THE URBAN OPEN SPACE MANAGER

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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 or islands that are heavily used 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 herb-shrub layers in forests, and invasion of native communities by exotic plants.

The Natural Resources Group was created within the parks and recreation department in 1984 "to investigate the factors that challenge the health of local ecosystems, and to find ways of ameliorating them through restoration and management programs." Marc Matsil and Michael Feller, both of the Natural Resources Group, report some of the habitat restoration work being done by the department in a recent paper published in *Restoration & Management Notes*. They note that early work of the group focused on mapping and inventory at a city-wide scale followed by similar work on an individual park scale (community-based vegetation mapping). GPS (global positioning system) technology was used to map features, and information, including inventory maps, soils, contours, and hydrology, was incorporated into a GIS (geographic information system). Management plans were then prepared and two types of restoration practices were implemented: 1) restoration of degraded ecosystems and habitats, and 2) creation of new habitat.

Restoring Existing Communities

Forests

The New York City Parks and Recreation Department maintains some 2,000 ha of forests and woodlands. A problem in some of the parks is invasion of exotic plants like Norway maple, porcelain berry, and oriental bittersweet. Restoration efforts have included removal of invasive exotic species from 160 ha, planting of more than 100,000 native trees and more that 10,000 native shrubs and forbs, removal of more than 260 abandoned vehicles, and installation of 30 km of highway guard rail to discourage car dumping.

Meadows

Herbaceous communities were historically present in the area comprising New York City and restoration practices to maintain or create such communities include removal of weedy vegetation through cutting of trees and shrubs and application of herbicides to cut stumps.

Some areas are regularly burned by arsonists every few years, but such fires seem not to suppress woody species. Matsil and Feller speculate that fires set by humans may not be the same as historic fires or perhaps increased atmospheric deposition of nitrogen and phosphorus enriches soils favoring woody plants.

Freshwater Wetlands

Most streams and riparian wetlands have been converted to underground storm sewers in the area. Ones remaining are typical of urban streams elsewhere--eroded stream channels, steep banks, highly variable stream flow. Stormwater detention, including use of constructed wetlands, is now receiving more attention as a means of better managing water resources in the urban environment.

Salt Marshes

Several projects have been undertaken to restore salt marsh habitat. The largest effort is an 8-year project to restore the Arthur Kill marshes that were damaged by an oil refinery spill. Some 2 km of oiled shoreline have been planted with more than 250,000 salt-marsh cordgrass plants. A monitoring program is in place to evaluate the program. In other instances, common reed beds are cleared before planting to cordgrass.

Creating New Habitat

In the past, there has been much filling in of salt marshes with trash and construction debris (typically topped with ocean-dredged sand) to create parks. Many

of these areas are dominated by phragmites and mugwort but offer potential for restoration of meadow and forest covertypes. Human disturbance (use of brush hogs and glyphosate herbicide) creates gaps that are filled in by fast-growing early successional trees, which can shade out phragmites. These include grey birch, black cherry, red maple, and sassafras. Fire, as a form of disturbance, tends to increase stem density of phragmites by removing litter. In some areas, plans have been developed to spread leaf mulch from the city and to introduce species of viburnum, vaccinium, azalea, and other shrubs once common to the area.

Grasslands

Restoration of dune grasslands on phragmites-dominated landfill sites is a goal for some areas. Phragmites dominates where sand cover is less than 1.2 m thick (root depth of phragmites). Sites with greater sand cover have vegetation more characteristic of original dune grasslands, including little bluestem, switchgrass, false heather, pinweeds, and lichens. Two projects are planned to bring in sand to create relatively stable plant communities of great ecological value.

Forests

Matsil and Feller state that early-successional forest stands will develop in phragmites stands if the areas are not burned on a regular basis. Species like black-cherry, black locust, honey locust, cottonwood, and grey birch will grow. Management practices to encourage such development include mowing of fire-breaks to curtail fires and selectively removing nonnative species and replacing with appropriate natives to enhance species diversity. Addition of sand cover on a smaller scale than for grassland establishment can promote development of more diverse ground layers.

Reference: *Restoration & Management Notes* 14(1):5-14, 1996.

Managing Urban Deer

(Editor's Note: A recent special issue of the Wildlife Society Bulletin *(Vol. 25, No. 2, 1997) was devoted entirely to management issues related to deer overabundance. A limited number of copies of this special issue of the* Bulletin *are available for sale ($15.00/copy, Maryland residents add 5% sales tax) from The Wildlife Society, 5410 Grosvenor Lane, Bethesda, MD 20814-2197 (Fax, 301-530-2471).)*

A particularly difficult problem facing many wildlife managers is how to control deer populations in urban parks and other open space areas where hunting is illegal or impractical. Much discussion focuses on contraception, which has wide public appeal. However, contraception as a means of deer population control is still in the research phase--although promising, the technique is not yet suitable for management application.

Early work on deer contraception dealt largely with steroid drugs like DES (diethylstilbestrol) and MGA (melengestrol acetate). Although effective in inhibiting reproduction, these drugs pass through food chains, may cause cancer, and they have other effects.

The latest work on deer contraception focuses on immunocontraception using porcine zona pellucida (PZP) antigen. The zona pellucida is a noncellular translucent protein substance covering the ovum and PZP is derived from pig ovaries. PZP appears to inhibit fertilization through blockage of sperm-binding sites on the ovum by anti-PZP antibodies. PZP is free of many of the disadvantages of steroids and it has been demonstrated that the vaccine can be remotely delivered by dart gun to captive, unrestrained white-tailed deer.

Researchers John Turner (Medical College of Ohio, Toledo), Jay Kirkpatrick (Deaconess Research Institute, Billings, Montana), and Irwin Liu (University of California, Davis) have been pioneers in studying the use of immunocontraception for animal population control. Two questions these researchers recently addressed were whether or not PZP immunocontraception is effective in inhibiting reproduction in white-tailed deer and whether or not deer can resume normal reproductive function following treatment with PZP. The study was conducted at a private deer facility in Ohio, 1989-1993. Adult female deer were given either a single injection of PZP vaccine, two injections, or three injections. A control group was used for comparison.

Results of the study are promising. The average reproductive success among control does was 93.8%. Of does receiving a single injection, 20% produced a fawn. Does receiving two or three injections produced no fawns in the treatment year. The authors state, "These results indicate that at least 2 exposures to PZP may be necessary to produce maximal anti-PZP antibody titers in one breeding season." The two-injection protocol may last 2 years, but this is not known for certain.

