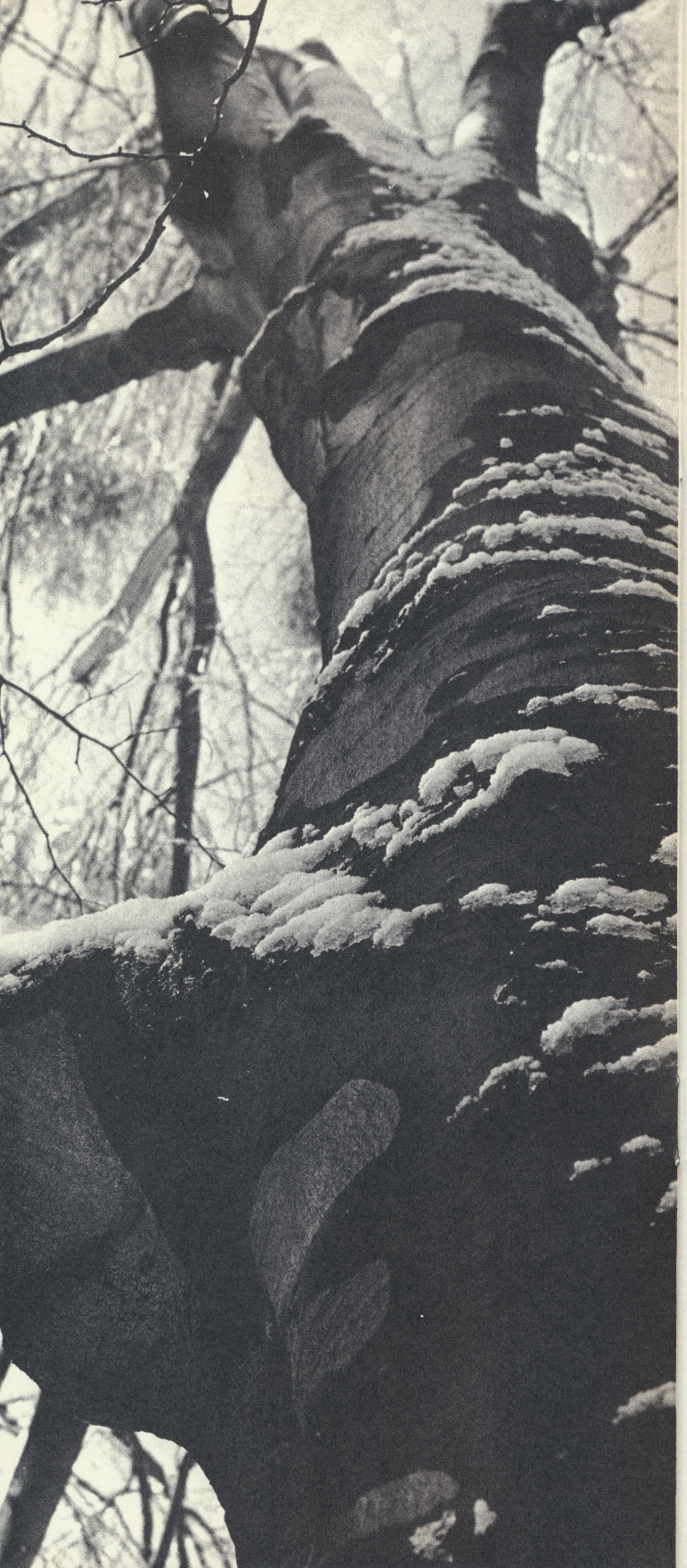
MAN
NATURE
CITY

The Urban Ecosystem



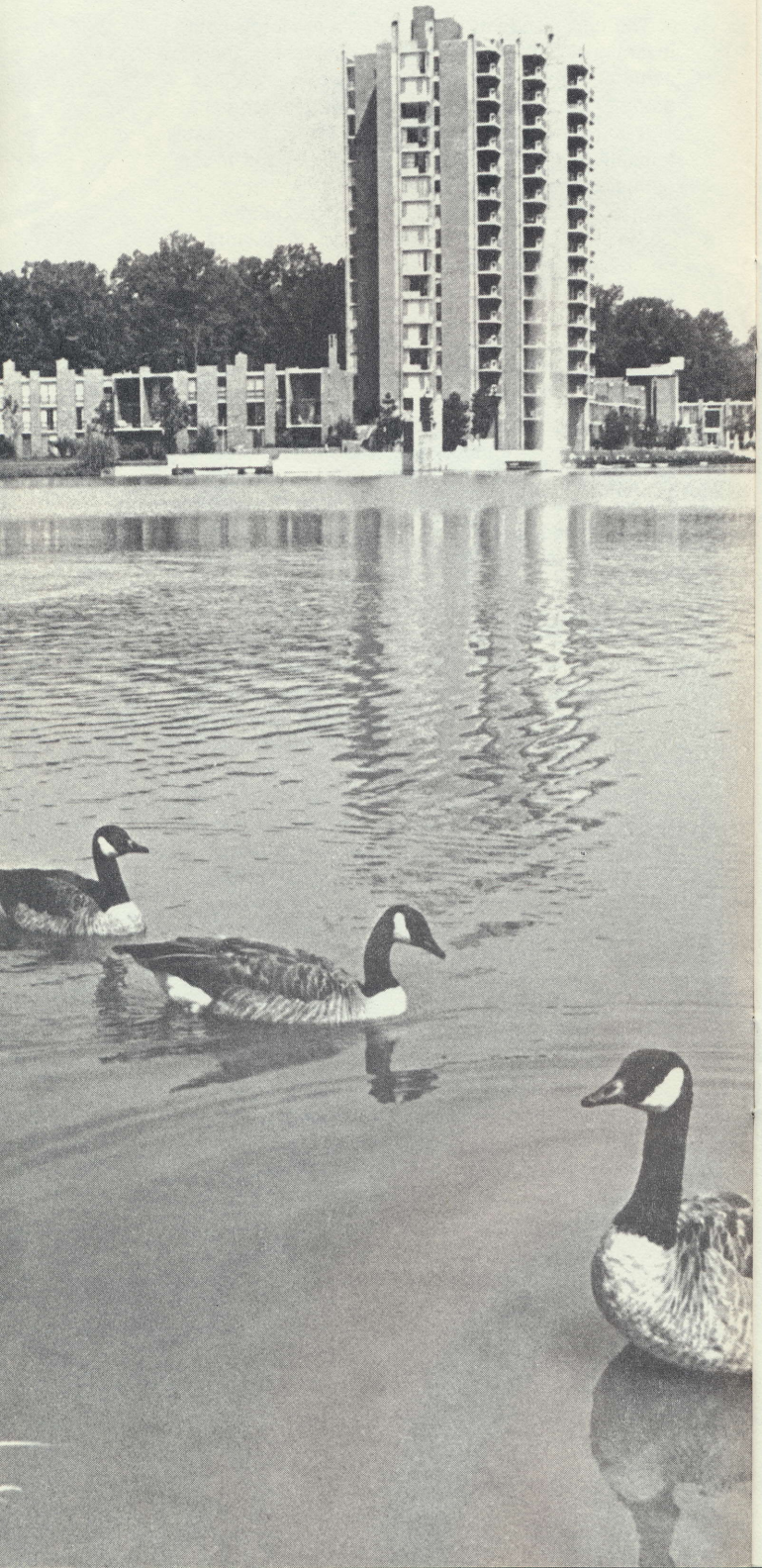
The City as a Biological Community

The city stands as one of man's most intriguing inventions. Though certainly not ancient in the time scale of human evolution, the idea of the city has come to be regarded as his highest development.

It is not by chance that man chose to associate himself with other men and with plants and other animals. The inhabitants of cities, however, do not usually consider them biological communities. To be sure, in one sense the history of the city can be regarded as a history of architecture or engineering; and our modern cities are truly marvels of engineering and technology—so much so that to a large extent the nonengineering and the nontechnical aspects of cities have come to be forgotten or ignored, in some instances with catastrophic consequences.

It is the nonengineering, nonarchitectural, nontechnical components of cities that make them comparable wherever they are found. These factors are the ecological and biological components of cities that are now the great concern of environmental designers. Clean air, clean water, food, clothing, and shelter are the common requisites of all men, in cities and out. Providing these commodities while providing the environment for the technical activity of man is in essence the function of the city. It is in the ecological relations of man—his environment and his work—that the true forms of the city are to be found. This preliminary discussion on the ecology of the city is intended, therefore, to be a reminder to engineers, city planners, and architects that, while virtually any conditions can be engineered, the goal of their efforts should be the establishment of the most favorable conditions for man, and these most favorable conditions can best be achieved through ecological understanding and management.

