

Exploring the ecology of suburban wildlife

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The fringes of cities, and rural properties within commuting distance of cities, experience some of the highest rates of development in the world. This can cause dramatic changes to the landscape, the alteration of ecological functions, and a reduction in biodiversity. With the spread of suburbia, however, come opportunities for some species to exploit new resources. While many wild creatures can enrich the lives of suburban dwellers, large increases in the populations of species such as deer, beaver, and coyotes can lead to a change in status from resource to pest. For several decades, wildlife managers have alternately embraced and ignored issues related to urban and suburban wildlife. Today, management of suburban areas challenges wildlife agencies on two fronts: the threat to habitat and biodiversity and the problem of “overabundant” wildlife. This is not only a tremendous management challenge, but also an educational opportunity to help people understand the natural world and their place in it.

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“In God’s wildness lies the hope of the world – the great fresh unblighted, unredeemed wilderness. The galling harness of civilization drops off, and wounds heal ere we are aware.” So said John Muir a century ago (Wolfe 1945). We are fortunate to have his writings to ponder, and some large expanses of wilderness left in North America to cherish and protect. Many people view wilderness as a unique and important component of the American landscape, and most associate wildlife – grizzly bears (*Ursus arctos*), Golden Eagles (*Aquila chrysaetos*), elk (*Cervus elaphus*), and wolves (*Canis lupus*) – with wild country.

Ever since the first towns sprang up along the Atlantic coast, however, has changed the fauna of North America (Figure 1). Some animals were pushed further into the wilderness or exploited to the point of extinction, while other species were able to cope with life in and near cities and towns. As early as 1641, it was

known that Chimney Swifts (*Chaetura pelagica*) nested in the chimneys of colonists’ homes (Josselyn 1672). More recently, it is not uncommon to see local newspaper reports on wildlife invading suburbia, including moose (*Alces alces*) wandering into suburban Boston, mountain lions (*Puma concolor*) hunting in the foothill developments of Colorado and California, coyotes (*Canis latrans*) patrolling the neighborhoods of Tucson and Phoenix, black bears (*Ursus americanus*) visiting the backyards of suburban houses, and Canada geese (*Branta canadensis*), raccoons (*Procyon lotor*), and foxes showing up everywhere. Human–wildlife encounters are taking place not only in the national forests and parks, or wilderness areas of America; more and more often, they are occurring in backyards and neighborhoods. Wild animals have visited the suburbs, and in many cases they have decided to stay.

Wildlife ecologists traditionally sought research sites in areas that were relatively free of human influences. National parks, refuges, and wilderness-type settings offer opportunities to observe and examine wildlife populations existing without undue human influence. In other cases, biologists study the effects of specific human activities, such as timber harvesting (DeStefano and Haight 2002), outdoor recreation (Knight and Gutzwiller 1995), or hunting (Freese 1997) on wildlife habitats and populations. Although such research has usually taken place away from human habitation, since the early 1970s there has been a growing interest among biologists in studying wildlife in places where people live (VanDruff *et al.* 1994; Miller and Hobbs 2002).

In this paper, we examine studies aimed at the ecology of wildlife populations in urban and suburban environments. We review the history of interest in urban and suburban wildlife, discuss the concepts and issues related to urban and suburban ecology, and propose approaches to increase our understanding of these ecosystems and human–wildlife relationships.

In a nutshell:

- Suburban development is widespread in developed nations, altering landscapes and affecting wildlife populations.
- Some species do well in suburban environments, enriching the lives of suburban dwellers
- Some do so well that their populations grow to the point of overabundance, causing property damage and threatening human health and safety
- Still others, particularly species with specific habitat requirements, low reproductive capability, or sensitivity to disturbance, cannot cope with increased human densities and become rare or locally extinct
- Part of the challenge of dealing with the spread of suburban development lies in understanding the complexity of suburban environments as ecosystems for humans and wildlife

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Figure 1. The juxtaposition of towns and natural areas, and the spread of suburban sprawl throughout the US and other developed nations, has brought wildlife and humans into increasing contact.

