HOW GREEN INFRASTRUCTURE CAN IMPROVE CLIMATE RESILIENCE

Green infrastructure (GI) is an approach to managing stormwater that enables it to filter into the ground near where it falls, or captures it for later use. Keeping runoff out of the storm sewer system improves water quality and minimizes localized flooding.

One goal of green infrastructure is to improve a municipality's climate resilience to extreme weather events like more intense storms, sea level rise, and hotter days. To address more intense storm events, GI projects can combat flooding by capturing, treating, storing, and infiltrating stormwater runoff from smaller, more frequent storms. For larger storm events like hurricanes and Nor'easters, GI can capture the first few inches of runoff from these storms and divert additional flow to storage systems (gray or green) that can release the flow after the major storm by sequestering water away from flood-prone areas for different uses (Carter et al., 2017; Staddon et al., 2018).

Rising sea levels are an issue for coastal and bayshore communities. For rising sea levels, the beneficial infiltration component of GI usually is limited as a result of the higher groundwater table. However, GI can be used to store water and release it after the storm, or can store stormwater runoff during high tide to be discharged during low tide.

Another way GI can help reduce the impacts of climate change is through the reduction of the urban heat island effect (Knight et al., 2016). Heat islands are urbanized areas that experience higher temperatures than outlying areas. Structures such as buildings, roads, and other infrastructure absorb and re-emit the sun's heat more than natural landscapes like forests and water bodies (USEPA, 2022). GI projects that incorporate vegetation like bioretention systems, city parks, and urban forests provide cooling benefits (Pamukcu-Albers et al., 2021) by reducing heat-absorbing surfaces and through evapotranspiration. Replacing traditional asphalt with porous asphalt can help cool urban areas, since porous asphalt has been shown to absorb less heat than traditional asphalt because its porosity allows increased airflow through the paved surface.

Green infrastructure can create mutually reinforcing systems to boost resilience against extreme weather events and can provide new social and recreational opportunities for municipalities (Staddon et al., 2018). However, it is important for municipalities to ensure that a given GI project is designed for extreme weather conditions that are specific to the site and address the needs of the local population (Carter et al., 2017; Derkzen et al., 2017). Directly engaging the population in conversations surrounding the installation and maintenance of a particular GI project will help ensure both the popular support of a project, and—if planned accordingly—equitable resilience against climate change.

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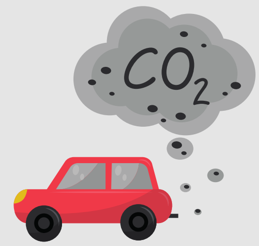
HOW GREEN INFRASTRUCTURE CAN INCREASE CARBON SEQUESTRATION

The sequestration of carbon dioxide from the atmosphere is one of the central focuses of green infrastructure. Within urban and suburban areas, a stronger focus is needed to improve air quality impacted by vehicle emissions. There are unseen yet significant carbon sequestration efforts already occurring because of municipal GI in parks. Not only do the edges of temperate forests and its soil sequester more carbon dioxide resulting in 24.1–36.3% more growth, but they induce a 15% increase in productivity in metropolitan areas (Morreale et al., 2021). Even trees enhanced with biochar can sequester 520 kilograms of carbon dioxide per resident over a 50-year period with proper and equitable green planning in urban residential areas (Ariluoma et al., 2021). However, carbon sequestration doesn't have to stop at trees. Rain gardens sequester nearly all of the carbon footprint needed to install them and are the best sequestering tools; however, not to skim over the total findings, bioretention basins are the next best at sequestering carbon dioxide at 70% of their carbon footprint, followed by green roofs (68%), vegetated swales (45%), and stormwater ponds (8%) (Kavehei et al., 2018).



The urban heat island effect occurs when buildings, roads, and other structural infrastructure absorb and re-emit the sun's heat more than natural landscapes, such as forests and water bodies (USEPA, 2022). Emissions that are produced by tailpipes, air conditioning, and other polluting sources also contribute to warming urban areas. Due to factors including air pollution, anthropogenic heat, surface waterproofing, thermal properties of fabric, and surface geometry, ultraviolet (UV) radiation from the additional heat from these sources can get trapped causing a dome effect over a given urban area (Shahmohamadi et al., 2010; Knight et al., 2016). This trapped heat in urban settings then intensifies temperatures across the urban population, which can lead to many forms of heat-related illness and stress (Shahmohamadi et al., 2010). With GI and its beneficial carbon sequestration potential, the lack of heat-trapping emissions in the air would allow the heat to escape and cooling to set in (Shahmohamadi et al., 2010; Morreale et al., 2021; Pamukcu-Albers et al., 2021). However, there is another factor worth considering in carbon sequestration: turfgrass.

