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Cities as environments

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Introduction

In starting a new journal about urban ecosystems, it is useful to review some of the dominant themes that have run through recent and historic discussions of cities as environments. Although concern with urban environmental issues may seem to be new, because of the great amount of attention paid during the past several decades to the negative aspects of urban environments – air, water, and soil pollution – there is a long history of thought, writing, and design about cities as environments, extending back throughout most of western history. This long history has modern relevance, but is more often ignored than used. This paper briefly reviews some central aspects of the major ideas about city planning and design, relates these to modern urban dilemmas and contemporary ecological knowledge, and proposes a new synthesis of classical and contemporary ideas. The issues are general, relating to cities around the world, but when examples are given in this paper, the focus is on cities in the United States, because of space limitations and because of an emphasis on the thoughts of Frederic Law Olmsted, the great American planner.

In reviewing discussions of urban environments, we make five major points:

- First, it is a popular belief that we can ignore cities and perhaps abandon cities in the future of civilization.
- Second, past human population trends and present demographic forecasts show that our species is becoming increasingly urbanized, not less urbanized.
- Third, the contemporary antiurban bias runs contrary to the history of city and land planning during the past 2 000 years of western history.
- Fourth, if we are really going to practice biological conservation and create environments that are pleasant for people to live in, then we need a renewed emphasis on the positive aspects of urban environments.
- Fifth, the way to do that is to combine the wisdom learned from 2000 years of urban, land, and park planning with modern environmental scientific understanding. Together, these provide powerful approaches. If used correctly, we can develop cities of the future that will be pleasant to live in and contribute to biological conservation.

Finally, given these major points, we use Los Angeles as an example of some of the problems and some solutions. It is a useful example because it is one of the world's largest cities and it is often referred

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to as one of the most poorly designed cities and because we have been involved in an analysis of the role of vegetation in that city's environment.

The old and the new

When Frederick Law Olmsted completed Central Park in New York City, he was so pleased with the benefits of the park for all the people of the city, that he went down to lower Manhattan, where the poor immigrants lived, and distributed handbills telling them about the new park and inviting them to use it. Olmsted wrote that vegetation in cities plays social, medical, and psychological roles (Olmsted, Letter to George W. Elliott, April 28, 1890, unpublished).

People in business have long recognized the economic value of beauty and of vegetation in cities. During an early real estate boom in 1885 in Los Angeles, a group of businessmen tried to develop a place in the eastern part of the Los Angeles Basin – in Mojave desert country – which they called 'Widneyville-by-the-Desert.' They brought in people from New York City and other eastern cities and tried to interest them in buying the land, but these people were horrified by the sight of yucca, cactus, and Joshua trees.

The developers bought a train carload of oranges, put them on the spikes of the yuccas and the cacti, and trimmed the Joshua trees to make them look more presentable. Then they told the next batch of easterners that this was the 'natural home of the orange' (Botkin, B.A., 1978). The story goes on to say that Widneyville-by-the-Desert did not succeed. However, this story illustrates that people have long realized the power of vegetation on the landscape and the importance of aesthetics in an urban environment.

In contrast to Frederic Law Olmsted and land developers of the late 19th century, today we show relatively little concern about the beneficial aspects of urban environments. This is as true for the public in general as it is for professional environmental scientists. Of course we hear much and do much about the negative aspects of city environments – air and water pollution – but we have lost touch, as a society, with the importance of cities in civilization and in the value of a pleasing, sustained environment to make our lives productive and creative. In the science of ecology, scientists and practitioners have, in general, shown little interest or done little research in urban environments. Instead, they have ignored and even disdained urban environments.

In the development of the modern environmental movement in the 1960s and 1970s, it became fashionable to consider everything to do with cities as bad and everything to do with wilderness as good. Cities are polluted, dirty, artificial, and lack wildlife; therefore, urban environments are bad. Wilderness is unpolluted and full of wildlife and native plants; therefore, it is good.

Ironically, although it has been fashionable to disdain cities, most people, including most ecologists, live in urban or suburban environments and suffer directly from their decline. This antiurban bias goes even further, because it has become fashionable to talk about the end of the rationale for cities, based on the belief that telecommunications and computer technology will allow each of us to work wherever we want, in a houseboat or in the woods away from cities. Although technology exists to allow some of us to work in this manner, it is only the well-educated professionals, or elite, small segments of society, that will in fact be able to do this.

Urban demographic trends

For most people in the future, city life will continue to be a reality and a necessity. Contrary to the idea that cities may become less and less important, trends in human demography show that, even today, we are a heavily urbanized society. In developed nations, 80% of the people live in cities, whereas in the poorest nations only 20% live in cities. This suggests that urbanization will increase worldwide in the future: as economic development takes place, more and more people will leave the countryside for the city. It is projected that by the year 2000, 50% of the world's population will live in cities.

Not only is the human population becoming increasingly urbanized, but the number of large cities has increased. In 1950, there were only two cities containing 10 million people, including their suburbs. By 1975, however, there were seven such cities. It is projected that by the year 2000 there will be 27 cities with more than 10 million people. The population in 25 of these urban areas will total nearly 400 million residents (World Bank, 1984)!

In most countries in the future the majority of the population will live in the largest cities in that country. This population momentum means that the world will become increasingly urbanized; therefore, if we are interested in helping people live in better environments, we must focus on urban environments.

Also, cities are usually located in key environments – on rivers, at ocean harbors, or near the fall line, where waterfalls provide water power. Therefore, major cities tend to develop at locations crucial for biological conservation. If we are interested in biological conservation, then we must begin to design urban habitats and environments as well as to legally designate wilderness areas and rural nature preserves.

Once these points about population growth are laid out, they may seem rather obvious, perhaps pedestrian, but in our experience they are generally ignored. However, some environmental leaders are beginning to speak about the benefits of cities to civilizations and the environment. Roderick Nash, a well-known environmental historian, wrote that he hopes that in the future there will be an 'urban implosion' – a return to urban life. This will have dual benefits – improving the lives of most people and helping to conserve rural land and wilderness. He wrote that his dream for the next millennium is 1.5 billion human beings living in 500 concentrated habitats, creating an island civilization, a renewed urban-dominated civilization (Nash, 1991–1992). This is an important idea. It suggests that those who are interested in wildlands and those who are interested in urban environments have a common goal. As we improve urban environments, more people can find recreation in cities and there will be less pressure on wildlands to provide recreation or to be replaced by urban housing.

