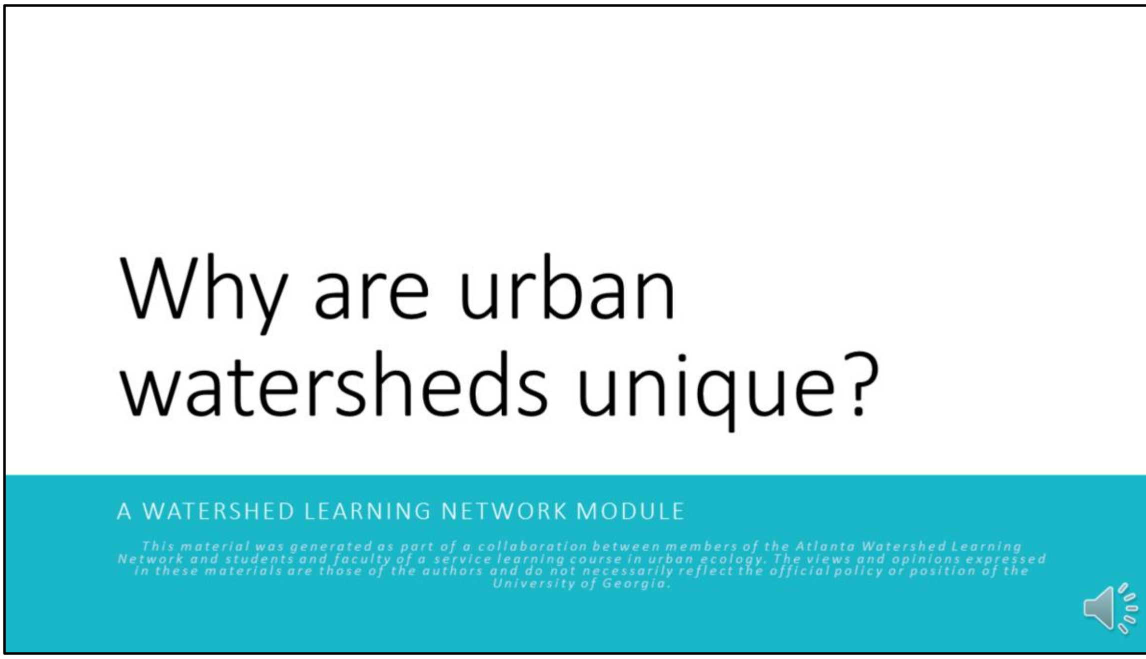


In this module, we will discuss what is a watershed and why they are important. We will discuss some important definitions and discuss how urbanization influences watershed function.

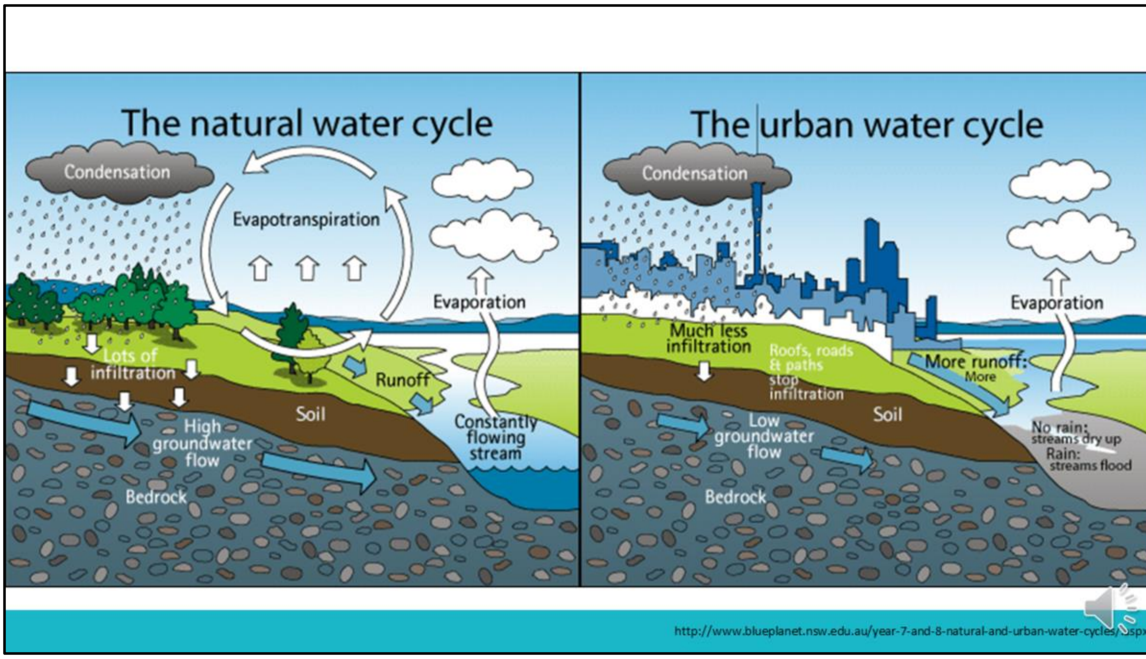
This material was based on a curriculum developed by members of the Atlanta Watershed Learning Network, led by Dr. Yomi Noibi of Eco-Action.

Unless otherwise noted, all of the diagrams and models used in the modules were created by Diane Kelment, the video material was captured and edited in large part by Allison Krausman, and the images used in the modules were taken by the students or instructor of the urban ecology course at UGA in 2018 or the West Atlanta Watershed Alliance.

