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National Water-Quality Assessment Program

Stream Ecosystems Change With Urban Development

Natural Stream Ecosystem

The healthy condition of the physical living space in a natural stream—defined by unaltered hydrology (streamflow), high diversity of habitat features, and natural water chemistry—supports diverse biological communities with aquatic species that are sensitive to disturbances.

Urban Stream Ecosystem

In a highly degraded urban stream, the poor condition of the physical living space—streambank and tree root damage from altered hydrology, low diversity of habitat, and inputs of chemical contaminants—contributes to biological communities with low diversity and high tolerance to disturbance.

What is a stream ecosystem? A stream ecosystem is defined by the hydrology, habitat, and chemistry conditions and the biological communities within the stream, all of which are influenced by activities in the surrounding watershed. A complex and well-balanced ecosystem provides recreation, aesthetics, food, water, nutrients, and many other valuable assets to humans, animals, and plants that live in the area. Natural stream ecosystems are well adapted to seasonal environmental changes, such as annual flooding and drought cycles.

Every stream is connected downstream to other water bodies including rivers, reservoirs, and ultimately coastal waters. Inputs of chemical contaminants or sediments at any point along the stream can cause degradation downstream with adverse effects on biological communities and on economically valuable resources, such as fisheries and tourism.

Urban development is associated with changes in the natural environment such as alterations to the hydrology, habitat, and chemistry of a stream, which result in stressors to biota in stream ecosystems. Impervious surfaces, such as parking lots, roads, and rooftops, limit the amount of rainwater seeping into the ground, which increases stormwater runoff. Urban areas often experience a rapid rise in streamflow after a rainfall, which can erode streambanks and bottoms and degrade fish spawning and feeding habitats. Stream channels are often reinforced with concrete or large rock to minimize erosion and control flooding. Water temperature increases when tree cover is removed along the banks, thus exposing the stream to more sunlight. Chemicals, wastes, and sediment—from industry, animal production, water treatment, and runoff from impervious surfaces—increase in the stream and can be toxic to biological communities. Biological communities have different life cycles and requirements for food, shelter, and reproduction; consequently, their responses also vary with changes in physical and chemical conditions related to urban development.

Understanding how algal, invertebrate, and fish communities respond to physical and chemical stressors associated with urban development can provide important clues on how multiple stressors can be managed to protect stream health as a watershed becomes increasingly urbanized.

Natural Stream Ecosystem Hydrology, Habitat, Chemistry Conditions

Rainfall gradually reaches a stream in a natural or undeveloped setting by flowing over the land surface into the stream and by seeping into the soil and flowing underground (as groundwater) toward the stream. These natural seasonal patterns of **hydrology**, together with seasonal changes in light and temperature, serve as life cycle cues to the biological communities.

Stream **habitat** is the physical living space of aquatic biota and includes the channel size and shape, water depth and velocity, and structures within the stream, such as woody debris and boulders. Slow moving, deeper areas of a stream are called pools, and faster flowing shallow areas are referred to as riffles. A natural stream with multiple habitats generally will have a diverse biological community.

Some **chemicals** and nutrients, such as nitrogen and phosphorous, are required for all stream life. Nutrients are incorporated into algae, which are then consumed by other biota, such as invertebrates and fish, thus introducing the nutrients into the aquatic food web. Oxygen dissolved in water is essential for all biological communities, and adequate amounts of oxygen are necessary to support a diverse biological community.

Videos, podcasts, articles, and fact sheets describing the USGS assessment of the effects of urban development on stream ecosystems in nine metropolitan areas of the United States are available at *http://water.usgs.gov/nawqa/urban/*.

Natural Stream Ecosystem Biological Communities

Fish have life cycles that can span years and are affected by stream hydrology, habitat, chemistry, and other biological communities. Fish are relatively mobile along the stream as they search for food. Smallmouth bass can hide under logs or undercut banks, along stream edges or in pools, and emerge to feed on crayfish and small fish. Greenside darters live in riffle habitats of streams, where they feed on aquatic invertebrates, such as dragonfly larvae.