Lessons from the history of city planning

Our bias against cities is contrary to the history and ideas of land planning in western civilization. In the more than 2000 years of city planning, those who have written about cities have agreed on three points: (1) cities are the centers for innovation and creativity in civilization, an idea that we do not hear much about any more; (2) the more pleasant a city is, the more likely it is that its residents will be innovative and creative; (3) vegetation is the key to making cities pleasant.

In the history of city planning, there have been two dominant goals – defense and beauty. Roman cities were typically designed along simple geometric patterns which were believed to have both practical and aesthetic benefits (Botkin and Keller, 1995). During the height of Islamic culture, after the decline of the Roman empire, Islamic cities contained beautiful gardens. One of the most famous of these is the Alhambra Palace in Granada, the last stronghold of Islam in Spain. This is a marvelous garden, which today draws 2 million visitors a year, thereby creating an economic benefit, in addition to the aesthetic benefit to the city and the historic value of the garden.

After the fall of the Roman Empire, the earliest planned European cities were walled fortresses designed primarily for defense. Even in these cities, planners considered the aesthetics of the town. For example, in the 15th century, planner Leo Alberti argued that large and important towns should have broad and straight streets whereas smaller, less fortified towns should have winding streets to increase their beauty.

Beginning in the 16th century, cities began to expand beyond their fortified walls, into areas that were planted with rows or groves of trees to provide the upper classes with places for promenading and for games. In the 17th century, Paris began to decorate its boulevards with trees, a practice that soon spread to other cities. By the 19th century, street trees had become common in European cities.

The twin problems of rapid population expansion and overcrowding, which occurred in the great cities of Europe during the industrial revolution, resulted in the creation of public open space available to all classes – the modern city park.

The primary purpose of the urban park movement in the 19th century was neither aesthetics nor biological conservation, but was part of a series of sanitary reforms by which those governing cities sought to counteract the threat of ill health produced by industrialization and rapid urbanization. These were pragmatic developments. Among the leaders in the 19th century was Frederick Law Olmsted, who designed New York City's Central Park and had a great deal to say about planning. Olmsted's goal was not aesthetics in itself – he had no interest in beauty for beauty's sake – he was interested in public institutions that met urban psychological and social needs.

We, the authors of this paper, became involved in urban environmental issues in Los Angeles during the drought in the 1980s in Southern California. The Los Angeles Metropolitan Water District came to us and said that government leaders in Northern California, along with leaders of environmental groups, were telling them that there should be no lawns or trees in Los Angeles because these wasted water. The Water District asked us to analyze and report on the use of vegetation in cities in semiarid environments.

The research for our report began with an in-depth analysis of the characteristics of a semiarid city, considering the environment, the heat island effect, the water and soil, and the city's ecological functions.

A city's ecological functions

A city changes the landscape and therefore the relationship between biological and physical aspects of the environment. For example, natural soils and ecosystems that readily absorb rain water are converted to water-impervious roadways, walkways, and buildings. Everything is concentrated in a city, including pollutants. City dwellers are exposed to more kinds of toxic chemicals in higher concentrations and to more human-produced noise, heat, and particles than are their rural neighbors.

There are four basic environmental goals for a city: reducing energy use, reducing and removing pollutants, helping to create a pleasing environment, and aiding in biological conservation. Of these, recent scientific work has focused on reducing energy use, especially using shade trees to reduce air pollution (Akbari *et al.,* 1992).

The heat island effect

Cities are warmer than surrounding areas, because of increased heat production (caused by burning fossil fuels and by other industrial and residential activities) and because there is a decreased rate of heat loss (there is less water available at the surface for evaporative cooling). Concrete, asphalt, and roofs also tend to act as solar collectors and quickly emit heat, thereby further increasing the air temperature in cities (Butti and Perlin, 1980). In the United States, the average observed increase in temperature in urban areas is approximately 1–2°C in the winter and 0.5–1.0°C in the summer for midlatitude areas.

As cities become warmer, the heat-island effect results in an increase in electrical power demand for air conditioning. Information from the Los Angeles Department of Water and Power and Southern California Edison indicates that, for every degree Fahrenheit (F) rise in average annual temperature, an additional 300 MW of electricity is used. There has been a 5° F rise in the average temperature of Los Angeles since 1940 as a result of the heat-island effect, which translates into an added electrical demand of 1.5 GW. The Environmental Protection Agency (EPA) calculates that electrical costs to counteract summer heat-island effects alone could be more than $1 billion a year for US cities (Akbari *et al.,* 1992). Recent research demonstrates that proper planting of vegetation can lead to considerable savings in air conditioning use (up to 24% in cities in semiarid environments) (Rowntree *et al.,* 1982).

The heat-island effect accelerates chemical reactions that produce high ozone concentrations, consequently increasing urban air pollution. The EPA estimates that the number of polluted days may increase by 10% for each 5° F rise in temperature. The production of ozone, induced by photochemical reactions, increases with the rise in temperature. Models of air pollution have shown that, in general, ozone levels in Los Angeles are acceptable below 74° F; above 94° F all days are projected as unacceptable (Huang *et al.,* 1992). Ozone is a primary stress factor for urban vegetation. Thus, in summary, the heat-island effect increases the need for air conditioning, puts additional stress on vegetation, and leads to an increased benefit of vegetation for shading.

Water and soil in the urban environment

The construction of modern cities has a great impact on the water cycle. This, in turn, affects soils, causing stress on plants and animals in the city. Paved city streets and city buildings prevent water infiltration. As a result, most rainfall runs off directly and is channeled into storm-sewer systems. Under traditional urban engineering, this water is lost to the city. Hard city surfaces prevent water in the soil from evaporating to the atmosphere. In natural ecosystems, evaporation is an important means of surface cooling. Pavement also increases the chances of local flooding within the city. In turn, increased runoff from the city to the countryside can increase the chances of flooding downstream.