The views and opinions expressed in these materials are those of the authors and do not necessarily reflect the official policy or position of the University of Georgia.

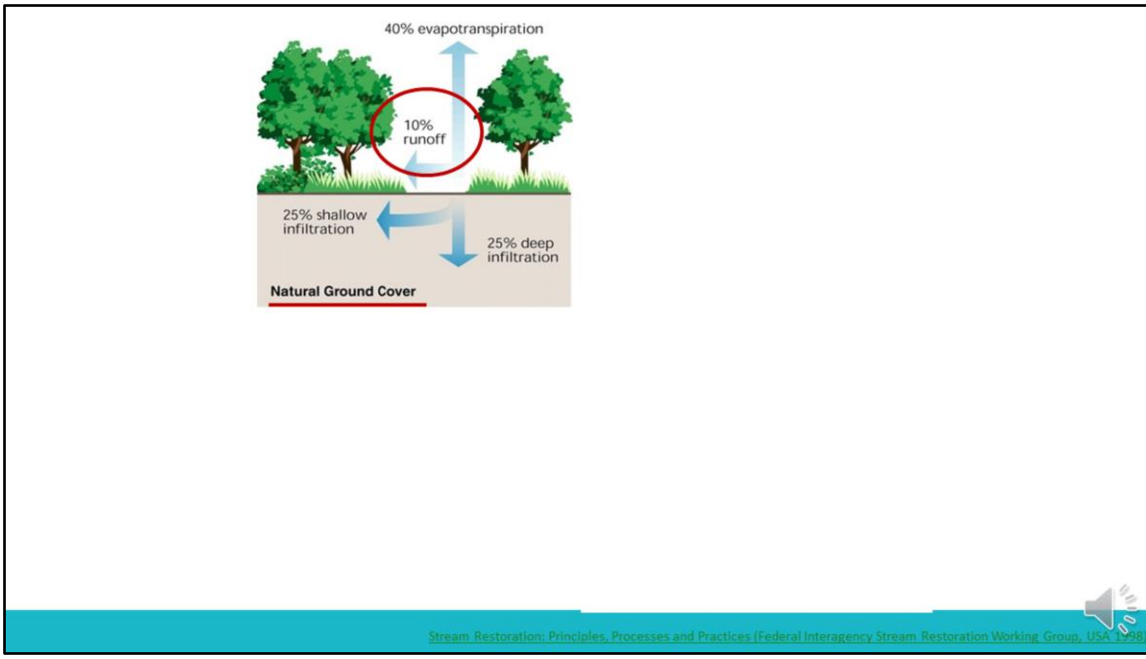
It is true. Everyone does live in a watershed. A watershed is an area of land where water from rain or snow drains into a larger body of water, such as rivers, marshes, lakes or oceans. As you can see in this figure, water entering a watershed through surface water, such as rain or snow, flows downhill. If surface water percolates, or drains through soil, it can enter the ground water. Both surface water and ground water flow into larger bodies of water. Trees, grass, and other plants play important roles in watersheds by transpiring water and stabilizing soil with their roots. They can play important roles in preventing erosion, which in extreme cases, can lead to landslides.

If you live in the United States and would like to see your watershed, please click on the link on the slide.



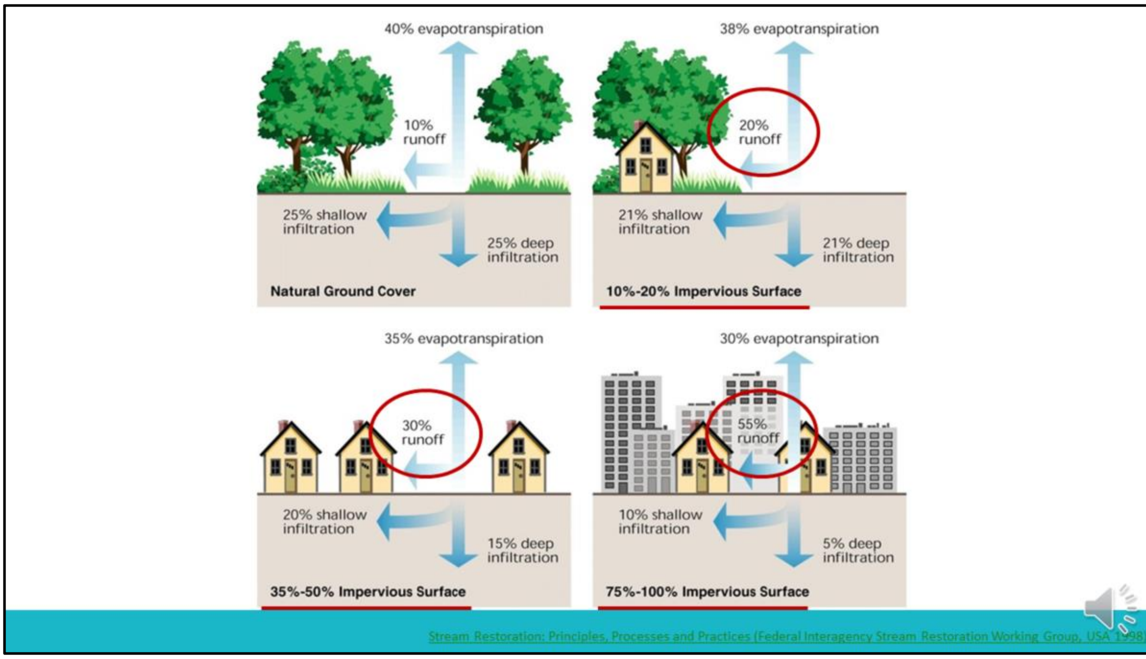
The natural water cycle is a series of connected processes of evaporation, condensation, precipitation and groundwater flow. The water cycle still exists in urban areas, but it is influenced by the amount of and type of development and changes in climate and geology associated with growing towns and cities. Urbanization influences the water cycle in many important ways, however, for the purpose of our discussion, we will primarily be focusing on increases in surface runoff due to decreases in infiltration (or the ability off the water to filter through the ground and enter the groundwater.

