THE URBAN OPEN SPACE MANAGER

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Browsing Deer in Suburban Woodlots

The concept of "edge effect" with regard to wildlife populations was introduced by Aldo Leopold many years ago in his classic text *Game Management* where he articulated his "Law of Dispersion." The law states that the density of those wildlife species requiring two or more habitat types is proportional to the amount of edge between or among those habitat types. Deer are among the "edge species" recognized by Leopold and much discussion continues today regarding edge effect and wildlife populations.

Of particular relevance to urban-suburban forest managers and restorationists is a recent article published in *Restoration & Management Notes* by researchers Andrew Wester, of Fordham University in New York City, and Truman Young, of the University of California, Davis. In 1996, these investigators studied white-tailed deer activity in the Westmoreland Sanctuary, Westchester County, New York. The sanctuary comprises some 250 ha of mixed maple-oak-hickory forest.

Wester and Young found that most deer browsing occurred within 50-70 m of the forest edge and that deer were three to four times more likely to be near the forest edge than 70-100 m inside the forest (based on track counts in snow). Deer trails were ten times more abundant at the forest edge. These investigators point out that browsing by deer in areas of substantial deer populations may be particularly damaging to seedlings of species such as northern hemlock and red cedar in perimeter zones of forests undergoing restoration. Control of deer populations, seedling protection, or some combination of the two may be needed for successful restoration to occur.

References: *Game Management*, published by Charles Scribner's Sons, New York, 1933; *Restoration & Management Notes* 15(2):186-187, 1997.

Urban Stream Management

To protect property and human life, urban streams typically have been managed to reduce flooding through channel clearing, straightening, stabilization, and enlargement. However, researcher Gregor Auble of the U.S. Geological Survey and four of his colleagues of that agency present evidence in a recent issue of *Wetlands* that such practice has negative effects on natural riparian vegetation. They note that such practice decreases the rate of cottonwood seedling establishment along western U.S. streams historically dependent on natural disturbance to maintain cottonwood communities.

During 1989 and 1990, Auble and his colleagues studied a 12-ha riparian nature preserve (Cottonwood Grove) along Boulder Creek in Boulder, Colorado. Boulder Creek has been subjected to diversion, straightening, stabilization, and clearing. These researchers were interested in determining vegetation response along the stream to management practices involving the regulation and constraining of stream flow through the urban area.

The bottomland associated with Boulder Creek was classified as channel bed, floodplain, and terrace. The floodplain was dominated by plains cottonwood and sand bar willow (both native species), but also containing green ash (native to Kansas and Nebraska), and crack willow and Russian-olive (both native to Eurasia).

Woody plants greater than 10 cm in diameter were largely restricted to the terrace and these consisted mostly of crack willow, green ash, and boxelder (native to the site). A few old plains cottonwoods also were on the terrace, but no seedlings or saplings of this species were there. "The isolation of the terrace from riverine disturbance has apparently reduced cottonwood establishment and favored other species (mostly exotics) that do not require disturbance for continued reproduction."

Cottonwood seedlings need bare, moist, unshaded sites created by channel movement and flood deposition. Naturally-occurring riparian cottonwood communities are dependent upon flood disturbance, but the other woody species on Boulder Creek floodplain are not. "By preventing these processes of bottomland change, channel maintenance and flow regulation have greatly reduced the area available for cottonwood recruitment."

Auble and his colleagues provide several management options for urban riparian forests. One option is to continue current management practices. Under this scenario, the authors predict that "...urban riparian cottonwood populations can be expected to decline over the long term even when they are protected from on-site industrial or residential development." A second option is to mimic the effects of flood disturbance to remove exotics and encourage establishment of cottonwood naturally from seed. This could be done with earth-moving equipment and irrigation. A third option is to plant larger, pole-sized cottonwoods. Lastly, the authors recommend that, outside of the urban core, channel stabilization activities should be minimized.

Restoration practices involving use of boulders (to prevent bank erosion) and elimination of woody debris reduce channel movement and subsequent formation of new bare moist sites needed for cottonwood establishment. "Managers need to be aware that bank erosion, shifting channels, sediment transport, and overbank flooding are natural processes that promote and maintain native ecosystems in the Great Plains.

Reference: *Wetlands* 17(1):138-148, 1997.

Monitoring Recreational Use in Urban Nature Parks

Parks, whether at the national, state (provincial), or local level, typically are managed to maintain their ecological integrity and to be used by people. Meeting both objectives is not always easy. Popular parks risk degradation from overuse by people, which may very well destroy the original natural values that make the parks popular attractions. Management should be based on the best available information.

In order to balance human use of parks with maintenance of ecological integrity, managers need to monitor sites on a regular basis. Researcher Denyse Lajeunesse, of the Montreal Botanical Garden, and three of her colleagues, developed a protocol to monitor the effects of human recreational use for the Montreal Urban Community nature parks network. The methodology is relatively easy to implement and interpret yet accurate enough to detect changes and suggest necessary actions to recover degraded sites. The protocol consists of three levels of monitoring intensity.

Level 1

Level 1 monitoring involves inventorying and evaluating the trail system. All trails are identified, mapped, and measured to length. The evaluation process is designed to focus future monitoring effort on trails most susceptible to degradation. This is determined by evaluating the risk of trail users overflowing off the trails and signs of such overflow. Risk of overflow is measured by trail cover type, type of habitat along trail, and presence or absence of trail edging. Trail cover type (surface) is classified into one of six types from asphalt to bare soil (the latter is most susceptible). Type of habitat is classified into one of five types from dense shrubs (low susceptibility) to forest with an open understory (high susceptibility). Trails with edging, like logs or rocks, are not as susceptible to degradation as are trails without edging.

Signs of human overflow from the trail system are indicated by unapproved paths and trampling of vegetation (both with five categories from none to very numerous). Based on this evaluation, trails are classified into one of four classes of susceptibility from low to very high.

Level 2

Level 2 monitoring measures trail degradation. Priority is given to trails classified as more susceptible to degradation in Level 1.

The following eight variables were selected for monitoring the degree of trail degradation based on an earlier pilot study. Evaluations were made systematically along the entire length of a trail. For each variable, a range of categories was established and a number assigned to each (1 to 3, or 1 to 4). For each variable described below, the number scale runs from lowest to highest. After surveying a trail, numbers for each variable are summed and trails are classified as not degraded (score of 8-10), lightly degraded (11-16), moderately degraded (17-24), or highly degraded (25-30).

