Chapter 14
Managing Urban Wildlife Habitat at the Local Scale

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Homeowners and managers of municipal properties can make a significant contribution to urban wildlife conservation in backyards, neighborhood common areas, or local parks (Goddard et al. 2009). Although only 2.8 % of the earth's surface, the urban land base comprises more than 41.5 billion ha, yielding ample space to create and maintain habitat for wildlife (Millennium Ecosystem Assessment 2005). A majority of the urban land base lies in suburban and commercial developments, where individual home or business owners have local control over many of the factors (e.g., establishment and maintenance of vegetation in the landscape) that influence wildlife habitat. Herein, I provide a road map to successful management of wildlife habitat at the local scale, beginning with several guiding principles that should hold true in nearly every urban area around the globe. I describe key challenges to managing local habitat patches in the urban landscape and strategies that should improve the likelihood the habitat is managed appropriately for target wildlife. Most of these approaches involve protecting or restoring vegetation communities. Where vegetation has been mostly or entirely replaced by the built environment and associated impervious surfaces, opportunities to manage habitat locally will be limited. On the other hand, where large expanses of natural area were protected, relatively low levels of management may be required to conserve wildlife. Because every habitat patch has a unique management history, vegetation composition and structure, and surrounding context, each deserves a unique plan for its conservation.

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Finally, I address strategies to mitigate the potential detrimental effects of human structures that are common in urban areas (e.g., windows, communication towers, and power lines).

14.1 Guiding Principles

Habitat management in the urban environment will be most effective if conducted with consideration for four key factors that influence use of habitat patches by wildlife: (1) composition of the plant community; (2) species richness of the plant community, especially the prevalence of native plants; (3) vertical and horizontal structure of the vegetation; and (4) successional stage of the plant community. Each wildlife species has a unique set of requirements, and no single habitat patch can provide usable space for all local wildlife species. Therefore, management efforts should target the habitat requirements of focal wildlife species so resources are used efficiently and conservation goals are reached.

Composition of urban plant communities affects the distribution, amount, and timing of food and cover availability and, therefore, influences which wildlife species use habitat patches and when. For example, some animals associate with conifers (e.g., pine warbler (*Setophaga pinus*)), whereas others most commonly associate with hardwoods (e.g., eastern gray squirrel (*Sciurus carolinensis)*). Additionally, a diverse plant community ensures that food and cover are available year round and that alternative food sources, also known as buffer foods, are available when primary foods are not. Each plant species flowers and fruits at a different time, so greater diversity of plants generally results in a greater length of time that food resources are available to wildlife. Some plant species produce fruit crops in a cyclical pattern so that there can be boom and bust years, as is the case with acorn production by some species of oak (*Quercus* spp.). In the bust years, animals that depend on that food source must seek alternative buffer foods, which are likely to be more available in patches with a greater diversity of plant species.

The conservation of native plants is especially critical for wildlife in urban landscapes. For example, studies have shown that density and diversity of native birds in urban landscapes are greatest in areas with greater cover and volume of native plants (Mills et al. 1989; Germaine et al. 1998). Conversely, abundance of nonnative bird species may be greatest in areas dominated by nonnative vegetation (Germaine et al. 1998). Insects, especially lepidopteran caterpillars, are linked closely to native host plants, and many are absent when urban areas lack the native host plants (Burghardt et al. 2009). Additionally, avian nests constructed in nonnative plants in the urban landscape may experience greater rates of failure than nests placed in native plants (Schmidt and Whelan 1999; Borgmann and Rodewald 2004). These are just a few examples of problems posed for wildlife by increasing coverage of nonnative, invasive plants, and ongoing research is likely to expand our understanding of these relationships.

In forested systems, wildlife diversity tends to increase with the complexity of vertical vegetation structure. Vertical structure is the distribution of different layers of vegetation, including the ground layer, shrub layer, midstory layer, and canopy layer. Many wildlife species, especially birds, are able to distribute themselves vertically among these layers in a forest. Indeed, temperate hardwood forests with more forest layers tend to harbor a greater diversity of bird species (MacArthur and MacArthur 1961). However, well-developed canopy and midstory layers shade forest understories, thereby eliminating food and cover near the ground where most wildlife species persist. Canopy openings maintained via natural disturbance or management activities can help encourage development of the shrub and ground layers, thereby improving the habitat suitability for wildlife of lower forest layers (Moorman and Guynn 2001; Bakermans et al. 2012). In short, multi-dimensional plant communities provide more niches for wildlife than lawn and other two-dimensional plant communities.

