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THE ECOLOGICAL IMPORTANCE OF URBAN VEGETATION

INTERIM HEARING

June 1992

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THE ECOLOGICAL IMPORTANCE OF URBAN VEGERATION

An Introduction to the Uses and Benefits of Vegetation in Urban Environments Including Southern California

REPORT TO THE

METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA

FROM

THE CENTER FOR THE STUDY OF THE ENVIRONMENT

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PREFACE

Policies, Approaches and Activities of CSE

The Center for the Study of the Environment (CSE) was established as a private, non-profit organization to serve all facets of society by providing critical information, analysis and optimal solutions to common environmental problems.

Practical, equitable and rational solutions to environmental problems exist. Finding them requires an interdisciplinary and non-ideological approach. When presented with a problem, The Center for the Study of the Environment identifies the information necessary for obtaining a solution; employs scientific data-gathering methods to fill any critical information gaps; and applies the latest scientific models to identify the most likely outcomes of policy options.

The Center rejects the artificial distinction between human activities and natural processes. Humans are an integral part of the ecology of the planet. The only lasting environmental solutions are those that take into account the dynamics of human society as well as those of natural systems. CSE sees the combined roles of the public, business and government as critical to problem solving.

This report is a work in progress, written in response to a request for an analysis. It introduces issues and concerns and is an attempt to suggest the scope of the topic. It is neither a final nor a definitive statement of all of the issues.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

With California continuing to suffer from the impact of a six-year drought and Southern California still experiencing rapid urban growth, policy debates over water use continue to intensify. Some would argue that arid Southern California cities are extravagant consumers of water and that the existing landscapes and vegetation are inappropriate. However, vegetation in cities provides the following significant 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; helping to create private, domestic space; helping to improve 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 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.

These uses require a variety of vegetation with a variety of water requirements. Vegetation limited to xerophytes (plants of deserts, semi-deserts, or other dry habitats) can meet some, but not all of these uses. A greater variety of vegetation as discussed in this report, with the type of vegetation varying within the city depending on environmental conditions and needs, ecological history and ecological potential, as well as social and economic considerations, could meet many of these uses, while at the same time achieving the combined goals of conserving water and energy resources.

The purpose of this report is to analyze and synthesize information about: the history of the role of cities in civilization; the use of vegetation in cities; and the significance attached to vegetation in urban environments, including existing parks, private yards, and landscapes at commercial buildings.

The following are some key conclusions of the report:

- Cities are and will continue to be important as centers of civilization, commerce, innovation, and as the home for millions of people, including millions of poor.

- Worldwide, we are becoming an increasingly urbanized species. In the United States, about 70 percent of the people live on 3 percent of the land area and three-quarters live in urban-suburban areas. It is projected that 50 percent of the people in the world will live in cities by the year 2000.

- Living in an environment of good quality means living in a city that has managed carefully to maintain that environmental quality. A city cannot exist without a countryside to support it. If the city environment declines, the environment of its surroundings will also decline.

- City planning has a long history. At many times city planners have taken environmental factors carefully into consideration. A dominant theme in the history of city planning throughout civilization has been an emphasis on design for aesthetics: a goal of making a city beautiful and pleasant to inhabit — the "park city" and the "garden city."

- The goals of urban environmental management are: (1) to make the internal, local environment as pleasant, beautiful and healthy as possible; (2) to provide residents with access to parks and other contact with plants and animals; (3) to make wise use of natural resources that sustain the urban life-support system; (4) to minimize the negative environmental effects of the city on the countryside; and (5) to create a city that aids, rather than harms, conservation of biological diversity.

- Trees and shrubs are an important part of urban environments. In addition to aesthetic values, they reduce the need for air-conditioning and the use of fossil fuels. Trees and shrubs also can absorb and concentrate pollutants and improve the air quality in a city. Recent EPA and other reports suggest that use of trees to shade houses may result in savings of electrical energy of 24 percent in Sacramento and 12 percent in Phoenix.

- Vegetation native to Southern California can be grouped in four categories — xerophytic, mesic, riparian and wetland. Each has its own uses, its own set of species and its own ecological history.

- Southern California, with its Mediterranean climate, has a high biological diversity, including many endemic species (those species native to and found only within Southern California).

- Stress on urban vegetation and lack of diversity of urban species are problems that should be considered in planning.

- There is considerable wildlife in cities, much of it unnoticed by all but a few residents. There is also a growing recognition that urban areas provide and can be modified to provide habitat for wildlife that people can enjoy and that this can be an important method for biological conservation. Urban parks can provide good wildlife habitats; the importance of these parks will increase as truly wild areas dwindle.

- Increasingly, cities are becoming places where endangered species are conserved. There are current efforts to develop urban ecological corridors — vegetated pathways that lead through a city and provide routes for the migration of wildlife, transport of seeds of native vegetation, and recreation for city residents. These corridors will become more important to biological conservation in the future as cities grow in size and number and pressures on nature preserves in rural areas continue to increase.

- Parks and urban vegetation are essential elements in creating a sense of well-being for urban residents. An American tradition in park planning and design was established by Frederick Law Olmsted, who believed that parks should be designed to meet psychological and social needs. Today we find there are many social benefits of vegetation in cities, including parks and community gardens where residents can grow vegetables and flowers. Some studies suggest that urban residents have reduced levels of stress when they visit city parks.

- Urban environments can be managed to help reduce the undesirable effects of global environmental problems. Urban tree plantings can reduce energy use, reducing the demand for fossil fuels; vegetation can be used to cool houses and commercial structures, reducing the use of polluting refrigerants.

- The more we make urban environments pleasant and desirable with increased opportunities for recreation, the less pressure there will be on delicate natural areas in rural areas. Thus, improving urban environments can help conserve wilderness and endangered species in rural areas. Those who support the conservation of wilderness will benefit their cause by supporting better urban environments.

- Since urban vegetation depends on an adequate water supply for its sustenance, a reduction in that supply could adversely affect many of the benefits or values of an urban environment discussed in this report.

I. INTRODUCTION

Recently, because of drought and increasing burdens on water supplies, the use of vegetation in cities has come under criticism, especially in regards to Southern California. The suggestion has been made by some that vegetation is not necessary in cities and, since vegetation requires water, most or all vegetation should be eliminated. On the other hand, the recent riot in Los Angeles brings to the forefront the question of the quality of life in our cities, especially for the urban poor. Although the quality of our surroundings is not an answer to all urban problems, the recent disturbances make us reconsider the importance of urban environments. These two considerations — water supply limitations and the quality of urban life — force us to ask the practical questions: Can we improve the quality of life in our cities? Can we improve that quality of life without vegetation? What are the uses of vegetation in a city?

These questions raise several fundamental issues, including: the role of cities in civilization; the roles, uses, and value of vegetation in urban environments; and the uses and importance of ecosystems that depend on vegetation within urban environments. This report is an analysis and synthesis of these issues.

In the development of the modern environmental movement in the 1960s and 1970s, it was fashionable to consider everything about cities bad and everything about wilderness good. Cities were thought of simply as polluted, lacking in wildlife and native plants, dirty and artificial — and therefore bad. Wilderness was thought of as unpolluted, clean, full of wildlife and native plants — natural — and therefore good. But while it was fashionable to disdain cities, most people lived in their environments and have suffered directly from their decline.

Recently, comparatively little public concern has focused on urban ecology. As a result, many urban people have seen environmental issues as outside their "realm." In fact, city dwellers are at the center of some of the most important environmental issues. Today there is a rebirth of interest in urban environments and in the development of urban ecology. Increasingly people are realizing the city and wilderness are inextricably connected. We cannot hike in the wilderness while our Romes burn from sulfur dioxide and nitrogen oxide pollution.

Premises of this Study

1. Historically, cities have been the centers of civilization. Much of the innovation, invention and creativity of civilizations has occurred in cities and this continues today. A city provides recreational and leisure opportunities important to the quality of life of its citizens.

2. The size and population of cities is expected to increase throughout the world, as part of the continued growth of the human population.

3. Increasing population pressures in cities will make it more imperative to improve the quality of life in urban areas and to increase recreational and leisure opportunities.

4. Cities play an increasingly important role in biological conservation, including the conservation of endangered species. There will be increasing needs for habitats, reserves, and migrating corridors for threatened and endangered species and ecological communities; urban environments will increasingly be called upon to provide these.

5. Energy and water are resources that are essential to cities; both should be used wisely for optimum benefit.

6. If managed wisely, water is a renewable resource and should be treated as such.

7. The water demands in semi-arid urban environments such as Southern California pose unique challenges for water use and management.

Given these premises, this report analyzes the role of vegetation and associated ecosystems within cities, both at the present and for the future, with a special emphasis on cities in the semi-arid environments of Southern California.

This report was supported under Contract 3645 from the Metropolitan Water District of Southern California. The material expressed in this report, however, are those of CSE and are not opinions or policy of the Metropolitan Water District.

Cities and Civilization

Although it is common to think of cities as unpleasant environments, cities have been centers of civilization and their builders have often created an environment found to be beautiful and nurturing by the inhabitants. For example, a 20th-century writer remembered earlier days in a city with great nostalgia. "The clicking of the hoofs upon the hard macadam, the rhythmical creaking of the harness, the merry rattle of the lead bars," he wrote, "are delectable sounds." [1] Cities are one of the ways that human society is able to pass beyond the direct limitations that the environment imposes on nonhuman species. In the past, the creation of a city in a desert or semi-arid region was considered one of the triumphs of civilization. In planning for our future, it is useful to consider the relationships between a city and the environment. How will a city change as the environment changes? Is a city's environment healthy or unhealthy? How can we plan a city to make it more livable?

The goals of urban environmental management are: (1) to make the internal, local environment as pleasant, beautiful and healthy as possible; (2) to provide residents with access to parks and other contact with plants and animals; (3) to optimize the use of natural resources and sustain the urban life-support system; (4) to minimize the negative environmental effects of the city on the countryside; and (5) to create a city that aids, rather than harms, conservation of biological diversity.

In recent years there has been a growing development of community programs, as well as the establishment of private groups to improve city environments and develop better methods for people to live in harmony with their urban environment. These activities range from comparatively informal urban gardening programs to formal organizations devoted to planting of vegetation, such as the American Forestry Association, which publishes the journal, *Urban Forests*. Other efforts center on: urban restoration and conservation; tree planting; city beautiful organizations; and community garden associations.

II. AN ECOLOGICAL PERSPECTIVE ON CITIES

Recently, it has become fashionable to talk about the end of the rationale for cities, based on the belief that telecommunications and computers will allow each of us to work wherever we want — on a houseboat, in the woods — generally away from cities, dispersed in suburban neighborhoods, but connected in a "global village." While technology may exist to allow some of us to work in this manner, in fact only well-educated professionals will be able to do so. For most, city life will continue to be a reality and necessity.

Urban Population Growth

Contrary to the belief that cities might become less important in the future are the facts of the last decades and projections of population trends. Based on these, one can only conclude that, worldwide, we are becoming an increasingly urbanized species. In the United States, about 70 percent of the people live on 3 percent of the land area[2] and three-quarters live in urban-suburban areas.[3] It is projected that 50 percent of the people in the world will live in cities by the year 2000. In the developed countries, almost 80 percent of the people live in cities, while in the poorest developing countries only 20 percent of the people live in cities. Thus, economic development leads to urbanization; the greater the economic development, the more likely urban concentration will be in the future.

Not only is the human population becoming increasingly urbanized, there is a rapid growth of huge metropolitan areas with more than 10 million residents. *In 1950 there were only two areas in the world with more than 10 million residents — New York City and its nearby New Jersey areas (12.2 million residents) and greater London (12.4 million).* By 1975 there were seven such areas with the addition of Mexico City, Los Angeles, Tokyo, Shanghai, and Sao Paulo, Brazil. It is estimated that by the year 2000, 20 more cities and their surrounding areas will have more than 10 million residents and 25 urban areas will have a total of almost 400 million residents.[4] (See Figure 1. Largest urban areas in the world.) In the future most people will live in cities and, in most nations, most of the urban residents will live in the country's single largest city. In the future, living in an environment of good quality will mean living in a city that is managed carefully to maintain that environmental quality.

Some environmental leaders are beginning to speak once again of the benefits of cities to civilization and for the environment. Dr. Roderick Nash, one of the contemporary leaders in environmental history and a frequent spokesman and writer about the environment, has recently called for an urban "implosion" — a return to urban life as a way to conserve rural land and wilderness. "My dream for the next millennium," he has written, is "1.5 billion human beings living in five hundred concentrated habitats" creating an "island civilization," a renewed, urban-dominated civilization.[5] Others recognize that, even if we live in distant suburbs and commute infrequently, those long commutes may be as great a burden on resources as daily, shorter trips to and from work. In the near future, this interest in a renewal of urban life as a way to assist conservation in the larger sense may increase.

The City and Countryside as One System

A city is not a self-contained system. It depends on other cities and rural areas. (See Figure 2. The city as a system.) A city takes in raw materials from the surrounding countryside: food, water, wood, energy, mineral ores — everything that a human society uses. In turn, the city produces and exports material goods and, if it is a truly great city, exports ideas, innovations, inventions, arts, and the spirit of civilization. A city cannot exist without a countryside to support it. As was said half a century ago, city and country, urban and rural, are one thing — one connected system of energy and material flows, not two things.[6]

Consequently, *if the environment of a city declines, almost certainly the environment of its surroundings will also decline.* Cities export waste products: polluted water, air and solids, which the countryside has had to absorb and dispose of. It has been estimated that the average city resident in an industrial nation uses annually, directly or indirectly, 208,000 kg of water, 660 kg of food, and 3,146 kg of fossil fuel, and produces 1,660,000 kg of sewage, 660 kg of solid wastes, and 200 kg of air pollutants. If these are exported without care, they pollute the countryside, harming the ability of the surroundings to provide necessary resources for the city, and making life in the surroundings less healthy and less pleasant.

A city can never be free of environmental constraints, even though its human constructions give us a false sense of security. As Lewis Mumford, the historian of cities, has written, "Cities give us the illusion of self-sufficiency and independence and of the possibility of physical continuity without conscious renewal," but this is only an illusion.[7]

III. PARK PLANNING & URBAN PLANNING

There is a strong tradition in the history of 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 concern is as much a central issue for environmentalists as is the goal of conservation of rural natural areas. At various times city planning took environmental factors carefully into consideration. Although many cities in history have grown without any conscious plan, formal plans for new cities can be traced in modern history as far back as the 15th century. Sometimes cities have been designed for specific social purposes, with little consideration of the environment; in other cases, the environment and its effect on city residents have been major planning considerations.

Dominant Themes: Defense and Beauty

Two dominant themes in formal city planning have been planning for defense and planning for beauty. Roman cities were typically designed along simple geometric patterns with both practical and aesthetic benefits. During the height of Islamic culture, in the first millennia A.D., Islamic cities typically contained beautiful gardens, often within the grounds of royalty.

After the fall of the Roman Empire, the earliest European planned towns and cities were walled fortress cities, designed for defense. But even in these, city planners considered the aesthetics of the town. In the 15th century, one such planner, Leon Battista Alberti, argued that large and important towns should have broad and straight streets; smaller, less fortified towns should have winding streets to increase their beauty. He also advocated the inclusion of town squares and recreational areas.[8] These continue to be important considerations in city planning.

The Historical Park and Public Open Space Movement

Prior to the end of the middle ages, vegetation in cities of the West was concentrated in gardens of limited extent, or in orchards and pleasure grounds of wealthy citizens in the outer parts of cities, near fortified walls.

European Innovation: Beginning in the 16th century some cities began to expand beyond their fortified walls and areas with rows or groves of trees were planted to provide the upper classes with places for promenades, games and festivities.

The *Cours la Reine,* created outside Paris in 1616 by Queen Marie de Medicis, wife of Henry IV, was one of the earliest planted gathering places. Soon after, the walls of Paris and its bastions (boulevarts) were transformed into planted "boulevards" for carriages and pedestrians. The practice was adopted gradually in other cities. Vienna began construction of its Ringstrasse along the old city walls in 1857, the year New York City held its design competition for Central Park.