Trail Width--Classified into four categories based on width from less than 50 cm to over 100 cm.

Surface Rocks--Trails were placed in one of four categories on the basis of presence of surface rocks (from none to high abundance).

Forest Litter--Four categories were scaled from high abundance to none.

Surface Roots--Three categories were scaled from

none to high abundance.

Soil Erosion--Four categories were scaled from none to high abundance.

Bike/Vehicle Tracks--Three categories were scaled from none to high abundance.

Soil Resistance--Four categories were scaled of soil compaction.

Plant Cover on Trail--Four categories were scaled from high abundance to none.

Level 3

Level 3 monitoring focuses more intense effort on trails of high ecological value traversing sensitive areas and receiving strong pressure from user activities. Level 3 monitoring measures plant species composition in relation to distance from trail. Transects of 1-m^2 quadrats are established perpendicular to the trail, the number depending on length of the trail. Each side of the trail is sampled.

Seven cover classes were established for the following variables: total plant cover, area occupied by trees, area covered by surface rocks, area of bare soil, and forest litter. Two additional variables were measured--saplings and shrubs--and in each case, a species count was made. Each species also was evaluated by cover classes.

Six indices were calculated to record plant compositional change (a diversity index, heliophyte index (a measure of sun-loving plants), life form index, exotic species index, hydrophyte index, and a similarity coefficient index). The latter index was calculated to compare species composition in space (position from trail) and in time (same position from trail but measured over time).

The procedure described here was tested in a pilot study in Pointe-aux-Prairies nature park on the eastern end of Montreal island, Quebec. It seems to be workable and practical, although future improvements certainly will evolve. The authors concluded that "Monitoring systems remain, nonetheless, valuable tools in the ecosystem management programs of protected areas. However, these programs require long-term investments, which are not always easy to maintain in today's context. Prioritizing efforts is one way to bypass these constraints and allow us to continue managing ecosystems, to be able to assess our management actions, and to ensure that we are maintaining the quality and integrity of our protected areas."

Reference: *Natural Areas Journal* 17(4): 366-379, 1997.

Disease Control in Urban Raccoons

Will vaccinating urban raccoons against canine distemper or rabies reduce the prevalence of disease in wild populations? Will disease reduction or eradication result in increased populations of animals that are a nuisance to humans? These are questions of interest to many open space managers in the urban environment.

To help answer these questions, researcher Claudia Schubert, of the University of Guelph, Guelph, Ontario, Canada, and four of her colleagues at the university and the Ontario Ministry of Natural Resources, studied urban raccoons in the city of Scarborough, Ontario. During 1991-1993, raccoons in a 32-km^2 treatment area of the city were trapped, vaccinated intramuscularly against canine distemper, and released at the site of capture. The rest of the city (some 200 km^2) served as a control area.

The researchers found that during a canine distemper epizootic in 1992 prevalence of the disease was significantly lower in the treatment area (1.4%) compared to the control area (8.3%). Patterns of population change were similar for treatment and control areas during the study period so the investigators reasoned that canine distemper did not limit the raccoon population. Schubert and her colleagues concluded that "...our results indicate that reducing or eradicating diseases such as canine distemper will not necessarily result in increased local populations of nuisance animals, nor in increased costs of managing them."

Reference: *Ecological Applications* 8(2): 379-387, 1998.

Butterfly Use of Building Walls

Artificial structures in urban open spaces may provide habitat for some wildlife species. Two researchers, A. Ruszczyk and C.F. Silva, of Porto Alegre, Brasil, studied butterfly use of external building walls of the Federal University of Uberlandia, in southeast Brasil, during 1993 and 1994. They note that such walls may be used as sites for thermoregulation, perching-roosting, and for larval pupation.

Both adult butterflies and pupae appeared to select

certain microhabitats on the walls (they were not randomly distributed). "Girders and columns were especially utilized by adults, while slots, window frames, overhangs, and other protected microhabitats were preferred as pupal attachment sites." Thirty-three species of adult butterflies (almost one-fourth of the species pool in the area) used walls as perching sites. Long-tailed skippers constituted about half of adults observed on the walls. Similar numbers of perched butterflies were recorded during sunny, cloudy, or rainy weather so the researchers believe that the butterflies do not congregate under protected areas of buildings during rainy weather.

These investigators concluded that "Many elements of the urban fauna utilize human artifacts. The presence of these interactive faunal elements should be considered in planning and designing new architectural features on buildings. The emphasis could be on repelling noxious or harmful species and attracting desirable species. For example, small cavities on the base of the walls (or in other places which do not conflict with architectural design) like retracted skirting boards could enhance pupal survival in some urban butterflies..."

Reference: *Landscape and Urban Planning* 38: 119-127, 1997.

Effects of Development on Wildlife Habitat

In a recent paper published in *Landscape and Urban Planning*, David Theobald, of Colorado State University, and two of his colleagues present a general approach to estimating wildlife habitat disturbance resulting from different development densities and patterns. The approach is based on a Colorado project called *A System for Conservation Planning* that "provides planning tools to aid county officials, citizens, and developers in making informed decisions regarding the potential effects of residential development on wildlife habitat." It is based on an assumption that the magnitude of human-related effects decreases with distance from the source of disturbance. This "building effect" results in a "disturbance zone" with a radius equal to the assumed building-effect distance.

The authors examine relationships among development density, pattern, and disturbance zone using a range of building-effect values. They also compare one development pattern to another assuming the same building-effect distance. Seven hypothetical subdivision patterns, ranging from dispersed to tightly clustered, are examined and for each three indices were calculated: 1) disturbance zone area, based on building-effect distances of 50 m, 100 m, 200 m, 300 m, 400 m, and 500 m; 2) length of edge, which was the perimeter of all parcel boundaries; and 3) perimeter-to-area ratio, a measure of shape. The three clustered patterns included in the analysis had less disturbance zone area, lower edge length, and more compact shape compared to more traditional (dispersed) lot layout.

These authors concluded that "Clustering development reduces disturbance of development on wildlife habitat." Further, "While clustered subdivisions reduce total disturbance zone area, the positioning of adjacent clustered subdivision[s] should be considered to limit fragmentation effects at a coarser scale. That is, the same issues important in determining negative impacts associated with different subdivision patterns apply at a broader scale as well. In particular, rules which result in the clustering of clustered subdivisions that minimize overall habitat fragmentation are needed."

Reference: *Landscape and Urban Planning* 39: 25-36, 1997.