Evidence from this study also indicates that reproductive inhibition is reversible. One year following treatment, 28%-75% of does produced fawns and two seasons following treatment there was no difference in fawn production between treated and control does.

Currently, two vaccine injections are needed to inhibit reproduction. Investigators are working on an effective single injection protocol, which is really needed for the technique to be practical in the field. Research also is needed on the influence of long-term PZP treatment on deer. The effect of immunocontraception on breeding period extension needs further study. Treated does that do breed may do so later--thus, producing fawns later in the year. Do such fawns have difficulty surviving their first winter?

Source: *Journal of Wildlife Management* 60(1):45-51, 1996.

Streams, Fish, and Urban Development

Researcher Claudia P.D. Silva, of the National Institute of Amazon Investigations, in Manaus, Brasil, recently added to our knowledge base regarding the effects of urbanization on stream fish populations. She studied two streams during 1990-1991, one urban and one exurban. The urban stream flowed through a section of Manaus where industrial effluent was discharged. The exurban stream flowed through a natural forest area. In both streams, Silva measured dissolved oxygen (DO), biochemical oxygen demand, total suspended solids, nitrogen compounds, temperature, and pH. She sampled the fish communities by drag net, hand net, and electrofishing gear.

Most of the measured parameters differed between the two streams. The average annual DO concentration in the urban stream was 4.8 ppm, compared to 10.4 ppm in the forest stream. During the dry season (August - September), DO averaged 2.4 ppm in the urban stream but always remained above 6.0 ppm in the forest stream. In Manaus, stream temperature averaged 27.5 C compared to 25.0 C in the forest. Total suspended solids in the urban stream were 37.9 ppm compared to 2.0 ppm in the forest. In the forest stream, highest concentrations of nitrogen were in the form of nitrate and nitrite. High concentration of ammonium was present in the urban stream.

Fish populations also differed between the two sites, influenced largely by low DO and high sediment loads and increased temperature in the Manaus stream. Twelve species were recorded in the urban stream, whereas 44 were found in the forest stream. The community structure in the urban stream was dominated by species with accessory organs for air breathing, thus allowing them to survive in low oxygen conditions. The lower species richness in the urban stream also may be due to low habitat diversity. The loss of riparian vegetation in Manaus contributed to increased sediment loads resulting in reduction of stream depth, loss of pools and riffles with leveling of the stream bed, and increased water temperature.

Results of this study fit the pattern emerging from other research. They reflect the importance of maintaining riparian vegetation, reducing sediment loads, and maintaining high DO concentrations in streams undergoing urbanization.

Reference: *Amazoniana* 13(3/4):221-236, 1995.

Urban Wetland Hydrology and Amphibian-Plant Communities

Researchers Amanda Azous (University of Washington) and Klaus Richter (King County Environmental Division, Washington) have studied how altered hydrology due to urbanization affects amphibian and plant communities. Specifically, they have investigated the effects of water level fluctuation on amphibians and plants by studying 19 wetlands in King County, where they conducted field work in 1988-1989.

These investigators found that the richness of amphibian communities is lower in wetlands with mean water level fluctuation greater than 0.2 m. Such wetlands "were significantly more likely to have low amphibian richness with three or fewer different species present." Emergent plant communities showed a similar trend. Emergent zones subjected to mean water level fluctuations greater than 0.2 m contained fewer plant species than emergent areas with less water level fluctuation.

The authors conclude that "Management of WLF [mean water level fluctuation] regime in urbanizing wetlands may be critical to maintaining diverse amphibian and plant communities. Some losses of amphibian species may already be occurring in Puget Lowland wetlands due to land-use changes and stormwater management practices. Whenever we can maintain or only moderately increase the pre-development frequency of peak flows occurring in a wetland, it will likely benefit both amphibian and plant biodiversity." These results should be useful in designing and imple-

menting better stormwater management practices in urban areas.

Reference: *Puget Sound Research '95: Proceedings.* Volume 1. Puget Sound Water Quality Authority, Olympia, Wash.

More on Amphibians and Wetlands

In related work to that described above, and using the same study sites, researchers Richter and Azous investigated other wetland factors that might help to explain amphibian distributions. These factors included wetland size, vegetation classes, presence of predators (bullfrogs and fish), water flow rate and permanence, and land use.

Two of the factors were found to significantly affect amphibian distribution. Low water flow velocity was correlated with high species richness and percent watershed urbanization was correlated with low richness. "Wetlands with watershed in which more than 40% of the land area is urban were significantly more likely to have low amphibian richness of less that four species than wetlands with less urbanized watersheds." This observation is probably related to increased impervious surface that results in increased duration and frequency of flooding and increased discharge rates (high water flow velocity).

The other factors did not significantly affect amphibian populations in the study. Ongoing work indicates that microhabitat attributes, like stem size of emergent vegetation as sites for egg laying, are important factors not necessarily related to broader vegetation classes.

In conclusion, these authors recommend that "jurisdictions take a conservative approach and implement steps to manage land use and stormwater such that increases in WLF [water level fluctuation] and flow velocity are minimized in the developing watersheds of wetlands. Steps to prevent isolation of wetlands within the urban landscape will further reduce losses of amphibian species.

Reference: *Wetlands* 15(3):305-312, 1995.

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Wildlife and Garbage Cans

(Editor's Note: In the article below, author Barbara Rosenman describes a protocol she finds effective for dealing with a common wildlife problem in the urban environment. The Urban Open Space Manager *welcomes contributions from other readers dealing with wildlife management and nature conservation in urban areas.)*

Many species of wildlife have adapted well to the urbanized environment, and animals that are mother-reared in suburbia have different survival mechanisms than their rural counterparts. A popular feeding spot often is the garbage can.

By human standards, garbage cans are nasty and smelly. By animal standards, they are an endless buffet table of free and enticing goodies. The problem is not really the raccoons, skunks, opossums, and other creatures that raid garbage cans. The problem is the garbage cans themselves.

Trapping and translocating animals that make use of this food supply does not really solve the problem. Such effort simply opens the territory so new animals can partake of the garbage. Death of the offending animals has a similar effect.