■ A two-edged sword

Many conservation biologists would agree that the net effect of rapid suburban growth (sometimes called “sprawl”) on biodiversity is negative (Marzluff 2002). Development and its effects on local and regional fauna and flora is a worldwide phenomenon associated with all developed and many developing nations (Vitousek *et al.* 1997; Wu and Overton 2002). Decreases in open space cause habitat loss and degradation, and the resulting effects can contribute to changes in species diversity and the genetic isolation of animals with low mobility (Knight 1990). Suburban development is now arguably one of the largest threats to biodiversity in developed nations (Marzluff 2001).

While suburban development has a negative impact on some species, others are either predisposed to existence in human-dominated environments (Johnston 2001), or are able to disperse into these areas, survive, and reproduce by taking advantage of the available resources and environmental conditions. For example, sheds and building foundations in the towns of southern New England provide important winter cover for opossums (*Didelphis virginiana*), contributing to the northward expansion of the opossum’s geographic range (TK Fuller, pers comm). Suburbanites assist the geographic spread and population growth of some species by either purposefully or unwittingly providing food, shelter, and protection (Figure 2). Feeders provide food for seed-eating birds, and gardens and ornamental shrubs provide forage for deer and nectar for hummingbirds and

butterflies. The resulting assemblage of species can have a tremendous positive effect on suburban dwellers, as many people enjoy viewing wildlife near their homes. However, populations of some species can grow to the point where they harm property, create road hazards, or spread disease. The result is a confusing dichotomy: suburban development can be either a detriment or a benefit to wildlife, depending on the species.

■ The challenge of suburban development

In 1990, there were 274 metropolitan areas in the US, covering 20% of the country’s land area and containing almost 200 million people – 80% of the country’s total population (Heimlich and Anderson 2001). While populations in and around some of these urban centers grew by only 3–5% in the past decade, the area of land

developed grew by more than 50% during that time.

Heimlich and Anderson (2001) identified two major types of development that impact open space: growth along the edges of urban areas, and the development of large house lots (at least 0.5 ha in size, with many ≥ 4 ha) beyond the edges of existing urban areas and out into rural countryside. This rapid change in land use characteristically involves low-density development that is dispersed, uses a lot of land, causes an almost complete dependence on automobiles, and separates essential places such as homes, offices, and shopping areas (Heimlich and Anderson 2001).

In addition to the loss of open space, suburban develop-



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Figure 2. Wild turkeys (*Meleagris gallopavo*) are among many species that can take advantage of the resources, including food and shelter, available in suburban environments.



Figure 3. Among the species that inhabit suburban environments in the Southwest are collared peccaries (a) and Greater Roadrunners (b). By introducing new water sources, either as freestanding water or irrigation for landscaping, desert suburbs may increase local wildlife diversity.

ment brings other changes to the biota and the landscape. Non-native plants and animals are much more common around human developments than in natural areas. The spread of invasive exotic species can be correlated with the spread of humans (Withers *et al.* 1998). This list includes domestic or feral cats, which compete with and prey on the native fauna (Barratt 1998). Increased road densities and traffic volume are an additional source of mortality for native wildlife (VanDruff *et al.* 1994).

Despite these changes, some wildlife species are able not only to exist in suburban areas, but to thrive there. White-tailed deer (*Odocoileus virginianus*), coyotes, beaver (*Castor canadensis*), raccoons, and opossums, among others, do well in and around suburban neighborhoods in the northeastern US, because there is little hunting or trapping, abundant food and cover, and few remaining predators. In the Southwest, collared peccaries (*Pecari tajacu*), ringtails (*Bassariscus astutus*), and Greater Roadrunners (*Geococcyx californicus*) inhabit cities and towns (Ticer *et al.* 1998; Webster and DeStefano *in press*; Figure 3). Several raptor species and many types of songbird take advantage of suburbanized environments, which provide nest sites and plenty of food (Boal and Mannan 1998; Johnston 2001). When there is adequate food and water, Canada geese often take up year-round residence in urban and suburban parks and on golf courses (Ankney 1996).