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Urban Nesting Cooper's Hawks

What factors influence nesting of Cooper's hawks in urban landscapes? Can these birds be retained in the bird community of urbanizing areas? These are questions of interest to Clint W. Boal and R. William Mannan, of the University of Arizona, who studied a population of Cooper's hawks in Tucson, Arizona. During 1993-1996, these investigators identified features of urban landscape associated with nest sites of the species.

Thirty-three hawk territories were located and 60 different nest trees used by hawks were identified. Most of these were located in frontyards and backyards of private residences or high-use recreation areas. Birds preferred to nest in high residential use areas (3 or more residences/0.4 ha), and in high recreational use areas (district and regional parks 4 or more ha in size, golf courses, and school grounds).

Birds showed tree preference for nesting. Those most often selected were eucalyptus, aleppo pine, and cottonwood. Birds also selected the taller trees and those with larger dbh. Site features that were important to nesting birds were basal area, canopy cover, and number of trees more than 10 m tall. Nesting density in the Tucson study area was 1 nest/437 ha, which is at the high end of reported densities. Exurban areas typically have lower densities than this.

The authors discuss three factors important to nesting Cooper's hawks in Tucson. Firstly, birds are attracted to groves of tall, full-canopied, exotic trees. Human activity did not appear to disturb the birds, but birds did nest high in trees, perhaps for a sense of security. A second important factor to the birds is availability of water. This is provided by way of bird baths, pools, and irrigation systems. Thirdly, prey abundance is high in the area, particularly Inca doves and mourning doves, which are correlated with increasing housing density.

Reference: *Journal of Wildlife Management* 62(3): 864-871, 1998.

Winter Birds in Finland

Most research on urban bird-habitat associations has focused on the breeding season, although knowledge of bird use of habitats at other times of the year also is important. Jukka Jokimaki, of the University of Lapland, and Jukka Suhonen, of the University of Jyvaskyla, both of Finland, recently studied urban wintering birds in that country. Their research, conducted during the winter season (December-February), focused on 31 urban settlements in Finland. Habitats were classified as wooded parks, open fields, or built-up areas, and birds were grouped as seed-berry eaters, omnivores, or insectivores.

Twenty-six species and 5,155 individual birds were recorded in the study. The data support other European findings that the structure of urban bird communities is very similar over differing geographical locations. Omnivores were most common, ranging from 44% of the bird community in less urbanized areas to 79% in heavily urbanized areas. Included here were the rook, hooded crow, jackdaw, rock dove, and house sparrow, all of which correlated positively with human population density. Seed-berry eaters like the fieldfare and waxwing were attracted to planted European mountain-ash trees. Insectivores were least common, averaging 3% of the urban bird community. Most of the insectivores live in coniferous forest and were negatively correlated with human population density. Included here were the coal tit, crested tit, willow tit, tree-creeper, and great woodpecker.

Conifers are particularly sensitive to air pollution and are less favored in urban planning throughout Europe than deciduous trees and shrubs like alder, mountain-ash, birch, plum, and cherry. The authors recommend that effort be made to plant coniferous trees in urban park management schemes where possible. They also recommend increasing the number of berry-producing trees and shrubs to benefit the urban bird community.

Reference: *Landscape and Urban Planning* 39: 253-263, 1998.

Habitat Selection by Urban Coyotes

Timothy Quinn, of the Washington Department of Fish and Wildlife, studied urban coyotes in the Seattle, Washington, metropolitan area for his Ph.D. dissertation (University of Washington) and continues to publish results of his research. In a recent article in *Northwest Science*, he reports on coyote use of urban habitat during routine movements of the animals.

In 1989-1990, Quinn radio-collared and tracked six coyotes. He found that, in order of decreasing importance, they used forest/shrub areas, densely mixed vegetation, moderately mixed vegetation, and sparsely mixed vegetation. Quinn concluded that "Coyotes preferred to travel through, and remain in close proximity to, relatively undisturbed (Forest and Shrub) habitats in urban environments of Washington State." Coyotes persisted, or established home ranges, in urban areas with less than 25% combined forest and shrub habitat. They patterned movements to stay close to hiding cover, thus, suitability of the urban environment for coyotes may be more a function of distribution, rather than overall quantity, of preferred habitats.

Reference: *Northwest Science* 71(4): 289-297, 1997.

Red Fox Use of Urban Habitats

Urban red foxes have received considerable research attention in Britain, where concern centers on the high density of foxes in many cities and on controlling rabies if the disease should spread to the country from the European mainland. Past research has shown that foxes are most common in residential suburbs consisting of privately owned, low density housing. At present, the method of control would be use of poison baits. However, limited research shows that uptake rates of poison by foxes would be too low to affect control of the disease. Higher uptake rates might be achieved by concentrating baits in preferred habitats.

Researchers G. Saunders, P.C.L. White, and S. Harris, of the University of Bristol, recently quantified habitat preferences of suburban foxes in Bristol, England. They radio-collared and tracked seven foxes over three or more seasons (spring, summer, fall, winter). Habitats were classified as: 1) back gardens; 2) front gardens and common gardens; 3) playing fields, parklands, churchyards and cemeteries; 4) roads, verges, shops and commercial centers; and 5) woodlands, rough ground and allotment gardens.

These investigators found that habitats one and five (relatively undisturbed areas) were preferred by foxes with regard to time spent and distance moved in each. Those habitats also were most used as daytime resting sites. With regard to the rabies control strategy, Saunders and his colleagues suggest concentrating baiting effort in the preferred habitats.

Reference: *Mammalia* 61(4): 497-510, 1997.

Restoring and Creating Wetland Habitat for Amphibians

Little attention has been given to amphibian habitat requirements in past wetland mitigation projects. This may be changing now because of current heightened awareness and concern for amphibians resulting from widespread reports of the decline of many species. Multiple factors may be responsible for these declines, including habitat loss and deterioration. Land development, including for urbanization, continues to influence wetland loss through draining, filling, and altering these habitats by modifying hydrology, water quality, and vegetation. Upland feeding and refuge habitats also are impacted.

Watershed protection and wetland restoration can stabilize or reverse amphibian declines if needs of amphibians are considered. Habitat needs for all life stages--aquatic and terrestrial--must be met. Important considerations include the spatial arrangement between wetland breeding and upland feeding/refuge patches, and interconnecting corridors between wetland and upland habitats. Amphibians requiring water for breeding and egg laying must be able to travel to upland feeding and wintering sites. Also important are wetland design features that optimize oviposition (egg attachment) and egg and larval survival.