Many specialist wildlife species are linked to specific stages of succession. For example, indigo bunting (*Passerina cyanea*) and least shrew (*Cryptotis parva*) commonly are associated with early succession plant communities dominated by herbaceous plants and shrubs. Protection, restoration, and management of early successional meadows and grasslands in urban areas help conserve unique plant and animal species. Conversely, salamander species typically are most abundant in late-succession plant communities, where the tree canopy shades the forest floor that contains a thick layer of leaf litter and cool, moist microclimate. However, these habitat types rarely are conserved in urban areas and both early and late seral stage specialists often are absent there; instead, the majority of wildlife species occurring in the urban landscape are generalists able to persist across a range of fragmented habitat types and successional stages.

The success of efforts to restore, create, or improve vegetation communities locally will be affected by distribution and management of habitat at the neighborhood (Chap. 13) and landscape scale (Chap. 12). For example, a small, isolated habitat patch surrounded by commercial development will not sustain area-sensitive wildlife species no matter how well the patch vegetation is managed. Conversely, large-scale efforts to conserve wildlife habitats in the urban landscape will not reach their full potential if conserved green spaces are not managed in a manner that maintains vegetation conditions appropriate for target wildlife species. Therefore, habitat conservation for urban wildlife must occur in an integrated fashion across every scale to be most successful (Goddard et al. 2009).

14.2 Managing Green Space

Protecting land from development provides a direct benefit to wildlife by conserving wildlife habitat, but management actions will be necessary to maximize the value of these natural areas. For example, hand removal or herbicide applications can be used to limit the spread of nonnative plants or canopy openings can be created or maintained to increase vertical and horizontal vegetation structure.

14.2.1 Using Disturbance as a Management Tool

Urbanites often attempt to limit anthropogenic and natural disturbance (e.g., fire suppression, pest insect management, tree care, few timber harvests), because they perceive it as detrimental to wildlife. Yet, all wildlife are well-adapted to disturbance and a majority of animals benefit from the habitat conditions created or maintained by some degree of disturbance (Hunter et al. 2001). In urban areas, species that use vegetation communities created or maintained by disturbance suffer because appropriate habitat management either violates local ordinances or norms for neat and orderly landscaping. For example, commercial timber harvest is unpopular in part because it often leaves woody debris considered unsightly. Increasingly restrictive air quality standards and the complexities of managing smoke make the use of prescribed fire a challenge, especially near areas of concentrated human dwellings. Many local governments also have land use regulations, including zoning or tree protection and landscaping ordinances, which can restrict the cutting of trees or disturbance of vegetative buffers. These regulations ultimately limit the use of timber harvesting and prescribed burning as conservation tools when managing for wildlife. Managers can work with local planners to ensure that zoning ordinances and other land use regulations do not restrict habitat management practices beneficial to wildlife in urban settings, but options for habitat management in the urban setting are likely to be less flexible than in more rural areas.

Where allowed, timber harvests and prescribed burning can be used to manage succession and maintain habitat conditions for disturbance-dependent plants and animals. Periodic (every 1 to 2 years) disturbance (e.g., mowing) of grassy areas or the margins of ball fields or other open areas will prevent woody encroachment and yield weedy or shrubby vegetation used by early succession wildlife. Similarly, restored prairie or a planted wildflower meadows that contain a diversity of native plants may be aesthetically pleasing to local residents, in addition to providing habitat for grassland wildlife (Lindemann-Matthies and Bose 2007).

The location and type of management for early succession vegetation, however, can be modified for urban contexts. Early succession vegetation communities can be maintained along utility rights-of-way or power line corridors, especially with the appropriate frequency and type of disturbance; often, this may happen unintentionally as a by-product of vegetation management to protect access. Conservation of larger, more contiguous habitat patches allows more cost-efficient implementation of management activities, such as prescribed burning and timber harvest. Similarly, special zoning areas with no development or low density development around green spaces can help buffer adjacent areas of higher density development from the aesthetic effects of timber harvest or fire and the smoke generated during prescribed burning. In forested natural areas, the use of intermediate timber management activities (e.g., thinning) or regeneration harvests (e.g., group selection harvests or shelterwood harvests) that leave standing canopy reduce aesthetic effects of timber harvest as compared to clearcuts. Finally, mowing and herbicides can be used to manage vegetation where prescribed fire and timber harvest are not an option, although these practices may not yield the habitat conditions required by some wildlife or plants.

