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Impact of Urbanization on the Plant Biodiversity and its Conservation Strategies

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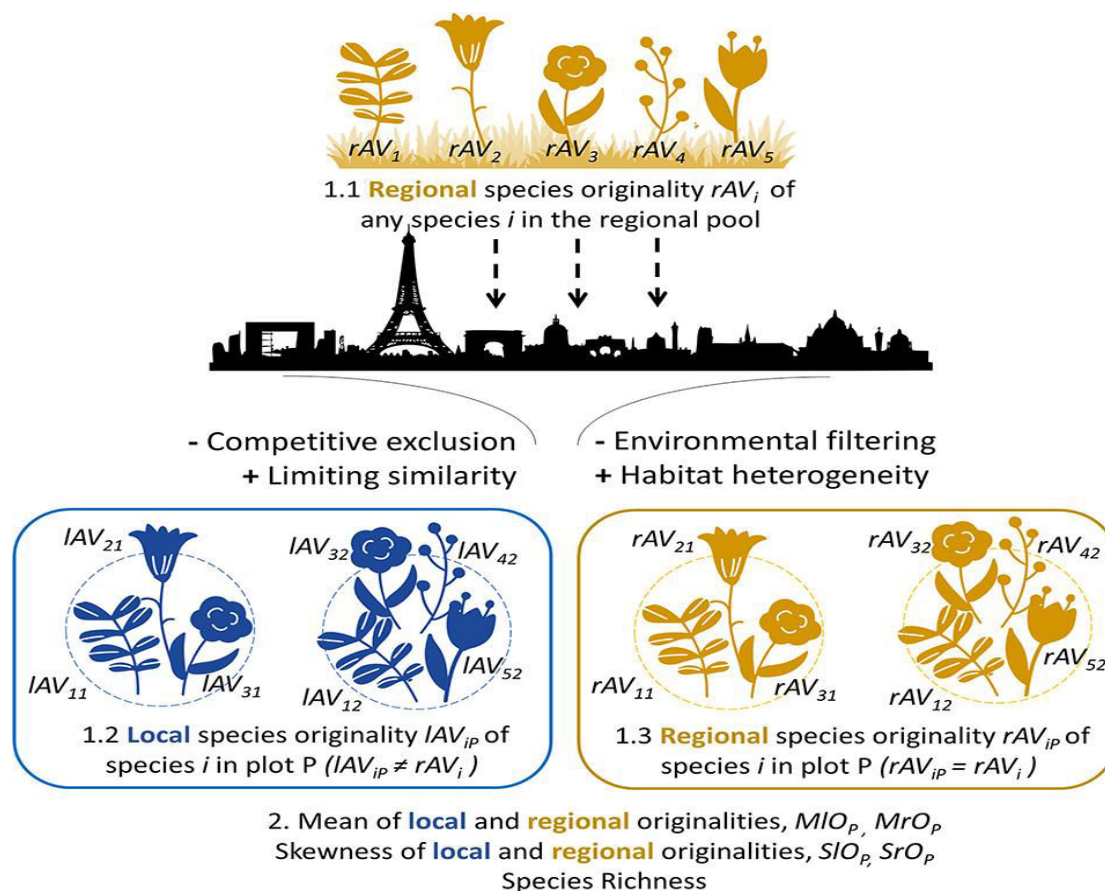
ABSTRACT: Urbanization and biodiversity interact in multifaceted and complex ways. Both the size and spatial configuration of urban areas matter for biodiversity. While some urban areas have high local species richness, this is typically at the cost of native species. Urban expansion may lead to habitat fragmentation, potentially resulting in genetic or demographic isolation of native species. A major impact of the expansion of urban areas on native species is on their dispersal through changes in habitat configuration and connectivity. Urbanization is also a major threat to endemic species due to increased incidence of colonization by introduced species. Urbanization impacts biodiversity and ecosystem services both directly and indirectly. Direct impacts primarily consist of habitat loss and degradation, altered disturbance regimes, modified soils and other physical transformations caused by the expansion of urban areas. Indirect impacts include changes in water and nutrient availability, increases in abiotic stressors such as air pollution, increases in competition from non-native species, and changes in herbivory and predation rates.

KEYWORDS: urbanization, plant, conservation, biodiversity, strategies, impact, species

I. INTRODUCTION

Urban conservation strategies are increasingly part of the global urban agenda. The New Urban Agenda, the declaration from the third bi-decadal United Nations Habitat conference on human settlements, calls for universal access to green space but also the conservation of species in cities [1]. The Sustainable Development Goals call for the loss of biodiversity to be halted, and the extinction of threatened species prevented. Integrating this thinking into the built environment has been identified as a key pathway to achieving these outcomes [2]. The Intergovernmental Panel on Biodiversity and Ecosystem Services identifies “Building sustainable cities that address critical needs while conserving nature, restoring biodiversity, maintaining and enhancing ecosystem services” as a key approach for achieving sustainability [3].