■ Rising interest and changing issues

Scientists and managers have long been interested in urban and suburban wildlife in North America. In the early 1900s, papers on wildlife in towns and cities emphasized artificial habitat elements such as nest boxes and feeding stations, particularly for birds (McAtee 1914). In the classic work *Game management*, Aldo Leopold explained how gardening and landscaping could be used to attract songbirds (Leopold 1933).

During the mid-20th century, studies were published on the distribution of birds and mammals, such as squirrels and opossums, in developed areas (Lay 1942; Brown and Yeager 1945). There was also an increasing interest in attracting birds to urban settings and suburban backyards (McElroy 1951), with the general attitude that the presence of wild creatures – birds in particular – enriches human lives. The positive social and economic values of wildlife living in conjunction with people were recognised, and there was a heightened awareness and understanding of the natural environment (Lewis 1951). Despite this, the ornithologist W Erz (1966) wrote that, “Studies of the artificial habitats of towns and cities seem to be no popular subject of real ‘nature’ study.”

Interest in urban and suburban wildlife increased greatly in the late 1960s and 1970s. Several proceedings and bibliographies were published, containing hundreds of articles on a wide range of topics (USDI BSWF 1968; Noyes and Progulsk 1974; Euler *et al.* 1975; Leedy 1979). For example, Leedy (1979) listed 464 papers and reports on aspects of the urban environment, the effects of urbanization on wildlife, plantings for wildlife, animal damage and human health and safety, planning and management, and research and education.

The emphasis at this time was still largely on attracting birds, but there were dozens of papers on other vertebrate groups, and even a few on invertebrates such as butterflies. Many articles not only dealt with the positive aspects of attracting wildlife to towns and cities, but also how development was negatively impacting populations of native fauna. Urban and suburban areas were now beginning to be recognized as ecosystems in and of themselves, or as integral parts of larger regional systems (Holling and Orians 1971), albeit with altered functions and processes (Stearns 1978).

Problems were also beginning to develop with some species of wildlife in urban and suburban settings at this



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Figure 4. Predators such as red foxes (*Vulpes vulpes*) frighten some suburban residents, in part because they can carry rabies and occasionally prey on pets. Wildlife can be unpredictable, but education may help residents learn how to live with these animals.

time (Figure 4). Many of the papers on animal damage and control focused on birds, particularly near airports. Authors also discussed aspects of human health and safety (Karstad 1975) and human preferences for wildlife (Gray *et al.* 1979), including rising public sentiment against sport hunting and trapping (Shaw *et al.* 1978). Despite these concerns, the emphasis was still positive, with biologists urging enhancement of wildlife habitats and more and more homeowners showing interest in having songbirds and small mammals, such as chipmunks and rabbits, visit their property. In 1974, 20% of US households fed wild birds, spending almost two billion dollars in current value (DeGraaf and Payne 1975).

After a proliferation of symposium proceedings in the 1970s, the wildlife profession appeared to lose interest in urban wildlife. Conservation entered a period of intense focus on endangered species recovery and concerns over issues such as the fragmentation of old growth forest, the impacts of livestock grazing on public lands, biodiversity loss, and reserve design. Much of this activity took place away from cities and towns, with debates raging on how public lands (including national forests and parks) should be managed.

However, in the 1990s, human–wildlife interactions once again came to the forefront, albeit with a new and more urgent emphasis. Populations of species such as white-tailed deer, Canada geese, black bears, coyotes, and beaver were growing in numbers, particularly in the Northeast. At the same time, animal rights groups were gaining support and winning referenda to limit or abolish hunting and trapping, especially in states with high concentrations of urban dwellers, such as Arizona, California, Massachusetts, and Oregon (Deblinger *et al.* 1999).

Suburban development and home building in open areas were bringing people into contact with wildlife more frequently. These factors combined to create and intensify problems from the standpoint of human health, safety, and property damage.

The recent scientific literature reflects these growing concerns. Articles on urban and suburban wildlife are no longer confined to symposium proceedings, but are published in mainstream scientific journals such as *Ecology* and the *Journal of Wildlife Management*. Wildlife management now includes dealing with problems brought about by overabundant wildlife, or issues that are perceived to be problems by an increasingly concerned but sometimes uninformed and often inexperienced public.