14.2.2 Minimizing the Effects of Recreational Use

User-related impacts on open space resources include loss of soil and ground vegetation, soil erosion along trails, tree damage, and wildlife harassment (Cole and Landres 1996). Impacts on wildlife can be either indirect through habitat alteration or direct as excessive noise or disturbance from people and their pets. In Colorado, specialist birds (e.g., western meadowlark (*Sturnella neglecta*) in grasslands, western wood-pewee (*Contopus sordidulus*) in forest) were less common and nest predation rates were greater near recreational trails (Miller et al. 1998). Conversely, Miller and Hobbs (2000) documented lower rates of nest predation by mammals nearer to trails than in areas away from trails. Extensive clearing of vegetation along trails can improve sight lines for recreational uses but also breaks the forest canopy, essentially creating two narrower corridors that are less suitable to forest-interior birds; alternatively, recreational trails with narrow strips of managed vegetation did not affect forest-interior bird abundance (Mason et al. 2007). To avoid fragmenting forest habitat, trails can be consolidated along forest edges, as opposed to through the interior, or located in open areas (Miller et al. 1998; Mason et al. 2007). Additionally, visitor impacts on open space can be contained by closing sensitive areas to users or by concentrating use along designated trails (Leung and Marion 1999). Pets that accompany users should be leashed to prevent disturbance or predation of wildlife, and pet waste should be collected to prevent contamination of adjacent water bodies.

14.2.3 Managing Invasive Plants

Invasive, nonnative plants typically are more abundant in urban areas than in rural environments (Chap. 5). The colorful berries that make many nonnative plant species attractive as urban ornamentals also make them highly prone to become invasive. Birds and other wildlife commonly eat the fruits of nonnative plants such as olives (*Eleagnus* spp.) and privet (*Ligustrum* spp.) and disperse the plants great distances across the landscape as they defecate the seeds (Lafleur et al. 2007). Vegetation communities dominated by nonnative plant species typically are lower value to wildlife, especially urban avoider species, so prevention or control of nonnative plant invasions is important to conservation of urban wildlife habitat.

Accordingly, homeowners or other urban land managers can remove nonnative plants using a variety of methods. Where invasive plants are well established, complete elimination generally is not possible. In such cases, removal efforts must be balanced against the long-term cost, especially for species that spread quickly or where infestations are extensive. To save on costs and engage the local community in conservation efforts, volunteer groups (e.g., clubs, student organizations, and friends groups) can be enlisted to help remove invasive plants. Plants either can be removed by hand, mechanically (e.g., mowed, dug up, or pulled using a weed wrench), or with herbicides, and sometimes a combination of approaches may be necessary. However, removal efforts typically must be widespread and continuous to be successful, and therefore are costly over the long term (Kettenring and Adams 2011).

As with any risk, prevention is first principle of control. A majority of invasive plant species around the globe, especially woody plants, were first introduced by the horticultural industry (Reichard and White 2001). Therefore, an effective strategy to limit the spread of invasive plants is to avoid planting nonnative species known to be invasive or potentially invasive. Because there is a time lag between when a nonnative plant is first introduced and when it becomes invasive, identifying potentially invasive plant species can be challenging (Reichard and White 2001). Hence, an emphasis on native plants when landscaping for wildlife not only avoids introduction of known invasive plants but also helps limit the risk of nonnative species becoming invasive. Ultimately, efforts to reduce the introduction of invasive plants as landscaping ornamentals will require educating consumers, which in turn will help drive change in the nursery trade (Reichard and White 2001). These outreach messages should not only highlight the potential for nonnative plants to invade nearby natural areas, but also emphasize the benefits of native plants to wildlife.

14.2.4 Maintaining Dead Wood

Snags (i.e., standing dead trees) and downed coarse woody debris (CWD) are important features of forest ecosystems (Harmon et al. 1986). Diverse organisms, including invertebrates, vertebrates, fungi, and plants, require standing and downed CWD (e.g., Freedman et al. 1996; Hunter 1999). Downed CWD also may be important for nutrient retention (Harmon et al. 1986; Krankina et al. 1999) and water dynamics (Fraver et al. 2002). Because CWD could represent a long-term carbon reservoir in some forests, it has implications for atmospheric carbon balance and global climate change (Currie and Nadelhoffer 2002). However, snags decay and fall quickly in warm, humid regions, so snag loss must be balanced with constant recruitment (Moorman et al. 1999). In urban areas, snags are removed for safety reasons, because they are considered unsightly, or out of ignorance about the ecological values they provide. In turn, cavity-nesting bird densities are lower in urban areas than in natural areas (Tilghman 1987; Blewett and Marzluff 2005). To ensure the availability of snags to birds and other wildlife in urbanizing areas, Blewett and Marzluff (2005) recommended conserving patches of forest with the greatest densities of existing snags (>8 snags ≥ 25 cm DBH/ha). In addition to protecting snags that pose little safety risk, trimming dead trees to reduce the risk of deadfall onto valuable property and replacing lost snags with appropriate nest boxes increases habitat quality for cavity-nesting species (Blewett and Marzluff 2005). Efforts to conserve snags will need to be linked to educational efforts designed to convince planners, developers, and homeowners of the environmental value of dead wood (Blewett and Marzluff 2005).

Can Golf Courses Play a Role in Urban Wildlife Conservation?