What does solve the problem? For $5 and 30 minutes of your time, **you** can solve the problem. The odor of food is attracting animals to your garbage cans. By reducing or eliminating such odor, you can reduce or eliminate the attractiveness of your garbage cans. Scrub the cans inside and out with hot, soapy water, and rinse them well. Pour a quarter inch of cleaning ammonia into the bottom of the cans. All food containers should be well rinsed before going into garbage bags that are placed inside the cans. Scrape all left over food wastes into a freezer bag after each meal and store the bags in the freezer until garbage pickup day. This practice will reduce odors.

Double bag all garbage. Place the now odorless garbage bags in the outside cans and insert a bungee cord through the handles and across the lid. This will keep the lid from popping off if the cans are knocked over. If the cans do get knocked over, the ammonia will leak out and offend the animals. After several nights of nothing interesting in the cans, raccoons and other animals will lose interest and move on to more productive food supplies.

Author: Barbara Rosenman, Urban Biologist, Kentucky Department of Fish and Wildlife Resources, 4865 E. Highway 22, Smithfield, KY 40068.

Managing Urban Geese

Populations of Canada geese are expanding in many urban-suburban areas of North America (and in some such areas beyond North America). Canada geese are majestic birds, highly prized by hunters and nonhunters alike. However, too many birds at a particular site may create a nuisance or safety hazard. Large populations at airports, golf courses, and parks, lakes, and other urban open spaces may pose such problems. In such situations, managers must implement socially acceptable control techniques.

Researcher Elaine Christens and three of her colleagues recently reported results of a study conducted in southern Ontario that inhibited production of young geese. The technique involved spraying eggs in goose nests with white mineral oil. The study was conducted during spring and early summer of 1992 at two sites in the Toronto metropolitan area.

Eggs from 32 nests were sprayed and all failed to hatch. However, an increase was noted in nest abandonment of oiled eggs by adult birds (about 45% compared to 16% for nonoiled nests). Christens and her colleagues do not know whether or not birds renested. If they did renest, they did not do so nearby the oiled nests.

Birds continuing to sit on oiled eggs incubated eggs about 14 days longer than the normal 27-28 day incubation time period. The authors speculate that these birds probably did not renest because of the lateness of the season. Although results of the study are quite pronounced, the authors caution that "Long-term effects of oiling on local goose populations are unknown and will depend on the extent of renesting by geese that have abandoned their oiled clutches."

Readers interested in oiling eggs to inhibit reproduc-

tion in geese are cautioned that oil used in the study (Daedol 50 NF) is registered in Canada as an avicide but is not so registered in the United States. Anyone contemplating such work needs to check with appropriate federal (U.S. Fish and Wildlife Service, Canadian Wildlife Service) and state/provincial wildlife authorities for necessary permits.

Reference: *Wildlife Society Bulletin* 23(2):228-230, 1995.

Raccoons and Rabies

Raccoon rabies is not present in Ontario, Canada, but in recent years it has been moving northward along the east coast of the United States and is now in New York close to the international boundary with Ontario. Ontario is allocating considerable effort to prevent the disease from becoming established in the province.

In 1991, an interagency Raccoon Rabies Task Force was formed to design a contingency plan to keep raccoon rabies out of the province. The plan calls for every municipality in Ontario to have a local contingency plan to deal with unexpected raccoon rabies cases.

In 1994, a comprehensive plan was prepared for the Niagara Region of Ontario. Components of that plan are to: "(1) *prevent* raccoon rabies from becoming established in Ontario, (2) *detect* raccoon rabies as soon as it enters Ontario, (3) *contain* and eradicate the disease if a few isolated cases are reported, and (4) *communicate* to the public information about raccoon rabies."

To prevent raccoon rabies from entering the province, authorities are creating buffer zones of vaccinated raccoons near likely points of entry of the disease. The current tactic is to live trap raccoons, vaccinate them with an intramuscular injection of killed rabies virus vaccine, and then to release the animals at the sites of capture. Research is being conducted on development of an effective bait and oral vaccine. Education is viewed as important in preventing influx of the disease as well. Considerable effort is expended on enlisting the cooperation of agencies and organizations in spreading the word about dangers of the disease.

Authorities hope that, with widespread awareness of the issue, early detection will be possible if the disease does enter the province so that an immediate control response can be implemented. Raccoons submitted to the responsible federal agency for rabies testing are generally limited to animals that have contacted humans.

If raccoon rabies does appear in the province, the plans call for halting the spread of the disease and eliminating it. For isolated cases of rabies, as many raccoons as possible would be live-captured and euthanized within a 4-km radius of the incident if in a rural area and a 2-km radius if in an urban area. Beyond this distance, a buffer zone 4 km wide in rural areas and 2 km wide in urban areas would be created and as many raccoons as possible would be trapped, vaccinated, and released. All work should be done within a 2-week time period. The density of raccoons in southern Ontario (3-11 per km^2) could accommodate rapid spread of the disease.

A comprehensive provincial communication plan has been prepared to support local contingency plans and a 10-point province-wide education initiative has been prepared. A variety of education and awareness support materials have been produced and are being maintained.

Raccoon rabies is considered more of a public health problem than other strains of the disease because raccoons are found in high densities in urban areas and humans have relaxed attitudes toward the species. Free-roaming cats also are abundant in urban areas and both cats and raccoons are basically nocturnal, providing easy opportunity for transfer of the disease to cats, leading to increased human exposure. A public education program is needed to encourage confinement of cats to minimize their contact with rabid raccoons and subsequent exposure of their owners.

Reference: *Wildlife Society Bulletin* 25(1): 110-116, 1997.

Controlling Deer in Urban Open Spaces

White-tailed deer populations continue to increase in many metropolitan areas of the United States, and state and local authorities are grappling with options for managing these populations. Contraception is a potential technique for use as an alternative to hunting or use of sharpshooters where the latter techniques may not be feasible or desirable from safety or public relations standpoints.

The latest contraception research deals with PZP (porcine zona pellucida) vaccine (please see Vol. 3, No. 1 of *The Urban Open Space Manager* for further discussion). Injected into female deer, PZP stimulates production of antibodies that prevents sperm attach-

ment to the egg. The technique holds promise but is not yet suitable for practical management application. Researchers are still trying to answer a number of questions, some of which relate to the effects of PZP treatment on the behavior and reproduction of deer. William J. McShea, of the National Zoological Park, Conservation and Research Center, Front Royal, Virginia, and seven of his colleagues address these matters in a recent issue of *The Journal of Wildlife Management*. They studied wild white-tailed deer in two enclosures (12 ha and 20 ha in size) during 1992-1994 at the Front Royal research center.