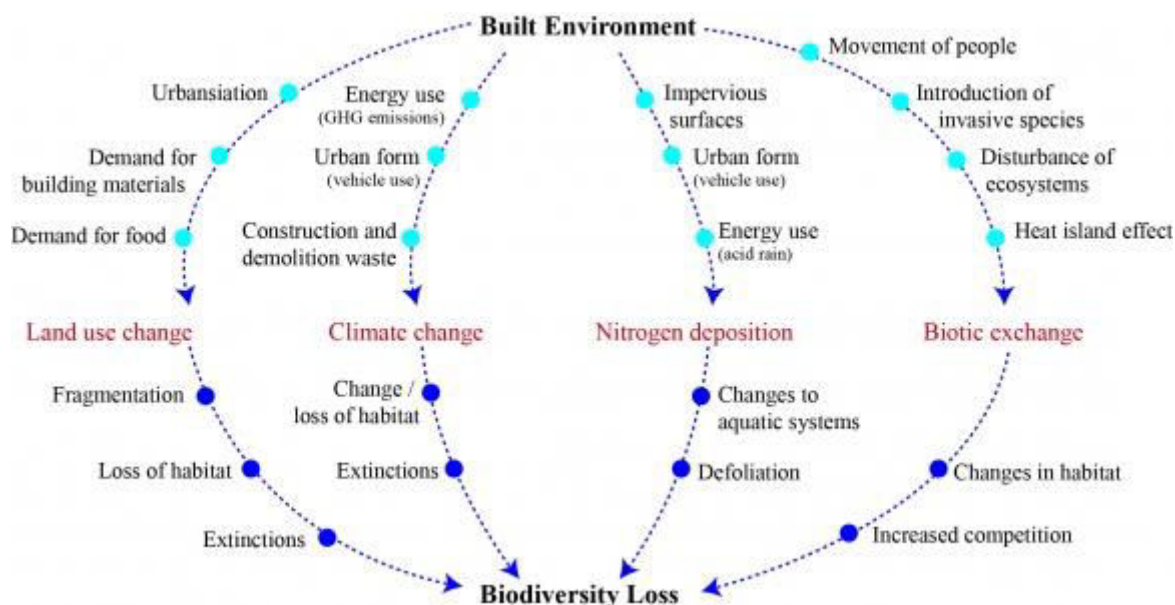
To achieve their goals, urban biodiversity conservation strategies must consider the nature of cities as socio-ecological systems by incorporating people’s values, attitudes and behaviors [4]. A better understanding of the people–biodiversity intersection promises to drive success in developing cities that are attractive as shared habitats for people, plants and animals. The contributions to this Special Issue on “Biodiversity Conservation and Sustainable Urban Development” in the journal Sustainability aim to increase our understanding of the role of urban environments as pressures on biodiversity, and also envision pathways towards developing more biodiverse urban environments that are accepted and supported by people.



The role of cities in harboring high levels of biological diversity and important components of biodiversity such as endangered species is increasingly evidenced. However, the habitat functions of distinct urban land-use types differ conspicuously. In-depth information about conservation opportunities associated with individual urban land-uses or ecosystem types would support policies supporting biodiversity-friendly development. A range of papers in this Special Issue demonstrate how different urban ecosystems can support biodiversity in urban settings, and expand opportunities for biodiversity-related management approaches. Designed urban greenspaces offer many opportunities as shared habitats of people, plants and animals. One important opportunity is the introduction of biodiversity-sensitive management techniques to manage particular land uses. Smith and Minor [3] show that cemeteries in Chicago, United States, are home to a considerable number of cavity nesting birds. They reveal how landscape-level features explain patterns in the species richness of these bird species, and site-level features influence habitat selection for some species. Their conclusions on creating more biodiversity-friendly cemeteries include promoting sufficient snag availability, sympathetic mowing regimes, and planting designs such as clusters of trees and shrubs to promote particular species. Researchers show how novel management techniques could help overcome some pressures on native grasslands, such as using trees to create habitat complexity and refugia for some native species in grasslands where natural disturbance by fire has been suppressed. Biodiversity sensitive planning is also an important pathway to achieving conservation with sustainable development. While habitat fragmentation is a ubiquitous challenge in urban regions, Scientists show in a case study of a set-aside railway bridge in Basel, Switzerland, that small-scale measures can make a useful contribution to addressing this challenge. They reveal that abandoned elements of the transportation infrastructure can help connect urban habitats for a range of animal taxa and should thus be integrated into urban biotope network schemes. Researchers demonstrate the habitat functions of forests emerging on vacant urban land in Berlin, Germany, for plants and invertebrates, and argue that we should integrate these informal ecosystems into the urban green infrastructure.[1]

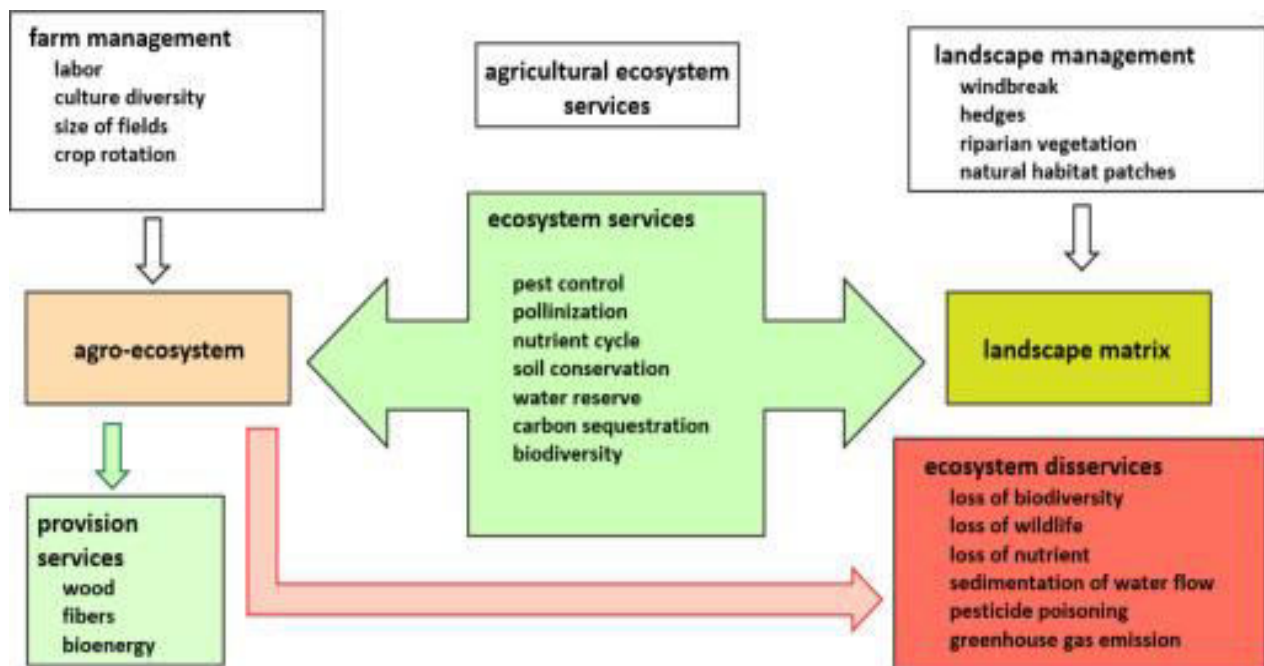
II. DISCUSSION

EcoVeg is a recent method that combines floristics and physiognomy, in addition to ecological descriptors, and that applies different rationales depending on whether the vegetation is natural or cultural [4]. Combining both approaches may be necessary to generate informative data from sites subjected to different disturbance conditions. The application of floristics in urban habitats may present a challenge when interpreting the data, since many studies reported an over-representation of ruderal species and high taxonomic diversity between relatively close sites. In contrast, the application of physiognomic and structural vegetation description, may be more useful in urban habitats as the data informs about predominance of life strategies adopted by different life forms, and the method is applicable in highly modified sites, and at both, macro- and micro-climate conditions .