Paris set the example for European cities in the 19th century with the creation of wide, planted boulevards cut through the old sections of the city. Also under the Second Empire of Napoleon III, from 1850 to 1870, public parks were created in Paris from what had been royal hunting forests on the edge of the city — the Bois de Boulogne and Bois de Vincennes. A similar development took place in London, beginning with the opening of the royal parks in the city to the general public, followed by the construction of Victoria and Battersea parks in industrial and working-class areas.

The twin problems of rapid population expansion and overcrowding that occurred in the great cities of Europe during the Industrial Revolution resulted in the creation of public open space, extending to all classes amenities that at the beginning of the modern age had been enjoyed only by the wealthy and powerful. In England the creation of urban parks came in direct response to Parliamentary investigations that revealed horrendous living conditions among the urban poor.

The park movement of the 19th century was part of a series of "sanitary" reforms, by which those governing cities sought to counteract the threat to health produced by industrialization and rapid urbanization. The second element of this sanitary "revolution" was the provision of an adequate supply of pure water. The coalescence of these two movements can be seen in the park movement in the United States, where Philadelphia set aside some 4,000 acres along the Schuylkill River as a public park (Fairmount Park); the park also protected the watershed for the city's waterworks. In New York City the reservoirs supplied by the new Croton water source were located in the middle of the site for Central Park.[9]

North American Design: Ideas of the "fortress city" and the "park city" influenced the planning of cities in North America. The importance of aesthetic considerations is illustrated in the plan for Washington, D.C., designed by Frenchman Pierre-Charles L'Enfant. He mixed a traditional rectangular grid pattern of streets (which can be traced back to the Romans) with broad avenues set at angles. The intention was to design a city of beauty, with many parks, including small ones at the intersections of avenues and streets.

The discussion to this point should make clear that it has long been the belief that planting of trees, shrubs and flowers improves the beauty of a city.[10] Plants provide for different needs in different locations.[11] Traditionally, trees provide shade, reducing the need for air conditioning and making travel in the city much more pleasant in hot weather. In parks, trees and shrubs can block some city sounds and create a sense of solitude. Plants also provide habitat for wildlife such as birds and squirrels.

Prior to the time of the European Renaissance, trees and shrubs were set apart in gardens, to be viewed as scenery, but not experienced as part of ordinary activities. Among the first tree-lined streets — found first in the 18th century — were the Rue de Rivoli in Paris and Bloomsbury Square in London. As an indication of the importance of trees in urban planning today, major cities have large tree planting programs. For example, in New York City 11,000 trees are planted each year. The City of Vancouver, B.C., plants 4,000 per year.[12]

Central Park was the first major urban park to be created in this country. It marked the beginning of the career of a man who would most influence park building and the profession of landscape architecture in the 19th-century United States, Frederick Law Olmsted. In 1858 he and his collaborator, English architect Calvert Vaux, won the design competition for Central Park with their plan entitled "Greensward."

The inspiration for this landscape was private estates of the British aristocracy. It was Olmsted's intent to take such an amenity from the private realm and make it available to all American city-dwellers.[13] (See section on Parks & Vegetation for more information on Olmsted and his designs.)

IV. THE CITY AS AN ENVIRONMENT

A city changes the landscape and therefore the relation 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 particulates than are their rural neighbors.

The Heat Island Effect

Cities are warmer than surrounding areas, because of increased heat production (due to burning fossil fuels and other industrial and residential activities) and because there is a decreased rate of heat loss (due to less water available on the surface for evaporation, which cools the surface). Concrete, asphalt, and roofs also tend to act as solar collectors and quickly emit heat, helping to increase the heat in cities.[14] The observed increase in temperature in urban areas is approximately 1-2° Centigrade (C) in the winter and 0.5-1.0° C in the summer for mid-latitude areas (See Figure 3. Urban heat island effect.) One study suggests that 25 to 50 percent of the excess air temperature due to the urban heat-island effect can be reduced through tree planting.[15]

The use of electricity for air conditioning increases as cities become warmer. Information from the Los Angeles Department of Water and Power and Southern California Edison indicate that, for every degree Fahrenheit (F) rise in average annual temperature, 300 megawatts of electricity is used. There has been a 5 degree F rise in the average temperature of Los Angeles since 1940 due to the heat island effect, which translates into an added electrical demand of 1.5 gigawatts. The Environmental Protection Agency (EPA) calculates that electrical costs for summer heat island effects alone could cost more than $1 billion a year for U. S. cities.[16]

The heat-island effect accelerates chemical reactions that produce high ozone concentrations, increasing urban air pollution. The EPA estimates that the number of polluted days may increase by 10 percent for each 5-degree F rise in temperature. In Los Angeles, ozone levels are acceptable below 74 degrees F; above 94 degrees all days are projected as unacceptable. The heat island effect increases the need for air-conditioning, puts additional stress on vegetation and leads to the increased benefit of vegetation in shading.

Water and Soil in the Urban Environment

The construction of modern cities affects the water cycle greatly. This, in turn, affects soils and, consequently causes stress on plants and animals in the city. (See section on Urban Stress on Vegetation later in this report.) Paved city streets and city buildings prevent water infiltration. As a result, most rain 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 to 10 percent more precipitation and considerably more cloud cover and fog than do surrounding areas.

V. VEGETATION IN CITIES

Semi-Arid Environments

Recently, because of the drought in Southern California, there has been an emphasis on plants that use little water, called xerophytic, and on plantings, called xeroscapes, that need little irrigation. Because Southern California, except at high elevations, lies within a semi-arid climatic zone, one might think that only xerophytic vegetation is native. However, vegetation native to Southern California, including the Los Angeles area, can be grouped more simply in four categories in relation to water use and water requirements: (1) xerophytic vegetation — vegetation that needs little water (a fancy term for desert, semi-desert, and dry-country plants); (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, its own ecological history and associated animals. This section reviews the uses, advantages and disadvantages of each kind for a city in a semi-arid 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 land around a house, providing an aesthetic surrounding with a minimum of water use. For many situations where the only considerations are aesthetics and minimizing water use, xerophytic vegetation meets the 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. Vegetation that occurs near riparian zones, benefiting from the higher water table of such areas — but far enough away from the stream drainage to be rarely flooded — would be part of this type. Some other vegetation on north slopes at higher elevations would also be mesic.

Riparian Vegetation: Most of the trees native to Southern California are riparian or occur at higher elevations in the mountains. (Trees occurred primarily along water courses at low elevations prior to European settlement.) The characteristic habitat of the coast live oak is near to or along drainages. Other Southern California riparian trees include maple, sycamore and 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 percent — as much as 95 to 97 percent — of riparian ecosystems have been lost in Southern California, and that riparian habitats have supported more species of birds than any other in California.[17]

Wetland Vegetation: Wetlands are, in general, a threatened habitat throughtout California. Approximately 90 percent 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 habitat for stages in the life cycle of species valued for commercial and conservation uses. There are fresh water, brackish, and salt water wetlands. 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, Calif.[18] Considerable conservation effort is currently being extended in an effort to save some remaining wetlands. Some wetlands still can be found within the City of Los Angeles.

Wetlands are 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. These wetlands require some 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 can destroy these wetlands. Traditional methods of converting river basins in Southern California by straightening and cementing channels also destroy wetlands.

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. Wetlands require surface water inputs as well as the maintenance of the water table at or near the surface. A well-known example is the Ballona wetlands near Los Angeles Airport, discussed in a later section of this report.

With this general background, we can consider the vegetation communities that are native and characteristics to Los Angeles County.

Natural Vegetation of the Los Angeles Basin: 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 percent of the Earth's surface area.[19] Other areas with Mediterranean climate occur along the west coast of Chile, the south coast of South Africa, southwestern and south Australia, and, of course, in the Mediterranean region. Although covering only a small area of the Earth, Mediterranean habitats are biologically diverse and support many rare species. Southern California vegetation includes 92 species listed by the California Native Plant Society as rare, threatened, endangered, or of limited distribution. (See Table 1.)[20]

For our purposes, the Los Angeles Basin will be defined as the parts of Los Angeles County south of the Transverse Ranges (here the San Gabriel Mountains) to the area of the Santa Monica Mountains, and the northwestern 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.[21] However, floras

Table 1. (continued)

California Native Plant Society's Inventory of
Rare and Endangered Vascular Plants Found
In Los Angeles County

CALIFORNIA NATIVE PLANT SOCIETY'S INVENTORY (Cont.)			
SCIENTIFIC NAME	COMMON NAME	STATUS	COMMENTS
Calandrinia maritima	Seaside Calandrinia	Endangered in portion of range	
Calochortus catalinae	Catalina Mariposa Lily	Endangered in portion of range	CA endemic
C. striatus	Alkalai Mariposa Lily	Few populations; End. in portion of range	
Calystegia peirsonii	Peirson's Morning-glory	Limited dist. (LA Co. only)	CA endemic;Chaparral & Coastal Scrub
Castilleja gleasonii	Mt. Gleason Indian Paint Brush	Rare; Endangered in portion of range	CA endemic; LA County only
C. plagiotoma	Mojave Indian Paint Brush	Limited Distribution; not endangered	CA endemic
Centrostegia leptoceras	Slender-Horned Spineflower	Rare & Endangered	CA endemic; LA, Riverside & San Bernardino Cos.
Cercocarpus betuloides ssp. blancheae	Island Mountain Mahogany	Limited Distribution; not endangered	CA endemic; Chaparral
Chorizanthe californica var. suksdorfii	El Segundo Dunes Spineflower	Rare & Endangered	CA endemic; LA & Santa Barbara Cos. only
C. parryi var. fernandina	San Fernando Valley Spineflower	Extinct	Last seen, 1940; Coastal Scrub
C. spinosa	Mojave Spineflower	Limited distribution; not endangered	CA endemic; LA, Kern & San Bernardino Co. only
C. wheeleri	Wheeler's Spineflower	Limited distribution; not endangered	CA endemic
Cordylanthus maritimus ssp. m.	Salt Marsh Bird's Beak	Endangered in part of range	Rare outside CA
Crossosoma californicum	Catalina Crossosoma	Limited distribution	Rare outside CA; LA County & Channel Islands

Table 1. (continued)

California Native Plant Society's Inventory of Rare and Endangered Vascular Plants Found In Los Angeles County

CALIFORNIA NATIVE PLANT SOCIETY'S INVENTORY (Cont.)			
SCIENTIFIC NAME	COMMON NAME	STATUS	COMMENTS
Cymopterus deserticola	Desert Cymopterus	Endangered in part of range	CA endemic; Kern, LA & San Bernardino Cos. only
Dichondra occidentalis	Western Dichondra	Endangered in part of range	Widespread outside CA
Dithyrea maritima	Beach Spectaclepod	Rare & Endangered	Rare outside CA
Dudleya blochmaniae ssp. b.	Blochman's Dudleya	Endangered in portion of range	Rare outside CA
D. cymosa ssp. crebrifolia	San Gabriel River Dudleya	Known only from one occurrence	CA endemic; LA County only
D. c. ssp. marcescens	Santa Monica Mountains Dudleya	Rare & Endangered	CA endemic; LA & Ventura Cos. only
D. c. ssp. ovatifolia	Santa Monica Mountains Dudleya	Limited distribution	CA endemic; LA & Orange Cos. only
D. densiflora	San Gabriel Mountains Dudleya	Rare; endangered in part of range	CA endemic; LA County only
D. multicaulis	Many Stemmed Dudleya	Rare; endangered in part of range	CA endemic
D. virens	Bright Green Dudleya	Rare; endangered in part of range	CA endemic; LA County & Channel Islands
Eriastrum pluriflorum ssp. sherman-hoytae	Many flowered eriastrum	Limited range	CA endemic; LA & Kern Cos. only
E. virgatum	Virgate eriastrum	Limited range	CA endemic
Eriogonum microthecum var. johnstonii	Johnston's Buckwheat	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only
E. umbellatum var. minus	Alpine Sulfur-Flowered Buckwheat	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only

Table 1. (continued)

California Native Plant Society's Inventory of
Rare and Endangered Vascular Plants Found
In Los Angeles County

CALIFORNIA NATIVE PLANT SOCIETY'S INVENTORY (Cont.)			
SCIENTIFIC NAME	COMMON NAME	STATUS	COMMENTS
Erysimum suffrutescens var. s.	Suffrutescent Wallflower	Rare, not endangered	CA endemic; LA, Kern, San Bern. & Ven. Cos.
Frasera neglecta	Pine Green Gentian	Rare, not endangered	CA endemic; LA, SB, SLO & Ven. Cos. only
Galium angustifolium ssp. gabrielense	San Antonio Canyon Bedstraw	Rare, not endangered	CA endemic; LA, SB, SLO & Monterey Cos. only
G. cliftonsmithii	Santa Barbara Bedstraw	Rare, not endangered	CA endemic; LA, San Bernardino Cos. only
G. grande	San Gabriel Bedstraw	Few populations; not endangered	CA endemic; LA County only
G. jepsonii	Jepson's Bedstraw	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only
G. johnstonii	Johnston's Bedstraw	Rare, not endangered	CA endemic
G. nuttallii ssp. insulare	Nuttall's Island Bedstraw	Rare, not endangered	CA endemic; LA, S. Bar., S. Barbara & S. Diego Cos.
Gilia latiflora ssp. cuyamensis	Broad-Flowered Gillia	Rare, not endangered	CA endemic; LA, Kern, S. Barb & Ven. Cos.
Harpagonella palmeri var. p.	Palmer's Grappling Hook	Endangered in portion of its range	More common elsewhere
Helianthus nuttalli ssp. parishii	Los Angeles Sunflower	Apparently extinct	Last seen 1937
Hemizonia australis	Southern Tarplant	Little known about distribution	CA endemic
H. laevis	Smooth Tarplant	Little known about distribution	CA endemic
H. minthornii	Santa Susana Tarplant	Rare & endangered	CA endemic; LA & Ventura Cos. only

Table 1. (continued)

California Native Plant Society's Inventory of
Rare and Endangered Vascular Plants Found
In Los Angeles County

CALIFORNIA NATIVE PLANT SOCIETY'S INVENTORY (Cont.)			
SCIENTIFIC NAME	COMMON NAME	STATUS	COMMENTS
Heuchera abramsii	Abram's Alum Root	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only
H. elegans	Urn-Flowered Alum Root	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only
Juncus acutus var. sphaerocarpus	Spiny Rush	Rare, not endangered	More common elsewhere
J. mertensianus var. duranii	Duran's Rush	Rare, not endangered	CA endemic; more common elsewhere
Lepechinia fragrans	Fragrant Pitcher Sage	Rare, not endangered	CA endemic; more common elsewhere
Lilium parryi	Lemon Lilly	Rare, not endangered	More common elsewhere
Linanthus concinnus	San Gabriel Linanthus	Little known about distribution	CA endemic
L. orcutti	Orcutt's Linanthus	Extremely rare, but not endangered	
Lupinus elatus	Silky Lupine	Rare, not endangered	CA endemic; LA & Ventura Cos. only
L. excubitus var. johnstonii	Interior Bush Lupine	Rare, not endangered	CA endemic; LA & Kern Cos. only
L. peirsonii	Peirson's Lupine	Rare, not endangered	CA endemic; LA County only
Mahonia nevinii	Nevin's Barberry	Extremely rare and endangered	CA endemic
Malacothamnus davidsonii	Davidson's Bush Mallow	Endangered in portion of its range	CA endemic; LA & SLO counties only
Monardella cinerea	Gray Monardella	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only

Table 1. (continued)

California Native Plant Society's Inventory of
Rare and Endangered Vascular Plants Found
In Los Angeles County

CALIFORNIA NATIVE PLANT SOCIETY'S INVENTORY (Cont.)			
SCIENTIFIC NAME	COMMON NAME	STATUS	COMMENTS
M. viridis ssp. saxicola	Rock Monardella	Rare, not endangered	CA endemic; LA & San Bernardino Cos. only
Muilla coronata	Crowned Muilla	Endangered in part of its range	More common elsewhere
Opuntia basilaris var. brachyclada	Short Joint Beavertail	Exremely rare and endangered	CA endemic; LA & San Bernardino Cos. only
Orcuttia californica	California Orcutt Grass	Rare & endangered	Extiprated in LA county
Oreonana vestita	Wooley Mountain Parsley	Rare, not endangered	CA endemic; LA & Santa Barbara Cos. only
Oroganche valida ssp. v.	Rock Creek Broomrape	Rare, not endangered	CA endemic
Oxytheca caryophylloides	Chickweed Oxytheca	Rare, not endangered	CA endemic
Pentachaeta lyonii	Lyon's Pentachaeta	Extremely rare and endangered	CA endemic; LA & Ventura Cos. only
Perideridia gairdneri ssp. g.	Gardner's Yampah	Endangered in partion of its range	Extirpated in LA county
P. pringlei	Pringle's Yampah	Rare, not endangered	CA endemic
Polygala cornuta var. fishiae	Fish's Milkwort	Rare, not endangered	CA endemic
Potentilla multijuga	Ballona Cinquefoil	Extinct	Last seen 1890
Quercus engelmannii	Engelmann Oak	Rare, not endangered	More common elsewhere
Ribes divaricatum var. parishii	Parish's Gooseberry	Rare, not endangered	More common elsewhere

Table 1. (continued)

California Native Plant Society's Inventory of
Rare and Endangered Vascular Plants Found
In Los Angeles County

CALIFORNIA NATIVE PLANT SOCIETY'S INVENTORY (Cont.)			
SCIENTIFIC NAME	COMMON NAME	STATUS	COMMENTS
Rorippa gambellii	Gambel's Watercress	Extremely rare and endangered	Extirpated in LA county
Senecio ionophyllus	Tehachapi Butterweed	Rare, not endangered	CA endemic; LA, Kern & San Bernardino Cos.
Suaeda esteroa	Estuary Suaeda	Rare, not endangered	More common elsewhere
Syntrichopappus lemmonii	Lemmon's Syntrichopappus	Rare, not endangered	CA endemic

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.[22] [23] [24] [25] The flora of the Santa Monica Mountains includes 640 native and 234 introduced species[26] but the number of native species for the lower elevations in the Los Angeles Basin probably is much lower. Shmida (1981) estimated the total number of plant species for the Mediterranean areas of California to be 307.[27] Hundreds of species have been introduced to these areas and very many of these are naturalized. Therefore it seems reasonable to assume some 500 species make up the natural plant communities of the Los Angeles Basin.