These investigators demonstrated a marked reduction in fawn production under certain circumstances. Females given a 2-shot treatment with PZP produced no fawns the first year, but one out of 10 produced one fawn the second year. A 1-shot treatment with PZP was not effective--78% of the females receiving such treatment produced fawns the first year. Treated females that were productive produced fewer fawns, and the fawns were produced later in the year. Normal birth dates in Virginia are late May through early June. The average birth date of fawns from treated females was mid-July. Biologists speculate that late birth dates might affect winter survival of fawns. Histological examination revealed no observed differences in ovaries of treated compared with control deer. It is unknown if repeated treatment would result in ovarian atrophy. Eighty-two percent of females in a control group (not treated with PZP) produced fawns in the first year of the study and 89% produced fawns in the second year.

Differences also were noted in the behavior of treated compared with control deer. Treated females were more active than non-treated individuals and increased activity was associated with estrous periods. Females that did not become pregnant continued with estrous cycles, and they continued estrous periods later into the season than is the normal pattern.

Some differences also were noted in male behavior. Male breeding activity was extended in response to extended estrous cycling of females (this may be 2 months longer than the normal pattern). The effect of this on male mortality is unknown. Another issue of possible concern is the effect of prolonged deer activity on incidence of vehicle collisions.

From research conducted to date, immunocontraception continues to hold promise as a technique for deer population control under certain circumstances, particularly in urban areas where deer are habituated to humans and where areas are enclosed with little or no movement of deer in or out. Implementation is labor intensive. Current technology requires a 2-shot protocol. Single injection application will greatly enhance practicality of the technique. Also, with current technology, one must get to within 30-40 m of an animal for darting it with a high degree of certainty. Even with deer habituated to humans this is not always easy to do. Some research has shown that fawn production and survival are compensatory--that is, production and/or survival increase at lower densities. Thus, unless all females are treated in a population, the effect of the technique on lowering population may be less than one might initially assume.

It is still unknown whether or not the technique can achieve the management objective of a lower population while providing safe and humane contraception. According to McShea and his associates, "For both sexes, long-term studies on natural populations are needed to determine the consequences for both individuals and populations."

Reference: *Journal of Wildlife Management* 61(2): 560-569, 1997.

Ecological Landscape Planning and Design

Better collaboration among planners, landscape architects, and biologists-ecologists can only lead to better environmental conditions for humans and other organisms alike. Landscape architect Sharon Collinge, of the University of California, Davis, assists this effort by reviewing the ecological literature on effects of habitat fragmentation (habitat loss and isolation) on plants and animals in a recent paper published in *Landscape and Urban Planning*. Collinge focuses on the consequences of habitat fragmentation for ecological processes and argues that landscape architects and planners can lessen the detrimental impact of development through creative design and planning that make use of ecological knowledge.

Collinge reviews the theoretical basis on which the relationship between habitat fragmentation and plant and animal populations is grounded. She discusses the theory of island biogeography and supporting research into species composition and fragment size and isolation. Also reviewed are metapopulation dynamics with a focus on habitat connectivity and interchange between spatially distributed populations. A metapopulation is a set of spatially separated groups of conspecific individuals. Local populations undergo periodic extinc-

tion and recolonization but the metapopulation as a whole persists.

Collinge presents a good review of the characteristics of habitat fragments, which are briefly highlighted here. As fragment size decreases, proportionally more edge is created (compared to interior habitat). More light penetrates the fragment and temperature increases. Also, wind velocity increases and relative humidity decreases. These modifications alter plant and animal communities, with more pioneer and xeric plant species occurring at the edge. More shrubs and herbaceous plants also are found there and greater species richness is typical. In urban-suburban areas, human activities often are concentrated along edges, and some of these may be harmful. Examples include dumping of grass clippings and rubble, gathering of fire wood, pruning of tree limbs and building of tree houses.

Fragment size and shape influence plant and animal use. Research shows that, for a given habitat, the number of species present decreases as size of the habitat decreases. From what we know, different factors are responsible for this observation for different organisms. For forest interior dwelling birds, nest predation and nest parasitism increase with decreasing size of forest fragment. For mammals, home range size is a factor--those requiring large home ranges are first to go. Dispersal ability is a factor for insects. For colonial plant species, colonization is limited by habitat disruption. A circular shaped habitat fragment would maximize area for interior species. Linear shaped fragments provide more edge relative to interior area and thus would be of less value to those species requiring interior habitat.

Fragment connectivity, heterogeneity, and the habitat context within which the fragment appears also influence plant and animal use. Vegetated corridors among habitat fragments moderate negative effects of fragmentation by facilitating movement of plants and animals. Within any given fragment size, greater heterogeneity will result in greater species richness (number of species). The surrounding habitat will influence use of the fragment. The degree of habitat dissimilarity, human activity and land use is important in this regard.

Collinge argues that landscape architects acting on ecological knowledge can plan and design development projects with less environmental impact. She concludes that "Landscape architecture as a discipline is uniquely situated to integrate results of ecological studies of landscape spatial structure with social, cultural, and aesthetic concerns into the design of landscapes at many spatial scales. Because landscape architecture is a discipline focused on landscape change, as human population growth continues, creative design of the spatial configuration of landscapes will become increasingly important in sustaining the integrity of ecological systems."

Reference: *Landscape and Urban Planning* 36:59-77, 1996.

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Mountain Lions in Colorado

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During the last decade, interactions between people and mountain lions have become more frequent along the Front Range. At the same time, social changes in the area have created new challenges for mountain lion management. Residential development and the designation of many greenbelts and open space preserves have made it increasingly difficult to control Front Range lion populations with hunting. Despite this, many residents appear to expect a high level of security from conflict with mountain lions. At the same time, there has been strong public pressure to minimize conflict between humans and lions without destroying mountain lions.

To help managers at the Colorado Division of Wildlife (CDOW) decide how to meet these new challenges, the Human Dimensions in Natural Resources Unit at Colorado State University (CSU) surveyed residents of the Denver and Colorado Springs areas about their attitudes toward mountain lions, knowledge of how to respond to mountain lions, and preferences for management actions toward mountain lions along the Front Range. We surveyed four separate populations: the Denver Metro area, the Colorado Springs area, the Foothills area west of Denver, and individuals who have reported mountain lion encounters to the CDOW's Central Region office.

