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Excerpt
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Part one

Urban entomology

1 Introduction

Introduction

The urban environment is a complex of habitats developed by humans from natural sites or agricultural land. Houses, villages, towns, cities, buildings, roads, and other features that characterize the urban environment have gradually and irrecoverably changed the landscape of natural and agricultural areas. As a part of this change, some habitats and their associated plant and animal communities were eliminated, while others were expanded and new ones were created. Many of the new habitats were intentional – parks, waterways, street trees, turfgrass, food stores – but some were consequential – standing water in roadside ditches, garbage and landfill sites near residential neighborhoods, the underground sewer and storm drain network in urban and suburban areas. They all provided habitats for a select group of insects and other arthropods, some of which attained pest status.

Local conditions, climate, and available resources determine the distribution of some arthropods in the urban environment, and for some species their abundance is limited. Other species are broadly adapted to the resources and harborages in and around buildings, and these are cosmopolitan in their distribution and pest status. Stable habitats with resources and conditions suitable for long-term survival support reservoir populations of pest species, and from these habitats individuals or groups move or are transported to establish infestations in unstable or temporary habitats.

Peridomestic and domestic habitats

Within and around buildings, houses, and other urban structures are habitats that support individuals or populations of plants and animals. Peridomestic habitats are outside, around the perimeter of structures. They include the external surfaces of buildings, the ornamental trees, shrubs, and turfgrass that characterize the urban and suburban landscape. Domestic habitats are indoors, and include the plant- and animal-based materials in this controlled, anthropogenic environment.

Peridomestic

Harborage substrates, food resources, and environmental conditions of urban landscapes around the world generally support a large number of different species, if not individual species in large numbers. The soil-inhabiting and -nesting arthropods in this environment include ants that forage indoors and termites that damage structural wood, ground-nest bees and wasps, and occasional or nuisance pests such as clover mites, millipedes, centipedes, and springtails. Plant-feeding insects utilize the cultivated urban and suburban trees and shrubs, and many are aesthetic pests. Blood-feeding mites (chiggers), ticks, mosquitoes and other biting flies are associated with domestic and feral vertebrates. Species utilizing building surfaces or perimeter substrates include the umbrella wasps, hornets, yellowjackets, spiders, and scorpions. Underground sewer and storm drainage pipes provide some cockroach and rodent species access to urban and suburban neighborhoods. The garbage disposal network of collection, sorting, and landfill provide harborage and food for cockroaches, flies, rodents, and pest birds.

Reservoir populations for many of the pest species established in peridomestic habitats are in nearby natural or undisturbed areas. Woodland tracts and other small or large patches of greenspace can support populations of biting flies, wasps and hornets, ticks, and spiders. Here are the populations that provide the individuals or groups that establish or replenish infestations in less stable habitats, or re-establish populations lost to habitat destruction.

Domestic

Environmental conditions indoors are generally stable, and the harborages and food resources are somewhat limited. There may be few species, but those adapted to specialized resources often occur in large numbers. Stored food, including packaged whole food and vegetables, organic fabrics, and other materials are the most common harborages and food resources in the domestic habitat. Directly or indirectly associated with these are dermestid beetles, flour beetles and moths, flies, and cockroaches. The global distribution of domestic products and similar storage environments across cultures has contributed to the cosmopolitan pest status of many of these insects, in both residential and commercial sites. Blood- and skin-feeding species that breed indoors are limited, but lice, fleas, bed bugs, and mites are medically important pests for more than one socioeconomic level of society. Insects and other arthropods in the living space are nuisance pests when they are few and their presence brief, but are not tolerated when they pose a health threat or persist in large numbers.

Natural habitats and populations for some domestic species, especially those infesting stored food, have been lost. Only populations in the urban environment represent many of these species, or they survive only through their link to humans (bed bugs, lice). Other indoor pests have reservoir populations in peridomestic and natural areas. Many of the common species occur in the nests of bird and rodents and from there have access to indoor habitats.

Pest status and control

In the agroecosystem, pest status and the decision to apply control measures for arthropods are based primarily on economics. Pests can be measured by their damage and reduction in animal weight or crop yield, and controls are applied to prevent or minimize predictable loss. Pest status for insects and other arthropods in the urban environment may or may not be based on a measurable feature. The damage caused to structural wood by termites or other wood-infesting insects can be measured, and the control and repair costs determined. The health threat or medical importance, such as from stinging insects, can be measured by medical costs. A decision to apply control measures may be based on potential damage or personal injury, or solely or in part on emotion. The control decision is no less appropriate when it is based on emotion. Arthropods in the living space are generally unwanted and unwelcome, whether their numbers are few or many.