The terrestrial vegetation of the Basin can be divided into ten types: coastal sage scrub; chaparral; valley grassland; southern oak woodland; riparian woodland; intermittent streambed; lake, pond and quiet stream aquatic; freshwater marsh; coastal salt marsh; and coastal beach and dunes. Urban and rural areas often have characteristic communities of plants and animals as well. In the mountain areas surrounding the Basin many more communities are to be found, including: mixed evergreen forest; closed-cone pine and cypress forests; Southern California mixed conifer forest; Southern California white fir forest; montane chaparral; Pinyon-Juniper woodland, and — on the highest mountains in the San Gabriel, San Bernardino and San Jacinto Mountains — Southern California subalpine forest. The following discussion is a brief description of the natural communities of the now almost entirely urbanized areas of lower elevations of the Los Angeles Basin.

Table 2

Some Rare and Endangered Vascular Plants of the Los Angeles Basin*

Plants of coastal sage scrub communities	
Centrostegia leptoceras	Slender 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 grassland communities	
Orcuttia californica	California orcuttia
Pentachaeta lyonii	Lyon's pentachaeta

* 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. Table 1 is a related list, compiled by the California Native Plant Society, and listed in alphabetical order by genus.

(Source: Smith, J.P. Jr., and R.K. Berg. 1988. *Inventory of Rare and Endangered Vascular Plants of California*. California Native Plant Society.)

Southern Coastal Sage Scrub: Southern coastal sage scrub is most common near the coast, but widespread on the lower foothills of the interior. Before urbanization, it was the dominant plant community of the Los Angeles Basin. Coastal sage scrub communities consist of a more or less uniform cover of low soft-woody and soft-leaved shrubs, about 0.5 to 2.0 meters (m) tall. Growth occurs in late winter and spring following the winter rains. The plants are usually dormant in summer; many species shed their leaves to avoid the long period of summer drought. Coastal sage scrub usually occurs on drier sites and generally lower elevations than those of chaparral. Human impact on southern coastal scrub has most frequently been destructive and many stands have been cleared for housing or other construction. Many plant species of coastal scrub communities of the Los Angeles Basin are endangered or extinct. (See Tables 1 and 2)[28]

Table 3

Some Dominant Species of the Southern Coastal Scrub

Artemisia californica	Coastal sagebrush
Rhus integrifolia	Lemonade berry
Salvia mellifera	Black sage
Salvia leucophylla	White-leaved sage
Salvia apiana	White sage
Eriogonum fasciculatum	California buckwheat
Encelia californica	Bush-sunflower

Chaparral: The chaparral community is composed of deep-rooted, hard-leaved evergreen shrubs, 2 to 4 m tall, that form a dense woody vegetation. There is little or no understory. This community occurs on dry rocky or sandy soils, often on steep slopes. Active growth begins in spring and continues into early summer. During the dry summer the activity slows but the plants are generally not dormant. This vegetation is highly adapted to fire and regenerates from seeds or by sprouting from root crowns. After a fire there is often a period with high densities of annual and bulbiferous plants, many of which only germinate after a fire. Chaparral vegetation in California is very extensive and highly variable and several plant associations are recognized, depending on the dominant species. Although chaparral communities are not typical of the Los Angeles Basin, they dominate the slopes of the surrounding mountains.[29]

Table 4

Some Dominant Species of Chaparral

Adenostema fasciculatum	Chamise
Adenostema sparsifolium	Ribbon bush
Ceanothus spp.	Ceanothus
Arctostaphylos glauca	Manzanita
Arctostaphylos glandulosa	Manzanita
Cercocarpus betuloides	Mountain-mahogany
Heteromeles arbutifolia	Toyon
Fraxinus dipetala	Flowering ash
Prunus ilicifolia	Holly-leaved cherry
Rhus ovata	Sugar bush
Dendromecon rigida	Bush poppy
Garrya veatchiana	Silk-tassel bush
Leptodactylon californicum.	Prickly-phlox

Valley Grassland: Prior to cultivation by settlors, most of the Los Angeles Basin probably was covered by a mosaic of coastal sage scrub and valley grassland. Since then, most of the grassland has been destroyed or greatly altered by invasion of exotic plant species, grazing pressure by domesticated animals, cultivation, and a decrease in the frequency and intensity of fires. Perennial native bunch grasses have largely been replaced by annual weedy species, primarily from Europe. Grassland communities are generally found on fine-textured, poorly-drained clay soils, moist in winter but very dry in summer. The vegetation is dominated by grasses. Broadleaved annuals may produce spectacular flower displays in the spring of favorable years.[30]

Table 5

Some Dominant Species of Valley Grasslands

Stipa pulchra	Needle grass
Stipa lepida	Needle grass
Avena sp.	Wild oat
Hordeum sp.	Wild barley
Bromus sp.	Brome grass
Calochortus catalinae	Maripos lily
Hemizonia fasciculata	Tarweed
Sisyrinchium bellum	Blue-eyed grass
Dichelostemma pulchellum	Wild hyacinth
Orthocarpus purpurascens	Owl's clover
Lupinus sp.	Lupine
Eschscholzia californica	California poppy

Southern Oak Woodland: The southern oak woodland is dominated by spreading broadleaved trees, 5 to 35 m tall, which are evergreen or deciduous. There may be a continuous tree cover, or the trees may occur as scattered individuals, forming a savanna. The understory is usually dominated by valley grassland species. In the Los Angeles Basin, oak woodland is restricted to mostly north-facing slopes, or may be integrating into riparian woodland. One of the oak species of the area, Engelmann's oak (*Quercus engelmannii*), is listed as an endangered species. It only occurs in the interior parts of the Basin. Engelmann oak woodland is one of the most endangered natural communities of California. In Los Angeles, one of the last stands of Engelmann oak in the area is located in the Los Angeles State and County Arboretum in Arcadia.[31]

Table 6

Some Dominant Species of Southern Oak Woodlands

Quercus agrifolia	Coast live oak
Quercus engelmannii	Engelmann
Quercus lobata	Valley oak
Juglans californica	California walnut

Riparian Woodland: The riparian woodland occurs on riverbanks, creekbanks, floodplains and in the vicinity of springs. It also occurs along the margins of some man-made lakes and reservoirs. In the Los Angeles Basin, most trees are restricted to these riparian habitats and almost all of the 17 tree species listed as native for the area are found in this community. This woodland is dominated by large- to medium-sized broadleaf- deciduous trees with an understory of shrubs and vines.

Table 7

Native Trees of the Los Angeles Basin

(mostly in riparian forests)

Acer macrophyllum	Bigleaf maple
Acer negundo ssp. *californicum*	California boxelder
Alnus rhombifolia	White alder
Fraxinus velutina	Velvet ash
Heteromeles arbutifolia	Toyon
Juglans californica	California walnut
Platanus racemosa	California sycamore
Populus fremontii	Fremont cottonwood
Populus trichocarpa	Black cottonwood
Quercus agrifolia	Coast live oak
Quercus chrysolepis	Canyon live oak
Quercus engelmannii	Engelmann oak
Quercus lobata	Valley oak
Salix laevigata	Black willow
Salix lasiandra var. *lasiandra*	Golden willow
Salix lasiolepis	Arroyo willow
Umbellularia californica	California-bay

Table 8

Other Native Trees of the Los Angeles Area*

Abies concolor	California white fir
Arbutus menziesii	Madrone
Calocedrus decurrens	Incense-cedar
Cornus nutalii	Pacific dogwood
Cupressus forbesii	Tecate cypress
Juniperus occidentalis	Western juniper
Pinus attenuata	Knobcone pine
Pinus murryana	Lodgepole pine
Pinus coulteri	Coulter pine
Pinus jeffreyi	Jeffrey pine
Pinus lambertiana	Sugar pine
Pinus monophylla	Singleleaf pinyon pine
Pinus ponderosa	Ponderosa pine
Pseudotsuga macrocarpa	Bigcone Douglas-fir
Quercus kellogii	California black oak
Salix melanopsis	Black willow
Salix scouleriana	Nuttal willow

* The Santa Monica Mtns., the San Gabriel Mtns., the San Bernardino Mtns. and the Cleveland National Forest.

(Sources: Griffin, J.R., W.B. Critchfield. 1972. *The Distribution of Forest Trees in California.* USDA Forest Service Research Paper PSW-82/1972; Munz, P.A. 1974. *A Flora of Southern California.* Berkeley: University of California Press; Raven, P.H., H.J. Thompson, B.A. Prigge. 1986. *Flora of the Santa Monica Mountains, California.* Southern California Botanists Special Publication No. 2.)

Intermittent Streambed: The intermittent streambed community is composed of non-persistent herbaceous plants within the banks of an intermittent stream or channel. It is generally well developed on sandy or muddy substrates.[32]

Table 9

Some Characteristic Species of Intermittent Streambeds

Leptochloa uninervia	Mexican sprangletop
Carex spp.	Sedge
Cyperus eragrostis	Umbrella sedge
Artemisia douglasii	Sagebrush
Rumex spp.	Dock
Polygonum spp.	Knotweed
Veronica anagallis-aquatica	Brooklime
Festuca arundinacea	Fescue

Lake, Pond, and Quiet Stream Aquatic: This is an aquatic community that occurs in permanent bodies of nonpolluted, clear freshwater, where the current is not too strong.[33]

Table 10

Some Characteristic Species of Lakes, Ponds, and Quiet Streams

Elatine californica	Waterwort
Ludwigia peploides	Ludwigia
Azolla filiculoides	Azolla
Lemna spp.	Duckweed
Nuphar luteum	Water lily

Freshwater Marsh: The freshwater marsh occupies river estuaries near the coast and river floodplains in the interior. Both freshwater and salt marshes could once be found in extensive areas in the estuaries of the Los Angeles Basin. This community is typically dominated by a dense growth of reeds and sedges, 1 to 3 m tall. The soil is more or less permanently flooded or wet.

Table 11

Some Characteristic Species of Freshwater Marsh

Carex sp.	Sedge
Eleocharis sp.	Pike-rush
Juncus sp.	Rush
Scirpus sp.	Bulrush
Typha sp.	Cattail

Coastal Salt Marsh: Extensive coastal salt marshes occupied the mouths of the San Gabriel, Los Angeles and Santa Ana rivers. Today there are only small remains to be found because they have been drained or filled for urban development or transformed into marinas. Salt marshes are important as nesting and feeding sites for birds. Ecologically, they are unique in that they are exposed to continuously changing amounts of submergence and salinity. The communities are generally dominated by a dense growth of low-growing perennial shrubs and grasses. Most species are more or less succulent. The vegetation generally shows a strong zonation within the marsh, depending on the frequency and duration of inundation and exposure.[34]

Table 12

Some Dominant Species of Coastal Salt Marsh

Salicornia virginica	Pickleweed
Salicornia bigelovii	Pickleweed
Frankenia grandiflora	Frankenia
Monanthochloe littoralis	Monantochloe
Distichlis spicata	Salt grass
Jaumea carnosa	Fleshy jaumea
Batis maritima	Batis
Limonium californicum	Sea-lavender
Spartina foliolosa	Cordgrass

Coastal Beach and Dune: This community is restricted to the sandy beaches and dunes along the coast. The appearance of these communities vary from a patchy cover of mostly prostrate plants on exposed beaches to 2 m tall shrubs on more protected, stabilized dunes, forming a very open to nearly complete cover. With the exception of the river estuaries, nearly all of the Los Angeles Basin's coast was dominated by coastal beach and dune vegetation. Most of the area that once supported coastal strand vegetation is now lost to development or recreational use.[35]

Table 13

Some Dominant Species of Coastal Beach and Dunes

Cakile maritima	Sea rocket
Abronia spp.	Sand-verbana
Ambrosia chamissonis	Ragweed
Camissonia cheiranthifolia	Beach evening primrose
Atriplex spp.	Saltbush

Coastal Urban and Rural Communities: Urban communities are to be found in parks, cemeteries and vacant lots and are often highly diverse. Cultivated croplands, pastures, fruit and nut orchards, alfalfa fields, garden produce fields and vineyards, mostly on valley floors where irrigation is available, are also home for many plant and animal species. Many of the plants in these areas are non-natives. A variety of introduced trees, shrubs, crops and garden flowers as well as native and introduced weeds are characteristic for these areas.[36]

VI. USES AND RESPONSES OF VEGETATION IN URBAN ENVIRONMENTS

Cities are ecological islands. Plants and animals are isolated within them and outside them. Because cities create their own environment, they favor certain kinds of animals and plants. Some kinds of plants and animals that cannot survive in cities are confronted with cities as a barrier to movement and migration. Animals and plants that thrive in an urban environment, but cannot survive in the nearby rural countryside, can be isolated within the city, unable to migrate to another habitat.

Naturalistic habitats in city parks and preserves will become more important for biological conservation as true wilderness and other rural natural areas decrease in number, area and habitat diversity. Trees in a city have become an important part of urban environments. The urban environment, however, creates many stresses on trees, and special attention must be paid to the condition of urban soils and the supply of water for trees, as well as to the physical stress to which trees are subjected.

Urban Stress on Vegetation

Vegetation in cities is under special kinds of stress. Trees along city streets are often surrounded by cement, which prevents normal access to water and air. The root systems are more likely to experience extremes of dryness and soil saturation (immediately following or during a rain storm). Because city soils tend to be compacted and do not drain well, trees planted in a city sidewalk tend to be overwatered and the roots die of lack of oxygen. A solution, as suggested by the landscape architect Anne Spirn, is to connect the plantings of a series of trees so that a larger volume of soil is available to each of them and water can drain between them.[37] Other solutions involve careful use of soil, artificial structures, and special containers.[38]

Many species of trees and plants are very sensitive to air pollution. For example, Eastern white pine of North America is extremely sensitive to ozone pollution and does not do well in cities with heavy motor vehicle traffic or along highways. Dust can interfere with the exchange of oxygen and carbon dioxide, necessary for photosynthesis and respiration of the trees. City trees also suffer direct damage from physical impact from bicycles, cars and trucks, and from vandalism. Trees subject to such stress are more susceptible to attacks by fungus diseases and insects. The lifetime of trees in a city is generally shorter than in their natural woodland habitats, unless they are given considerable care.