This recognition that every city functions as a biological community will oblige city planners to reconcile human needs for greenery, clean air, and space with the purely technical solutions to city problems. Faster traffic flow or expanded office and manufacturing facilities must not preempt the need to preserve favorable living conditions for the human organism. The city-limit signs that outline a community also define a distinct ecological setting, which must be managed as an ecosystem if it is to continue to function for the benefit and productivity of its inhabitants.



The Function of Cities

A traveler in any country may well wonder why man builds cities in the places he does, when often there are environmental factors present which seem detrimental to human habitation—dry and infertile soil, isolation, excessive rain, or extremely cold weather. Cities are built to serve particular functions, which are usually of major economic importance and which are often independent of the environment.

Few if any cities have been built merely to provide shelter, and it is doubtful that any city with that as its sole function would survive, much less thrive. So-called bedroom communities are dependent on the core city they serve; and the new satellite cities must attract industry and commerce even to become populated. Besides providing a place to live, a city serves a regional activity (or a combination of activities) such as farming, manufacturing, finance, or government.

Because they must serve a region, cities are built in a location characterized by some geographical or geological advantage. Many cities of the eastern seaboard were built on the fall line, to take advantage of waterpower and water transportation. Some sites were chosen because they provided easy access to the hinterland and its resources. St. Louis is a prime example of a city that served as the gateway for the exploration of a vast territory. Though the location of a city may have been selected for reasons now irrelevant, it still exists in a biological and geological environment.

Cities have been located on the banks of rivers, at the confluence of rivers, around harbors, at the intersection of roads and/or railroads, near rich deposits of ores, near plentiful sources of waterpower, etc. In the Great Plains region of the United States (North Dakota particularly) the cities were distributed, like beads on a string, at intervals along the railroad right-of-way, each one serving a farm hinterland as a collection and shipping point. Larger cities have sprung up as the financial or cultural centers of vast regions. Minneapolis-St. Paul is an island of culture, education, manufacturing, and finance in a vast sea of agriculture. Similar centers are scattered through the central reaches of the continent: Milwaukee-Chicago to the east, Winnipeg to the north, Omaha to the south, and Denver to the west. Several hundred miles apart, they serve comparable hinterlands in a comparable way.

Vegetation and Climate

Since the functions of business, commerce, manufacturing, and processing are largely independent of local biological and vegetational factors, major cities have been built in the United States in every vegetational and climatic region: Los Angeles, in the Mediterranean-like climate of southern California with its chaparral vegetation; Phoenix and Albuquerque, in the desert shrub; Denver, in the short-grass prairie of the high plains; and Boston, Hartford, New York, Philadelphia, Pittsburgh, Washington, Baltimore, all in the deciduous forest of Eastern North America. Duluth is in the hemlock-hardwood forest of the Great Lakes States, as are Green Bay, Milwaukee, Buffalo, and Detroit; Savannah was built in the broad-leaved evergreen ("magnolia") forest of the southeastern Atlantic Coastal Plain. The clue to the climate of these cities can be found in the vegetation type in which they are located.

Nashville and Knoxville are near the center of distribution of the deciduous forest of Eastern North America, and the diversity and size of forest species that grow in the surrounding forests are ample evidence of it. On the other hand, Minneapolis-St. Paul is at the edge of the oak-hickory forest (the dry phase of the decidous forest), of the tall-grass prairie, and of the hemlock-hardwood forest of the lakes, and is far enough north that snow persists all winter long. Phoenix and Tucson are at the northern edge of the Sonoran Desert, a region with 15 or less inches of rainfall per year; Spokane is in the Palouse, the grassland of eastern Washington; and Seattle and Portland are located in the Sitka spruce-western hemlock forests of the Pacific Northwest, where rainfall may exceed 150 inches and 200 feet of snow may fall in the mountains.

Seattle and Portland, since they are on the western shore of a continent, have mild marine climates. International Falls, Minn., at the same latitude as Seattle, has the climate of the continental interior: very hot in the summer and very cold in the winter—a climate exactly like that of much of the steppes of central Asia. New York, at the latitude of Rome, has remarkably colder weather than Rome. Halifax, Nova Scotia, is much colder than London, which is at approximately the same latitude.

