PennState Extension

Green Parking Lots: Mitigating Climate Change and the Urban Heat Island

Designing green parking lots with large canopy trees can reduce urban heat loads, air and water pollution, and mitigate the adverse effects of climate change on our communities.

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Large canopy trees providing shade and cooler temperatures to a parking lot

It appears that over the past three to four decades, parking lots have been one of the fastest-growing land uses, covering acres upon acres of land with impervious asphalt. Because we take our cars everywhere we go, most parking lots are overbuilt for a few peak days of holiday shopping. With a continuing shift towards online shopping, there are numerous parking spaces in shopping malls that very rarely see a car anymore, but outdated municipal codes continue to require large-capacity parking lots in retail shopping developments.

Those seas of asphalt now fuel several environmental issues for our communities. Forest Service research in the late 1990s documented elevated temperatures in neighborhoods up to a quarter mile downwind of unshaded parking lots. This asphalt absorbs more heat and re-radiates that heat load throughout the day and into the evening when the sun goes down. As a result, residential areas near large parking lots warm up quicker, leading to potentially higher energy use during the summer months to stay cooler (air conditioning usage).

Those same parking lots are also sources of large quantities of polluted stormwater that degrade our waterways, scouring and eroding streambanks and adding heavy metals, gasoline, oils, and hydrocarbons that impact aquatic life and downstream water quality.

As climate change continues to warm our communities, elevating temperatures, especially seasonal low and evening temperatures, parking lots are exacerbating the problem by trapping heat that affects human health and energy use. Unshaded parking lots become mini-urban heat islands (a dome of elevated temperature) that can adversely affect human health. Excessive heat can induce heat stokes, impact respiratory illnesses, and increase stress and anti-social behaviors.

One relatively easy and inexpensive way to mitigate these environmental issues is to design green parking lots with plenty of large tree canopy cover that provides shade along with stormwater interception and infiltration (if the plantings are designed properly). USDA Forest Service research in Davis, California showed that air temperatures were 4–8 degrees cooler in shaded parking lots. The shade from trees in those parking lots reduced surface asphalt temperatures by 36 degrees F. and vehicle interior temperatures by 47 degrees F. The cooler parking lot temperatures reduced ozone concentrations and hydrocarbon emissions from parked cars (fuel evaporation).

The Role of Trees

Healthy large canopy trees provide shade that keeps air temperatures and asphalt surfaces cooler during the day. With less heating of asphalt surfaces during the day, there is less heat radiating from those surfaces after sunset, allowing air temperatures to cool faster into the evening and overnight.

Trees also transpire water through their leaves, increasing the surface area contributing to evaporation. When a molecule of water evaporates, it takes with it some heat that energy that would otherwise be used to warm the nearby environment. Trees provide an evaporative cooling effect that can decrease local air temperatures by several degrees. This effect typically reaches its peak when evaporation levels are highest during the middle of the day.

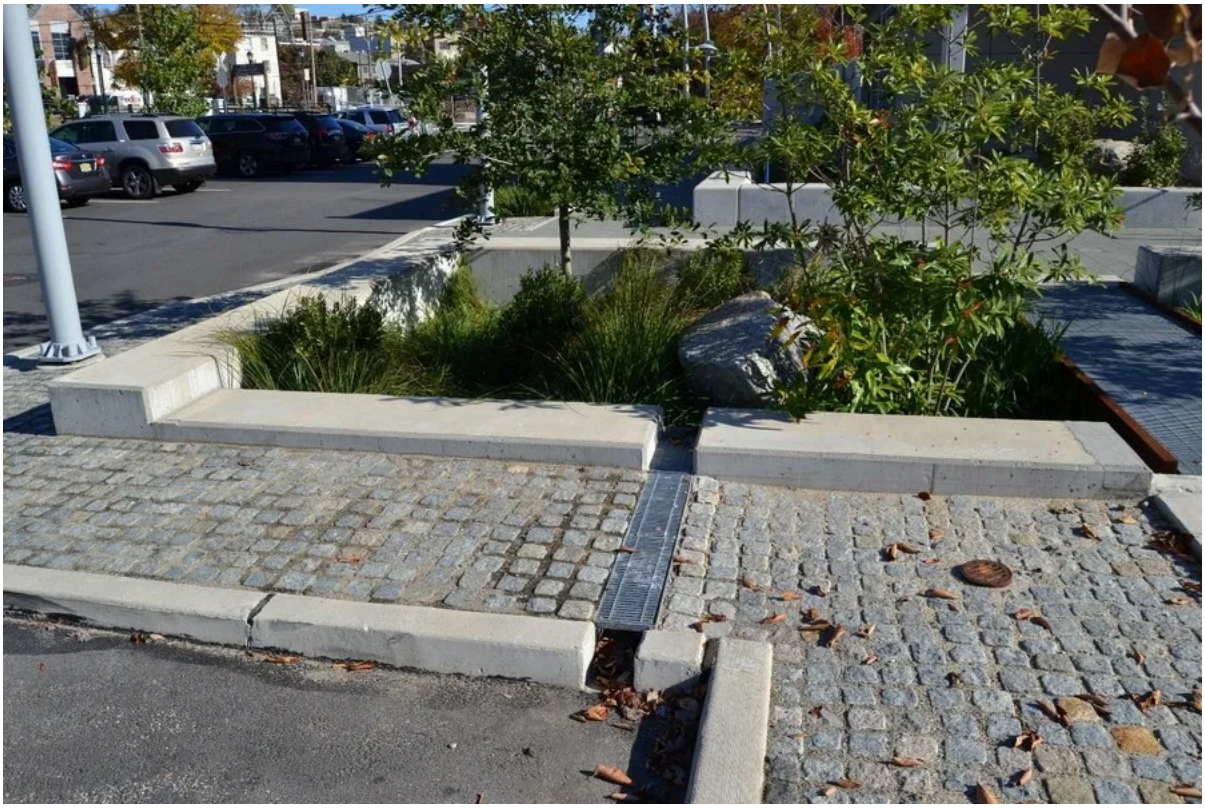
Trees in parking lots also have a positive impact on air and water quality by intercepting particulate matter, absorbing ozone, nitrogen dioxide, and sulfur dioxide gases, and intercepting rainfall in their canopies. If parking lot planting areas are designed properly, trees and other landscape plants can allow stormwater to infiltrate into the soils, providing much-needed moisture for the plants while filtering out pollutants.