A widely used functional type or physiognomic vegetation description system is the life form classification of Raunkiaer . Although physiognomic and structural vegetation description methodologies were developed to describe vegetation over large areas, these methods have been considered as potentially more useful tools than floristics in highly modified sites because they better reflect life strategies, for example, the ruderal strategy, encompassed by certain life forms . Scientists resorted to life-form in studying reclamation of spoil heaps .[2]

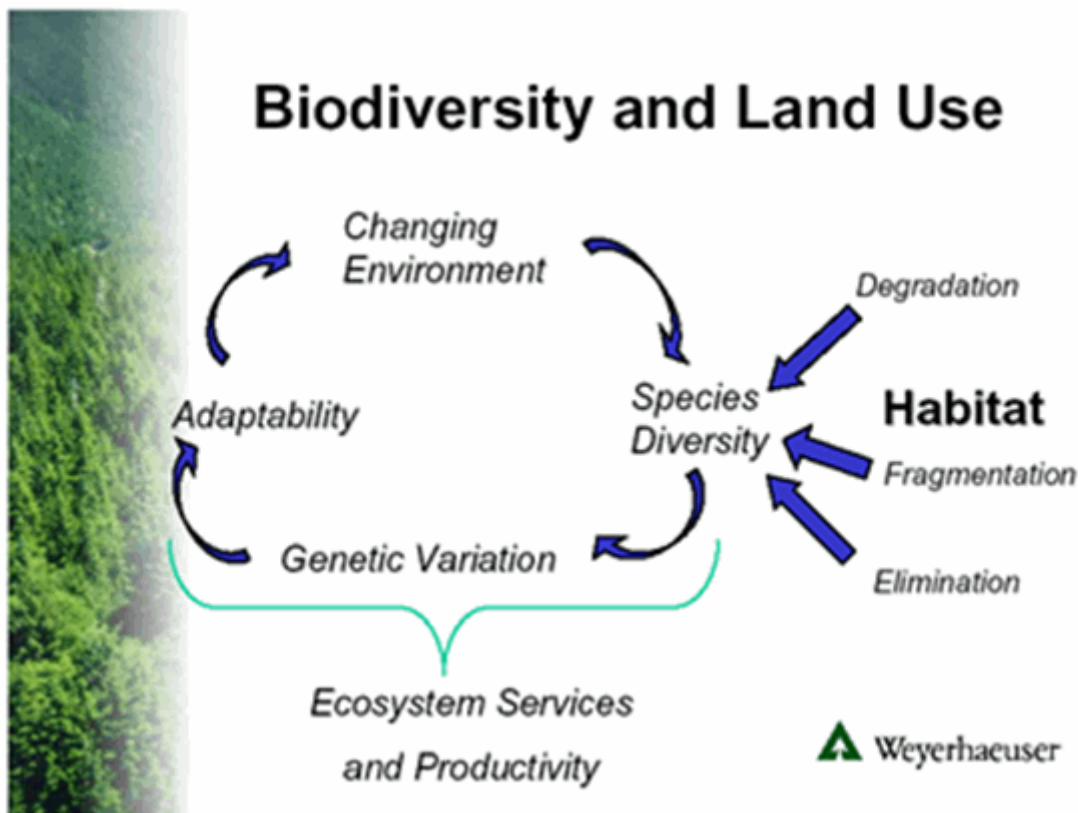
There is consensus that physiognomic and physiological characteristics of plants, including species life-history strategies and population biology, are also important descriptors of vegetation communities . Plant communities were shown to be important indicators to determine suitable habitats for rare species and for ecologically and economically important species . Some of these studies, however, deliberately exclude disturbed areas from sampling .



One aspect of urban vegetation that might challenge classification is the abundance of ruderal plant species which, benefit from the absence of interspecific competition that normally occurs in later successional stages, and colonize bare and disturbed land. By spreading from nearby semi-natural vegetation, ruderals contribute to high variability in urban plant diversity, even between close sites, limiting the value of vegetation classification using floristic methods. Some of these ruderal species may be distantly related to agricultural weeds and others to plant species found across transportation networks. Ruderals are also populating green walls in cities. The overrepresentation of ruderals and the haphazard management of green spaces in Beirut make vegetation classification difficult due to the small scale of associated biotopes and abundance of structured biotope complexes.







The success of plant conservation strategies is highly influenced by perceptions and social preferences which should be taken into consideration in addition to field assessment challenges in cities. For example, studies have shown that spontaneous 'unmanaged' vegetation may not appeal to residents as aesthetically pleasing nor is it perceived as acceptable 'urban nature' by decision-makers. This is further complicated by the fact that plant selection and management, is driven by landscape architects and landscape contractors who have limited experience with native species, and do not have clear guidelines on how to contribute to biodiversity conservation in cities. [3,4]

While several studies show how vegetation description using floristic assessments in urban areas is limited by overrepresentation of ruderal species, abundance of exotic plants, and a high taxonomic diversity between relatively close sites other studies suggest that descriptions of functional types, such as life form, may permit ecological comparisons among areas of similar ecology on a more general scale than would be possible when using a taxonomic approach. For instance, structural and adaptation characteristics of beach and dune vegetation were found similar, even if their taxonomic spectrum differed. Furthermore, life-form, among other descriptions of functional types, were associated with plant responses to environmental change, to plant competitive strength, and to plant effects on biogeochemical cycles and disturbance regimes. Recently, life form and life history were found to be stronger predictors of underlying population processes than native status. The first meta-analysis on intra-urban biodiversity variation worldwide showed that patch area and corridors have the strongest positive effects on biodiversity, and that vegetation structure, local scale, biotic factors, and management habitat variables, are significantly more important than landscape scale, abiotic factors, or design related variables.