These images were taken from the BluePlanet website, who credit the Aukland Council with the development of the images.



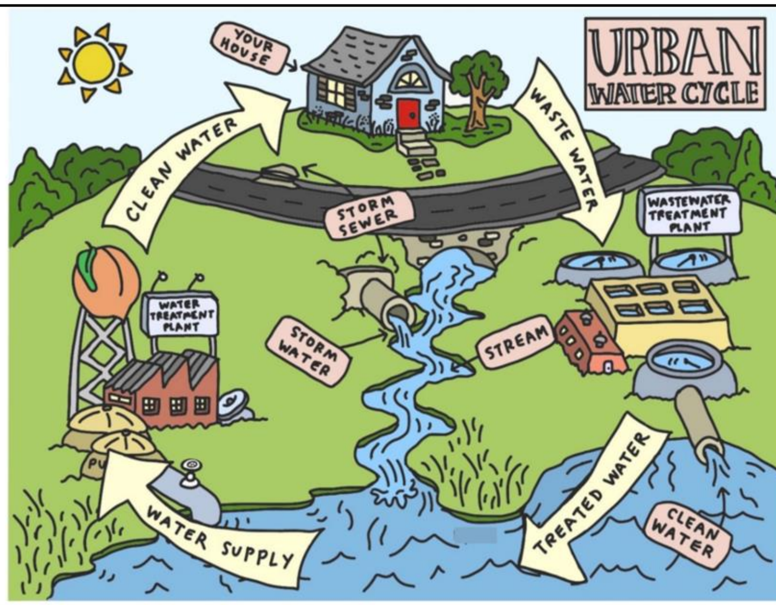
In a natural system, approximately only 10% of the water coming into the system as precipitation will create surface runoff, or water flowing over land. The remaining water will either filter into the ground through the soil or go back into the atmosphere through evapotranspiration, the process of water evaporating from land and water and or being transpired or released by plants.

From: Stream Restoration: Principles, Processes and Practices (Federal Interagency Stream Restoration Working Group, USA 1998).
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044574.pdf



However, increasing impervious cover, or surfaces that do not permit water filtration through the soil, in a watershed results in increased surface runoff. Impervious surfaces include roads, parking lots, and roofs. As we can see from this figure, as little as 10 percent impervious cover in a watershed can result in increases in the amount of water running over land. In addition to creating problems with flooding, increases in surface runoff can lead to stream degradation and can carry large amounts of pollutants into urban streams.

From: Stream Restoration: Principles, Processes and Practices (Federal Interagency Stream Restoration Working Group, USA 1998).
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1044574.pdf



- The flow paths of water within a city can also be complex. Often, rivers flowing near cities function as both the sources of drinking water and the disposal site for wastewater once it has been treated. This has important implications especially when cities and towns are facing challenges of aging and obsolete water infrastructure and are subject to system failures or situations where untreated sewage enters the watershed.

Urban watersheds are influenced by the urban climate

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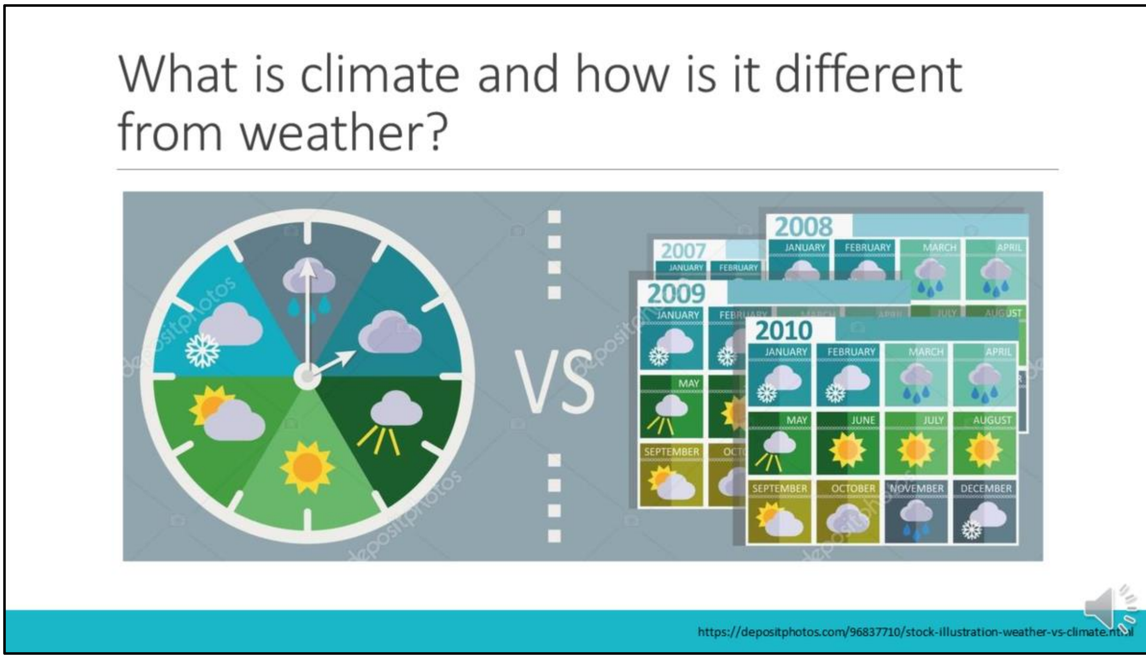


One of the important concepts that is needed to understand how urban watersheds function is the difference between climate and weather. In general, “weather is what conditions of the atmosphere are over a short period of time, and climate is how the atmosphere "behaves" over relatively long periods of time” (https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html). Another way to think about it is that weather describes the conditions today or tomorrow, and climate is the average weather over years or even longer periods of time.