Turfgrass's relationship to green infrastructure is a very important factor in carbon sequestration. A 2018 study found that with a 41.2% decrease in carbon sequestration potential from a loss of green spaces in Seoul, a 120% increase in grasslands was able to somewhat remedy the loss (Han, Kang, and Song, 2018). Basically, a large amount of grassland is needed to counter the loss in green spaces that host native vegetation species and soil organisms which already sequester more carbon dioxide than turfgrasses. In fact, replacing native species with turfgrass in Australian peri-urban environments resulted in an increase in the soil's release of carbon dioxide emissions, due to nitrogen-based fertilizer and irrigation practices accelerated by a subtropical environment (Delden et al., 2016).

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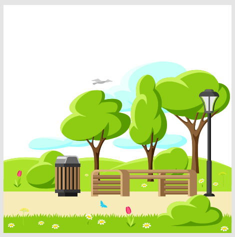
HOW GREEN INFRASTRUCTURE CAN BE USED TO IMPROVE HEALTH

Green infrastructure can reduce cases of heat-related stress and illness by reducing the urban heat island effect. The reduced entrapment of heat within urban settings consequently leads to a reduced risk of heat stroke; respiratory distress and diseases; and potential exacerbation of existing conditions including diabetes, asthma, pneumonia, and chronic obstructive pulmonary disease (Shahmohamadi et al., 2010).



Green infrastructure can also be used to create green space that significantly improves the health of those living near it, thus improving mental and physical health in the public sphere. Across all ages, spending significant time in greener spaces promotes psychological well-being, improved sleep, reduced stress, and reduced mental fatigue, which supports enhanced mental effectiveness, decreased incidence of anxiety, ADHD, and depression (Tzoulas et al., 2007; McCormick, 2017; Bratman et al., 2019). In children, it was observed that time in green parks led to improved focus, increased confidence, and heightened opportunities to form supportive social groups (Chawla et al., 2014). In direct tandem with mental health, GI also provides several benefits for physical health, especially in recreational settings.

One of the most obvious factors of improved physical health resulting from GI and carbon sequestration is cleaner air to breathe. One project proposal based in Rome estimated that the nearly 300,000 people surrounding that project would experience an improvement in air quality, which would save between 40,700 and 130,200 euros per year in health-related costs. Action to remediate air quality through GI and carbon sequestration becomes more imperative in NJ when considering that one-in-four children in Newark have asthma associated with the city's poor air quality (Johnson, 2015; Capotorti et al., 2019).

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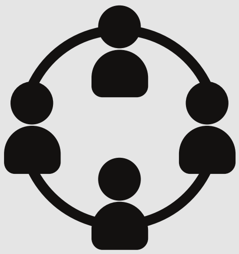
GREEN INFRASTRUCTURE'S IMPACT ON EQUITY



Green infrastructure's impact on equity has been complex. There are numerous benefits of GI on public health and environmental resilience. However, what often gets overlooked is the flexibility of GI, the placement of these projects, and depending on the location, the displacement of others in its wake. Due to the wide scope of what GI can be without proper clarification, the placement of certain projects can amount to little more than "greenwashing"—where the public is misled on the eco-friendliness of a product or project (Matsler et al., 2021). In tandem with "greenwashing," the placement of these projects can, and has been shown to, lead to an entrenchment of historic socioeconomic trends and green gentrification—where GI projects are more likely to be placed in affluent and wealthy neighborhoods instead of lower-income communities.

Examples of green gentrification can be found in South Africa, where the placement of GI reflects socioeconomic trends stemming from the apartheid regime, and in the United States, through projects like the NYC High Line and the Chicago 606 projects (Rigolon & Németh, 2018; Venter et al., 2020). In fact, the physical distance a person lives from a green space has noted effects on physical and mental well-being; lower-income children who lived 20 minutes away from a green space had lower test scores, worse general health, and watched an average of two hours more worth of television than children with a five-minute walk to green space (Aggio et al., 2015).

The best way communities can be equitably uplifted through green infrastructure and ensure its optimization of GI projects, is to hire people for these projects within those communities. While tracking how long a dollar stays within the economy of a specific ethnic community is unverifiable, hiring within local neighborhoods to care for GI does have various economic benefits to empower communities (Madison, 2015). Forming these connections harnesses urban ecological diversity through shared knowledge, nurtures local stewardship of these infrastructures, and changes the character of the reduction of a carbon footprint (Andersson et al., 2020). In the economically beneficial scope, systems which can calculate economic and equity benefits already exist today. The Economics of Ecosystems and Biodiversity (TEEB) values "social cohesion" in relation to greenspaces, while the Green Infrastructure Equity Index offers a nuanced view of the need for GI through "equity voids." (Hamann et al., 2020; Heckert and Rosan, 2016). Some of these systems value different impacts and effects, so it is best to use a system suited for the specific nature of the green infrastructure project (Hamann et al., 2020). By ensuring that these projects are tailored to the community, and ensure the community's full and specialized involvement, equity will be able to grow within these projects.

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