Worldwide there are over 25,000 golf courses, with over 17,000 in the USA, more than 2600 in UK, and a rapidly increasing number in China, Japan, and Taiwan (Terman 1997; Cristol and Rodewald 2005; Tanner and Gange 2005). In the USA, golf courses average 55 ha in size and therefore provide substantial land area for conservation (Cristol and Rodewald 2005). In fact, numerous studies have demonstrated that golf courses harbor a high diversity and abundance of native wildlife, especially birds (Jones et al. 2005; White and Main 2005), and a study in New Mexico showed that native bird richness was greater on each of five urban golf courses than on the paired natural areas (Merola-Zwartjes and DeLong 2005). Intermediate disturbance can yield maximum levels of wildlife diversity, and support for this trend has been shown in studies of urban birds (Blair 1996). Similarly, golf courses represent an intermediate level of urbanization, greater than undeveloped natural areas and less than higher levels of urbanization dominated by human structures and impervious surface (Tanner and Gange 2005). Golf courses may include wetlands and structurally diverse planted vegetation, absent in surrounding urban and natural areas, especially when the native plant community is fairly simple (e.g., desert or grassland). Wildlife associated with wetlands may be especially abundant on golf courses that have substantial area of artificial ponds or riparian vegetation (Merola-Zwartjes and DeLong 2005; White and Main 2005).

Although wildlife present on golf courses typical are generalist species of relatively low conservation value (Cristol and Rodewald 2005), there are a variety of design strategies and management activities that can be used to increase the likelihood that urban avoiders are conserved on golf courses. Naturalistic golf courses that include substantial amounts of native vegetation communities are especially attractive to urban avoiders, including threatened species (Terman 1997; Merola-Zwartjes and DeLong 2005). There are large acreages of out-of-play areas on many golf courses, and conservation of critical habitat elements, including older, large-diameter trees with cavities, streamside vegetation, and native grassland, in these areas can provide habitat for native wildlife (Cristol and Rodewald 2005). Reduction of mowing, irrigation, and pesticide application in out-of-play turf can provide habitat for some grassland wildlife. Also, planting native trees and shrubs can increase plant species diversity and structural complexity of vegetation on golf courses, thereby improving the habitat quality for native wildlife. Clustering of remnant natural areas into larger habitat complexes and connecting these natural areas with habitat corridors can increase the size of habitat patches and facilitate dispersal by wildlife within golf course properties. However, the overall potential of individual golf courses largely depends on the context of the landscape surrounding the course, with greater potential for conserving native wildlife on courses surrounded by greater cover of undeveloped natural areas (Porter et al. 2005). Ultimately, acceptance of conservation practices by golfers and golf course managers is critical to success of conservation efforts, and use of interpretive signage can help facilitate education and buy-in by these stakeholders. Finally, Audubon International's (http://www.auduboninternational.org/acspgolf-program-overview) certification program for golf courses assists golf course managers with conservation of wildlife habitat and other environmental services (e.g., protection of water quality) and provides recognition for these efforts.

14.3 Managing Individual Home Lots

Individual home lots have tremendous potential for providing critical wildlife habitat if the preurban plant community can be preserved or if the property can be landscaped with a species rich and structurally diverse plant community. Further, managing vegetation on home lots to attract wildlife can increase property values while decreasing energy costs with careful selection and placement of trees (McPherson and Rowntree 1993; Donovan and Butry 2009). These energy savings, however, may be relatively modest in cities with temperate climates and high tree cover (Nelson et al. 2012). Additionally, backyard wildlife habitats can provide children a place to explore and develop a lifelong interest in wildlife and conservation (Louv 2005).

Attracting wildlife to home lots involves the same principles that guide management of larger green spaces. The process should start with by mapping and inventorying the property, making sure to identify where water, cover, and foods already are available. Special note should be taken of native trees or shrubs that provide fruits or seeds during at least some part of the year, nectar producing flowers, and old snags and stumps. Then, homeowners should decide what animals could prosper in their yards and determine what will need to be added or removed to support them. Homeowners should focus on native plants that provide food or shelter for target species (Table 14.1), and nonnative invasive species should be removed. Supplemental food, including bird feeders, and cover, including nest boxes and brush piles, can be added to complement the resources provided by the plant community.