Species and Diversity

Some species of trees are more useful and successful in cities than others. An ideal urban tree would be resistant to all forms of urban stress; have a beautiful form and foliage; and produce no messy fruit, flowers, or leaf litter that requires cleaning. In most cities, only a few species of trees are used for street planting. Sometimes a single species will be used, as American elms once were, to provide a pleasing uniform series of arches over the pavement. However, the reliance on one or a few species results in an ecologically fragile urban planting, as was learned when the Dutch Elm disease spread throughout the eastern United States, destroying urban elms. It is prudent to use a greater diversity of trees to avoid outbreaks of insect pests of the trees and tree diseases.[39]

Wild plants that do particularly well in cities are those characteristic of disturbed areas and of early stages in ecological succession. City roadsides in Europe and North America have wild mustards, asters, and other early successional plants. Disturbances in cities promote the occurrence of certain kinds of plants. Curiously, during World War II, many species of wildflowers not recorded previously were found near bombed (and therefore cleared) areas in London: 342 species of plants were recorded where fewer than 100 had been recorded before. Bracken fern, rare in an English city, became common during that war and persisted afterward in London.[40]

Stresses of trees and other vegetation in cities of semi-arid environments may be especially severe during periods of drought. For example, during the recent drought in Santa Barbara, Calif., water conservation practices led to much less water available to many trees. Landscape surveys in 1990 indicated that almost 250,000 trees died during the drought, representing approximately 5 percent of the total stock of trees on private lands in the county. Approximately one-half million additional trees were in poor health or degraded condition by late 1990.[41] [42]

Some of the species listed in Table 1 are found only in wetland and riparian habitats. Decreases in the water table and available surface water flow could pose additional threats to these species. If global warming were to occur as projected by computer models of climate, increases in temperature and water evaporation would place additional threats to the habitats of these plants. Sea level rises associated with global warming could destroy some existing coastal wetlands and increase the need to restore or create additional wetlands in order to conserve these species. Such restoration would require sufficient surface water flows and high water tables.

If these effects were spread throughout Southern California, they could cause long-term damage to urban environments over wide areas.

VII. WILDLIFE IN CITIES & CITIES AS WILDLIFE HABITAT

Peregrine falcons once hunted pigeons above the streets of Manhattan. Unknown to most New Yorkers, the falcons nested on the ledges of skyscrapers and dived on their prey in an impressive display of predation. The falcons disappeared when DDT and other organic pollutants caused a thinning of their eggshells and a failure in reproduction, but they have been reintroduced into the city recently. In New York City's Central Park, approximately 260 species of birds have been observed — 100 in a single day. Foxes live in London, feeding on garbage and road kills (animals run over by motor vehicles); shy and nocturnal, they are seen by few Londoners.[43]

Except for some birds and small, docile mammals such as squirrels, most forms of wildlife in cities are considered pests. However, as the example of the Peregrine Falcon indicates, this is not really the case. There is considerable wildlife in cities, much of it unnoticed by all but a few residents. Cities are a habitat, even if artificial. They provide all the needs — physical structures and necessary material resources (food, minerals, water) — for many plants and animals. (See Figure 4. An urban ecological food chain.)

Biological Conservation

There is a growing recognition that urban areas provide habitat for wildlife that people can enjoy and that this can be an important method for biological conservation.[44] Many areas in cities could be modified to provide more habitat for wildlife. In the Los Angeles Basin, such areas would include Santa Monica Mountains, Griffith Park, urban streams and flood channels such as the Santa Ana River and the San Gabriel River, portions of the Los Angeles River and coastal wetlands. (See Table 15.) Furthermore, smaller public parks and vegetation around private residences hold significant value to some wildlife, such as migrating birds. The United States Department of Agriculture (USDA) Forest Service has prepared *A Guide to Urban Wildlife Management* which describes how private property and public lands in cities can be managed to promote wildlife.[45] This guide points out that most people believe that an urbanized area loses its capacity to support wildlife. This need not be the case.

Proper management, especially in the use of vegetation, can promote wildlife in cities to the benefit of the residents, while simultaneously allowing control of those wildlife that are pests. Columbia, Md., is a city designed to include parks, vegetation and habitat for wildlife. A survey of the residents shows that 94 percent agreed that, when possible, stormwater control basins should promote habitats for fish and wildlife as well as provide for flood and sediment control; 73 percent said that they would pay more for a house in a neighborhood having water basins designed for fish and wildlife habitat.[46]

Areas in a city with a diversity of plant species and plants of many sizes and shapes tend to enhance wildlife habitats. Where it is desirable to promote wildlife habitats, the traditional neat park of wide lawns with evenly-spaced trees and all underbrush removed, is not the most desirable form. A denser vegetation of many sizes and shapes, including more trees and shrubs, will more likely attract wildlife. (See Figure 5. Vegetation diversity promotes wildlife diversity.)

We can divide city wildlife into the following categories: (1) those species that cannot persist in an urban environment and disappear; (2) those that tolerate an urban environment, but do better elsewhere; (3) those that have adapted to urban environments, are abundant there, and are either neutral or beneficial to human beings; and (4) those that are so successful that they are pests.

For some species, the city's artificial structures are sufficiently like their original habitat to be a home. For example, chimney swifts originally lived in hollow trees but are now common in factory chimneys and other vertical shafts of some cities. Their nests are glued to the walls with saliva. A city can easily have more chimneys per square kilometer than a forest has hollow trees. As another example, peregrine falcons can nest on ledges of a bridge in a city. Vegetation can be planted around residential buildings in ways that promote wildlife. (See Figure 6(A). How vegetation can be planted to promote wildlife.)

Parks and Preserves

Cities include natural habitats in parks and preserves. Modern parks provide some of the world's best wildlife habitats and the importance of parks will increase as the truly wild areas are encroached upon. Jamaica Bay, a park in New York City, was recovered from natural marshes and wetlands. Until the 1960s, the area had been polluted by sewage and had become a wasteland, supporting only a few species.

After restoration, it now includes 7,000 ha (15,000 acres) with a diverse population of birds. During the spring and fall migration, many bird watchers from New York visit the bay to see avocets, dowitchers, sandpipers, and godwits, among others.[47] Jamaica Bay is unusual in that it was planned as a naturalistic park, emphasizing native vegetation and habitats, and has succeeded in attracting native species of animals.

Cities that are major harbors often have many species of marine wildlife at their doorsteps. New York City's waters include sharks, bluefish, mackerel, tuna, shad, striped bass, and nearly 250 other species of fish.[48] Small ponds contain freshwater fish and frogs.

Urban streams, rivers and flood channels provide wildlife habitat. Examples are the Santa Ana, San Gabriel and portions of the Los Angeles rivers. Also, different parts of a wetlands can provide habitat for different species. For example, in the coastal wetlands of Southern California, least terns feed in the near-shore water and nest in the upper lands of the wetlands, while the clapper rail makes use of wetter habitats near the ocean. (See Figure 6(C). Diagram of the habitat requirements of three endangered species.)

Ballona Freshwater Wetlands

The plan to restore the Ballona freshwater wetlands is as an example of this type of land use in the Los Angeles area. The Ballona wetlands are found along the coast near the location of 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 habitat for 50 species of birds; that the habitats within it would be suitable to 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 would provide 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 western pond turtle.[49] 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.

VIII. URBAN CONSERVATION CORRIDORS

An urban conservation corridor, also called a greenway, is a continuous strip or area of naturalistic vegetation and ecosystems that connect rural and open land on one side of a city with rural or open land on another. Through these corridors wildlife can move and migrate and the seeds of plants can be transported. People can use these corridors for recreation. Corridors will be increasingly important to biological conservation in the future, as well as to urban recreation.

Throughout the United States, including San Francisco and Sacramento, many people are in the process of implementing urban corridors for biological conservation. 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.

One example of a major greenway is the Chesapeake and Ohio Barge Canal passing through Washington, D.C. The canal and the paths along it have become a major greenway, near to heavily-used roadways of the nation's capital.[50] Other greenways are being formed 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. (See Figure 7(A). Greenways of the U.S.) Other greenways of cities of the American West include: the Yakima Greenway in 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, Co. greenway. (See Figure 7(B). Two greenway loops being built around San Francisco Bay.)

Environmental groups currently are promoting the idea of a greenway for Los Angeles that would begin at the mouth of the Los Angeles River, continue upstream along the Los Angeles River, and connect to the Santa Monica Mountains, assuming of course, that the river and its riparian zones were restored and provided with adequate water. This greenway would provide a corridor from the ocean to the coastal mountains and could have benefits for recreation and conservation of representative native vegetation and wildlife, including rare and endangered species, as described in the next section.

Other greenways could be developed in Los Angeles County that could help overcome the common criticism of the Los Angeles Basin as lacking sufficient landscape design. Greenways could provide structure to the landscape, helping to distinguish one urban center from another.

Rare and Endangered Species

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.

Some animals listed as endangered by the state of California occur or did occur in the vicinity of Los Angeles. (See Table 14.) For example, the Least Bell's Vireo (*Vireo bellii pusillus*) is a summer resident in riparian habitats of Southern California, including areas of willow, cottonwood, oak (primarily *Quercus agrifolia*), and dry washes with willows. This species once ranged from interior Northern California near Red Bluff to the Sacramento and San Joaquin valleys to the Sierra Nevada foothills and the coast ranges into Baja California. By the late 1980s, its breeding range had been restricted to the Amargosa River in Inyo County and small 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.[51] Protection and restoration of riparian habitats in Southern California, as might occur through the development of greenways, could help save this species.

There are 88 taxa of vegetation occurring in Los Angeles County that are listed as rare or endangered by the California Native Plant Society. (See Tables 1 and 2.) As explained elsewhere in this report, urban environments are stressful to vegetation. Conditions and actions, including those that provide adequate water supplies, that protect and improve the habitats and environments suitable to any of these species within the urban areas of Los Angeles County could assist in the conservation of these taxa.

Table 14

Some Endangered Animals Originally Found In the Vicinity of Los Angeles

Common Name
Least Bell's Vireo
California Least Tern (most of the colonies were gone from L.A. and Orange County beaches in 1940)
Light Footed Clapper Rail
Belding's Savannah Sparrow
Unarmored Threespine Stickleback
Palos Verdes Blue Butterfly
El Segundo Blue Butterfly

(Source: Steinhart, Peter. *California's Wild Heritage - Threatened and Endangered Animals in the Golden State.* 1990)

Table 15

Some Natural Areas In the Vicinity of Los Angeles

Location	Administrative Unit Name	Wilderness Acres
Cucamonga	Angeles National Forest San Bernardino National Forest	4,200
San Gabriel	Angeles National Forest	36,118
San Gorgonio	San Bernardino National Forest	56,722
San Jacinto	San Bernardino National Forest	32,248
Santa Rose	San Bernardino National Forest	13,787
Sheet	Mountain Angeles National Forest	39,482
	San Bernardino National Forest	2,401

(Source: Hendee, John C., Stanking, George H., Lucas, Robert C.. *Wilderness Management.* 1990.)

IX. PARKS & URBAN VEGETATION: BENEFITS TO PEOPLE

Vegetation greatly enhances the quality of the environment for city residents. This enhancement occurs in many ways: plantings around homes, trees lining streets; and parks and other plantings forming part of the foreground or the distant view of the scenery. A study of two kinds of parks in Sacramento — one the traditional park, primarily of lawns and widely spaced trees and the second of community gardens, where residents could plant vegetables and were 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 simply as temporary measures. However, residents placed considerable value on these gardens, which provided activities and 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.[52] Where 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 can be important to the future of our cities. Vegetation and ecosystems in a city should not be seen as simply passive decoration, but as opportunities for active involvement by residents, and as a part of the life of a vibrant city.

Frederick Law Olmsted: The Design of Urban Parks to Meet Psychological and Social Needs

Frederick Law Olmsted was an innovator not only in landscape design but also in perceiving the social benefits of parks and urban plantings to the public psyche.

It was Olmsted's belief that every large city should have a public park devoted to landscape scenery, and that the most important element of that scenery was broad expanses of "greensward" — gently rolling lawn and meadow dotted with wide-spreading deciduous trees.

His purpose in this was not primarily aesthetic, since he had no interest in beauty simply for beauty's sake. 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 possible 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 the skills of both engineering and landscape design 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 work day. 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, 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, a bit of the "Catskills and Adirondacks" for persons unable to frequent those popular vacation spots, and the central social and gathering place of the city.

The large landscape park was only one element in Olmsted's program for using public open space to create a sense of community and meet the needs of city-dwellers. The large park served a particular psychological and social function that other public spaces in a city could not, and it 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. But Olmsted also sought to provide a number of spaces that would serve all-city functions. To those places people would be drawn from throughout the city for a shared experience or activity. With these elements of park, parkway and park system, Olmsted proposed to provide both community and amenity through landscape design.

Since the time of Olmsted's work, a number of researchers have found that vegetation in urban areas can 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.[53]

Energy Use & Air Conditioning Requirements

Today there is growing use of trees to ameliorate the climate near houses. (See section on heat island effect on page 11.) In colder climates, rows of conifers planted to the north of a house can protect it from winter winds, while deciduous trees to the south can provide shade in the summer, reducing requirements for air conditioning while permitting sunlight to warm the house in the winter. (See Figure 8. Diagram of trees around a house.)[54] [55] Computer-based simulations done by scientists at Lawrence Berkeley Laboratory of the University of California at Berkeley project that houses with trees located properly around them could use 24 percent less energy in Sacramento and 12 percent less in Phoenix. Direct effects of shading by trees accounted for 10 to 35 percent of the savings, the results of evaporation of water by the trees. (See Figures 9(A). & 9(B). Temperature reductions in Sacramento and Phoenix.)[56] The use of shade trees can significantly improve the efficiency of energy use and reduce renergy costs. (See Figures 9(C), 9(D), 9(E).)

Calculations for Los Angeles assumed a comparatively small air conditioning requirement, characteristic of houses in locations where the microclimate is modulated by the ocean; houses located East of the Los Angeles Basin would have responses similar to those of Sacramento and Phoenix.[57]

Benefits of urban vegetation become all the more important in the context of the potential of global warming. Some have suggested that urban plantings could provide a sink for carbon dioxide, thereby reducing the rate of global warming. More important is the potential, just discussed, that plantings can reduce energy use, thereby reducing the burning of fossil fuel. An additional benefit of urban vegetation under rapid climate change is that this vegetation could provide havens and corridors for endangered species threatened by rapid warming, providing an additional aid to biological conservation. (See Figure 10. How urban trees can help us deal with the effects of global warming.) Should global warming occur, along with continued human population increase and increases in the area encompassed by cities, these benefits will become more important.

X. LANDSCAPE DESIGN FOR SEMI-ARID REGIONS

Having discussed the uses of vegetation in cities, the question arises: what kind of vegetation makes sense for cities of semi-arid climates? Here, we need to discuss vegetation in all of its uses, including the possible roles of vegetation in making cities more livable, with special considerations for cities in semi-arid environments. To answer this question, we return to the ideas of Frederick Law Olmsted.