Cities may have higher local rainfall than their surroundings, because dust above a city provides particles for condensation of raindrops. Some urban areas have 5–10% more precipitation and considerably more cloud cover and fog than do surrounding areas (Botkin and Keller, 1995).

Olmsted's ideas for urban environments

With these environmental factors in mind, it is useful to return to the ideas of Olmsted, so that we can combine an interest in an aesthetically pleasing city with a city that serves biological conservation. Olmsted specifically discussed the use of lawns in a semiarid environment. He believed that every large city should have a public park devoted to landscape scenery, and that the most important element of that scenery was a broad expanse of 'greensward' – gently rolling lawn and meadow dotted with wide-spreading deciduous trees. For him, the park was a public institution carefully designed to meet basic urban psychological and social needs. He designed the scenery of the park to provide the most effective relief from the noise, pace, artificiality, hard-surface, and close-built character of the city. The park provided a peaceful setting where one could ramble through open space and find relief from the tension and stress of city life. Through careful shaping of the land and construction of well-drained and surfaced all-weather walks and roads, followed by creation of open space integrating grass, shrubs, and trees, Olmsted used both engineering and landscape design skills to create areas that would produce a particular, restorative psychological effect. Olmsted also intended his parks to provide medical benefits for small children and persons convalescing from sickness, and designed certain sections specifically for that purpose.

For Olmsted, the social purpose of the park was as important as its psychological and medical role. The large landscape park was to be the one place where all elements of a city's population could gather and mingle without the competitiveness and hostilities of the workaday world. In some cases they would join in common amusements – public gatherings or concerts – but much of the time they would simply walk, picnic and play with family and friends; being conscious of shared pleasure in a place owned in common with their fellow citizens. The park was to be the yard for those without yards, for persons unable to frequent those popular vacation spots, and the central social and gathering place of the city.

Olmsted believed that the large park needed to be supplemented by many other areas that together would make up a comprehensive recreational system. Some of the elements of such a park system would be local playgrounds and ballfields serving a particular neighborhood.

The possible variety of elements in an Olmsted park system is well illustrated by Boston's 'Emerald

Necklace,' which he planned in the 1880s. His plan for Franklin Park, the part of the park system farthest from the city center, contained a 'country park' section of open landscapes and natural woods. There was also to be a formal 'Greeting' for promenades, concerts, and children's games, and a 'Playstead' for team sports, overlooked by a massive carriage concourse. Nearby to the north is the Arnold Arboretum, maintained jointly by Harvard University and the City of Boston, serving both as a public pleasure-ground and as a scientifically arranged collection of plants. Between the Arboretum and the Charles River, Olmsted was able to reserve for public use a series of ponds and the valley of a stream. This retaining of the flood plain of streams and rivers for public greenspace was one of the leading characteristics of Olmsted's park planning. In the 20th century, his successors in his firm applied the concept widely – particularly in the extensive park systems they planned for the cities of Seattle and Baltimore.

Olmsted also proposed that a city should have a continuous green thread of parkway. Part of the purpose of the parkway was efficient transportation through the city, particularly from the city center to outlying parks and from one part of the park system to another. Olmsted's parkways included separate ways for each kind of transportation – pedestrians, equestrians, and bicyclists – and sometimes made provision for street railways as well. In addition to creating a green and shaded route through the city, parkways provided neighborhood greenspace. As Olmsted described the overall result:

> Thus, at no great distance from any point of the town, a pleasure ground will have been provided for, suitable for a short stroll, for a playground for children and an airing ground for invalids, and a route of access to the large common park of the city, of such a character that most of the steps on the way to it would be taken in the midst of a scene of sylvan beauty, and with the sounds and sights of the ordinary town business, if not wholly shut out, removed to some distance and placed in obscurity. The way itself would thus be more park-like than town-like (Olmsted, 1868).

Since the time of Olmsted's work, several researchers have found that vegetation in urban areas can indeed provide emotional and psychological benefits. For example, one study found that visitors to Detroit's Belle Isle Park, most of whom were from low-income, inner-city areas, experienced significant reduction in stress while in the park (Huang *et al.,* 1992).

An important extension of the 'park town' idea was the 'garden city,' a phrase coined in 1902 by Ebenezer Howard. Howard's idea was the *city* and *countryside* should be planned together. A garden city meant one that was surrounded by a greenbelt. The idea was to locate garden cities in a set connected by these greenbelts, forming a system of countryside and urban landscapes (Howard, 1946).

The garden city idea caught on, and garden cities were planned and developed in Great Britain and the United States. Greenbelt, Maryland, just outside Washington, D.C., is one of these cities, as is Lecheworth, England. Olmsted's use of the natural landscape in designing city parks and Howard's garden city still influence city planning today.

From this history, we can see that there is a strong tradition in western civilization in general and in the United States in particular that defines aesthetics and vegetation as key qualities in determining the success of urban planning. This tradition provides a focus for those who want to save endangered species to complement the goal of conservation of rural natural areas.

Los Angeles as a case study

Although some people have believed that reduction in water use in California cities would lead to a major reduction in water use statewide, the cities of California actually use only about 15% of the total water used in the state. Much of the water use in California is for agriculture, especially in the production of cotton, rice, alfalfa, and other crops that have a heavy water demand. Thus, a major reduction in water use in Los Angeles would result in only a few percentage reduction in water use throughout California.

In spite of its reputation as a city in a dry, flat, ugly plain, Los Angeles could be a considerable aid to biological conservation. Because of the drought in Southern California, there has recently been an emphasis on plants that use little water, called xerophytic, and on plantings that need little irrigation, called xeriscapes. Southern California, except at high elevations, lies within a semi-arid climatic zone; therefore, one might think that xerophytic vegetation is the only native kind. This is not the case. Los Angeles covers a large area and the terrestrial vegetation of the Basin and foothills can be divided generally into mesic, riparian, and wetland, as well as xerophytic, as discussed below. Those who study this vegetation often divide it more finely into ten types: coastal sage scrub; chaparral; valley grassland; southern oak woodland; riparian woodland; intermittent stream bed; lake, pond and quiet stream; fresh-water marsh; coastal salt marsh; and coastal beaches and dunes (Abrams, 1917; Allen, 1984; Boughey, 1968; Raven *et al.,* 1986). In the mountain areas surrounding the Basin, many more communities are to be found, including: mixed evergreen forest; closed-cone pine and cypress forest; Southern California mixed conifer forest; Southern California white fir forest; a montane chaparral; Pinyon-Juniper woodland; and – on the highest mountains in the San Gabriel, San Bernardino and San Jacinto Mountains – Southern California subalpine forest (Raven *et al.,* 1986).