We collected data using mail-back questionnaires and obtained an overall response rate of 59%. A telephone non-response check revealed little difference between respondents and non-respondents, so we did not weight data for non-response. However, because 70% of the respondents were male, we weighted data to reflect true gender ratios in the study populations.

Over three-quarters of each sample expressed positive attitudes toward mountain lions. People who expressed positive attitudes typically believed that mountain lions are beautiful, that they are a sign of a healthy environment, and that they pose little real risk to people living near them. People who expressed negative attitudes toward mountain lions were unlikely to believe these things. Instead, they were likely to believe that mountain lions are dangerous.

To measure public knowledge of how to minimize risk in an encounter with a mountain lion, we asked subjects if they agreed or disagreed with several possible responses to a lion. Responses recommended in CDOW educational materials include "stand tall, talk loudly, and try to back away slowly"; "notify the authorities as soon as possible"; and "if attacked, fight back." A majority from each sample agreed that they would try to do these things.

Responses that are not recommended include trying to crouch down and hide from a mountain lion, trying to scare the lion away, running away, and playing dead if attacked. Few respondents agreed that they would do any of these things.

About two-thirds of the respondents agreed that steps should be taken to limit the number of mountain lions coming into Front Range residential areas. But how to accomplish this was unclear. Among ways to control Front Range mountain lion populations, increasing public opportunities to hunt mountain lions or deer was acceptable to 40% of the respondents and unacceptable to the same number. Conducting controlled mountain lion hunts with trained hunters was acceptable to 30% to 40% of each sample; and developing sterilization or birth control methods for mountain lions was acceptable to 27-30% of each sample.

Respondents also expressed concern about how mountain lions that come into residential areas are treated. Monitoring a mountain lion in a residential area was widely accepted if the lion had done no harm, but became less acceptable as incidents grew more severe. Capture and relocation was acceptable to a majority of each sample, regardless of the severity of an incident. Frightening mountain lions away with rubber bullets or fireworks was unacceptable to a majority, regardless of the severity of an incident. Destroying a lion was highly unacceptable unless a human had been injured or killed. Fifty percent reported that they would accept destroying a lion that had injured a person, and 60% reported that they would

accept destroying a lion that had killed a person.

After reviewing the survey results, the CDOW/CSU study team concluded that education and public information should continue to play a large part in mountain lion management. We were pleased to see that a majority in each sample endorsed recommended actions in a mountain lion encounter (stand tall, talk loudly, and try to back away slowly; notify the authorities as soon as possible; and if attacked, fight back). This suggests that information campaigns conducted by the CDOW and a number of Front Range cities and counties have raised the level of public knowledge about how to respond in a mountain lion encounter. Continued education should further increase the number of people who know how to live safely with mountain lions. Education may also help widen the range of management actions accepted by the public. Capture and relocation was the only action that was widely accepted, regardless of the severity of a situation. This approach may be successful in moving a lion to a new area, but CDOW managers indicate that it has several drawbacks. A relocated lion might die, sometimes causes problems elsewhere, or could wander back into the area where it was caught. If the lion stays away, a new lion sometimes takes its place. An educational campaign explaining these drawbacks may help people understand and accept other management actions.

Funding for this project was provided through the Cooperative Human Dimensions Initiative sponsored by the CDOW and CSU. In addition to the authors, the study team included Dave Clippinger, Janet George, Katie Kinney, Mary Lloyd, and Pat O'Connor Adam (all from the CDOW) and Rhonda Brown (from CSU). For more information or a copy of the project report, contact Mary Lloyd, CDOW Human Dimensions Section, 6060 Broadway, Denver, CO 80216, (303) 291-7488.

Reference: Zinn, H., M. Manfredo, L. Sikorowski, and J. Jones. 1997. What Front Range Residents Think About Mountain Lions and Mountain Lion Management. *Urban Wildlife Newsletter*, Number 27, published by the Colorado Division of Wildlife, Denver.

Urban Land Use and Butterfly Diversity

Robert Blair, of Miami University, Ohio (formerly of Stanford University) and Alan Launer, a Stanford colleague, recently studied butterfly community changes across an urban gradient in Santa Clara County, California. During 1992 and 1993, they censused butterflies in six types of habitats. Representing increasing urbanization, these were a biological preserve, recreational area, golf course, residential neighborhood, office park, and business district. The original habitat at all sites before development was oak woodlands.

Twenty-three species of butterflies were recorded in the study. Six of these were classified as "urban avoiders"; examples are the woodland skipper and the common checkerspot. Their abundance increased from the downtown business district to the biological preserve. Seventeen species were classified as "suburban adaptable." Included here are the field skipper and the western tiger swallowtail. Abundance of these species peaked at intermediate levels of development. No species had maximum abundances in the business district so none was classified as "urban exploiter."

Suburban adaptable species possess the following life history characteristics. Most produce multiple broods per year. Thus, they can take advantage of the extended growing season resulting from irrigation. Most as larvae can feed on exotic Bermuda grass of managed lawns. And they typically feed on a wide range of larvae food plants, including cultivated plants or common weedy species. On the other hand, species of the natural site tend to produce a single brood per year and they are limited in their larvae diet to one or a few native plant species.

The relative abundance of all butterfly species generally decreased with increasing urbanization and ten of the oak woodland species gradually were lost along the gradient. However, species diversity was highest at intermediate levels of development. Intermediate levels of development may offer new resources that butterflies exploit. Included are ornamental vegetation, introduced grasses, water sources, and increased amount of edge habitat. However, more extensive development (increased pavement and structures) decreases available resources.

Blair and Launer found that the most effective environmental variables for separating sites and their assemblage of species are the amount of cover in buildings, lawns, and trees and shrubs. They concluded that the predevelopment community of butterflies is sensitive to changes from development. If one wants to maintain the original butterflies then some of the original habitat must be retained as development proceeds.

Reference: *Biological Conservation* 80: 113-125, 1997.

Dragonflies and Urban Streams

Dragonflies are major predators in aquatic and terrestrial ecosystems. Many serve as indicators of environmental quality and some are threatened or endangered. These are a few good reasons for considering these organisms in conservation efforts.