Growing Large, Healthy Trees in Parking Lots

All too often, trees are required by codes to be planted in large new parking lots, but little consideration is given to the site requirements to grow large canopy trees, or the harsh site conditions of parking lots, such as extreme temperatures, compacted and low-quality soils, and heavy usage of deicing salts. In many parking lots, designers are failing to provide adequate soil volumes, selecting inappropriate species that will not survive, and creating curbed miniature islands that receive little to no water when it rains.

The goal of maximizing parking spaces is often in conflict with providing room for those trees (or rooting space), but it does not have to be. Landscape islands that sit below grade can receive stormwater runoff from parking lots, serving as living filters, while providing needed water for heat stressed plantings.

Landscape islands should be designed with high-quality, well-drained, loamy soils or structural soils (http://www.hort.cornell.edu/uhi/outreach/pdfs/custructuralsoilwebpdf.pdf) (PDF) that can be compacted and utilized under pavement (even better with porous asphalt) to allow for deeper rooting and better stormwater infiltration and treatment. Research into the use of structural soils in parking lots has been conducted by Cornell University's Urban Horticulture Institute(https://blogs.cornell.edu/urbanhort/), the University of California at Davis, and Virginia Tech University. A demonstration and research parking lot(http://www.hort.cornell.edu/uhi/outreach/pdfs/cu_porous_asphalt.pdf) (PDF) utilizing structural soils and porous asphalt was installed in Ithaca, New York by Cornell University approximately 10 years ago. The porous surface and gravel-based structural soils allow for a six-inch rain event to be infiltrated. Accolade elms were planted in the structural soils and have grown very well due to water infiltration and deep rooting space in the soils. Within five years of planting, the elm trees were providing useful shade to parked cars and cooling air and surface temperatures.



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This planter is designed to receive and filter stormwater runoff from the parking lot

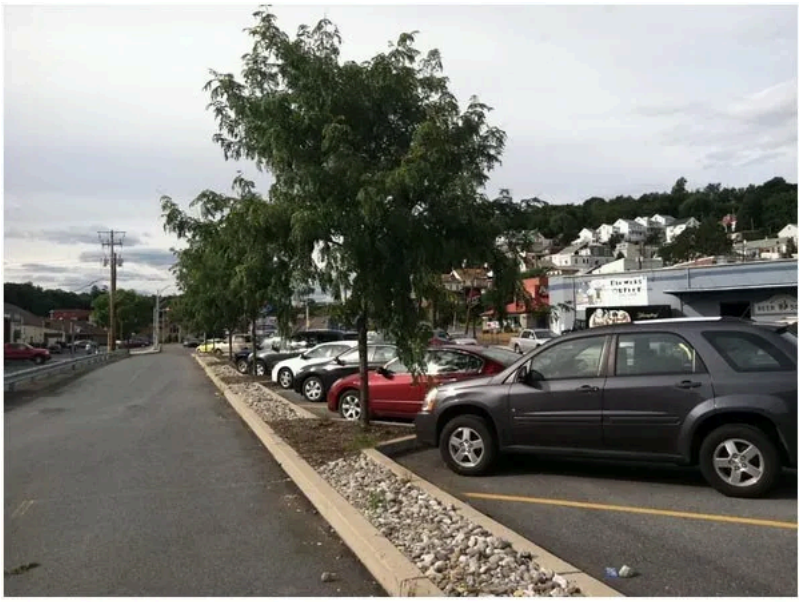
Retrofits and De-paving

Many parking lots have been poorly designed for successful tree and landscape plantings or the incorporation of trees was never given any thought during the parking lot design process. Retrofitting existing parking lots to enhance tree canopy can and should be done. It just takes planning, partnerships, communications, and resources. It is not impossible, and we see it completed all the time. It is often best to start with municipal-owned parking lots, which can be used as an example of what can be done. Discussions with private commercial properties about greening up parking lots can then follow; if private properties complete retrofits, they can often lead to a stormwater credit, good publicity, and increased business. Research by Dr. Kathleen Wolf(http://www.naturewithin.info/consumer.html) at the University of Washington illustrated that greener commercial districts across the country led to an increase in shoppers, more frequent visits, longer stays, and increases in spending from shoppers and visitors.