14.3.1 Landscaping Principles

To conserve wildlife habitat, as much of the predevelopment plant community should be retained as possible during land clearing and construction of new home lots or commercial developments (Mills et al. 1989). During construction, contractors should protect residual trees and other native vegetation from fill dirt and heavy equipment. Contractors should use well-maintained silt fences to prevent silt from entering water bodies. Consideration of wildlife habitat should not end with the

Table 14.1 Recommended plants that are useful landscaping additions for wildlife in residential areas of North America. Check with local sources for native plants best suited to a local region. This table provides examples that might not be native or suited to all regions of North America

Kinds of plants	Wildlife needs fulfilled	Example species
Conifers	Conifers provide escape cover, winter shelter, and summer nesting sites. Some also provide sap, buds, and seeds.	Pines, spruces, firs, arborvitae, junipers, cedars, and yews
Produce fruits or berries from May through August	Provide foods for small mammals, thrashers, catbirds, robins, thrushes, waxwings, woodpeckers, orioles, cardinals, towhees, and grosbeaks.	Cherry (*Prunus* spp.), blackberry and raspberry (*Rubus* spp.), serviceberry (*Amelanchier* spp.), blueberry (*Vaccinium* spp.), grape (*Vitis* spp.), mulberry (*Morus* spp.), plum (*Prunus* spp.), and elderberry (*Sambucus* spp.)
Produce fruits or berries from August through December	Important foods for migratory bird fat reserves prior to migration and for nonmigratory species that need to enter the winter in good condition.	Dogwoods (*Cornus* spp.), blackgum (*Nyssa sylvatica*), buffaloberries (*Shephirdia* spp.), persimmon (*Diospyros virginiana*), spicebush (*Lindera benzoin*), and Virginia creeper (*Parthenocissus quinquefolia*)
Fruits that remain attached to the plants through winter; many are not palatable until they have frozen and thawed multiple times	Provide long-lasting foods for animals through the toughest periods of winter.	Chokecherry (*Aronia* spp.), crabapple (*Malus* spp.), hollies (*Ilex* spp.), snowberry (*Symphoricarpos* spp.), sumacs (*Rhus* spp.), viburnums (*Viburnum* spp.)
Nectar producing plants	Provide nectar that attracts hummingbirds, orioles, bees, and butterflies.	Flowers with tubular corollas attract hummingbirds. Other fruiting trees, shrubs, vines and flowers also provide nectar and sugars.
Grasses and legumes	Provide cover for small mammals and ground nesting birds—especially if the area is not mowed until after the peak of the bird nesting season. Some grasses and legumes also provide seeds. Legumes commonly are used as butterfly caterpillar host plants.	Native prairie grasses, including grammas (*Bouteloua* spp.), switchgrass (*Panicum virgatum*), and bluestems (*Schizachyrium scoparium* and *Andropogon* spp.), are becoming increasingly popular for landscaping purposes.
Mast or nut producing plants	Nuts and acorns are eaten by a variety of wildlife. These plants also provide tall plant structure and nesting cover.	Oaks (*Quercus* spp.), hickories (*Carya* spp.), buckeyes (*Aesculus* spp.), chestnuts (*Castanea* spp.), butternut (*Juglans cinerea*), walnuts (*Juglans* spp.), and hazels (*Corylus* spp.)

Table 14.1 (continued)

Kinds of plants	Wildlife needs fulfilled	Example species
Host plants for caterpillars, which are food for other wildlife	Caterpillars, other insects, and spiders are eaten by a variety of wildlife including birds, lizards, frogs, toads, and mice. These plants are known to attract the greatest number of caterpillar species.	Oaks (*Quercus* spp.), black cherry (*Prunus serotina*), willows (*Salix* spp.), birches (*Betula* spp.), blueberry (*Vaccinium* spp.), and elms (*Ulmus* spp.)

construction phase (Hostetler and Drake 2009). Where vegetation was cleared during construction, native plants should be planted to restore wildlife habitat. Any shared open space in a new neighborhood should be managed perpetually to sustain biodiversity, following the guidelines for green space management provided earlier in the chapter.

In addition to emphasizing native plants, landscaping activities should:

- Select the right plant for the right site by matching light and soil moisture condition requirements of plants with site characteristics.
- Include a diversity of native plants species known as hosts for butterfly and moth larvae, which are important food sources for birds (Tallamy 2007). Oaks (*Quercus* spp.), cherries (*Prunus* spp.), and willows (*Salix* spp.) are three types of trees known to serve as hosts for the greatest variety of caterpillars in the eastern USA (Tallamy 2007).
- Select plants that flower and bear fruit at different times of the year, thereby assuring fruits, seeds, and nectar will be available throughout most of the year.
- Cluster similar types of vegetation to allow wildlife easy access to seasonally abundant food sources without excessive movement and increased exposure to predators.
- Plant low-growing herbs and shrubs under taller shrubs and trees. This helps to provide the vertical complexity of the vegetation that is important to birds and other wildlife linked to specific vegetation layers. For example, different birds nest and feed in the ground, shrub, mid-story, and canopy layers of a landscape (MacArthur and MacArthur 1961). Other taxa, including reptiles, amphibians, and mammals, often are ground-dwelling and benefit from low shrubs and herbaceous plants.
- Avoid planting large-maturing trees and shrubs where they will overgrow their space and interfere with overhead utilities or crowd homes and other structures. Shrubs and trees should be at least 6 feet away from structures.
- Avoid planting fruit-bearing shrubs in medians or along roadsides; birds and other wildlife attracted to the food or cover provided by these plants may be killed by collisions with passing vehicles.
- Collect soil samples from different areas on a property, especially when soils have been altered significantly during the development process (local cooperative

extension centers often provide detailed information on how to proceed with a soil sample analysis).