Olmsted believed that the broad expanses of greensward essential to his designs for Eastern and Midwestern parks were inappropriate for the semi-arid West. In a plan for public grounds in San Francisco, Olmsted proposed to use a considerable number of native plants. However, he did not intend that they should go through the full cycle of summer drought. The promenade was to be for public pleasure and enjoyment; that meant retaining an effect of freshness and green in the plantings throughout the year. To secure this, he proposed to irrigate the plantings, as needed, by means of a line of water hydrants set along the upper edge of the artificial valley. Thus, as he observed, "Much less water would be required to keep the plants on the slopes in flourishing condition than would be needed if they were on the open ground, and the water would be distributed with much greater rapidity and economy."[58]

Nor did Olmsted feel it necessary to restrict himself to native plant materials. Here, as elsewhere in his practice, he wished to have available the full complement of plants that could thrive in the particular micro-climate for which he was designing. He wanted the richest possible palette available to him. In other climates his chief purpose in this regard was to secure the greatest possible subtle range, variety and richness of tone, color and texture with which to secure a coherent, unified landscape effect. This was to some extent Olmsted's purpose in planting the slopes of the San Francisco promenade as well. However, in California, where he was unwilling to undertake landscapes that were hundreds of acres in extent, he was more willing to plant for decorative or instructional effect. Accordingly, he suggested that each section of the promenade between the bridges be given a distinctive treatment. For instance, he suggested that:

> at some points, the border may be decorated with vases elevated on pedestals, baskets of flowers, yuccas, aloes, orange trees, or other exotic plants in tubs . . . . Another section of the mall should be planted with fastigiate [pointed or columnar in shape] trees and shrubs, another with cactuses, another with standard roses, another with a particular class of flowering shrubs, another with creeping plants pegged down, another with a vegetable embroidery upon fine turf, another with beds of tulips, of violets, or of callas, etc.[59]

He proposed that some sections of the slopes have the character of an arboretum, illustrating the shrubs of California in one place, and of Australia, China, or Japan in others.

At the end of the promenade there was to be a large open area for a parade ground, with space adjacent for a playground. Beyond the parade ground, nestled between the hills now topped by Alamo Square and Buena Vista Park, Olmsted envisioned a small bit of eastern park-like scenery, with a shaded ramble on the hillsides and "ornamental water" and "lawn" on the lower level section. This narrow passage of pastoral scenery, some three blocks long, was to be San Francisco's "greensward," a communal treasure of emerald green, too precious to be reserved for the enjoyment of a single individual.[60]

Lawns as Public Benefits: The idea of irrigated lawn as a communal possession is to be found repeated in the proposal for the campus of the College of California and the adjacent residential neighborhood that Olmsted planned at the same time. 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."[61]

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."[62]

In regard to 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 unclear 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 semi-arid 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 in which dryness and dustiness were not evident, even in 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.[63]

Principles of Semi-Arid Design: Based on his and his son's analysis of landscape planning in semi-arid climates, Olmsted proposed four principles of semi-arid design: first: to leave little bare ground exposed to view; instead plant vegetation wherever possible; second: to arrange heavily-visited places so vegetation in and near them can be easily watered, assuring 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 semi-arid environments; and fourth: to plant as much vegetation on or around buildings so as to connect them visually to the surrounding countryside.

The work of Frederick Law Olmsted and his son suggest how vegetation be used to improve cities of the American West. Their plans suggest that vegetation can be planted that meets 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: a city in an arid environment without vegetation and a city in a semi-arid environment made to look like a city of England. The semi-arid 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 Experience of Tucson, Arizona

It is a truism that the use of vegetation must take into account the local environment. In this regard, the experience of Tucson, Ariz., is instructive. Tucson's polices regarding vegetation went through three stages. In the first, there was essentially an open-use policy wherein vegetation was planted that required considerable water. Water meters showed a high use in the summer. City planners found that landscaping accounted for more than one-half of total city water use. As a result of severe water shortages, new policies and ordinances were established to encourage replacement of grass, trees and shrubs with rocks, sand and other non-living decorations. But the rock and sand surfaces heated up, stored little water, and led to water loss through evaporation. The benefits of trees in cooling houses and reducing air conditioning were lost.

Landscape architects McPherson and Gallagher suggested an alternative: take an ecological approach to landscapes, selecting vegetation to match the climate, soils, and moisture conditions; slow the transportation of storm water drainage so that rain water could be used to irrigate vegetation; and use drip irrigation, mulch and gray water.[64] (See Figure 11. *Annual costs and benefits of tree planting programs.*)

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; helping to create private, domestic space; helping to improve 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 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.

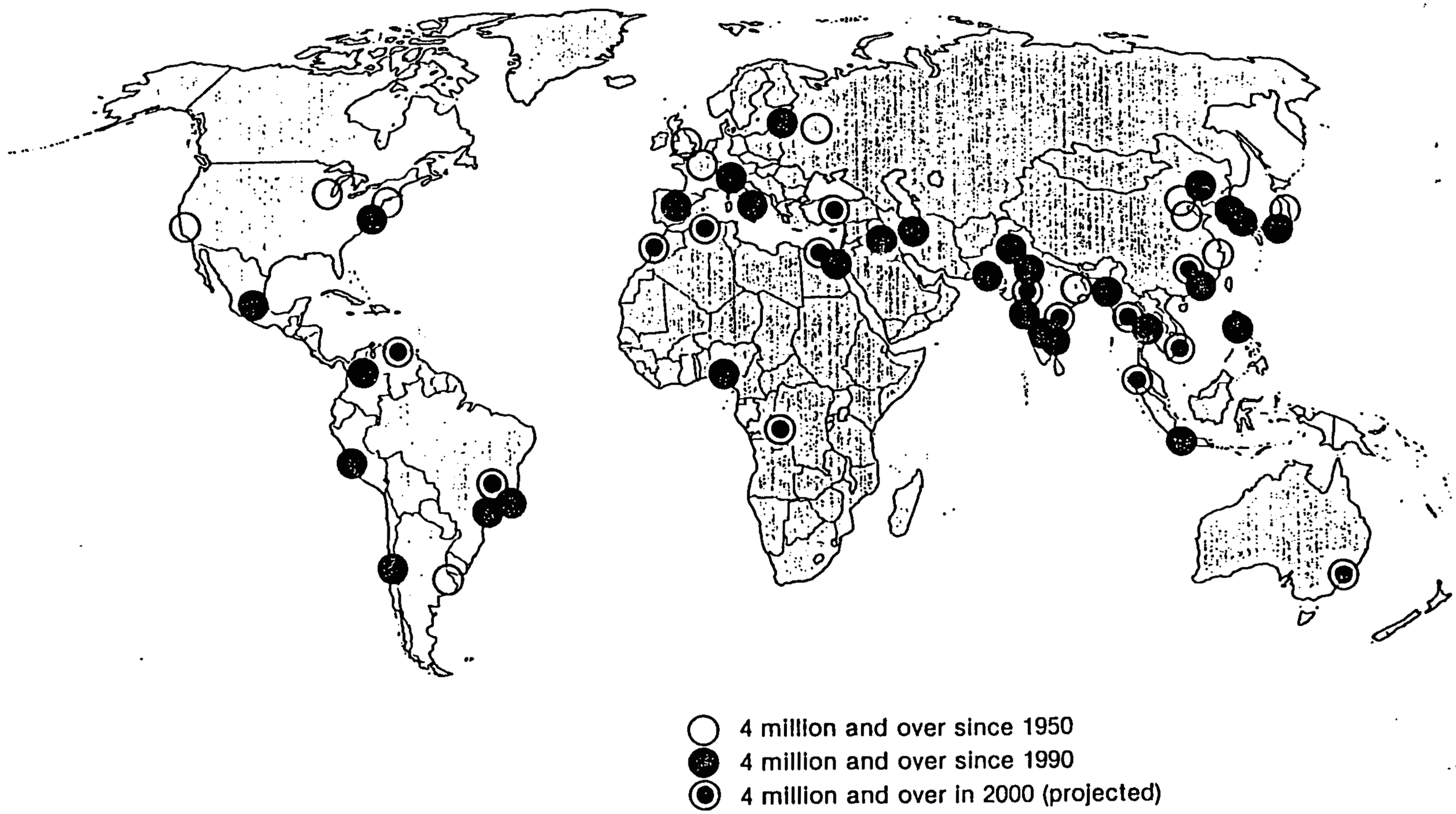
These uses require a variety of vegetation with a variety of water requirements. Vegetation limited to xerophytes (plants of deserts, semi-deserts, or other dry habitats) can meet some, but not all of these uses. A greater variety of vegetation as discussed in this report, with the type of vegetation varying within the city depending on environmental conditions and needs, ecological history and ecological potential, as well as social and economic considerations, could meet many of these uses, while at the same time achieving the combined goals of conserving water and energy resources.

CONCLUSION

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 that we improve the conditions of urban residents, especially the urban poor, people must understand that vegetation is an integral part of the city environment.

Largest Urban Areas in the World in 1950, 1990 and 2000



Source: United Nations.

Population Reference Bureau, Inc.

Figure 1. Largest urban areas in the world.
(Source; Kent, M. M. 1990, *World Population: Fundamentals of Growth*. Population Reference Bureau, Inc., Washington, D. C.)

The city as a system: energy and materials flow. A city must function as part of a city-countryside ecosystem, with an input of energy and materials, internal cycling, and an output of waste heat energy and material wastes. As with any natural ecosystem, recycling of materials can reduce the need for input and the net output of wastes.

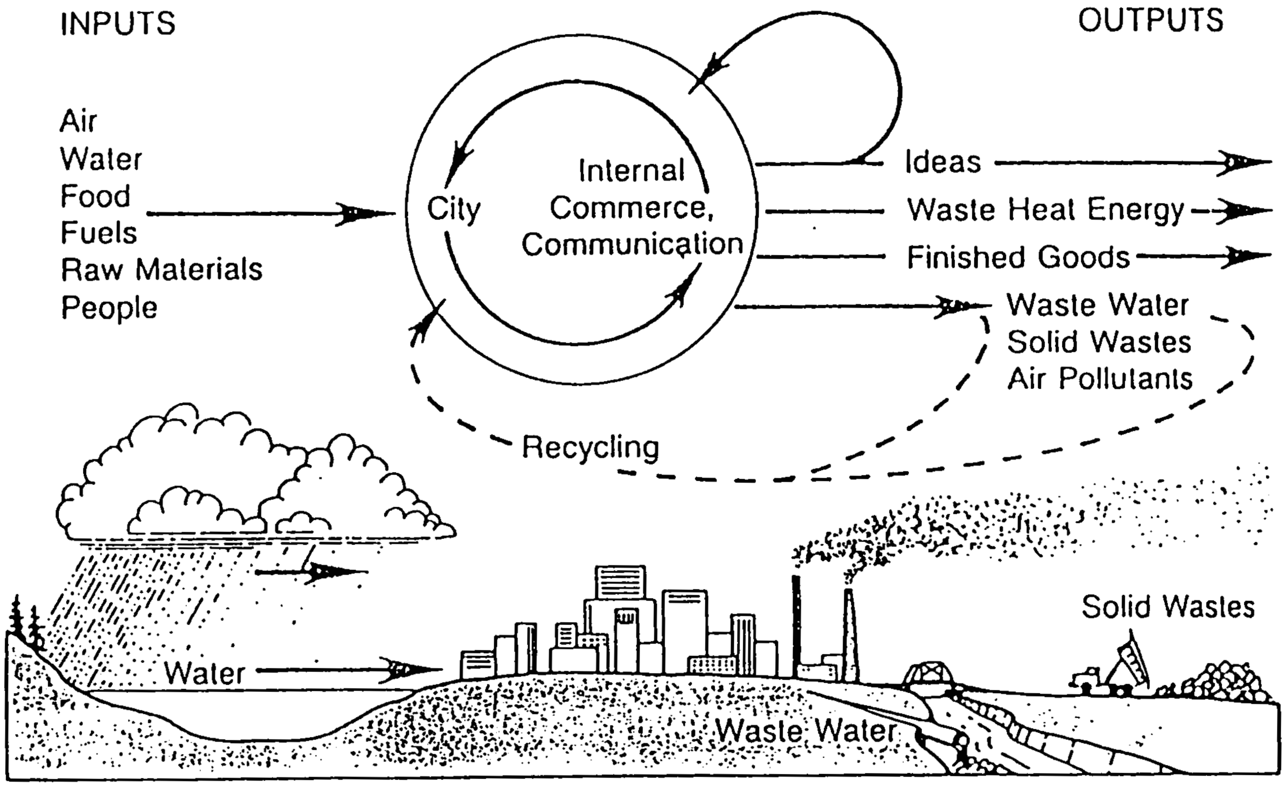
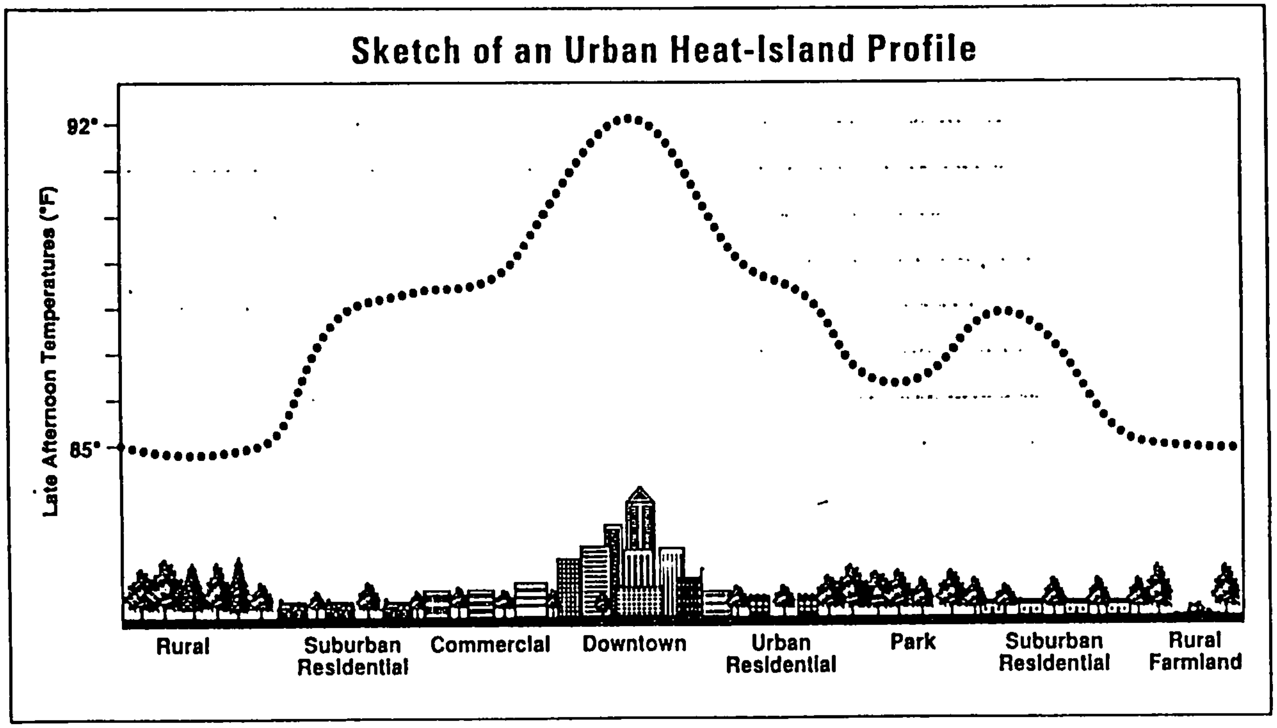


Figure 2. The city as a system.