The vegetation of the coastal region of Southern California, including that of the Los Angeles Basin, lies within a Mediterranean climate. This kind of climate occurs in only a few areas of the Earth, occupying approximately 1.7% of the Earth's surface area (Lenz and Dourley, 1981). Other areas with Mediterranean climates occur along the coast of central Chile, the Cape region of South Africa, south-western and south Australia, and, of course, in the Mediterranean region. Although they cover only a small area of the Earth, Mediterranean habitats are biologically diverse and support many rare species. The California Native Plant Society, as of 1994, had listed 133 plants as rare, threatened, endangered, or of limited distribution (Skinner and Pavlik, 1994) in Los Angeles County (Table 1).

For our purposes, the Los Angeles Basin can be defined as the parts of Los Angeles County bounded by the Transverse Ranges (the San Gabriel Mountains), the Santa Monica Mountains, and the north-western part of Orange County (Anaheim and Santa Ana). The only existing flora of the area is Abrams' *Flora of Los Angeles and Vicinity,* which includes the mountain areas as well (Abrams, 1917). However, floras for two areas bordering the Los Angeles Basin have been published and inferences can be drawn from these as well as from other publications about the natural history of Southern California (Allen, 1984; Boughey, 1968; Jaeger and Smith, 1966; Raven *et al.,* 1986). The flora of the Santa Monica Mountains includes 640 native and 234 introduced species (Raven *et al.,* 1986) but the number of native species for the lower elevations in the Los Angeles Basin is probably much lower. Shmida (1981) estimated the total number of plant species for the Mediterranean areas of California to be 307. Hundreds of species have been introduced to the Los Angeles Basin and many of these are naturalized. Therefore, it seems reasonable to assume that approximately 500 species make up the natural-plant communities of the Los Angeles Basin.

Some animals listed as endangered by the state of California occur or did occur in the vicinity of Los Angeles (Table 2). For example, the Least Bell's Vireo is a summer resident in riparian habitats of Southern California, including areas of willow (*Salix*), cottonwood (*Populus fremontii*), oak (primarily *Quercus agrifolia*), and dry washes with willows. This vireo once ranged from interior Northern California (from Red Bluff to the Sacramento and San Joaquin valleys) to the Sierra Nevada foothills, and then to the coast ranges into Baja, California. By the late 1980s, its breeding range had been restricted to the Amargosa River in Inyo County on the east slope of the Sierras, and small scattered populations in Southern California in Santa Barbara, Riverside, and San Diego counties. This species has become endangered because of habitat loss, as well as by nest parasitism by the cowbird (California Department of Fish and Game, 1988). Protection and restoration of riparian habitats in Southern California, as might occur through the development of greenways, could help save this species.

Table 1. Some rare and endangered vascular plants of the Los Angeles Basin[a]

Plants of coastal sage scrub communities	
Centrostegia leptoceras	Slendar horned centrostegia
Chorizanthe parryi var. *fernandina*	San Fernando Valley spineflower
Chorizanthe staticoides var. *compacta*	Turkish rugging
Dudleya multicaulis	Many-stemmed dudleya
Dudleya stolonifera	Laguna beach dudleya
Eriastrum densifolium ssp. *sanctorum*	Santa Ana River woolly-star
Mahonia nevinii	Nevin's barberry
Potentilla multijuga	Ballona cinquefoil (extinct?)
Plants of freshwater and salt marshes and other wetlands	
Arenaria paludicola	Swamp sandwort
Cordylanthus maritimus ssp. *maritimus*	Salt marsh bird's beak
Perideridia gairdneri ssp. *gairdneri*	Gairdner's yampah
Astragalus psycnostachyus var. *lanosissimus*	Ventura marsh milk-vetch
Helianthus nutallii ssp. *parishii*	Los Angeles sunflower (extinct?)
Plants of chaparral communities (on mountain slopes)	
Astragalus brauntonii	Braunton's milk-vetch
Dudleya densiflora	San Gabriel Mtns. dudleya
Galium grande	San Gabriel bedstraw
Plants of coastal beach and dunes	
Astragalus tener var. *titi*	Coastal dunes milk-vetch
Dithyrea maritima	Beach spectaclepod
Plants of gassland communities	
Orcuttia californica	California orcuttia
Pentachaeta lyonii	Lyon's pentachaeta

[a]The plants in this list are known to occur or to have occurred in the Los Angeles Basin and are either extinct, rare, or endangered in California and elsewhere. Plants in this table are listed by community. (source: Skinner and Pavlik, 1994)

Water use and vegetation in Southern California

In terms of water use, vegetation native to Southern California, including the Los Angeles area, can be grouped in four categories: (1) xerophytic vegetation – vegetation that needs little water; (2) mesic vegetation – vegetation that grows on uplands in well-drained but well-watered areas; (3) riparian vegetation – vegetation that grows along flowing water courses – streamside and riverside vegetation; and (4) wetland vegetation – vegetation that grows in marshes, both fresh and salt water. Each has its uses, its own set of species, and its own ecological history and associated animals. This section reviews the uses, advantages, and disadvantages of each kind for a city in a semiarid environment.