Pest status is generally based on persistence or recurrence of an arthropod indoors or outdoors, due to the failure of control methods, or the ability to reinfest from reservoir populations. The persistence of many species in the urban environment is based on a network of reservoir populations, from which individuals or groups move to infest or reinfest domestic or peridomestic habitats. Undisturbed woodlands may support populations of yellowjackets, subterranean termites, and carpenter ants, and serve as a reservoir for colonies and infestations in adjacent and distant residential areas. Sewer pipes often provide conditions suitable for American cockroach populations, and from this habit, adults and nymphs infest and reinfest buildings.

For pest control or management programs to be successful, reservoir populations and habitats must be identified and reduced. The only functional reservoir populations for some peridomestic and domestic species are in secondary habitats in the urban environment. Pests whose abundance is based on the limited availability of artificial habitats and resources are vulnerable to effective chemical and nonchemical control methods, and may be eliminated.

Pest dispersal and distribution

International transportation, economic exchange, and globalization have brought a degree of uniformity to the urban area around the world, and increased the movement and exchange of arthropods. The majority of household and stored-food pests, including fruit flies, cockroaches, flour beetles, moths, and mites, have moved with infested commercial goods and now have cosmopolitan distribution. Peridomestic mosquitoes, subterranean termites, and wood-infesting beetles share the same potential for widespread distribution. Current distribution records for many household and structural pests are subject to change with increased movement of people and materials around the world.

Information on pest identification, biology, and habits, compiled on an international basis, is appropriate for the urban environment. A global census indicates that nearly 2300 insects and other arthropods have some level of pest status around the world. Some are only occasional invaders of houses and other buildings, some are closely associated with the foods, fabrics, and other aspects of dwellings, and others are linked to plants and animals in domestic and peridomestic habitats. Many of these species are capable of adapting to the soil conditions, climate, and building construction in other regions of the world, and becoming established in pest populations. Regional conditions may alter some behaviors, but morphological features and the basic life cycle will remain unchanged, and control strategies are usually transferable from region to region.

Urbanization

The quality of life for most people in the future will be determined by the quality of cities. In 1950, 60% of the world's population lived in villages and small towns in countryside. By the year 2030, 60% of the world's people will be living in metropolitan areas anchored by a large city. Those cities will be bigger than ever and dominate the landscape: most of these cities will be in developing countries. Explosive growth in urban populations and the steady stream of migration of people from the countryside put great strains on city services and the quality of life. The housing, health care, water, and sanitation systems must keep pace with the growth, and the threat of disease. Despite the conditions, migration to cities continues, and that is good news. Cities provide development and growth, and generally a better life than in rural areas. The future of many developed countries is linked to their cities. Urban growth is inevitable: the challenge is how to address the consequences and improve the quality of life from city center to the unplanned housing at the perimeter of the metropolis.

Insects and other arthropods that carry and transmit disease organisms present a threat to the cities and densely populated urban areas of the world. In these areas, crowded living conditions and poor sanitation support vector populations, and the concentration of human hosts can maintain common diseases and rapidly spread new ones. Pest management and control strategies will be based on pest identification and life-cycle information, an understanding of reservoir habitats, and effective chemical and nonchemical control materials.

Bibliography

Bornkamm, R., J. A. Lee, and M. R. D. Seward. *Urban Ecology: Second European Ecological Symposium*. London: Blackwell, 1982.

Boyden, S. *An Integrated Ecological Approach to the Study of Human Settlements*. MAB technical notes 12. Paris: UNESCO, 1979.

Boyden, S., S. Miller, K. Newcombe, and B. O'Neill. *The Ecology of a City and its People: The Case of Hong Kong*. Canberra: Australian National University Press, 1981.

Bronfenbrenner, U. *The Ecology of Human Development*. Cambridge, MA: Harvard University Press, 1979.

Chinery, M. *Collin's Guide to the Insects of Britain and Western Europe*. London: Collins, 1986.

Ebeling, W. *Urban Entomology*. Berkeley, CA: University of California Press, 1975.

Frankie, G. W. and L. E. Ehler. Ecology of insects in urban environments. *Annu. Rev. Entomol.*, **23** (1978), 367–87.

Frankie, G. W. and C. S. Koehler (eds.) *Perspectives in Urban Entomology*. New York: Academic Press, 1978.