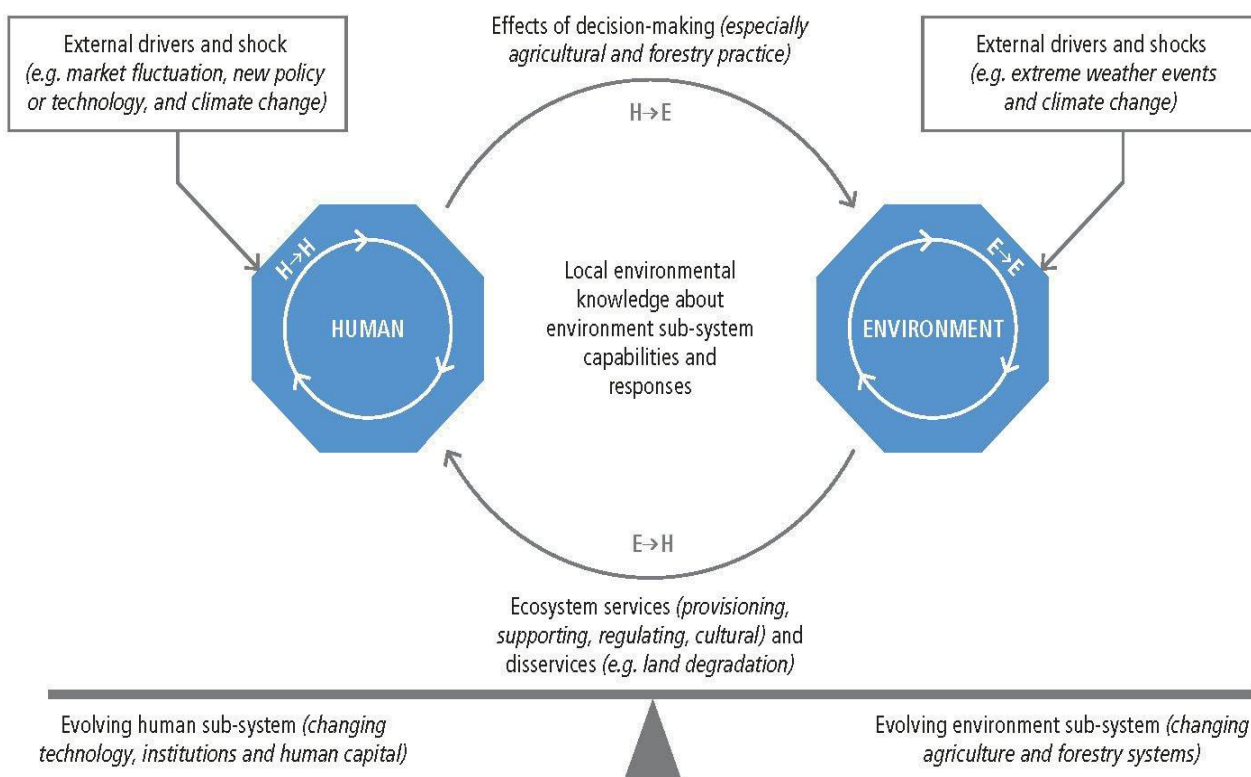
III. RESULTS

These are merely obvious examples of an accelerating decline in the global diversity of living things. The term biological diversity has been used to describe "the variety of life forms, the ecological roles they perform, and the genetic diversity they contain" (Wilcox, 1984, p.640). While scientists argue about the relative enormity of tropical deforestation and its impact on biological diversity, the loss of populations, species, and entire ecological communities in human population centers and their surrounding landscapes is well documented and inarguably immense. In urban areas of the eastern United States, only species with the most general habitat and resource requirements have remained in urban corridors. Moreover, the prospect of further erosion of biological diversity looms. In Great Britain, where the sustained assault on the environment is measured in millennia rather than in centuries, and where most vertebrate species are distant memories, a cascade of invertebrate extinctions is now being observed. For example, 80% of the resident butterfly species have declined in number in at least a major part of their British ranges during the past decade. A number of those survive only on reserves and under rigorous management regimes. An estimated 18% of all European butterfly species are considered to be vulnerable to or imminently faced with extinction. [5,6]

	Urban noise	Noise coming from cities and urbanization in general
	Transportation noise	Noise coming from all types of civil transportation activities including cars/trains, aircraft (helicopters, airplanes, <i>etc.</i>) and boats (or vessels/ships)
	Industrial noise	Noise coming from all types of industrial activities (mining, pile-driving, construction, commercial fishing, wind parks, aquaculture, <i>etc.</i>)
	Recreational noise	Noise coming from recreational activities (visitors to a zoo, surf, music festival, sport fishing, tourist disturbance, <i>etc.</i>)
	Military noise	Noise coming from military activities (water gun, sonic booms, explosion, jets and aircraft, naval sonar, <i>etc.</i>)
	Abstract noise	All types of abstract noise produced by computers (warning sounds, acoustic stimuli, pingers, pulses, tones, white noise, <i>etc.</i>)
Other sources of noise		All other sources of noise (aerators, aquaria filters, human voices, dog barks, <i>etc.</i>)

Unfortunately, losses of animal and plant species are restricted neither to temperate zone urban areas nor to the developed world. Urban impacts on biological diversity reach their most devastating in the Third World. Less than 2% of the Atlantic forests of coastal Brazil within the urban reach of Sao Paulo remain, and it has been estimated that thousands of species from this region of high endemism have been driven to extinction, most never having been described by taxonomists.