Klaus Richter, of the King County Natural Resources Division (Seattle, Washington), recently published *Criteria for the Restoration and Creation of Wetland Habitats of Lentic-Breeding Amphibians of the Pacific Northwest*. With a focus on the Puget Sound Basin and from literature review and his own research, his objectives were to identify habitat requirements of amphibians and to quantify wetland site-selection and design criteria.

Site-selection Criteria

Many wetland-breeding amphibians spawn in wetlands during a short time period and spend most of the year

in terrestrial feeding and refuge habitats. In general, upland habitat should be cool and humid. Richter states that, based on present knowledge, it is "best to select wetland restoration sites adjacent to, or as close to, forested habitats as possible." Based on published research of others, he recommends a 1,000-m maximum distance between source and mitigation wetland in undisturbed forested landscapes. Barriers such as roads, fences, and housing may prevent or disrupt colonization. Corridors between wetland and upland sites should provide cool, moist microclimates. According to Richter, "Corridor widths should provide a core area of large diameter logs and other coarse wood to provide refuge habitat..., cover to minimize predation, and cover to limit potential agonistic behavior between species, sexes and age classes." He recommends a core corridor width of 30 m. The core corridor should be buffered by additional vegetation to maintain soil moisture and ground temperature of the core (60-120 m), to stabilize air temperature and humidity (120-180 m), and to negate vegetation responses (240 m). Thus, combining the core corridor with buffers would yield widths of 150-270 m to maintain soil moisture, 270-390 m to maintain air temperature, and 510 m to retain intact and self-sustaining vegetation in the core. However, Richter points out that migrating and dispersing amphibians will move through sub-optimum vegetation and climatic conditions so a width of 150 m is suggested as suitable. Also, with regard to site-selection criteria, Richter recommends locating restoration or mitigation wetlands in watersheds in which imperviousness (sum of roofs, sidewalks, parking lots, roads) does not exceed 10-15% unless specific methods are used to minimize hydrological and water-quality impacts on wetlands.

Wetland Design Criteria

Important wetland factors to breeding success of most amphibians are current velocity, degree of water permanence, water depth, and water level fluctuation. Current that is too swift can prevent breeding, reduce fertilization, dislodge eggs from attachment sites, or physically damage eggs with suspended silt, sediment, and large floating debris. Richter recommends that velocities not exceed 5 cm/second through mitigation wetlands.

Some semi-permanent wetlands are important within a region for many amphibians because such wetlands preclude establishment of predators, such as fish, other amphibians, and invertebrates like crayfish and dragonflies, on the eggs and young of amphibians. According to Richter, "Several closely situated wetlands with differing hydroperiods, or one two-celled wetland in which one cell is vernal and the other remains permanently flooded, would provide breeding and spawning habitat for the full compliment of native species."

Oviposition of most temperate amphibian species is at depths of 10-100 cm. Therefore, Richter recommends, "To encourage spawning by Puget Sound Basin amphibians, mitigation wetlands with depths of 10-50 cm should be available from December through May. Terraced shores of 10-20 cm, 30-40 cm, and 50-60 cm depths, or alternately, a gradual side slope gradient of 10-horizontal to 1-vertical or shallower slope, to a total depth of 50 cm, should provide spawning habitat for all species."

Amphibians are sensitive to water level fluctuations. Therefore, with consideration to amphibians, water level should be stabilized from spawning through hatching. Many species spawn within 10 cm of the water surface. Too much fluctuation can dry out or kill eggs. Mean water level fluctuation greater than 20 cm is correlated with decreased amphibian richness.

Wetland vegetation is important to breeding amphibians. Research indicates that most species may prefer an interspersion of open water and vegetation for oviposition. Richter recommends a 25:75 to 75:25 ratio of open water to vegetation to encourage spawning. Plant species *per se* are not particularly important. However, stem diameter is important. Stem diameters averaging 3-4 mm are used most, with smaller amphibians using smaller stems (1-2 mm) and larger amphibians using larger stems (6-8 mm).

Several factors are important with regard to wetland layout. Wetland size is not particularly meaningful, but configuration, orientation, and buffers are significant. With regard to wetland configuration, shoreline length is important because of vegetation and water depth. Vegetated shorelines are effective in providing food and shelter to larvae. Configurations increasing shoreline length to area ratio are beneficial to amphibians. Wetland orientation in relation to the sun (and thus water temperature) is important. Research shows a preference to northern shores for egg deposition. Thus, providing gradual shallow slopes along northern shores will benefit amphibians. Upland buffers around wetlands provide staging habitat for breeding and food and cover for young. Such areas have been little studied, but maintaining a treed riparian zone with a buffer width equal to 2-3 tree heights around a wetland is recommended. Some authors recommend a 30- to 95-m

buffer but no hard data are available to support these figures.

Richter concludes, "Finally, siting mitigation to benefit amphibians by the suggested criteria will preserve upland habitat, contribute undeveloped areas of open space, and provide places for passive recreation. Maintaining urbanizing areas in forest cover also increases stormwater infiltration, promoting groundwater recharge and flood control. These important landscape features, which are disappearing from watersheds under increasing development pressures, should be protected and maintained."

Reference: *Wetland and Riparian Restoration: Taking a Broader View* (K.B. Macdonald and F. Weinmann, eds.). Publication EPA 910-R-97-007. U.S. Environmental Protection Agency, Region 10, Seattle, Washington, 1997.

Green Networks in England

George Barker, Urban Coordinator for English Nature, recently authored a report entitled *A framework for the future: green networks with multiple uses in and around towns and cities*. Barker argues that to be most widely supported, these green networks should be managed to meet multiple objectives such as providing recreation (walking, hiking), transport (cycling), water management (including stormwater/flood control and water quality enhancement), air pollution control (trees and other vegetation to trap airborne particles and to provide shade, thus reducing the urban heat island effect), outdoor education, and wildlife habitat (corridors connecting to habitat patches). He states, "Where green networks serve a variety of functions, the benefits of which are clearly understood and supported by evidence, they are readily defended if needs be. They are less likely to be challenged in any case because their value across a range of functions is more likely to be respected by a wide audience."

Barker also argues that natural greenspace has human social value and people living in towns and cities should have:

"• an accessible natural greenspace less than 300 metres (in a straight line) from home;

"• statutory Local Nature Reserves provided at a minimum level of 1 hectare per thousand population;

"• at least one accessible 20 hectare site within 2 kilometres of home; one accessible 100 hectare site within 5 kilometres of home; and one accessible 500 hectare site within 10 kilometres of home."