Urban Entomology: Interdisciplinary Perspectives. New York: Praeger, 1983.

The Ecology of Urban Insects. London: Chapman and Hall, 1989.

Gerozisis, J. and P. Hadington. *Urban Pest Control in Australia*, 4th edn. Sydney: University of New South Wales Press, 2001.

Gold, R. and S. C. Jones (eds.) *Handbook of Household and Structural Insect Pests*. Lanham, MD: Entomological Society of America, 2000.

Hartnack, H. *202 Common Household Pests in North America*. Chicago, IL: Hartnack Publications, 1939.

Unbidden House Guests. Hartnack Publishing: Tacoma, WA: 1943.

Hedges, S. and D. Moreland (eds.) *Handbook of Pest Control: The Behavior, Life History and Control of Household Pests*. Cleveland, OH: GIE Media, 2004.

Lee, C.-Y., H. H. Yap, N. L. Chong, and Z. Jaal (eds.) *Urban Pest Control: A Malaysian Perspective*. Penang, Malaysia: School of Biological Sciences, University of Sains, 1999.

Lynch, K. *The Image of the City*. Cambridge, MA: MIT Press, 1960.

McIntyre, N. Ecology of urban arthropods: a review and a call to action. *Ann. Entomol. Soc. Am.*, **93** (2000), 825–35.

Odum, E. P. The strategy of ecosystem development. *Science* **164** (1969), 262–70.

Phillips, D. Urbanization and human health. *Parasitology* **106** (1993), 93–107.

Pisarski, B. and M. Kulesza. Characteristics of animal species colonizing urban habitats. *Memorabilia Zool.*, **37** (1982), 71–7.

Robinson, W. H. *Urban Entomology: Insect and Mite Pests in the Urban Environment*. London: Chapman and Hall, 1996.

Stearns, F. W. and T. Montag. *The Urban Ecosystem: A Holostic Approach*. Stroudsburg, PA: Dowden, Hutchinson and Ross, 1974.

Story, K. (ed.). *Handbook of Pest Control: The Behavior, Life History and Control of Household Pests by Arnold Mallis*, 7th edn. Cleveland, OH: Franzak and Foster, 1990.

Tasutomi, K. and K. Umeya. *Household Pests*. Tokyo: Zenkoku Noson Kyoiku, 1995.

Tischler, W. Ecology of arthropod fauna in man-made habitats: the problems of synanthropy. *Zool. Anz.*, **191** (1973), 157–61.

Yanitsky, O. N. Towards an eco-city: problems on integrating knowledge with practice. *Int. Soc. Sci. J.*, **34** (1982), 469–80.

2 The urban ecosystem

Introduction

Major ecosystems can be broadly classified as natural, agricultural, and urban. Natural ecosystems are primitive sites where the interacting plant and animal communities have not been altered by human activity. There are few, if any, of these in the world today, and a more practical definition of natural ecosystems might be undisturbed habitats that have had limited human influence, and retain a portion of their original flora and fauna. An important feature of these habitats is the populations of native plants and animals. These are the reservoir populations of many species that have adapted to agricultural and urban conditions. Agricultural and urban ecosystems are defined by their use and the degree to which their biotic and abiotic features have been altered by human activity. These ecosystems contain few of the features that characterize their natural origins; many of the features were built or brought there, or designed by humans. The degree of change and land use can be used to subdivide these two cultural ecosystems.

Agroecosystem A is the least developed form of agriculture. It consists of small farms with a mix of domesticated animals and crop plants; it is generally expected to provide food and fiber for family groups or communities. Agroecosystem B is the most developed form of agriculture. It is characterized as mechanized farming of a single crop (soybeans, maize, wheat) or single-animal species (swine, cattle, poultry). Modern definitions of this ecosystem would include use of genetically improved or engineered crops.

The term urban is often used synonymously with city, but when used in the context of the urban environment it extends to plant and animal communities in cities and surrounding suburbs. There is a continuum of inhabited sites and human activity from the primitive farmhouse to metropolitan office building, and the division between urban, suburban, and rural is indistinct. The urban environment has levels of modification and changes in the physical landscape and biotic communities similar to those found in the agricultural ecosystem. Urban-ecosystem A is the rural–suburban landscape, and includes natural and undisturbed sites, such as small wood lots or agricultural fields. Urban-ecosystem B is the cityscape of commercial and residential neighborhoods, with a limited amount of planned greenspace and undisturbed areas. As in agriculture, these divisions are based on human interaction and intervention with the landscape and associated plant and animal communities.