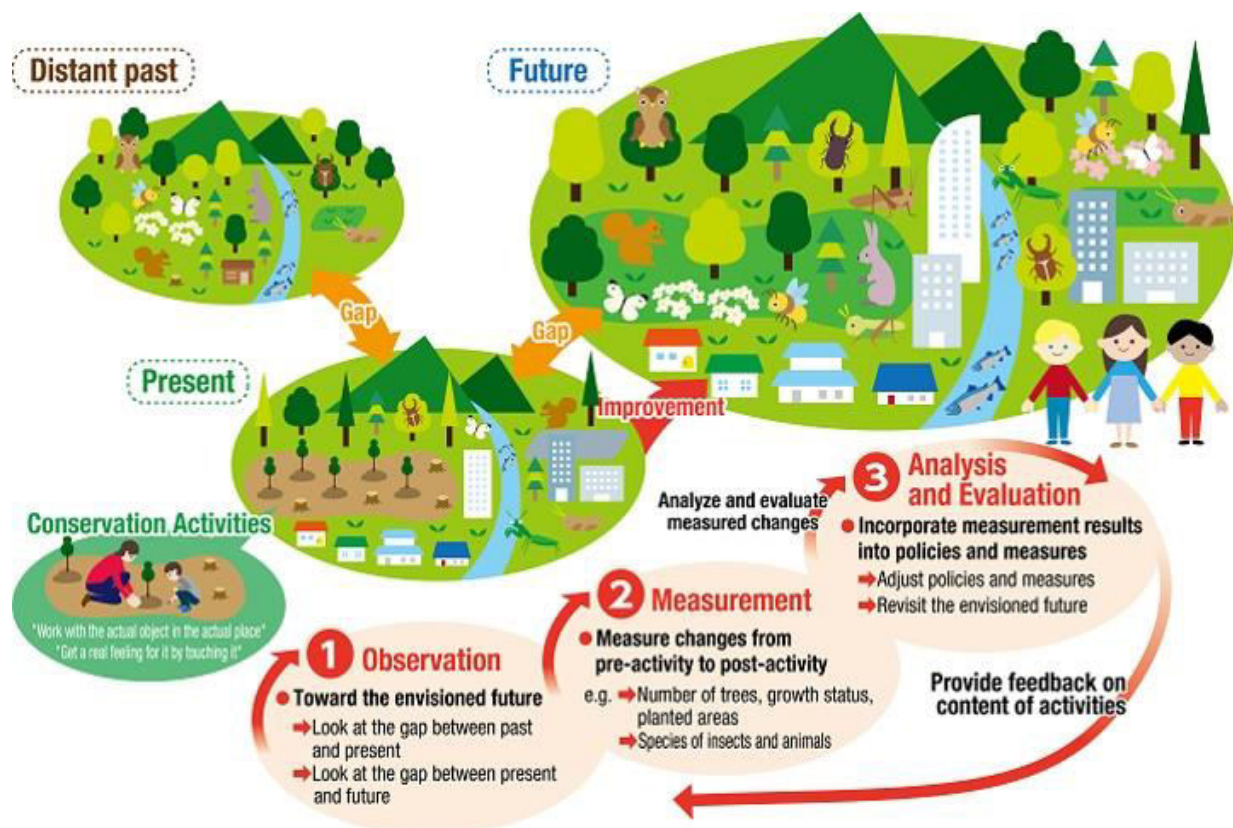
Although the full extent of this urban environmental degradation is virtually impossible to convey, its underlying causes are comparatively simple to identify. With few exceptions, losses of naturally occurring biological diversity are incidental to human activities. Thus, urban areas are effectively synonymous with ecosystem disruption and the erosion of biological diversity. Natural habitats are replaced directly by houses, condominiums, hotels, and malls, as well as by streets, highways, and utilities that support them. Historically, urban areas were the first regions subjected to local overkill of wildlife for food, fur, and feathers, and through misdirected predator control programs. They were also the first to experience logging and weed eradication programs. The biological diversity of urban areas has also been among the most severely affected by the introduction of animal species, which prey on native animal populations, compete for limited resources, and act as vectors for novel diseases and parasites to which native organisms can be particularly susceptible.



Great effects on biological diversity in urban areas also can result from less direct sources, including many of the air- and water-borne pollutants that imperil human health. Toxic by-products of industrial production, such as polychlorinated biphenyls (PCBs), sulfur dioxide, and oxidants as well as pesticides directed at noxious species, have been found to disrupt natural ecosystems [7,8]. Airborne pollutants are especially insidious, since they expand the reach of urban blight far beyond city limits. More subtle impacts on biological diversity result from overdrafting local aquifers, dropping water tables, and ground subsidence. These processes are often compounded by changes in natural patterns of groundwater percolation caused by the destruction of wetlands and diversion of runoff.

This wide array of obvious and subtle factors contribute to the disruption of ecosystem function, the decoupling of interactions among species, and the disappearance of populations of organisms from urban locales. Why should that concern us? Because losses of just a few populations can result in a great destabilization of natural ecological communities and, as a consequence, in a decrement in the ability of those communities to provide a wide array of services. Thus, many reasons for protecting diversity in urban areas are often highly utilitarian. Benefits include amelioration of climate, because foliage in cities contribute to the reduction of ambient temperatures. Large trees and shrubs reduce wind velocity and reduce evaporation of soil moisture. Plants are also useful in architecture, erosion control, watershed protection, wastewater management, noise abatement, and air pollution control.