Xerophytic vegetation

This vegetation has the advantage of requiring the least water, and therefore can provide some green surroundings, along with flowering plants, with minimum water use. There has been a growing emphasis on xerophytic vegetation for home landscaping and lawns. For example, the Santa Barbara Botanic Garden has a demonstration garden that shows how xerophytic vegetation can be used to decorate the

Table 2. Some rare and endangered animals of Los Angeles County

Common name	Scientific name
Arroyo Southwestern Toad	Bufo microscaphus californicus
California Condor	Gymnogyps californianus
California Least Tern	Sterna antillarum browni
Western Yellow Billed Cuckoo	Coccyzus americanus occidentalis
San Clemente Loggerhead Shrike	Lanius ludovicianus mearnsi
Least Bells Vireo	Vireo bellii pusillus
Beldings Savannah Sparrow	Passerculus sandwichensis beldingi
Mohave Tui Chub	Gila bicolor mohavensis
Unarmored Threespine Stickleback	Gasterosteus aculeatus williamsoni
Tidewater Goby	Eucyclogobius newberryi
Mohave Ground Squirrel	Spermophilus mohavensis
El Segundo Blue Butterfly	Euphilotes battoides allyni
Palos Verdes Blue	Glaucopsyche lygdamus palosverdesensis

Source: California Department of Fish and Game, 1995.

land around a house, providing an aesthetic surrounding with a minimum of water use. In many situations the only considerations are aesthetics and minimization of water use; therefore, xerophytic vegetation meets these needs.

Mesic vegetation

Mesic vegetation occurs on upland areas that are well drained and well watered. Given the Mediterranean climate of Southern California, this kind of vegetation is less common than in the eastern states or in other temperate climatic zones. In Southern California, mesic vegetation occurs near riparian zones, benefiting from the higher water table of such areas, but far enough away from the stream drainage to be virtually free from flooding. Mesic vegetation also occurs on mountainous north slopes at higher elevations.

Riparian vegetation

Except for the mesic trees that occur at high elevations in the mountains, most of the trees native to Southern California are riparian (trees occurred primarily along water courses at low elevations before European settlement). The characteristic habitat of the coast live oak is near to or along drainages. Other Southern California riparian trees include bigleaf maple, California sycamore, and white alder. Riparian zones can aid in biological conservation and be integrated into greenways and ecological corridors discussed later in this report. It is estimated that more than 90% – as much as 95–97% – of riparian ecosystems have been lost in Southern California, and that riparian habitats have supported more species of birds than any other in California (Faber *et al.,* 1989).

Wetland vegetation

Wetlands are a threatened habitat throughout California. Approximately 90% of the original wetlands of the state have been destroyed, primarily through conversion to other uses. Wetlands typically have a high species diversity and are habitats for stages in the life cycle of species valued for commercial use and biological conservation. As an example, 212 species of birds, 24 mammals, 6 amphibians, and 16 reptile species have been observed in the San Joaquin Marsh in Irvine, California (Chambers Group, 1991, unpubl. report). Considerable conservation efforts are currently underway to save remaining wetlands.

Wetlands are a habitat for many rare and endangered species. By definition, they require considerable water. Before intense settlement of the Los Angeles Basin, some wetlands occurred near the shore where fresh water drainages – rivers and streams – reach the ocean. Some wetlands can still be found within the City of Los Angeles. Coastal wetlands require a fresh water input, a high water table, and contact with the ocean. Subsidence and the lowering of the water table by the removal of groundwater have destroyed some of these wetlands. Others have been destroyed by straightening and cementing channels, a practice that has become almost a tradition in Southern California.

Where there is an interest in biological conservation of native species of Southern California, there will be an interest in maintaining existing wetlands and restoring damaged or destroyed wetlands. A well-known example is the Ballona wetlands near the Los Angeles Airport. A report from the Chambers Group in 1991 proposes creating a 52-acre freshwater wetland with 25 acres of riparian habitat and 27 acres of freshwater marsh to replace 23 acres of scattered wetlands, as part of a development project. This report projects that the restored wetlands might become habitat for more than 100 species of vegetation, compared to 25 species in the present degraded habitats.

The report also projects that the restored wetlands could provide nesting habitats for 50 species of birds, that the habitats within it would be suitable for 80 species of birds, and that they could be used by more than 20 species of mammals and more than 10 reptiles and amphibians. The year-round open water of the wetland would provide a habitat for shorebirds and waterfowl. Rare and endangered or otherwise declining species that might use this wetland include Least Bell's vireo, warbling vireo, yellow warbler, yellow-breasted chat, least bittern, Wilson's warbler, tricolored blackbird, black shouldered kite, Cooper's hawk, white-faced ibis, the long-eared owl, the California red-legged frog, and the western pond turtle (Chambers Group, 1991, unpubl. report). The proposed wetlands are estimated to require 7 million gallons of water a month in the summer and 5.7 million gallons a month in the winter.

Urban conservation corridors

As mentioned earlier, urban corridors, greenways and parks, as well as wetlands, riparian zones, and other areas representative of native ecosystems within urban areas, can be an aid to the conservation of biological diversity and endangered species. An urban conservation corridor is a continuous strip or area of naturalistic vegetation and ecosystems that connect rural and open land in one part of a city with rural or open land in another. Naturalistic vegetation is vegetation that appears to be original, but is dynamic in time and may include some introduced species. Through these corridors wildlife can move and migrate and the seeds of plants can be transported. People can use corridors for recreation. These corridors will be increasingly important to biological conservation in the future, as well as to urban recreation. Such corridors can be especially effective for biological conservation when a city has a set of isolated nature preserves, as does Los Angeles (Table 3). Many citizens' groups are involved in creating urban corridors for biological conservation throughout the United States, including San Francisco and Sacramento.

One example of a major greenway is the Chesapeake and Ohio Barge Canal passing through Washington, D.C., located near heavily used roadways of the nation's capital (Grove, 1990). Other greenways have been formed in the Washington, D.C. area along old railroad rights-of-way. In Denver, the Platte River Greenway transforms an old, decayed riverfront area into one of the city's most popular recreation areas. Other greenways in the American West include: the Yakima Greenway in the state of Washington; the San Francisco Area Bay and Ridge Trails which, when completed, will total 800 miles in two loops around the Bay; Sacramento's 23-mile long American River Parkway; and the Pueblo, Colorado greenway.