Recent major trends

Interest in urban wildlife in the United States dates back at least to the early 1900s,

and has been periodic, judging by the published literature we were able to examine. After the appearance of Leopold's *Game Management* in the 1930s, many papers on urban wildlife appeared in the 1950s, 1970s, and 1990s. There seems to have been a 20-year cycle of interest, but the intensity has grown each time, with larger numbers of papers on broader topics being published in a greater variety of outlets. Interest in urban and suburban environments is now a worldwide phenomenon, with information being generated from many continents, including Australia and Europe. Among this proliferation of information, we have identified the following trends.

Urban versus suburban wildlife

Much of the early literature focused on wildlife in cities. The large number of symposia proceedings published in the 1970s included the term “urban” in their titles, although the intent was to include smaller towns, neighborhoods, and backyards, as well as cities or urban centers. In the 1990s, however, suburban areas as well as cities have been a major focus of activity. We believe the following factors contributed to the increasing interest in suburban wildlife, although the last two are untested hypotheses: (1) most development and loss of open space occurs as suburban development, along the urban–rural interface (Heimlich and Anderson 2001), (2) numbers and diversity of species are greater in suburban than urban areas (Clergeau *et al.* 1998), (3) human–wildlife interactions, both positive and negative, are highest in suburban areas, and (4) for most local wildlife management agencies, problems with wildlife are greatest in suburban areas. For these reasons, we propose that suburban and urban envi-

ronments are different in their structure, function, and assemblage of wildlife issues in many cases, even though these areas are connected and share many of the same attributes with regard to wildlife.

Urban and suburban environments as ecosystems

Despite some structural differences, both urban and suburban areas are increasingly being recognized as ecosystems, or at least part of larger regional ecosystems (Zipperer *et al.* 2000). People who live in cities or suburban developments often think of nature as something that exists outside their neighborhoods. However, ecological functions such as hydrology, energy flow, and plant and animal community dynamics happen within urban and suburban environments, albeit in altered states (Pickett *et al.* 2001). The National Science Foundation has established two long-term ecological research (LTER) areas in metropolitan Baltimore and Phoenix to study these relationships, including the responses of wild species, particularly birds.

Growing emphasis on pest management

In the past decade, suburban wildlife has involved pest management much more than in the past. While the focus in the 1970s and earlier was on bird species, and actively attracting them to homes and backyards, the focus since 1990 has often been on mammals such as deer, beaver, coyotes, and bears, and the problems and conflicts they can have with people (Figure 5). There are several reasons for this shift: (1) we continue to build homes further into wildlife habitat, thus coming into direct contact with a greater variety of animals; (2) many animal populations have responded to changes in habitat availability by increasing in numbers and distribution; and (3) interest in hunting and trapping has declined in some areas, or has been restricted, thus limiting an effective method of control. As an animal population grows beyond a region's cultural carrying capacity (Carpenter *et al.* 2000), defined as the level at which most people will tolerate a species, it starts to be considered a problem. Deer, beaver, and geese are now overabundant in some places and, because they, eat shrubbery, flood property, and defecate prolifically, respectively, they are regarded as pests.

Less trust in management agencies

With emphasis shifting away from hunting and trapping as legitimate activities and a greater involvement of animal rights and other groups in wildlife management, political referenda have superseded the role of wildlife management



Figure 5. The adaptable nature of many wildlife species has created problems for suburban residents.

Courtesy of W. Larson

agencies, particularly at the state level. Public trust in these agencies is declining, often because they are perceived as overseeing, regulating, and promoting traditional uses of wildlife, such as hunting and trapping (Rutberg 2001). These views have exacerbated the pest-management problem, allowing some wildlife populations to grow under favorable conditions, while at the same time removing game laws and regulations, an effective and controllable method of mortality (Deblinger *et al.* in press). In most cases, mortality factors such as motor vehicle deaths, pest control methods, and predation by domestic or feral animals, such as dogs and cats, have replaced hunting and trapping. While the more traditional methods generated funds for use in wildlife management, including the purchase of open space for conservation, vehicle accidents and pest control are costly to society.