These recommendations have been adopted by English Nature and the city of Birmingham has formally adopted standards linked to them.

Reference: English Nature Research Reports No. 256, *A framework for the future: green networks with multiple uses in and around towns and cities*, English Nature, Northminster House, Peterborough PE1 1UA, UK.

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Urban Remnant Grasslands

Research is showing that it is often difficult to maintain the integrity of small remnant patches of native vegetation in the face of urbanization. Invasion of native plant communities by exotic species is common. In Australia, remnant volcanic plains grasslands have been reduced in extent over 99%. Such grasslands (dominated by the C4 grass *Themeda triandra*) are now found mostly in cemeteries and along roads and railways.

John Morgan, of La Trobe University, Bundoora, Victoria, Australia, studied the pattern of exotic plant invasion of an urban native grassland remnant (100 m wide and 400 m long) 30 km northwest of Melbourne. He found that non-native species richness was higher at the edges and that native seedling density was higher in the center of the remnant. It appears that native species richness is generally low when the percent overlapping cover of non-native species exceeds 40%. Morgan also correlated higher levels of soil phosphorus along edges with both number and cover of non-native species. Soil phosphorus was negatively correlated with number and cover of native species.

In Morgan's study, many non-native species tended to be generalists with non-specialized habitat or germination requirements. Species with these characteristics included fescue, spotted catsear, and little quaking grass. Some non-native species were "resource limited," and responded to increased phosphorus levels and/or soil disturbance. Species with these characteristics included bentgrass, common Bermudagrass, and perennial ryegrass.

According to Morgan, "Management must aim to minimize increases in cover of any non-native species or the disturbances that favour the establishment of competitive non-native grasses if the native grassland flora is to be conserved in small, fragmented remnants." Non-native generalists should be maintained at low cover and density by repeated spring burning to prevent seed set. Resource-limited non-natives should be contained by minimizing soil disturbance and soil nutrients (from fertilizer drift or movement of nutrient-rich soil from adjoining agricultural fields). The author noted a third group of non-native species with characteristics somewhat overlapping those of generalists and resource-limited species. Examples in this group include canary grass and common velvetgrass. These plants need further study.

Reference: *Journal of Vegetation Science* 9: 181-190.

Winter Birds in Finland

The number of species of plants and animals decreases from the earth's tropics to the poles, and ecologists continue to study reasons for the pattern. Researchers Jukka Jokimaki, Jukka Suhonen, Kimmo Inki, and Simo Jokinen, of the University of Lapland and the University of Jyvaskyla, recently investigated effects of geographical latitude on wintering urban bird assemblages in the northern coniferous forest biome. They studied 31 small and large settlements in Finland, where more than 60% of human residents reside in urban areas.

Twenty-eight species of wintering birds were recorded in the study. In medium and highly urbanized areas, the number of species did not decrease from south to north, nor did density of birds. Bird density increased with level of urbanization, particularly for feral pigeon, hooded crow, and house sparrow. Also included as dominant urban birds were great tit, blue tit, greenfinch, and magpie. Urban areas were dominated by a few resident species with wide geographic ranges. They tended to be omnivores with behavioral plasticity. Dominant species did not differ between north and south and made up 89%-95% of bird assemblages in the study. In an earlier North American study, Art Johnsen and Larry VanDruff noted a similar pattern in winter birds. Three introduced species--house sparrow, pigeon, and starling--made up 94% of the winter bird community in Syracuse, New York. This pattern also is reflected in several other European studies. Warmer temperatures and a more abundant food supply from bird feeders-tables and other sources may help to explain the pattern.

The Finnish researchers concluded that..."bird species richness decreased northwards in small settle-

ments, but not in more urbanized areas. Bird density did not decrease northwards at all. We supposed that continuous and rich food resources may explain the high bird density and the lack of decreasing trend of species richness towards north in urban areas. Energy rich supplementary food may overcome the problems of severe climate in northern areas."

Reference: *Integrating Man and Nature in the Metropolitan Environment*. Natl. Inst. for Urban Wildl., Columbia, Md., pages 123-127, 1987.
Journal of Biogeography 23: 379-386, 1996.

Damselflies in Italy

Life history features of dragonflies and damselflies in human-stressed environments have not been well studied. However, researchers at the University of Rome (Angelo Solimini, Giuliano Tarallo, and Gianmaria Carchini) recently added data to our knowledge base on this subject. From September 1993 through July 1994, these investigators studied the species composition and life history of the damselfly assemblage along the lower part of the Tiber River in central Italy, where the river flows through the city of Rome. Earlier work showed that physical and chemical variables of water had values typical of organic-polluted rivers, with water quality lower below the city.

Six species were recorded from 1,422 individual damselflies collected. The three most prevalent species, considered common "generalists" in central Italy, characteristically inhabit still and moderately flowing waters. Two species were typical riverine species and decreased with increasing pollution downstream from the city. The authors concluded that, "The long reproductive period, the absence of growth synchronization by egg or larval diapause and a better adaptation to low oxygen conditions are probably the main reasons for the preponderance of generalist species...over the specialized riverine species. The species composition appeared altered mainly in the last, more polluted site, while the life histories features appeared already altered in the intermediate, slightly less polluted site. This suggests that life history features are more sensitive biological indicators of environmental deterioration than modification in the species composition." Loss of "specialist" species and an increase of "generalists" in urban areas is a pattern seen in other animal groups, including birds and mammals.

Reference: *Hydrobiologia* 356: 21-32, 1997.

Birds of Turin, Italy

A considerable literature base shows a pattern of bird response to urbanization. Typically, the number of species declines and density of a few species increases with increased urban development. Antonio Rolando, of the University of Torino, Italy, and three of his colleagues studied birds in the city of Turin (northwestern Italy) along a vegetation gradient from highly urbanized to completely wooded habitat and evaluated avian community organization in relation to degree of urbanization. Field work was conducted during all seasons (autumn, winter, spring, and summer) between 1990 and 1994.

One hundred seven species were recorded and results fit the typical pattern mentioned above. The lowest number of species was found in the most urban part of the city. Here, during autumn and winter the bird community was limited largely to pigeon, house sparrow, starling, and crow. During spring and summer, the same birds were found, along with common swift, pallid swift, house martin, greenfinch, and black redstart.

Most birds responded to vegetation. In wooded or semi-wooded habitat, the researchers observed nuthatch, jay, long-tailed tit, and chaffinch. In parks and gardens, they found magpie, white wagtail, and collared dove. Some species ("habitat generalists") made use of both wooded and open habitats. Included here were the blackbird, robin, and great tit. This research, as does earlier work, points out the importance of vegetation composition and structure to birds.