- Minimize lawn coverage.

14.3.2 Managing Lawn

In 2005, more than 16 million ha of land were dedicated to turfgrass in the USA; this amount of land area was three times greater than dedicated to corn production (Milesi et al. 2005). Lawn cover occupies a substantial portion of land cover in urbanizing regions (>20 %), and lawn management contributes to the deposition of chemical pesticides and fertilizers at densities greater than agriculture (Robbins and Birkenholtz 2003). Movement of these pollutants into urban water bodies significantly degrades water quality and leads to eutrophication of aquatic systems. Further, irrigation of turfgrasses constitutes a significant portion of residential and commercial water use, especially in arid or semiarid regions where it can account for 75 % of household water consumption (Mayer et al. 1999). Because lawns commonly are managed as monocultures of single grass species, they are characterized by simplified vegetation structure devoid of food and cover; accordingly, lawns offer poor habitat quality for all but a select few ubiquitous wildlife species (e.g., American robin—*Turdus migratorius*).

Although complete elimination of lawn is unnecessary to conserve urban wildlife, reduction in the extent of turfgrass cover in exchange for increasing cover of native plants would increase the availability of food and cover for wildlife. Urban residents may be more receptive to this change than one might think, and in fact, Peterson et al. (2012b) showed that urban residents preferred a 50 % native plant garden over 100 % turfgrass. The study also demonstrated that many homeowners maintain extensive lawns because they inaccurately assume it's the social norm. Where lawn is maintained, fertilizer and pesticide application should be minimized. In addition, tolerating a diversity of plant species (e.g., clovers or native forbs) will increase the value of the lawn to insects and other wildlife while reducing maintenance costs.

14.3.3 Creating Brush Piles

Brush piles, although not appropriate for every urban lot, can be constructed to provide cover for songbirds (e.g., winter sparrows, towhees, wrens, and thrashers), rabbits, and other small mammals. Brush piles should be placed near food sources (e.g., bird feeders) or along travel corridors in the urban environment. They can be constructed from downed limbs, hedge clippings, or old Christmas trees. As the wood decays and settles, new material should be stacked on the pile. Before construction, homeowners should check that brush piles are not prohibited in their neighborhood landscaping ordinance. Homeowners also should be aware that a variety of animals, including those sometimes unwanted, like snakes, rabbits, and mice, may be as likely to use brush piles as songbirds.

14.3.4 Erecting Artificial Nest Boxes and Platforms

Nest boxes may be used as surrogates for natural cavities to provide nesting sites for a variety of wildlife species, especially birds such as great crested flycatcher (*Myiarchus crinitus*), screech owl (*Megascops asio*), chickadees (*Poecile spp*.), wrens (*Troglodytidae*), titmice (*Baeolophus* spp.), and bluebirds (*Sialia spp.*). Several considerations must be addressed when building and erecting nest boxes for wildlife.

- Nest boxes that benefit native birds should be designed with species specific dimensions for entrance holes, nest box interiors, and box depth.
- A well-designed nest box is made of sturdy lumber (e.g., pine, redcedar, or cypress wood), has a metal entrance guard to prevent expansion by woodpeckers (*Picidae*) or squirrels, and does not have a perch. Perches increase the use of nest boxes by aggressive birds like house sparrows (*Passer domesticus*) and European starlings (*Sturnus vulgaris*) and may limit use by native birds.
- Do not paint or stain the interior of the box. If you decide to paint or stain the exterior, use a nontoxic paint or stain. If painting, use a light colored paint (e.g., white) to allow the box to reflect, rather than absorb, radiant heat.
- To prevent easy access by nest predators (e.g., snakes and squirrels), next boxes may be placed on a wooden or metal post with a predator guard, or baffle, placed below.
- Boxes should be placed in a habitat and location appropriate for the target bird species.

14.3.5 Erecting Bat Houses

Bat houses are an excellent way to provide shelter for bats in urban environments, where natural tree cavities and other forms of cover can be limited. Proper roost temperature is probably the most important factor for a successful bat house. Interior temperatures should be warm and as stable as possible (ideally 80 °F to 100 °F in summer) for maternity roosts. Bat house construction should be tight, roosting partitions should be rough, and roosting crevices should be 1.9 to 2.5 cm wide (Tuttle et al. 2004). Plans for constructing bat houses are readily available on the internet or at a local library or wild bird store. Keys to occupancy involve temperature, location, and maintenance. Houses should come with instructions (appropriate to the region) on best exterior color of houses and how they should be located to receive adequate solar heating. Failure to consider the factors that affect the thermal environment of boxes accounts for more than 80 % of bat house rejection (White 2004).