The cities on the eastern shores of continents, receiving their weather from the interior of the continent, are colder in winter and hotter in summer than cities at the same latitudes with marine climates. A city as far inland as Moscow, U.S.S.R., enjoys a modified marine climate, because there

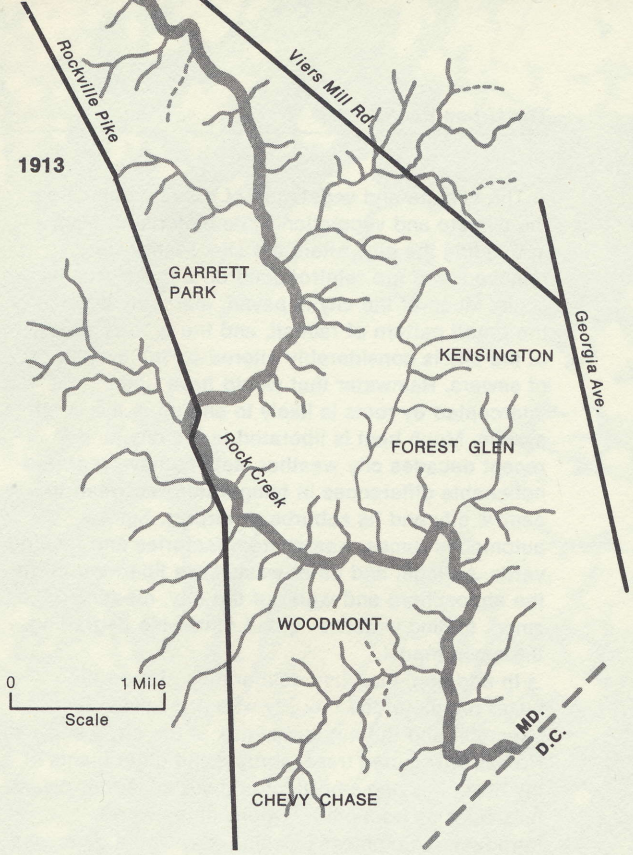
are no mountain barriers between it and the sea, which is some 2,000 miles to the west. Minneapolis-St. Paul has colder winters than Moscow, which is 500 miles farther north. Miami and Key West are the only subtropical cities in the United States (Honolulu is oceanic and tropical). Juneau, Anchorage, and Sitka are among the farthest north of our cities, but each enjoys a marine climate that considerably ameliorates the effect of the high latitude. Settlements across the Alaska Range on into the Yukon (Dawson) are in a climate that is considerably more harsh than the cities on Alaska's western shore.

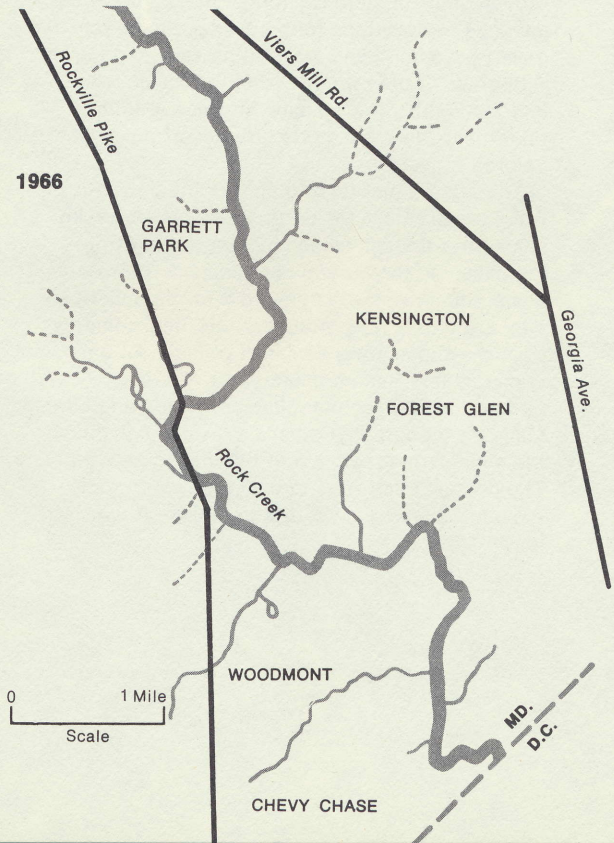
Inasmuch as climate is the major factor controlling the development of the vegetation of the regional ecosystem, it follows that the vegetation of cities imbedded in those regional ecosystems will be similarly affected.