If you want to learn or teach more about the differences between weather and climate, you may want to check out this episode of Crash Course where Sabrina talks about the difference between the two concepts!

Urban climates are different and this can affect urban watersheds!

Urban climates are different and this can affect urban watersheds!

Urban Heat Island

Urban areas have higher average temperatures than the surrounding non-urban areas

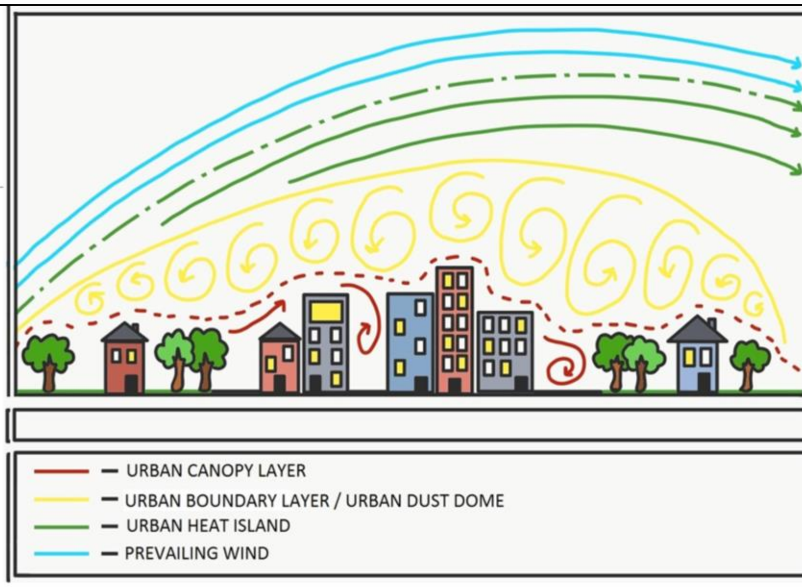


Image concept from Adler, F. R., & Tanner, C. J. (2013). *Urban ecosystems: Ecological principles for the built environment*. Cambridge: Cambridge University Press.

One of the most important concepts to understand about urban climates is the urban heat island.

Urban areas have higher average temperatures than the surrounding rural areas. For example, the US Environmental Protection Agency states that the annual mean air temperature of a city with 1 million people or more can be 1.8–5.4°F (1–3°C) warmer than its surroundings. In the evening, the difference can be as high as 22°F (12°C). (https://www.epa.gov/heat-islands)

Consider this, have you ever been in a city and then left the city for a more rural area on a summer day? It is typically, much cooler when you leave the city.

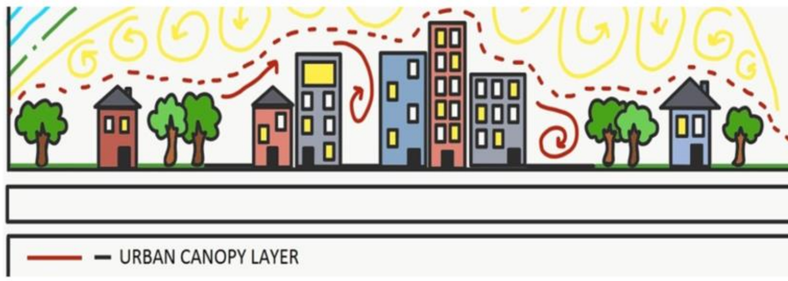
As seen in this diagram, the urban heat island is created when the urban boundary layer prevents the prevailing wind from entering and influencing temperatures in the developed area. The urban boundary layer is the area above a city where the climate within that layer is modified by the presence of the city itself.

Heat islands can affect communities by increasing summertime peak energy demand, air conditioning costs, air pollution and greenhouse gas emissions, heat-related illness and mortality, and water quality. (https://www.epa.gov/heat-islands)

Urban Canopy Layer

Urban Canopy Layer - Air beneath the skyline is trapped and then heated by absorbed sunlight and human activity.