Research and conservation in suburbia

DeGraaf and Thomas (1974) identified three main components to serve as a framework for new research on urban and suburban wildlife: human preferences, habitat requirements, and human-wildlife interactions. Not only did the authors state the importance of understanding how wildlife populations function in cities and towns, especially as related to the distribution and structure of vegetation, they also clearly recognized the importance of the human dimension to wildlife ecology and management. The merging of human ecology (the study of the role of humans in their environment) and wildlife ecology with the study of the relationships between human societies and the conservation of natural resources, including philosophies, economics, and public policy, is critical to conservation success in human-dominated landscapes. Trying to understand and solve urban and suburban wildlife issues without fac-



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Figure 6. A Northern Flicker (*Colaptes chrysoides*) advertises its suburban presence to biologists and fellow birds.

toring in the human dimension is like trying to understand wildlife population dynamics, endangered species recovery, and other major conservation endeavors without taking into account human population growth and resource consumption. Without the human component, we are doomed to failure.

Along with human ecology, researchers need to consider several approaches to examining suburban ecology (VanDruff *et al.* 1994). The ecosystem approach focuses on the magnitude, flow, and changes in energy, nutrients, and products and services that ecosystems can provide (Zipperer *et al.* 2000). A patch-dynamic approach recognizes the urban/suburban landscape as a mosaic of biological and physical patches within a matrix of infrastructure and social institutions (Nilon and Pais 1997; Zipperer *et al.* 2000). Metapopulation dynamics, including concepts such as sources and sinks, as well as wildland-to-urban gradients (McDonnell and Pickett 1990) and the influence of the surrounding landscape matrix, should also be considered. The responses of wildlife populations to development probably vary among ecological regions, for instance between the forests of the northeastern US and the deserts of the Southwest. It is also vital to understand the influence of development on the demographic performance of populations (for example, reproduction, survival, and dispersal), rather than merely documenting presence and relative abundance of species. Underscoring all of these approaches is the need to promote more experimental designs with adequate replication, rather than simple correlative studies.

Finally, professionals and policy makers need to recognize the mounting resentment that some suburban residents feel toward wildlife, notably deer, beaver, and coyotes. Although there is evidence that these negative attitudes toward wildlife are held by a vocal minority (Coluccy *et al.* 2001), there is growing concern over an apparent attitude

shift from wildlife as a resource to wildlife as pests, with the consequent tendency to deal with these animals in much the same way that we have dealt with problem insects (Winston 1997). Some segments of society are vehemently opposed to hunting and trapping, even to control problem animals, and have moved to alienate hunters and trappers from the conservation movement. Others see a changing role for wildlife agencies in controlling nuisance wildlife (Hadidian *et al.* 2001). It is obvious that the multifaceted problems and challenges of urban and suburban wildlife management spark diverse opinions. The keys to progress in human-wildlife relationships lie in understanding public attitudes and perceptions, promoting wildlife education, and initiating sensible methods of control when necessary.

■ Conclusion

In the introduction to *An annotated bibliography on planning and management for urban-suburban wildlife*, Leedy (1979) states that “the thoughtless elimination of habitat... is now being replaced by conscientious planning to maintain a diversified natural environment”. That was perhaps a rather optimistic view. In fact, the rate of suburban development has increased greatly in the intervening decades. Loss of habitat and open space, with the associated threats to biodiversity and quality of life, is an increasingly serious problem for native flora and fauna.

After varying levels of interest during the 20th century, however, it seems that concern for urban and suburban wildlife issues is here to stay. We believe that wildlife managers will not only maintain an interest in this aspect of wildlife ecology, but that the study of animal populations in human-dominated landscapes will be viewed as a major and legitimate area of ecological research. Most importantly, we hope that wildlife ecology and human dimensions become integral, coordinated components with common goals. What was perhaps viewed as peripheral to the science of ecology in the 1970s is now a dominant theme in all developed and most developing nations. If nothing else, public demand and political pressure will probably force wildlife biologists out of the woods and into the suburbs and cities (Figure 6).