Urban ecosystems

Development of what is known as suburbia began in the 1800s with people from the upper and middle classes moving to the perimeter of the industrial cities. The crowded living and poor sanitary conditions in the early cities was an incentive to move to the rural conditions of the periphery. Movement to the suburbs continued in the 1920s and 1930s, and it increased worldwide after 1945 with improvements in transportation and highways systems. By the 1960s, major cities in the industrial countries had a distinct suburban perimeter (urban-ecosystem A), and a commercial core (urban-ecosystem B). Urbanization continues around the world through urban sprawl; this is a process in which the suburban residential and commercial land use spreads into peripheral farmland and natural areas. The outward spread and fusing-together of adjacent towns has led in many places to the formation of conurbations. The traditional concept of the city as a clearly defined entity has given way to terms that better describe its size, such as megalopolis, or ecumenopolis.

The outlines of such large urban areas can be discerned in the Great Lakes area and the northeastern seaboard of the USA, along the highways and transportation systems that link Tokyo and Osaka, Japan, and in Europe, in the zone of intense urban development that extends from London through Rotterdam to the Ruhr in Germany.

Urban-ecosystem A is typically 60% greenspace and 40% built landscape, and has a range of soil types, drainage systems, ground cover, and plant and animal species. It is a mix of land use: undisturbed areas, planned and unplanned greenspace, and commercial and residential buildings. Greenspace varies in size and use, and includes golf courses, tracts of recreation and parkland, lakes, and waterways, and the ornamental shrubs, trees, and turfgrass associated with the gardens and yards of residential housing. Undisturbed areas may be plots of trees or secondary vegetation on land bordering residential or commercial sites. The interface of suburbia with small-scale agriculture may be abrupt and with little space (often a roadway) between them. The spread of suburbia often brings residential areas close to established livestock and poultry farms, landfills for household waste, dumps for automobile tires, or industrial refuse sites. These operations have insects and other animals that become pests in adjacent areas. Interface with the city may be a gradual decrease in greenspace and increase in residential and commercial built areas.

At the periphery of cities in developing countries are zones of dense, unplanned, and impoverished housing. These shantytowns vary from country to country, but they are an established feature of major cities, and represent 20–30% of the new urban housing in the world. Most new housing in developing countries is built on unclaimed land by squatters, without consideration for local or government regulations. This housing is considered the *septic fringe*; it is composed of crowded conditions, substandard housing, and with limited access to clean water and waste removal. Here are habitats suitable for populations of vertebrate and invertebrate disease vectors with a flight and foraging range to bring them into contact with a large portion of the city's population.

Suburbia is composed of planned communities and structured greenspace; some of these peripheral areas are considered the *affluent fringe*. Houses and other buildings are surrounded by ornamental shrubs, trees, and turfgrass, and the landscape includes flower gardens, and in some neighborhoods there may be water fountains and swimming pools. As in the septic fringe, there are habitats in the affluent fringe suitable for insect vectors of disease, and successful populations of rodents and wildlife species. Planned development and improved living conditions often mean reduced diligence and less compliance with insect control programs. In these neighborhoods there may be more rather than fewer breeding sites for pests, such as mosquitoes, black flies, wasps, and beetles. The mix of vegetation and the availability of food and harborage often provide an abundance of vertebrate hosts and arthropod vectors of pathogenic organisms.

Urban-ecosystem B is the most developed ecosystem, with about 60% of the surface area consisting of hard-surface and built structures. It is the built landscape of the city and characterized by an uneven distribution of exposed soil and sparse vegetation. It is dominated by the hard surfaces of roads, sidewalks, parking lots, and permanent structures. Here the land surface has been radically altered, and the existing plants and animals selected and maintained by human activity. This ecosystem typically interfaces with a suburban landscape. The mixed-density landscape of houses, low- and high-rise residential buildings, and single-family homes at the edge of a metropolis is sometimes considered semiurban or the inner suburbs; perhaps it is a transition zone between urban-ecosystems A and B.