Invertebrates have complex life cycles that occur over time spans of weeks to years. Most aquatic insects spend nearly all their life in the water as eggs and larvae, and then leave the water and develop wings as adults. This dragonfly larva lives in areas of slower streamflow, where it preys on other invertebrates and even some small fish. Many species of dragonflies are sensitive to pollution, as are mayflies and stoneflies. These invertebrates crawl on the surfaces of rocks and feed by gathering and shredding leaf debris, scraping off algae, or preying on other insects.

Algae, such as these diatoms, are microscopic plants and are the foundation of aquatic foodwebs. Algae have short life cycles of days to weeks, and they can respond rapidly to changes in sunlight, water chemistry, and streamflow. The most common algae reported in natural streams of small-to-moderate size are diatoms, which attach to underwater surfaces, such as rocks and aquatic plants. *Cymbella* is found in riffles, while *Epithemia* is found in both pools and riffles.

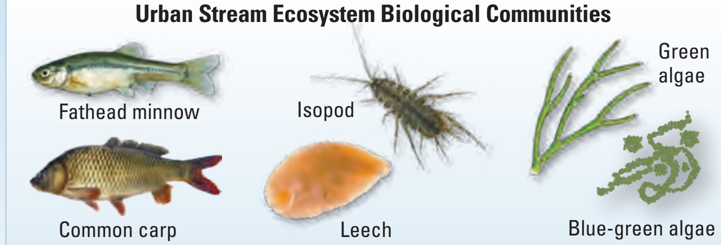
Urban Stream Ecosystem Hydrology, Habitat, Chemistry Conditions

Urban development in a watershed alters the **hydrology** or movement of water through a watershed. As the amount of impervious surface and artificial drainage systems (for example, storm drains) increases with urban development, stormwater runoff from developed sites occurs more quickly. The higher streamflows that often result can alter stream channels through streambank erosion and can increase the magnitude of seasonal floods to a level that damages homes and property near the stream and in the flood plain.

Urban development can alter **habitats** that provide living spaces for the biota in and around the stream. Plants and trees near a stream can be removed to increase the amount of light reaching streams, and cement or rock can be added to the channel to protect it from high streamflow. Sediment from erosion can fill spaces between rocks on the stream bottom, thus reducing living space or habitat for the biological communities.

Urban development might increase the inputs of **chemicals** to levels that greatly exceed those that occur naturally in streams and can be toxic to the biological communities. For example, excess amounts of nutrients from fertilizers can lead to an abundance of algae and might result in extreme high and low levels of dissolved oxygen in a stream. Pesticides from lawn care or insect control and heavy metals from industry and vehicles can be ingested or absorbed by the biological communities.

Urban Stream Ecosystem Biological Communities



Native **fishes** that are sensitive to changes in the stream ecosystem generally become less abundant with increased urban development, while tolerant fishes can thrive. The fathead minnow, although native to streams in the United States, tolerates muddy, low-oxygen water that is typical of many urban streams. Fish that are more tolerant to urban stressors are often non-native species, such as the common carp, that prefer slow or still water and silty stream sediments.

Urban development leads to a loss of **invertebrate** species that are sensitive to pollution, such as mayflies and stoneflies, and an increase in more tolerant species, such as leeches and isopods. The loss of species that are sensitive to pollution can begin at very low levels of urban development. Tolerant species, such as leeches are most common in warm, protected shallow areas of streams. Isopods prefer slower moving streams with relatively low dissolved oxygen levels.

An increase in urban development often results in a high abundance of **algae** that are tolerant of pollution. Diatom algae tend to decrease and non-diatom algae tend to increase with urban development. Some non-diatom algae, such as green or blue-green algae that appear as a green coating on the surface of the water and rocks, are in low abundance in natural streams but might increase in abundance to nuisance levels from open sunlight- and nutrient-rich conditions in many urban streams.

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