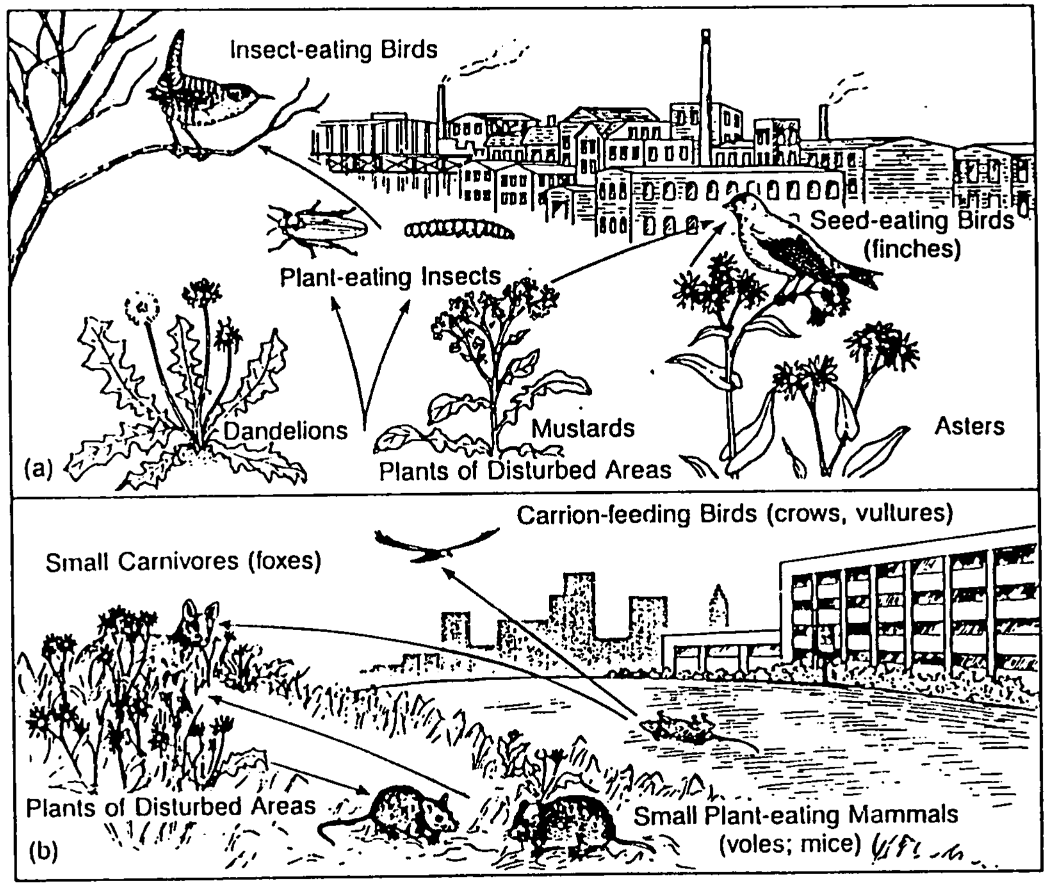
(Source: Botkin, D. B. and E. A. Keller. 1987. *Environmental Studies.* Merrill, Columbus and John Wiley Pub., in press.)



Sketch of a typical urban heat-island profile: This graph of the heat island profile in a hypothetical metropolitan area shows temperature changes (given in degrees Fahrenheit) correlated to the density of development and trees.

Figure 3. Urban heat island effect.

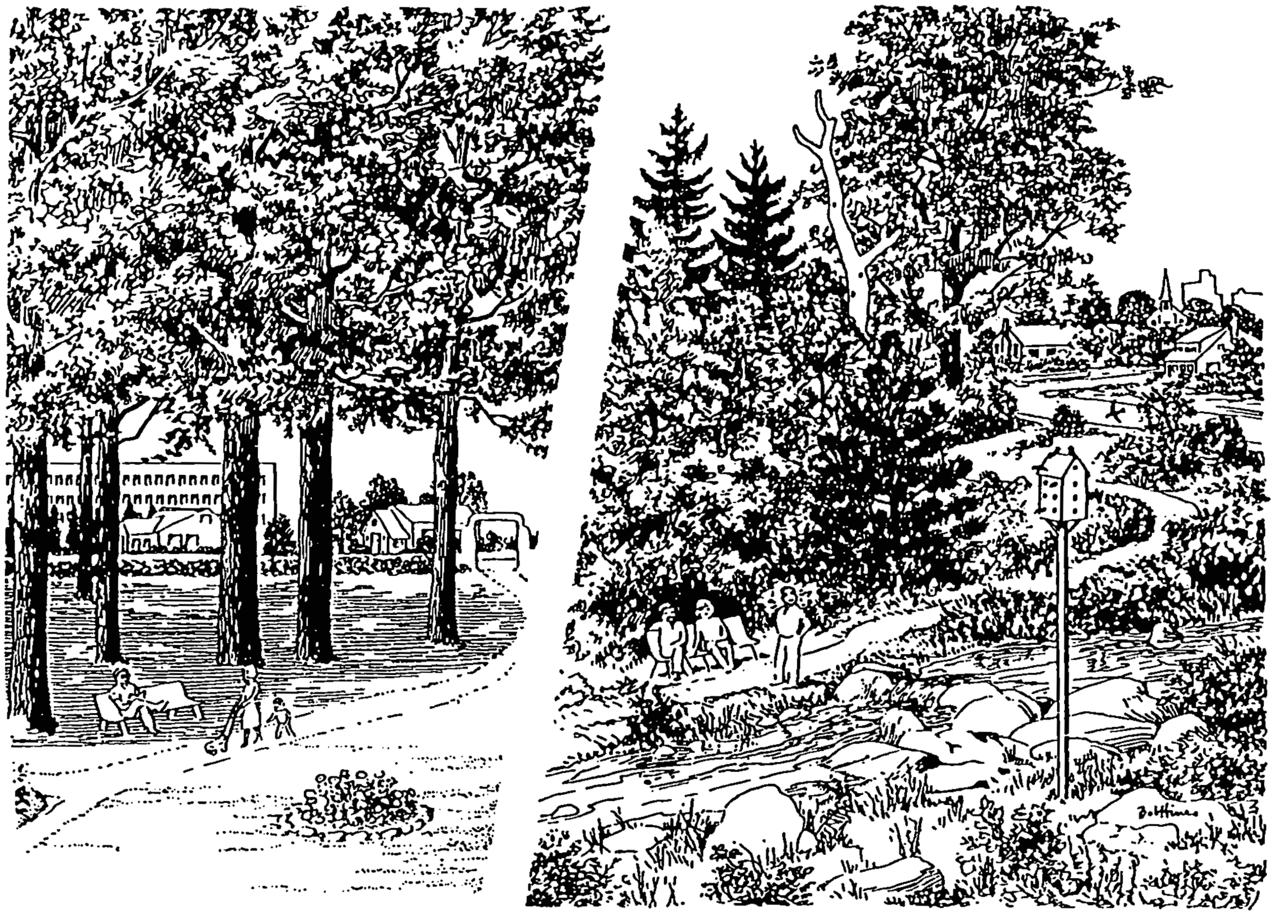
(Source: Akbari, H. et al. 1992. *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing.* U. S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)



(a) An urban food chain based on plants of disturbed places and insect herbivores. (b) An urban food chain based on road kills.

Figure 4. An urban ecological food chain.

(Source: Botkin, D. B. and E. A. Keller. 1987. *Environmental Studies.* Merrill, Columbus and John Wiley Pub., in press.)



A park or wooded open space area consisting of mature deciduous trees with a ground cover of closely cropped grass has far less value for wildlife than an area with mixed deciduous and evergreen species of different ages and multiple layers of vegetation. Dead trees, snags, or limbs provide desirable diversity.

Figure 5. Vegetation diversity promotes wildlife diversity in city park land.
(Source: Leedy, D.L. and L.W. Adams. 1984. *A Guide to Urban Wildlife Management.* National Institute for Urban Wildlife. Columbia, Md.)

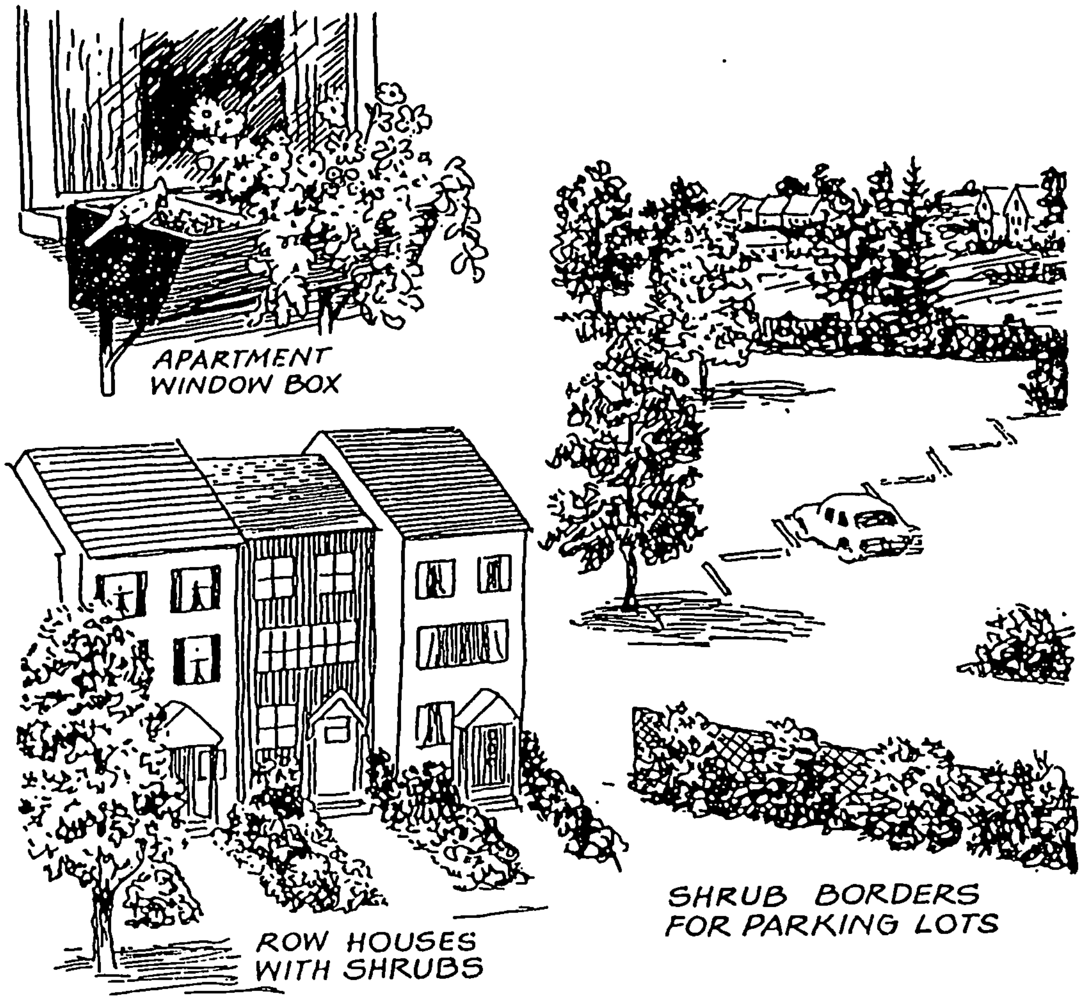


Figure 6(A). How vegetation can be planted around residences to promote wildlife.
(Source: Leedy, D.L. and L.W. Adams. 1984. *A Guide to Urban Wildlife Management.* National Institute for Urban Wildlife. Columbia, Md.)

Concrete-lined ditches result in rapid runoff from the community on the right and have little value to fish and wildlife. In developing the community on the left, the natural stream and marsh were preserved. Water is retained between rains and excellent habitat is provided.

Figure 6(B). Two kinds of urban wetlands

Naturalistic with wetlands vegetation and slow moving water courses (left) and channelized and straightened with substrate (right).

(Source: Leedy, D.L. and L.W. Adams. 1984. *A Guide to Urban Wildlife Management.* National Institute for Urban Wildlife. Columbia, Md.)

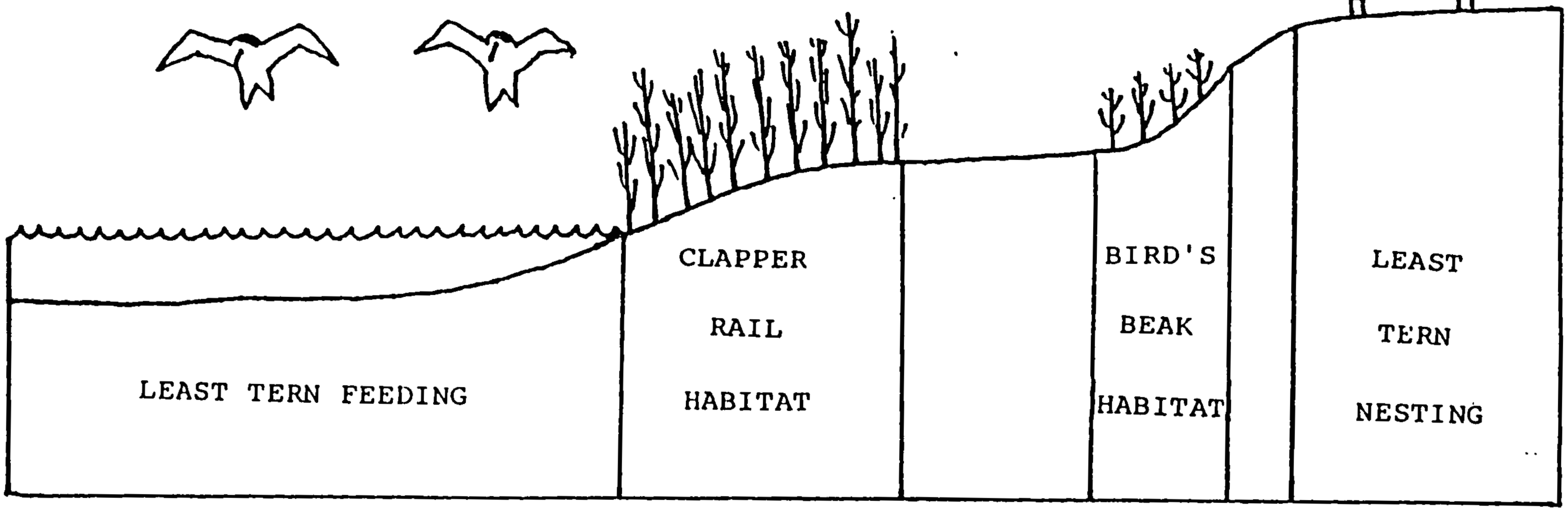
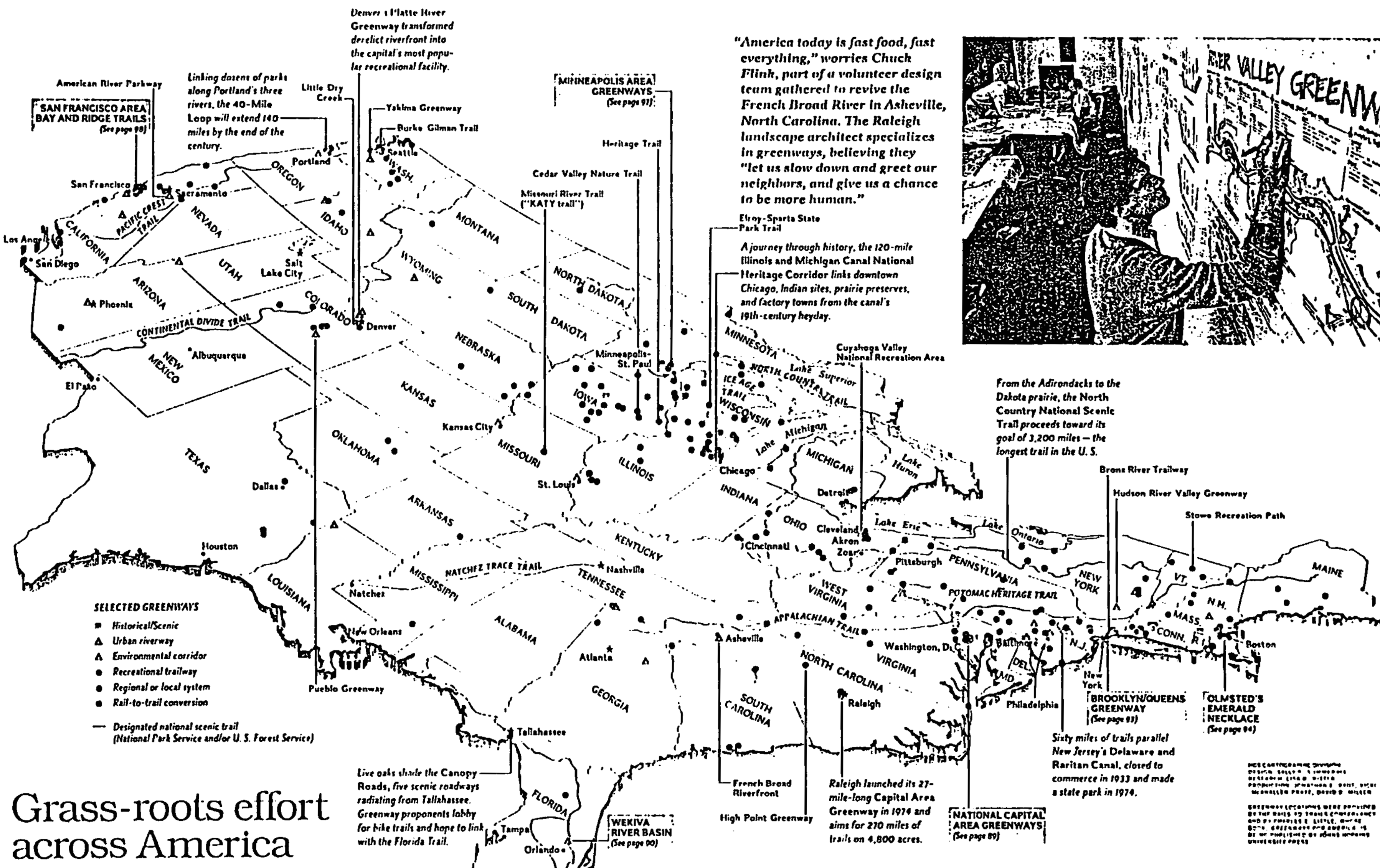


Figure 6(C). Representational diagram of the habitat requirements of three endangered species in the coastal wetlands of Southern California.