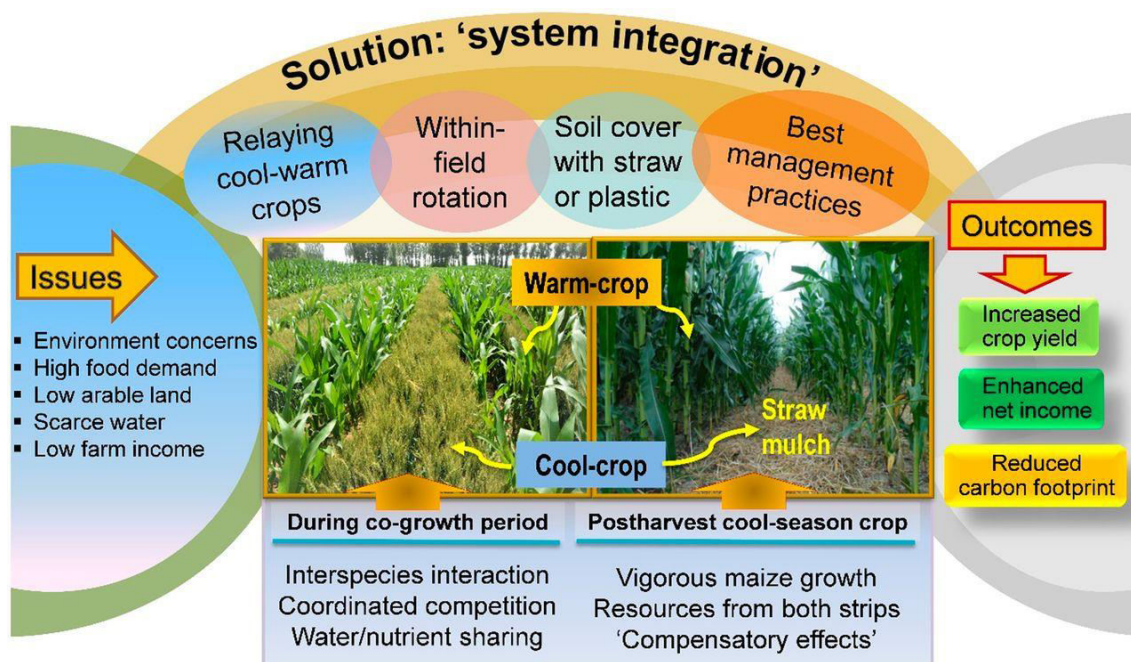
Nevertheless, the aesthetic reasons for preserving biological diversity are often those that most obviously affect the populace of urban areas. The great parks and natural areas of the world's major cities, such as Central Park and the Gateway National Recreation Area in New York City and Golden Gate Park and the Golden Gate National Recreation Area in San Francisco, are regarded as prized jewels, providing opportunities for recreation and relaxation as well as habitat for a wide variety of species.



The arguments for protecting biological diversity in urban areas seem straight-forward, but the implementation of conservation programs in urban areas is among the most difficult problems faced by environmentalists. Some areas are so disturbed that functioning, naturally occurring ecosystems are no longer identifiable, whereas other urban habitats remain effectively undisturbed. Open spaces in inner cities often support only species that are particularly well adapted to human impact. Such areas are nearly always small and extremely isolated, and their maintenance and enhancement demand extensive and continuous hands-on management. The conservation goals in such areas must usually aim at maximizing biological diversity to the extent possible, rather than preserving all remaining resident species.[9]

Inner city park developers have traditionally introduced plantings of exotic species. Such settings fulfill many of the aesthetic and utilitarian roles that natural habitats offer, but their establishment and maintenance costs tend to be high, since few of the self-regenerating functions of natural ecosystems are available. Yet, although human-induced intervention such as the replacement of ecosystem components can increase the number of species locally over at least the short run, these processes nearly always upset the ecological balance of communities; hence it ultimately exerts a negative impact on naturally occurring biological diversity.

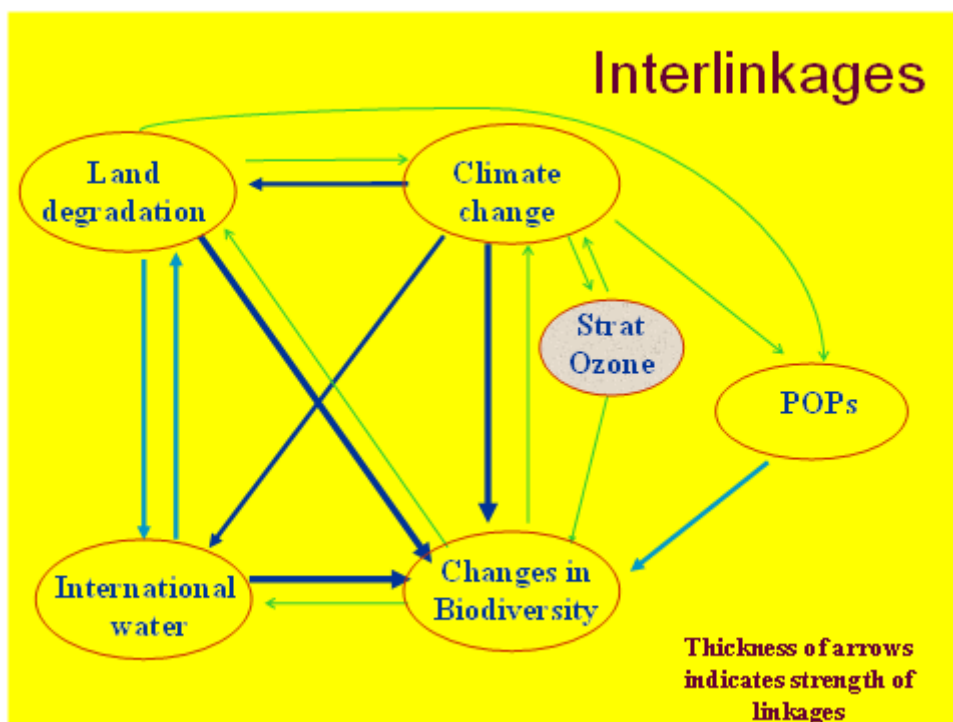
Where larger, intact ecosystems exist within cities, they are often restricted to corridors alongside steep stream canyons, such as Rock Creek Park in Washington, D.C., and Fairmont Park in Philadelphia. But the most extensive expanses of natural habitat in urban areas are those surrounding city limits. In those relatively undisturbed areas, prescriptions for the preservation of biological diversity are quite different from those for maximizing diversity in more disturbed areas. Corridors and surrounding habitats are among the most valuable urban natural areas, providing for extensive biological diversity and reducing the isolation of the largest surviving ecosystems, which may be far from urban centers.