Michael Samways and Nicholas Steytler, of the University of Natal, South Africa, studied dragonflies along a 10-km stretch of the Dorpspruit River that flows through Pietermaritzburg, South Africa. These researchers were particularly interested in species diversity and numbers of dragonflies in reference to four landscape types along the river--plantation forest, parkland, residential area, and industrial area.

Twenty-six species of dragonflies were recorded in the study. Ten were found along the stretch of river flowing through the forest, 22 in the park, 20 in the residential area, and 13 in the industrial area. The number of individuals tended to increase with increasing development.

The different landscapes had different species assemblages, with some overlap of species. Species noted along the forest were most dissimilar to those found along the other landscape types. Park and city landscapes had similar species assemblages.

The three most important environmental variables influencing species presence were exposed macrophytes, water temperature, and shade. Habitat along the forest provided more shade, lower water temperature, and fewer exposed macrophytes. At the other end of the environmental gradient, in the urban area, there was no shade, high water temperature, and more exposed macrophytes.

Some species, like *Trithemis furva*, *Macromia picta*, and *Pantala flavescens*, tolerated the whole environmental gradient. Others were found only in specific habitats. For example, *Chlorolestes tessellatus* was found only in forest and *Enallagma glaucum* only in the city. *Chlorolestes tessellatus* has an affinity for low water temperature and shade and serves as an indicator of disturbance to indigenous riparian vegetation. Numbers drop substantially with replacement of indigenous trees with exotic commercial trees. The species needs indigenous bushes for perching and for egg laying. The authors suggest retention of a 30-m wide riparian strip to maintain the species in the dragonfly community. They conclude "Management should not see the landscape elements in isolation. An approach that considers the relationships between separate landscape elements is crucial."

Reference: *Biological Conservation* 78: 279-288, 1996.

Bird Diversity in Olsztyn, Poland

The importance of urban greenspace to birds is reflected in a recent study of the breeding bird community of Olsztyn, Poland. Olsztyn, about 88 km^2 in size, is located in Northeast Poland. Greenspace makes up some 4% of the city.

Researchers Beata Dulisz and Jacek Nowakowski, of Teachers Training College, Olsztyn, were interested in how the type and age of buildings, spatial structure, and greenspace affect breeding bird diversity of the city. During 1991-1993, they studied five types of built up areas in the city differing in age, building type, degree of vegetation development, and percentage of vegetation cover. Birds were surveyed by a modified territorial mapping method.

The largest number of breeding species was recorded in the "villa" type of development. This was suburban residential development 10-15 years old and rich in shrubs, trees, and gardens. The lowest number of species was recorded in the "tower block" type of housing 1-5 years old with a very low percentage of vegetation in a very limited degree of development. These researchers concluded that important factors accounting for observed differences in bird diversity in the city were proportion of greenspace and degree to which vegetation had developed, environmental heterogeneity (including small bodies of water), and percentage of built up area. The first two factors were positively associated and the latter factor negatively associated with bird diversity.

Reference: *Acta Ornithologica* 31(1):33-38, 1996.

New Uses for Old Military Bases

The Presidio, a 602-ha Army base in the city of San Francisco, California, closed in 1994. The land and buildings were transferred to the National Park Service, and the site now is part of the Golden Gate National Recreation Area, one of the largest urban parks in the world, encompassing some 30,600 ha.

Located on the southern cliffs of the Golden Gate headlands, original habitat of the site consisted of sand dunes, grasslands, oak thickets, streams, and tidal and freshwater marshes. However, coast live oaks were all but eliminated by the mid 1800s from firewood gathering and other plant communities were altered as well. Over the years, some reforestation has occurred, largely

with alien species including blue gum, Monterey cypress, and Monterey pine. About 10% of the area now supports a fragmented mosaic of native plant communities providing habitat for 12 rare plant species and subspecies.

Restoration of rare plant habitat began in 1993. Early on it was recognized that a focus on community-based restoration was needed for a successful program. This means that all who live and work in the community, both rich and poor, must be equal partners and full participants, and all must equally participate in the decision-making process.

Use is being made of the San Francisco Conservation Corps, volunteers, and high school and college student interns. Work involves conducting baseline inventories and rare plant censuses, mapping locations of invasive species, removing invasive non-native plants and planting native plants.

A native plant nursery was established with the goal of producing 50,000-70,000 plants yearly for revegetation projects. More than 40 native plant species are being grown, mostly for revegetation of dunes and serpentine grasslands. On ground restoration efforts to date have focused on removal of iceplant, Monterey pine, and other alien species, seeding of native annual grasses, and outplanting nursery grown species. Early results are promising.

Reference: *Restoration & Management Notes* 14(2): 112-123, 1996.

Urban Coyotes

Coyotes are becoming common in many urban areas throughout North America. Research conducted to date on these animals indicates that, compared to rural areas, they typically have smaller home ranges in the urban environment. Increased availability of food resources in urban areas may be one reason for smaller home ranges.

Timothy Quinn, of the University of Washington (now with the Washington Department of Fish and Wildlife), studied the annual diet of coyotes in three habitat types of varying degree of human modification in western Washington, 1989-1990. Residential habitat consisted mostly of single family housing development averaging 1,413 humans/km^2. Mixed agricultural-residential habitat was mostly pasture and dairy farms averaging 348 humans/km^2, and mixed forest-residential habitat was mostly second growth forest with interspersed single family housing development averaging 126 humans/km^2.

Fruits (predominantly apple, cherry, and plum) and mammals were the most important food items in all habitats. In the residential habitat, coyotes were closely associated with remnant patches of second growth forest of parks and riparian areas. Cats and squirrels (21.0% combined) were the most abundant mammals in the diet (fruit made up 42.6%). In mixed agricultural-residential habitat, mammals (55.0%) were the major food item with voles (41.7%) accounting for most of the mammals eaten and fruit making up 37.2% of the diet. Coyotes in the mixed forest-residential habitat ate the most fruit (57.0% of diet).

In summary, coyotes took advantage of the seasonal availability of mammals and fruits and also altered their diet in relation to human density and land-use patterns. Such behavior aids coyotes in exploiting urban habitats.

Reference: *Northwest Science* 71(1): 1-5, 1997.