Comprehensive planning for environmental enhancement should take into account the adaptation of vegetation to the climate; the vegetation of the city should reflect the suitability of plant species for the area, as indicated by the presence of them or their ecological equivalents in the natural vegetation.

Generally these species are ideal for reintroduction into urban areas. If it is intended to have an area returned to a nearly natural state of vegetation, native species, when transferred to suitable drainage and exposure situations, are the most economical to utilize and the least likely to conflict with existing plants. Reestablishment of naturally occurring vegetation also serves to provide for animals that use the plant species for food and cover. Birds and mammals that once may have been common near an urban area might return if berries and preferred shrubs are reintroduced.

But while a program for enhancement of native species may be desirable, and perfectly suited to the overall climate and geographic location, it can be hampered by conditions brought about by man. Plant growth and the suitability of habitat for all living things are significantly affected by the technology of man, particularly in cities.





This 26-square-mile section of the Rock Creek watershed in Maryland, now a heavily populated suburb of Washington, was rural in 1913, with many small tributaries fed by springs and seeps. Ensuing development, carried out in ignorance of natural processes, covered most of the old aquifer recharge areas with pavements and rooftops, so that more precipitation ran rapidly off the land instead of soaking in and flowing out gradually into streams. Flooding during storms and loss of flow at other times caused most of the tributaries to be covered over as storm sewers; of 64 miles of natural flowing stream channels that existed in 1913 in this section, only 27 miles could be found above ground in 1966.

The Urban Ecosystem

The climate and vegetation of the city differ from the climate and vegetation of its hinterland. Man, in building the city, alters the site. Plants are removed, and are reintroduced on a much smaller scale. Much of the city is paved, markedly altering the runoff pattern of rainfall, and the ground water of the city is considerably altered by the system of sewers. Rainwater that would have been intercepted by roots is likely to end up in the sewer system. Much heat is liberated in the city, and in recent decades city weather stations have reported noticeable differences in temperature between the central city and its suburbs or airport. Smoke, automobile fumes, wastes from factories and feeding yards, sewage, and other wastes are liberated into the atmosphere and water of the city, creating smog, fouling waterways, and otherwise degrading the environment.

In addition, man has deliberately altered the water regime of the city (by watering lawns, for example) and the nutrient status of the city's soil. He has introduced trees, shrubs, and other plants of his own choosing—horticultural varieties that please him. Species from other regions of the world, introduced into places in which they would otherwise never have occurred, may flourish in the new environment; an example is the Australian eucalyptus brought into southern California. Almost universally man has replaced the herb cover of the forests, the desert pavement, and the wild grasses and herbs with grass of his own choosing and selection—and remarkably few species of grass at that. (In Phoenix, lawns may be turf, desert pavement, or colored gravel.)

The factors that tend to control the behavior of living organisms in the urban environment are the same ones that influence the behavior of living organisms in the natural environment. There are some differences, of course, but for the most part they are differences in quality resulting primarily from the engineering activities of man. All biological communities—man-dominated or not—are affected by three sets of factors: climatic, biotic, and edaphic (soil and topography). Man's activities constitute the engineering factors and the management factors. The polluting activities of man tend to degrade the ecosystem to the extent of making it unfit for all life.

Climate controls all living organisms. It is the chief factor determining the distribution of plants and animals on the surface of the earth. Extremes of temperature, progression of day lengths, and amount and distribution of precipitation are climatic factors controlling living organisms, particularly those that cannot (metabolically) control their own temperatures. In addition, the periodic onslaughts of extreme climatic conditions have pronounced effects on long-lived organisms, especially trees. The once-in-50-years cold spell that freezes otherwise tolerant species and the very occasional ice storm that completely debranches mature trees have the same kinds of control over the distribution and establishment of long-lived tree species as do the yearly extremes of weather. A drought that occurs once every 30 years is sufficient to eliminate a species that requires 60 drought-free years to reach maturity. All organisms have temperatures below which or above which they will not grow, or will die.

Man is no exception to this rule. He differs from most organisms in being able to regulate his body temperature metabolically (a characteristic he shares with other warm-blooded animals) and in being able to manage his immediate environment. (Garments, igloos, tents, houses, apartment buildings, and heating and cooling systems all function essentially to help man to regulate his body temperature.) A change of only a few degrees in a man's body temperature is sufficient to produce death. White oaks, sugar maples, purple violets, tulips, and hydrangeas have a critical temperature as well as minimum and maximum light and water requirements. All these factors affect the growth and development of individual species, and the distribution of these species on the surface of the earth. The city and the urban environment can be altered somewhat by man's regulation and management. Though man cannot completely change the climate, he can alter some factors of it—water, for example.

