wildlife refuge system: a strategy for regional natural resource planning. In *Wildlife Conservation in Metropolitan Environments* (L.W. Adams and D.L. Leedy, eds.), pp. 225–229. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Jokimäki, J. and Suhonen, J. (1993) Effects of urbanization on the breeding bird species richness in Finland: a biogeographical comparison. *Ornis Fennica* **70**, 71–77.
- Jones, D.N. and Nealson, T. (2003) Management of aggressive Australian magpies by translocation. *Wildlife Research* **30**, 167–177.
- Kieran, J. (1959) *A Natural History of New York*. Houghton Mifflin Company, Boston, Massachusetts, USA.
- Kuo, F. and Faber Taylor, A. (2004) A potential natural treatment for attention-deficit/hyperactivity disorder: evidence from a national study. *American Journal of Public Health* **94**, 1580–1586.
- Leedy, D.L. (1979) *An Annotated Bibliography on Planning and Management for Urban-suburban Wildlife*. FWS/OBS-79/25. Fish and Wildlife Service, U. S. Department of the Interior, Washington, D.C., USA.
- Leedy, D.L. and Adams, L.W. (1984) *A Guide to Urban Wildlife Management*. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Leedy, D.L., Franklin, T.M. and Maestro, R.M. (1981) *Planning for Urban Fishing and Waterfront Recreation*. FWS/OBS-80/35. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., USA.
- Leedy, D.L., Maestro, R.M. and Franklin, T.M. (1978) *Planning for Wildlife in Cities and Suburbs*. FWS/OBS-77/66. Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C., USA.
- Leopold, A. (1933) *Game Management*. Charles Scribner's Sons, New York, USA.
- Link, R. (1999) *Landscaping for Wildlife in the Pacific Northwest*. University of Washington Press, Seattle, USA.
- Luniak, M. (1990) Avifauna of cities in central and eastern Europe—results of the international inquiry. In *Urban Ecological Studies in Central and Eastern Europe* (M. Luniak, ed.), pp. 131–149. Ossolineum, Wroclaw, Poland.
- Lyons, J.R. and Leedy, D.L. (1984) The status of urban wildlife programs. *Transactions of the North American Wildlife and Natural Resources Conference* **49**, 233–251.
- Maestas, J. D., Knight, R.L. and Gilgert, W.C. (2003) Biodiversity across a rural land-use gradient. *Conservation Biology* **17**, 1425–1434.
- Marzluff, J.M., Bowman, R. and Donnelly, R. (eds.) (2001) *Avian Ecology and Conservation in an Urbanizing World*. Kluwer Academic Publishers, Boston, Massachusetts, USA.
- Matsil, M.A. and Feller, M.J. (1996) Natural areas restoration in New York City: a bite of the apple. *Restoration & Management Notes* **14**, 5–14.
- Montgomery County Department of Park and Planning. (2004) Natural Resources Division (www.mcnpc.org/naturalresources).
- Murphy, D. D. (1988) Challenges to biological diversity in urban areas. In *Biodiversity* (E.O. Wilson, ed.), pp. 71–76. National Academy Press, Washington, D.C., USA.
- National Park Service. (2004) Center for Urban Ecology (www.nps.gov/cue/).
- National Science Foundation. (2004) Cityscapes Are Landscapes, Too (www.nsf.gov).
- National Wildlife Federation. (1974) *Gardening With Wildlife: A Complete Guide to Attracting and Enjoying the Fascinating Creatures in Your Backyard*. National Wildlife Federation, Washington, D.C., USA.
- National Wildlife Federation. (2004) Backyard Wildlife Habitat™ Program (www.nwf.org).
- Nilon, C.H., Rowntree, R.A. and Natural Resources Group. (1987) Wildlife management in natural areas of New York City parks. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), p. 239. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Penland, S. (1987) The urban wildlife program of the Washington Department of Game. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), p. 241. National Institute for Urban Wildlife, Columbia, Maryland, USA.

- Roberts, D.C. (1994) The design of an urban open-space network for the city of Durban (South Africa). *Environmental Conservation* **21**, 11–17.
- Rolando, A., Maffei, G., Pulcher, C. and Giuso, A. (1997) Avian community structure along an urbanization gradient. *Italian Journal of Zoology* **64**, 341–349.
- Rollinson, D.J. and Jones, D.N. (2002) Variation in breeding parameters of the Australian magpie *Gymnorhina tibicen* in suburban and rural environments. *Urban Ecosystems* **6**, 257–269.
- Rollinson, D.J., O’Leary, R. and Jones, D.N. (2003) The practice of wildlife feeding in suburban Brisbane. *Corella* **27**, 52–58.