Agriculture interface

The urban interface with agriculture often occurs when suburban sprawl, bringing with it residential and commercial land use, is developed close to animal farms. Dairy cattle, livestock (swine and beef), and poultry operations are often encroached upon as the suburban ring of cities spreads. The flies typically associated with the manure at these operations can disperse several kilometers and create a nuisance during nearly all months of the year. Dairy cattle herds may have 50–200 cows; in temperate regions they are housed in barns or buildings for part of the year; in warm regions they are outside most of the time. Poultry egg production is usually in 100 000-bird buildings in groups of 10 or more, and they function year-round. Manure produced at these operations can support large populations of house fly (*Musca domestica*) and stable fly (*Stomoxys calcitrans*), and in some regions *M. sorbens*. An average 1.8-kg laying hen produces about 113 g of wet manure daily; this is 11 300 kg per day or 4139 metric tons per year for each 100 000-bird poultry building. Feedlots may have 1000–3500 cattle at one time, and each feedlot cow produces about 23 000 g of wet manure daily. Stable fly and house fly maggots require about 2 g of manure to complete development, thus the potential for livestock and poultry operations to produce flies and problems is significant. Other feedlot operations, such as those for turkey and chicken production, have accumulations of manure. Accompanying the accumulation of animal and poultry manure is a concentrated manure odor, and this is also a nuisance during most of the year. Adult flies can travel 20 km or more from breeding sites, or be carried by prevailing winds to nonfarm sites and be a nuisance and sometimes a health hazard. In some countries, right-to-farm laws provide some protection to farmers, but fly control is an important feature of modern agriculture.

Other sites in or around urban areas may have accumulations of animal dung and associated flies feeding on this resource. Zoos, kennels for dogs and cats, stables for riding horses, and large recreation theme parks have large animals, and manure disposal at these sites can be difficult since it may not be easily spread on adjacent farmland. Fly populations at these sites may be seasonal in temperate regions, but small numbers of adults will be present during winter months. Other insects are associated with the manure and the fly populations, including yellowjackets, carabids, and dung beetles.

Natural area interface

The urban interface with undisturbed or natural areas occurs when suburban sprawl brings residential housing developments close to or at the edge of land set aside or preserved as a natural site. Wilderness or relatively undisturbed areas may provide reservoir populations for domestic and peridomestic pest species, including yellowjackets and carpenter bees, carpenter ants, subterranean termites, and some species of ticks and mites (chiggers). Large- and small-animal populations would increase the potential of arthropod-borne diseases, such as Lyme disease, Rocky Mountain spotted fever, West Nile virus, and plague.

Many mountainous or wilderness areas used for recreation in the western USA contain large populations of plague-positive rodents. A large number of plague cases in the USA have been contracted during recreational pursuits, or in suburban areas adjacent to wilderness land. Increased urban growth has resulted in large numbers of people living in or near areas with rodent populations that harbor plague. The peridomestic habitats created in residential neighborhoods provide harborage and food for adaptable rodent species, such as ground squirrels and rock squirrels, chipmunks, and prairie dogs. These species have increased in density, and their fleas are efficient vectors of plague to humans and other animals, such as domestic cats. Most cats acquire plague by ingesting infected rodents, and they spread plague by a scratch or bite, or by aerosolized droplets in the case of pneumonic plague. The number of confirmed cases of plague in the USA directly transmitted by domestic cats is increasing, and is usually associated with residential areas.

Urban habitats

The structural complexity of cities includes features that provide harborage and food for arthropods and other animals. Parks, recreation areas, and other greenspace have natural habitats for vertebrates and invertebrates; the system of storm water and sewer pipes provides artificial habitats for other animals. Garbage collection points and landfills are consistent features of urban environments around the world, and these sites provide habitats for arthropods, rodents, and pest birds. Livestock agriculture in the form of poultry egg and meat production, feedlots for swine, and beef cattle often interface with residential and commercial land.

Parks, greenspace, and gardens

Many cities have been designed to include space for large and small parks, peripheral green belts, or forested areas along small streams and rivers. These areas break the monotony of residential and commercial buildings, influence local temperature and humidity, and provide neighborhoods with an open recreation site. Early in the development of cities in the USA and Europe large tracts of land were set aside for parks: New York's Central and Prospect Park, and Hyde Park in London are examples of this planned and dedicated space. Once established and integrated into the landscape and seasonal activities, they become an important part of the urban environment.

Cities can have two classes of open areas or greenspace: those that have been intentionally established as parks or recreation plots, and the unplanned sites of vacant lots and roadways. In the former, the diversity of plants and animals may be limited, and these sites are somewhat influenced by use patterns of people and domestic pets. Vacant lots, backyards, roadway median strips, and the rights-of-way of railroads and other roads may have a great variety of plants and animals. Modern highway and expressway systems that enter or circle urban areas often have broad medians and shoulders, and these may be planted with turfgrass, wildflowers, trees and shrubs. These narrow strips of land often have a large and diverse invertebrate fauna.