The regulation of water can be detrimental or beneficial. In paving streets, impermeable surfaces may block the flow of water to tree roots. Irrigation systems can provide much needed water for turf and ornamentals during intervals between rain. The cost of irrigation in the city may be high, but it is more easily absorbed into the economics of the city than is irrigation of the surrounding hinterland.

Since the city is constructed of hard materials which can gain and lose heat more readily than surrounding natural vegetation, extremes of temperature may be greater in the city than in the countryside. The city weather report always differs from that of nearby farmland and the airport.

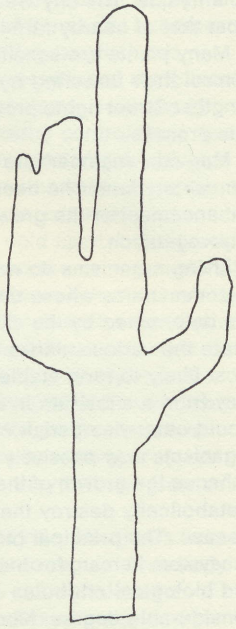
Many plants are sensitive to day length and control their flowering by the progression of day lengths. Street lights provide enough light to alter this process.

Man can engineer into the urban environment almost any factor he deems necessary to the enhancement of the growth and development of city vegetation.

Living organisms do not live alone. They exist in communities whose constitution and distribution are determined by the climate. Organisms that can share the various niches of the environment are most likely to form stable communities, and, in turn, may form a substrate in which organisms that would otherwise perish can survive. Biological organisms may passively exist together, they may enhance the growth of their neighbors, or they may metabolically destroy them through parasitism and disease. The principal biotic factor of the urban ecosystem is man, for man can alter the physical and biological attributes of the environment to a considerable degree. Man can enhance or man can destroy the community of organisms in which he lives, either by design or through thoughtlessness.

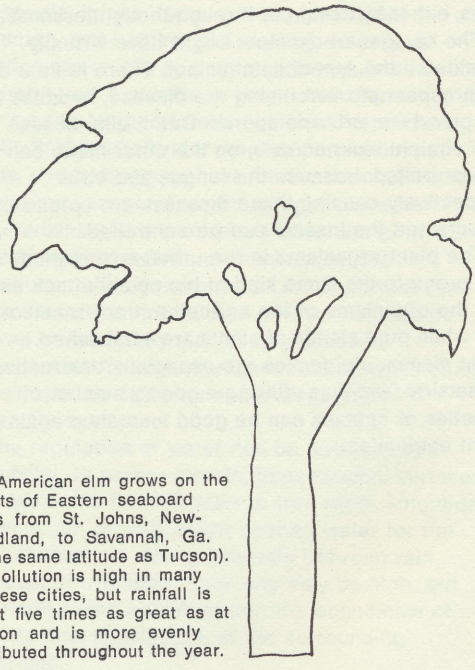
The ravages of chestnut blight have virtually eliminated the American chestnut. There is little or no prospect of overcoming the disease, because it is spread via airborne spores. Dutch elm disease and elm phloem necrosis, on the other hand, can be controlled, because the fungus and virus respectively causing these diseases are spread by insects and the insects can be controlled.

The plant organisms in the urban environment are prone to the same kind of biological attack as are the organisms of the agricultural environment. For when pure stands of plants are established, plant disease epidemics are especially destructive. Streetside plantings utilizing a goodly number of varieties or species can be good insurance against plant epidemics.



Saguaro

The giant saguaro cactus is native to the desert near Tucson, Ariz., with an annual rainfall of only about 10 inches and lengthy spring and autumn rainless seasons. It has adapted to the harsh environment with water-storage devices and a low transpiration rate, but seems to be highly susceptible to air pollution from the city.



Elm

The American elm grows on the streets of Eastern seaboard cities from St. Johns, Newfoundland, to Savannah, Ga. (at the same latitude as Tucson). Air pollution is high in many of these cities, but rainfall is about five times as great as at Tucson and is more evenly distributed throughout the year.