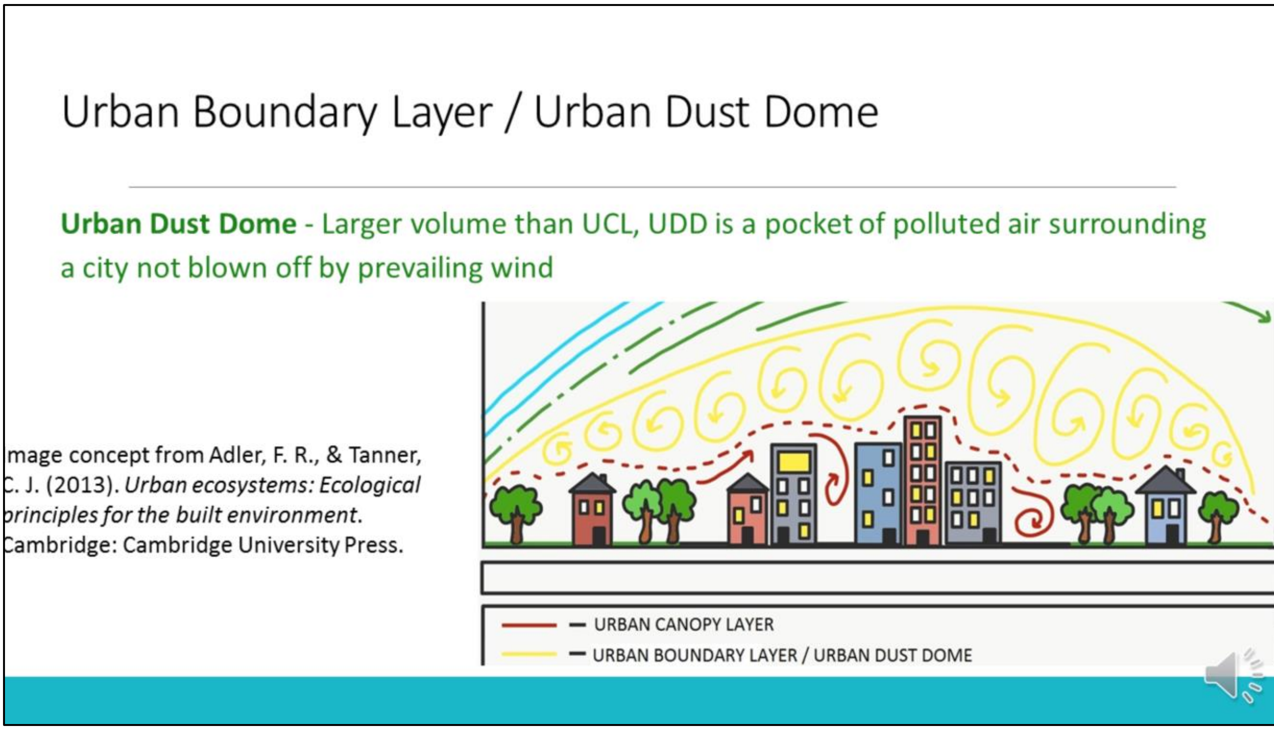
Image concept from Adler, F. R., & Tanner, C. J. (2013). *Urban ecosystems: Ecological principles for the built environment*. Cambridge: Cambridge University Press.



The Urban Canopy Layer is the air at and below the skyline in an urban area. This air is heated by light energy that has been absorbed by urban surfaces, as well as by human activities within the city (e.g., exhaust from cars and emissions from air conditioning units). Much of the air in the UCL remains within the system, trapped between the buildings. Some of the air rises above the skyline, leaving the UCL and entering the Urban Boundary Layer.

Douglas, I., & James, P. (2015). *Urban ecology: An introduction*. Oxon: Routledge.

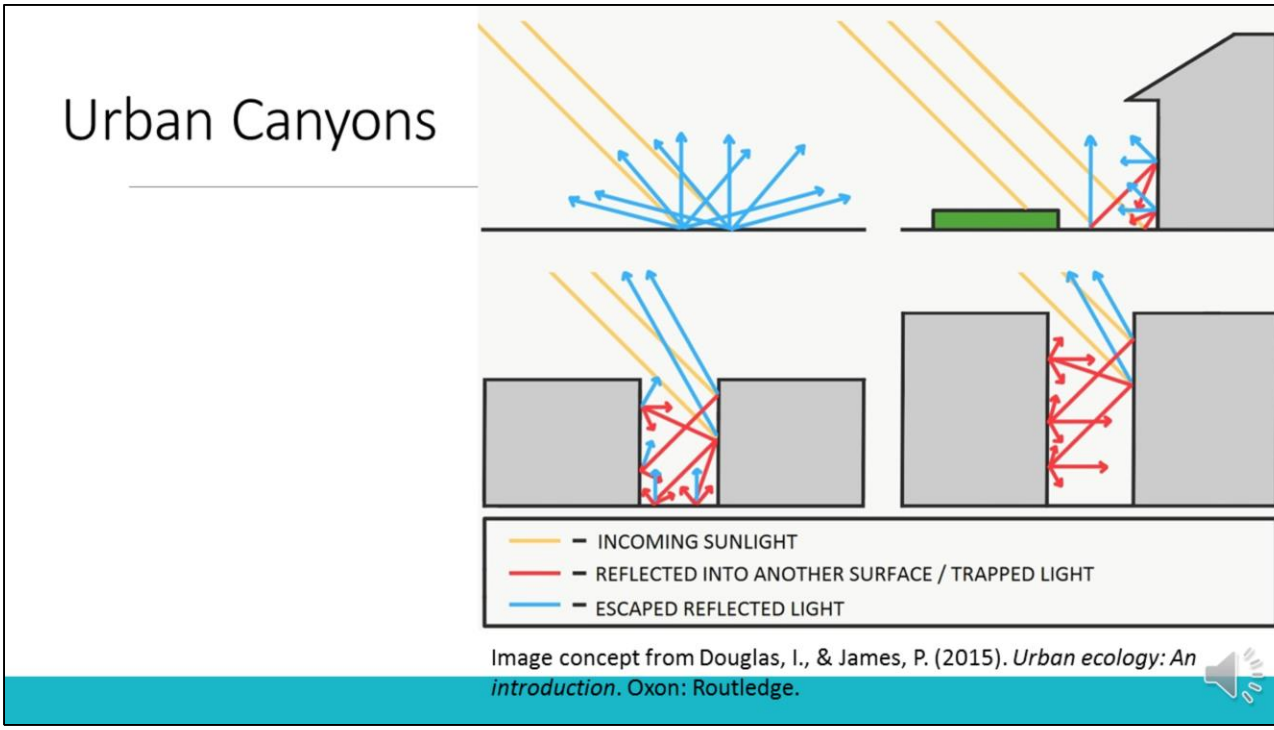
Adler, F. R., & Tanner, C. J. (2013). *Urban ecosystems: Ecological principles for the built environment*. Cambridge: Cambridge University Press.