Reference: *Italian Journal of Zoology* 64: 341-349, 1997.

Controlling Urban Gulls

There has been an increase in nesting populations of herring gulls and ring-billed gulls in the Great Lakes region of the United States and Canada in the past 30 years. Along with this trend has been increased use of urban habitats (e.g., roofs of buildings and mowed grass fields of airports). Large numbers of birds may cause problems by harassing maintenance personnel, defecating on vehicles, obstructing drain pipes and vents with nest material, causing structural damage to buildings, or, at airports, increasing the potential for gull-aircraft collisions.

Little research has been conducted on the effectiveness of various techniques in controlling populations of

nesting gulls. Sheri Ickes, Jerrold Belant, and Richard Dolbeer, of the U.S. Department of Agriculture, National Wildlife Research Center, Sandusky, Ohio, address this research need in a recent paper published in the *Wildlife Society Bulletin*. Specifically, these investigators studied the effectiveness of five nest-disturbance techniques in reducing herring gull and ring-billed gull nesting activity in urban habitat: 1) nest-and-egg removal, 2) egg removal, 3) nest-and-egg destruction, 4) egg destruction, and 5) egg replacement. The study was conducted in northern Ohio, 1993-1996, and focused on gull nesting colonies on flat roofs of buildings and two mowed grass fields, one of the latter at a local airport.

These researchers found that "Egg removal was at least as effective as nest-and-egg removal and required about 60% less effort...however, removal of nests may reduce structural damage to roofs caused by nesting material...Egg replacement was the least effective of the techniques evaluated. Unless structural damage to buildings is of concern, egg removal is recommended over other nest disturbance techniques evaluated for inexpensive, long-term reductions of roof-nesting colonies. Nest-and-egg or egg destruction is recommended for ground-nesting colonies. Use of other control methods (e.g., habitat modification, frightening techniques) in addition to nest disturbance may increase the potential for colony abandonment."

Reference: *Wildlife Society Bulletin* 26(2): 269-273, 1998.

Nesting Starlings

European starlings are aggressive birds and during the nesting season often out-compete more desirable bluebirds, wood ducks, and other cavity-nesting species for nest sites. Jerrold Belant and three of his colleagues at the U.S. Department of Agriculture, National Wildlife Research Center, in Sandusky, Ohio, recently compared an odor-based repellent (phenethyl alcohol), eyespots, magnetic fields, and avian-predator effigies for effectiveness in deterring starling nesting in artificial cavities. During 1993, 1995, and 1996 in northern Ohio, they studied starling nesting activity in 81 constructed nest boxes. Phenethyl alcohol was placed inside test boxes as were the magnets. The latter were about 150-200 times greater than the earth's magnetic field. Test boxes with eyespots had two of these items mounted 6 cm apart above the entrance hole on the outside of the box. The eyespots were 2-cm diameter, straw-colored taxidermy eyes with 1-cm black pupils. Great-horned owl and merlin effigies were placed just above nest boxes.

These investigators concluded that "PEA [phenethyl alcohol], eyespots, magnetic fields...and avian-predator effigies are ineffective as deterrents for starlings nesting in artificial structures."

Reference: *Wildlife Society Bulletin* 26(2): 264-268, 1998.

Fertility Control of Overabundant Wildlife Populations

Researchers Lowell Miller, Brad Johns, and Donald Elias, of the National Wildlife Research Center, Fort Collins, Colorado, recently discussed perspectives on immunocontraception as a wildlife management tool in the *Wildlife Society Bulletin*. They point out that four decades of contraceptive research has not yet led to development of effective programs for controlling wildlife populations. Early research in the 1960s and 1970s focused on use of synthetic steroids, estrogens, and progestins (i.e., chemosterilants) in a variety of animals. More recent research has focused on immunocontraception. Immunocontraception involves the production and delivery of a vaccine that stimulates production of antibodies in the animal's body. For example, a vaccine stimulating production of antibodies to the gonadotropin-releasing hormone (GnRH) can block production of GnRH. GnRH is produced in the brain by the hypothalamus and controls release of follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which control functions of ovaries and testes. Antibodies to GnRH reduce the level of the hormone thereby reducing release of the reproductive hormones FSH and LH, which leads to atrophy of gonads and infertility in both sexes. Miller and his associates are conducting research at the National Wildlife Research Center on use of GnRH to control fertility of white-tailed deer. They point out that melatonin, which stimulates GnRH secretion, may prove useful as a contraceptive agent with further research.

There is considerable current interest in the research community on use of porcine zona pellucida (PZP) vaccine, particularly for white-tailed deer. (Please see Volume 3, Numbers 1 and 2 (1998) of *The Urban Open Space Manager* for review of some of the current research in this regard.)

A vaccine also can be produced to stimulate production of antibodies to chorionic gonadotropin hormone

(CG), a hormone produced by the implanted embryo in some species. CG induces the corpus luteum on the ovary to continue production of progesterone needed for maintenance of pregnancy. Antibodies to CG reduce blood levels of the hormone, precluding successful implantation of the fertilized egg.

Riboflavin is a water-soluble vitamin required by the developing embryo. The embryo gets this vitamin from active transport across the placenta. Transport of riboflavin from mother to embryo is facilitated by a riboflavin carrier protein (RCP), which is important in birds and mammals. Some research indicates that antibodies to RCP may serve as an immunocontraceptive.

Miller and his associates also point out that sperm antibodies are being studied for contraception in the red fox and rabbit in Australia.

In addition to the challenge of producing a vaccine that will function as an immunocontraceptive is the challenge of delivering the vaccine to the target animal. Traditional delivery has been by subcutaneous or intramuscular injections. For free-roaming animals this generally involves use of a "dart gun" firing a dart syringe or a "biobullet." This technology may prove effective in confined situations, but Miller and his associates argue that in open areas oral vaccine delivery is needed. The goal of immunocontraceptive studies at the Denver Wildlife Research Center and the National Wildlife Research Center is to produce oral vaccine. Some work has been done with regard to oral rabies vaccines for raccoons and foxes, and researchers are considering mechanisms for delivering an oral immunocontraceptive vaccine.

Immunocontraception has not yet advanced to management application. Active research continues and advances must be made in the technology before it has usefulness as a management tool. Miller and his colleagues conclude that "This is a promising technology to be integrated with traditional methods of wildlife population management. Continued research is the key to developing the full potential of this technology."