In Southern California, some corridors could include existing stream and river channels which, with sufficient surface water flows, would support adequate vegetation for wildlife habitat and migration. Environmental groups are currently promoting the idea of a greenway for Los Angeles that would begin at the mouth of the Los Angeles River, and continue upstream to the Santa Monica Mountains. This would require that the river and its riparian zones be not only restored but also provided with adequate

Table 3. Some natural areas in the vicinity of Los Angeles

Location	Administrative unit name	Wilderness acres
Cucamonga	Angeles National Forest	4,200
	San Bernardino National Forest	
San Gabriel	Angeles National Forest	36,118
San Gorgonio	San Bernardino National Forest	56,722
San Jacinto	San Bernardino National Forest	32,248
Santa Rosa	San Bernardino National Forest	13,787
Sheep Mountain	Mountain Angeles National Forest	39,482
	San Bernardino National Forest	2,401

Source: Hendee *et al*., 1990.

water. Other greenways could be developed in Los Angeles County that could help overcome the common criticism that the Los Angeles Basin is a formless sprawl. Greenways could provide structure to the landscape, helping to distinguish one urban center from another.

A study of two kinds of parks in Sacramento – one the traditional park, primarily made up of lawns and widely spaced trees and the second of community gardens, where residents could plant vegetables and be active participants – revealed some interesting distinctions. Government officials in charge of parks tended to discount the value of the gardens, seeing them as less aesthetic and as simply temporary measures. However, residents placed considerable value on these gardens, which provided activities and opportunities for socializing, as well as vegetables.

This study suggests that urban areas set aside for active use as gardens by urban residents can be of considerable value (Francis, 1987). When people are crowded in otherwise unattractive neighborhoods, it is possible that land made available for urban gardens might assist in promoting self-help and citizen-involvement attitudes that could be important to the future of our cities. Vegetation and ecosystems in a city should not be seen as simply passive decorations, but as opportunities for active involvement by residents, and as a part of the life of a vibrant city.

Landscape design for semi-arid regions

Having discussed the ecological function of vegetation in cities, we return to the ideas of Frederick Law Olmsted as applied to the semiarid western states including California. Although broad expanses of greensward, as discussed earlier, were an essential part of Olmsted's designs for parks in the East and the Midwest, he believed that such a landscape practice, based on styles that had developed in the rainy climate of England, was inappropriate for the Mountain States and California. The semi-arid American West called for development of a new style of landscape design, he concluded. The cost of irrigation of large areas to secure good turf was too expensive, for one thing. In addition, he hoped to devise a kind of landscape design that was based more directly on the natural scenery and climatic conditions of the region.

Olmsted made these ideas clear in the advice he offered to William Hammond Hall during the designing of Golden Gate Park in San Francisco in the 1870s. The shape and size of the park were closely patterned on Central Park in New York City. Olmsted objected to this approach, and to the idea of replicating eastern landscape practices in California:

> I have given the matter of pleasure grounds for San Francisco some consideration and fully realize the difficulties of your undertaking. Indeed I may say that I do not believe it practicable to meet the natural but

> senseless demand of unreflecting people bred in the Atlantic states and the North of Europe for what is technically termed a park under the climatic conditions of San Francisco (Olmsted, Letter to William Hammond Hall, October 5, 1871, unpublished).

Instead, Olmsted urged Hall to experiment with plant materials that would make possible broad landscape effects of 'rich, constant and varied verdure' with little watering:

> Cutting yourself completely clear of the traditions of Europe and the East, and shaping your course in details by no rigorously predetermined design, but as you find from year to year that nature is leading you on, you will, I feel sure, be able to give San Francisco a pleasure ground adapted to the peculiar wants of her people, with a scenery as unusual in parks as the conditions social, climatic, and of the soil, to which your design is required to be accommodated (Olmsted, 1874).

Olmsted proposed that irrigated lawns in the American West be thought of as communal possessions that served civic functions rather than as a normal part of private properties that met only the needs of individual land owners. This idea is repeated in two of Olmsted's proposals. One proposal was for the campus of the College of California and an adjacent residential neighborhood that Olmsted published in 1866. He proposed to group the college buildings on high land on the property, and planned the surrounding areas for residential lots. In a lower section, he proposed to set aside 27 acres for a park, with spreading shade trees around its edges and in the center 'a perfect living greensward' (Olmsted, 1866).

This was clearly to be the principal area of turf in the community, sited where natural conditions made the successful growth of grass most likely. The turf was to be watered daily during the dry season from hydrants set in the surrounding shrubbery. Olmsted was reluctant to plan for even this much lawn, given the expense of keeping it, but acceded because of his client's original desire for a much larger 'park,' as well as a consciousness of the beauty it would add to the whole campus and the effect such an area would have 'upon the health and spirits of the students and those who would be associated with them' (Olmsted, 1866).

Along roadsides, Olmsted proposed heavy planting of shrubs and trees that could survive without irrigation. These plantings, in time, would block out the view of dusty unimproved land along the roads and provide a thick cover of shade from the summer sun.

In a measure that Olmsted would often repeat during his career, he urged that the valley of Strawberry Creek above the college's property be reserved for public use. A carriage drive would be constructed along the side of the creek, through the dense growth of trees and chaparral along its borders, to a vista point on one of the hills above.

Olmsted did not give specific directions for the planting of the residential lots to be laid out, so it is not clear how much private lawn he felt should be attempted or allowed. His main concern in discussing the plantings around individual houses was to find a way for those plantings to contribute to the common landscape. Here he introduced another element of his design concept for the semiarid West: plantings should be concentrated close to houses, providing an atmosphere of lushness, green and shade, while blocking out the dusty middle distance and setting off distant views so that the dryness and dustiness were not evident, even in a drought season. If such an approach were carried out on hillsides like those at Berkeley, the plantings around the house of one's neighbor below would become a green 'middle distance' in the outlook from one's house, and one's own plantings would do the same for neighbors above (Olmsted, 1866).

Principles of semi-arid design

Based on his and his son's analysis of landscape planning in semiarid climates, Olmsted proposed four principles of semiarid design: first, to leave as little bare ground exposed to view as possible by planting vegetation; second, to arrange heavily visited places so that vegetation in and near them can be easily watered, assuring that dust and dryness is kept to a minimum; third, to plant vegetation so that it frames the distant vistas and obscures the dusty middle distance common in semiarid environments; and fourth, to plant as much vegetation on or around buildings to connect them visually to the surrounding countryside.