(Source: Leedy, D.L. and L.W. Adams. 1984. *A Guide to Urban Wildlife Management.* National Institute for Urban Wildlife. Columbia, Md.)



"America today is fast food, fast everything," worries Chuck Flink, part of a volunteer design team gathered to revive the French Broad River in Asheville, North Carolina. The Raleigh landscape architect specializes in greenways, believing they "let us slow down and greet our neighbors, and give us a chance to be more human."

Grass-roots effort across America

COMBINING the words and the attributes of greenbelt and parkway, a greenway can take many forms. Chiefly it is linear, linking parks, natural features, or historic sites into a greater whole. Demographics point to greenways as the paths of the future. Nearly 80 percent of the U. S. population lives in cities and towns. When the President's Commission on Americans Outdoors reported to Ronald Reagan in 1987, the greatest need cited was for recreational facilities close to home. Urbanization has reduced open land and often made it too expensive to set aside for parks. But corridors such as rivers and streams and old canals and railbeds lend themselves to renewal as greenways. The commission championed the greenway solution and advised community-level planning. But even before the committee's report, greenways had been a citizen-led movement.

In a recent development the American Gas Foundation is considering running greenways over pipeline rights-of-way—bringing a national greenway network closer to reality.

Figure 7(A). Map of greenways in the United States.
(Source: *National Geographic*, June 1990. p. 82.)

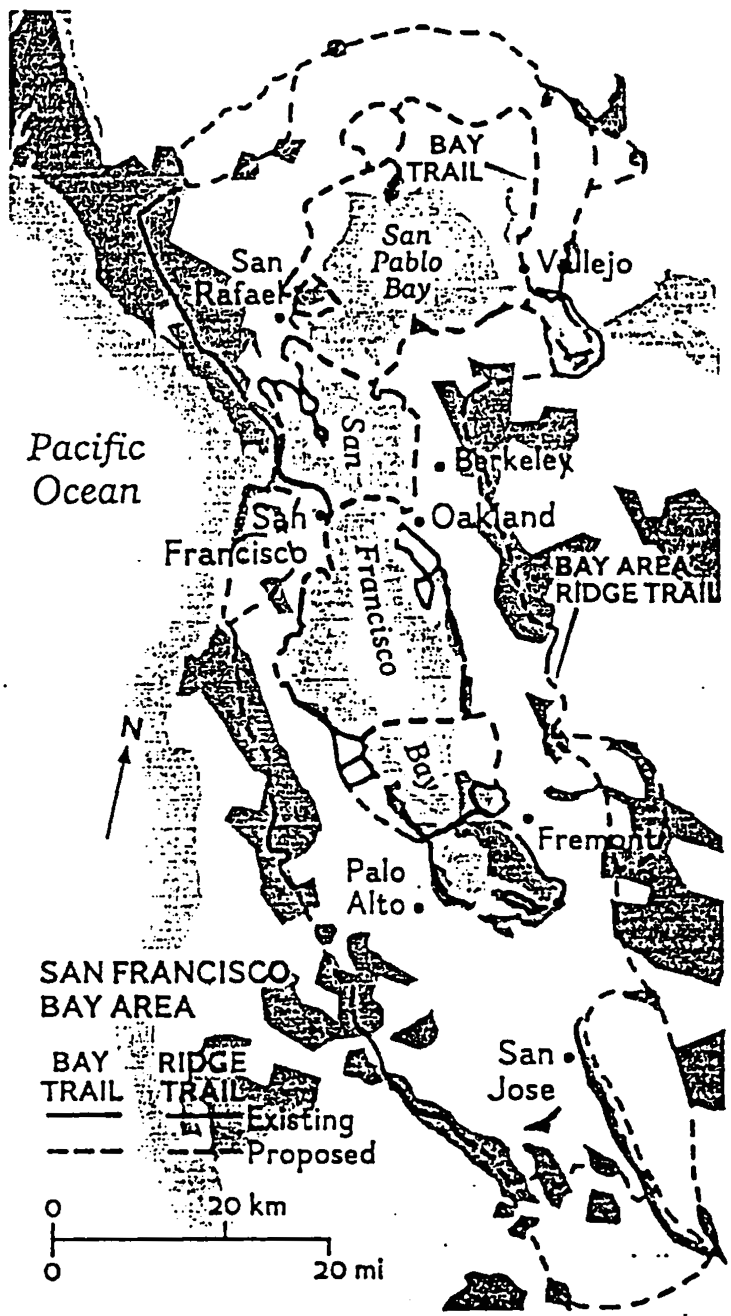


Figure 7(B). Map of two greenway loops being built around San Francisco Bay.
(Source: *National Geographic,* June 1990. p. 98.)

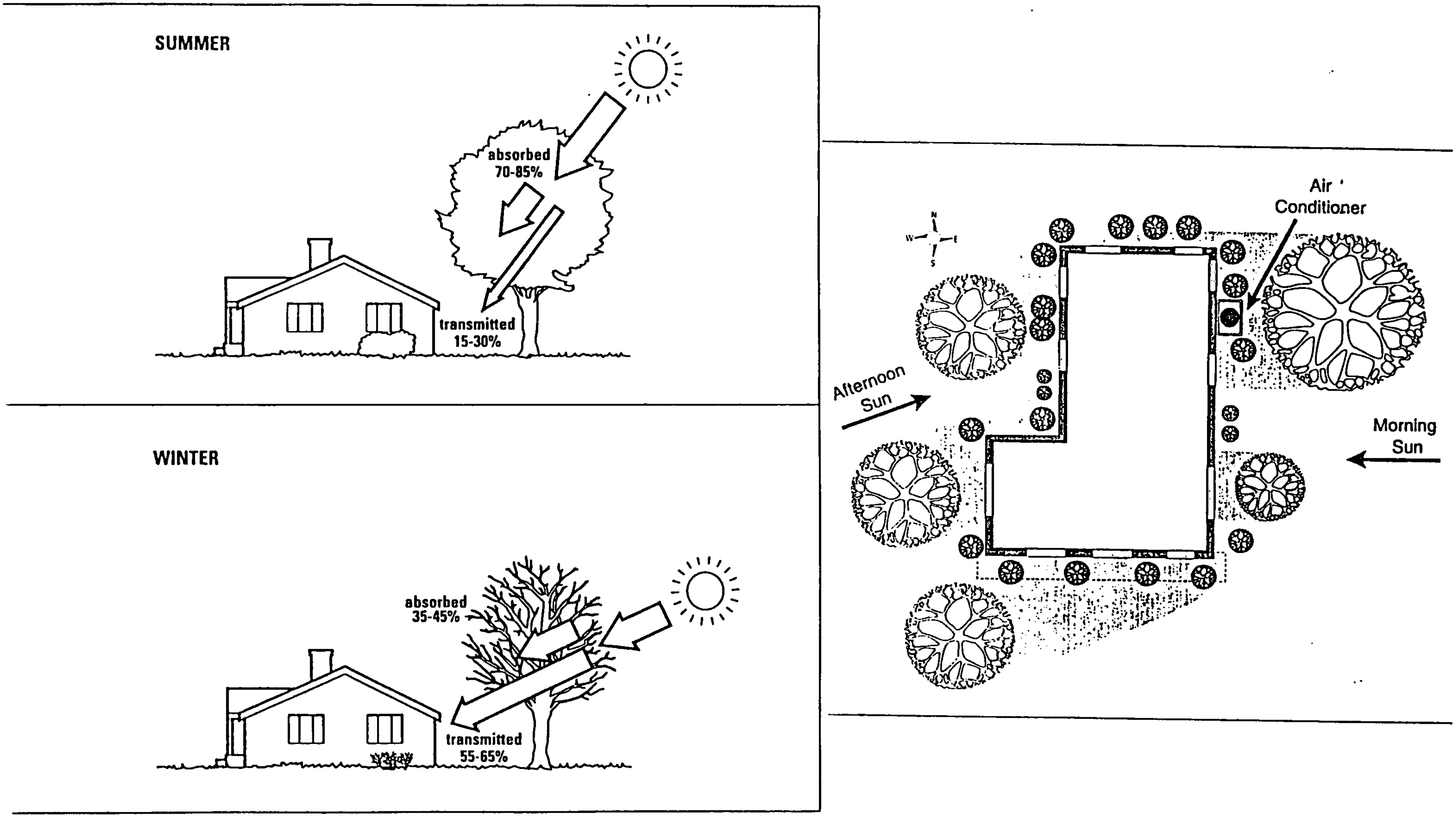
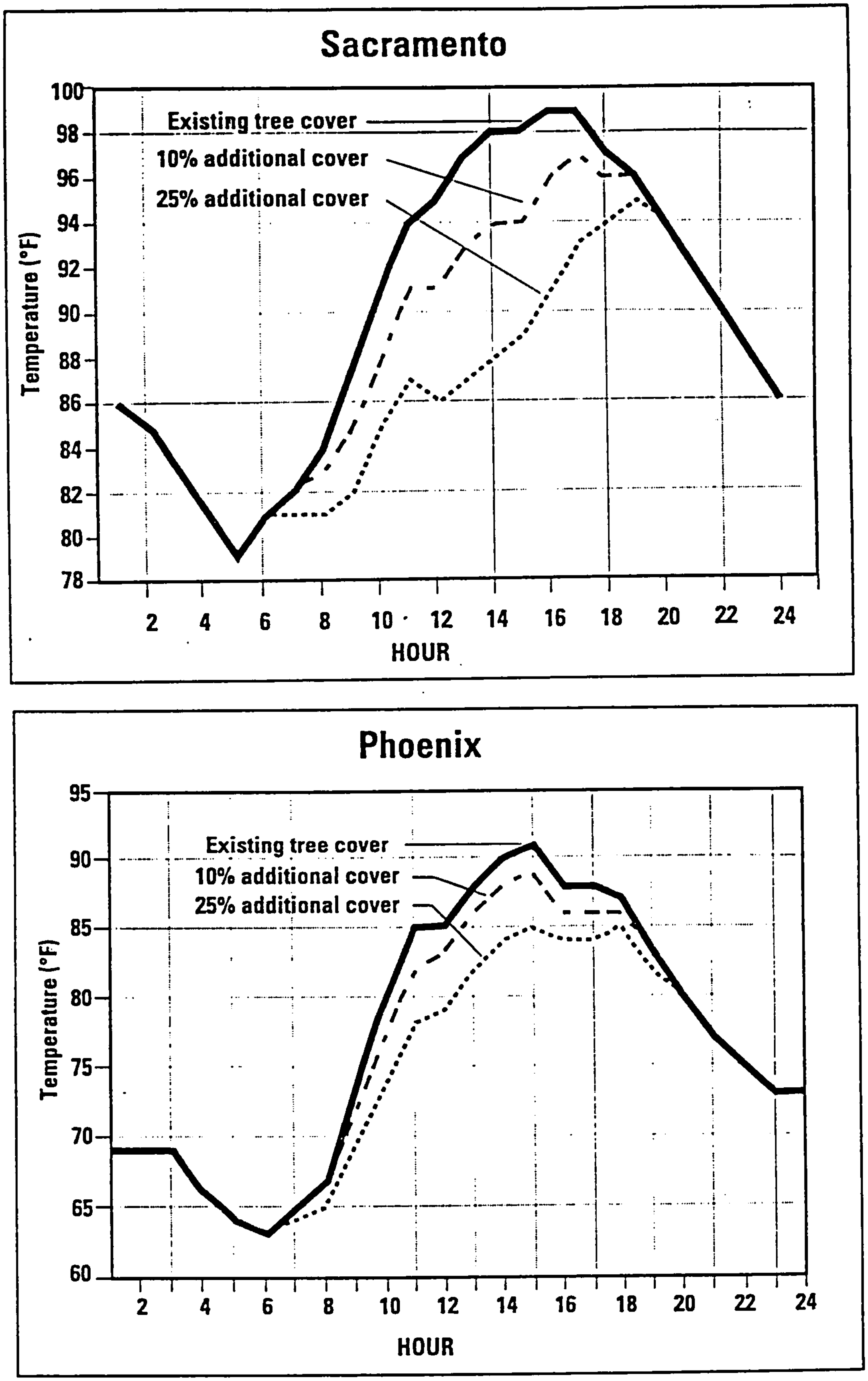
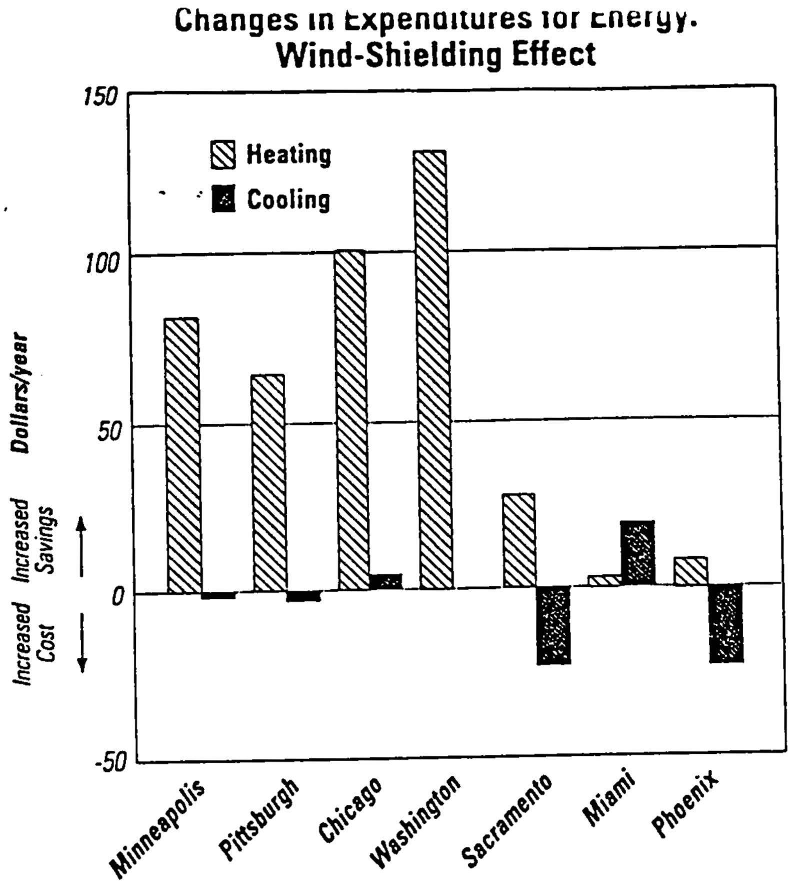
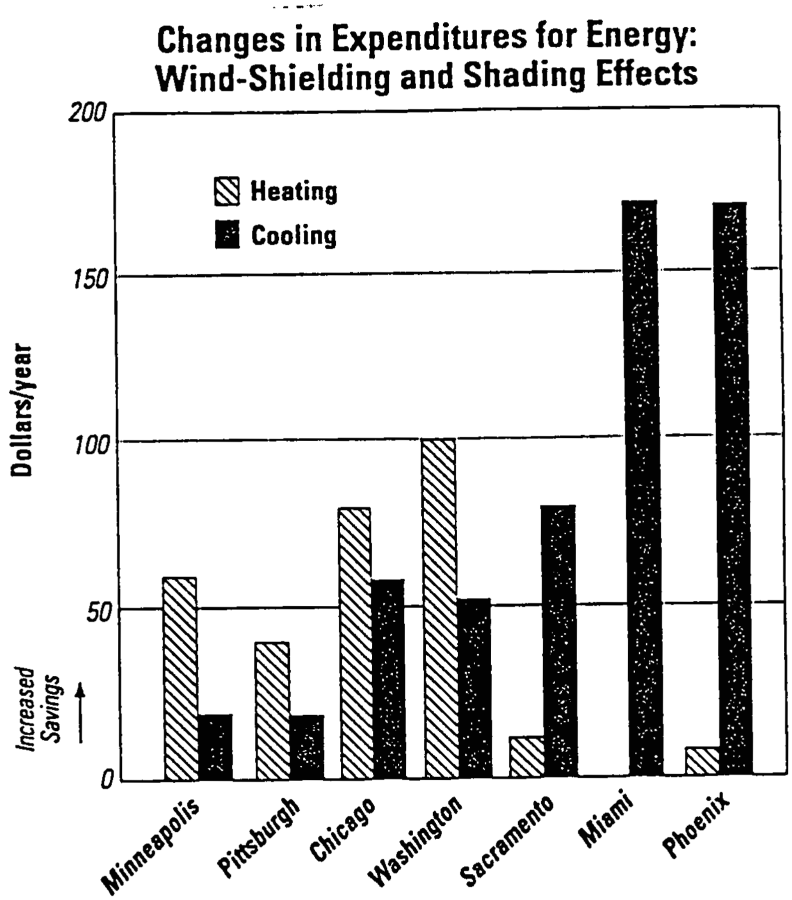