14.3.6 Providing Supplemental Food

In the USA, over 50 million people feed birds, and bird-feeding is a critical means for people to remain connected to wildlife in urban settings (USFWS and US Census Bureau 2012). However, the effect of supplemental feeding on bird populations is variable and often debated (Temple 1988; Brittingham 1991). Potential positive effects include improved physiological condition resulting in greater overwinter survival, especially during extreme weather, and greater reproduction. Potential negative effects include greater rates of disease transmission among individuals at feeders, greater rates of accidental collisions with windows near feeders, or increased predation (Klem 1990; Brittingham 1991). Feeders also may favor granivorous bird species at the expense of insectivorous species, cause birds to shift their geographic ranges (e.g., allow birds to survive harsher winters and shift ranges north), or alter migratory patterns (Brittingham 1991). To minimize disease risk, feeders should be cleaned regularly, usually at least every 2 weeks, washing them thoroughly with hot, soapy water. Feeders should be incorporated into residential areas only as a complement to an appropriately designed landscape that includes a diversity of native plants and adequate cover. Placing feeders within close proximity to dense vegetation or brush piles provides feeding birds a quick access to escape cover.

14.3.7 Managing Free-Ranging Pets

Free-ranging domestic pets can have substantial effects on urban wildlife. For example, there are approximately 600 million nonnative and invasive domestic cats (*Felis catus*) introduced by humans around the world. Cats are well known for their ability to depredate native wildlife wherever they occur, especially in urban areas where their densities are greatest (Dauphine and Cooper 2009). Recent empirical evidence suggests free-ranging domestic cats kill 1.4 to 3.7 billion birds and 6.9 to 20.7 billion mammals in the USA annually (Loss et al. 2013). Domestic cats can cause local extinctions of wildlife in urban habitat fragments (Crooks and Soulé 1999). Additionally, cats and other domestic pets can serve as reservoirs and vectors for diseases and parasites that jeopardize populations of native wildlife (Dauphine and Cooper 2009). To reduce the detrimental impacts of cats and other domestic animals on native wildlife, pets should always be kept indoors, contained within a fenced environment, or placed on a leash. Indoor pets are less likely to be killed or injured by automobile collisions, depredated by coyotes (*Canis latrans*) or other predators, or injured by fights with other free-ranging pets. Feral cat colonies should be discouraged and free-ranging cats and dogs should be humanely captured and removed (Dauphine and Cooper 2009). Supplemental feeding by humans allows feral cat populations to remain at high densities, thereby increasing the negative effects on native wildlife and providing a source population of cats to disperse into nearby areas (Schmidt et al. 2007). A small but vocal group of cat colony caretakers and advocates dispute effects of outdoor cats on wildlife, and even believe feral cats are native wildlife (Peterson et al. 2012a). These groups have successfully institutionalized outdoor cat colonies in some areas despite opposition from the scientific community and local citizens (Lohr and Lepczyk 2013), so it is critical that the public knows about outdoor cats, their impacts, and any surreptitious efforts to legalize maintenance of colonies on public lands, or worse, on private lands that do not belong to caretakers.

14.4 Minimizing Strikes with Structures

14.4.1 Reducing Bird Collisions with Communication Towers

It is estimated that 7 million birds, primarily those that are migratory, are killed annually by collisions with communication towers and their associated infrastructure across North America (Longcore et al. 2012). Over a 29-year period, 44,007 individuals from 186 species of birds were collected under a single tower at Tall Timbers Research Station near Tallahassee, Florida, USA (Crawford and Engstrom 2001). And, the number of annual bird mortalities can be expected to rise as new and taller towers are erected, especially in urban areas. Therefore, it is important to consider several recommendations for reducing tower kills. Because mortality risk rises with increasing tower height, especially when guy wires are present, towers should be less than 100 m tall and should be constructed without guy wires (Longcore et al. 2008). Birds are most attracted to continuously illuminated lights, especially white lights (Longcore et al. 2008). Therefore, strobe or flashing lights are suggested over the use of steady-burning lights. Other suggestions to reduce bird collisions include co-location of new towers on existing towers or structures and avoidance of locating new towers in areas of extensive migrant bird activity (e.g., mountain ridge tops, boundaries of large water bodies).

14.4.2 Reducing Bird Collisions with Windows

Conservative estimates of annual bird mortality from collisions with windows in North America exceed 1 billion birds (Klem 1990; Dunn 1993). However, there are a number of strategies that can be employed to reduce bird collision with windows in the urban environment. Bird strikes with existing windows can be reduced by placing feeders close (within 1 m) to a window, and removing reflective vegetation from areas in front of windows (Klem et al. 2004, 2009). Additionally, planting trees and installing window awnings to block the sun from hitting the window may eliminate some reflection. Window screen, flash tape, and bird netting can be used to prevent birds from reaching the glass surface or to break up the reflection enough to direct flying birds away from the glass. Falcon or owl silhouettes attached to windows typically do not effectively reduce bird collisions, except when they reduce reflection of glass. In new construction, the proportion of glass should be minimized or less reflective glass material should be used. Also, angling windows downward 20 to 40° from vertical can aid in reducing collisions (Klem et al. 2004).