When retrofitting parking lots, it might be as simple as digging out landscape islands that are not functioning well, creating a shallow below-grade bowl, and replacing soils and plants and cutting notches in the curbing so water can enter the curbed island. It is often best to utilize some large stone where the curb cuts are made to reduce the velocity and impact of the water entering the landscaped area.

If there are no landscape islands, look for room in the parking lots where cars cannot fit (corners and dead zones or linear strips between the parking stalls), or consider removing (or de-paving) an entire parking space and creating a landscaping island that is usually 10 feet wide by 20 feet long. Losing a few parking spaces in large parking lots is typically not detrimental because the lots are designed for overly large capacities.

De-paving can be costly, but it does not have to be. In some cities like Portland, Oregon, non-profits organize volunteer projects that work to remove asphalt parking lots that are no longer needed. DePave Portland and DePave Chicago(https://www.depavechicago.org/) are two examples of this work. The Guide to DePaving (https://www.depave.org/resources)is also very helpful for organizations and municipalities that wish to begin removing some unneeded asphalt or concrete in their communities. Watershed organizations and stormwater authorities might partner with the community to remove impervious surfaces that negatively impact the watershed and local water quality.



(https://extension.psu.edu/media/wysiwyg//extensions/catalog_product/3ad6aeca381e440d96512c1a87a70fb6/b/u/bump-out-planters.jpg)
This narrow strip with bump-out plantings of honey locusts was a retrofit

Selecting the Right Tree for the Parking Lot

When it comes to selecting trees for parking lots, first remember the goals: mitigating urban heat and reducing and filtering polluted stormwater. So, choosing small, low-growing flowering trees really isn't going to achieve those goals, nor will they survive those harsh conditions. If they do survive, their low-growing branches will create conflicts with cars, pedestrians, and winter snowplows. Avoid small-stature trees and select heat and salt-tolerant large canopy trees such as London planetree, honeylocust, hackberry, hybrid elms, zelkova, and oaks like willow oak and swamp white oak. If the site is designed to receive stormwater, the above-mentioned species will tolerate those conditions as will river birch, pin oak, and sweetgum.

Requiring Trees in Parking Lots in Your Community

If your community is concerned about the increasing number of parking lots, both large and small, it should consider enacting a landscape ordinance to require tree plantings be installed when any new development including a parking lot (residential and commercial) is proposed. Some ordinances set standards and requirements such as one tree planted per certain number of parking spaces, while others simply require 10% of the parking lot be landscaped. If a percentage of the parking lots is required to be landscaped, it does not mean that trees will be planted. Shrubs and flowers around the perimeter might meet the percentage requirement and those plantings will not provide shading, cooling, stormwater management, and other ecosystem services our communities deserve.

Some newer ordinances are requiring 50% of a parking lot to be covered with tree canopy within 15 years (if the trees survive). This approach certainly requires the designer to create more room for trees, especially in the interior of the parking lot and not just planting the perimeter or edges, as is often done. Codes should consider spelling out the size of the tree islands or landscape strips to ensure that there is enough soil volume to grow healthy trees that will provide shade and survive. Parking lot designers can find room for trees by considering one-way aisles with angle in parking stalls and creating planting islands between the rows of stalls.

(https://extension.psu.edu/media/wysiwyg//extensions/catalog_product/c40c0dfb350a4e74a4cd9e985573cf62/a/e/aerialimageofparkinglotwithtrees-jp.jpg)

This properly designed downtown parking lot has achieved good canopy cover and provides park like benefits.

Helpful Resources

To learn more about designing green parking lots and establishing codes and regulations for your community you might want to consider the following references:

- EPA Green Parking Lot Resource Guide(https://www.slideshare.net/Sotirakou964/green-parking-lot-resource-guide)
- Sustainable Green Parking Lots Guide (https://www.montcopa.org/DocumentCenter/View/9735/Green-Sustainable-Parking-Guide-2_10_2016-Web?bidId=) (PDF) – created by the Montgomery County, Pennsylvania planning department
- Green Parking Lots – Naturally Resilient Communities Partnership(https://nrcsolutions.org/solution-4/)
- Better Site Design – Center for Watershed Protection – Green Parking (https://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool4_Site_Design/GreenParking.htm)

Realize that the parking lot is not going away anytime soon, but instead of allowing acres upon acres of hot and barren seas of asphalt to consume our communities, we can design and install “cool,” green parking lots that are attractive and might just help our communities mitigate climate change, water, and air pollution, and the urban heat islands that can result.

Citations

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