Olmsted's son, F. L. Olmsted, Jr., carried on the process of devising an approach to the use of vegetation in the region which his father had initiated 50 years earlier. Their combined work suggests how vegetation should be used to improve cities of the American West. Their plans suggest that vegetation can be planted to meet social and psychological needs, and that irrigation can be used carefully and wisely to enhance the city environment. Olmsted and his son rejected both extremes: of a city in an arid environment without vegetation, and of a city in a semiarid environment made to look like a city of England. The semiarid environment places certain constraints but also offers certain opportunities for landscape design. Their experiences and ideas can be useful in planning for the future use of vegetation in cities of Southern California.

The discussion to this point explains that vegetation in cities provides the following uses and beneficial effects: aesthetics and scenic design including plantings on private property that not only benefit the land owner but also contribute to the public landscape; embellishment of private dwellings and surroundings; the creation of private, domestic space; improving the quality of the grounds where people work, including corporate and public institutional areas; community involvement activities, as in community gardens; public amenities such as public parks, parkways, greenways, and scenic reservations; reduction in the use of fossil fuels for air conditioning and heating with a concomitant reduction in production of certain pollutants; absorption of certain air pollutants; in wetlands, reduction in water pollution; resistance to erosion, especially in areas of steep slopes, unstable soils, and variable rainfall; as an aid in flood control; as a means of providing privacy; and in biological conservation, including conservation of endangered species and native ecosystems.

Vegetation options

With these uses in mind, we can consider a set of options for cities in semiarid environments ranging from using only vegetation that require the minimum water to allowing unlimited plantings of all kinds of vegetation. We will list these and then explain why option 4 is preferable.

Option 1: Eliminate as much vegetation as possible. This reduces demand for irrigation, but it does not allow for any of the other uses of vegetation. It is difficult to imagine an attractive city without vegetation. Such a city would be hotter, have higher energy uses for air conditioning and heating, and probably more air pollution and less absorption of air pollutants, presenting greater health risks for its citizens. The city would be unable to contribute to biological conservation and, as the city grew in size, it would present an increasing threat to biological diversity. Given the already great reduction in the wetlands and riparian zones of Southern California, it is possible that this policy could result in significant effects on threatened, rare, or endangered species of these ecosystems and habitats, including some of the rare, threatened, endangered species characteristic of wetland and riparian habitats listed in Table 1.

Option 2: Plant only xerophytic vegetation. Under this option the city has vegetation, but minimizes the water used in irrigation. Certain kinds of scenic and aesthetic qualities of the city could be achieved. It is possible that an attractive city could be designed using only xerophytic vegetation. However, this vegetation would be of less value – perhaps of questionable value – in erosion control and little use in flood control. Slow-growth typical of xerophytic vegetation, the open structure of xerophytic vegetation communities, and the few trees in this category mean that a city with only this kind of vegetation would have fewer benefits from vegetation in reduction of air conditioning and heating demands, less aid in absorbing air pollutants, and less privacy. Community gardens would not be possible and the social benefits of the vegetation would be much less. Ballparks, golf courses, and other playing fields would be eliminated except where artificial materials were used. The contribution to biological conservation would be restricted to desert and semi-desert ecosystems. As in Option 1, given the already great reduction in the wetlands and riparian zones of Southern California, it is possible that this policy could result in significant effects on threatened, rare, or endangered species of the ecosystems and habitats listed in Table 1.

Option 3: Vegetation planted uniformly (and therefore water made available uniformly for vegetation irrigation) per unit area of the city. Under this option, everyone would receive the same allocation of water for each square foot, regardless of the social or economic use, the terrain, soil, bedrock, or ecological history of the area. Each landowner would have to partition the use of his water. This option would allow some increased benefits from vegetation for reduction in air-conditioning and heating requirements, and social benefits for privacy. The benefits for erosion and flood control are difficult to predict but are likely to be minimal, because the homogeneous use of water would not allow for the growth of more water-using trees on steep slopes. There would be some use of the vegetation as an aid to biological conservation, but entire native ecosystems, riparian and wetland, would not be available, and greenways, corridors, and parks would be highly restricted in their characteristics. Although there might be enough total water available for conservation of wetlands and riparian zones, the geographic distribution of the water supply might not meet the needs of these ecosystems. Therefore, as in Options 1 and 2, given the already great reduction in the wetlands and riparian zones of Southern California, it is possible that this policy could result in significant effects on threatened, rare, or endangered species of ecosystems and habitats such as those listed in Tables 1 and 2.

Option 4: Vegetation includes types that require moderate- and high-water availability but these occurring in limited areas, so that the total water use approximates that of Option 3, but with the water and vegetation use per unit area varying spatially. Vegetation use would vary according to social and economic uses of the land, taking into account terrain, soil, bedrock, ecological history, and ecological potential of different sites. In this option, high-water-use vegetation would be permitted but would be considered a valuable community resource, similar to the public transit perception. Thus water use would be determined based on local environmental characteristics and social and economic needs. Parts of the city would have less vegetation than in Option 3. Native wetlands and riparian ecosystems would be restored along water courses. These could be combined and integrated into greenways, parks, and corridors to assist in biological conservation. The entire native variety of ecosystems could be supported. This option would seem to provide the greatest flexibility in responding to the need to conserve threatened, endangered, and rare species. Trees would provide the full compliment of aesthetic and ecological benefits. Many kinds of trade-offs could be allowed under this option. A trade-off could be made between fossil-fuel use for air conditioning and water requirements for shade trees to approach an optimum use of these valuable resources. Community gardens with relatively high water use could be developed in exchange for minimization of water use for vegetation around residences. Thus there could be considerable community-determined choices in the partitioning of water use for vegetation and in the kinds of vegetation. This option appears to provide more of the benefits of vegetation in the city while simultaneously providing benefits and reducing demands on the environment external to the city.