14.4.3 Reducing Wildlife Mortality from Power Lines and Power Poles

Birds commonly are killed from electrocution or collision with any of the over 65 million km of medium-high voltage power lines in use around the world (Bevanger 1994, 1998; Jenkins et al. 2010). In general, rapid flying birds with relatively large bodies and small wings (e.g., ducks and geese, rails, cranes, gallinaceous birds, and tinamous), or those often characterized as "poor fliers", are at the greatest risk of collision with power lines (Bevanger 1998; Janss 2000). In contrast, perching raptors are most prone to death from electrocution (Bevanger 1998). Electrocution takes place when a bird simultaneously touches two phase conductors and an earthed (i.e., grounded) wire; hence, larger species are more likely at risk of electrocution because the conductors and earthed wire often are far apart (Bevanger 1998). A comprehensive description of strategies to reduce avian mortality from interaction with power lines was published by Avian Power Line Interaction Committee (2012). Construction of new power infrastructure should undergo rigorous environmental review and the risks to wildlife should be considered. When possible, power lines should be buried (Jenkins et al. 2010). Additionally, new lines can be located in areas less likely to support collision-prone birds or birds of high conservation value; because many rare bird species are less likely to occur in urban areas, power lines in urbanizing regions may be less likely to pose a risk to these species. Removal of earthed-wire can reduce bird collisions and electrocutions, but this step is unlikely until economical alternatives for lightning conduction are developed (Jenkins et al. 2010). Marking lines to make them more visible or appear thicker seems to reduce collisions, but more extensive field testing of these approaches is needed (Bevanger 1994; Jenkins et al. 2010). Because birds often fly above tree-top height, power lines passing through forest can be situated below the height of the tree canopy to reduce risk of collision (Bevanger 1994). Wider spacing between lines can reduce the likelihood a bird contacts two lines simultaneously, and elevated perches or perching guards can remove perching raptors from electrocution risk by preventing contact with electrical wires (Bevanger 1994).

Conclusions

Efforts to protect and manage wildlife habitat locally in urban landscapes can yield substantial conservation benefits, especially when conducted in a coordinated fashion over larger spatial scales (Chaps. 12, 13). Efforts to maximize native plant

Table 14.2 Sample list of internet sites which provide unbiased information about attracting wildlife to residential areas. (Accessed August 2014)

Topic	URL
Landscaping for wildlife	http://web4.audubon.org/bird/at_home/rethink_lawn.html
	http://www.ncsu.edu/goingnative
Bird houses	http://www.ncsu.edu/goingnative
Bird feeders	http://www.ncsu.edu/goingnative
Birds and glass windows	http://digitalmedia.fws.gov/cdm/ref/collection/document/id/1431
All about birds	http://www.allaboutbirds.org/
Attracting bats	http://www.batcon.org/
Butterflies and moths	http://www.butterfliesandmoths.org/
Reptiles and amphibians	http://www.northeastparc.org/products/backyard.htm

species diversity and the structural complexity of vegetation communities tend to conserve a wider variety of wildlife species. Proactive efforts to design or retrofit wildlife-friendly urban structures, namely windows, telecommunication towers, and power infrastructure, can reduce wildlife mortality, especially for birds. However, these and other mitigation strategies can be costly and would benefit from technological advances that improve the ease and cost efficiency of implementation. Although many of these mitigation measures may be beyond the control of individual homeowners, there are many sources of information on the internet for people interested in ways to enhance their residential or commercial property for wildlife (Table 14.2). I caution against information from commercial vendors selling their products, who often may not have the best interests of wildlife or homeowners in mind. For example, farmhouse, windmill, and gingerbread bird houses are designed for consumer appeal and may be less attractive to target wildlife. There are so many information sources and great ideas that individual homeowners may be too overwhelmed to act. In the USA, the simplest starting point is to contact the National Wildlife Federation about the certified backyard habitat program, which is designed to help individuals or corporations plan and apply a wildlife habitat plan for a home site or small acreage (http://www.nwf.org/How-to-Help/Garden-for-Wildlife/Certify-Your-Wildlife-Garden.aspx). Similarly, the Wildlife Habitat Council in the USA provides a third-party certification program for corporate sites (http://www.wildlifehc.org/certification/). In summary, efforts to think and act locally contribute to global efforts to conserve wildlife in urbanizing landscapes.

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