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Small Mammals in Southern California

There is considerable current interest among biologists in learning the effects of habitat fragmentation (habitat reduction and isolation) on wildlife populations and communities. Can small mammals persist in fragments over time? What ecological factors are important in this regard--habitat fragment size, degree of isolation, habitat quality/quantity, predation and/or competition with commensal species? These are questions of interest to Douglas Bolger, formerly of the University of California and now at Dartmouth College, New Hampshire, and several of his southern California colleagues. These investigators recently studied small rodents in isolated fragments of coastal shrub habitats in San Diego County, California. During 1986-1987, these mammals were sampled with Sherman live traps in 25 habitat fragments isolated by urbanization and ranging from 1-80 ha in size.

Small rodents commonly found in coastal shrub habitat include the California mouse, cactus mouse, dusky-footed woodrat, desert woodrat, and western harvest mouse. However, 13 of the 25 fragments did not support native rodents. Area of shrub habitat was the most important predictor of species richness. Age of fragment also was an important factor, with older fragments having fewer species. Species that were most abundant in nearby unfragmented habitat persisted longer in habitat fragments than did less common species. Bolger and his colleagues conclude that "It is safe to say that fragments in the 25-80 ha range sustain native rodent populations better than smaller fragments, at least over the time period considered in this study. To support populations for intervals > 80 yr, it is likely that larger areas would be required." They further state "To link populations in separate fragments and achieve the oft-hypothesized benefits of gene flow, supplementation of depleted populations, and recolonization following local extinctions, habitat corridors will be necessary. It seems likely that relatively small patches could still support populations of rodents if they were connected by movement corridors."

Reference: *Ecological Applications* 7(2): 552-563, 1997.

Gray Foxes in Residential Landscapes

During 1992-1994, University of New Mexico researcher Robert Harrison studied gray foxes in several rural residential communities of Bernalillo County, New Mexico (average density of residences was 26.1/km^2). He also studied foxes in a nearby undeveloped area. His research adds to our understanding of gray fox ecology in developing landscapes.

Foxes in the residential community were heavier and their diet was somewhat different from the diet of foxes in the undeveloped area. A greater number of food items and more mammals and birds (and less plant material) were eaten by residential foxes. The importance of these differences is unknown.

The relative density of foxes in the two areas was unknown but no difference was detected in the home range size of foxes from the two areas. However, foxes in the residential area tended to use developed areas of their home range more at night and less during the daytime. Harrison suspects that unrestrained dogs may have influenced this behavior. Foxes avoided high-density rural subdivisions (more than 128 residences/km^2 [1 residence/2 acres]) although habitat appeared to be suitable for foxes. Harrison concludes that "Gray foxes appear to be tolerant of, and perhaps benefit from, residential development until residence density exceeds a threshold beyond which gray foxes avoid residential areas. The threshold for avoidance of residential areas appears to be between 50 and 125 residences/km^2...Gray foxes can use areas bisected by major roadways if culverts are provided. Irregularly shaped areas of otherwise suitable habitat may not be as useful to foxes as more simply shaped areas. Corridors should be provided and maintained in order to allow efficient travel within home ranges."

Reference: *Journal of Wildlife Management* 61(1):112-121, 1997.

Greenways in Singapore

In 1992, the National Parks Board of Singapore initiated efforts to create an island-wide park connector network linking coastal areas and national, regional, and neighborhood parks. The primary purpose of the network is to meet the perceived growing needs of humans for outdoor recreation facilities. A secondary objective is to provide habitat for wildlife, with a particular focus on birds. This is a long-term project, estimated to take up to 30 years to complete.

A pilot study of this long-term effort, focused on the Ulu Pandan Canal in Clementi, Singapore, was recently completed by the National University of Singapore, the National Parks Board, and the Nature Society, Singapore and a report written by Clive Briffett, Lily Kong, Belinda Yuen, and Navjot Sodhi. The Ulu Pandan Canal is an almost completed park connector corridor about 5 km long that passes through a number of different habitat types. It includes a 20-m wide open concrete water drainage culvert and a 6-m wide pedestrian trail. Many trees and some shrubs have been planted in the landscape scheme. The pilot study looked at bird and human use of the corridor along with peoples' attitudes toward it. To determine human uses and attitudes, questionnaire surveys were conducted of corridor users and local residents, observation surveys were conducted at access points and along the connector, and focus group discussions were held with selected groups of users and nonusers. Birds were surveyed by use of transects. Work was done in 1996. Recommendations also were made to help guide planning and design for future segments of the project.

The researchers found that the greenway was well used by people and that many used it on a regular basis. Most were residents of nearby housing estates and most use it for jogging, walking, and cycling.

Although 60 species of birds were recorded in the corridor, bird watching was a low use activity. However, users liked most the "natural surroundings" of the canal and the "quiet and peaceful" setting it offered. Over 70% of respondents agreed with the statement that "In general, nature contributes to my sense of well-being" but 64% "prefer to take a walk through tidy and well-trimmed greenery than naturally-growing greenery." Nonetheless, high preference was given to presence of trees and shrubs; shade was an important factor. It seems to this editor that these results suggest opportunity to plant trees and shrubs in future landscaping schemes that meet peoples' needs and also have value to birds and other wildlife.

Reference: *The Planning and Ecology of Park Connector Systems in Urban Areas: Pilot Study Based on Ulu Pandan Canal, Clementi, Singapore*, 1997. For report availability, contact Clive Briffett, 22 Prince Georges Park, Singapore 118421.

Constructed Wetlands and Urban Stream Restoration

North America has lost a considerable amount of its wetlands to urban and agricultural development since European settlement. Not too many years ago, wetlands were viewed as wastelands, with little or no practical value. More recently, however, the multiple benefits of wetlands have begun to be better appreciated. Included are the high wildlife value of these areas.

Along with the increased recognized value of wetlands, there has been some interest and activity in constructing wetlands in urban areas for multiple benefits--stormwater control, water quality enhancement, groundwater recharge, and fish and wildlife habitat (please see the *Urban Open Space Manager* Vol. 2, No. 2, 1997). James Helfield and Miriam Diamond, of the University of Toronto, Toronto, Canada, question the appropriateness of using constructed wetlands for combining the objectives of water quality improvement with fish and wildlife habitat enhancement. They carried out a critical analysis of a proposed constructed wetlands project for the lower Don River in Toronto. These authors point out that the lower Don is quite heavily contaminated from urban and agricultural runoff, combined sewer overflows, treated sewage effluent, industrial discharges and spills, landfill leachate, and atmospheric deposition. Provincial water quality objectives, for protection of human health and aquatic life, are frequently exceeded for a range of conventional, metallic, and organic parameters.