The Urban Boundary Layer includes the air above the skyline. This air is still a part of the Urban Heat Island, but it does not necessarily come into contact with the buildings or ground. The UBL can be lifted off of the city by the prevailing wind and rise into the atmosphere, causing an urban plume. This plume affects weather patterns downwind of the UHI. The air within the UBL can become trapped around the city when the prevailing wind fails to move it away. This results in an Urban Dust Dome. This bubble of trapped air contains large amounts of air pollution generated by the city beneath. Smog forms when this polluted air descends into the UCL.

Douglas, I., & James, P. (2015). *Urban ecology: An introduction*. Oxon: Routledge.

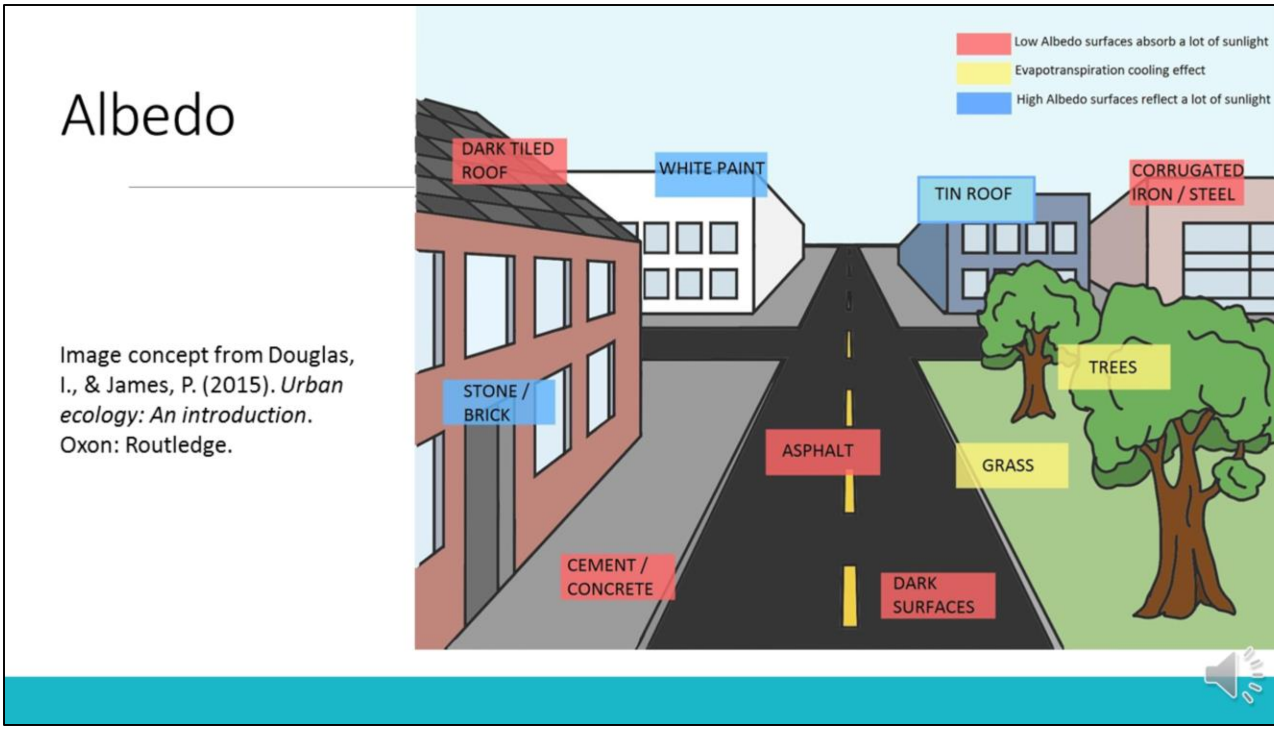
Adler, F. R., & Tanner, C. J. (2013). *Urban ecosystems: Ecological principles for the built environment*. Cambridge: Cambridge University Press.



In urban areas, light is not always reflected out of the system after first contact. The Urban Canyon is the area in a city that can trap reflected light within the walls of the buildings. Some of the light is absorbed at each point of contact, the more points of contact that there are, the more light energy is trapped and stored as heat. In an urban canyon, light can reflect off of multiple surfaces and be absorbed at a much higher rate than in an open area where reflected light escapes more freely. Tall buildings amplify this effect and add heat to the urban heat island.

Douglas, I., & James, P. (2015). *Urban ecology: An introduction*. Oxon: Routledge.

Adler, F. R., & Tanner, C. J. (2013). *Urban ecosystems: Ecological principles for the built environment*. Cambridge: Cambridge University Press.