Option 5: Allow unrestricted planting of all kinds of vegetation, including vegetation characteristic of high- or moderate-rainfall temperate environments. Under this option there could be an emphasis on plantings characteristic of temperate, moderate- to high-rainfall areas of Western Europe and northeastern North America. This option would require the greatest amount of water use for irrigation. It would allow the city to use vegetation to reduce air conditioning and heating requirements, but the intensity of the care of vegetation might tend to balance savings in fossil-fuel use. Vegetation could be used to help in erosion control and flood control, for privacy, and for community amenities. However, there might be an emphasis on non-native vegetation which would mean that the city might contribute less to biological conservation. This approach would likely overemphasize the planting of non-native, high-water requiring, temperate-zone vegetation.

Conclusion

Although it may be a popular belief that we can ignore cities and perhaps abandon cities in the future of civilization, on the contrary, human population trends show that we are becoming an increasingly urbanized species. Moreover, cities have always been important in civilization, and are likely to continue to be so as centers of innovation and creativity. As cities become larger and larger, and as populations become more and more urbanized, urban environmental effects will increase. If we are to practice biological conservation, and also create environments pleasing to people, then we need a renewed emphasis on the positive aspects of urban environments. One way to achieve this is to combine modern environmental scientific knowledge with the ideas of the great planners of the past, such as Frederick Law Olmsted. Using Los Angeles as a case example, this paper reviews the uses of vegetation in cities, with an eye toward good planning to meet human needs and the needs of biological conservation.

There are four basic ecological functions in a city: reducing energy use, reducing and removing pollutants, helping to create a pleasing environment, and aiding in biological conservation. There is a strong tradition in the history of western civilization, particularly in the United States, that defines aesthetics and vegetation as key qualities in determining the success of urban planning. The use of vegetation in a city not only makes it more pleasing to the senses, but also has economic value. It is well known that decorative plantings increase the economic value of private buildings, but at the same time vegetation can reduce air-conditioning needs and improve air quality, both of which have economic benefits. Indeed, the primary purpose of the urban park movement of the 19th century was sanitary reforms, which had both quality of life and economic values. Olmsted saw the use of vegetation as a way to meet urban psychological and social needs, and did not see the value of plantings and parks simply as beauty for beauty's sake.

A city changes its environment. A large city creates a heat island – the city is warmer than the surrounding countryside. Urban development alters soils, water flow, water quality, and air quality. Each of these can be improved through the proper use of vegetation and urban open space.

The qualities that make a location good for a city often also make it an important location for biological conservation. For example, river mouths are good sites for cities because of the access to transportation. However, estuaries are widely polluted and wetlands and riparian zones are eliminated over large areas. There is, therefore, an important need to plan urban parks and vegetated corridors to provide habitats and migration routes for native species. This brings together the need for biological conservation with the need for a better quality of life for city residents.

When droughts occur in cities, it is common to hear that there should be fewer lawns and trees in order to reduce water use. Olmsted and his firm discussed the uses of vegetation in cities in semiarid environments, noted specific needs, and recommended specific uses for each kind of vegetation. He argued that lawns have important communal value and that cities – even those in semi-arid and arid areas – should have parks where the public can enjoy the benefits of this kind of landscape. Thus, where water is limited, the use of lawns is also limited to where it is most important, but it is not eliminated. Meanwhile, flowers, trees, and shrubs planted around homes and business buildings serve specific functions, including those just mentioned – reduction of air-conditioning needs, improvement in air quality, and improvement in the aesthetics and therefore the psychological and social benefits which result.

Olmsted argued for a system of urban parks, large and small, including corridors. Today we recognize that these meet not only human needs but can be valuable for biological conservation. In addition, Olmsted planned parks and open space to serve multiple functions, such as flood control (allowing a place for flood waters to fill) as well as recreation during times without floods.

From the earliest civilizations, aesthetics has been an important consideration in city planning, although greater emphasis on the use of vegetation and open space has developed during the last two centuries. During the 19th century, the park town idea grew in importance. It developed in the 20th century into the garden city, when the city and its countryside are planned together. This type of large-scale planning was done for a number of cities in the United States. The idea of garden cities takes on more importance as the world becomes increasingly urbanized and applies greater pressures on endangered species.

Even Los Angeles, which is often thought of as a flat, unaesthetic landscape crowded with buildings, has a wide variety of native vegetation and could benefit greatly from improved use of vegetation, parks, and corridors. The kinds of vegetation found in the Los Angeles Basin and its many uses are reviewed in this paper. Although much emphasis has been placed on xerophytic vegetation as a means to reduce water use, urban wetlands and riparian habitats are especially important for biological conservation and these will require more attention in the future.

There are a growing number of examples of the multiple uses of vegetation, parks, and corridors in cities, many with strong citizen involvement; some of these are reviewed in this paper.

The future of our cities depends on our ability to conserve and use our resources wisely. As we have reviewed in this report, vegetation in cities can play an important role in the aesthetics and design of cities, biological conservation, reduction in the use of fossil fuels, and reduction in some forms of pollutants. Those who have designed and planned cities have seen that, beyond its roles in the physical, biological, and conservation realms, vegetation has an important societal function.

Vegetation is essential to achieving the quality of life that creates a great city and that makes it possible for people to live a reasonable life within an urban environment. As long as people agree that cities are important to civilization and that it is essential to improve the conditions of urban residents, especially the urban poor, people must understand that vegetation is an integral part of the city environment.

Finally, this paper proposes five options for the use of vegetation in cities: (1) eliminate as much vegetation as possible on the grounds that vegetation wastes water; (2) plant only xerophytic vegetation; (3) plant vegetation uniformly so that water is uniformly made available for irrigation per unit area of a city, on the basis that this is a democratic distribution of a scarce resource; (4) partition the use of water for irrigation spatially so that some areas can be maintained as wetlands and riparian zones, but at the same time the overall water use for the city approximates that of Option 3; (5) allow unrestricted plantings of all kinds of vegetation, including those characteristic of moderate or high rainfall areas, and seek to increase water supply as needed. Of the five options presented, the fourth provides the greatest benefit for biological conservation and human uses of the land. We propose it as a guideline for cities in semi-arid environments.

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