- Rudd, H., Vala, J. and Schaefer, V. (2002) Importance of backyard habitat in a comprehensive biodiversity conservation strategy: a connectivity analysis of urban green spaces. *Restoration Ecology* **10**, 368–375.
- Ruff, A.R. (1987) *Holland and the Ecological Landscapes 1973-1987*. Delft University Press, Delft, Netherlands.
- Savard, J.-P.L., Clergeau, P. and Mennechez, G. (2000) Biodiversity concepts and urban ecosystems. *Landscape and Urban Planning* **48**, 131–142.
- Shaw, W.W. and Supplee, V. (1987) Wildlife conservation in rapidly expanding metropolitan areas: informational, institutional, and economic constraints and solutions. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 191–197. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Shenstone, J.C. (1912) The flora of London building sites. *Journal of Botany* **50**, 117–124.
- Stearns, F.W. (1967) Wildlife habitat in urban and suburban environments. *Transactions of the North American Wildlife and Natural Resources Conference* **32**, 61–69.
- Sukopp, H. (1990) *Urban Ecology—the Case of Berlin*. D. Reimer Verlag, Berlin, Germany.
- The Humane Society of the United States. (2004) Urban wildlife—our wild neighbors. (www.hsus.org).
- The Trust for Public Land. (1994) *Healing America’s Cities: Why We Must Invest in Urban Parks*. The Trust for Public Land, San Francisco, California, USA.
- The Wildlife Trusts. (2003) (www.wildlifetrusts.org).
- The Wildlife Society. (2003) Wildlife policy statement – urban wildlife. (www.wildlife.org).
- Thompson, G.F. and Steiner, F.R. (eds.) (1997) *Ecological Design and Planning*. John Wiley & Sons, Inc., New York, USA.
- Thorne, D.H. and Witter, D.J. (2001) Developing urban programs in Missouri. In *Human Dimensions of Wildlife Management in North America* (D.J. Decker, T.L. Brown, and W.F. Siemer, eds.), pp. 200–201. The Wildlife Society, Bethesda, Maryland, USA.
- Tufts, C. (1987) The National Wildlife Federation’s urban wildlife programs... working for the nature of tomorrow™. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 241–242. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- Tufts, C. and Loewer, P. (1995) *Gardening for Wildlife: How to Create a Beautiful Backyard Habitat for Birds, Butterflies and Other Wildlife*. Rodale Press, Emmaus, Pennsylvania, USA.
- Twiss, R.H. (1967) Wildlife in the metropolitan landscape. *Transactions of the North American Wildlife and Natural Resources Conference* **32**, 69–74.
- Tylka, D.L., Schaefer, J.M. and Adams, L.W. (1987) Guidelines for implementing urban wildlife programs under state conservation agency administration. In *Integrating Man and Nature in the Metropolitan Environment* (L.W. Adams and D.L. Leedy, eds.), pp. 199–205. National Institute for Urban Wildlife, Columbia, Maryland, USA.
- UK-MAB Urban Forum. (2003) Annual report 2002/03 & work programme 2003/04 (www.ukmaburbanforum.org.uk).
- Ulrich, R.S. (1979) Visual landscape and psychological well-being. *Landscape Research* **4**, 17–23.
- UNESCO. (2003) The MAB programme (www.unesco.org/mab).
- Urban Ecology Australia. (2003) Urban Ecology Australia (www.urbanecology.org.au).
- U.S. Fish and Wildlife Service. (2003) Urban Conservation Treaty for Migratory Birds (<http://birds.fws.gov/urbantreaty>).
- U.S. Fish and Wildlife Service. (2004) America’s National Wildlife Refuge System (<http://refuges.fws.gov>).
- VanDruff, L.W. and Rowse, R.N. (1986) Habitat association of mammals in Syracuse, New York. *Urban Ecology* **9**, 413–434.

- VanDruff, L.W., Bolen, E.G. and San Julian, G.J. (1994) Management of urban wildlife. In *Research and Management Techniques for Wildlife and Habitats* (T.A. Bookhout, ed.), pp. 507–530. The Wildlife Society, Bethesda, Maryland, USA.
- Walcott, C.F. (1974) Changes in bird life in Cambridge, Massachusetts from 1860 to 1964. *Auk* **91**, 151–160.
- Werner, J.E. and Tylka, D. (1984) Urban biology: the Missouri prototype. In *Proceedings—Workshop on Management of Nongame Species and Ecological Communities* (W.C. McComb, ed.). University of Kentucky, Lexington, USA.
- Zalewski, A. (1994) A comparative study of breeding bird populations and associated landscape character, Toruń, Poland. *Landscape and Urban Planning* **29**, 31–41.
- Zerbe, S., Maurer, U., Schmitz, S. and Sukopp, H. (2003) Biodiversity in Berlin and its potential for nature conservation. *Landscape and Urban Planning* **62**, 139–148.