Another important concept in understanding urban climate is “albedo”. Urban surfaces are made from different materials that reflect and absorb light at different rates. **The amount of light that is reflected off of a surface is called the albedo.**

Many natural surfaces have higher albedos than those found in urban areas, and reflect more light. Moreover, green spaces like forests, counteracts much of the heat gain from light absorption by processes such as evapotranspiration. As many urban areas have limited green space, this process is often limited in urban areas.

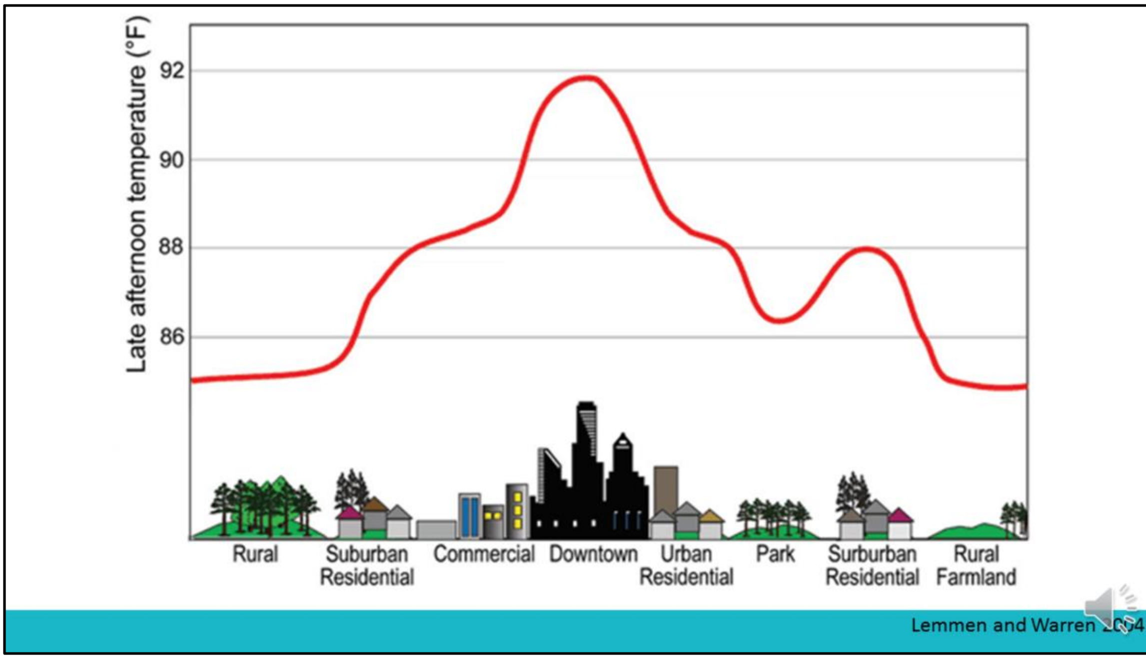
Conversely, many urban surfaces can have lower albedos and absorb more sunlight, heating these surfaces to higher temperatures. This absorbed light is stored and slowly released as heat, which adds to the urban heat island.

As you can see in the figure, certain surfaces, such as asphalt, have exceptionally low albedos and absorb a lot of heat, whereas other surfaces, such as buildings that are painted lighter colors or tin roofs, have much higher albedos and reflect, rather than absorb much of the light energy.

Adding more green space and prioritizing building with low albedo materials are ways to lessen the heat absorption in an urban area.

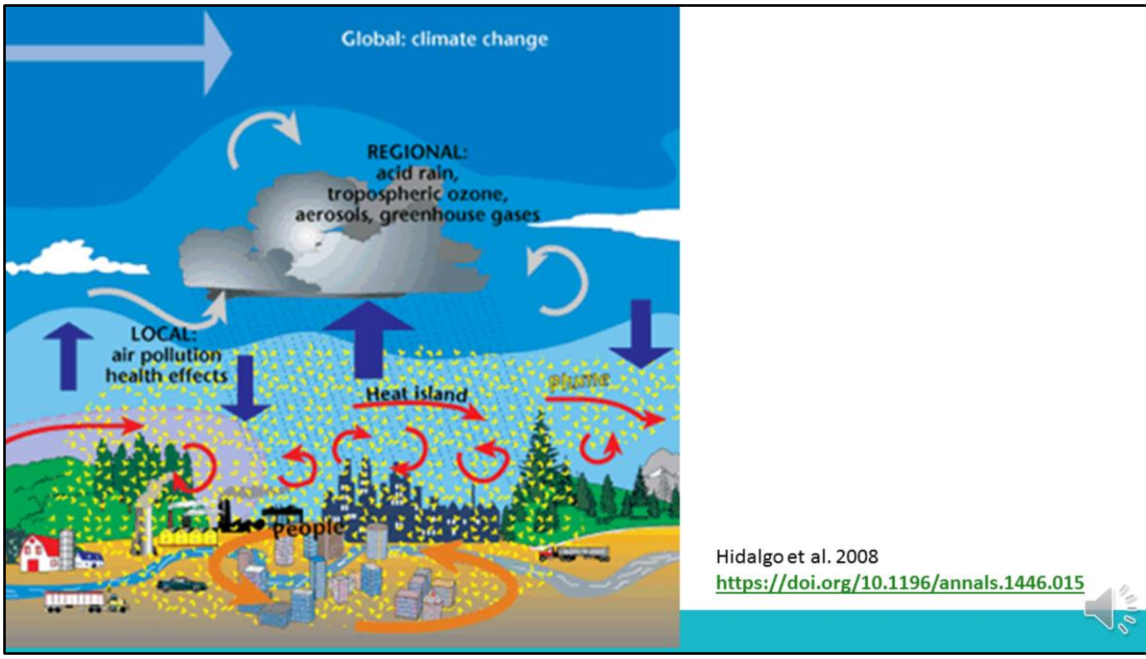
Douglas, I., & James, P. (2015). *Urban ecology: An introduction*. Oxon: Routledge.