Reference: *Wildlife Society Bulletin* 26(2): 237-243, 1998.

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Metropolitan Greenways for Recreation

Most people in the United States (and in many other countries) now live in metropolitan areas. Nearby greenways can provide considerable recreational benefit to these residents, like walking, bicycling, bird watching, or just general nature enjoyment.

Researcher Paul Gobster, of the USDA Forest Service in Chicago, is interested in people's perception and use of greenway trails. During weekends throughout the summer of 1989, he surveyed users of trails in the Chicago metropolitan area. He was specifically interested in recreationists' use patterns and preferences for 13 greenway trails in the six-county Chicago metropolitan region. Five trails were local, seven were regional, and one was state maintained. Two thousand eight hundred seventy-three usable surveys were collected from respondents on the 13 trails.

Gobster found that trail location, design, and management were important factors influencing people's perception and use of trails. Local trails were used mostly by local individuals and tended to be reused by the same people. According to Gobster, local trails "meet people's everyday needs for recreation, commuting, and access to nature...small loop trails through existing parks and neighborhoods might be more useful on an everyday basis than long-distance trails, and would be more cost effective in crowded areas where linear greenways would be difficult to develop." He recommends developing local trails so that they can be reached from a distance of 8 km or less (1.6-km distance is more appropriate for adults 55+ years of age).

Design issues of importance to trail users focused on trail surfacing, facilities and services, and enhancement of the natural environment. Although not universal (and depending on user group), there was a dominant preference for having more asphalt-paved trails in the metropolitan area. Location of drinking water and clean restrooms at reasonable intervals along the trail also were important items for trail users.

Contact with nature was a top reason why people liked greenway trails. Vegetation management, particularly tree and shrub planting, is one of the few cost-effective tools to introduce natural variety and interest to many greenway trails, especially straight-line rail-trail corridors. (See Volume 2, Number 2, Page 3 of *The Urban Open Space Manager* for further discussion of rail-trail greenways.)

Management considerations important to trail users focused on two issues, maintenance and use-safety problems. Poor maintenance (particularly "rough trail surface") was a major concern, along with litter and vandalism. Crowding and conflicts among user groups were of concern on high-use trails. Possible solutions here might be widening the trail or providing separate paths for different users. Lack of personal safety was not a big issue but should not be taken lightly. Special trail police officers (on bikes or off-road vehicles) help to increase actual and perceived safety.

Gobster concluded that "By recognizing the importance of location, design, and management factors discussed in this paper, planners and managers can better set objectives for greenway development that will serve a broad range of recreational users." He points out, however, that greenways are often developed to provide multiple benefits and functions, including habitat protection and preservation of regional biodiversity. Thus, greenway planners and managers must weigh many factors in designing and managing these areas.

Reference: *Landscape and Urban Planning* 33: 401-413, 1995.

Establishing Trees and Shrubs in Urban Open Spaces

Urban open space managers desiring trees and shrubs on a particular site have two basic choices for woody vegetation establishment. One option is to plant species of interest; the second is to let nature take its course through natural colonization and plant succession. The latter option offers free trees and shrubs, provides a patchy distribution (more natural looking), and the genetic stock of species is matched to a site.

During 1992 and 1993, researchers S.J. Hodge and R. Harmer, of the Forestry Authority in Surrey, Eng-

land, studied natural colonization on 46 unmanaged urban sites in that country. Study sites were randomly selected and were located in the County of Avon, the Forest of Mercia (South Staffordshire District and Walsall Metropolitan Borough), and the Black Country (in the Metropolitan Boroughs of Sandwell and Dudley in the West Midlands). Previous land use was recorded as one of four broad categories: agriculture, industry, transport, or landfill.

Twenty-five species of woody plants were recorded on the sites, with ash (*Fraxinus excelsior*), birch (*Betula* spp.), goat willow (*Salix caprea*), and hawthorn (*Crataegus monogyna*) making up 85% of woody cover. Seed dispersal of woody species was classified as "light wind dispersed" (birch, goat willow), "heavy wind dispersed" (ash, sycamore), or "animal dispersed" (hawthorn, oak). There seemed to be a reduction in the extent of animal dispersed and heavy wind dispersed seed and an increase in extent of light wind dispersed seed with increasing urbanization.

Overall, the presence of parent trees visible from a site was the most important factor influencing presence of colonizing plants. The type of vegetation on a site when abandoned and type of substrate also were important factors affecting tree and shrub establishment. Dense grassland (and grazed grassland) hindered tree and shrub colonization more than did sparse grassland. Dense grassland tended to be associated with more fertile soils. Although such soils provide good growth media for trees and shrubs, competition from other vegetation tended to hinder tree and shrub establishment. Also the dense grassland habitat supported populations of voles and mice which ate the seed and browsed the woody vegetation. Therefore, sparse grassland on thin, infertile soils provided better sites for establishment of trees and shrubs.

The authors found no significant relationship between time since abandonment and the number of colonizing species. Possible explanations for this observation were the short time periods between abandonment and the study (generally less than 25 years), the lack of parent tree species such as oak and hawthorn with seed capable of colonizing vegetated sites, and lack of long distance dispersal of this type of seed that is dependent on the activity of birds and mammals.

Overall, natural colonization was unpredictable and urban woodlands derived from the process tended to be species poor. Half of the sites studied had less than 10% of the area colonized to an adequate woodland standard. This was attributed to high site variability and few, widely scattered parent trees in built up areas.

The authors concluded that "Although natural colonization can sometimes be an effective way of producing woodland it is unpredictable. If an abandoned site has already been colonized, and the distribution and species mix of trees accord with the overall management plan then the natural colonization should be accepted. However, the characteristics of sites with no existing trees should be carefully appraised before the decision to rely on natural colonization woodland establishment is made."

Reference: *Forestry* 69(3): 245-261, 1996.

Effects of Nature Trails on Vegetation in an Urban Forest

Studies have shown that soil compaction (from human foot traffic or other causes) inhibits plant growth and increases soil erosion (from increased surface runoff and less infiltration). Researchers Dinesh Bhuju and Masahiko Ohsawa, of Chiba University, Japan, contribute to our knowledge base in this regard. These investigators studied sections of an urban forest with and without human foot traffic. The study area was the Sonno Shellmound Forest, a remnant man-made forest in Chiba City. No management of the forest has occurred for the last few decades and understory colonization by unplanted species is underway. Humans on foot used some areas of specified or marked trails and other areas of trails that were unspecified or not marked. Some areas of the forest were not used by people and control study sites were located there.