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■ References

- Ankney CD. 1996. An embarrassment of riches: too many geese. *J Wildlife Manage* 60: 217–23.
- Barratt DG. 1998. Predation by house cats, *Felis catus* (L.), in

- Canberra, Australia. II. Factors affecting amount of prey caught and estimates of the impact on wildlife. *Wildlife Res* 25: 475–87.
- Boal CW and Mannan RW. 1998. Nest-site selection by Cooper's hawks in an urban environment. *J Wildlife Manage* 62: 864–71.
- Brown LG and Yeager LE. 1945. Fox squirrels and gray squirrels in Illinois. *Bull Ill Nat Hist Surv* 23: 449–536.
- Carpenter LH, Decker DJ, and Lipscomb JF. 2000. Stakeholder acceptance capacity in wildlife management. *Hum Dim Wildlife* 5: 5–19.
- Clergeau P, Savard JPL, 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: 413–25.
- Coluccy JM, Drobney RD, Graber DA, et al. 2001. Attitudes of central Missouri residents toward local giant Canada geese and management alternatives. *Wildlife Soc B* 29: 116–23.
- Deblinger RD, Field R, Finn JT, and Loomis DK. A conceptual model of suburban wildlife management: a case of beaver in Massachusetts. In: Shaw WW and Harris L (Eds). *Proceedings of the Fourth International Symposium on Urban Wildlife Conservation*. Tucson, AZ. In press.
- Deblinger RD, Woytek WA, and Zwick RR. 1999. Demographics of voting on the 1996 Massachusetts ballot referendum. *Hum Dim Wildlife* 4: 40–55.
- DeGraaf RM and Payne BR. 1975. Economic values of nongame birds and some urban wildlife research needs. *T N Am Wildl Nat Res* 40: 281–87.
- DeGraaf RM and Thomas JW. 1974. A strategy for wildlife research in urban areas. In: Noyes JH and Progulsk DR (Eds). *Wildlife in an urbanizing environment*. Amherst, MA: Cooperative Extension Service, University of Massachusetts.
- DeStefano S and Haight RG (Eds). 2002. *Forest wildlife-habitat relationships: population and community responses to forest management*. Bethesda, MD: Society of American Foresters.
- Euler D, Gilbert F, and McKeating G (Eds). 1975. *Wildlife in urban Canada*. Guelph, Ontario, Canada: Office of Continuing Education, University of Guelph, and Ontario Ministry of Natural Resources.
- Erz W. 1966. Ecological principles in the urbanization of birds. *Ostrich, Suppl* 6: 357–63.
- Freese CH (Ed). 1997. *Harvesting wild species: implications for biodiversity conservation*. Baltimore, MD: Johns Hopkins University Press.
- Gray GG, Larson JS, and Braunhardt DA. 1979. Urban conservation leadership and the wildlife resource. *Urban Ecol* 4: 1–9.
- Hadidian J, Childs MR, Schmidt RH, et al. 2001. Nuisance-wildlife control practices, policies, and procedures in the United States. In: Field R, Warren RJ, Okarma H, and Sievert PR (Eds). *Wildlife, land, and people: priorities for the 21st century*. Bethesda, MD: The Wildlife Society.
- Heimlich RE and Anderson WD. 2001. Development at the urban fringe and beyond, impacts on agriculture and rural land. Washington, DC: US Department of Agriculture.
- Holling CS and Orians G. 1971. Toward an urban ecology. *Bull Ecol Soc Am* 52: 2–6.
- Johnston RF. 2001. Synanthropic birds of North America. In: Marzluff JM, Bowman R, and Donnelly R (Eds). *Avian ecology and conservation in an urbanizing world*. Boston: Kluwer Academic Publications.
- Josselyn J. 1672. *New England's rarities discovered*. Boston: W. Veazie. Reprinted 1860.
- Karstad L. 1975. Disease problems of urban wildlife. In: Euler D, Gilbert F, and McKeating G (Eds). *Wildlife in urban Canada*. Guelph, Ontario, Canada: Office of Continuing Education, University of Guelph.
- Knight RL. 1990. Ecological principles applicable to management of urban ecosystems. In: Webb EA and Foster SQ (Eds). *Perspectives in urban ecology*. Denver, CO: Denver Museum of National History.