Adler, F. R., & Tanner, C. J. (2013). *Urban ecosystems: Ecological principles for the* *built environment*. Cambridge: Cambridge University Press.



So what does the urban heat island have to do with the human condition in urban watersheds? First, increased temperatures can negatively impact the health of communities of people living in urban areas. Secondly, increased temperatures in urban areas may promote more intense rain events which can lead to more flooding in urban watersheds. In coastal cities, problems could be exacerbated by increasing sea-level rise due to global climate change.

Climate Change Impacts and Adaptation: A Canadian Perspective, Edited by D. S. Lemmen and F. J. Warren. Ottawa, ON: Climate Change Impacts and Adaptation Program, Natural Resources Canada, 2004.



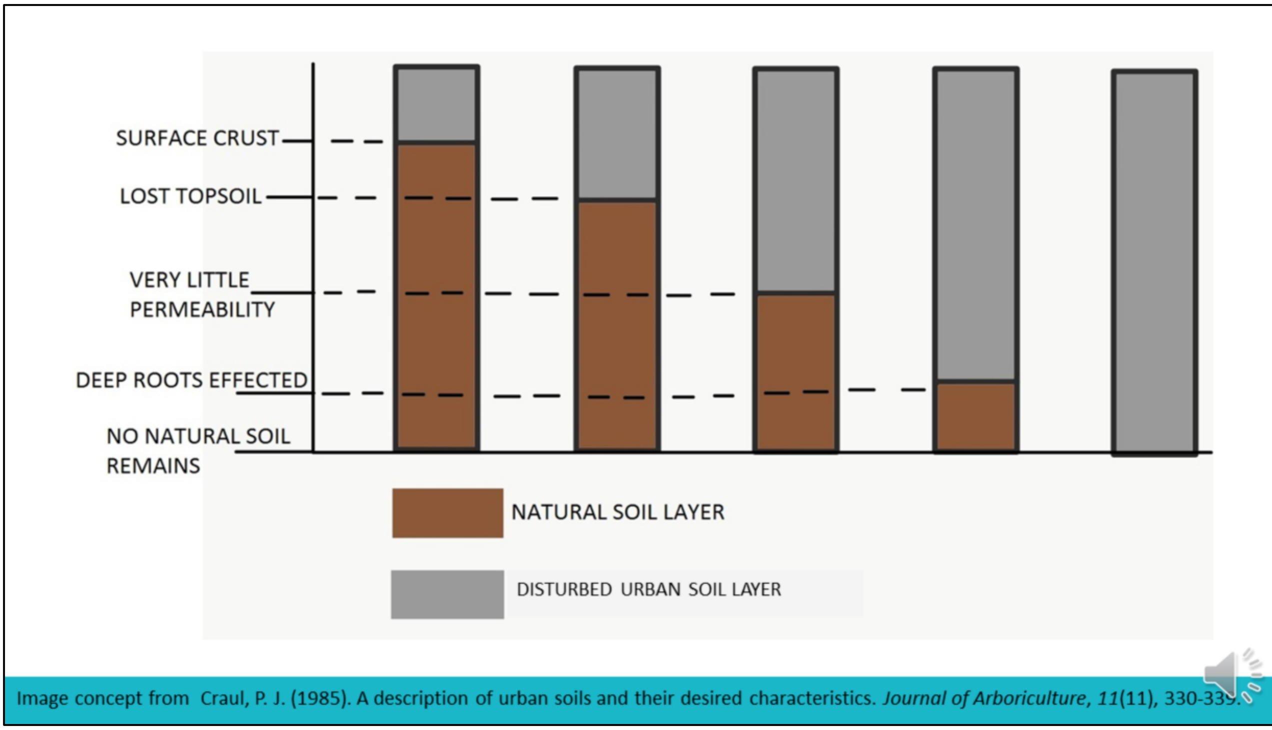
Urban areas can increase the amount of precipitation that falls in a region and the number of rainy days a region experiences. The urban boundary layer creates an area of warm temperatures and low pressure.

Though the total amount of evapotranspiration from plants is typically much lower than surrounding rural areas, evapotranspiration occurs rapidly in urban areas due to increased temperature. This can produce cumulus clouds that can produce precipitation.

Additionally, the low air pressure changes regional wind patterns and the urban boundary can act as a barrier, split apart moving air, and generate rain clouds that produce rain.

Air pollution may also play a role in producing more precipitation. Fine particulates that are emitted into the air as pollution can also increase condensation rates and help generate clouds. (Shepherd 2009; *https://doi.org/10.1175/EI156.1*)

Urbanization can also influence urban soils and can impact flooding in urban watersheds



Urbanization changes the composition and characteristics of soil. Aeration, or the space between soil particles, is an important feature for healthy soil. If the soil becomes too compacted, it loses its permeability. Urban soils are often much more compacted than natural soils due to the creation of impervious surfaces (such as pavement) and the large amounts of traffic on the surface. Compacted soil does not promote infiltration by precipitation; therefore urban soils can generate more surface runoff relative to soils found in rural areas. Learn more about the reasons why urban watersheds often flood in the other presentation in this module.

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