The urban community contains not only plants and animals that man desires but also many that he would like to eliminate. Through management, circumstances may be created where unwanted organisms, even though rare, can flourish because they share the optimum conditions of environment with more desirable species. A good example is the dandelion, which thrives in the environment of a city lawn—where it is not wanted. The pigeon, English sparrow, and starling could be cited as "weed" species of animals; the Norway rat is a pestilence in itself, causing economic loss and great costs in human health wherever it has migrated and taken hold. These organisms exist in an environment created by man, and the need to control them has posed the most refractory of biological problems.

Why have songbirds left the cities? Is it because of competition with the English sparrow and starling, or is it that the overall quality of the city has changed and only the English sparrow and starling have been able to survive the change? Man introduced dogs and cats to the city and has essentially removed the horse.

Agricultural activities have largely been banned from cities, which formerly had thriving businesses in cattle, swine, and chickens, with many householders keeping animals. The ban is mainly for reasons of health but is enforceable only where adequate facilities permit storage of freshly killed meat.

Aedes egypti, the yellow fever mosquito, breeds exclusively in containers, such as tin cans, made by man. The *Aedes egypti* control program entails keeping the area free of such manmade containers. And of course the rat problem seems to be a simple relation between man's handling of garbage and the rat itself.

For better or worse, man has created an environment in the cities that may be favorable for many species of plants and animals detrimental to his well-being, health, and comfort, and he has created environmental circumstances where desirable plants and animals have been driven away. What is obvious is that man controls the biological relations of the urban environment. How he exercises that control will be largely dependent upon his understanding of the urban ecosystem itself.

City Soils

The edaphic factors—that is, the factors of the soil—of the urban environment differ radically from those of the natural environment. To accommodate the automobile, most of the areas likely to be used by automobiles have been hard surfaced. (There are some notable exceptions; St. Paul, for instance, still has 300 miles of unpaved—but oiled—streets.) Sidewalks and streets, parking lots, and shopping centers have been paved. The paving of great areas of the cities has created a runoff problem, requiring storm sewers as well as sewers for domestic and industrial wastes, and has lowered the water table of the cities. These losses and the use in many cases of plants with high water requirements have made the demands of the urban ecosystem for water much higher than the natural ecosystems of the hinterland. This condition becomes more accentuated as cities move farther into the grasslands, savannahs, and deserts.

The soil of the city often is composed primarily of graded subsoil. The original soil may have been an impoverished forest soil with shallow topsoil that was lost in grading, leaving only organically poor sand and clay on the surface. Such soils may be high in minerals but are usually low in humus and other organic matter and are of poor quality for the growth of plants, often necessitating the bringing in of new topsoil. On the other hand, more resources are usually available in the city than in the country, acre for acre, for rehabilitating soils; funds are usually available to provide fertilizer, sod, soil conditioners, and even new soil.

Since plants grow in soil and not in the paving materials of the urban ecosystem, it is the quantity and quality of that soil that determine the health and vigor of the roots of the plants, which in turn contribute greatly to the overall vigor of the plant. Plant roots can and do break the pavement and grow into sewer lines and clog them or break them. The micro-organisms of the soil can and do attack anything that is buried in the soil, even if it is plastic or lead coated. (Ceramics seem to be the only really durable material that can be buried.)

No higher plants have been successfuly grown without roots. For the ecosystem of man to be populated with the species of higher plants that he seems to want, allowances must be made for the occupation of the soil by their roots. For most forest trees used for street or yard plantings the root systems are widespread (depending largely on the proximity of other trees) and shallow. The root environment of the plant is probably the most critical factor for its survival in the urban ecosystem.

Creating the Urban Ecosystem

The factors of the urban ecosystem peculiar to man's activities are the engineering factors. Utilities, sewers, streets, walks, and buildings are usually located with the highest priority. Man's engineering capacity makes no task insurmountable, and the landscape can be arranged to suit. Soil is compacted, ground water is diverted, great areas of shade are created by large buildings, and rivers are relocated or encased in concrete. Most plants and animals are included in the urban ecosystem only after all other economic requirements have been satisfied; funds for plants have lower priority than those for engineering—a building and a street are functional without landscaping. In budget squeezes these items are usually reduced or eliminated. The plants of the urban ecosystem must be provided for under some provision other than construction or engineering funds. Plants—particularly trees—then must be selected for their adaptability to the respective niches of the community. This has worked out remarkably well in many cases—and very poorly in others (in many downtown areas to the complete exclusion of plants other than those in pots). The obvious conclusion is that the urban ecosystem can be arranged to provide adequate environmental circumstances for the plants—if they are wanted.