- Knight RL and Gutzwiller KJ (Eds). 1995. *Wildlife and recreationists: coexistence through management and research*. Washington, DC: Island Press.
- Lay DW. 1942. Ecology of the opossum. *J Mammal* 23: 147–58.
- Leopold A. 1933. *Game management*. New York: Scribners.
- Leedy DL (Ed). 1979. *An annotated bibliography on planning and management for urban–suburban wildlife*. Washington, DC: US Fish and Wildlife Service.
- Lewis HF. 1951. Wildlife in today's economy: aesthetic and recreational values of wildlife. *T N Am Wildl Conf* 16: 13–16.
- Marzluff JM. 2001. Worldwide urbanization and its effects on birds. In: Marzluff JM, Bowman R, and Donnelly R (Eds). *Avian ecology and conservation in an urbanizing world*. Boston: Kluwer Academic Publications.
- Marzluff JM. 2002. Fringe conservation: a call to action. *Conserv Biol* 16: 1175–76.
- McAtee WL. 1914. *How to attract birds in northeastern United States*. Washington, DC: US Department of Agriculture.
- McDonnell MJ and Pickett STA. 1990. Ecosystem structure and function along urban–rural gradients: an unexploited opportunity for ecology. *Ecology* 71: 1232–37.
- McElroy TP Jr. 1951. *Handbook of attracting birds*. New York: Alfred A. Knopf.
- Miller JR and Hobbs RJ. 2002. Conservation where people live and work. *Conserv Biol* 16: 330–37.
- Nilon CH and Pais RC. 1997. Terrestrial vertebrates in urban ecosystems: developing hypotheses for the Gwynns Falls Watershed in Baltimore, Maryland. *Urban Ecosys* 1: 247–57.
- Noyes JH and Progulsk DR (Eds). 1974. *Wildlife in an urbanizing environment*. Amherst, MA: Cooperative Extension Service, University of Massachusetts.
- Pickett STA, Cadenasso ML, Grove JM, et al. 2001. Urban ecological systems: linking terrestrial ecological, physical, and socioeconomic components of metropolitan areas. *Ann Rev Ecol Syst* 32: 127–57.
- Rutberg AT. 2001. Why state agencies should not advocate hunting or trapping. *Human Dimensions of Wildlife* 6: 33–37.
- Shaw WW, Carpenter EH, Arthur LM, et al. 1978. The American disposition toward hunting in 1976. *Wildlife Soc B* 6: 33–35.
- Stearns FW. 1978. Urban ecology – opportunity or tar pit? *Bull Ecol Soc Am* 59: 7–9.
- Ticer CL, Ockenfels RA, deVos JC Jr, and Morrell TE. 1998. Habitat use and activity patterns of urban-dwelling javelina. *Urban Ecosys* 2: 141–51.
- USDI BSWF (US Department of the Interior, Bureau of Sport Fisheries and Wildlife). 1968. *Man and nature in the city*. Washington, DC: US Government Printing Office.
- VanDruff LW, Bolen EG, and San Julian GJ. 1994. Management of urban wildlife. In: Bookhout TA (Ed). *Research and management techniques for wildlife and habitats*. Bethesda, MD: The Wildlife Society.
- Vitousek PM, Mooney HA, Lubchenco J, and Melillo JM. 1997. Human domination of Earth's ecosystems. *Science* 277: 494–99.
- Webster CM and DeStefano S. Distribution and habitat of roadrunners in urban and suburban Tucson. *J Wildlife Manage*. In press.
- Winston ML. 1997. *Nature wars*. Cambridge, MA: Harvard University Press.
- Withers MA, Palmer MW, Wade GL, et al. 1998. Changing patterns in the number of species in North American floras. In: Sisk TD (Ed). *Perspectives on the land use history of North America: a context for understanding our changing environment*. Washington, DC: US Geological Survey.
- Wolfe LM. 1945. *Son of the wilderness: the life of John Muir*. New York: Alfred A. Knopf.
- Wu J and Overton C. 2002. Asian ecology: pressing problems and research challenges. *Bull Ecol Soc Am* 83: 189–94.
- Zipperer WC, Wu J, Pouyat RV, and Pickett STA. 2000. The application of ecological principles to urban and urbanizing landscapes. *Ecol Appl* 10: 685–88.