The single greatest threat to the biological diversity of relatively intact natural communities in and around urban areas is the destruction of natural habitats and their conversion to other uses. The paving over of natural habitats as urban activities sprawl outward destroys and fragments remnant functioning ecosystems. The redistribution of water through channelization and impoundment of flowing waters, and the draining of some wetlands and the flooding of others, destroys undeveloped habitat areas. Activities as seemingly benign as the planting of exotic trees and shrubs in parks and along byways or the conversion of open space to golf courses disrupt the distribution of natural components of biological diversity. These activities combine to decrease habitat area and disturb the equilibrium between extinction and immigration among remaining natural habitats, with the frequent result that some species are permanently lost.

Decreases in local biological diversity resulting from losses of habitat area and insularization of habitat remnants are compounded by the more subtle effects of fragmentation. Losses of single, specific microhabitats within an otherwise undisturbed habitat can cause the local extinction of certain species. Disruption of even narrow corridors of natural habitat between large habitat patches can lead to losses of species. The removal of understory foliage in manicured park areas and suburban housing developments can result in the loss of numerous species, most conspicuously species of birds. Vast differences in temperature, humidity, light availability, and wind exposure exist between forest edges and interiors and affect habitat suitability for some species. In addition, losses of certain species due to any one or more causes can affect closely associated species sometimes leading ultimately to secondary extinction events.

In light of these basic ecological facts, conservation of the full range of urban biological diversity necessitates the protection of the largest possible expanses of natural habitat. Yet, that simple prescription is usually impossible to fill in urban areas, where the forces acting to decrease the size of remaining natural habitats are greatest. These conflicting pressures interact to determine urban conservation policy and to force biologists to justify the sizes of biological preserves.



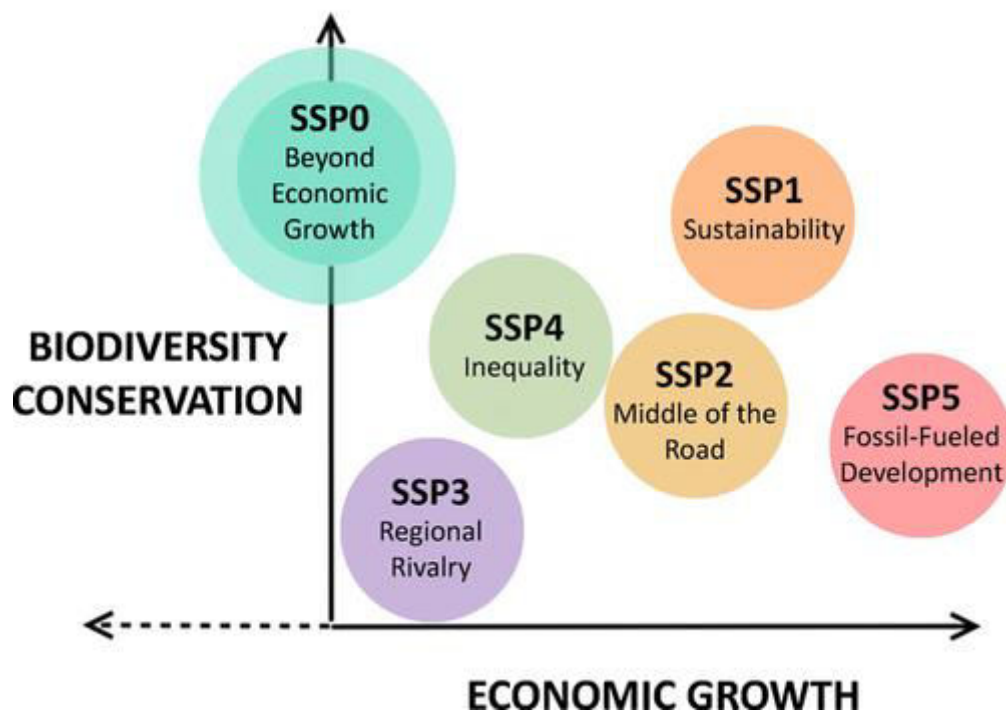
Economic and political considerations in urban areas make preservation particularly difficult. Land costs are high because of high demand, and the vast majority of urban space is private property. The few publicly owned open spaces are subject to intensive, varied uses, many of which are incompatible with preserving biological diversity. Local political institutions usually favor development over preservation, and many agencies concerned with land and resource management, such as the U.S. Forest Service and Bureau of Land Management, have no presence in urban areas. Many conservation organizations with largely urban memberships virtually limit their concern to nonurban environments, and those involved with local issues rarely have the resources available for protracted fights over development.[10]

IV. CONCLUSION

The Endangered Species Act with its mandate outlawing the "take" of any endangered species is the best tool for protecting biological diversity in urban areas of this country. Although the goal of the Act is protection of individual species of concern, its "purposes ... are to provide a means whereby the ecosystems upon which endangered species depend may be conserved". Its strength resides in its ability to protect species regardless of land ownership.

Efforts to conserve the full extent of biological diversity by using the Endangered Species Act must target species that are most susceptible to habitat loss. The protection of extinction-prone species can be the key to facilitating the conservation of biological diversity in urban areas. Species especially prone to extinction include those high on trophic pyramids, widespread species with low vagility (i.e., with poor dispersal ability), endemic and migratory species, and species with colonial nesting habits. Many such species inhabit urban areas during all or major portions of their lives and can act as umbrellas of sorts, often conferring protection to great numbers of species in the same habitats.