And like all other engineering contingencies, preparations for incorporating vegetation into the city must be made before the streets are paved and the foundations excavated. It is probably true that most of our oldest, most valuable street plantings date from a time before the streets were paved. Originating about 1910 or 1915, they grew to maturity without pavement over their roots and with abundant fertilizer from animal traffic.

If construction of facing buildings is carried out in such a way that maturation of streetside plantings is possible, living beauty can easily be designed into the city environment.

Once created, the urban ecosystem is managed and maintained by man. The choice of species in the plant communities of the ecosystem is not left to chance. Species that would otherwise not occur in the geographical area can be introduced. Species that otherwise would be quite rare can be propagated and used in large numbers. Species can be genetically improved. The latter is not a simple problem with species that may require 20 years to produce flowers, but great strides can be made by selecting seeds or cuttings from outstanding individuals of the species. The plant community of the urban ecosystem, like any other part of man's environment, can be designed.

. . . and Degrading It

No other species is quite like man in his ability to degrade the environment. Pollution—from industry, from households, from automobiles—can and does occur on a scale that endangers not only man but the green plant matrix in which man lives. Life in heavily polluted areas is tolerated because of the economic benefits and a general disbelief that the destruction is irreversible. Like the man who smokes, we tell ourselves that we can quit any time we want to. It is doubtful that man will pollute the environment to the irreversible destruction of the green plants or even himself. The immediate cause of degradation of the environment is the lowering of the quality of life. Our intellect tells us that we can live a better life, that we can live in prosperity and grace with instant communication and great wisdom. We know that pollution is an expediency that produces a temporary gain in the rate of wealth accumulation. It is also certain that industry will not willingly incur economic disadvantages not incurred by everyone else and that pollution abatement is an all-or-nothing proposition. Either everyone must stop polluting or those that do will suffer economically in the marketplace.

The effects of the polluted environment on the quality of life are so certain that the question is not *what* to do about pollution, but *when.*

Man can live in his urban ecosystem parasitically, like a disease organism that takes its life necessities from the environment regardless of the consequences. He can live commensally in his ecosystem, largely ignoring it, looking inward to his painted walls, concrete and steel, and plastic flowers, regarding the ecosystem only aesthetically. Or he can live in his ecosystem symbiotically with other organisms, creating not merely a collection of trees and houses and factories and streets and gardens, but a total living community that offers its members beauty, peace of mind, health and vigor, and the understanding that they are a regenerating part of the living community of the earth.

Historically, parasitic ravaging of resources for quick economic gain has resulted in shortages of supplies and extinction of species. Even innocent preoccupation with one's own yard leaves the rest of the environment to the vagaries of unconscionable use. As we see the effects of all of man's actions on the environment, our responsibility becomes clear.

The Choice

It is obvious that man is now at a crossroads in his development. His technology has been developed to the extent that not only does he produce great wealth and great technical achievements—the greatest the world has ever known—but he has generated forces and conditions that threaten to alter the very environment in which he lives. The crossroads at which man stands can lead him, paradoxically, to an amelioration of the environment with consequent enhancement of human life or to the degradation of the environment with the resulting debasement of human life.

The knowledge and understanding necessary to predict the consequences of man's activities are far more available than they were even a decade ago, and with the accelerating generation of all knowledge, the information necessary either to despoil or to enhance the environment will also be generated in an accelerated fashion.

By harnessing its great vitality the city can be transformed into the most favorable environment for man. But before this can come to pass, it will be necessary to reconsider some of the fundamental ecological relationships of individual men to each other and of men living in communities to the environment as a whole.

—Theodore W. Sudia

Urban Ecology Series, No. 1

Photographs by Peter Pettus

As the Nation's principal conservation agency, the Department of the Interior has basic responsibilities for water, fish, wildlife, mineral, land, park, and recreational resources. Indian and Territorial affairs are other major concerns of America's "Department of Natural Resources." The Department works to assure the wisest choice in managing all our resources so that each will make its full contribution to a better United States—now and in the future.

U.S. Department of the Interior

National Park Service

☆ U.S. GOVERNMENT PRINTING OFFICE : 1974 O—528—438

For sale by the Superintendent of Documents
U.S. Government Printing Office, Washington, D.C. 20402
Price 35 cents