Accompanying the recent phenomenon of urban sprawl and expanding suburbs has been the increase in household flower gardens. Despite the conditions of urban high-rise buildings and a concrete and asphalt substrate, urban gardens are flourishing in many regions. Although gardens have been a feature in European cities since the 1760s, the availability of potted plants and exotic species have made it a personal pastime with psychological and economic benefits. An urban or suburban landscape of trees, shrubs, or flowers adds economic value to property: in some cases an increase of 12–30% can be achieved. However, the widespread popularity of household and public gardens can also be accompanied by some health hazards. Whether native or exotic plant species are used, urban gardens may provide food, habitat, or harborage for invertebrate disease-vectors and their vertebrate hosts. Urban wildlife, such as rabbits (*Sylvilagus*), deer (*Odocoileus*), chipmunks (*Tamias*), mice (*Peromyscus*), and voles (*Microtus*), feed on a variety of garden plants and seeds, and populations often become large and difficult to control or even manage. Their pest status is based on damage to garden plants, nesting habits, and serving as hosts for ticks and other blood-sucking insect vectors. Increases in Lyme disease and Rocky Mountain spotted fever in eastern USA may be attributed to deer and rabbit populations.

Sanitary sewers and storm sewers

An essential urban infrastructure is the network of underground pipes that remove waste water from toilets and kitchens, and storm water runoff. Many of the urban sewers and storm drains constructed in the 1700s and 1800s are still in use, and in some cities they have been extended or connected to recently developed networks. This elaborate drainage system is hidden from view, and perhaps from the realization that it often provides food and harborage for mosquitoes, cockroaches, rats, and other invertebrate and vertebrate pests. The availability of resources and uniform environmental conditions often results in year-round pest populations in these underground pipes.

Urban areas may have different systems for handling household waste water and for removing surface or storm water. A combined system brings together household waste and surface runoff water into one network of pipes and delivers the combined discharge to a centralized sewage treatment facility. Some cities have a system which diverts household waste and storm water to separate pipes. Those pipes carrying only surface water discharge at various points into natural watercourses, and the waste water is directed to a sewage-treatment facility. The separate system diverts the majority of surface water to storm sewers, but some of it may be combined with sewage and treated before being released. While both methods can provide harborage and other resources for pests, the combined waste water system is most likely to support pest populations, because of the food contained in the toilet and kitchen refuse.

The storm water drainage system of pipes carries away large amounts of water that may otherwise accumulate on roads and streets following excessive rain or snow. Water from streets and sidewalks flows into the underground network of pipes through inlets and catch basins positioned along the curb and street corners. Inlets are covered by a grate and connected to a catch basin before leading to a drainpipe. A catch basin is usually a rectangular storage box located under the street. It is designed to trap street debris before it enters and obstructs the flow of water into drainpipes. Not until water reaches a certain height in the catch basin does it flow into the major storm drain. Because of their construction and underground location, catch basins often retain water for long periods. The combination of organic matter and standing water in a dark and protected location provides a breeding site for several species of mosquitoes. These sites also provide a source of food for cockroaches and rats. Similar conditions are present in some of the underground mass-transit systems and shopping areas in major cities of the world.

Solid waste disposal and landfills

Collection and disposal of solid waste is important to human health and the daily operation of a city. Waste produced by households and commercial sources is collected and transferred to a landfill, a site dedicated and specifically managed for waste disposal. It may be close to the city or carried to a distant location. Municipal solid waste originates from daily activity in households, hotels, hospitals and health care facilities, and restaurants, and it contains 10–50% wet and putrescible organic material. The high organic content is a potential food resource and harborage for insects, pest birds, and rodents. The utility this material has to these pests is influenced by the techniques used for collection, and the short- and long-term disposal.

Open refuse sites may be the primary method for collecting the garbage from small communities or neighborhoods in some parts of the world. These sites are usually exposed, three-walled bins, large metal containers, or simply a vacant plot of land. Depending on the size of the areas served, there may be one or more of them in a neighborhood. Although this method leaves organic refuse vulnerable to pest infestation, concentrating household refuse in designated sites enables efficient removal and is better than uncollected garbage in the street. Depending on climate and seasonal temperatures, frequency of collection, and the organic content, open public refuse sites support large infestations of flies and rodents, and often attract birds, dogs, cats, goats, and other animals. Rodents and flies may establish long-term populations at these sites, and move from there to forage in or infest surrounding buildings. Fly maggots within the garbage at the time of collection may be removed from the population; full-grown larvae leave the refuse to pupate and avoid collection, and remain to reinfest. Hot and dry weather can reduce the attractiveness of refuse piles to flies, and hot and wet weather may extend it.