Figure 8. Diagram of trees around a house for cooling in summer and warming in winter.
(Source: Akbari, H. et al. 1992. *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing.* U. S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)



Figures 9(A). & 9(B). Temperature reductions in Sacramento and Phoenix.
(Source: Huang et al. 1987. Cited in *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing.* 1992. U. S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)





Figures 9(C). & 9(D). Changes in expenditures for energy: wind-shielding & shading effects.
(Source: Huang et al. 1987. Cited in *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing*. 1992. U. S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)

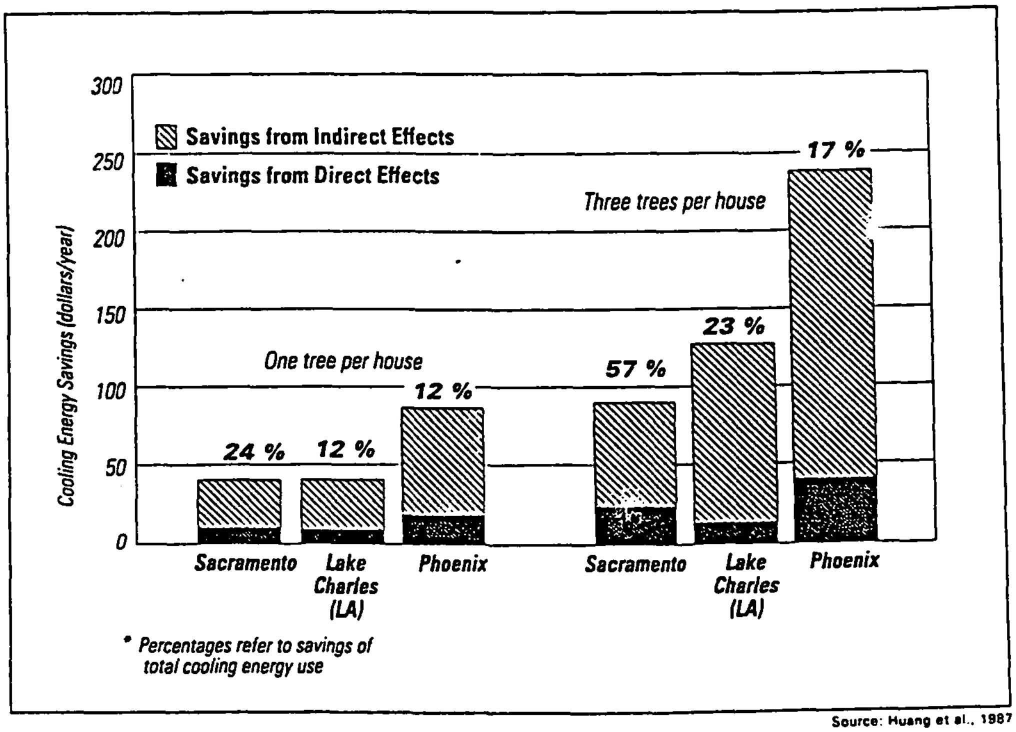
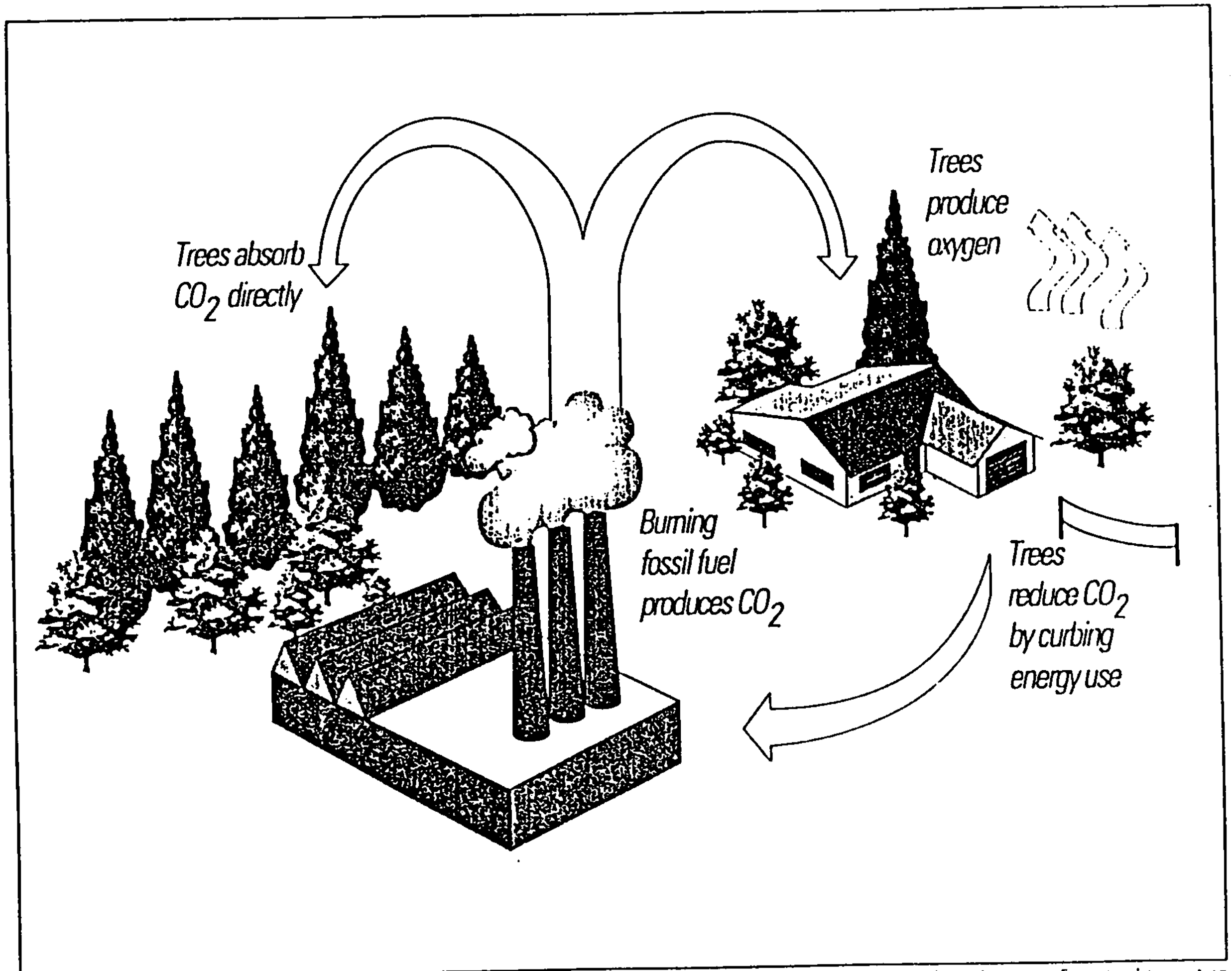


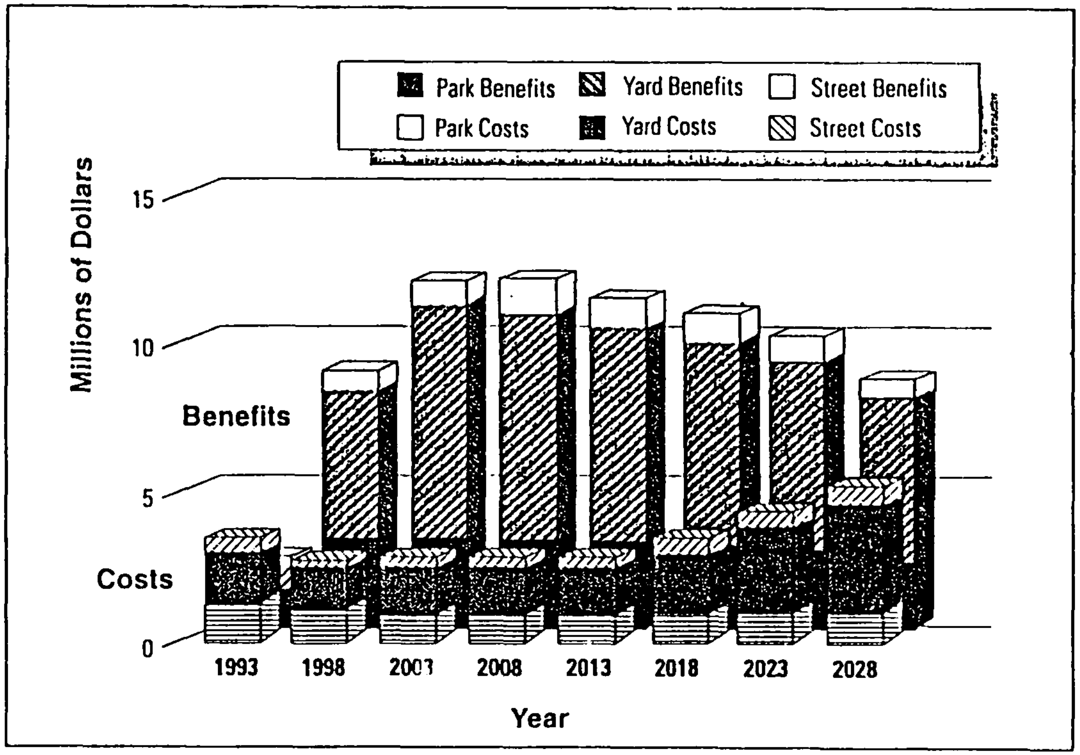
Figure 9(E). Cooling energy savings for direct and indirect effects.
(Source: Huang et al. 1987. Cited in *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing*. 1992. U. S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)



Source: Adapted from American Forestry Association

Trees can help reduce the greenhouse effect in two ways. First, trees directly absorb CO_2—the primary greenhouse gas—from the atmosphere during photosynthesis. Second, shade from trees can reduce air-conditioning energy use, which reduces the amount of CO_2 emitted by power plants.

Figure 10. How urban trees can help us deal with the possible effects of a global warming. (Source: Akbari, H. et al. 1992. *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing.* U.S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)



Source McPherson, 1991

Figure 11. Annual costs and benefits of tree planting programs in Tucson.
(Source: Akbari, H. et al. 1992. *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing.* U.S. EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)

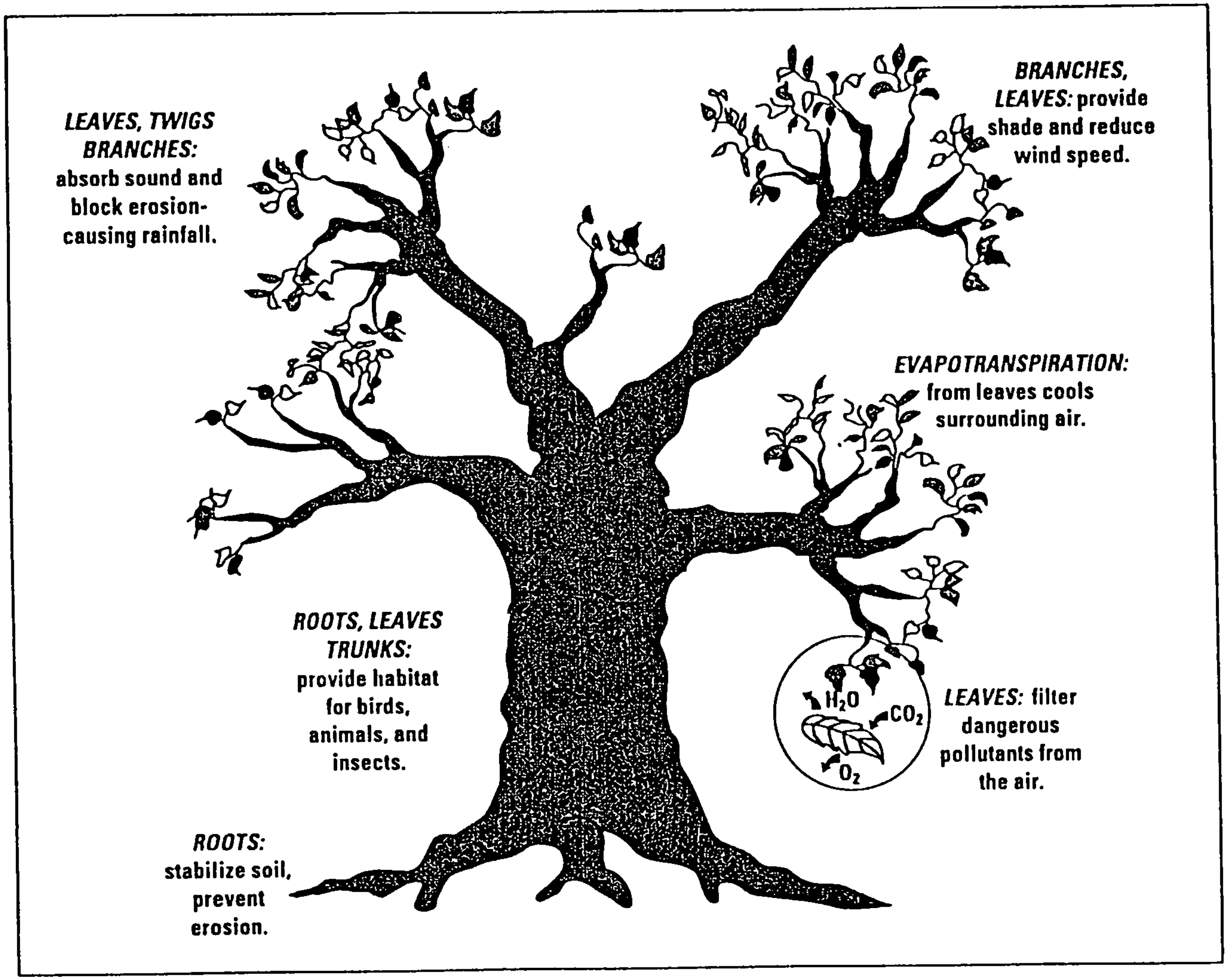


Figure 12. The benefits of urban trees.

(Source: Huang, J. et al. 1991. pp. 27-42. From: Akbari, H. et al. 1992. *Cooling Our Cities: A Guidebook on Tree Planting and Light-Colored Surfacing.* U. S, EPA Office of Policy Analysis, U. S. Superintendent of Documents, ISBN 0-16-036034-X, Washington D.C.)

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