Soil bulk density and porosity were affected by human foot traffic. Near the ground surface, bulk density (a measure of soil compaction) was higher at sites used by people than at sites not used by people. Soil compaction affected root growth of trees. Root systems were shallower and lateral expansion greater in compacted soil. Soil porosity near the ground surface was lower at sites receiving human foot traffic. Good soil porosity is needed to supply oxygen to root systems. In heavily compacted soils, anaerobic (without oxygen) conditions can develop that kill plants by depriving them of needed oxygen. Compaction of soil inhibited growth of woody plants by restricting root penetration, thus restricting water and minerals needed by plants. Little to no effect was noted the first year or two, but in later years growth rates were greater at sites lacking human foot traffic. Overall, less herbaceous ground cover and lower sapling density were present in areas used by

humans.

The authors concluded that "The total loss of the understory stratum in two nature trail sites signifies the extent of trampling disturbance compounded by superfluous paths and occasional sand surfacing [to check soil erosion and to improve walking conditions]. Such successional suppression is due to soil compaction in the heavily trampled site that impedes root proliferation of seedlings of colonizing species and confines them to a few poor saplings under canopy refugia. With increased outdoor recreation, practical management options become essential." In this regard, the authors suggest that trails be well marked and perhaps used on a rotational basis. Confinement of humans to trail systems also is important.

Reference: *Biological Conservation* 85: 123-135, 1998.

Urban Soil Characteristics and Management

Urban soils have been little studied and typically are taken for granted in tree planting schemes. However, some focus on soils is needed because urban soils are often heavily disturbed during construction phases.

Researcher C.Y. Jim, of the University of Hong Kong, is interested in evaluating urban park soil as a medium to support vegetation and to absorb user impacts. Jim recently studied the soils of 40-year-old Victoria Park in Hong Kong, a 17-ha park acquired by filling a shallow bay with fill material from surrounding hillsides. Six soil pits about 1 m deep were dug in selected areas to conduct the study.

Inspection of soil profiles from the pits revealed an absence of natural soil horizons. However, different layers were observed, most probably due to filling with different materials. Little "biological mixing" of soil by soil organisms and little to no organic matter were noted. "The harsh soil environment has not been conducive to the normal growth of soil fauna, allowing the initial state of synthetic stratification to be retained... Overall, four decades of soil formation has done little to alter the profile morphology of the fill material." The poor initial state of parent material and continual trampling by people (with associated erosion) are factors slowing soil development. In recent years, Victoria Park has averaged more than 2 million users per year.

Park soils tended to be coarse textured at all depths with high stone content at subsurface depths. A shortage of fine particles and little organic matter limit good soil structure due to lack of aggregating agents. However, the coarse texture of most park soils resulted in bulk density measurements below 1.4 gm/cm^3. Bulk density is a widely used measure of soil compaction and a range of 1.1-1.4 gm/cm^3 is expected for natural soils in humid tropics. Because of human foot traffic, some soils, particularly in the near surface zone, had bulk densities exceeding 2.0 gm/cm^3. In some cases, subsurface compaction also was found at greater depths due largely to the presence of heavy machinery during construction activities when the park was built.

The nutrient content of park soils was low due to a number of factors. The solubility and availability of manganese and iron in the soil were affected by the soil's unnatural alkaline nature. High soil alkalinity was due to the calcarious nature of construction rubble containing cement, mortar, and other construction material. Low soil organic matter curtailed supply of available nitrogen and phosphorus.

Jim concluded that lightly impacted areas can be ameliorated by suitable mechanical operations and amendments in order to rebuild soil structure, strengthen aggregate stability and resistance to trampling, and to augment fertility. Replacement of soil might be the only effective measure for heavily-impacted areas. According to Jim, park authorities should:

- take preventive measures during construction phases to minimize soil compaction;
- retain enclaves with good soil for vegetation;
- deep plow to loosen compacted soil;
- use only good-quality fill of adequate depth without undesirable composition and properties;
- consider, in areas with heavy foot traffic, a soil mix with a coarse matrix that can support trampling pressure, but with sufficient fine materials and porosity to meet root requirements;
- choose more trampling-resistant grasses and other ground cover species; and
- guide visitor movement and access to spread out and reduce overall impacts on green areas.

Reference: *Environmental Management* 22(5): 683-695, 1998.

Soils and Street Trees

In addition to the work cited above, C.Y. Jim, of the University of Hong Kong, studied the physical and chemical properties of street-tree soils throughout the old city core of Hong Kong. Soils were studied at 85 pits excavated for tree planting. Most pits were 1 m^3 in

size.

Soil horizons were absent in the pits examined, although artificial layering was common. Layering was attributed to the random dumping of materials of diverse composition and origin. Presence of building debris, including cement, mortar, and other foreign materials, was common. Soils typically were course-grained. Numerous stones were common and fine-earth material was dominated by sand; little silt and clay were present. These characteristics contribute to instable soil structure (poor aggregation) and limit storage of plant-available moisture--properties that are not conducive to plant growth. Aggregate stability is a property that allows soil to resist breakdown due to disruptive forces like rain or mechanical manipulation. Silt, clay, and organic matter are needed for good aggregate stability.

Soils were compacted at all depths. About two-thirds of the samples had high bulk density measurements, averaging 1.65 gm/cm^3, which inhibits root growth.

Over half of the soils were strongly to very strongly alkaline, with an average pH of 8.68. High pH values resulted from calcareous construction waste mixed with the soil. High pH influences nutrient solubility by suppressing the dissolution and availability of iron, manganese, copper, zinc, and cobalt. Such soils are unfavorable to humid-tropical plant species that are adapted to the natural acidic soils of the area.

Other problems were noted with the chemical properties of the soils. Lack of organic matter contributed to low levels of nitrogen and phosphorus. Most samples had elevated levels of zinc, lead, and cadmium, but soils were not polluted to the extent of causing acute physiological problems for plant growth.

Jim proposed the following management recommendations.

1. Poor quality soil (often simply construction waste) should not be used as plant growth medium.
2. A site survey, including field assessment and laboratory soil tests, should be included as part of land scape projects.
3. If soil import is needed, proper soil specifications should be drawn up.
4. In areas undergoing alteration, topsoil should be stockpiled separately from subsoil for later respreading.
5. Construction rubble should not be mixed with soil.
6. Organic matter should be added to soil as needed, and maintained.

Source: *Landscape and Urban Planning* 40: 235-249, 1998.

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