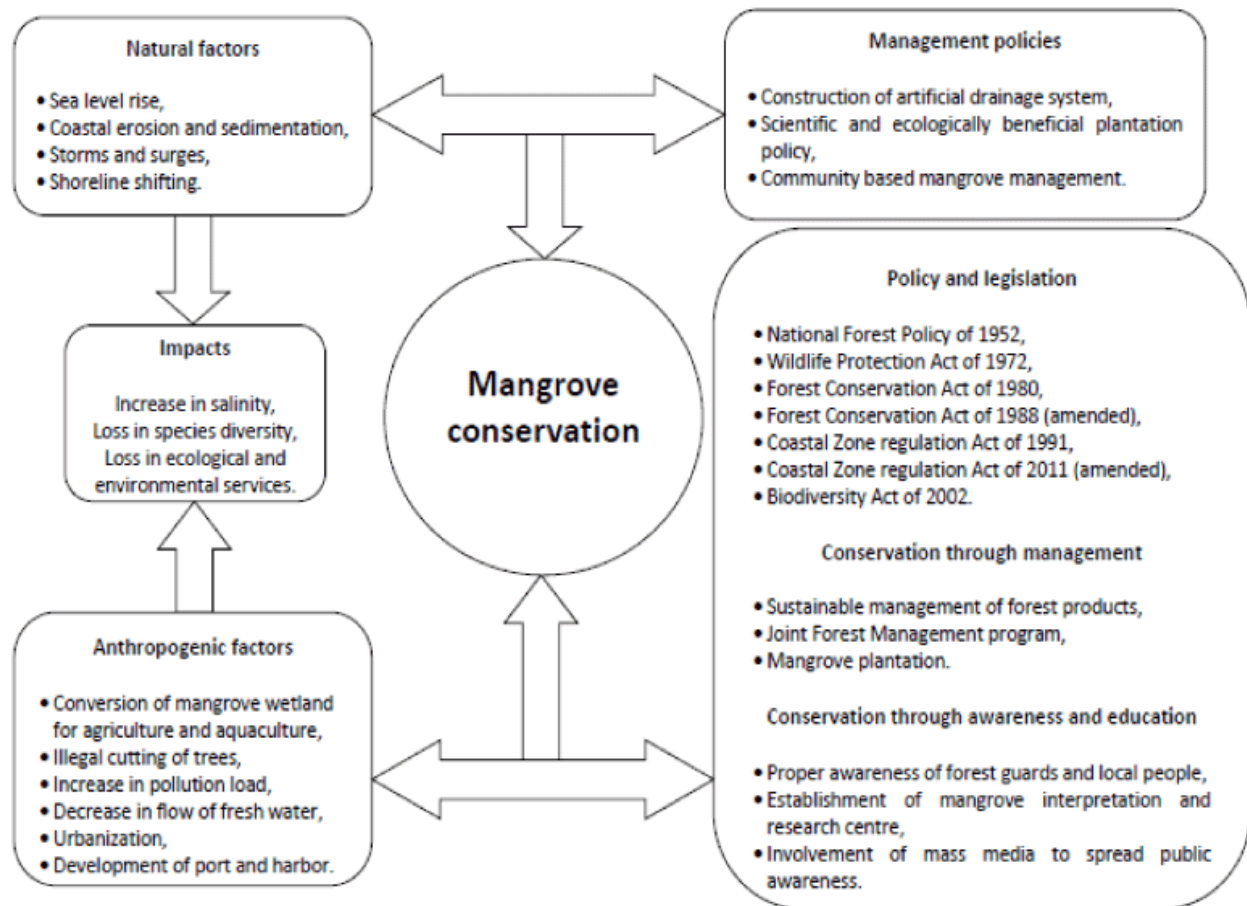
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The greatest erosion of extinction-prone species has usually occurred in habitat remnants that survive in those urban areas with the longest histories of settlement. Hence prescriptions for conserving remaining biological diversity differ substantially among urban areas. For example, forest patches support many more bird species than do grassland patches of similar size. All else being equal, therefore, protection of the total remaining biological diversity of oak woodlands surrounding San Francisco will demand more and larger preserves than protection of similar habitats to achieve a similar goal near less biologically diverse Washington D.C. In addition, the sizes of preserves necessary to protect biological diversity within an urban area will vary because the diversity itself varies greatly among different natural communities. Oak woodland preserves near San Francisco are likely to require more area to protect their complement of biological diversity than will native grassland preserves in the same geographic area.

In the urban United States, three groups must interact to assist the Endangered Species Act in protecting biological diversity. Field biologists must aid in the identification and survey of potential umbrella species. Conservation organizations must use that information and citizen petitions to get appropriate umbrella species protected via the endangered list. In response, the Office of Endangered Species will have to reassess listing priorities.

The San Francisco Bay Area exemplifies the challenge of preserving urban biological diversity. Without the grizzly bear, tule elk, and even the Xerces blue butterfly, San Francisco might be viewed as biologically impoverished in a sense, but the urban Bay Area remains an exceptionally rich natural region in the biologically richest state in the union. The ecological communities within a 25-kilometer radius of Berkeley include redwood, Douglas fir, and digger pine forests as well as coastal sage and inland chaparral, annual grasslands, dunes, riparian corridors, freshwater lakes, bay marshlands, and even pelagic marine communities and offshore seabird rookeries, an extraordinary array of ecological communities supporting immense biological diversity. The conservation challenge is great, especially in the shadow of a population growing at more than 3% per year; moreover, that shadow is not cast evenly. Less than 15% of San Francisco Bay marshlands remain, but much inland chaparral remains untouched.[9]



Can this urban biological diversity be protected? In this country, the answer is a qualified yes. In many other countries the outlook is not that sanguine. In Austria, prohibitions against the collection of wildlife and plants are strictly enforced, while the conversion of natural habitats to cultivation is effectively subsidized by the government. In the Federal Republic of Germany, as the Black Forest dies from acidification, powerful lobbies thwart the implementation of speed limits on the autobahns; consequently high levels of pollution continue to prevail. Overpopulation, chronic poverty, and fuel shortages in the Third World create unrelenting pressures to exploit all available local resources. These pressures certainly will become more overwhelming in the future.

Our urban centers can be viewed as bellwethers of our global environmental fate. Our success at meeting the challenges of protecting biological diversity in urban areas is a good measure of our commitment to protect functioning ecosystems worldwide. If we cannot act as responsible stewards in our own backyards, the long-term prospects for biological diversity in the rest of this planet are grim indeed.[10]

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