Galvanized steel or plastic containers with lids are typically used to hold household dry and putrescible material. Ideally, the garbage is secure until emptied into a collection vehicle, but lids on garbage containers may not completely prevent entry of rodents, flies, wasps, and other insects. Various species of flies can infest these containers: fruit flies access openings that are 1–2 mm wide and adult blow flies are capable of moving through openings 3.2 mm wide. Holes or cracks in the bottom of containers allow full-grown maggots to leave, or large blow fly maggots may climb the inside surface of metal containers to find a suitable pupation site outside. In some cities, 60% of the garbage containers may be infested with fly larvae. Rodents gnaw small holes in the bottom and sides of plastic containers, and leave them accessible to further attack. The lids of garbage containers are often not used and garbage is exposed. Daily or weekly garbage collection is partly a function of climate and the local authorities. Long collection intervals, combined with putrescible waste, loose-fitting lids, and damaged containers often result in pest problems.

Many of the large cities of the world rely on a local landfill to take their daily garbage; these sites are usually originally established at the periphery of the city. Landfill sites must be easily accessible and large to accommodate the quantity of solid waste and other material a city produces in the course of 10–15 years. For disposal in most large metropolitan landfills, garbage is first taken to a transfer site where it is emptied from the collection vehicle and loaded into a compactor or incinerator to reduce the volume. It is then transported to the landfill, which may be local or a long distance away. Key to the successful operation of transfer stations is the rapid processing of refuse. Regardless of their efficiency, transfer stations often attract flies, rodents, and pest birds, and their presence can cause problems in surrounding neighborhoods.

Compacted or loose garbage at the landfill is usually covered to reduce odor and the attraction it has to various pests. Soil is commonly used for cover, and the thickness of the layer is important to fly control. Cover soil that is less than about 150 mm is not sufficient to prevent fly emergence completely. House fly adults are capable of moving to the surface from beneath 250 mm of soil, and blow flies and flesh flies are known to emerge from feeding sites 450 mm within compacted refuse. When soil is unavailable or the costs for it are high, other materials, such as paper pulp, fragmented plastic, sand, woven geotextiles, and plastic sheets may be used. In direct sunlight plastic sheets create in the underlying refuse a microclimate with temperatures high enough to prevent fly development. However, these sheets may interfere with rainwater percolation and natural compaction, and trap landfill gases.

The house fly and local species of blow flies are the most common insects at urban landfills around the world. At landfills, these flies may breed continuously through the year, but with decreased numbers in the cold months. Crickets and cockroaches, including the German cockroach, can become established at landfills, depending on local conditions. Infestations of cockroaches have been linked to buried lots of household material that came to the landfill infested. Once at the site, populations were maintained by the available food and only limited compaction to provide harborage. The pest bird species varies according to location, but the most common are gulls, crows, starlings, and kites. They rarely nest at the site, but usually include the landfill within their foraging territory. The brown rat is common in landfills around the world. Large vertebrates, such as foxes, feral dogs, and goats also regularly occur.

There may be few stable habitats directly on the landfill to support vertebrate populations; most pest species only move to the landfill for feeding and have established nests offsite. Although there is a continuous source of garbage, the working face for dumping changes and there is regular (day and night) disturbance by workers and vehicles. Sudden disturbance of house fly, cricket, and cockroach populations can result in the dispersal of large numbers to areas surrounding the landfill. House flies and blow flies are capable of traveling 1–3 km from infested sites, and cockroaches can move across a varied landscape to building perimeters. Large numbers of seagulls at landfills can disrupt the operation of compaction and earthmoving equipment and spread disease. Feces from gulls at landfill sites have been shown to contain human pathogenic bacteria, such as *Escherichia coli* 0157. Landfill gulls have the potential of transporting such bacteria to farm and urban sites.