Helfield and Diamond review the fate of contaminants entering wetlands, including microbial decomposition, aquatic plant uptake, and sorption of contaminants onto sediment particles. Storage in plants is temporary unless plants are removed from the wetland. Periodic dredging is needed to get rid of contaminant loads in the sediment. Provisions must be made to deal with harvested plants and dredged material.

Next, the authors review the assimilative capacity of the proposed wetland for the lower Don. A key question is can the size of the proposed wetland handle the contaminant load. They calculate conservatively that, based on estimated phosphorus loadings of 61,000 kg/yr to the lower Don, about 110 ha of wetland would

be needed to reduce phosphorus levels to meet regulatory objectives. (The proposed wetland would be 50.6 ha in size.) They also calculated that about 67% of the chemical loading to the lower Don occurs between fall and spring when vegetation production and growth rates are low.

If appropriately sized, the authors believe that constructed wetlands are better suited for removing suspended solids, dissolved nutrients, and bacteria rather that heavy metals and organic compounds. Thus, in addition to wetland construction for water quality enhancement, and particularly for metals and organic compounds, contaminants must also be controlled at the source. Such practice will help to reduce the potential for toxicity to wetland fish and wildlife.

Reference: *Environmental Management* 21(3): 329-341, 1997.

Effects of Urbanization on Stream Aquatic Life

A generalized pattern has emerged regarding the effects of urbanization on streams. With more buildings and pavement, less precipitation infiltrates the ground to maintain underground water tables. Instead, greater water volume flows overland (stormwater runoff) to nearby streams. This leads to increased variation in stream flow. During and immediately following storm events, more water at greater velocity enters these waterways, speeding up erosion of the stream channel and depositing sediment on stream bottoms. Conversely, during dry periods, urban streams experience very low, or no, flow. Contaminants may also be carried into the stream from the surrounding watershed. Water temperature typically increases with urbanization too, because of loss of streamside vegetation, water flowing over warm paved surfaces, and the construction of stormwater control impoundments (which slow the movement of water and allow it to warm from the sun). These actions generally lead to a loss of cold-water species, like trout, and an increase of warm-water species, like sunfish and carp. Overall species diversity in the stream generally declines.

Stanley Kemp and James Spotila, of Drexel University in Philadelphia, Pennsylvania, recently studied the effects of urbanization on fish and bottom-dwelling macroinvertebrate communities in the Valley Creek watershed of metropolitan Philadelphia. Valley Creek supports a naturalized population of brown trout within the metropolitan area. Unlike the more typical pattern, development in the watershed is more pronounced in the upper reaches of the watershed rather than in the lower portions.

Twenty-one species of fish were recorded in the study. Most abundant species were blacknose dace, brown trout, and white sucker. Urbanization affected species composition and abundance. In the upstream portion of the watershed (industrial and commercial-residential development), mostly pollution-tolerant species were found, such as the creek chub and green sunfish. The undeveloped lower portion of the watershed supported trout, tessellated darter, longnose dace, and cutlip minnow.

Changes in the aquatic macroinvertebrate community, similar to those for fish, also were noted. The downstream portion of the watershed supported more food for insectivorous fish. In summary, the lower, non-developed portion of the watershed supported a cold-water fish and bottom-dwelling invertebrate community and the upstream developed portion of the watershed did not.

Reference: *The American Midland Naturalist* 138(1): 55-68, 1997.

Urban Stream Restoration

Can urban streams be restored to reflect pre-urban characteristics? Planting trees, shrubs, and other vegetation along a stream will help to buffer the impact of urbanization. In addition, removing accumulated sediment from sections with large depositions and replacement with gravel beds will enhance fish habitat by providing spawning sites. Where erosion of the stream bank is severe, riprap, gabions, or "root wads" may be needed. Root wads are somewhat "more natural appearing" than riprap or gabions. They are currently being used in reconstruction of streambeds and essentially are uprooted trees from which the tree crowns have been removed. The trunk and attached "root wad" are placed perpendicular to the flow of water and earth is placed over the trunk, with the root wad thus providing support to the streambank. Several root wads may be placed together along a stream.

Other techniques may be effective in restoring stream habitat. Small dams called check dams, perhaps comprising no more than a log across the stream, sometimes are used to reduce water velocity and its erosive capabilities. Care must be taken in the design and construction of such dams to ensure that migratory fish can continue to use the stream unimpeded by the

dam. Artificial riffles and pools may be constructed, if lacking in the stream. Stone boulders can be used to create riffles that help to oxygenate the water. Quiet, deeper pools provide cool retreats for fish. Restoring degraded streams is expensive. It is far better to protect such habitat as development expands than to institute corrective measures at a later date.

Reference: *Urban Wildlife Habitats: A Landscape Perspective*, by L.W. Adams, published by University of Minnesota Press, Minneapolis, 1994.

Citywide Bird Monitoring

Considerable research has been conducted on bird-habitat associations, including work in urban-suburban areas. However, few studies have looked at entire cities for patterns of bird distribution in association with land use patterns. John Hadidian of the U.S. National Biological Service (now with The Humane Society of the United States) and several of his colleagues recently reported results of such a study for the city of Washington, D.C. in *Urban Ecosystems*.

These investigators entered seven land use classes for the city (low, moderate, and high residential areas, commercial sites, public-institutional grounds, parkland, and industrial-airport sites) into a GIS (geographic information system) and associated breeding birds with the classes. Birds were recorded by 5-minute point counts from late May through June by more than 100 skilled volunteers.

Ninety-one species were observed and species distribution was associated with the land use classes. Sixty-eight percent of species were associated only with, or exhibited strong affinity for, a single land use category. For example, Wood Thrush was found mostly in large parkland areas. Four species--Eastern Kingbird, Blue Jay, Fish Crow, and Common Grackle--were found across all land use classes. As one would expect, Rock Doves (pigeons), European Starlings, and House Sparrows were among the ten most common species, which also included the Northern Mockingbird, American Robin, Northern Cardinal, and Song Sparrow. Species richness was highest in parklands and lowest in commercial areas.

The authors point out that results of the study can provide city planners, urban ecologists, conservation groups, and others with good information on bird distributions and abundance in association with land use classes over large areas. The technique could be useful in conservation planning for future development.

Reference: *Urban Ecosystems* 1:87-102, 1997.

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