Urban environmental features

Urbanization has pronounced effects on the abiotic components of the environment. Concentrations of heat-absorbing surfaces of streets, highways, parking lots, the limited amounts of greenspace and open soil, and large amounts of pollution and particulate matter in the air result in cities having a climate different from the surrounding countryside. Climatic changes can occur in the form of seasonal temperature highs and lows, in intensity and direction of the windfields around buildings, and in amount of rainfall and runoff conditions. Climate is the net combination of temperature, water vapor in the air, precipitation, solar radiation, and speed of the wind. Meteorological variables that are usually distinctly different between cities and open country include day and night temperature and relative humidity, rainfall, and fog. The most recognized city-climate phenomena are persistent smog, early blooming or leafing of flowering plants, and longer frost-free periods in north temperate regions.

Urban substrates

Up to 33% of the land surface in cities is occupied by hard surfaces in the form of roads, sidewalks, and parking lots. A nearly equal proportion is taken up by buildings and other built structures, with the result that 60–70% of urban areas in modern cities consists of surfaces formed from nonporous materials. Only the remaining third of urban surface can be considered porous for water circulation and water vapor exchange, but these may be covered with refuse and other debris. Hard surfaces of cities generally accept more heat energy in less time than an equal amount of soil; by the end of the day, brick or concrete surfaces will have stored more heat than an equal surface of soil. However, hard surfaces of buildings and pavement release or conduct heat about three times as fast as it is released by moist, sandy soil. The variety of light- and dark-colored building and sidewalk surface, the reflection and absorption of sunlight, and conduction of absorbed heat energy are linked to city–countryside climate differences. Urban buildings have a breaking effect on wind, and this may reduce the amount of heat that is carried away.

Buildings and other features add to the three-dimensional complexity of cities. The result is a rise in the mean temperature, forming what is called an *urban heat island*. This island results from the reduced amount of evaporative cooling, heat retained by surfaces, and heat produced by vehicles and machines. One feature of the heat island is the limited range of daily high and low temperatures. Despite the large amount of (sunlight) heat absorbed and heat radiated by structures, shading by buildings and narrow streets keeps sunlight from many urban surfaces, thus lowering the maximum daily temperature. Summer nights in the suburbs may be cool, but in the city temperatures may be only a few degrees lower at midnight than at sundown. The physical mass of the city acts as a buffer, damping temperature extremes. Since air is primarily heated more by contact with warm surfaces than it is by direct radiation, city surfaces (buildings, roads, and pavements) are capable of heating large volumes of air. The dome of warm air that is regularly over large cities forces moisture-laden clouds upward into colder air, which initiates rain. Solid, liquid, and gaseous contaminants characterize the air of most modern cities, some more than others. About 80% of the solid contaminants are particles small enough to remain suspended for long periods. These particles directly influence rainfall and air temperature in cities. Particulate matter provides nuclei for the condensation of atmospheric moisture into rain. The general rule is, as cities increase in size, air pollution increases, and rainfall increases.

Measurable rainfall in cities is shed from hard surfaces and quickly removed through drainpipes, street gutters, and storm sewers. The urban landscape was developed from agricultural or natural land; construction usually involves removing native vegetation along with upper layers of soil (topsoil), and reshaping the existing topography. One of the outcomes of these changes is altering the natural routes of rainfall runoff. Once an urban center has been developed, flood peaks in streams and rivers that are a part of the habitat often increase two to four times in comparison with preurbanization flow rates. The increases are due to pavement and roadways that cover a large percentage of the surface in suburban areas, and nearly all the surface in business and industrial areas. This reduces the amount of rainwater that infiltrates soil, and increases runoff and sediment in streams and rivers. Pollution from increased runoff affects plant and animal communities in and along the bands of these waterways.

Prevailing winds are usually rapidly decelerated over towns and cities compared with the open countryside. Wind velocity may be half what it is in the open countryside, and at the edge of the urban area wind velocity may be reduced by a third. One reason for this is the increased surface texture caused by the mixture of short and tall buildings. Cities have reduced average wind velocity in direct proportion to their size and density. Along roads and highways parallel to the wind direction, wind velocity increases and may be disruptive to people and flying insects. Trees along these wind routes, and trees in greenspace and parks can help to reduce urban wind speeds. However, the presence of large patches of vegetation and blocks of urban trees can contribute harborage and breeding sites for pests, such as birds, rodents, and other wildlife. Some insects that naturally occur in suburban or rural areas are easily moved by winds, and may be carried into the edges of the city. Cloudless skies at night and the horizontal temperature gradient across the urban/rural boundary can be sufficient to create a low-level breeze from the rural area into the city. This flow of air from suburban or agricultural areas into the city can aid and direct the movement of small, dusk- or night-flying insects, such as mosquitoes.